BEFORE THE STATE OF SOUTH DAKOTA
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES

BOARD OF MINERALS AND ENVIRONMENT

IN THE MATTER OF CLEAN NUCLEAR	)
ENERGY CORP.URANIUM EXPLORATION	)
PERMIT APPLICATION	)
	)
EXNI 453	)
	)

INTERVENOR GREAT PLAINS TRIBAL WATER ALLIANCE, INC.

DISCLOSURE OF WITNESSES AND EXHIBITS

COMES NOW, intervenor Great Plains Tribal Water Alliance, Inc., and discloses witnesses that shall testify and exhibits to be entered into the record at the hearing in this matter, as follows:

I. Witnesses

Erroll "Doug" Crow Ghost Jr.
Box D
Fort Yates, North Dakota 58538

Michael Gutzmer, PhD
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Buckeye, Arizona 85396

Syed Huq
2533 Legion Avenue South
Rosebud, South Dakota 57570

Timothy Mentz Sr.
Post Office Box 492
Fort Yates, North Dakota 585385

Sarah Peterson
510 Jennings
Hot Springs, South Dakota 57747

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Post Office Box 4052
Pine Ridge, South Dakota 57770

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Post Office Box 119
Keystone, South Dakota 57751

Kurt Tooley
678 S. Red Fox Lane
Columbus, Nebraska 68601

II. Exhibits – to be numbered beginning 201

20_ Treaty of Fort Laramie of September 17, 1851

20_ Treaty of Fort Laramie of April 29, 1868

20_ Society of American Archaeology, letter to Lt. Gen. Todd Semonite (Sept. 13, 2016)

20_ S.D. GF & P, Bats of the Black Hills: A Description of Status and Conservation Needs (2003)

20_ U.S. Forest Service, DRAFT ENVIRONMENTAL ASSESSMENT, CRAVEN CANYON MINERAL WITHDRAWAL, map

20_ U.S. Forest Service, DRAFT ENVIRONMENTAL ASSESSMENT, CRAVEN CANYON MINERAL WITHDRAWAL (2010)

20_ Memorandum of Agreement between USFS and ACHP (1977)

20_ Michael Gutzmer, et al., *Documentation of the Northern Long-Eared Myotis on the Standing Rock Reservation*, PROCEEDINGS OF THE SOUTH DAKOTA ACADEMY OF SCIENCE, Vol. 95 (2016)

20_ Kant, Joanita M., *Heavy Metals in Traditionally-Used Fruits Among the Lakota* (2013) Electronic Theses and Dissertations 1448

20___ Pegasus Resources, Inc., Press Release (Dec. 3, 2022)

20___ Photos of certain plants

20___ State of South Dakota, County of Fall River, Certificate of Initiated Measure, Nov. 10, 2022

20___ State of South Dakota, Certificate, Fall River County Initiated Measure, Nov. 15, 2022

20___ Treaty map of the Oceti Sakowin Oyate as filed in U.S. Court of Claims

20___ United Nations, Declaration on the Rights of Indigenous Peoples 61/295 (General Assembly 2007)

RESPECTFULLY SUBMITTED this 1st day of December 2025

By: ____________________

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Attorneys for the Great Plains Tribal Water Alliance, Inc.

Certificate of Service

The undersigned hereby certifies that the afore documents were served as electronic files on a USB portable storage device sent a via U.S. mail with proper postage attached to –

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Dated this 1st day of December 2025

Peter Capossela

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Articles of a treaty made and concluded at Fort Laramie, in the Indian Territory, between D. D. Mitchell, superintendent of Indian affairs, and Thomas Fitzpatrick, Indian agent, commissioners specially appointed and authorized by the President of the United States, of the first part, and the chiefs, headmen, and braves of the following Indian nations, residing south of the Missouri River, east of the Rocky Mountains, and north of the lines of Texas and New Mexico, viz, the Sioux or Dahcotahs, Cheyennes, Arrapahoes, Crows, Assinaboines, Gros-Ventre Mandans, and Arrickaras, parties of the second part, on the seventeenth day of September, A. D. one thousand eight hundred and fifty-one.[a]

Sept. 17, 1851.
11 Stats., p. 749.

Peace to be observed.

ARTICLE 1. The aforesaid nations, parties to this treaty, having assembled for the purpose of establishing and confirming peaceful relations amongst themselves, do hereby covenant and agree to abstain in future from all hostilities whatever against each other, to maintain good faith and friendship in all their mutual intercourse, and to make an effective and lasting peace.

Roads may be established.

ARTICLE 2. The aforesaid nations do hereby recognize the right of the United States Government to establish roads, military and other posts, within their respective territories.

Indians to be protected.

ARTICLE 3. In consideration of the rights and privileges acknowledged in the preceding article, the United States bind themselves to protect the aforesaid Indian nations against the commission of all depredations by the people of the said United States, after the ratification of this treaty.

Depredations on whites to be satisfied.

ARTICLE 4. The aforesaid Indian nations do hereby agree and bind themselves to make restitution or satisfaction for any wrongs committed, after the ratification of this treaty, by any band or individual of their people, on the people of the United States, whilst lawfully residing in or passing through their respective territories.

Boundaries of lands.

ARTICLE 5. The aforesaid Indian nations do hereby recognize and acknowledge the following tracts of country, included within the metes and boundaries hereinafter designated, as their respective territories, viz:

Sioux.

The territory of the Sioux or Dahcotah Nation, commencing the mouth of the White Earth River, on the Missouri River; thence in a southwesterly direction to the forks of the Platte River; thence up the north fork of the Platte River to a point known as the Red Bute, or where the road leaves the river; thence along the range of mountains known as the Black Hills, to the head-waters of Heart River; thence down Heart River to its mouth; and thence down the Missouri River to the place of beginning.

Grosventre, etc.

The territory of the Gros Ventre, Mandans, and Arrickaras Nations, commencing at the mouth of Heart River; thence up the Missouri River to the mouth of the Yellowstone River; thence up the Yellowstone River to the mouth of Powder River in a southeasterly direction, to the head-waters of the Little Missouri River; thence along the Black Hills to the head of Heart River, and thence down Heart River to the place of beginning.

Assiniboin.

The territory of the Assinaboin Nation, commencing at the mouth of Yellowstone River; thence up the Missouri River to the mouth of the Muscle-shell River; thence from the mouth of the Muscle-shell River in a southeasterly direction until it strikes the head-waters of Big Dry Creek; thence down that creek to where it empties into the Yellowstone River, nearly opposite the mouth of Powder River, and thence down the Yellowstone River to the place of beginning.

Blackfoot.

The territory of the Blackfoot Nation, commencing at the mouth of Muscle-shell River; thence up the Missouri River to its source; thence along the main range of the Rocky Mountains, in a southerly direction, to the head-waters of the northern source of the Yellowstone River; thence down the Yellowstone River to the mouth of Twenty-five Yard Creek; thence across to the head-waters of the Muscle-shell River, and thence down the Muscle-shell River to the place of beginning.

Crow.

The territory of the Crow Nation, commencing at the mouth of Powder River on the Yellowstone; thence up Powder River to its source; thence along the main range of the Black Hills and Wind River Mountains to the head-waters of the Yellowstone River; thence down the Yellowstone River to the mouth of Twenty-five Yard Creek; thence to the head waters of the Muscle-shell River; thence down the Muscle-shell River to its mouth; thence to the head-waters of Big Dry Creek, and thence to its mouth.

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The territory of the Cheyennes and Arrapahoes, commencing at the Red Bute, or the place where the road leaves the north fork of the Platte River; thence up the north fork of the Platte River to its source; thence along the main range of the Rocky Mountains to the head-waters of the Arkansas River; thence down the Arkansas River to the crossing of the Santa Fé road; thence in a northwesterly direction to the forks of the Platte River, and thence up the Platte River to the place of beginning.

Cheyenne and Arapaho.

It is, however, understood that, in making this recognition and acknowledgement, the aforesaid Indian nations do not hereby abandon or prejudice any rights or claims they may have to other lands; and further, that they do not surrender the privilege of hunting, fishing, or passing over any of the tracts of country heretofore described.

Rights in other lands.

ARTICLE 6. The parties to the second part of this treaty having selected principals or head-chiefs for their respective nations, through whom all national business will hereafter be conducted, do hereby bind themselves to sustain said chiefs and their successors during good behavior.

Head chiefs of said tribes.

ARTICLE 7. In consideration of the treaty stipulations, and for the damages which have or may occur by reason thereof to the Indian nations, parties hereto, and for their maintenance and the improvement of their moral and social customs, the United States bind themselves to deliver to the said Indian nations the sum of fifty thousand dollars per annum for the term of ten years, with the right to continue the same at the discretion of the President of the United States for a period not exceeding five years thereafter, in provisions, merchandise, domestic animals, and agricultural implements, in such proportions as may be deemed best adapted to their condition by the President of the United States, to be distributed in proportion to the population of the aforesaid Indian nations.

Annuities.

ARTICLE 8. It is understood and agreed that should any of the Indian nations, parties to this treaty, violate any of the provisions thereof, the United States may withhold the whole or a portion of the annuities mentioned in the preceding article from the nation so offending, until, in the opinion of the President of the United States, proper satisfaction shall have been made.

Annuities suspended by violation of treaty.

In testimony whereof the said D. D. Mitchell and Thomas Fitzpatrick commissioners as aforesaid, and the chiefs, headmen, and braves, parties hereto, have set their hands and affixed their marks, on the day and at the place first above written.

D. D. Mitchell
Thomas Fitzpatrick
Commissioners.

Sioux:
Mah-toe-wha-you-whey, his x mark.
Mah-kah-toe-zah-zah, his x mark.
Bel-o-ton-kah-tan-ga, his x mark.
Nah-ka-pah-gi-gi, his x mark.
Mak-toe-sah-bi-chis, his x mark.
Meh-wha-tah-ni-hans-kah, his x mark.
Cheyennes:
Wah-ha-nis-satta, his x mark.
Voist-ti-toe-vetz, his x mark.
Nahk-ko-me-ien, his x mark.
Koh-kah-y-wh-cum-est, his x mark.
Arrapahoes:
Bè-ah-té-a-qui-sah, his x mark.
Neb-ni-bah-seh-it, his x mark.
Beh-kah-jay-beth-sah-es, his x mark.

Crows:
Arra-tu-ri-sash, his x mark.
Doh-chepit-seh-chi-es, his x mark.
Assinaboines:
Mah-toe-wit-ko, his x mark.
Toe-tah-ki-eh-nan, his x mark.
Mandans and Gros Ventres:
Nochk-pit-shi-toe-pish, his x mark.
She-oh-mant-ho, his x mark.
Arickarees:
Koun-hei-ti-shan, his x mark.
Bi-atch-tah-wetch, his x mark.

In the presence of—

A. B. Chambers, secretary.
S. Cooper, colonel, U. S. Army.
R. H. Chilton, captain, First Drags.
Thomas Duncan, captain, Mounted Riflemen.
Thos. G. Rhett, brevet captain R. M. R.
W. L. Elliott, first lieutenant R. M. R.
C. Campbell, interpreter for Sioux.
John S. Smith, interpreter for Cheyennes.
Robert Meldrum, interpreter for the Crows.
H. Culbertson, interpreter for Assiniboines and Gros Ventres.
Francois L'Etalie, interpreter for Arickarees.
John Pizelle, interpreter for the Arrapahoes.
B. Gratz Brown.
Robert Campbell.
Edmond F. Chouteau.

[a] This treaty as signed was ratified by the Senate with an amendment changing the annuity in Article 7 from fifty to ten years, subject to acceptance by the tribes. Assent of all tribes except the Crows was procured (see Upper Platte C., 570, 1853, Indian Office) and in subsequent agreements this treaty has been recognized as in force (see post p. 776).

TREATY WITH THE SIOUX—BRULÉ, OGLALA, MINICONJOU, YANKTONAI, HUNKPAPA, BLACKFEET, CUTHEAD, TWO KETTLE, SANS ARCS, AND SANTEE—AND ARAPAHO, 1868.

Apr. 29, 1868.

15 Stats., 635.
Ratified, Feb. 16, 1869.
Proclaimed, Feb. 24, 1869.

Articles of a treaty made and concluded by and between Lieutenant-General William T. Sherman, General William S. Harney, General Alfred H. Terry, General C. C. Augur, J. B. Henderson, Nathaniel G. Taylor, John B. Sanborn, and Samuel F. Tappan, duly appointed commissioners on the part of the United States, and the different bands of the Sioux Nation of Indians, by their chiefs and head-men, whose names are hereto subscribed, they being duly authorized to act in the premises.

War to cease and peace to be kept.

ARTICLE 1. From this day forward all war between the parties to this agreement shall forever cease. The Government of the United States desires peace, and its honor is hereby pledged to keep it. The Indians desire peace, and they now pledge their honor to maintain it.

Offenders against the Indians to be arrested, etc.

If bad men among the whites, or among other people subject to the authority of the United States, shall commit any wrong upon the person or property of the Indians, the United States will, upon proof made to the agent and forwarded to the Commissioner of Indian Affairs at Washington City, proceed at once to cause the offender to be arrested and punished according to the laws of the United States, and also re-imburse the injured person for the loss sustained.

Wrongdoers against the whites to be punished.

If bad men among the Indians shall commit a wrong or depredation upon the person or property of any one, white, black, or Indian, subject to the authority of the United States, and at peace therewith, the Indians herein named solemnly agree that they will, upon proof made to their agent and notice by him, deliver up the wrong-doer to the United States, to be tried and punished according to its laws; and in case they wilfully refuse so to do, the person injured shall be re-imbursed for his loss from the annuities or other moneys due or to become due to them under this or other treaties made with the United States. And the President, on advising with the Commissioner of Indian Affairs, shall prescribe such rules and regulations for ascertaining damages under the provisions of this article as in his judgment may be proper. But no one sustaining loss while violating the provisions of this treaty or the laws of the United States shall be re-imbursed therefor.

Damages.

Reservation boundaries.

ARTICLE 2. The United States agrees that the following district of country, to wit, viz: commencing on the east bank of the Missouri River where the forty-sixth parallel of north latitude crosses the same, thence along low-water mark down said east bank to a point opposite where the northern line of the State of Nebraska strikes the river, thence west across said river, and along the northern line of Nebraska to the one hundred and fourth degree of longitude west from Greenwich, thence north on said meridian to a point where the forty-sixth parallel of north latitude intercepts the same, thence due east along said parallel to the place of beginning; and in addition thereto, all existing reservations on the east bank of said river shall be, and the same is, set apart for the absolute and undisturbed use and occupation of the Indians herein named, and for such other friendly tribes or individual Indians as from time to time they may be willing, with the consent of the United States, to admit amongst them; and the United States now solemnly agrees that no persons except those herein designated and authorized so to do, and except such officers, agents, and employés of the Government as may be authorized to enter upon Indian reservations in discharge of duties enjoined by law, shall ever be permitted to pass over, settle upon, or reside in the territory described in this article, or in such territory as may be added to this reservation for the use of said Indians, and henceforth they will and do hereby relinquish all claims or right in and to any portion of the United States or Territories, except such as is embraced within the limits aforesaid, and except as hereinafter provided.

Certain persons not to enter or reside thereon.

Additional arable land to be added, if, etc.

ARTICLE 3. If it should appear from actual survey or other satisfactory examination of said tract of land that it contains less than one hundred and sixty acres of tillable land for each person who, at the time, may be authorized to reside on it under the provisions of this treaty, and a very considerable number of such persons shall be disposed to commence cultivating the soil as farmers, the United States agrees to set apart, for the use of said Indians, as herein provided,

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such additional quantity of arable land, adjoining to said reservation, or as near to the same as it can be obtained, as may be required to provide the necessary amount.

Buildings on reservation.

ARTICLE 4. The United States agrees, at its own proper expense, to construct at some place on the Missouri River, near the center of said reservation, where timber and water may be convenient, the following buildings, to wit: a warehouse, a store-room for the use of the agent in storing goods belonging to the Indians, to cost not less than twenty-five hundred dollars; an agency-building for the residence of the agent, to cost not exceeding three thousand dollars; a residence for the physician, to cost not more than three thousand dollars; and five other buildings, for a carpenter, farmer, blacksmith, miller, and engineer, each to cost not exceeding two thousand dollars; also a school-house or mission-building, so soon as a sufficient number of children can be induced by the agent to attend school, which shall not cost exceeding five thousand dollars.

The United States agrees further to cause to be erected on said reservation, near the other buildings herein authorized, a good steam circular-saw mill, with a grist-mill and shingle-machine attached to the same, to cost not exceeding eight thousand dollars.

Agent's residence, office, and duties.

ARTICLE 5. The United States agrees that the agent for said Indians shall in the future make his home at the agency-building; that he shall reside among them, and keep an office open at all times for the purpose of prompt and diligent inquiry into such matters of complaint by and against the Indians as may be presented for investigation under the provisions of their treaty stipulations, as also for the faithful discharge of other duties enjoined on him by law. In all cases of depredation on person or property he shall cause the evidence to be taken in writing and forwarded, together with his findings, to the Commissioner of Indian Affairs, whose decision, subject to the revision of the Secretary of the Interior, shall be binding on the parties to this treaty.

Heads of families may select lands for farming.

ARTICLE 6. If any individual belonging to said tribes of Indians, or legally incorporated with them, being the head of a family, shall desire to commence farming, he shall have the privilege to select, in the presence and with the assistance of the agent then in charge, a tract of land within said reservation, not exceeding three hundred and twenty acres in extent, which tract, when so selected, certified, and recorded in the "land-book," as herein directed, shall cease to be held in common, but the same may be occupied and held in the exclusive possession of the person selecting it, and of his family, so long as he or they may continue to cultivate it.

Others may select land for cultivation.

Any person over eighteen years of age, not being the head of a family, may in like manner select and cause to be certified to him or her, for purposes of cultivation, a quantity of land not exceeding eighty acres in extent, and thereupon be entitled to the exclusive possession of the same as above directed.

Certificates.

For each tract of land so selected a certificate, containing a description thereof and the name of the person selecting it, with a certificate endorsed thereon that the same has been recorded, shall be delivered to the party entitled to it, by the agent, after the same shall have been recorded by him in a book to be kept in his office, subject to inspection, which said book shall be known as the "Sioux Land-Book."

Surveys.

The President may, at any time, order a survey of the reservation, and, when so surveyed, Congress shall provide for protecting the rights of said settlers in their improvements, and may fix the character of the title held by each. The United States may pass such laws on the subject of alienation and descent of property between the Indians and their descendants as may be thought proper. And it is further stipulated that any male Indians, over eighteen years of age, of any band or tribe that is or shall hereafter become a party to this treaty, who now is or who shall hereafter become a resident or occupant of any reservation or Territory not included in the tract of country designated and described in this treaty for the permanent home of the Indians, which is not mineral land, nor reserved by the United States for special purposes other than Indian occupation, and who shall have made improvements thereon of the value of two hundred dollars or more, and continuously occupied the same as a homestead for the term of three years, shall be entitled to receive from the United States a patent for one hundred and sixty acres of land including his said improvements, the same to be in the form of the legal subdivisions of the sur-

Alienation and descent of property.

veys of the public lands. Upon application in writing, sustained by the proof of two disinterested witnesses, made to the register of the local land-office when the land sought to be entered is within a land district, and when the tract sought to be entered is not in any land district, then upon said application and proof being made to the Commissioner of the General Land-Office, and the right of such Indian or Indians to enter such tract or tracts of land shall accrue and be perfect from the date of his first improvements thereon, and shall continue as long as he continues his residence and improvements, and no longer. And any Indian or Indians receiving a patent for land under the foregoing provisions, shall thereby and from thenceforth become and be a citizen of the United States, and be entitled to all the privileges and immunities of such citizens, and shall, at the same time, retain all his rights to benefits accruing to Indians under this treaty.

Certain Indians may receive patents for 160 acres of land.

Such Indians receiving patents to become citizens of the United States.

ARTICLE 7. In order to insure the civilization of the Indians entering into this treaty, the necessity of education is admitted, especially of such of them as are or may be settled on said agricultural reservations, and they therefore pledge themselves to compel their children, male and female, between the ages of six and sixteen years, to attend school; and it is hereby made the duty of the agent for said Indians to see that this stipulation is strictly complied with; and the United States agrees that for every thirty children between said ages who can be induced or compelled to attend school, a house shall be provided and a teacher competent to teach the elementary branches of an English education shall be furnished, who will reside among said Indians, and faithfully discharge his or her duties as a teacher. The provisions of this article to continue for not less than twenty years.

Education.

Children to attend school.

Schoolhouses and teachers.

ARTICLE 8. When the head of a family or lodge shall have selected lands and received his certificate as above directed, and the agent shall be satisfied that he intends in good faith to commence cultivating the soil for a living, he shall be entitled to receive seeds and agricultural implements for the first year, not exceeding in value one hundred dollars, and for each succeeding year he shall continue to farm, for a period of three years more, he shall be entitled to receive seeds and implements as aforesaid, not exceeding in value twenty-five dollars.

Seeds and agricultural implements.

And it is further stipulated that such persons as commence farming shall receive instruction from the farmer herein provided for, and whenever more than one hundred persons shall enter upon the cultivation of the soil, a second blacksmith shall be provided, with such iron, steel, and other material as may be needed.

Instructions in farming.

Second blacksmith.

ARTICLE 9. At any time after ten years from the making of this treaty, the United States shall have the privilege of withdrawing the physician, farmer, blacksmith, carpenter, engineer, and miller herein provided for, but in case of such withdrawal, an additional sum thereafter of ten thousand dollars per annum shall be devoted to the education of said Indians, and the Commissioner of Indian Affairs shall, upon careful inquiry into their condition, make such rules and regulations for the expenditure of said sum as will best promote the educational and moral improvement of said tribes.

Physician, farmer, etc., may be withdrawn.

Additional appropriation in such cases.

ARTICLE 10. In lieu of all sums of money or other annuities provided to be paid to the Indians herein named, under any treaty or treaties heretofore made, the United States agrees to deliver at the agency-house on the reservation herein named, on or before the first day of August of each year, for thirty years, the following articles, to wit:

Delivery of goods in lieu of money or other annuities.

For each male person over fourteen years of age, a suit of good substantial woolen clothing, consisting of coat, pantaloons, flannel shirt, hat, and a pair of home-made socks.

Clothing.

For each female over twelve years of age, a flannel skirt, or the goods necessary to make it, a pair of woolen hose, twelve yards of calico, and twelve yards of cotton domestics.

For the boys and girls under the ages named, such flannel and cotton goods as may be needed to make each a suit as aforesaid, together with a pair of woolen hose for each.

And in order that the Commissioner of Indian Affairs may be able to estimate properly for the articles herein named, it shall be the duty of the agent each year to forward to him a full and exact census of the Indians, on which the estimate from year to year can be based.

Census.

And in addition to the clothing herein named, the sum of ten dollars for each person entitled to the beneficial effects of this treaty shall be

Other necessary articles.

annually appropriated for a period of thirty years, while such persons roam and hunt, and twenty dollars for each person who engages in farming, to be used by the Secretary of the Interior in the purchase of such articles as from time to time the condition and necessities of the Indians may indicate to be proper. And if within the thirty years, at any time, it shall appear that the amount of money needed for clothing under this article can be appropriated to better uses for the Indians named herein, Congress may, by law, change the appropriation to other purposes; but in no event shall the amount of this appropriation be withdrawn or discontinued for the period named. And the President shall annually detail an officer of the Army to be present and attest the delivery of all the goods herein named to the Indians, and he shall inspect and report on the quantity and quality of the goods and the manner of their delivery. And it is hereby expressly stipulated that each Indian over the age of four years, who shall have removed to and settled permanently upon said reservation and complied with the stipulations of this treaty, shall be entitled to receive from the United States, for the period of four years after he shall have settled upon said reservation, one pound of meat and one pound of flour per day, provided the Indians cannot furnish their own subsistence at an earlier date. And it is further stipulated that the United States will furnish and deliver to each lodge of Indians or family of persons legally incorporated with them, who shall remove to the reservation herein described and commence farming, one good American cow, and one good well-broken pair of American oxen within sixty days after such lodge or family shall have so settled upon said reservation.

Appropriation to continue for thirty years.

Army officer to attend the delivery.

Meat and flour.

Cows and oxen.

ARTICLE 11. In consideration of the advantages and benefits conferred by this treaty, and the many pledges of friendship by the United States, the tribes who are parties to this agreement hereby stipulate that they will relinquish all right to occupy permanently the territory outside their reservation as herein defined, but yet reserve the right to hunt on any lands north of North Platte, and on the Republican Fork of the Smoky Hill River, so long as the buffalo may range thereon in such numbers as to justify the chase. And they, the said Indians, further expressly agree:

Right to occupy territory outside of the reservation surrendered.

Right to hunt reserved.

1st. That they will withdraw all opposition to the construction of the railroads now being built on the plains.

Agreements as to railroads.

2d. That they will permit the peaceful construction of any railroad not passing over their reservation as herein defined.

3d. That they will not attack any persons at home, or travelling, nor molest or disturb any wagon-trains, coaches, mules, or cattle belonging to the people of the United States, or to persons friendly therewith.

Emigrants, etc.

4th. They will never capture, or carry off from the settlements, white women or children.

Women and children.

5th. They will never kill or scalp white men, nor attempt to do them harm.

White men.

6th. They withdraw all pretence of opposition to the construction of the railroad now being built along the Platte River and westward to the Pacific Ocean, and they will not in future object to the construction of railroads, wagon-roads, mail-stations, or other works of utility or necessity, which may be ordered or permitted by the laws of the United States. But should such roads or other works be constructed on the lands of their reservation, the Government will pay the tribe whatever amount of damage may be assessed by three disinterested commissioners to be appointed by the President for that purpose, one of said commissioners to be a chief or head-man of the tribe.

Pacific Railroad, wagon roads, etc.

Damages for crossing their reservation.

7th. They agree to withdraw all opposition to the military posts or roads now established south of the North Platte River, or that may be established, not in violation of treaties heretofore made or hereafter to be made with any of the Indian tribes.

Military posts and roads.

ARTICLE 12. No treaty for the cession of any portion or part of the reservation herein described which may be held in common shall be of any validity or force as against the said Indians, unless executed and signed by at least three-fourths of all the adult male Indians, occupying or interested in the same; and no cession by the tribe shall be understood or construed in such manner as to deprive, without his consent, any individual member of the tribe of his rights to any tract of land selected by him, as provided in article 6 of this treaty.

No treaty for cession of reservation to be valid unless, etc.

ARTICLE 13. The United States hereby agrees to furnish annually to the Indians the physician, teachers, carpenter, miller, engineer, farmer, and blacksmiths as herein contemplated, and that such appropriations shall be made from time to time, on the estimates of the Secretary of the Interior, as will be sufficient to employ such persons.

United States to furnish physician, teachers, etc.

ARTICLE 14. It is agreed that the sum of five hundred dollars annually, for three years from date, shall be expended in presents to the ten persons of said tribe who in the judgment of the agent may grow the most valuable crops for the respective year.

Presents for crops.

ARTICLE 15. The Indians herein named agree that when the agency-house or other buildings shall be constructed on the reservation named, they will regard said reservation their permanent home, and they will make no permanent settlement elsewhere; but they shall have the right, subject to the conditions and modifications of this treaty, to hunt, as stipulated in Article 11 hereof.

Reservation to be permanent home of tribes.

ARTICLE 16. The United States hereby agrees and stipulates that the country north of the North Platte River and east of the summits of the Big Horn Mountains shall be held and considered to be unceded Indian territory, and also stipulates and agrees that no white person or persons shall be permitted to settle upon or occupy any portion of the same; or without the consent of the Indians first had and obtained, to pass through the same; and it is further agreed by the United States that within ninety days after the conclusion of peace with all the bands of the Sioux Nation, the military posts now established in the territory in this article named shall be abandoned, and that the road leading to them and by them to the settlements in the Territory of Montana shall be closed.

Unceded Indian territory.

Not to be occupied by whites, etc.

ARTICLE 17. It is hereby expressly understood and agreed by and between the respective parties to this treaty that the execution of this treaty and its ratification by the United States Senate shall have the effect, and shall be construed as abrogating and annulling all treaties and agreements heretofore entered into between the respective parties hereto, so far as such treaties and agreements obligate the United States to furnish and provide money, clothing, or other articles of property to such Indians and bands of Indians as become parties to this treaty, but no further.

Effect of this treaty upon former treaties.

In testimony of all which, we, the said commissioners, and we, the chiefs and headmen of the Brulé band of the Sioux nation, have hereunto set our hands and seals at Fort Laramie, Dakota Territory, this twenty-ninth day of April, in the year one thousand eight hundred and sixty-eight.

N. G. Taylor, [SEAL.]
W. T. Sherman, [SEAL.]
Lieutenant-General.
Wm. S. Harney, [SEAL.]
Brevet Major-General U. S. Army.
John B. Sanborn, [SEAL.]
S. F. Tappan, [SEAL.]
C. C. Augur, [SEAL.]
Brevet Major-General.
Alfred H. Terry, [SEAL.]
Brevet Major-General U. S. Army.

Attest:
A. S. H. White, Secretary.

Executed on the part of the Brulé band of Sioux by the chiefs and headmen whose names are hereto annexed, they being thereunto duly authorized, at Fort Laramie, D. T., the twenty-ninth day of April, in the year A. D. 1868.

Ma-za-pon-kaska, his x mark, Iron Shell. [SEAL.]
Wah-pat-shah, his x mark, Red Leaf. [SEAL.]
Hah-sah-pah, his x mark, Black Horn. [SEAL.]
Zin-tah-gah-lat-skah, his x mark, Spotted Tail. [SEAL.]
Zin-tah-skah, his x mark, White Tail. [SEAL.]
Me-wah-tah-ne-ho-skah, his x mark, Tall Mandas. [SEAL.]
She-cha-chat-kah, his x mark, Bad Left Hand. [SEAL.]
Bella-tonka-tonka, his x mark, Big Partisan. [SEAL.]
Mah-to-ho-honka, his x mark, Swift Bear. [SEAL.]
To-wis-ne, his x mark, Cold Place. [SEAL.]
Ish-tah-skah, his x mark, White Eyes. [SEAL.]
Ma-ta-loo-zah, his x mark, Fast Bear. [SEAL.]
As-hah-kah-nah-zhe, his x mark, Standing Elk. [SEAL.]
Can-te-te-ki-ya, his x mark, The Brave Heart. [SEAL.]

No-mah-no-pah, his x mark, Two and Two. [SEAL.]
Tah-tonka-skah, his x mark, White Bull. [SEAL.]
Con-ra-washta, his x mark, Pretty Coon. [SEAL.]
Ha-cah-cah-she-chah, his x mark, Bad Elk. [SEAL.]
Wa-ha-ka-zah-ish-tah, his x mark, Eye Lance. [SEAL.]
Ma-to-ha-ke-tah, his x mark, Bear that looks behind. [SEAL.]
Shunka-shaton, his x mark, Day Hawk. [SEAL.]
Tatanka-wakon, his x mark, Sacred Bull. [SEAL.]
Mapia shaton, his x mark, Hawk Cloud. [SEAL.]
Ma-sha-a-ow, his x mark, Stands and Comes. [SEAL.]
Shon-ka-ton-ka, his x mark, Big Dog. [SEAL.]

Attest:

Ashton S. H. White, secretary of commission.
George B. Withs, phonographer to commission.
Geo. H. Holtzman.
John D. Howland.
James C. O'Connor.
Chas. E. Guern, interpreter.
Leon F. Pallardy, interpreter.
Nicholas Janis, interpreter.

Execution by the Ogallalah band.

Executed on the part of the Ogallalah band of Sioux by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized, at Fort Laramie, the twenty-fifth day of May, in the year A. D. 1868.

Tah-shun-ka-co-qui-pah, his x mark, Man-afraid-of-his-horses. [SEAL.]
Sha-ton-skah, his x mark, White Hawk. [SEAL.]
Sha-ton-sapah, his x mark, Black Hawk. [SEAL.]
E-ga-mon-ton-ka-sapah, his x mark, Black Tiger. [SEAL.]
Oh-wah-she-cha, his x mark, Bad Wound. [SEAL.]
Pah-gee, his x mark, Grass. [SEAL.]
Wah-non-reh-che-geh, his x mark, Ghost Heart. [SEAL.]
Con-reeh, his x mark, Crow. [SEAL.]
Oh-he-te-kah, his x mark, The Brave. [SEAL.]
Tah-ton-kah-he-yo-ta-kah, his x mark, Sitting Bull. [SEAL.]
Shon-ka-oh-wah-mon-ye, his x mark, Whirlwind Dog. [SEAL.]
Ha-hah-kah-tah-miech, his x mark, Poor Elk. [SEAL.]
Wam-bu-lee-wah-kon, his x mark, Medicine Eagle. [SEAL.]
Chon-gah-ma-he-to-hans-ka, his x mark, High Wolf. [SEAL.]
Wah-se-chun-ta-shun-kah, his x mark, American Horse. [SEAL.]
Mah-hah-mah-ha-mak-near, his x mark, Man that walks under the ground. [SEAL.]
Mah-to-tow-pah, his x mark, Four Bears. [SEAL.]
Ma-to-wee-sha-kta, his x mark, One that kills the bear. [SEAL.]
Oh-tah-kee-toka-wee-chakta, his x mark, One that kills in a hard place. [SEAL.]
Tah-ton-kah-ta-miech, his x mark, The poor Bull. [SEAL.]
Oh-huns-ee-ga-non-sken, his x mark, Mad Shade. [SEAL.]
Shah-ton-oh-nah-om-minne-ne-oh-minne, his x mark, Whirling Hawk. [SEAL.]
Mah-to-chun-ka-oh, his x mark, Bear's Back. [SEAL.]
Che-ton-wee-koh, his x mark, Fool Hawk. [SEAL.]
Wah-hoh-ke-za-ah-hah, his x mark, One that has the lance. [SEAL.]
Shon-gah-manni-toh-tan-ka-seh, his x mark, Big Wolf Foot. [SEAL.]
Eh-ton-kah, his x mark, Big Mouth. [SEAL.]
Ma-pah-che-tah, his x mark, Bad Hand. [SEAL.]
Wah-ke-yun-shah, his x mark, Red Thunder. [SEAL.]
Wak-sah, his x mark, One that Cuts Off. [SEAL.]
Cham-nom-qui-yah, his x mark, One that Presents the Pipe. [SEAL.]
Wah-ke-ke-yan-puh-tah, his x mark, Fire Thunder. [SEAL.]
Mah-to-nonk-pah-ze, his x mark, Bear with Yellow Ears. [SEAL.]
Con-ree-teh-ka, his x mark, The Little Crow. [SEAL.]
He-hup-pah-toh, his x mark, The Blue War Club. [SEAL.]
Shon-kee-toh, his x mark, The Blue Horse. [SEAL.]
Wam-Balla-oh-con-quo, his x mark, Quick Eagle. [SEAL.]
Ta-tonka-suppa, his x mark, Black Bull. [SEAL.]
Moh-to-ha-she-na, his x mark, The Bear Hide. [SEAL.]

Attest:

S. E. Ward.
Jas. C. O'Connor.
J. M. Sherwood.
W. C. Slicer.
Sam Deon.
H. M. Matthews.
Joseph Bissonette, interpreter.
Nicholas Janis, interpreter.
Lefroy Jott, interpreter.
Antoine Janis, interpreter.

Execution by the Minneconjon band.

Executed on the part of the Minneconjon band of Sioux by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized.

At Fort Laramie, D. T., May 26, '68, 13 names.

Heh-won-ge-chat, [SEAL.]
his x mark, One Horn.
Oh-pon-ah-tah-e-manne, [SEAL.]
his x mark, The Elk that bellows Walking.

At Fort Laramie, D. T., May 25, '68, 2 names.

Heh-ho-lah-reh-cha-skah,
his x mark, Young White Bull. [SEAL.]

Wah-chah-chum-kah-coh-kee-pah, his x mark, One that is afraid of Shield. [SEAL.]
He-hon-ne-shakta, his x mark, The Old Owl. [SEAL.]
Moc-pe-a-toh, his x mark, Blue Cloud. [SEAL.]
Oh-pong-ge-le-skah, his x mark, Spotted Elk. [SEAL.]
Tah-tonk-ka-hon-ke-schne, his x mark, Slow Bull. [SEAL.]
Shonk-a-nee-shah-shah-a-tah-pe, his x mark, The Dog Chief. [SEAL.]
Ma-to-tah-ta-tonk-ka, his x mark, Bull Bear. [SEAL.]
Wom-beh-le-ton-kah, his x mark, The Big Eagle. [SEAL.]
Ma-toh-eh-schne-lah, his x mark, The Lone Bear. [SEAL.]
Mah-toh-ke-su-yah, his x mark, The One who Remembers the Bear. [SEAL.]
Ma-toh-oh-he-to-keh, his x mark, The Brave Bear. [SEAL.]
Eh-che-ma-heh, his x mark, The Runner. [SEAL.]
Ti-ki-ya, his x mark, The Hard. [SEAL.]
He-ma-za, his x mark, Iron Horn. [SEAL.]

Attest:

Jas. C. O'Connor.
Wm. H. Brown.
Nicholas Janis, interpreter.
Antoine Janis, interpreter.

Execution by the Yanctonais band.

Executed on the part of the Yanctonais band of Sioux by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized.

Mah-to-non-pah, his x mark, Two Bears. [SEAL.]
Ma-to-hna-skin-ya, his x mark, Mad Bear. [SEAL.]
He-o-pu-za, his x mark, Louzy. [SEAL.]
Ah-ke-che-tah-che-ca-dan, his x mark, Little Soldier. [SEAL.]
Mah-to-e-tan-chan, his x mark, Chief Bear. [SEAL.]
Cu-wi-h-win, his x mark, Rotten Stomach. [SEAL.]
Skun-ka-we-tko, his x mark, Fool Dog. [SEAL.]
Ish-ta-sap-pah, his x mark, Black Eye. [SEAL.]
Ih-tan-chan, his x mark, The Chief. [SEAL.]
I-a-wi-ca-ka, his x mark, The one who Tells the Truth. [SEAL.]
Ah-ke-che-tah, his x mark, The Soldier. [SEAL.]
Ta-shi-na-gi, his x mark, Yellow Robe. [SEAL.]
Nah-pe-ton-ka, his x mark, Big Hand. [SEAL.]
Chan-tee-we-kto, his x mark, Fool Heart. [SEAL.]
Hoh-gan-sah-pa, his x mark, Black Catfish. [SEAL.]
Mah-to-wah-kan, his x mark, Medicine Bear. [SEAL.]
Shun-ka-kan-sha, his x mark, Red Horse. [SEAL.]
Wan-rode, his x mark, The Eagle. [SEAL.]
Can-hpi-sa-pa, his x mark, Black Tomahawk. [SEAL.]
War-he-le-re, his x mark, Yellow Eagle. [SEAL.]
Cha-ton-che-ca, his x mark, Small Hawk, or Long Fare. [SEAL.]
Shu-ger-mon-e-too-ha-ska, his x mark, Tall Wolf. [SEAL.]
Ma-to-u-tah-kah, his x mark, Sitting Bear. [SEAL.]
Hi-ha-cah-ge-na-skene, his x mark, Mad Elk. [SEAL.]

Arapahoes:

Little Chief, his x mark. [SEAL.]
Tall Bear, his x mark. [SEAL.]
Top Man, his x mark. [SEAL.]
Neva, his x mark. [SEAL.]
The Wounded Bear, his x mark. [SEAL.]
Thirlwind, his x mark. [SEAL.]
The Fox, his x mark. [SEAL.]
The Dog Big Mouth, his x mark. [SEAL.]
Spotted Wolf, his x mark. [SEAL.]
Sorrel Horse, his x mark. [SEAL.]
Black Coal, his x mark. [SEAL.]
Big Wolf, his x mark. [SEAL.]
Knock-knee, his x mark. [SEAL.]
Black Crow, his x mark. [SEAL.]
The Lone Old Man, his x mark. [SEAL.]
Paul, his x mark. [SEAL.]
Black Bull, his x mark. [SEAL.]
Big Track, his x mark. [SEAL.]
The Foot, his x mark. [SEAL.]
Black White, his x mark. [SEAL.]
Yellow Hair, his x mark. [SEAL.]
Little Shield, his x mark. [SEAL.]
Black Bear, his x mark. [SEAL.]
Wolf Mocassin, his x mark. [SEAL.]
Big Robe, his x mark. [SEAL.]
Wolf Chief, his x mark. [SEAL.]

Witnesses:

Robt. P. McKibbin, captain, Fourth Infantry, brevet lieutenant-colonel, U. S. Army, commanding Fort Laramie.
Wm. H. Powell, brevet major, captain, Fourth Infantry.
Henry W. Patterson, captain, Fourth Infantry.
Theo. E. True, second lieutenant, Fourth Infantry.
W. G. Bullock.
Chas. E. Guern, special Indian interpreter for the peace commission.

FORT LARAMIE, WO. T., *Nov. 6, 1868.*

Makh-pi-ah-lu-tah, his x mark, Red Cloud. [SEAL.]
Wa-ki-ah-we-cha-shah, his x mark, Thunder Man. [SEAL.]
Ma-zah-zah-geh, his x mark, Iron Cane. [SEAL.]
Wa-umble-why-wa-ka-tuyah, his x mark, High Eagle. [SEAL.]
Ko-ke-pah, his x mark, Man Afraid. [SEAL.]
Wa-ki-ah-wa-kou-ah, his x mark, Thunder Flying Running. [SEAL.]

Witnesses:

W. McE. Dye, brevet colonel, U. S. Army, commanding.
A. B. Cain, captain, Fourth Infantry, brevet major, U. S. Army.
Robt. P. McKibbin, captain, Fourth Infantry, brevet lieutenant-colonel, U. S. Army.
Jno. Miller, captain, Fourth Infantry.
G. L. Luhn, first lieutenant, Fourth Infantry, brevet captain, U. S. Army.
H. C. Sloan, second lieutenant, Fourth Infantry.
Whittingham Cox, first lieutenant, Fourth Infantry.
A. W. Vogdes, first lieutenant, Fourth Infantry.
Butler D. Price, second lieutenant, Fourth Infantry.

HEADQRS., FORT LARAMIE, *Novr. 6, '68.*

Executed by the above on this date.

All of the Indians are Ogallalahs excepting Thunder Man and Thunder Flying Running, who are Brulés.

WM. MCE. DYE,
Major Fourth Infantry, and Brevet-Colonel
U. S. Army, Commanding.

Attest:

Jas. C. O'Connor.
Nicholas Janis, interpreter.
Franc. La Framboise, interpreter.
P. J. De Smet, S. J., missionary among the Indians.
Saml. D. Hinman, B. D., missionary.

Executed on the part of the Uncpapa band of Sioux, by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized.

Execution by the Uncpapa band.

Co-kam-i-ya-ya, his x mark, The Man that Goes in the Middle. [SEAL.]
Ma-to-ca-wa-weksa, his x mark, Bear Rib. [SEAL.]
Ta-to-ka-in-yan-ke, his x mark, Running Antelope. [SEAL.]
Kan-gi-wa-ki-ta, his x mark, Looking Crow. [SEAL.]
A-ki-ci-ta-han-ska, his x mark, Long Soldier. [SEAL.]
Wa-ku-te-ma-ni, his x mark, The One who Shoots Walking. [SEAL.]
Un-kca-ki-ka, his x mark, The Magpie. [SEAL.]
Kan-gi-o-ta, his x mark, Plenty Crow. [SEAL.]
He-ma-za, his x mark, Iron Horn. [SEAL.]
Shun-ka-i-na-pin, his x mark, Wolf Necklace. [SEAL.]
I-we-hi-yu, his x mark, The Man who Bleeds from the Mouth. [SEAL.]
He-ha-ka-pa, his x mark, Elk Head. [SEAL.]
I-zu-za, his x mark, Grind Stone. [SEAL.]
Shun-ka-wi-tko, his x mark, Fool Dog. [SEAL.]
Ma-kpi-ya-po, his x mark, Blue Cloud. [SEAL.]
Wa-min-pi-lu-ta, his x mark, Red Eagle. [SEAL.]
Ma-to-can-te, his x mark, Bear's Heart. [SEAL.]
A-ki-ci-ta-i-tau-can, his x mark, Chief Soldier. [SEAL.]

Attest:

Jas. C. O'Connor.
Nicholas Janis, interpreter.
Franc. La Framboise[e], interpreter.
P. J. De Smet, S. J., missionary among the Indians.
Saml. D. Hinman, missionary.

Executed on the part of the Blackfeet band of Sioux by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized.

By the Blackfeet band.

Can-te-pe-ta, his x mark, Fire Heart. [SEAL.]
Wan-mdi-kte, his x mark, The One who Kills Eagle. [SEAL.]
Sho-ta, his x mark, Smoke. [SEAL.]
Wan-mdi-ma-ni, his x mark, Walking Eagle. [SEAL.]
Wa-shi-cun-ya-ta-pi, his x mark, Chief White Man. [SEAL.]
Kan-gi-i-yo-tan-ke, his x mark, Sitting Crow. [SEAL.]
Pe-ji, his x mark, The Grass. [SEAL.]
Kda-ma-ni, his x mark, The One that Rattles as he Walks. [SEAL.]
Wah-han-ka-sa-pa, his x mark, Black Shield. [SEAL.]
Can-te-non-pa, his x mark, Two Hearts. [SEAL.]

Attest:

Jas. C. O'Connor.
Nicholas Janis, interpreter.
Franc. La Framboise, interpreter.
P. J. De Smet, S. J., missionary among the Indians.
Saml. D. Hinman, missionary.

Executed on the part of the Cutheads band of Sioux by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized.

Execution by the Cutheads band.

To-ka-in-yan-ka, his x mark, The One who Goes Ahead Running. [SEAL.]
Ta-tan-ka-wa-kin-yan, his x mark, Thunder Bull. [SEAL.]
Sin-to-min-sa-pa, his x mark, All over Black. [SEAL.]
Can-i-ca, his x mark, The One who Took the Stick. [SEAL.]
Pa-tan-ka, his x mark, Big Head. [SEAL.]

Attest:

Jas. C. O'Connor.
Nicholas Janis, interpreter.
Franc. La Frambois[e], interpreter.
P. J. De Smet, S. J., missionary among the Indians.
Saml. D. Hinman, missionary.

Executed on the part of the Two Kettle band of Sioux by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized.

By the Two Kettle band.

Ma-wa-tan-ni-han-ska, his x mark, Long Mandan. [SEAL.]
Can-kpe-du-ta, his x mark, Red War Club. [SEAL.]
Can-ka-ga, his x mark, The Log. [SEAL.]

Attest:

Jas. C. O'Connor.
Nicholas Janis, interpreter.
Franc. La Framboise, interpreter.
P. J. De Smet, S. J., missionary among the Indians.
Saml. D. Hinman, missionary to the Dakotas.

Executed on the part of the Sans Arch band of Sioux by the chiefs and headmen whose names are hereto annexed, they being thereunto duly authorized.

By the Sans Arch band.

He-na-pin-wa-ni-ca, his x mark, The One that has Neither Horn. [SEAL.]
Wa-inlu-pi-lu-ta, his x mark, Red Plume. [SEAL.]
Ci-tan-gi, his x mark, Yellow Hawk. [SEAL.]
He-na-pin-wa-ni-ca, his x mark, No Horn. [SEAL.]

Attest:

Jas. C. O'Connor.
Nicholas Janis, interpreter.
Franc. La Frambois[e], interpreter.
P. J. De Smet, S. J., missionary among the Indians.
Saml. D. Hinman, missionary.

Executed on the part of the Santee band of Sioux by the chiefs and headmen whose names are hereto subscribed, they being thereunto duly authorized.

Execution by the Santee band.

Wa-pah-shaw, his x mark, Red Ensign. [SEAL.]
Wah-koo-tay, his x mark, Shooter. [SEAL.]
Hoo-sha-sha, his x mark, Red Legs. [SEAL.]
O-wan-cha-du-ta, his x mark, Scarlet all over. [SEAL.]
Wau-mace-tan-ka, his mark x, Big Eagle. [SEAL.]
Cho-tan-ka-e-na-pe, his x mark, Flute-player. [SEAL.]
Ta-shun-ke-mo-za, his x mark, His Iron Dog. [SEAL.]

Attest:

Saml. D. Hinman, B. D., missionary.
J. N. Chickering,
Second lieutenant, Twenty-second Infantry, brevet captain, U. S. Army.
P. J. De Smet, S. J.
Nicholas Janis, interpreter.
Franc. La Framboise, interpreter.

SOCIETY FOR AMERICAN ARCHAEOLOGY

September 13, 2016

Lieutenant General Todd Semonite
Commanding General and Chief of Engineers
Headquarters
U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314-1000

Dear General Semonite:

On behalf of the Society for American Archaeology (SAA), I write to you urgently regarding the process by which the U.S. Army Corps of Engineers (USACE) has handled its National Historic Preservation Act (NHPA) Section 106 responsibilities in relation to Dakota Access Pipeline (DAPL). SAA is an international organization that since its founding in 1934 has been dedicated to the research on, and interpretation and protection of, the archaeological heritage of the Americas. With more than 7800 members, SAA represents professional archaeologists in colleges and universities, museums, government agencies, and the private sector. SAA has members in all 50 states as well as many other nations around the world.

After review of many documents associated with DAPL (see below), we conclude that there are unresolved questions regarding whether the USACE has fulfilled their Section 106 responsibilities in relation to the NHPA. SAA believes an integrated and thorough plan for Section 106 consultation for the entire DAPL, as one undertaking, may be appropriate. SAA also wonders if the USACE may have inappropriately used its Nationwide Permit 12 (NWP 12) to avoid fully complying with NHPA's Section 106.

SAA has reviewed the data presented in USACE documents, letters of concern (e.g., April 22, 2016 and May 19, 2016) from the Advisory Council for Historic Preservation (ACHP), letters of concern from the Bureau of Indian Affairs (March 29, 2016), from the Environmental Protection Agency (March 11, 2016), and from others, as well as the deposition of the former Tribal Historic Preservation Officer for the Standing Rock Sioux Tribe on recent grading of previously surveyed land, and a number of other documents.

Our concerns with the USACE's handling of Section 106 consultation are on two levels. First and most immediate is an apparent clear conflict between the USACE's finding of "No Historic Properties Affected" for ten of eleven crossings of waters of the U.S. (WOUS) subject to Department of the Army authorization under its Regulatory Program and requiring Pre-Construction Notifications (PCNs) and the now much-publicized survey and tribal documentation of the existence of burial cairns and other traditional cultural properties (TCPs) in the DAPL right-of-way (ROW) in the Lake Oahe area.

These rare traditional cultural properties of singular spiritual value have been, according to the September 4, 2016 court deposition of cultural resource manager Tim Mentz, Sr., completely graded by Dakota Access as of September 3, 2016. The deposition, as well as tribal sources cited

Tribal Water Alliance
Exhibit 20_____

in the Standing Rock Sioux Tribe's request for a preliminary injunction, note that these stone formations may not be apparent to archaeological surveyors who lack *the benefit of complete tribal consultations*. The USACE may not have taken the consultative requirements of Section 106 sufficiently so as to avoid such events as have been documented over the last two weeks.

Second, and related to this, is our assessment of the USACE's Section 106 process for the DAPL project as a whole. We agree with the May 19, 2016 letter of the ACHP that the USACE handling of the project may be in error because:

- The USACE may have incorrectly delineated the Area of Potential Effect (APE), restricting much Section 106 compliance to the WOUS crossings rather than the entire ROW.
- Despite requests and specific information from various tribes, the USACE did not conduct TCP surveys along the entire ROW.
- Overall tribal consultation appears to have been piecemeal and inadequate (see ACHP letter March 15, 2016).

SAA feels strongly that the USACE should find that the entire pipeline project be considered a federal undertaking, because, without USACE permits, it could not be constructed. Furthermore, SAA supports the ACHP's request for a Programmatic Agreement for the project as a whole.

Finally, although DAPL is SAA's immediate concern, we believe that a broader and deeper issue stems from the USACE operating under its own set of Section 106 rules (Appendix C to 33 CFR Part 325), which has never been approved by the ACHP, a federal panel of experts on archaeological and historic preservation. USACE implementation of Appendix C renders any undertaking liable to the same issues as DAPL, particularly with regard to inadequate APE and undertaking definitions.

Moreover, given the events of the last two weeks, SAA has concerns that it is possible that there may have been violations of the Archaeological Resources Protection Act, as well as North Dakota State Law 23-06-27 (the "Protection of Human Burial Sites, Human Remains, and Burial Goods" section of "Care and Custody of the Dead"). It behooves USACE to investigate whether development activities have violated these laws.

As should we all, the USACE hopefully does learn from past errors in dealing with cultural heritage, human remains, and sacred traditional cultural properties. The SAA reminds the USACE that early missteps in following legally mandated procedures with regard to the Kennewick Man discovery continue to resonate to the detriment of the USACE decades afterwards. We therefore sincerely urge the USACE to consider how best to comply with *all* aspects of Section 106, as well as how to design large-scale projects such as DAPL so as to minimize the problems, delays, and unresolved concerns of descent communities so amply in evidence at Lake Oahe today.

Sincerely,

Diane Gifford-Gonzalez

Diane Gifford-Gonzalez
President

cc:
Hon. Barack Obama, President
Standing Rock Sioux Tribe
Advisory Council on Historic Preservation
U.S. Department of the Interior
U.S. Department of Justice
Hon. Jack Dalrymple, Governor, North Dakota
Hon. Dennis Daugaard, Governor, South Dakota
Hon. Terry Branstad, Governor, Iowa
Hon. Bruce Rauner, Governor, Illinois
Mr. Kelcy L. Warren, CEO, Energy Transfer Partners
Ms. Claudia Berg, SHPO, North Dakota
Mr. Jay Vogt, SHPO, South Dakota
Ms. Susan Kloewer, SHPO, Iowa
Ms. Heidi Brown-McCreery, SHPO, Illinois

Bats of the Black Hills
A Description of Status and Conservation Needs

Joel Tigner and Eileen Dowd Stukel
South Dakota Department of Game, Fish and Parks
Wildlife Division Report 2003-05
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Tribal Water Alliance
Exhibit 20_____

CONTENTS

INTRODUCTION

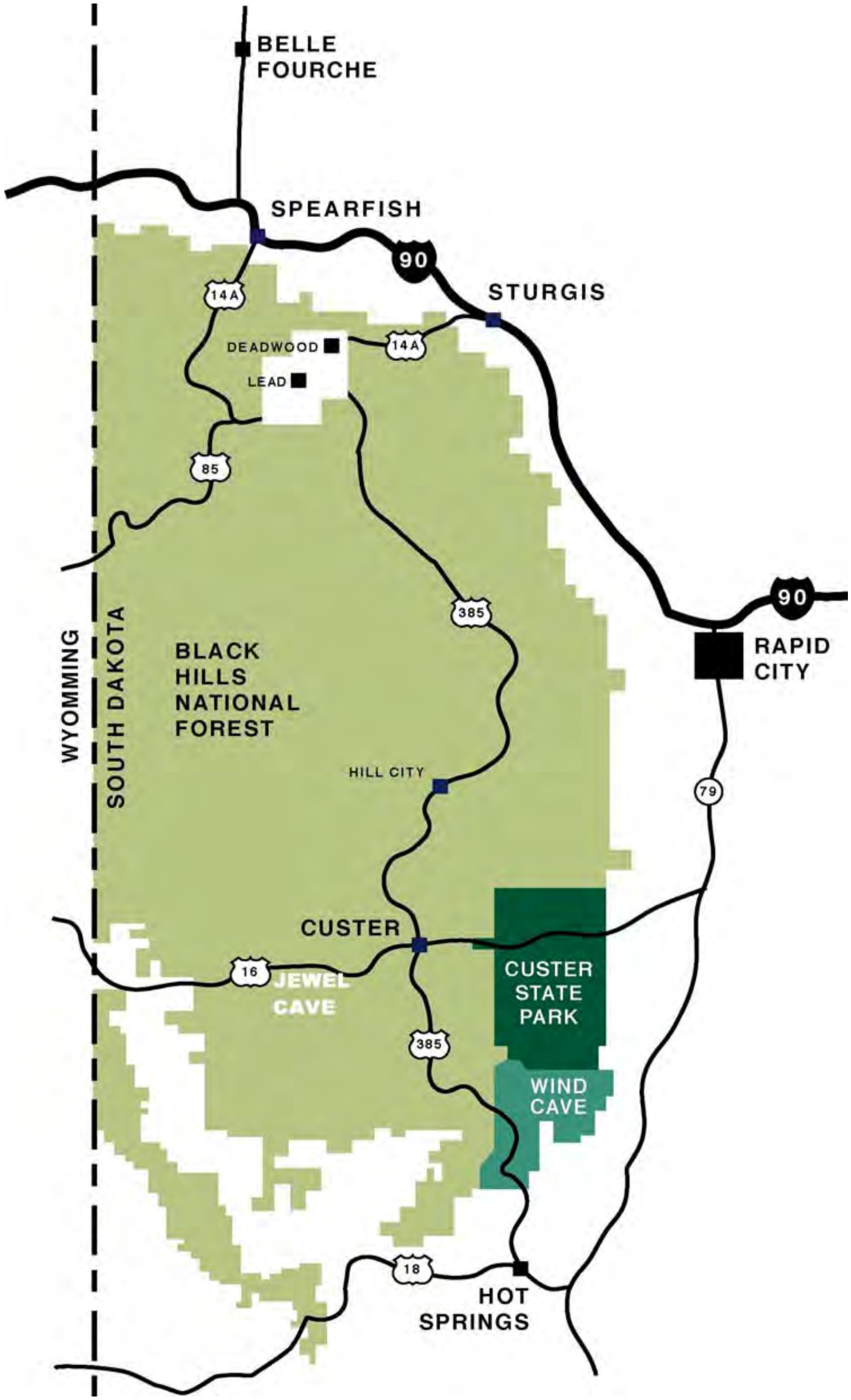
"**. . to most of us they are still nearly as unknown as the stars. .**" G.M. Allen *BATS*

Little has changed since that observation of bats was made in 1939. Despite the recent increase in the study of bats, they remain among the least understood and most maligned of animals. Falling victim to popularly held misconceptions and changes in habitat, few animals are as susceptible to human vagaries as bats (Hill and Smith 1984). In recent years, significant declines in bat populations have been documented worldwide, most in response to loss of roosting habitat (McCracken 1988). Reversing this trend will require widespread recognition of their ecological contributions as well as protection of foraging and roosting habitat (Kunz and Pierson 1994).

To gain a better understanding of bats and their requirements, this study was conducted to identify species residing in the Black Hills and their roosting habits. Each species was studied to gain insight about management actions needed to protect significant roosting and foraging sites.

This publication summarizes previous work conducted in the Black Hills, supplemented with results of fieldwork conducted primarily during the 1990s. The authors would like to acknowledge that much of the research cited during this period was funded by the South Dakota Department of Game, Fish and Parks, the Federal Aid in Wildlife Restoration Program, and the U.S. Forest Service.

The goal of this publication is to create a resource tool for others to use to continue the study of bats in the Black Hills. It is also a source of information in which species-specific management recommendations are made to protect the current populations within the region. It is hoped this publication will provide a summary of the information collected, and that by consolidating such findings, this work will suggest direction for future research, prevent costly duplication of effort, and enable informed responses to questions on management issues.


BELLE FOURCHE
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BAT SPECIES OF THE BLACK HILLS

Bats represent one of the most diverse groups of animals. Within the class of Mammalia, they are second only to rodents in total number of species. Their order, Chiroptera, is comprised of over 900 species, nearly a quarter of all mammal species. Chiroptera is then divided into two sub-orders, the Megachiroptera and the Microchiroptera (van Zyll de Jong 1985). The former are found only in the Old World tropics while the latter, to which all of the Black Hills' species belong, are represented in all but extreme arctic regions (van Zyll de Jong 1985). All bats found within the Black Hills belong to the family Vespertilionidae and are exclusively insectivorous (van Zyll de Jong 1985). Until recently, their importance as the primary predator of nocturnal flying insects, many of which are responsible for substantial damage to forests and crops, has gone largely unrecognized (Tuttle 1988).

The physiological adaptations of bats to their environment are highly specific and sophisticated. Fossil evidence suggests their unique morphological adaptations to the environment have been present for at least the last 50 million years (Habersetzer et al. 1994, Jepson 1970, Novacek 1985). While displaying such typical mammalian characteristics as fur bearing, live birth and nursing of young, bats are unique among mammals with their ability of sustained flight (Fenton 1992).

One of their more amazing characteristics is their use of echolocation in foraging and navigating. Bats emit ultrasonic pulses, then receive and interpret reflection of these pulses' echoes much like sonar systems (Griffin 1958). These echoes produce a "sound picture" within the bat's brain that enables it to forage and navigate with phenomenal speed and pinpoint accuracy.

Regional bat species diversity is typically linked to habitat diversity (Stebbings and Griffith 1986). Within the Black Hills, mixtures of forest, grassland, and riparian habitat coupled with the occurrence of numerous caves and abandoned mines combine to create diversity unique to the central plains of the United States.

The South Dakota Natural Heritage Program currently monitors five species of bats found within the Black Hills. The Wyoming Game and Fish Department (1996) has set objectives for bat inventories statewide. The following bat species can be found within the Black Hills of South Dakota and Wyoming and are known to be year-round residents (Anderson 1993, Choate and Jones 1981, Martin and Hawks 1972, Tigner and Aney 1994, Turner 1974, Worthington and Bogan 1993):

Species names used throughout this document are based upon current conventions as noted at NatureServe Explorer: An online encyclopedia of life [web application]. 2002. Version 1.6. Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer.

Myotis ciliolabrum (Western Small-footed Myotis)

Myotis evotis (Long-eared Myotis)*

Myotis lucifugus (Little Brown Myotis)

Myotis septentrionalis (Northern Myotis)*

Myotis thysanodes pahasapensis (Fringed Myotis)*

Myotis volans (Long-legged Myotis)

Corynorhinus townsendii pallescens [formerly *Plecotus t. p.*] (Townsend's Big-eared Bat)*

Eptesicus fuscus (Big Brown Bat)

Three other species, considered "tree-roosting" bats, are migratory and winter in milder climates. These are:

Lasionycteris noctivagans (Silver-haired Bat)*

Lasiurus borealis (Eastern Red Bat)

Lasiurus cinereus (Hoary Bat)

*indicates species monitored by SD Natural Heritage Program

Based upon the presence of suitable habitat, Turner (1974) suggested another species, *Euderma maculatum* (Spotted Bat), may occur in the Black Hills, though there are no records to date.

A hibernaculum survey conducted at an abandoned mine in the central Black Hills on 01/07/03 yielded a single specimen of *Pipistrellus subflavus* (Eastern Pipistrelle). This is the first record for this species in the Black Hills. Additional regional records for this species include three identified hibernating in a cave in Goshen County, Wyoming (Grenier personal communication) and from Greeley, Colorado (Fitzgerald et al.1989).

Vocal signatures for this species were also recorded using the ANABAT detector system at McKenna Spring in the southern Black Hills (Mike O'Farrell [O'Farrell Biological Consulting, Las Vegas, Nevada] personal communication).

DATA COLLECTION

Surveys

A variety of survey methods has been employed to study bat populations in the Black Hills (Cryan and Bogan 1996, and others). One limiting factor directly affecting the ability to draw conclusions from survey work conducted to date is lack of historical data to serve as a baseline with which comparisons can be made. Changes in population dynamics and patterns of distribution within the Black Hills are difficult to assess based upon current information. As such, one of the more important contributions made by recent studies is the establishment of baseline population data. If collected regularly and objectively, future biologists can use the information to monitor population trends.

Historically, reported population sizes and declines were largely based upon hibernacula surveys (Humphrey 1975, Ransome 1990, Tuttle 1977). In the Black Hills, there are only three known hibernacula that contain more than 300 bats. Most support fewer than 25 bats. Given the well-documented colonial behavior of many of the region's species during hibernation, such numbers demonstrate a significant lack of information regarding wintering behaviors. An alternative premise suggests wintering bats of the region hibernate in cracks and fissures, a common feature of Black Hills geology. If true, hibernacula surveys as a basis for gauging population trends are untenable.

One long time resident, on whose property lies a popular "show cave," described bats emerging on a summer evening in 1932 as a "column of smoke." He recalls this daily emergence lasting several minutes. Today there are no known sites in the Black Hills whose numbers would compare with this observation.

Recent Black Hills studies have exploited newer technology, such as radio telemetry, to identify roost sites for poorly understood species (Cryan and Bogan 1996, Mattson 1994).

Banding

Tigner and Aney (1994) collected information via banding and year-round roost monitoring. Banding was the primary method used to collect seasonal range and roost fidelity data beginning in 1992. Surveys conducted since 1992 have reported no observations of bats banded during earlier studies.

Bats were banded only during the active time of year. No hibernating bats were banded or disturbed to read bands. Band numbers were often hidden by roosting posture or roosting location. As a result, information from winter observations was often limited to species and sex. Males were banded on the left forearm, while females were banded on the right. This distinction was rigidly observed to enable sex determination during hibernation surveys when bats could not be disturbed. See TABLE 1 for banding information.

Bats were captured with mist nets and harp traps outside night roosts and at foraging sites. Some were caught via static hand-held nets inside the roost. Captures within a roost were only used at roosting sites where exclusion from the roost was imminent, such as building remodeling or demolition, mine closure, and intentional roost exclusion.

Survey Bias

Environmental characteristics, such as surface water, may affect distribution patterns. Riparian areas, with their higher insect prey densities, consistently yield higher capture rates than uplands (Cross 1988). Capture rates were highest in the southern Black Hills where limited surface water likely served to concentrate insect prey.

Roost availability also affects species distribution (Kunz 1982, Tuttle and Stevenson 1982). Bats with specific roost requirements are more susceptible to changes in habitat than more opportunistic species. Human induced change, such as firewood collection, timber harvest, natural or deliberate mine closure, and disturbance or vandalism within natural caves all can influence roost availability resulting in changes in distribution. In addition to roost availability, proximity to other requirements, such as foraging areas, can affect distribution (Kunz 1982).

Population trend data for migratory bats must be interpreted with caution. Migratory species may be affected by factors unrelated to summer habitats (Thomas and LaVal 1988), such as pesticide exposure during migration or on wintering range (Clark 1981). Species that are characteristically more sedentary, but about which limited information has been collected, are also difficult to assess (Thomas and LaVal 1988).

Sex segregation during maternity and nursery season also affects survey results. Netting surveys conducted at foraging sites in the southern Black Hills yielded a male:female ratio of 2:1 in *Myotis* species (Cryan and Bogan 1996, Mattson 1994, Tigner unpublished data). Similar findings are characteristic of capture rates in the northern Black Hills (Tigner unpublished data). Such segregation is likely a result of different summer roosting requirements. Cryan and Bogan (1996) have also suggested this segregation may serve to demonstrate the importance of areas in which reproductive females occur.

In general, reproductive females were more frequently captured at lower elevations (Cryan and Bogan 1996, Mattson 1994, Tigner unpublished data). Selection of lower elevations by reproductive females may be a response to thermoregulatory requirements during the maternity/nursery season.

Number of nets and net placement affect the capture rate at a given location (Kunz and Kurta 1988). Netting surveys may yield disproportionately high numbers of species less adept at obstacle evasion. While none of the Hills species could be characterized as bumbling, *C. townsendii* is the species least susceptible to traditional capture methods. This species can be commonly observed flying through small openings in mist nets requiring folded wings. Similarly, this species frequently evades capture by harp traps. After several apparent reconnaissance approaches, individuals will dive with folded wings through the top of the trap allowing momentum to carry them through the second bank of strings.

Natural population fluctuations also affect survey information. Poor foraging years or cold winters often result in high mortality or altered migration patterns (Ransome 1990). Without a historical perspective to gauge fluctuations, interpretation of "point-in-time" surveys becomes somewhat limited.

Seasonal variations in weather patterns may also affect population distribution. Variations between summers may yield different survey information. Such variations are important components in determining population trends.

Flooding may cause bat populations to decline. Many caves in the east-central region of the Black Hills exhibit historical evidence of complete flooding. While such flooding may only occur rarely, low reproductive rates in bats make population recovery slow. Such periodic cleansing may also remove evidence of historical use by bats.

BASIC BAT BIOLOGY AND ITS IMPLICATIONS

Understanding the biological adaptations that characterize bats is essential to design effective conservation objectives (Kunz 1982). It is beyond the scope of this report to detail all of these, but characteristics that may be affected by land management activities are discussed.

Hibernation

Increasing disturbance of known hibernacula throughout the Black Hills poses one of the most serious threats to year-round bat populations. Winter is one of the most critical times of year for bats (Ransome 1990). While some species demonstrate a degree of flexibility in summer roost site selection, diminished or non-existent winter food supplies require year-round resident species[1] to seek hibernacula that meet specific conditions. Some hypogeal species travel great distances to winter roosting sites (Fenton and Barclay 1980, Ransome 1990), but there is no information to suggest this behavior is characteristic of Black Hills species. Of the Black Hills' eight hypogeal species, seven[2] are confirmed year-round residents (Anderson 1993, Mattson and Bogan 1993, Tigner and Aney 1994).

During hibernation, bats lower their metabolic rate reducing the expenditure of stored energy (Ransome 1990). Each species has an optimal temperature range at which there is a minimum expenditure of these hibernal reserves (McNab 1974, Ransome 1990). Deviation from this optimal range requires the bat to regulate its metabolism. If the microclimate of the hibernaculum becomes too cold, stored reserves must be used to prevent the bat from freezing. In contrast, warm conditions prevent bats from lowering metabolic rates, and hibernal stores are depleted too rapidly. While winter survival can be completely dependent upon stored reserves, brief warm spells may also permit bats to supplement reserves by foraging and drinking (Ransome 1990).

In addition to temperature and relative humidity, physical environment is another important feature of suitable hibernacula (Ransome 1990). The hibernacula must contain an area that affords bats protection from predators. Bats are unable to evade predators during hibernation.

Thermoregulating behaviors exhibited by bats vary according to species (McNab 1974, Ransome 1990). Two of the more common behaviors adopted as means of maintaining stable temperatures are clustering and roosting within cracks and crevices (McNab 1974, Ransome 1990). If a hibernaculum microclimate becomes unsuitable, the bat will arouse from hibernation and seek conditions that are more favorable. Such movement may involve simple shifting within the hibernaculum or may require complete site abandonment and relocation (Ransome 1990).

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[1] *L. noctivagans, L. borealis* and *L. cinereus* are considered migratory.

[2] No winter records have been recorded for *Myotis evotis* in the Black Hills.

The habit of forming hibernation clusters can put large segments of bat populations at risk. Disturbing a small number of bats in a cluster may result in a cascade effect. The movement of a few bats in contact with other hibernators could disturb a large percentage of the collective roost (Thomas 1995). Identifying such sites and protecting them from disturbance is an important component of any conservation strategy for bats in the Black Hills.

Arousal from hibernation is extremely demanding on stored energy reserves. Each arousal that elevates a bat's body temperature to permit flight can cost 10 to 30 days of hibernal reserves (Tuttle 1991). Frequent disturbances within hibernacula can result in exhaustion of energy reserves resulting in starvation (Ransome 1990). Unusually cold winters or poor foraging seasons can result in lower hibernal reserves, thereby increasing susceptibility to disturbance (Tuttle 1991). In addition to environmental causes of arousal, human disturbance can be deleterious. Examples include spray-painting cave and mine interiors, constructing campfires, and discharging fireworks. Less obvious is the increase in ambient temperature caused by body heat dissipation and lighting sources. Noises generated by movement and talking can also disturb hibernating bats (Thomas 1995). Complete arousal from hibernation can be prolonged with the bat awakening after the source of disturbance has departed, leaving those responsible unaware of their impact.

Historically, hibernal requirements were probably met by the abundant natural caves found throughout the limestone periphery of the Black Hills. Based upon numbers, the largest known hibernacula in the Black Hills are located in natural caves. Through a variety of circumstances, many natural caves are no longer suitable. Commercial cave development, natural erosion, and human disturbance all contributed to a reduction in the number of available hibernacula.

Mining created artificial roosting and hibernacula alternatives for seven of the hypogeal bat species in the Black Hills. However, given the minimal amount of research conducted to date on mine utilization, it is difficult to determine the role mines play in sustaining bat populations. This relationship remains one of most important areas yet to be investigated. One abandoned mine identified in Custer County during the winter of 2002/03 contained the third largest collective of *Corynorhinus townsendii* yet identified in the Black Hills.

In the Black Hills, bats generally begin arriving at hibernacula in late September or early October. Depending upon weather conditions and the species, bats hibernate from October until April. Based upon observations of banded bats, hibernacula also serve as night roosts throughout the summer season. With two exceptions, all positive identifications in hibernacula were of bats banded at the same roost during the summer months.

Jewel Cave National Monument, located 18.5 km west of Custer, SD, is the largest known wintering site for bats in the Black Hills (Choate and Anderson 1997). Recent winter surveys yielded total counts of approximately 1200 bats comprised of seven species (Choate and Anderson 1997). These include: *Corynorhinus townsendii*, *Myotis ciliolabrum*, *Myotis lucifugus*, *Myotis septentrionalis*, *Myotis thysanodes pahasapensis*, *Myotis volans*, and *Eptesicus fuscus*. Jewel Cave serves as hibernacula to one of the largest known collectives of

Corynorhinus townsendii in the western United States (Worthington and Bogan 1993). As such, its ecological importance cannot be over-emphasized.

In addition to providing winter respite to resident species, Jewel Cave also contains large numbers of bats that are known to travel great distances to hibernacula (Fenton and Barclay 1980). For this reason, this cave may represent an important wintering location for bats from outside the immediate Black Hills region (Worthington and Bogan 1993).

While it is unknown when bats began using Jewel Cave, it has been an important hibernaculum since at least the 1950's (Worthington and Bogan 1993). Summer use of the cave is generally limited to night roosting, though small numbers were documented using the site as a day roost (Choate and Anderson 1997). All species that hibernate there have been documented using the site as a night roost (Choate and Anderson 1997, Mattson and Bogan 1993).

The documented success of this location as a hibernaculum for such a wide variety of species is likely attributable to two factors. First is the diversity of microclimate conditions found within the cave. As has been noted, differences in hibernaculum selection among species are well documented. The present number of species attests to the range of conditions.

The second important factor is the limited level of disturbance characteristic of the site. Bat access to the cave is via the original entrance, which is gated to restrict human access (Mattson and Bogan 1993). No winter tours are conducted through hibernal areas, and access is restricted from October through April to minimize disturbance to the bat population (Kate Cannon personal communication).

Reproduction

While significant variations occur among species, there are some general characteristics common to bat reproduction that are important considerations for conservation strategies.
In general, mating occurs in the fall of the year (Racey 1982). Females store the male's sperm until spring, whereupon fertilization and implantation occur (Racey 1982). Given poor environmental conditions, females can delay fertilization, implantation, and even gestational growth of the embryo by entering torpor until conditions are suitable (Racey 1982). Increased levels of precipitation and the resultant decrease in foraging activity delay reproduction and may prevent breeding entirely in some individuals (Grindal et al. 1992, Racey 1982).

Females begin to form maternity roosts upon emergence from hibernation in the spring. Such roosts are collectives of females that may have traveled to the site from a wide area. Requirements for such sites vary by species. Two important factors are proximity to foraging areas and roost temperature (Racey 1982).

Bats generally give birth to a single altricial pup and only once a year. As during hibernation, bats are particularly susceptible to disturbance at this time. Disruption of maternity roosts can result in reabsorption of the embryo or spontaneous abortion. Disturbance at nursery roosts can result in the abandonment of non-volant pups.

In some species, nursery roosts may be completely different sites from maternity roosts. Again, proximity to foraging areas and roost temperatures are common requirements (Tuttle and Stevenson 1982). Warm roosting temperatures hasten parturition and development of the juveniles (Racey 1982). A roost's proximity to foraging areas is particularly important before the pups are volant (Tuttle and Stevenson 1982). Females have very high energy demands during this time of year. Long flights to foraging sites consume high levels of energy. Additionally, females must return to the nursery roost periodically throughout the night to nurse offspring. Once pups are volant, mastering foraging technique and accumulating body weight for successful hibernation are more efficient in areas with high insect densities close to the roosting site (Tuttle and Stevenson 1982).

Nursery roost members begin to disperse in the late summer and early fall when bats either migrate or return to hibernacula. Low reproductive rates, susceptibility to disturbance, and specific roost requirements are three important elements that underlie the need for conservation strategies and habitat management.

Night Roosts

Night roosts serve a variety of functions. One of the more important functions is to provide a resting site following a period of foraging (Kunz 1982). Generally, night roosts are found close to foraging areas and provide bats a secure resting spot for digesting and socializing (Kunz 1982).

While some individuals may be opportunistic in night roost selection, larger collective sites (e.g. caves, mines, buildings) found in the Black Hills are not atypical. Many smaller caves in the Hills are used exclusively as night roosts by several bat species. All caves and mines identified as hibernacula are also used by those same species as night roosts throughout the summer. Segregation of species at night roosts has not been observed in the Black Hills. One cave in the northern Hills [T5N R5E Sec 28] yielded all eight species known to roost underground during a single evening's netting (Tigner and Aney 1994).

Night roosts frequently contain scattered droppings throughout the interior. In addition, some species transport larger prey back to a favorite feeding perch within a night roost beneath which small piles of droppings and discarded insect parts may be found. One sheltered porch of an abandoned cabin, used as a feeding perch by *C. townsendii*, contained a piling of moth wings and other assorted insect bits that was 3 cm in depth.

Seasonally, night roosts within the interior of the Black Hills demonstrate very different patterns of use. Following hibernation, until mid-summer, bats netted at night roosts were almost exclusively adult males. This capture pattern continues until late summer when adult females and juveniles are routinely caught having returned from nursery roosts. Evidence for this movement was displayed by the recovery of a banded *M. septentrionalis* in a building nursery roost at the periphery of the Black Hills near Sturgis, SD. The closest banding site was a night roost 13 km away.

Roost Fidelity

As noted, bats require specific roosting habitat that typically are used from year to year by the same bats and successive generations. Human residents of buildings with bat maternity roosts often notice and comment upon such seasonal use when seeking assistance with roost management. Accumulations of droppings frequently attest to the repeated use of summer roosts.

Strong roost fidelity may be due to a relative scarcity of suitable sites (Kunz 1982). This may be particularly true where bats continue to roost at sites with high disturbance levels. In addition, the permanency of the structure housing the roost may affect the degree of fidelity (Kunz 1982).

An understanding of roost fidelity and its potential impact on population dynamics is an important component for habitat managers. In a recent review of the literature on this subject, Lewis (1995) presents three benefits of roost fidelity. First, sites that provide high quality roosting conditions are more likely to show persistent use. Repeated use of quality sites eliminates energy depleting searches for alternate roosting sites.

Second, sites whose conditions are improved by occupancy may demonstrate higher levels of fidelity. The maintenance of roost microclimate resulting from collective inhabitance, as found within nursery roosts, may promote roost fidelity.

The third benefit is that of maintaining social relationships with other members of the species. For females that form maternity and nursery collectives, roost fidelity can serve to facilitate the collective's formation (Lewis 1995).

In addition to nursery roosts, site fidelity to night roosts and foraging areas has been observed in species residing in the Black Hills. While only limited information on reproductive behavior has been collected for most of the region's species, some differences have been noted. *M. lucifugus* and *E. fuscus* both demonstrated strong fidelity to maternity and nursery sites.

In contrast, maternity and nursery roosts of *M. t. pahasapensis* frequently change roost sites though some evidence of reuse may indicate a fidelity to a network of roosts (Cryan and Bogan 1996).

Mattson's (1994) study of *L. noctivagans* also demonstrated frequent roost-changing activity in maternity roosts. Such activity suggests potential benefits exceed the liabilities associated with frequent roost relocation (Cryan and Bogan 1996). Benefits may include avoidance of disturbance or parasites, predator evasion, roost microclimate selection, and minimization of flight distance to foraging areas (Lewis 1995).

Predation

Little information has been reported from the Black Hills on bat predation. Mattson (1995) observed owl predation on a probable juvenile *Lasionycteris noctivagans* resting on the bole of a roost tree. The species was thought to be an eastern screech-owl (*Otus asio*) or a northern saw-whet owl (*Aegolius acadicus*).

Backlund (personal communication) identified a skull of *L. cinereus* from the pellet of what was thought to be a long-eared owl (*Asio otus*) collected 100 km east of the Black Hills. Owls are one of the more common predators cited in the literature though no predators are known to be bat specialists (Fenton 1992).

While no evidence has been collected for owl predation at larger roosting sites in the Black Hills, Tuttle and Stevenson (1982) note that owl predation may be disrupted by human presence. Direct observation of predation at caves was made only while observers were concealed within a blind using night vision equipment.

In March 1992 two *C. townsendii* were identified hibernating in the lowest chamber of a natural cave [T3N R6E Sec 29]. While droppings and nests of the bushy-tailed woodrat (*Neotoma cinerea*) were present throughout the cave, no nests were located in the chamber in which the bats were hibernating. In November 1993 two *C. townsendii* were found in the same location, and a bushy-tailed woodrat nest had been constructed in the chamber. While two bats were observed hibernating in November of 1993, only a portion of a single forearm with a small attachment of wing membrane was found during a survey conducted in February 1994. It was located near the previously mentioned nest amid pieces of collected litter, providing circumstantial evidence of possible predation by this rodent species.

Raccoons (*Procyon lotor*) were frequently found in abandoned mines during winter surveys in the Black Hills. While no direct observations have been made in the Black Hills, this species is known to prey on bats (Barbour and Davis 1969). The same authors reported frequent predation of *L. borealis* by blue jays (*Cyanocitta cristata*). Other records of predation in the Black Hills include skunk, marten, voles, snakes, and raptors (Herreid 1961, Martin 1961, Sperry 1933, Nagorsen and Brigham 1993).

One of the more common predators is the domestic cat. Given the close association between many bat species and buildings, it is not a surprising relationship. In the United Kingdom, domestic cats are considered the single greatest predator of bats (Richardson 1985).

SPECIES ACCOUNTS AND IDENTIFICATION

"**Bats are such unusual creatures that some effort is required to think of them as actual animals living in a world of common sense and concrete reality.**" D.R. Griffin *Listening In The Dark*

The following pages provide individual descriptions of the bat species found within the Black Hills region. These include general descriptions of physical characteristics with an emphasis on points that aid in distinguishing species. For a more definitive key, see van Zyll de Jong (1985).

A brief natural history for each species is also provided. This section includes information on seasonal roosting requirements, reproduction, and range. Wherever possible, such information is based upon observations made within the Black Hills. References are made to northern and southern Black Hills. Such references indicate an area north or south of a line bisecting the region that runs through Rapid City, SD. In the interest of protecting roosting sites, specific locations to all sites referenced in this report are filed with the South Dakota Department of Game, Fish and Parks, Black Hills National Forest, and Wyoming Game and Fish Department.

In-hand identification of most Black Hills bat species is fairly straightforward. The *Myotis* species are at times difficult to distinguish owing to individual variation found within identifying characteristics. The following descriptions attempt to highlight features most common and useful in identification of species in the Black Hills. Sex determination is easily accomplished with a captive animal, as males display a conspicuous penis. Roosting posture generally prevents sex identification during hibernation when individuals cannot be disturbed.

Juvenile field identification is achieved by illuminating through the metacarpal-phalangeal joints within the wing membrane. Incomplete bone ossification at the joints in juveniles appears as translucent bubbles within the distal ends of bones. In adults, this characteristic is absent. These bubbles become less apparent with age and by summer's end are difficult or impossible to identify in juveniles born in the spring. Juvenile joints frequently give a rounded, more swollen appearance when compared with adult joints. However, given individual variation, age identification based solely on the latter of these two characteristics is likely to be less reliable.

Pelage color is not a reliable characteristic for species identification because of the substantial differences occurring within species. The exception to this rule is the Eastern Red Bat (*L. borealis*), which generally displays a pelage significantly different from other species found within the Hills.

See TABLES 3 and 4 for forearm measurements and weights.

Myotis ciliolabrum[1] (Western Small-footed Myotis)

M. ciliolabrum is the smallest bat in the Black Hills with an average forearm length of 31.27 mm and average weight of 5.72 gm. The calcar is keeled and as noted by its common name, the foot is small with average length being 6.5 mm (van Zyll de Jong 1985). The skull has a flattened appearance, and the ears are relatively long with a narrow tragus approximately half of the ear length. Though variations in color exist, it is frequently seen with near cream-colored pelage, lighter ventrally accentuated by a black mask, ears, and membranes.

M. ciliolabrum is a year-round resident of the Black Hills. Regarding behavior, it is a very gentle bat when handled properly. While this species is common, local populations are usually small in number though exceptions do occur. The largest number captured during a single evening's netting occurred at the historic entrance of Jewel Cave National Monument. On 8/5/93, Mattson and Bogan (1993) reported capturing 93 individuals, consisting of 80 males and 13 females.

At this same location, Turner (1974) reported an evening's capture of 48 individuals, 43 males and 5 females, on 7/24/68. These captures occurred within a span of three hours (Barbour and Davis 1969).

Another large group, 27 individuals consisting of 17 males and 10 females, was netted entering a cave [T3N R6E Sec 32] on 9/2/92 (Tigner unpublished data). Between 1992 and 1995, excluding the preceding references, average capture rate for this species at night roosts throughout the Black Hills was 3.5 individuals (Tigner unpublished data).

The largest known hibernation site for this species was an abandoned mine near Mystic, SD [T2N R4E Sec 33]. The site was an adit with a single southwest-facing portal. It was approximately 110 meters in length with several short drifts and rooms. This mine had been monitored since 1992 yielding consistent bat numbers during winter surveys. Totals for *M. ciliolabrum*: 1992:21, 1993:15, 1994:21, 1995:18, 1998:38. Five other species used this mine as a hibernaculum. As is common with many of the Black Hills' mines, the portal was located in unstable material and collapsed sometime during 1999. Such events serve to highlight the importance of identifying and protecting the remaining sites providing suitable bat habitat.

During foraging, the flight pattern is slow and erratic with orienting echolocation calls characterized by more rapidly emitted pulses than other Black Hills' species. Based on studies in other areas, *M. ciliolabrum* feeds primarily upon small insects, such as Diptera, Coleoptera, Cicadellids, and Trichoptera (van Zyll de Jong 1985).

This species characteristically hibernates individually, and movement is minimal. Our data indicate little change in hibernacula populations between November and February. *M.*

[1]Earlier literature has referred to this species as *Myotis leibii* or (earlier) *Myotis subulatus* (Say bat)

ciliolabrum is commonly found hibernating in mines and caves. No clusters have been observed in the Black Hills. Martin and Hawks (1972) report finding a single crevice containing four individuals in a natural cave in the southern Hills. It is frequently found to inhabit narrow crevices but also roosts on the surface of vertical walls and from ceilings. Both behaviors have been observed simultaneously by different individuals within the same hibernaculum. Frequently forearms are splayed outward away from the body during hibernation. Such posturing behavior is likely to be thermoregulatory, designed to disperse body heat and lower body temperature (Bakken and Kunz 1988). It prefers cooler, drier hibernacula and is frequently found at the same winter sites as *C. townsendii*.

Although no exact locations of maternity or nursery roosts have been identified in the Black Hills of South Dakota or Wyoming, the region's numerous rocky outcrops and crevices seem to offer abundant summer roosting sites. Tuttle and Heaney (1974) describe nursery roosts in the Badlands of South Dakota, 115 km east of the Black Hills, as cracks and crevices in the clay and volcanic ash mixture characteristic of the area. All roosts contained up to four lactating females. Females typically give birth to a single pup (Barbour and Davis 1969), though twins were reported at a roost in the Badlands of South Dakota (Tuttle and Heaney 1974).

Adult females and juveniles were commonly netted at night roosts throughout the Black Hills during the active time of year. In contrast, from spring through midsummer, captures at night roosts of *Eptesicus* and other *Myotis* species were nearly always adult males. This suggests that females select maternity and nursery roosts in the Hills proper and do not move to other areas. Elevational gradient has been suggested as an important determinant in formation of maternity/nursery roosts (Cryan and Bogan 2000).

In contrast, *M. ciliolabrum* may be able to achieve roost thermal requirements by selecting sites that mitigate temperatures based upon other factors. One such roost, near an abandoned mine on Custer State Park, exists in rock outcroppings at an elevation of approximately 6250 feet. Towering well above the surrounding forest canopy, these rock faces have a clear southerly exposure. Summer surveys during 2001 and 2002 have included mist netting a small pool immediately adjacent to these rock faces. Both years have yielded *en masse* captures of lactating females of this species. Approximate number of bats arriving collectively at this pool was ten. Early capture times, before and at sunset, support the assumption that there is a nearby nursery roost.

Another explanation for wider distribution of reproductive females and smaller local populations may be the result of prey availability. Diet analysis might provide information concerning varying population density.

Although successfully captured at night roosts with both mist nets and harp traps, its small size often allows escape from the latter. It frequently becomes blocked and entangled by the first bank of strings, but escapes by retreating. Despite its small size, this bat is a strong flier and can take off from a level surface.

For bats in general, small access points into roosts increase predation threat and may be avoided (Tuttle and Taylor 1994). *M. ciliolabrum* demonstrates the widest acceptance of restrictive roost entry size at hibernacula. One example is based upon observations made at a natural cave on private property near Rapid City, SD. The only access into the cave was via a ceramic drain tile inserted into a solid wall built by the cave's owner to prevent unauthorized entry. The tile, approximately 15 cm in diameter and 35 cm in length, was installed to provide access to the solid door's locking mechanism. It is uncertain whether this bat can fly through this opening without landing given the narrowness and irregularity of the approach to the closure wall, which is approximately 20 m from the access point. Three *M. ciliolabrum* were the only bats identified using this site as a hibernaculum.

Based on existing information, hibernacula selection is somewhat of a paradox. High body fat to mass ratios allow large species to use relatively cold, dry hibernacula (Ransome 1990). Fat reserves serve as a buffer against harsh or fluctuating hibernacula conditions. Given its diminutive size, this species clearly does not fall into this category. However, it may be able to avoid harsh conditions by selecting crevices.

At present levels of understanding, the principle threat to this species may be the availability of suitable hibernacula. This supposition is probably true if, as has been suggested, abundant sites for maternity and nursery roosts are available throughout the natural terrain of the Black Hills. More information is needed on maternity and nursery roosts and hibernacula requirements for this species.

Reproductive females were recorded from both the northern Hills (one pregnant female on 7/5/94 at a natural cave night roost [T3N R6E Sec 32]) and southern Hills of South Dakota (one pregnant female while foraging on 7/7/95 at Lower Woodcock Spring).

Lactating females were captured on 7/14/93 (foraging, Keystone, SD sewage lagoons) and 7/7/94 (foraging, Hazelrodt Picnic Ground, SD). Post-lactating females were captured on 8/17/94 and 9/9/94.

Earliest capture of a volant juvenile was on 7/24/68 entering Jewel Cave (Turner 1974). Other captures of juveniles:
7/31/92 - eight entering natural cave [T3N R6E Sec 32]
8/05/92 - three entering natural cave [T3N R6E Sec 29]
8/27/92 - two entering natural cave [T4N R5E Sec 12]
9/11/93 - one netted foraging at Roby Spring (Mattson 1994)
9/13/94 - one entering natural cave [T5N R5E Sec 28]
9/20/94 - three entering natural cave [T3N R6E Sec 28].

Three banded individuals, 2 adult male and 1 adult female, have been recaptured. All three occurred at two natural caves in the northern Hills. Both sites serve as summer night roosts for both sexes where they were originally banded.

A banded female was found hibernating high on an interior wall in the first cave [T4N R5E Sec 16]. Height prevented reading the band. This same cave, surveyed on 3/4/93, served as a hibernaculum to a banded male found head-down in a vertical crevice in the ceiling.

A banded adult male was recaptured at the second cave [T3N R6E Sec 32] on 6/26/95. It was banded at the same site on 9/2/92. Age could not be determined at banding.

Myotis evotis (Long-eared Myotis)

M. evotis is of medium size, with an average forearm length of 38.17 mm and an average weight of 7.5 gm. *M. evotis* generally has a shorter forearm, range 36-41 mm, than *M. t. pahasapensis*, range 40-43 mm. Total ear length is a good distinguishing feature. The ear length, 17-22 mm, is substantially longer than that of *M. septentrionalis*, 15-18 mm, and proportionally longer than *M. t. pahasapensis*, 19-20 mm (van Zyll de Jong 1985). When pressed forward, ears extend a minimum of 5 mm beyond the nose tip and overall ear length exceeds 50 percent of the forearm length. *M. evotis* has variable brown pelage with contrasting blackish ears and wing membranes. Individuals caught in the Black Hills have darker brown pelage.

Very little information regarding winter hibernation exists, but *M. evotis* may use caves and mines (Manning and Jones 1989). No winter records were recorded for this species in the Black Hills. This species is found in a wide variety of habitat types though most are associated with forested areas (Manning and Jones 1989, Nagorsen and Brigham 1993). *M. evotis* forages on a variety of insects with beetles and moths comprising most of the diet (Black 1974).

This report represents an extension in range for this species as only one confirmed specimen has been reported from Harding County in the northwestern corner of the state (Andersen and Jones 1971, Jones and Choate 1978). Earlier specimens from the Hills purported to be *M. evotis* were determined to be *M. t. pahasapensis* (Jones and Choate 1978). Identification of *M. evotis* has been made in the field based on the following description by van Zyll de Jong (1985). *M. evotis* exhibits a slightly shorter forearm than *M. t. pahasapensis* with a longer overall ear length. There is no conspicuous fringe around the free edge of the uropatagium on *M. evotis*, though slight inconspicuous fringes do occur. The fringe on *M. evoti*s is sparser than on *M. t. pahasapensis*. Variation in the degree of conspicuousness can make the distinction between these two species difficult. Overall ear length was used as the determining factor. Bats whose ears, when pressed forward, extended 5 mm beyond the nose tip and were greater than 50 percent of the forearm length were classified as *M. evotis*.

M. evotis was captured at night roosts in both mist nets and harp trap. Six adult males were netted at night roosts in the northern Black Hills of South Dakota (T3N R6E Sec 32; T5N R5E Sec 28; T4N R5E Sec 16), one adult female and one adult male were netted foraging over a small woodland pond in Wyoming (T55N R63W Sec 26), one male was netted over a stock tank near Jewel Cave National Monument, and one nursery roost was found near Sturgis, SD. One non-reproductive adult female was netted foraging adjacent to the Cheyenne River near Cascade, SD.

The nursery roost, comprised of approximately 20 to 25 individuals, was located (7/26/93) in the attic of an older, two-story brick building, constructed circa 1900, in Sturgis, SD. Based upon observed variation in body size, this figure includes juveniles. The bats were roosting at the edge of a large metal exhaust vent under adjacent flashing and roofing. The cluster roosting location was characterized by access to both the outside and interior of the attic, though numerous other access points were available throughout the attic.

One non-reproductive adult female was roosting approximately 1 m from the area containing the rest of the roost. Because of the longer ear length and distance from other bats, this female was captured by hand for examination. Though no measurements were taken, ear length was greater than 50 percent of the forearm length with ear tips extending well beyond the nose tip. Fringe on the free edge of the uropatagium was very sparse and finer than typically seen on *M. t. pahasapensis.* When returned to its roosting spot, the bat quickly rejoined the others. The roost was used during the summer of 1993, but not during 1994 or 1995. Extensive restoration, which included construction work in the attic coupled with simultaneous work in adjacent buildings, may have caused the bats to abandon the site.

Priday and Luce (1995) reported three captures northwest of Sundance, WY. The first was netted at a night roost in a mine on 6/20/94. The remaining pair was netted over a nearby stream approximately 400 m away.

Based on capture data this bat appears to be less abundant than *M. t. pahasapensis.* Range for this species includes all of the Black Hills.

Myotis lucifugus (Little Brown Myotis)

M. lucifugus, medium in size, has an average forearm length of 37.49 mm and an average weight of 8.33 gm. The calcar is not keeled, which helps distinguish it from *M. volans*. Ear length is less than *M. septentrionalis* and does not extend beyond the nose tip when pressed forward. Tragus is blunt and approximately half the length of the ear. Pelage color varies considerably ranging from light or medium brown to very dark brown, and it displays a characteristic glossy appearance that helps distinguish it from morphologically similar *M. volans*. Wing membranes and ears are dark brown.

M. lucifugus is common throughout the United States and abundant in the Black Hills. It is the current record holder for age longevity at over 34 years (Davis and Hitchcock 1995). This is one of the more opportunistic species both in foraging habits and roost selection (Fenton and Barclay 1980). It can be found in a variety of habitat types and is known to roost in buildings, caves, mines, and trees (Fenton and Barclay 1980). *M. lucifugus* commonly feeds flying low over water surfaces with a shallow wing beat. Aquatic insects comprise a large portion of this species' diet (Fenton and Barclay 1980).

As is common with many Vespertilionid species, males roost individually or in small groups during the summer months, segregated from females. As evidence of its opportunistic roosting characteristics, maternity roosts are now found more commonly in buildings than in natural roosting sites (van Zyll de Jong 1985). Trees also function as nursery roosts (Fenton and Barclay 1980). In the Black Hills, all known maternity and nursery roosts are in buildings.

Females give birth to a single pup with juveniles becoming volant at three weeks of age (Fenton and Barclay 1980). The earliest volant juvenile was captured (7/4/70) near Custer, SD (Turner 1974).

Four maternity and nursery roosts were identified in both the southern and northern Black Hills and all show signs of a high degree of roost fidelity. All known maternity and nursery roosts for this species are located within 0.5 km of water. In South Dakota, the largest known maternity roost is located within an attic at a camp near Custer State Park. This roost was first recorded during the summer of 1970 when it contained 100 to 150 adults (Turner 1974). It was estimated to contain 200 bats during the summer of 1993 (Mattson 1994).

Another large maternity roost of approximately 100 individuals was identified in the gable of a two-story wood framed house near the McNenny Fish Hatchery in South Dakota (6/15/93). Because of extensive renovations, including complete removal of the roof, approximately 100 bats were hand-captured from behind a shutter (6/24/93). Thirty-five individuals, all pregnant females, were banded.

A separate roost containing 20 pregnant females was found on the same evening approximately 1 km from the first roost in the attic of a building at McNenny Fish Hatchery. The fourth maternity roost was located in the attic of a two-story brick building near Sturgis, SD on 7/26/93.

Approximate roost size was 50 adults. Surveyed the following year (7/6/94), this roost contained approximately 100, which included some juveniles of the year.

With the exception of *C. townsendii*, this is the only species for which a probable maternity roost was identified underground. On 5/20/93, a natural cave [T5N R5E Sec 28] near Sturgis, SD contained a cluster of 18 individuals including three banded females. Bands were not read to minimize disturbance to the roost. The cluster was located in a dome above a main passage. Females of this species were banded previously at this location.

M. lucifugus was routinely captured with mist nets and harp traps at night roosts throughout the Hills though usually in smaller numbers. During the spring and early summer, captures at night roosts were comprised almost exclusively of adult males. Absence of females at this time was likely due to their congregation in maternity and nursery roosts in other areas (Turner 1974). Juveniles and adult females became more common at night roosts during the latter part of the summer and early fall.

Two caves in the northern Hills yielded the highest capture rates [T3N R6E Sec 32 and T5N R5E Sec 28]. Both sites were monitored during the winters of 1992-1995 with neither being used as a hibernaculum. On 9/2/92, the former of the two caves yielded 25 individuals, 20 males including one confirmed juvenile and 5 females; while the latter, on 9/9/92, yielded 29 individuals, 15 males and 14 females.

The largest number of *M. lucifugus* netted at a foraging site was 42, netted within one hour at the sewage lagoons of Jewel Cave National Monument. These bats probably were a portion of the bats known to roost at Jewel Cave (Cryan and Bogan 1996).

This bat hibernated only in sites, including natural caves and mines, with relatively high humidity including natural caves and mines. During hibernation, individuals were often found with droplets of condensation covering the entire body. Conservation strategies for this species should include protection of hibernacula that contain relative humidity greater than 90 percent.

The largest hibernaculum in the Black Hills for this species is Jewel Cave. The Dungeon Room, in which most of the *M. lucifugus* and *M. volans* hibernate, has a relative humidity of greater than 90 percent. These species apparently arrive at similar times with numbers remaining constant throughout the winter season.

Another natural cave [T3S R2E Sec 3], 15 km north of Jewel Cave, also serves as a hibernation site to large number of *Myotis.* Approximately 300 individuals were recorded during winter surveys with largest numbers comprised of *M. lucifugus* and *M. volans*. These two species are morphologically similar and, owing to the height of hibernating clusters, not easily distinguishable during hibernation. Based upon observations at this site, *M. lucifugus* and *M. volans* have a tolerance to limited roost entry size. While the area in which the bats hibernate is spacious, ceiling height is approximately 3-4 m, access requires flight through a narrow passage.

Given *M. lucifugus*' affinity for roosting within man-made structures, its maternity and nursery roosts may be at greater risk than species relying upon more natural roosting sites. As such, this species is one that should benefit from an increased public awareness of bat-related benefits.

Myotis septentrionalis[1] (Northern Myotis)

M. septentrionalis is a medium-sized bat with an average forearm length of 36.07 mm and average weight of 7.13 gm. It is distinguished primarily by its ear length and tragus. Average overall ear length is 16.4 mm. This measurement is greater than *M. lucifugus*, 13.8 mm, and *M. volans*, 13.3 mm, but less than *M. thysanodes*, 19.5 mm, and *M. evotis*, 19.8 mm (van Zyll de Jong 1985). The tragus is long, narrow and pointed at the tip. *M. septentrionalis* frequently has a mask that is balder than similar *Myotis* species. Membranes, ears, and mask are generally medium to dark brown.

This bat routinely displays an aggressive attitude when netted. It constantly vocalizes from time of capture until release and frequently attempts to bite handlers. Illumination by flashlight in roosts often caused this bat to vocalize. Little information exists on the dietary preferences of this species, though some evidence indicates it is a generalist (Nagorsen and Brigham 1993, van Zyll de Jong 1985).

M. septentrionalis is abundant throughout the Black Hills region, however, winter occurrence was only recently confirmed (Worthington and Bogan 1993, Tigner and Aney 1993, Tigner and Aney 1994). During the course of one survey conducted between 1992 and 1995, only seven hibernating individuals were located (Tigner and Aney 1994, Tigner unpublished data). There are no hibernation records in Wyoming (Bob Luce personal communication). Sites selected for hibernation include both natural caves and abandoned mines.

Several common features are exhibited by all hibernacula where this species was identified. The first of these is relative humidity greater than 90 percent. All sites contained standing water with condensation accumulations throughout the interior. All bats roosted in crevices protected from normal airflow. Of the seven hibernacula identified for this species, five are abandoned mines and two are natural caves. The abandoned mines, varying in interior length from 5 m to 200 m, contained short side drifts off the main adit, and all possessed standing interior water. Crevices in these side workings were selected for hibernation. Three of the adits were completely sealed by snowfall.

The first natural cave hibernaculum [T5N R5E Sec 29], near Sturgis, SD, has a history of human disturbance. Shortly after this site was identified, in mid-December 1994, a campfire was built in the cave's interior causing abandonment by hibernating bats for the balance of the winter.

There were only a handful of records noted from the second natural cave, Jewel Cave National Monument (Worthington and Bogan 1993). Given this species' apparent affinity for crevices, they may be easily overlooked.

The largest number of *M. septentrionalis* found in a hibernaculum in the Black Hills was in an extensive abandoned mine near Hill City, SD. A conservative count from the survey conducted

[1] Earlier literature referred to this species as *Myotis keenii* or Keen's Myotis.

during the winter of 2002/03 was forty individuals. Similar numbers were found during the site's initial survey during the winter of 2000/01.

M. septentrionalis was captured at night roosts with both mist nets and harp trap. Only one maternity or nursery roost was located within the Black Hills (Tigner and Aney 1994). It was identified on 7/6/94 near Sturgis, SD in the roof apex of a two-story brick building. The roost was comprised of approximately 75 individuals, including juveniles. A banded adult female was observed within the main cluster, but to minimize disturbance the band was not read. The closest banding site was a cave night roost approximately 13 km from this location. The observation of this banded female provides direct evidence of movement from within the Hills to a maternity roost at the periphery. This identification also indicates the possibility of locally important maternity and nursery roosts.

A small maternity and nursery roost containing less than 10 individuals was identified in Wall, SD (6/30/94) approximately 110 km east of the Black Hills. One lactating female was captured emerging from beneath shake roofing of a United States Forest Service visitor center building.

Thirty-seven juveniles were netted between 1992 and 1995 (Tigner unpublished data). During a single evening's netting (8/18/92), 13 of these juveniles, 12 males and 1 female, were captured entering a natural cave night roost [T4N R5E Sec 16]. Seasonally, the earliest volant juvenile was captured on 7/26/68 entering a natural cave night roost [T2S R2E Sec 17] (Turner 1974). Three male juveniles were netted entering a cave [T3N R6E Sec 32] on 7/31/92.

Two post-lactating females were netted during the summer of 1994. On 7/29/94, the first was netted while foraging at Red Bat Pond near Whitewood, SD. The second was captured on 8/11/94 entering a natural cave night roost [T4N R5E Sec 12].

Based on banding recoveries, *M. septentrionalis* demonstrates fidelity to night roosts. Eleven banded individuals were recaptured. Seven recaptures occurred at night roosts where the bat was originally banded. Seven of these, all males, were banded as juveniles. The table below gives the banding/recapture dates of these seven *M. septentrionalis*.

Site Type	Original Band Date (Age at Banding)	Recapture Date (Age at Recap)	Time Length
Night Roost (Cave)	8/12/93 (J)	9/2/93 (J)	21 days
Night Roost (Cave)	8/18/92 (J)	9/16/92 (J)	29 days
Night Roost (Cave)	9/30/93 (J)	7/5/94 (A)	9 months
Night Roost (Cave)	9/2/92 (J)	8/12/93 (A)	11 months
Night Roost (Cave)	8/27/92 (J)	6/17/94 (A)	1 year 10 months
Night Roost (Cave)	9/9/92 (J)	8/24/99 (A)	6 years 9 months
Night Roost (Cave)	7/31/92 (J)	6/7/02 (A)	9 years 10 months

***Myotis septentrionalis* - NIGHT ROOST SAME SITE BANDING RECAPTURES**

The remaining four recaptures may be evidence for fidelity to a specific foraging area or a home range. One male juvenile has been netted on three occasions at the same stock tank. Captured and banded on 5/31/94, Mattson (personal communication) recaptured this bat at the original site 24 days later. This same individual was again recaptured on 7/11/99 at the same location (Tanya Dewey personal communication). The table below gives the details of these four recaptures.

Site Type	Original Band Date (Age/Sex at Banding)	Recapture Date[s] (Age at Recap)	Time Length
Stock Pond	8/11/92 (J / Male)	6/23/94 (A)	1 year 10 months
Stock Pond	7/29/94 (A / Female)	8/8/01 (A)	7 years
Stock Tank	5/31/94 (J / Male)	6/24/94 (A) 7/11/99 (A)	5 years 1 month

***Myotis septentrionalis* - FORAGING SAME SITE BANDING RECAPTURES**

More information is required on this species' maternity roost habits. If characteristically found in buildings, this species would benefit from increased public awareness of maternity roost importance. Hibernacula requirements need further study. Given its affinity for crevices, quantifying microclimate conditions as well as physical characteristics are two areas that warrant further examination.

Myotis thysanodes pahasapensis (Fringed Myotis)

M. t. pahasapensis is a bat of medium size. The average forearm length is 40.82 mm and average weight is 7.8 gm. The common name is derived from the fringe of conspicuous coarse hairs around the free edge of the uropatagium. As with many identifying characteristics, the fringe is variable. Fringe variation does not appear to be age or sex related. Ears are longer than other *Myotis* species with the notable exception of *M. evotis*. *M. evotis* displays a proportionately longer ear than *M. t. pahasapensis* with overall ear length in *M. t. pahasapensis* being less than 50 percent of the length of the forearm length (van Zyll de Jong 1985). Wing membranes and ears are very dark to black in color.

M. t. pahasapensis' known range is restricted to the Black Hills area (Jones and Choate 1978, van Zyll de Jong 1985). Beetles represent the largest prey group but moths are also taken (Black 1974). Though a year-round resident, hibernating individuals were difficult to locate. Because of a preference to hibernate in cracks and crevices, identification is difficult. During the course of surveys conducted during the winters of 1992-1995 a total of 10 individuals were found hibernating. Five of these were in abandoned mines, roosting individually in crevices. The remaining five, three of which were in crevices, were found in natural caves roosting individually.

Identification during hibernation was made via the longer ear length, black membranes and overall size. Two individuals were roosting on the surface of the rock. One was hanging, head down, approximately 1.5 m from the floor on a vertical surface. The other was hanging by both feet from the ceiling, in a room with maximum height of about 1 m, and swaying with the air currents in the cave [T6S R5E Sec. 21].

The largest number of this species found hibernating in a single location is four. This site, surveyed in January 2003, is an extensive abandoned mine in the central Black Hills containing standing water throughout its interior. Three were located in crevices in the rock and one was found on the rock’s surface.

Given the comparatively low number of hibernating individuals discovered during the course of the survey, it is likely this species prefers cracks and fissures for hibernation. Such behavior would make location and identification difficult during winter. Martin and Hawks (1972) reported finding this species in Jewel Cave, frequently hibernating while facing up a vertical wall and clinging to the surface by both feet and thumbs with forearms slightly splayed away from the body. As noted under *M. ciliolabrum*, such posturing may be thermoregulatory in nature employed to lower body temperature by increasing exposed surface area (Bakken and Kunz 1988).

Using radio telemetry Cryan and Bogan (1996) conducted the most comprehensive study of roosting habitat in the southern Black Hills during the summer of 1995. Males were found to roost individually in rock crevices. Reproductive females formed communal maternity and nursery roosts in rock crevices that averaged 18.9 individuals (Cryan and Bogan 1996).

Maternity roosts were observed to move daily with evidence suggesting the possibility of roost fidelity (Cryan and Bogan 1996).

Maternity roosts have been identified in the northern and southern Black Hills of SD (Cryan and Bogan 1996, Tigner and Aney 1994). One maternity roost was in an attic of a two-story brick building near Sturgis, SD (6/8/94). The roost was divided into two locations approximately 1 m apart. The first was around an exhaust fan midway between the apex of the roof and the floor of the attic. The exhaust fan was located at the juncture of two wings of the building. The second location was closer to the floor, still at the roofline, around a black, cast iron standpipe. Both groups appeared to be of similar size, about 25 individuals, with apparent juveniles in both. Both sites appeared to contain crevices large enough for bats to exit. No bats were found during a survey of this site on 7/6/94. A single adult female was observed in this attic on 4/22/94, although no evidence of previous parturition or pregnancy was noted.

The earliest recorded volancy for juveniles is 8/10/68 (Turner 1974). This date compares well with later survey work which netted three juveniles entering a natural cave night roost [T4N R5E Sec. 16] on 8/18/92 and one juvenile netted foraging near Lower Woodcock Spring on 8/24/94.

M. t. pahasapensis was captured at night roosts with both mist nets and harp traps. The largest number caught during a single evening (5/22/94) was 12 adults, 11 male and 1 female, netted at Water Draw Spring (Mattson 1994). In addition, eight adult males and two non-parous females were netted entering a natural cave night roost [T3N R6E Sec. 32] on 9/2/92. One other significant series of captures occurred at a night roost [T4N R5E Sec. 12] on 9/10/93. Within a span of 15 minutes, eight individuals were netted entering the natural cave. Seven were post-lactating females and one an adult male displaying canines with greater than 50 percent wear. Effective closure of all openings at the cave's mouth was not achieved and other individuals were seen entering the cave at this same time.

A total of 75 individuals, 54 males and 21 females, were banded between 1992 and 1995. Five recaptures of banded individuals all occurred at the original banding site, all serving as night roosts. The first recapture was at a cave [T4N R5E Sec 16]. This juvenile male was originally banded on 8/18/92 and weighed 7 gm. He was recaptured on 9/16/92 and weighed 10 gm. Though recaptured within 30 days, the substantial difference in weights may be attributable to recent foraging activity rather than body weight increase.

The second recapture was at a natural cave night roost [T2S R2E Sec 16]. An adult male was banded on 8/25/94 and recaptured on 6/20/95. The three other recaptures all occurred at the same location, a natural cave [T3N R6E Sec 32] serving as a night roost. The first occurred on 5/20/94 and the last two on 9/20/94. All three adult males were originally banded on 9/2/92.

Males, when netted, were frequently found to have dirt or clay-like substance within their fur and crevices of the wing membrane. Such deposits were clearly present in early evening captures suggesting day roosting in soft soil crevices. One banded male, recaptured at a night roost, was found to have dirt between the band and the forearm. This dirt easily fell away when the band was manipulated for removal and likely would have been groomed away by the bat. No evidence of injury to the bat was noted.

The following table provides a listing of band recaptures for this species.

Site Type	Original Band Date (Age/Sex at Banding)	Recapture Date[s] (Age at Recap)	Time Length
Night Roost (Cave)	8/18/92 (J / Male)	9/16/92 (J)	29 days
Night Roost (Cave)	9/2/92 (J / Male)	9/20/94 (A)	2 years
Night Roost (Cave)	9/2/92 (J / Male)	5/20/94 (A)	1 year 9 months
Night Roost (Cave)	9/2/92 (J / Male)	9/20/94 (A)	2 years
Night Roost (Cave)	8/25/94 (A / Male)	6/20/95 (A)	10 months

***Myotis thysanodes pahasapensis* – Band recaptures**

Additional information is needed on the maternity and nursery roost requirements and habits for this species. While roosts were found in a building and natural rock crevices, additional roost locations would improve the knowledge base. The frequent relocation of maternity and nursery roosts is unreported in this species and warrants additional study (Cryan and Bogan 1996). Locally abundant captures may be indicative of unique or significant habitat characteristics (Cryan and Bogan 1996). Such characteristics should be identified.

Hibernacula requirements also need to be quantified. It is far more commonly identified during the summer months than in winter hibernation. While this is likely in response to an apparent affinity for winter roosting in crevices, the extent to which these sites are available to this species remains unknown.

Myotis volans (Long-legged Myotis)

M. volans is a medium-sized bat with an average forearm length of 37.93 mm and average weight of 7.84 gm. It is very similar to *Myotis lucifugus* in morphology, and the two are often difficult or impossible to distinguish during hibernation. It often displays a more dense line of furring extending from elbow to knee on the ventral surface of the wing membrane. The calcar has a distinct keel that is weak or lacking in *M. lucifugus.* Pelage is varying shades of dull brown lacking the characteristic glossy sheen often found on *M. lucifugus*. The ears and wing membranes are generally darker brown. Owing to its shorter rostrum and steep forehead (van Zyll de Jong 1985), this species can occasionally be distinguished from *M. lucifugus* by the smaller appearing head relative to body size (Tigner personal observation).

M. volans is one of the more common species found within the Black Hills and is a year-round resident. It demonstrates close associations with coniferous forests, foraging throughout the forest canopy (Barbour and Davis 1969) and feeds primarily on small moths (Whitaker, Jr. J.O. et al. 1981*a*). Roosting sites identified in the Black Hills include caves, mines, trees, and rock crevices (Cryan and Bogan 1996, Tigner and Aney 1994).

This bat hibernates in abandoned mines, but larger numbers were observed in natural caves with the largest known population wintering in Jewel Cave. As with *M. lucifugus*, this species seems to have an affinity for hibernacula with higher humidity. It is often found with droplets of condensation covering the entire body while hanging from a wall or ceiling. The largest concentration in Jewel Cave was in the Dungeon Room where relative humidity is typically greater than 90 percent.

As noted under *M. lucifugus*, another natural cave [T3S R2E Sec 3], 15 km north of Jewel Cave, also serves as a hibernation site to a large number of *Myotis.* Approximately 300 individuals were recorded during winter surveys at this site, the largest proportion being *M. volans* and *M. lucifugus*.

While two studies suggested *M. volans* to be the most common bat in the Black Hills (Turner 1974, Mattson and Bogan 1993), there is little information on its reproductive habits. In the southern Black Hills, adult males have been found to roost solitarily during the summer in rock crevices in the southern Black Hills (Cryan and Bogan 1996). They are segregated from females, which congregate in maternity roosts. Only two maternity and nursery roosts have been identified for this species in the Black Hills.

The first roost was located in the attic of an H-shaped two-story brick building near Sturgis, SD. The roost identified on 7/6/94 was comprised of approximately 75 individuals, including non-volant pups. The pups were in one cluster of approximately 30 individuals, which included adults, near the apex of the roof against a brick wall. The remaining bats roosted in smaller clusters or individually throughout the same wing of the building. Two volant juvenile males, one volant juvenile female, and three lactating females were captured by hand for cursory examination. All juveniles flew without apparent difficulty when released.

It is thought most maternity roosts are probably located in tree cavities (van Zyll de Jong 1985). Using radio telemetry, one lactating female was located, in the southern Black Hills, roosting beneath the bark of a large snag, dbh 66 cm, with at least six other bats (Cryan and Bogan 1996). These bats were observed emerging, but species of the others was not confirmed.

M. volans was successfully captured at night roosts in both mist nets and harp traps. Excluding the volant juveniles mentioned above, the earliest capture of a volant juvenile was on 7/31/92 when 2 male juveniles were netted entering a natural cave [T3N R6E Sec 32] serving as a night roost. Of the 13 juvenile captures between 1992 and 1995, 11 were at night roosts in natural caves with the remaining 2 netted while foraging at Lower Woodcock Spring on 8/24/94. Turner (1974) reported a juvenile capture on 9/7/67 at Roby Springs, SD.

One juvenile netted at a cave [T4N R5E Sec 16] was banded on 8/18/92 and was recaptured at the same site on 9/16/92. Only two other recaptures were recorded during this study. Both occurred at the same cave [T3N R6E Sec 32] on 9/30/93. The first recapture was an adult male originally banded at this site on 9/2/92, and the second, an adult male, was banded at the site earlier in the season on 9/2/93.

Additional information is needed on maternity and nursery roost requirements for this species. Absence of reproductive females from many summer foraging areas throughout the Black Hills suggests the possible occurrence of important roosting sites or areas with certain characteristics (Cryan and Bogan 1996). Such concentrations may also make this species more susceptible to habitat changes. Identification of specific habitat requirements is necessary for development of effective conservation strategies.

Corynorhinus townsendii pallescens[1] (Townsend's Big-eared Bat)

C. townsendii is a medium-sized bat with an average forearm length of 44.31 mm and an average weight of 11.59 gm. Pelage color varies but is generally buff with paler dorsal fur. When awake, this bat is easily identified by its very long rabbit-like ears and characteristic bulbous nose lumps. However, when roosting, especially in torpor and during hibernation, the ears may be much less visible. It folds its long ears back leaving only the pointed tragus erect. The erect tragus gives the appearance of *Myotis*-like ear tips resulting in frequent misidentification by the untrained observer. Record for longevity for this species is greater than 21 years (Perkins 1994).

Observed evening emergence time varied but generally occurs at lower light levels, approximately 30 minutes after sunset. It was commonly observed exhibiting "light sampling behavior"[2] prior to evening emergence from caves and mines. Such behavior is likely designed to insure light levels are low enough to minimize risks of predation by diurnal birds of prey (Erkert 1982).

Diet studies found *C. townsendii* to be a lepidopteran specialist whose diet is comprised almost exclusively of moths (Pierson et al.1999). It is known to forage within a wide variety of habitat types (Pierson et al.1999) and has been observed foraging within the canopy at wooded edges within the Black Hills.

This species was observed repeatedly returning to a feeding perch to feed on captured prey. Two such examples were documented in the Black Hills. The first was within a sheltered entry porch of an abandoned cabin and was used simultaneously by at least two individuals. The quantity of insect wings at this site indicated repeated use. The moth wing pile was 3 cm at its greatest depth. The second location was a cave serving as a night roost. Both sites were characterized predominantly by accumulation of moth wings and fecal droppings immediately beneath the perch.

C. townsendii is the most frequently encountered underground species within the Black Hills. To some extent, this is attributable to the species' propensity to roost on the surface of the rock and often in the twilight areas between daylight and darkness. Such roosting behavior allows for easy discovery compared with species that roost in crevices or darker areas. Such roosting selection also renders this species particularly susceptible to casual human disturbance. *C. townsendii* is the only Black Hills' bat dependent year-round upon underground roosting sites. Nearly all records of this species in the Black Hills are from natural caves or abandoned mines.

C. townsendii demonstrates a high degree of roost fidelity (Humphrey and Kunz 1976). This was observed in the Black Hills as this species accounted for more than half of the recaptures of

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[1] formerly *Plecotus townsendii pallescens;* see Frost and Timm 1992 and Tumlison and Douglas 1992 for a discussion of systematics.

[2]term coined by Twente (1955) for intermittently repeated return flights of short duration from roosting location within the cave/mine to the outside access point.

individuals banded between 1992 and 1995. Most were recaptured at the original banding site. *C. townsendii* is also considered sedentary and not known to migrate great distances between seasonal roosts (Kunz and Martin 1982). Some males were found to inhabit the same roost on a year-round basis.

In the Black Hills, males tend to roost individually during the summer months although small groups of three have been identified. One of the more common roosting sites for individual males is within short adits, 2 to 3 m in length, which are numerous throughout the region.

During seasonal surveys (four per year), two banded adult males were monitored at two separate abandoned mine adits. The first of these bats was monitored for three consecutive years and was absent during two fall surveys. The second was a year-round resident for two years and absent from one fall survey. Location within the mine is generally in the same vicinity during each survey. Individual males were observed within the same hibernaculum often at the same location during consecutive winters.

C. townsendii generally occurs in smaller numbers at night roosts. The largest number captured during an evening's trapping was five individuals. The site of these captures is also a large hibernaculum during the winter months. Netting surveys are likely to under-represent this species owing to its ability to avoid obstacles. *C. townsendii* also echolocates very softly and can be difficult to detect in the field on ultrasonic echolocation detectors.

While *C. townsendii* was successfully captured at night roosts with both mist nets and harp traps, the former were generally a more effective capture tool. When approaching a night roost staged with a harp trap, this species was observed turning back and departing resulting in no captures for the evening. Most individuals captured in the harp trap were males either entering at a high rate of speed or attempting to exit following day roosting at the site. Mist netting in open areas such as over water sources and meadows adjacent to forested areas rarely results in captures of this species. Most captures are achieved at restricted roost access points.

Females form maternity and nursery roosts and give birth to a single pup (Pearson et al. 1952). Roost fidelity to nursery roosts is high (Pearson et al. 1952). Only three confirmed maternity and nursery roosts were identified in the Black Hills. During the summer of 1993, two were located in natural caves in the northern Black Hills with the largest comprised of approximately 110 individuals, including juveniles. The other roost contained approximately 30 to 35 individuals during 1993 and 1994.

In circumstances unusual for this species, a nursery roost comprised of approximately 30 individuals was reported in an abandoned building south of Hot Springs, SD near Cascade Creek in July 1996 (Cryan 1997). Subsequent surveys yielded only isolated individuals using this location as a day roost with some evidence of night roosting (Luce 1998). High levels of disturbance associated with road construction in the immediate vicinity may have contributed to its abandonment as a maternity and nursery roost (Cryan 1997). Additionally, during the summer of 1998, a feral cat was observed entering the area of the building previously used by the bats (Tigner unpublished data).

Mattson (1994) cites reference to a shelter cave within Wind Cave National Park containing 50 females in 1991 and 75 females in 1992. This roost was not used during 1993 possibly due to cooler weather conditions (Mattson 1994). Additionally, a small natural cave on private land east of Custer State Park reportedly contained approximately 40 individuals one day in early August of 1994 (Travis Vickers personal communication). This site was also a small shelter cave that gave no evidence of long-term use.

One maternity roost was identified in an abandoned mine near Rochford, SD during the summer of 2002. Approximate size of this roost was 20 adults. This site also serves as a hibernaculum for the species. This is the first abandoned mine documented to serve as a maternity roost in the Black Hills.

Known maternity and nursery roosts in the region are characterized by spacious interiors with inaccessible domes or wide expanse ceilings. Both characteristics have been noted in nursery roost selection in other areas (Pierson et al.1999). These sites have fewer signs of disturbance than typically seen at caves in the region due probably to more remote location and difficulty of access. Access points for both roosts are large openings in vertical rock faces that overlook steep perennial drainages.

Extensive cave and mine surveys in the southern Black Hills failed to locate maternity and nursery roosts (Mattson and Bogan 1993). Unknown roosting locations, coupled with the absence of females from netting surveys, have been termed the greatest mystery of bats in the southern Hills (Cryan and Bogan 1996). Given this species' sedentary lifestyle and the existence of one of the largest hibernating populations in the western United States at Jewel Cave National Monument, maternity roost location remains one of the most important questions to be answered.

Parturition dates for *C. townsendii* vary substantially in the Black Hills. Weather conditions can have a detrimental effect on breeding success (Grindal et al. 1992). The first nursery roost was identified on 6/6/92 and was comprised of 75 individuals, including juveniles. At this time, juveniles were capable of flight, which would place parturition in early to mid-May (van Zyll de Jong 1985, Pearson et al. 1952). The preceding winter was comparatively mild for the Black Hills with prolonged warm spells. These milder climatic conditions likely contributed to the early parturition date.

In contrast, the spring and summer of 1993 were unusually cool and wet. Surveys of the same site yielded very different results. To minimize the disturbance associated with roost entry, the cave's access was monitored using a night vision scope (6/20/93). Approximately 10 individuals were counted emerging. A physical survey of the site was conducted (8/20/93) when approximately 110 individuals, including juveniles, were identified. There was a wide range of juvenile ages, the majority of which were non-volant. At least five with minimal furring were seen clinging to their mothers placing them at less than one week in age and moving the parturition date into August (Pearson et al. 1952). Unfavorable climatic conditions probably contributed to the delayed parturition. Survival of the first winter for young is estimated to be approximately 50 percent (Pearson et al. 1952). Such a late parturition date within the Black Hills almost certainly resulted in much higher, if not complete, mortality for the pups born in 1993.

The second maternity roost, found on 6/3/93, contained approximately 35 adults. The site was still in use on 7/7/93 and nearly the same size. There were no apparent juveniles, and all present were in torpor. The roost was abandoned by early August of 1993. Netting at the site on 9/3/93 yielded the capture of 11 adults, 1 male and 10 females. Seven of the females were parous though not lactating and three were non-reproductive. No juveniles were netted.

As further evidence of a poor reproductive season, no juvenile *C. townsendii* were captured in the Black Hills during summer 1993.

There were substantial increases in disturbance during the maternity season of 1994 at both sites. The larger of these two roosts was monitored (without entry) on 6/18/94 when approximately 15 individuals were observed exiting. At least two separate groups of people visited this site during July 1994. Vehicles and climbing equipment (required for access) were observed at the site on both occasions. An internal survey of the site conducted on 8/20/94 found no bats or evidence of use.

The second site was surveyed on 7/22/94. As no *C. townsendii* were observed within the cave, it was netted that same evening. In addition to other species, 27 *C. townsendii* were netted, the majority within a 30-minute period approximately one-half hour after sunset. Early captures were banded. This group consisted of seven lactating females, one probable pregnant female, six non-reproductive adult females, and one adult male. The balance were females, which were released upon extraction from the net to minimize further stress. The nets were closed to avoid stressing pregnant females. The early arrival of these bats *en masse* suggests another unknown roosting site in the area. To date this location has not been found. A daytime survey was conducted one week later when approximately 30 individuals were seen in a cluster. Upon observing the cluster, we immediately withdrew to minimize disturbance.

A survey of the site (8/20/94) found evidence of human activities. A large campfire was constructed within the cave's interior resulting in heavy deposition of soot on the upper portion. Three dead non-volant juvenile *C. townsendii* were on the floor of the cave. No adults were found. Such episodes highlight the need to protect important sites by restricting access during sensitive times of the year, as well as increasing public education.

In addition to this site's importance as a maternity roost, it also serves as the largest hibernaculum for this species in the northern Black Hills. During the first winter survey (1/27/94), there were 35 individuals. A survey conducted on 2/22/95 followed a week of unseasonably warm temperatures, and only seven individuals were identified. A survey conducted on 2/22/96 found 37 individuals (Oscar Martinez personal communication). In addition to its importance for *C. townsendii,* this site serves as the largest hibernaculum for *E. fuscus.* High levels of disturbance have continued at this site. As a result, this site has been lost as significant bat habitat.

Hibernacula are generally cooler and drier than for most *Myotis* species and include both mines and caves. *C. townsendii* seems to prefer hibernacula with a temperature below 10ºC (Pierson et al.1999). Lone individuals were identified hibernating throughout an entire winter in mine adits as shallow as 3 m in length. Such sites had recorded temperatures below 0ºC.

One of the largest hibernating populations in the western United States is at Jewel Cave National Monument (Choate and Anderson 1997). Recent surveys found approximately 800 to 900 individuals (Choate and Anderson 1997). Hibernation surveys at this site identified this bat roosting individually and within clusters comprised of up to 90 to 100 individuals (Worthington 1992). Arrival generally begins in early October, with peak numbers being observed in late December (Mattson and Giannuzzi 1994). Depending upon weather conditions, departure generally occurs during April (Mattson and Giannuzzi 1994).

Similar patterns of arrival and dispersal are known at other hibernacula within the Black Hills. To prevent disturbance, access to hibernation areas within Jewel Cave is restricted during this period (Kate Cannon personal communication). Though varying methods of census were employed during winter, numbers at this site are not thought to be decreasing (Choate and Anderson 1997). More systematic surveys were used in recent counts. If continued, such surveys should serve to improve census accuracy and permit trend assessments (C. Giannuzzi and T.A. Mattson personal communication).

The only evidence of use by *C. townsendii* during the summer months in Jewel Cave is night roosting by adult males (Choate and Anderson 1997, Mattson and Bogan 1993). A male banded on 7/25/93 by Mattson was observed hibernating within Jewel Cave during two surveys conducted during the winter of 1993-94 (Tigner personal observation, C. Giannuzzi personal communication).

No other bats banded between 1992 and 1995 were observed wintering in Jewel Cave. It should be noted, however, that clustering commonly observed in *C. townsendii* and some *Myotis* species could easily mask the presence of a band. Given the lack of information on dispersal of this population, the possibility of migration to the site by bats from northern portions of the Black Hills cannot be eliminated. Should future research uncover a migration, the viewpoint of *C. townsendii* as a sedentary species might require reevaluation.

The second largest hibernating population was located in a natural cave 14 km north of Jewel Cave National Monument. This cave contained 300 hibernating individuals during the winter of 1994-95. Though located in close proximity to Jewel Cave, no evidence of common roosting was observed. Those *C. townsendii* banded at the site during summer also were observed hibernating here.

In recognition of this site's importance, it has recently been placed within a no treatment buffer zone by the United States Forest Service to minimize potential disturbance to the roost. A gate was installed to protect this site from disturbance during the winter. No historical data on population size for this site were located.

Supporting evidence of this species' sedentary lifestyle, most recaptures of banded individuals were recovered at the original banding site. All hibernacula with banded bats whose band could not be read served as night roosts where banding occurred previously.

Five exceptions to same location band recovery were recorded. The first of these was an adult male originally banded on 8/27/92 while entering a natural cave night roost [T4N R5E Sec 12]. It was observed hibernating in another cave [T4N R5E Sec 16] on 2/16/94. The distance between these two sites is approximately 5.5 km. During the same survey on 2/16/94, a banded adult female was found hibernating. She was banded on 8/20/93 at a natural cave serving as a nursery roost. The distance between these two locations is 4 km.

While surveying a privately owned cave on 1/12/94, a banded female was identified. Though the band number could not be read, this cave is approximately 1 km from the cave serving as a nursery roost for this species. Given the close proximity of these two sites, it is likely this female was banded at the nursery roost on 8/20/93.

Finally, on 9/13/94 an adult female was captured and banded at a natural cave [T5N R5E Sec 28] being used as a night roost. She was observed hibernating in a mine adit [T3N R5E Sec 18] on 2/1/95. The distance between these two sites is 17.5 km (11 miles) and is the longest distance for a band recovery for any bat species within the Black Hills.

A survey of an abandoned mine known to serve as a *Corynorhinus* hibernaculum on 1/8/03 yielded identification of a banded male *C. townsendii*. Closest banding site to this location for a male of this species was at a mine approximately 3.5 miles away (5.5 km). Band number could not be read owing to the height of the bat within the mine.

Site Type	Original Band Date (Age at Banding)	Recapture Date(s) (Age at Recap)	Time Length
Night Roost/Hibernacula (Cave)	6/3/93 (A)	1/27/94 (A)	7 months
Night Roost/Hibernacula (Cave)	9/16/92 (J)	4/8/93 (A) 11/24/97 12/01/99	7 months 5 years 7 years
Night Roost/Hibernacula (Mine)	6/15/93 (A)	10/25/93 (A) 12/21/93 3/7/94 12/1/94	4 months 6 months 9 months 1 year 6 months
Night Roost/Hibernacula (Cave)	4/29/93(A)	12/29/93 (A) 2/23/94	8 months 10 months
Night Roost (Cave)	6/3/93 (A)	9/3/93 (A)	3 months
Night Roost/Hibernacula (Cave)	6/3/93 (A)	1/27/94 (A)	7 months
Night Roost (Cave)	7/31/92 (J)	5/20/94 (A)	1 year 10 months
Night Roost (Cave)	6/3/93 (A)	7/22/94 (A)	1 year 1 month
Night Roost (Cave)	5/10/94 (A)	5/26/95 (A)	1 year
Night Roost (Cave)	9/20/92 (J)	7/9/93 (A)	10 months
Night Roost/Hibernacula (Cave)	6/3/93 (A)	12/28/99 (A)	7 years
Night Roost/Hibernacula (Cave)	8/18/92 (J)	4/8/93 (A)	8 months

***Corynorhinus townsendii*- NIGHT ROOST / HIBERNACULA - SAME SITE BAND RECAPTURES**

Site Type (Orig. Banding / Recap.)	Original Band Date (Age at Banding)	Recapture Date[s] (Age at Recap)	Time Length/Distance Between Captures
Cave / Cave	8/20/93 (A)	2/16/94 (A)	6 months / 4 km
Cave / Cave	8/27/92 (J)	2/16/94 (A)	1 year 6 mo. / 5.5 km
Cave / Mine	9/13/94 (A)	2/16/95 (A)	4 months / 17.5 km
Cave / Cave	8/20/93*	1/12/94	5 months / 1 km
Mine / Mine	6/15/93*	1/8/03	8.5 years / 5.5 km

***Corynorhinus townsendii*- DIFFERENT SITE BAND RECAPTURES**

*****Probable; closest banding site for the species to the recapture location (no banding was conducted at the recap site)

Given our present knowledge about the species known to inhabit the Black Hills, *C. townsendii* is likely to be at greatest risk of significant population declines. This assessment is based upon *C. townsendii's* comparatively narrow range of acceptable roost requirements and its susceptibility to disturbance (Humphrey and Kunz 1976). Increasing disturbance levels at natural roosting sites coupled with closure of abandoned mines will, in the future, limit roost availability. Identification and protection of important roosting sites are important considerations.

C. townsendii accepts bat gates at hibernacula and at night roosts. While no maternity or nursery roosts have been gated in the Black Hills, gated, abandoned mines in Colorado and Wyoming are used by this species (K. Navo and B. Luce personal communications). Protection of important sites is presently considered the best management practice for this species.

A comprehensive conservation strategy has been completed for this species including an exhaustive review of the published literature (Pierson et al.1999).

Eptesicus fuscus (Big Brown Bat)

E. fuscus is a medium to large species with an average forearm length of 45.72 mm and an average weight of 17.54 gm. Pelage color varies substantially within the Black Hills but most frequently is a medium to dark brown. The fur is long with ears and membranes ranging from dark brown to black in color. Head and snout are broader than in *Myotis* species from which it can also be distinguished by its greater size.

It is the most common bat found roosting in buildings and is one of the more successful species within the Black Hills. Roost records include buildings, trees, railway tunnels, mines, caves, and at least one metal electrical fuse box. *E. fuscus* is found in a variety of hibernacula with varying microclimates. The variety of conditions is likely a result of its larger size and increased capacity for stored fat reserves (Kurta and Baker 1990).

E. fuscus was found hibernating in caves and mines and is the only species in the Black Hills known to hibernate in buildings. In colder locations, it is frequently found in crevices though it was observed roosting on rock surfaces. High relative humidity within hibernacula is not a requirement. Hibernation areas tend to be at spacious sites that do not require acrobatic flight through small passageways. Most of those hibernating at Jewel Cave were located in areas close to the historic entrance. Bat gates constructed to prevent unauthorized access into roosts did not deter this species. Monitoring at the two sites presently gated has shown they continue to use both sites as night roosts and hibernacula.

The largest known hibernaculum is a cave [T6N R4 Sec 6] in the northern Black Hills that contained approximately 100 individuals (1993-94 and 1994-95). Accurate counts are difficult due to the height and clustering in crevices, which is common at this site. It is also the largest hibernaculum in the northern Hills for *Corynorhinus*.

E. fuscus moves out of hibernacula earlier than *Myotis* species in the Black Hills. It is common for many to leave by the middle of March. Whether such hibernating groups are females, males, or a mixture of both is not known. It is likely the large body size allows for a wider range of acceptable roosting conditions during the early spring. As such, roosts considered marginal for hibernation may become acceptable with the approach of warmer weather.

Martin and Hawks (1972) suggested the possibility of female migration out of the Black Hills during winter. Subsequent hibernacula surveys identified four banded females at three separate caves, all located in the northern Black Hills. Band identification was not possible with three of these bats, because of height or clustering. All three of these sites were summer banding sites for females. The fourth banded female identified during hibernation was found on 2/23/94 and had been banded as an adult at the same location on 9/30/93. Turner (1974) also cites a record of a hibernating female being collected from a mine adit on 3/4/46 near Hill City, SD.

In addition to those banding recaptures previously mentioned, four other recaptures were recorded. All were recaptured at the original banding site. The first recapture was an adult male banded originally at a natural cave night roost [T3N R6E Sec 32] on 7/31/92. It was recaptured while night roosting at the same location on 8/12/93. The second recapture also occurred at this location. An adult male was banded on 9/2/92 and recaptured within the hour exactly one year later on 9/2/93.

The remaining two recaptures both occurred at Red Bat Pond in the northern Black Hills. The first was a pregnant female originally banded on 5/27/94 weighing 16.5 gm. She was recaptured at the same site on 8/12/94 post-lactating, weighing 25.0 gm. Increase in weight likely represents recent foraging activity. Griffin (1958) cites a record of this species ingesting 4.0 gm of insect prey in 90 minutes of foraging. The second recapture at this location was an adult male originally banded at this site on 8/12/94 weighing 23.0 gm and recaptured on 6/23/95, weighing 16.5 gm.

Considered an opportunistic forager, this species is found routinely throughout a variety of habitat types and demonstrates flexibility in roost selection and foraging behavior (Brigham 1991, Kurta and Baker 1990). Powerful jaws allow it to feed on large hard-shelled beetles though other smaller prey is also taken (Kurta and Baker 1990). Black (1974), analyzing dietary habits of this species, considered it a beetle specialist.

Of 158 adults examined between 1992 and 1995, 33 individuals (21 percent), 15 males and 18 females, displayed noticeable wear to the canines ranging from a slight noticeable rounding of canine tips to near complete wear (Tigner unpublished data). While nutritional deficiencies may contribute to this condition, it is likely to be related to selection of hard-shelled insect prey.

Though a strong, fast flying bat, it lacks the acrobatic and evasive abilities of smaller *Myotis* species. Grounded individuals are often unable to resume flight without climbing to an elevated launching position. Emerging from maternity roosts, this species frequently dives 1 to 2 meters before achieving flight. This species will often bounce off mist nets erected over surface water, lose momentum, and land in the water. It is a capable swimmer and can be difficult to catch in deeper water.

Maternity and nursery roosts in buildings are frequently discovered by human occupants by vocalizations and movement during periods of warm weather. In addition, this bat's larger size, hence, easier visibility at emergence, helped to identify roosts. In the Black Hills, all known maternity roosts are located in buildings. However, maternity roosts are also known to occur in snags (Brigham 1991). Though not located, evidence suggests a maternity roost occurred near Red Bat Pond in the northern Black Hills during the summers of 1994 and 1995. Very early arrival of large numbers of pregnant and lactating females coupled with the absence of structures in the immediate vicinity suggest a tree roosting colony.

Large maternity roosts of several hundred are not uncommon in the Black Hills. The largest maternity roost, comprised of 300 adults, was around a chimney in the attic of a two-story brick building near Sturgis, SD. Similar buildings located near this site also contained large numbers. Fluctuations in numbers at specific locations suggest these roosts share individual members.

Shared locations were confirmed when a small roost of 30 females was captured, banded, and relocated to an adjacent building prior to installation of a sprinkler system. Banded females were then observed in three other roosts during subsequent surveys. A conservative estimate in the vicinity of these buildings was 1000 individuals.

Variation in parturition dates in the Black Hills was observed within and between seasons. One nursery roost, located at the South Dakota School of Mines and Technology at Rapid City in a building scheduled for demolition, contained 28 individuals (7/14/94). The group was comprised of 18 adult females, 14 lactating, 2 pregnant, 1 non-reproductive, 1 unrecorded reproductive condition, and 10 juveniles, 4 male and 6 female, all volant. Volancy begins between 18 and 35 days of age (Kurta and Baker 1990). The group was held in a single holding cage in a cool environment for two days, which induced torpor, banded and released at the original location following the building's demolition.

As this bat frequently selects buildings for roosting sites, it is likely to benefit from an appreciation of bats and their habitat requirements. Of particular importance is the development of a public education program including the proper methods of excluding roosts from buildings. Complaints of noise, large dropping deposits, and odor associated with urine accumulation are the most frequent reasons individuals seek help to exclude this bat.

Lasionycteris noctivagans (Silver-haired Bat)

The silver-haired bat is a medium sized bat with an average forearm length of 41.30 mm and an average weight of 12.31 gm. Pelage is dark, usually black, with silver-tipped hairs scattered throughout. Fur continues onto the uropatagium. Ears are rounded with a blunt, rounded tragus and ears and wing membranes are black in color. *L. noctivagans* is substantially smaller than *L. cinereus*, which also presents a frosted appearance.

L. noctivagans is considered a seasonal migrant arriving in spring and migrating south to warmer climates in the fall. In the Black Hills, the earliest record for a capture is on 5/5/94 when three adult females were netted at Roby Spring (Mattson 1994). Farther north, three individuals were observed foraging over Apex Pond on 5/11/94. Latest record in the season for this species was 9/16/94 for a pair foraging over beaver dam ponds on East Creek in Wyoming.

All captures of *L. noctivagans* occurred over water sources. Most were caught during July, though it was commonly netted as late as September in the southern Black Hills. This is substantially later than the region's other common seasonal migrant, *L. cinereus*, which is generally a rare capture by the end of August.

Two records of possible migrants were recorded at Ellsworth Air Force Base, 20 km east of the Black Hills. The first capture on 9/5/92 was a nulliparous adult female day roosting in the fork of a tree only 1 m from the ground. The second record (8/31/93) was a parous female captured while day roosting in a crevice on tree bark 1.5 m from the ground.

Evidence of the migratory habits was confirmed with the recapture of an adult male, in Denver, CO in October 1997, which was banded 7/29/94 at a woodland pond near Whitewood, SD (P. Murphy personal communication). The distance between the banding site and the recovery location is approximately 523 km. This distance is one of the longest documented for this species.

Turner (1974) cites a record of a *L. noctivagans* being collected from a cave on 11/19/67 near Rapid City, SD, apparently in hibernation, and surmises that some individuals may winter in the Black Hills.

Support for this was found during hibernacula surveys in a natural cave immediately adjacent to French Creek in Custer State Park. A survey conducted on 1/25/02 identified a single individual of this species in a vertical crevice. A follow-up survey was conducted on 3/6/02 and found a single specimen hibernating in a different nearby location, the first roost location being abandoned. The following winter, 2002-03, the site was again surveyed. Two individuals roosting separately were identified on 12/18/02. Based upon diminishing fall capture rates coupled with increasing spring captures, it is likely that the majority of this population relies upon migration. These recent records appear to document a segment of the population remaining in the Hills throughout the winter months.

L. noctivagans is a slow flier commonly seen drinking over woodland ponds early in the evening, often prior to sunset, during periods of warm weather. In the Black Hills, roost emergence for foraging usually occurs approximately 30 minutes after sunset. Considered an opportunistic feeder, the diet is comprised of a variety of insects across its North American range (Kunz 1982, Whitaker et al. 1981*b*).

While all species of bats in the region will roost in trees, *L. noctivagans* is one of the three species of the Black Hills that roost almost exclusively in trees. Virtually all information collected on roosting preferences comes from work conducted in the southern Black Hills by Mattson (1994) using radio telemetry.

Males were found to roost solitarily beneath loose bark or within cracks or crevices on the boles of trees. They were also observed changing roost trees frequently, usually daily, and roosting at varying heights on the bole. Twenty percent roosted less than 2 m from the ground.

Females give birth to one or two pups with twins being more common (Kunz 1982). Ten maternity and nursery roosts were identified, all in Ponderosa pine snag cavities. Average height of maternity roosts was approximately 10 meters. The number of bats roosting at these sites ranged from 6 to 55 individuals.

Three of the maternity and nursery roosts identified in 1994 were monitored intermittently during the summer of 1995 with no evidence of reuse (Tigner unpublished data). The low number of observations coupled with the frequent relocation of this species does not warrant any conclusions regarding seasonal roost fidelity. Mattson (1994) found maternity roost inhabitance averaged eight days.

Though never located, a maternity and nursery roost was presumed to exist in the vicinity of the Keystone, SD sewage lagoons. On 7/14/93, shortly after sunset, approximately 11 individuals were foraging and drinking over a large pond adjacent to the lagoons. A lactating female from this group was netted.

Earliest capture of a volant juvenile was recorded on 7/11/94 near Hazelrodt Picnic Ground near Custer, SD. Thought to be newly volant, juveniles were observed flying around a snag serving as a nursery roost on 7/8/94 (Mattson 1994, Mattson 1995). Volancy in this species begins at 21 to 28 days (van Zyll de Jong 1985). This species has demonstrated considerable variability in parturition as a pregnant female was also netted earlier on 7/7/94 at Hazelrodt Picnic Ground. Post-lactating females were netted 8/12/94 and 9/6/94.

One lactating female was netted while foraging over water at Ranch A in Wyoming on 7/25/95. Priday and Luce (1995) report capturing two individuals on 6/20/94 over a stream northwest of Sundance, WY.

Mattson (1995) observed owl predation on a probable juvenile taken while resting on the bole of the roost tree. The predator was thought to be an eastern screech owl (*Otus asio*) or a northern saw-whet owl (*Aegolius acadicus*).

A difference in distribution was noted for *L. noctivagans* following comparisons between summers of 1993 and 1994 (Tigner and Aney 1994). Weather conditions between the two years were distinctly different with lower temperatures and greater rainfall characterizing the summer of 1993. Survey work conducted in 1993 in the northern Hills resulted in capture of only two individuals with six additional records based upon sightings and echolocation monitoring via ultrasonic detector. Mattson (1994), surveying in the southern Hills during the summer of 1993, frequently found this species to be the most common bat netted with 108 total captures including adult females and juveniles.

Based upon routine captures and frequent sightings of this bat in the northern Black Hills during the summers of 1994 and 1995, it is possible that unfavorable weather conditions limited the northward range of this bat during the summer of 1993.

Until recently, little was known about the natural history of this species. Difficulties in locating roosting sites have largely been overcome by the application of improved radio telemetry equipment and techniques. While definitive conclusions regarding this species' habitat requirements would be premature, several common factors have been identified.

Maternity roosts for *L. noctivagans* are located in snags, frequently old woodpecker cavities (Mattson 1994, Vonhof 1996). The snags tend to be large, with dbh 38-62 cm (Betts 1996, Mattson 1994, Vonhof 1996), which likely provides a relatively stable roost microclimate. They also typically have an unobstructed southern exposure that probably elevates roost temperatures (Betts 1996, Mattson 1994, Vonhof 1996). Communally roosting Vespertilionids typically select such warmer maternity and nursery roosts, as increased temperatures serve to shorten gestation length and promote rapid development of juveniles (Racey 1982). The selection of roost sites by bats is likely the most important factor determining juvenile survival (Tuttle and Stevenson 1982). Another common finding has been the frequent relocation of the roost generally within a localized area (Betts 1996, Mattson 1994, Vonhof 1996).

L. noctivagans is likely to be susceptible to changes in forested habitats. Reductions in snag numbers result in fewer roosting sites for this species. As such, forest management practices (e.g. timber management and firewood collection) need to maintain the availability of larger snags over time and in numbers necessary for sustaining this species.

Summer monitoring is important to assess *L. noctivagans* trends. As a seasonal migrant, summer surveys represent the only means of monitoring this bat. While additional information needs to be collected on specific habitat requirements, the role of snag management will undoubtedly serve as the basis for success of this species in the region.

Lasiurus borealis (Eastern Red Bat)

L. borealis is a medium sized bat with an average forearm length of 39.7 mm and an average weight of 12.5 gm (van Zyll de Jong 1985). It is one of the more colorful bats with reddish-orange pelage and long, pointed wings. Ears are short and rounded. The furring on this bat is long and dense and extends down onto the uropatagium (van Zyll de Jong 1985). It is easily distinguished from all other species found within the region by its coloration.

The Eastern Red Bat is the least common bat known in the Black Hills. They are fast fliers and forage in straight lines or large circular patterns feeding primarily on large moths and beetles (Shump and Shump 1982). In general, this is a solitary roosting species, though small family groups of 4 to 5 bats are not uncommon during the summer months (Shump and Shump 1982). In contrast to its solitary lifestyle, there is evidence of group migration (Shump and Shump 1982). It is thought to be a seasonal migrant arriving during the spring or summer and departing before cold weather arrives.

Considered a tree bat, this species roosts in the foliage of deciduous and coniferous trees, but generally does not rely upon cavities for protection (Barbour and Davis 1969). Multiple births of two to four pups are common and characteristic (Kunz 1982). It has been suggested the increased litter size may be in response to increased risks of predation owing to its characteristic exposed roosting posture within the branches of trees (van Zyll de Jong 1985). Common predators include blue jays (*Cyanocitta cristata*) and various raptors (Barbour and Davis 1969).

L. borealis was captured in five Black Hills locations. There are no records from the Hills in WY (Bob Luce personal communication). Based upon an earlier capture of a volant juvenile (7/29/68) and later, a lactating female, on 8/20/68, Turner (1974) surmised there were at least two families of *L. borealis* in the vicinity of Moon Campground that year. An adult male was captured at this same site on 8/8/93 (Mattson 1994). The westernmost record was an individual netted at Wildcat Peak on 8/1/93 (Mattson 1994). The third location was in the northern Black Hills near Whitewood, SD over Red Bat Pond where a non-reproductive adult female was netted on 8/12/94. She displayed slight wear of the canines.

Three individuals were captured during the summer of 1998. The first location, Alkali Creek near Sturgis, SD yielded the capture of a juvenile female (8/19/98). Two other individuals were netted at an ephemeral woodland pond (T3N R6E Sec. 32) on 8/23/98. The first of these was an adult male captured simultaneously with another that escaped the net (Tigner 1998).

Based upon the limited numbers of observations and its migratory characteristics, it is difficult to determine population characteristics within the region.

Lasiurus cinereus (Hoary Bat)

L. cinereus is the region's largest bat with an average forearm length of 52.69 mm and average weight of 27.6 gm (van Zyll de Jong 1985). It is also one of the more colorful bats with fur mixture of blacks and browns with frosted white on the tips. Ears are short and rounded with black trimming around the edges. Greater overall size distinguishes it from all other Black Hills species.

In flight, it is distinguishable by its large size, rapid speed, and forceful echolocating call which, when not foraging, is generally characterized by a slow emission of pulses at low frequency (18000 kHz). This species commonly hisses and emits a spitting sound when netted or disturbed while displaying a menacing, open-mouthed defensive posture. Such posturing is no bluff, and gloves should be worn and extra care taken if handling this species.

L. cinereus is a strong bat capable of flight from a level surface including from the surface of water. It is a fast flier that commonly feeds at treetop level above the forest canopy. The diet is comprised mainly of large moths with other insects being taken to a lesser extent (Black 1974, van Zyll de Jong 1985).

All captures in the Black Hills were over water sites with nearly all occurring well after dark, though it was observed flying high prior to sunset. Most captures begin in early June with capture rates and observations decreasing by the end of August, suggesting an early migration. Similar observations, made in Canada, noted mid-August as the beginning of migration (van Zyll de Jong 1985).

The earliest record is an adult male captured (5/27/94) at Red Bat Pond near Whitewood, SD. The latest seasonal record of capture is 8/31 (Turner 1974), though one specimen killed by a dog was turned into the veterinary office at Ellsworth Air Force Base, 13 km east of the Black Hills, on 10/14/94.

Westernmost records are from Ranch A in Wyoming. Two adult males were netted over a creek on 7/25/95. Priday and Luce (1995) reported capture of an individual over a stream northwest of Sundance, WY in the Black Hills National Forest on 6/20/94. Two other records occurred at Stots Springs in western South Dakota. An adult female was captured on 8/13/93 and an adult male on 7/27/94.

Findley and Jones (1964) described summer sexual segregation in portions of North America. In contrast, Black Hills surveys observed both sexes in the region (Mattson 1994, Turner 1974, Tigner unpublished data). Pregnant females, lactating females, and juveniles have all been captured in the Black Hills. Earliest capture of a volant juvenile was 7/18/94 (Mattson 1994), which suggests parturition before mid-June (van Zyll de Jong 1985).

Although considered migratory, one banded adult female was recaptured at the original banding site, Red Bat Pond, approximately one year after banding. Netted originally on 7/29/94, she was parous but not lactating and exhibited no signs of pregnancy. At recapture on 6/23/95, she was obviously pregnant. Tuttle (1995) cites an example from Wisconsin of a female returning to the same tree for three consecutive years to raise young.

Not considered a colonial bat, netting surveys generally yield low numbers of captures during an evening. There were exceptions to this low capture rate in the southern Black Hills. Four such examples were noted.

On 7/7/93, 9 adult individuals, 4 male and 5 female, were netted over the sewage lagoons at Jewel Cave National Monument (Mattson 1994). The second occurrence was on 6/29/94 at Log Trough Ponds when 8 adults, 7 male and 1 female, were captured (Mattson 1994). The third survey resulting in large numbers of captures was on 7/18/94 also at Log Trough Ponds when 6 individuals were netted. This group was comprised of 3 adult males, 2 juvenile males, and 1 juvenile female (Mattson 1994). Other individuals were noted flying in the immediate vicinity but were not captured (Tigner personal observation). The final survey was conducted on 7/7/95 in the bottom of a steep-walled, narrow canyon over two small pools near Lower Woodcock Spring. During this survey, 7 individuals, 3 males and 4 females, were captured. This group was comprised entirely of adults including 3 lactating females (Paul Cryan personal communication).

MANAGEMENT RECOMMENDATIONS

Low reproductive rates, susceptibility to variations in seasonal weather conditions, narrow habitat requirements, and susceptibility to disturbance combine to highlight the need for conservation strategies for bats in the Black Hills.

Roost Protection

Whether year-round residents or seasonal migrants, all bat species found within the Black Hills are affected by the availability of suitable roosting sites. It is this aspect of their biology that is considered the most important limiting factor for distribution (Humphrey 1975).

Eight of the 11 species discussed rely on underground roosting sites at some point during the year. Dependence upon sites that provide specific microclimate conditions is probably the greatest limiting factor for species in the region. As such, it is likely the future management of natural caves and abandoned mines will play a decisive role in conservation of bat species in the Black Hills. Such management frequently requires restricting access to sites that are deemed significant during sensitive times of the year to minimize disturbance.

Site significance is often based upon a judgment of existing conditions within an area (Pierson et al.1999). Sites that contain large collectives of individual species or high species diversity are two examples of sites that should be considered significant. Another example of a significant roost would be a maternity or nursery roost for a species such as *C. townsendii*, which is known to be particularly susceptible to disturbance (Pierson et al.1999).

Bat Gates

Controlling access to significant underground roosting sites is most often achieved via installation of a specially designed bat gate. Such gates are designed to allow passage of bats in flight while restricting unauthorized human entry. In addition to these two criteria, gate design and installation must also take a variety of other circumstances into account.

Restricting existing air movement at access points of underground sites can change internal microclimates, causing abandonment (Tuttle 1977). Successful gate designs generally allow channeling of air rather than blocking air movement. Designs proven successful to a species should be given first consideration. Alternative designs should be monitored for efficacy. As this is a relatively new form of management, recent information should be obtained on current design recommendations before proceeding with gate construction.

Timing of gate installation should be adapted to minimize disturbance to the target population. If the site being protected serves as a hibernaculum, gate construction should be completed prior to the arrival of bats in the fall. Optimal gate location within the site should also be considered. Gating small access points can facilitate predation on entering or emerging bats. Placing gates in larger openings allows bats more maneuverability in navigating restrictive openings.

For a more complete discussion of gates and effective designs, see Tuttle and Taylor (1994) and Pierson et al. (1999).

Caves

Historically, caves probably met the hibernal roosting requirements for year-round resident bats. From the perspective of bats that rely upon underground roost sites, not all caves are equivalent. Numerous factors contribute to determining whether a site will be used and for what purpose (Ransome 1990). As has been commonly found in other areas, only a small percentage of total sites may provide adequate habitat for resident bat species (Tuttle and Stevenson 1978).

For a variety of reasons, many of these locations may no longer be viable roost sites. Commercial development of natural caves can be incompatible with roosting bats. Higher levels of disturbance associated with frequent visitation during the warmer seasons can prevent bats from using sites as day roosts. In attempting to protect the unique physical features found in commercially developed sites, physical barriers that restrict entry may be erected. Non-commercial wild natural caves often are damaged if unprotected.

Solid door closures restrict ingress and can alter the microclimate by preventing natural air exchange (Tuttle 1977).

Equivalent levels of protection may be achieved by installation of bat friendly designs that allow bats access and permit natural airflow. Sites developed for commercial purposes are frequently larger than many of the wild caves and, as a result, may contain a variety of microclimates if natural conditions were permitted. Such wide-ranging conditions may provide habitat to a variety of species (Tuttle and Stevenson 1978).

Cooperative partnerships between private cave owners and public agencies could minimize the costs associated with converting access points and developing appropriate management plans. Encouraging such ventures could provide a cost effective method by which new and secure bat hibernacula could be developed.

Disturbance in wild caves has reduced the suitability and number of available roosting sites. With increasing outdoor recreation demands, such disturbance is likely to increase in the future. Recreational caving can often cause unacceptable disturbance to bat roosts, which is often unintentional but no less consequential in impact. Significant disturbance can result from many factors. Body heat and non-electric light sources increase ambient temperature; noise generated by moving or talking, and close examination of hibernating bats may prove deleterious. Such disturbance may go unnoticed due to a delay in the response time required for a bat to arouse from hibernation.

Increasing interest in recreational caving underscores the important role formal caving organizations can play in educating that segment of the population that adopts this activity as a pastime. Such caving organizations are often comprised of conservation minded individuals with an interest in protecting cave resources. Enlisting their participation in conservation strategies should be considered a priority of habitat managers.

Some people who enter caves, through either ignorance or malevolence, do not subscribe to any code of underground conservation. Examples of disturbance documented in underground sites in the Black Hills are numerous.

Some of the more disruptive and damaging activities inside caves and abandoned mines include discharging firearms and fireworks, spray-painting, campfire construction, and intentionally killing roosting bats and other wildlife. Fire building is particularly common and likely results in the greatest level of long-term disturbance. In addition to elevating interior temperatures, which are detrimental during hibernation, and accumulating smoke, deposition of soot on ceilings can eventually result in site abandonment.

Even those sites that require greater skill to enter may need restricted access to prevent multiple disturbances during sensitive times of the year. Such forms of disturbance are not limited to a particular season. Winter disturbance was documented with increasing frequency in many locations monitored since 1992.

The Black Hills contains a myriad of roads that allow access to much of the forest. This results in increased casual disturbance of roosts. Road closures may serve to reduce disturbance levels at roost sites by reducing the ease of accessibility.

Caves that are closed should be accompanied by signs explaining the reason for closure as well as times when the site is accessible for visitation. Increasing public awareness is key to developing effective bat protection strategies. Posting informational or prohibitory signs at roost locations that do not control access via gates is not recommended. Vandalism of such signs in remote locations is common. In addition, they may serve to increase the curiosity factor, which can result in increased levels of casual disturbance. Informational signs of this nature could be incorporated into more protected areas such as campgrounds and visitor centers.

One exception to this scenario would be posting educational signs at locations that are more difficult to access and would therefore have a lower visitation rate. For example, one such roost, requiring technical climbing to access, serves as a nursery roost for *C. townsendii*. Gating this location would be extremely difficult. Placement of a permanently affixed sign inside the site's access which describes its significance, times of year considered most sensitive, and appropriate responses should bats be observed, could serve to limit disturbance and increase awareness.

To date, six locations in the Black Hills, three natural caves and three abandoned mines have been gated to protect roosting bat populations. Gate design followed recommendations that met with success in other parts of the country. Site survey work was conducted for at least one year to determine how the location was used and by which species. The three sites were used by all[1] species documented from the site after gating.

Post-gating surveys found activity levels and patterns of use to be unchanged. (See TABLE 5.) One cave, which allows public access during the summer months but was gated to control access during winter hibernation, was used by juveniles and adults as a night roost. Recaptures of banded bats entering the site or observed during hibernation indicate the site continues to serve the same purposes.

An initial increase in number of bats hibernating within one of the gated mine was observed following installation. Unfortunately, the site was vandalized shortly after this observation and construction of campfires within the location resulted in roost abandonment for the duration of that winter. At this writing, this location has remained secure for five years. Winter surveys have shown overall numbers of bats to return to previous levels with the addition of a new species, *Myotis septentrionalis.* This species was not observed at this site during pre-gating winter surveys.

Of particular concern in the Black Hills is the protection of maternity nursery roosts for *C. townsendii,* as this is the only Black Hills species thought to characteristically form such roosts underground. While no maternity or nursery roosts have been gated to date within the Black Hills, similar gate designs proved acceptable to maternity and nursery roosts of *C. townsendii* in abandoned mines in Colorado and Wyoming (K. Navo and B. Luce personal communication). Protection of such sites should be given a high priority.

It should also be noted that access to hibernation sites at Jewel Cave National Monument requires bats to fly through or over a gate placed at the historic entrance. This gate was replaced with a more bat friendly design during the fall of 2000. With the exception of *M. evotis*, all other hypogeal species of the Black Hills have been documented utilizing this site (Mattson and Bogan 1993, Worthington and Bogan 1993).

[1]One exception to this was the capture of a single *M. evotis* at one of the locations prior to gate installation. Given the low capture rate for this species, coupled with its acrobatic flying ability, it is likely its absence from post-gating surveys (at this location) reflects a lower population density rather than a rejection of gating.

Abandoned Mines

The rate of abandoned mine closure has accelerated throughout the United States in recent years (Tuttle and Taylor 1994). Such closures have largely been in response to concerns of public safety and resulting liability (Tuttle and Taylor 1994). Public land management practices have historically not considered abandoned mines as wildlife habitat (Pierson and Brown 1992), but this viewpoint is changing as documentation of the importance of abandoned mines grows. As evidence of this recognition, the U.S. Bureau of Mines included bat gates in a recent publication describing mine closure guidelines (U.S. Dept. Interior 1994).

To date, closure of abandoned mines within the Black Hills has largely been restricted to private land or active claims on public land. Most of these closures have been conducted without any assessment of use as bat habitat. In addition to intentional closure of abandoned mines, many older sites are closing from natural degradation at entrances.

For North America north of Mexico, 29 species of hypogeal bats have been documented utilizing mines as roost sites (Kunz and Pierson 1994). In the Black Hills, seven bat species were found to roost in abandoned mines. The extent to which abandoned mines sustain bat populations in the Black Hills is unknown. Based upon observations in other regions, for those Black Hills' species that roost underground, closure of unsurveyed abandoned mines should be considered a substantial threat.

Abandoned mines are most commonly used as hibernacula and night roosts. It should also be noted that in other areas of the western United States, *C. townsendii* commonly use abandoned mines as maternity and nursery roosts (Pierson et al.1999).

In the Black Hills, most bat survey work has been limited to well known mines and safely accessible adits. Mines with vertical access entry or difficult interior passages have had minimal evaluation. Such sites are likely to have less human disturbance as well as natural predators. In other areas of the country, such characteristics have been associated with larger collectives of roosting bats (Tuttle and Taylor 1994).

The importance of abandoned mines as important bat habitat is well documented. One of the best examples occurred in 1992 when a mine in northern Michigan, slated for closure the following spring, was found to contain approximately one million hibernating bats (Tuttle and Taylor 1994). The site, Millie Hill Mine, Iron Mountain, MI, represents the second largest hibernaculum ever discovered in North America. This mine has since been protected by installation of a specially designed protective cage allowing bat access and preventing unauthorized human entry.

While the above scenario represents exceptional circumstances, the implication for the practice of unsurveyed mine closure is not diminished. Given our limited knowledge, it is entirely possible that a handful of sites within the Black Hills may provide shelter to significant populations. Loss of such sites, if they exist, would be detrimental to the bat populations of the region.

If appropriate microclimate conditions exist at such sites, it is possible they provide habitat to significant numbers of bats. For those sites that have (or are potential habitat), alternatives to complete closure have been developed and successfully employed to allow continued use by bats while restricting unauthorized human entry (Tuttle and Taylor 1994). In addition, such closures are often less costly to employ than traditional methods of closure (Tuttle and Taylor 1994). Sites requiring protection should be treated in the same manner as natural caves, including development of a comprehensive management plan. [See BAT GATES]

As with caves, not all mines meet roost habitat requirements. Temperature, humidity, physical structure, location, level of disturbance, and distance to other habitat requirements are important considerations when evaluating such locations. However, it is also important to recognize the potential variability between mines that may be in proximity to one another. As such, the significance of one location cannot be determined by survey work conducted at a separate, nearby site.

Some general mine characteristics are associated with bat roosting. Mines with multiple portals generally possess more complex airflow, which may provide for a wider range of internal temperatures and humidity (Tuttle and Taylor 1994). Such variability may provide roosting requirements to a wider variety of species.

Sites containing support timbers throughout are less likely to contain large numbers of bats. Many of the adits in the Black Hills have supporting structures located at the portals or for a short distance in less stable areas. These structural supports are frequently used by bushy-tailed wood rats (*Neotoma cinerea*) for nesting sites as well as ladders to higher levels within the mine. These mines rarely contain roosting bats. Avoiding these areas may be in response predation threats by these or other terrestrial predators. [See PREDATION]

The physical structure of the mine itself may play a role in site selection. In the Black Hills, mines with large interior chambers are likely to be used as roost sites. Such features provide bats a roosting location with minimal predation risk. Size of tailings or waste rock deposits cannot be used as a reliable determination of mine size. Such deposits, particularly at older sites, may have been altered by natural erosion or mechanical means.

Single portal mines comprised of long adits, greater than 25 m, are likely to be used by more bats than similar sites of shorter length. Such sites may contain a wider variety of roosting temperatures. Hibernating bats that roost on the rock surface were observed moving deeper into mines during periods of cold weather. Such sites may also provide more room for evading or hiding from potential predators if disturbed during summer day roosting.

Mines with portals blocked by vegetation are used less frequently than those with a clear open access, even if reduced. During road construction associated with timber sales, slash was deposited to block access to abandoned mines (Tigner personal observation). While likely done with the best of intentions, such practices may serve to restrict access to potentially important roosts and should be prohibited.

Sites that contain natural or man-made cracks and crevices are more likely to be used by a variety of species. These features are exploited by some species as a roosting thermoregulatory behavior (Ransome 1990), while others appear to roost exclusively during hibernation in such locations. For some species, crevice roosting may render interior microclimates acceptable when surface roosting would not.

In some cases, the instability of a mine or other hazards requires that the mine be closed. The following considerations can reduce the risk of trapping substantial numbers of bats. Temporary measures to prevent bat access should be employed in the time between interior survey and permanent closure. If the entire mine has been examined and found to contain no roosting bats, inexpensive plastic sheeting can be used to block portals and prevent bats from entering until permanent closure. If the entire interior of the mine cannot be surveyed completely, such closures should still be employed, but sheeting should be removed nightly to allow trapped bats to emerge. Closures should be employed during the late summer and early fall to permit adequate time for juveniles to achieve flying ability in case the site is used as a nursery roost.

Surveys of all mines should include evaluation by individuals trained to recognize bat signs. It is important to note that such surveys are often only specific to the season of survey. For example, sites used exclusively as hibernacula may give little indication of use if surveyed during July.

With the increasing pressures on natural caves, a management plan supplemented by protecting artificial roosting sites such as abandoned mines will enable larger numbers of sites to be protected with minimal impact upon recreational interests.

For detailed descriptions of evaluation methods of abandoned mines as bat habitat see Pierson et al. (1999) and Tuttle and Taylor (1994).

Land Management Surrounding Significant Bat Roosts

Altered roost microclimates can result from changes occurring in surrounding vegetation or landscape features. Such changes can be of particular significance within smaller sites with less complex airflow (Tuttle and Stevenson 1978). For example, increases in roost temperature can occur when overstory is removed permitting the roost's access point longer exposure to sunlight. Vegetation can also shelter access points. Changes in vegetation or landscape features that result in increased air movement across the access point can cause changes in roost microclimate.

One means of limiting changes to microclimate is to establish buffer zones around significant access points. While specific conditions may affect the size of such buffers, a minimum of 150 m horizontal radius to access points for roosts containing *C. townsendii* has been recommended (Pierson et al.1999).

This method was used on the Black Hills National Forest to protect the microclimate of a cave that functions as a large hibernaculum for *C. townsendii.* Once the cave's importance was explained to the timber contractor, he agreed not to harvest within the delineated buffer. The buffer is approximately two ha in area with the access point located roughly within the center. The cave lies within a narrow drainage with adjacent ridge tops serving as two buffer boundaries. Management intent is to retain the forest structure in the future. Heavy equipment is prohibited within the boundaries to further minimize disturbance.

Sites deemed significant should have formal site-specific management plans prepared to assure continuity of protection. Such plans should be comprehensive in scope including surrounding land management recommendations, forest dynamics, potential for natural disturbance such as fire, monitoring recommendations, and methodology.

Snag Management

Three Black Hills bat species, *L. noctivagans*, *L. borealis*, and *L. cinereus*, are considered tree-roosting bats. Trees are also known to be utilized as roosts by all other resident bats found in the Black Hills with the possible exception of *Corynorhinus*.

Though individuals may roost in protected areas of healthy trees, cavities within dead and dying trees are generally associated with collective roosting. Such colonies are required for the reproductive success of several of the bat species found in the Black Hills. The species for which the greatest documentation of this behavior has been collected is *L. noctivagans* (Mattson 1994).

Several factors have combined to reduce the number of snags. These include commercial timber harvest that began before the turn of the century in the Black Hills. Management of forests for commercial harvesting is designed to improve timber production, which results in the reduction of the number and quality of snags available for wildlife. Such reductions are owing to the practice of removing diseased trees and those posing physical hazards, as well as harvesting trees before maximum size is attained (resulting in an overall reduction in the mean size, age, and decadence of trees).

Firewood collection in forested close to urban areas has also resulted in a reduction of the number of available snags.

Bat Roosts in Buildings

Six bat species in the Black Hills are known to use buildings as maternity or nursery roosts. The extent to which other species have adopted such roosts in the Black Hills region remains unknown. In addition to collectives of bats, individuals will frequently roost on or within buildings.

As the human population increases, such roosting behavior is likely to continue and may increase. Collectives that commonly form in buildings are maternity or nursery roosts. Proper management techniques for building roosts may become an important component of future conservation strategies. Misconceptions about bats roosting in buildings are common. Public education will be an essential part of bat conservation.

Buildings offer a number of different attractive features as roost locations. The first of these is temperature. Warmer roost temperatures shorten gestation length and hasten physical development of juveniles. Attics typically have relatively warm temperatures and are frequently chosen for roosting.

An attic may provide a variety of temperatures. Such a range allows the bats to seek an area of optimal temperature without having to relocate. When roosts are located in buildings with pitched rooflines, the roosting location is frequently found at the apex during the cool evening temperatures. During the heat of the day, bats frequently move down the roofline away from the apex on the shaded side of the house. Roosts may also be located around chimneys and stone or masonry walls, which generally hold warmth longer than other materials.

A second feature of many maternity and nursery roosts identified within buildings in the Black Hills is the presence of a spacious and open attic. In addition to temperature variations, an open attic provides pups a secure area for learning to fly. Juveniles that fall to the ground can climb along unfinished wooden supports or rafters to rejoin the roost and the mother. Flying in large open areas within the confines of an attic minimizes predation risk.

Since ideal roosting sites are often accessible by only small access points, bats may exploit locations where they are less likely to confront large predators or roost competitors that may be more common in natural roosting locations.

The most effective means of ridding a building of unwanted bats is by removing the roost access (Barclay et al. 1980, Greenhall 1982). This generally requires blocking all openings. This strategy is more effective and less disruptive if completed prior to the arrival of the bats in the spring or following their departure in the fall.

Effectively evicting bats from a building requires a series of simple steps. Failure to follow the described procedures can result in bats becoming entrapped in the structure. Bats trapped inside roosts will seek alternative exits and may end up in the interior via openings around plumbing and electrical wiring. This is generally viewed as unsatisfactory for humans and bats.

The first step in excluding bats is to identify the main roost access point usually by observations at dusk or early evening. There may be several openings, but generally, one is used more than the others are. Following the identification of this access point, all other potential entrances should be closed or filled. Closure can be achieved using a variety of materials and must be conscientiously applied to the entire structure. Leaving unblocked access points often results in a new favorite being established.

Bats are not rodents and do not create or enlarge holes in buildings. They do not build nests, chew wiring or other similar activities characteristic of rodent infestation. In light of this, plugging openings with soft material such as insulation will suffice for closing small openings. Large openings for ventilation should be covered with screen. Smaller *Myotis* species have been observed entering and exiting through a single opening within the trough of pointing between two bricks and the overlapping wooden fascia board where roof meets wall. Such small openings can make restricting access to bats difficult in many older structures.

Once all cracks and openings have been sealed, the favorite access should be covered with a piece of plastic netting or sheeting that hangs over the opening and is attached only at the top. This creates a loosely hung flap over the opening. This flap must hang flat over the surface in which the hole occurs. The opening at the bottom allows bats inside to emerge but blocks their return.

Roost openings are frequently located in corners or areas that are difficult to cover with a flat lying piece of netting. If such is the case, a funnel shaped tube constructed of sheet plastic can be attached over the access point. The large end of the funnel is sealed around the roost access opening with the small end hanging down. Again, the bats are able to emerge but unable to reenter the tube and the roost.

These devices should be left in place for four to five evenings of good weather. During this period, all bats will have the opportunity to emerge. After this time, the temporary devices can be removed and the hole filled permanently. The exclusion process should only be undertaken in early spring before females have given birth or in late summer or early fall after the juveniles are volant. If done during the nursery season, non-volant pups can be separated from mothers. Searches for access points into the roost by the adult females are likely to be more thorough if pups are trapped inside.

If the roost is located within a large open attic in a building that is difficult or too costly to seal completely, measures can be taken to make the site a less desirable roost. When bats are not in residence, fall or winter are best, the attic can be divided into separate compartments. This can be achieved by stapling inexpensive sheet plastic to rafters forming a curtain within the attic. Curtains create a physical barrier to flight. The curtain should extend the full width of the attic and should come within 30 cm of the attic floor. Slitting the plastic curtain with vertical cuts will facilitate air movement and allow easier human passage within the attic.

In larger attics, these curtains can be hung up to 3 m apart if no access points to the outside occur within the compartments. Care should be taken to center such partitions between heads of fire sprinklers to prevent blocking the water spray in the event of a fire. Creating these smaller compartments restricts the flight area within the roost and may be enough of a nuisance to cause roost abandonment. If the bats continue to use the site, it usually limits their activity to one area and often prevents them finding their way into the building's interior by restricting movement within the attic.

Other Methods of Bat Exclusion

Many traditional methods for discouraging bats from roosting in buildings are ineffective. One of the more common remedies is scattering mothballs throughout the roosting area. Numerous roost surveys have found bats and mothballs frequently occupying the same area with no apparent effect on roost use.

Electronic devices that emit ultrasonic noise to drive away roosting bats are also ineffective (Bomford and O'Brian 1990, Hurley and Fenton 1980). One maternity roost of *Eptesicus fuscus* was observed immediately above one such device mounted to a supporting column within an attic in Hot Springs, SD (Tigner personal observation).

Poisons are the least effective method of control. They do not provide a long-term solution to the problem and can frequently be more problematic. In South Dakota, the use of poisons to kill bats is illegal. Poisoned bats often become grounded, which may bring them into contact with pets and children. Poisoned bats are often able to fly some distance from the roost thereby spreading the problem to surrounding areas (Greenhall 1982). All methods of bat roost control in Wyoming are subject to approval by the Wyoming Game and Fish Department (Bob Luce personal communication).

Public Education

Public education remains one of the keys to bat survival. As the greatest source of threats to bats originates with human activities, creating an increased public awareness of their ecological importance should provide a significant contribution to protecting these animals.

Since several species have been documented roosting in man-made structures, an increased public awareness of how best to manage undesired bat roosts is needed. Nuisance roosts are often maternity roosts which, if disturbed or disrupted, may result in the loss of a complete generation of bats. Owing to their low reproductive rate, such disruptions can have significant impacts on population size for many years. Bat topics can easily be incorporated into traditional public education media. Resources to supplement such public education undertakings are available through organizations such as Bat Conservation International in Austin, Texas [www.batcon.org].

Materials describing appropriate measures for dealing with unwanted bats are a particularly effective means of public education. Materials should be made available through offices of public agencies that are most likely to receive such requests. These include county extension offices, South Dakota Game, Fish and Parks offices, Wyoming Game and Fish Department, United States Forest Service.) [See Stukel et al. (1995) for examples.]

Public Health

One of the more frequent justifications cited for persecuting bats is based upon fear of threats to human health. The following information addresses some of the more commonly asked questions and popular misconceptions about bats and their impact on public health.

Rabies is probably the best known and most feared zoonotic disease of public health significance. While misconceptions about the relationship between bats and this viral disease are numerous, recent research has demonstrated this relationship to be far less menacing than is often portrayed. As with all mammal species, bats are susceptible to contracting this disease. While some bat species seem to be more susceptible to contracting rabies, the disease in bat populations is not thought to be increasing (Brass 1993). Occurrence of the disease in bats in North America has been estimated to be less than ½ of 1 percent (Constantine 1988).

The traditional view of bats as asymptomatic carriers of rabies, immune to its progression, is now known to be untrue (Brass 1994). Another common fallacy is that bats serve as reservoirs of the virus from which the disease is spread to other species. Research has not demonstrated bats to be an important link in transmission of the disease to terrestrial mammals (Brass 1993).

One of the surest methods of avoiding a possible exposure is simply not to handle wild mammals. Not handling a possibly infected bat will reduce your risk of contracting rabies to nearly zero. When handling dead or live animals is required, always wear thick gloves. Teaching children the importance of a hands-off approach to wildlife should be one of the primary goals of any education program. Natural inquisitiveness and innocence, coupled with anthropomorphizing common in children's media, can leave them particularly susceptible to contracting this disease. Indeed, worldwide statistics show children to be the group most frequently affected by this disease (Brass 1994).

Human exposure to rabies is far more likely to come via contact with an infected dog or cat than through contact with bats (Brass 1994). As such, vaccinating household pets against rabies is one of the most important preventive measures that can be taken against the spread of this disease (CDC 1996). Vaccinated pets that may have been exposed to an infected animal are generally prescribed a rabies booster, although a veterinarian should advise the appropriate course of action.

In the event of a possible exposure, one of the most effective means of preventing the disease is immediate and thorough washing of the infected site with soap and water. However, this is not to be considered an alternative to receiving prompt medical treatment (CDC 1991). All possible exposures should be promptly evaluated by qualified medical personnel (CDC 1991). Where possible, collection of the suspect animal for testing is recommended. Effectiveness of treatment of this disease is highest when begun soon after exposure (Berkow 1987).

The term exposure is not limited to a bite that results in rupture of the skin. Handling wildlife with cuts or scratches on hands, which become contaminated with saliva or other material of an infected animal, constitutes possible exposure. Such contamination can also occur through contact with a handler's mucous membranes (CDC 1991). These forms of potential exposure must be treated in the same manner as a bite (CDC 1991).

Incubation of the disease in a host can vary substantially from a few days to a year (Brass 1994). This finding is of particular importance to all mammalian wildlife handlers. The common belief that only healthy animals successfully hibernate through the winter is not valid, and such animals cannot be considered free of this disease (Brass 1994). In addition, handling specimens frozen for long periods may still pose a threat as freezing can preserve the virus that causes the disease (Constantine 1988).

The Center for Disease Control (CDC) recommends all individuals in high risk occupations, such as veterinarians, veterinary assistants, and wildlife handlers, receive a series of pre-exposure vaccinations to boost antibody levels in the event of an exposure (CDC 1991). The rabies pre-exposure vaccines do not provide immunity to contracting this disease. They are designed only to boost antibody titer and to improve the response to treatment that is still required following all possible exposures (CDC 1991).

For those individuals whose studies or work require handling bats and other mammalian wildlife, every effort should be taken to minimize potential exposures. These include pre-exposure vaccines followed by serology and vaccine boosters, promptly reporting and treating all potential exposures to the disease, and wearing protective gloves when handling animals. If gloves cannot be worn, animals should not be handled by people with cuts or abrasions on their hand.

For an exhaustive review of bats and rabies, see Brass (1994).

Other

Concerns about parasites are commonly expressed by many people. Nearly all parasites known to infest bats are species specific and pose little threat to pets or humans (Constantine 1988). No transmission of disease has been documented by parasites of bats to humans (Constantine 1988).

Histoplasmosis is primarily a disease of the respiratory system that manifests symptoms similar to tuberculosis (Berkow 1987). Infection comes from inhaling dust containing the fungal spores that cause the disease (Berkow 1987). The spores are commonly associated with pigeons, poultry, and bat droppings. Human exposure is generally associated with disturbing dry fecal deposits resulting in airborne dust containing the spores that is then inhaled. Individuals working in dry dusty conditions where fecal deposits may occur, particularly in confined spaces, should wear appropriate respirators. Spraying fecal deposits with water prior to disturbance will reduce dust and help minimize exposure (Benenson 1990).

FUTURE BAT RESEARCH IN THE BLACK HILLS

While much has been learned about bats in the Black Hills, many questions remain unanswered. Additional information is needed on the maternity roosting requirements of species for which there is minimal information. Further study also needs to be done on the role of abandoned mines in supporting bat populations and the identification and protection of important maternity roosts, nursery roosts, and hibernacula.

To facilitate the collection and dissemination of new information, agencies charged with the management of public lands and wildlife should develop formal relationships for the expressed purpose of maintaining monitoring and to continue habitat research. This networking would benefit those conducting research as well as the bats themselves. Alliances will provide benefits in two main areas. The first of these benefits is economic. Given the scarcity of resource agency funding, pooling resources will improve the quality and amount of work that can be conducted.

Agency participation in collaborative efforts may take a variety of forms and need not be limited to financial support. Providing vehicles, trained field personnel, researcher accommodations, and support equipment are some contributions that would be helpful.

The second benefit from collaborative ventures will be to provide a coordinated approach to future research. Cooperative ventures would prevent costly duplication of research, identify priority areas, and serve as a formal avenue of communication and dissemination of results. Consolidation of collected information into a commonly supported database would provide an effective and complete tool for future evaluation of species distribution and population trends.

Research duplication can also have a negative impact upon specific populations or roost sites. Hibernacula surveys can be a source of disturbance. Uncontrolled duplication, aside from wasting resources, can have detrimental effects on the site. Coordinated projects would reduce the possibility of excessive levels of disturbance at important roost sites. Permit applications for mist-netting, collection of specimens, and banding should include specific information as to where, how, and why the work is to be done. Such applications should be reviewed and evaluated by persons qualified to determine the applicant's ability and screened for possible duplication. This information would enable a uniform standard to be maintained in conducting future bat research.

The *Guidelines for the Protection of Bat Roosts*, as prepared and discussed by the American Society of Mammalogists (1992), could serve as the framework under which all future research would be conducted. In addition to these guidelines, the recent Idaho State Conservation Effort has additional measures specific to *C. townsendii* that should be incorporated into this framework of standards (Pierson et al.1999). Beginning in January 2001, SDGFP began requiring that applicants requesting scientific collector’s permits to sample or collect bats in South Dakota provide detailed descriptions of research/monitoring plans prior to being approved for a state collector’s permit [See Appendix II.]

To prevent unnecessary disturbance, specific locations of significant roosting locations, whether natural caves or abandoned mines, should be considered confidential and not for public distribution.

In Conclusion

Bat species of the Black Hills require a variety of habitat types. Changes within these habitat types will have an inevitable impact upon those species dependent upon them. Species such as *C. townsendii* or *L. noctivagans* with specific summer roosting requirements are particularly susceptible to these changes. The variation observed in hibernacula selection for year-round residents also demonstrates the diversity of required habitat. Accelerating changes resulting from increasing pressures on existing habitat likely represent the greatest threat to the survival of bat species in the region.

Given the rapid pace of change, the success of mitigation measures designed to maintain diversity could only be gauged through continued species monitoring. The importance of continued bat population monitoring in the Black Hills cannot be overemphasized. Though biological surveys are often judged to be an end in themselves, we agree with Bogan et al. (1989) in viewing them as the only reliable means to monitor population trends over time. As such, biological surveys should be viewed as an ongoing process for collecting information to assess effects of land management and help guide resource decisions.

Taken independently, much of the bat work conducted to date within the Black Hills can be considered little more than anecdotal. Lacking a historical perspective to provide points for comparison, individual point-in-time surveys only give a reflection of present conditions. Population trends are impossible to discern from such limited information. Collectively, this work, if combined with ongoing and future research, will provide a basis for understanding the complex interactions between bats and the unique habitat found within the Black Hills.

Fully understanding the complex relationship between bats and their environment must remain a goal for the future. Identifying habitat requirements is but the first step in long-term protection of these ecologically important species. Once identified, conserving these requirements becomes the challenge facing wildlife and land management agencies. Without the implementation of these identified management guidelines, future surveys will serve only to provide simple documentation of the extirpation of bats from the Black Hills.

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SPECIES BANDED	♂	♀	SPECIES TOTAL
M. ciliolabrum	55	21	76
M. evotis	05	01	06
M. lucifugus	101	74	175
M. septentrionalis	137	27	164
M. t. pahasapensis	54	21	75
M. volans	67	22	89
E. fuscus	72	90	162
C. townsendii	34	71	105
L. borealis	0	01	01
L. cinereus	18	05	23
L. noctivagans	43	18	61
SPECIES TOTALS	**586**	**351**	**937**

Table 1 Species, sex and total number of bats banded: 1992-1995.

SPECIES	♂	♀	TOTAL
M. ciliolabrum	2	1	3
M. lucifugus	2	0	2
M. septentrionalis	10	1	11
M. t. pahasapensis	5	0	5
M. volans	3	0	3
E. fuscus	3	11	14
C. townsendii	10	13	23
L. cinereus	0	1	1
L. noctivagans	1	0	1

Table 2 Banding recaptures by species: 9/92-12/02.

No records of recaptures have been noted for *M. evotis* or *L. borealis*.

Tables 3 and 4 provide common measurements collected from bats in the Black Hills (Tigner unpublished data).

SPECIES	**♂ FA [mm] (n)**	**♀ FA [mm] (n)**	**FA average for species (n)**	**FA range for species (mm)**
M. ciliolabrum	31.16 (76)	31.53 (32)	**31.27** (108)	29-34
M. evotis	37.80 (5)	40.00 (1)	**38.17** (6)	37-40
M. lucifugus	37.37 (108)	37.66 (73)	**37.49** (181)	32-41
M. septentrionalis	36.03 (141)	36.29 (28)	**36.07** (169)	32-43
M. t. pahasapensis	40.50 (54)	41.70 (20)	**40.82** (74)	37-44
M. volans	37.79 (72)	38.35 (23)	**37.93** (95)	35-41
E. fuscus	45.18 (73)	46.14 (96)	**45.72** (169)	41-51
L. borealis	**	42.00 (1)	**39.7**[1] (8)	36-42[2]
L. cinereus	52.35 (20)	53.83 (6)	**52.69** (26)	50-55
L. noctivagans	41.09 (45)	41.73 (22)	**41.3** (67)	39-44
C. townsendii	43.18 (34)	44.85 (72)	**44.31** (106)	40-47

Table 3 Forearm (FA) measurements by sex and species.

[1, 2] from van Zyll de Jong 1985

Weights are shown to provide a comparison between species only. In calculating the mean weights, no adjustments were made for variables such as pregnancy[1] or recent foraging activity[2].

SPECIES	**♂ weight [gm] (n)**	**♀ weight [gm] (n)**	**mean weight for species [gm] (n)**	**weight range for species [gm]**
M. ciliolabrum	5.72 (62)	5.71 (28)	**5.72** (90)	4.0-9.5
M. evotis	7.50 (2)	7.50 (1)	**7.50** (3)	7.5
M. lucifugus	8.23 (96)	8.64 (29)	**8.33** (125)	5.0-11.5
M. septentrionalis	7.14 (113)	7.09 (22)	**7.13** (135)	4.5-11.0
M. t. pahasapensis	7.70 (45)	8.11 (14)	**7.80** (59)	6.0-10.5
M. volans	7.73 (56)	8.18 (17)	**7.84** (73)	5.0-11.5
E. fuscus	17.18 (68)	17.88 (72)	**17.54** (140)	11.0-26.5
L. borealis[3]	**	20.00 (1)	**12.5**[4] (4)	10.0-17.44[4]
L. cinereus	23.58 (20)	20.50 (2)	**27.6**[4] (22)	25.4-30.3[4]
C. townsendii	11.04 (27)	12.21 (24)	**11.59** (51)	9.0-19.0

Table 4 Weight by sex and species.

[1] Kurta and Kunz (1987) in surveying published literature, found the mean weight of bat pups at birth to be 22.3 percent of the mother's post-partum body weight.

[2] One adult female *C. townsendii* banded emerging from a cave was recaptured 2.5 hours later reentering the cave. At emergence, she weighed 11.5 gm and at recapture (with bulging stomach) 16 gm, a gain of 4.5 gm or nearly 40% of its body weight (Tigner unpublished data).

[3] No males were netted; only one female was recorded.

[4] from van Zyll de Jong 1985.

SPECIES	**NIGHT ROOST**	**DAY ROOST**	**HIBERNACULUM**

	BEFORE➔AFTER	BEFORE➔AFTER	BEFORE➔AFTER
M. ciliolabrum	♂♀ ➔ ♂♀	♂✓ ➔ ♂✓	✓ ➔ ✓
*M. evotis**	♂ ➔ X		
M. lucifugus	♂♀ ➔♂♀	♂♀ ➔ ♂♀	
M. septentrionalis	♂ ➔ ♂	♂ ➔ ♂	
M. t. pahasapensis	♂♀ ➔ ♂♀	✓ ➔ ✓	✓ ➔ ✓
M. volans	♂♀ ➔ ♂♀		
C. townsendii	♂♀ ➔ ♂♀	♂♀ ➔ ♂♀	♂♀ ➔ ♂♀
E. fuscus	♂♀ ➔ ♂♀	♂✓ ➔ ♂✓	✓ ➔ ✓

***** Represents a single capture at only one of the 3 gated locations; ✓=unknown sex; X=no captures

Table 5 Roost usage at gated sites.

APPENDIX I BATS OF THE BLACK HILLS - BRIEF DESCRIPTIONS

The following is a brief description of the eleven bat species known from the Black Hills. Included are behavioral and physical observations.

Distinguishing among *Myotis* species can be frustrating at times and nearly impossible if the bat is hibernating since hibernating bats should not be disturbed. Pelage color alone is not a reliable identifying characteristic as significant variations occur within species.

Myotis ciliolabrum (Western Small-footed Myotis) - Forearm is 29-34 mm. *M. ciliolabrum* is the smallest bat found in the Black Hills. Its skull gives a flattened appearance, and bat has characteristic black mask and ears that often contrast with pale brown fur. Calcar is keeled. *M. ciliolabrum* is a year-round resident that hibernates in caves and mines in crevices and rock surfaces and generally prefers cooler hibernacula. No maternity roosts have been identified in the Black Hills.

Myotis evotis (Long-eared Bat) - Forearm is 36-41 mm. Ears very long, 22-25mm in length, extending 5 mm or more beyond nose tip when pressed forward. Ear length is more than ½ length of forearm. Fur is long with color varying in shades of brown. Ears and membranes are very dark to black, and there is often an inconspicuous fringe of minute hairs along edge of uropatagium.

Myotis lucifugus (Little Brown Myotis) - Forearm is 34-41 mm. Blunt tragus is approximately ½ length of ear. Fur varies in shades of brown often with a sheen. Membranes and ears dark brown. Calcar is absent or weak. *M. lucifugus* commonly feeds very low over water surface. Maternity roosts are common in buildings during summer. It is a year-round resident that hibernates in caves and mines with high levels of humidity and is found in crevices and roosting on rock surfaces.

Myotis septentrionalis (Northern Myotis) - Forearm is 32-39 mm. Size is similar to *M. lucifugus* but has longer ears, 17-19 mm, with long, pointed tragus. Calcar is not keeled, and fur is dull, not glossy. Membranes and ears medium brown. Face is often more bald than other *Myotis* species. A very vocal bat when disturbed. It is a year-round resident that hibernates in caves and mines and is found in crevices.

Myotis thysanodes pahasapensis (Fringed Myotis) - Forearm is 39-44 mm. Ears are long, 16-20 mm, and generally very dark to black as is the mask. A distinct fringe of small stiff hairs is found along the edge of uropatagium. Subspecies found only in the Black Hills region. *M. t. pahasapensis* is a year-round resident that hibernates in caves and mines and roosts in crevices and on rock surfaces.

Myotis volans (Long-legged Myotis) - Forearm is 35-41 mm. It often displays a characteristic furring from elbow to knee on underside of wing membrane and a well-developed keel to the calcar. *M. volans* generally has darker brown membranes. A shorter rostrum gives head a smaller appearance than *M. lucifugus*. This species is a year-round resident that hibernates in caves and mines and is found on rock surfaces and in crevices. Maternity and nursery roosts have been found in a building and a snag.

Corynorhinus townsendii (Townsend's Big-eared Bat) Forearm is 41-47 mm. Ears are very long, >25 mm, with two lumps near the end of the snout. This species is often misidentified as the ears are commonly folded back and adjacent to folded wings while roosting or hibernating. Tragus does not fold back with ear and are often mistaken for *Myotis* ear tips. It is dependent upon caves and mines. *C. townsendii* roosts in the open on rock surfaces often near the openings of caves and mines. Echolocation is very soft and can be difficult to detect in the field. A very acrobatic flier, this species is known to utilize feeding perches during foraging. *C. townsendii* is a year-round resident with the largest known hibernating population in the Black Hills located at Jewel Cave.

Eptesicus fuscus (Big Brown Bat) - Forearm is 41-51 mm. *E. fuscus* is generally larger than *Myotis* species with a broad head and snout. Ears are short with rounded tragus. Calcar is keeled. It commonly roosts in buildings during the summer months. *E. fuscus* is a year-round resident that hibernates in caves and mines roosting in crevices and on rock surfaces.

Lasionycteris noctivagans (Silver-haired Bat) Forearm is 37-44 mm. Fur is dark, usually black, and silver-tipped. Ears are short and rounded. Rarely found underground, this bat usually roosts on tree trunks in crevices or beneath loose bark. Maternity roosts are located in tree cavities. This species is a slow flier and feeds over woodland ponds and streams. Although a few winter records exist, *L. noctivagans* is considered a migratory species in SD.

Lasiurus borealis (Eastern Red Bat) - Forearm is 36-42 mm. Fur is reddish, and wings are long and pointed. Ears are short and rounded. Interfemoral membrane is heavily furred. *L. borealis* routinely gives birth to more than one pup. Twins, triplets and quadruplets are not uncommon. This species roosts almost exclusively in the branches of trees and is generally a high-flying bat. There are few records of *L. borealis* in the Black Hills. It is considered migratory.

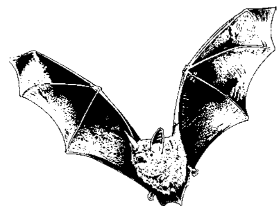
Lasiurus cinereus (Hoary Bat) - Forearm is 48-58 mm. *L. cinereus* is the largest bat in the Black Hills. Fur is multicolored and heavy. Ears are short and rounded edged in black. Many hairs tipped in white give the appearance of being frosted. It is not a colonial bat and is generally a high, fast flier. *L. cinereus* is a summer resident that migrates southward by the end of August.

APPENDIX II

BAT SAMPLING AND COLLECTION PROTOCOL GUIDELINES AND REQUIREMENTS
(Effective 1 January 2001)

SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS

523 E. Capitol, Pierre, SD, 57501



The Black Hills of South Dakota and Wyoming have historically been of interest to bat researchers and specimen collectors. Many specimens have been collected for a variety of purposes, and these specimens are housed in museum and university collections throughout the country. In recent years, natural and intentional mine closures combined with the continued interest in research on Black Hills bat populations have caused concern about impacts of sampling and collection on local bat populations. This document presents specific guidelines and requirements for bat sampling and collection related to monitoring and research activities throughout South Dakota. This document is not intended to provide recommendations on study or sampling design, which can be obtained from other sources (ex: *Inventory Methods for Bats – Standards for components of British Columbia's Biodiversity No. 20*. 1998. Resources Inventory Committee, British Columbia).

The overriding intent of this document is to provide for the safety of individual bats and for the long-term stability of bat populations in South Dakota. State Scientific Collector's Permits will be issued only for research and monitoring activities that are compatible with this overriding intent.

Components of this document are arranged as guidelines or requirements. The permittee should assume that deviations from requirements will not be approved unless justified to the satisfaction of the SD Department of Game, Fish and Parks.

This document is a supplement to the *South Dakota Department of Game, Fish and Parks Free Scientific Collector's Permit Application*. Legal authorities: SDCL 41-6-32 (scientific collector's license) and SDCL 41-1-2 (state authority for wildlife protection).

REQUIREMENTS:

1. Applicants must provide evidence that they are familiar with the desired sampling techniques and with identification of bat species likely to be found in the study area. This requirement applies to all parties that will operate under the Scientific Collector's Permit. The Scientific Collector's Permit cannot be transferred or delegated to individuals not covered under the Permit.
2. In addition to completing the *South Dakota Department of Game, Fish and Parks Free Scientific Collector's Permit Application*, applicants must submit a copy of their study or monitoring plan. At a minimum, the plan should include species of concern, number of individuals to be collected or handled, study area and duration, techniques, personnel, and eventual location of specimens or tissues.
3. Mist nets must be attended at all times. Harp traps must be checked frequently to minimize effects of predation, weather, absence of mother from pup, etc.
4. No collection or handling of bats will be allowed at hibernacula. Surveys or other activities at hibernacula will be reviewed on a case-by-case basis.
5. Live bats may not be held overnight without permission of SDGFP.
6. No surveys will be allowed for western big-eared bats (*Corynorhinus townsendii*) at known maternity/nursery roosts. If a researcher suspects that western big-eared bats are using a site as a maternity/nursery roost, surveys must end immediately, and SDGFP must be notified. In general, surveys of maternity/nursery roosts of all bat species are discouraged.
7. Applicants desiring to handle bats must submit proof of pre-exposure vaccinations for rabies.
8. Applicants desiring to band bats must comply with established South Dakota protocol for band type, placement, color, and numbering system.
9. In general, no collection of specimens or body tissue will be allowed of bat species monitored by the SD Natural Heritage Program. A current list of monitored species can be viewed at: http://www.state.sd.us/gfp/Diversity/index.htm. If individuals of monitored species are captured, they will be released immediately at the point of capture. Any unintentional collection of individuals of monitored species will be reported to SDGFP within 72 hours and surrendered to SDGFP.
10. Collection of any bat species must be approved by SDGFP. Collection of more than two specimens of nonmonitored species must be justified within the context of a study or monitoring plan. This plan should include a description of the method of killing and a description of availability of tissue or specimens for examination by other researchers.
11. Bat survey or monitoring activities should not alter or damage natural or artificial sites.
12. Only personal, battery-powered or non-heat-generating light sources will be used within roosts. No open-flame torches, smoke-producing instruments, photography equipment, carbide lamps, or toxicants will be taken into roost sites.
13. Permit holders will notify SDGFP of the location of any maternity roosts discovered during study or monitoring activities.

GUIDELINES:

1. Applicants should be familiar with humane methods of removing other nocturnal animals likely to be captured in bat sampling equipment.
2. Applicants should be familiar with property boundaries in their selected study area and should seek permission from the appropriate public or private landowner.
3. Applicant should notify public or private landowner when survey activities will be conducted.

GLOSSARY OF SELECTED TERMS

adit - horizontal underground mine passage that connects to the outside

calcar (keeled calcar) - a piece of cartilage attached to the heel of the foot that extends along the free-edge of the tail membrane; "keeled calcar" refers to a small portion (flap) of the membrane that extends beyond the edge of the calcar

cave - naturally formed underground cavity

day roost - general term for a roosting location used by bats during the active season (may include maternity and nursery roosts)

drift - horizontal underground mine passage that follows a vein or layer of rock

echolocation - a highly advanced "sonar" system used by bats to orient themselves and locate food

hibernaculum - location used for overwintering; usually characterized by cooler (above freezing) stable temperatures

hibernation - energy conserving behavior used during longer cold weather periods when food is scarce; characterized by lower metabolic rate and body temperature

hypogeal - occurring beneath the surface

insectivorous - feeding on insects (all SD and WY bats are insectivorous)

maternity roost - roost location used by a group of reproductive adult females

mine - man-made underground cavity

night roost - location used between bouts of foraging for resting, ingesting larger prey, and socializing

nulliparous – never given birth

nursery roost - roost location used by adult reproductive adult females and their offspring

parous - having given birth

pelage - fur

portal - access point or opening at a horizontal mine entrance

shaft - vertical opening/passage into a mine

thermoregulation - controlling body temperature to achieve optimal use of stored energy reserves

torpor - a short-term adaptive behavior for conserving energy characterized by lowered body temperature and metabolic rate

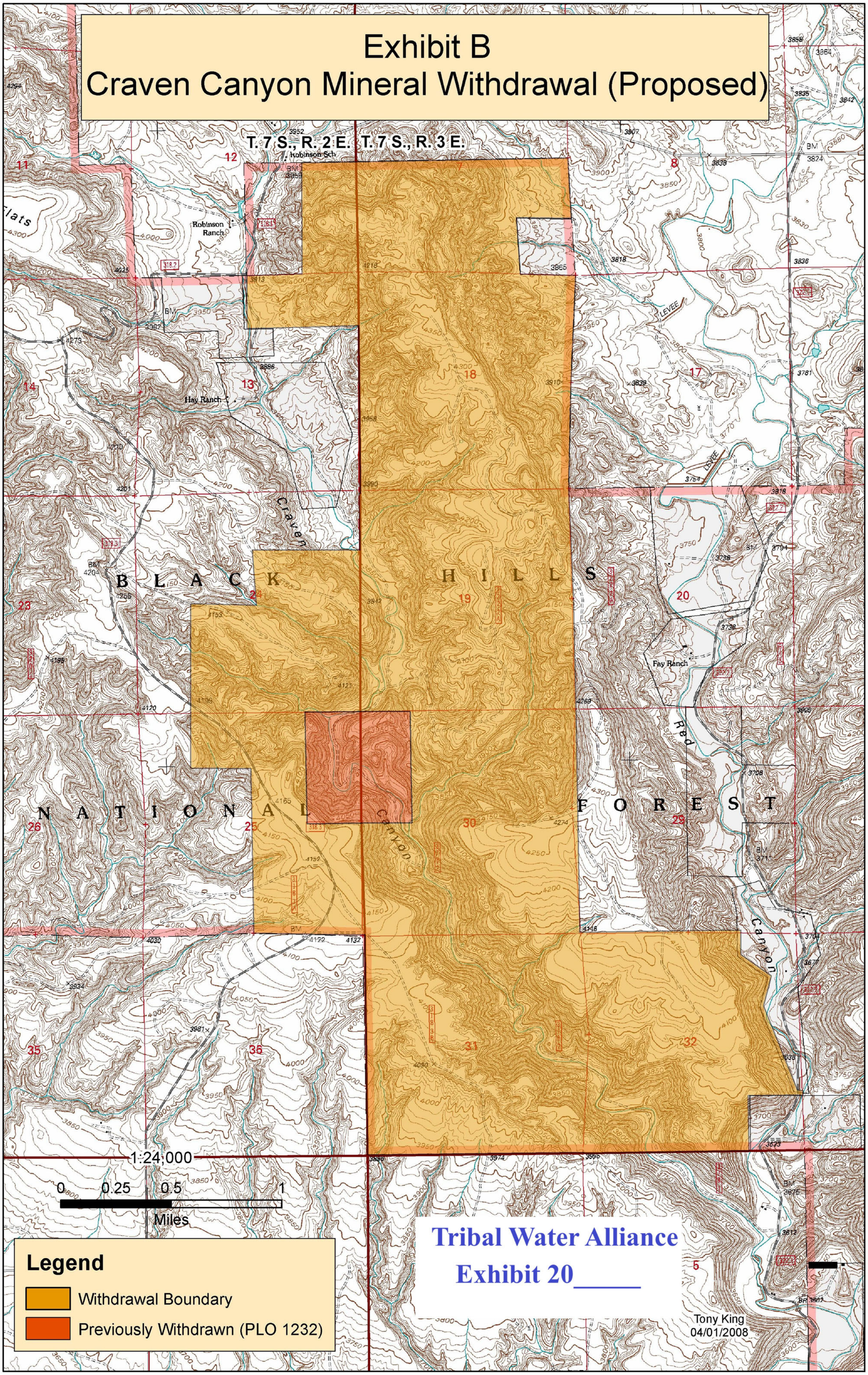
tragus - small, erect piece of cartilage attached at the base of and located in front of the ear

Harp trap (a.k.a. Tuttle trap) - portable capture device used primarily at roost access points or within restricted flyways; comprised of a frame of two vertical banks of filament (each strung in harp-like fashion) divided by a narrow space with a collection bag hung below this gap. Bats generally fold their wings to pass through the first bank of strings and become blocked by the second bank whereupon they drop down into the holding bag. The remaining area of the cave/mine opening not covered by the trap is blocked with plastic sheeting. (See Tuttle 1974)

ultrasonic echolocation detector - in its simplest form, an electronic bat survey instrument that receives the echolocation pulses, which are generally above the range of human hearing, that are emitted by bats and lowers them into the range audible to humans.

uropatagium - membrane of skin that extends between the legs (a.k.a. tail membrane)

volant - able to fly



Tribal Water Alliance
Exhibit 20_____

United States
Department of
Agriculture

Forest
Service

February 2010

Draft Environmental Assessment

Craven Canyon Mineral Withdrawal

Hell Canyon Ranger District
Black Hills National Forest
Fall River County, South Dakota

Tribal Water Alliance
Exhibit 20_____

Table of Contents

SUMMARY

The Black Hills National Forest proposes to recommend withdrawal of 3,968 acres of National Forest System land from mineral entry for 20 years to protect cultural resources, including rock art of great cultural, scientific and public interest. The significance of Craven Canyon from a traditional use perspective is not limited to the rock art. Rather, Craven Canyon should be viewed as an Ethnographic Landscape. National Park Service Preservation Brief 36 defines an Ethnographic Landscape as “a landscape containing a variety of natural and cultural resources that associated peoples define as heritage resources” (NPS 1994: 2). As mentioned above, some Lakota were more interested in Craven Canyon as a whole, and are not interested specifically in the rock art. For these individuals, the need for protection of Craven Canyon goes well beyond physical protection of the rock art, and includes a need for protecting the natural landscape features of Craven Canyon. For this reason, the proposed withdrawal includes consideration of the viewshed of the natural landscape as seen from the Rock Art sites. Additionally, archaeological and paleoenvironmental investigations in Craven Canyon indicate that there is still much to be learned about post-Pleistocene deposits and post-Pleistocene human activities. Much of the area north of Craven Canyon along what is known as Long Mountain has yet to be surveyed. Therefore, the proposed action also includes areas suspected to contain additional archeological discoveries on Long Mountain.

The project area is located approximately 30 miles southwest of Custer, SD and 17 miles west of Hot Springs, SD and is within the Hell Canyon Ranger District, Black Hills National Forest, South Dakota and Wyoming. The proposed action would withdraw these lands from mineral exploration and development under the General Mining Law of 1872, as amended. There are approximately 160 acres within the proposed withdrawal area that were previously withdrawn from mineral entry (PLO 1232), also for 20 years. This area is excluded from this proposal.

This action is needed to protect unique prehistoric and historic cultural properties in and surrounding Craven Canyon from disturbance and adverse effects associated with mineral extraction. Currently the Forest has no authority to deny mining exploration and development in this area.

The proposed action may preclude some mining opportunities in these areas. The proposed Craven Canyon withdrawal area has (1) a high potential for small to medium sized roll-front-type uranium and vanadium deposits in sandstone within fluvial unit 1 of the Lakota Formation and the lower unit of the Fall River Formation, (2) a moderate potential for oil and gas resources in subsurface Phanerozoic strata, (3) a low potential for subbituminous coal resources in the basal portion of fluvial unit 1 of the Lakota Formation, and (4) a low potential for mineral materials suitable for sand and gravel, clay, and building stone.

In addition to the proposed action (Alternative 2), the Forest Service also evaluated the following alternatives:

- **No Action Alternative –** This alternative is required as a comparison to the action alternatives. Under the No Action alternative, the existing withdrawal would remain in effect. No additional area would be withdrawn from mineral entry.

  Alternative 3. This alternative would reduce the area to be withdrawn by approximately 1,319 acres. Under this alternative about 2,649 acres would be withdrawn from mineral entry. This alternative would protect the prehistoric rock art within and along the canyon walls from exploration and development activities, but may not protect known sites above the canyon. This alternative would allow mineral entry in some areas above the canyon wall, which may not protect the visual resources and traditional cultural properties. Under this alternative, 27 of the 46 known archaeological sites would be protected, 81% of the Long Mountain Archaeological Research Interest Area would be protected, and 57% of the areas without previous archaeological survey would be protected. Alternative 3 would exclude 67 existing claims within the project area boundary.

Based upon the effects of the alternatives, the responsible official will recommend an alternative that would limit disturbance to the protected rock art sites and other archeological resources to the Bureau of Land Management. The Responsible Official will decide:

1) If mineral withdrawal is warranted to protect the resources and other values associated with Craven Canyon; and

2) If mineral withdrawal is warranted, to what extent should the withdrawal be applied?

The Responsible Official will then make a recommendation to the Regional Forester, who will in turn transmit a recommendation to the Bureau of Land Management. The United States Department of the Interior (USDI) Bureau of Land Management is a cooperating agency in the development of this document.

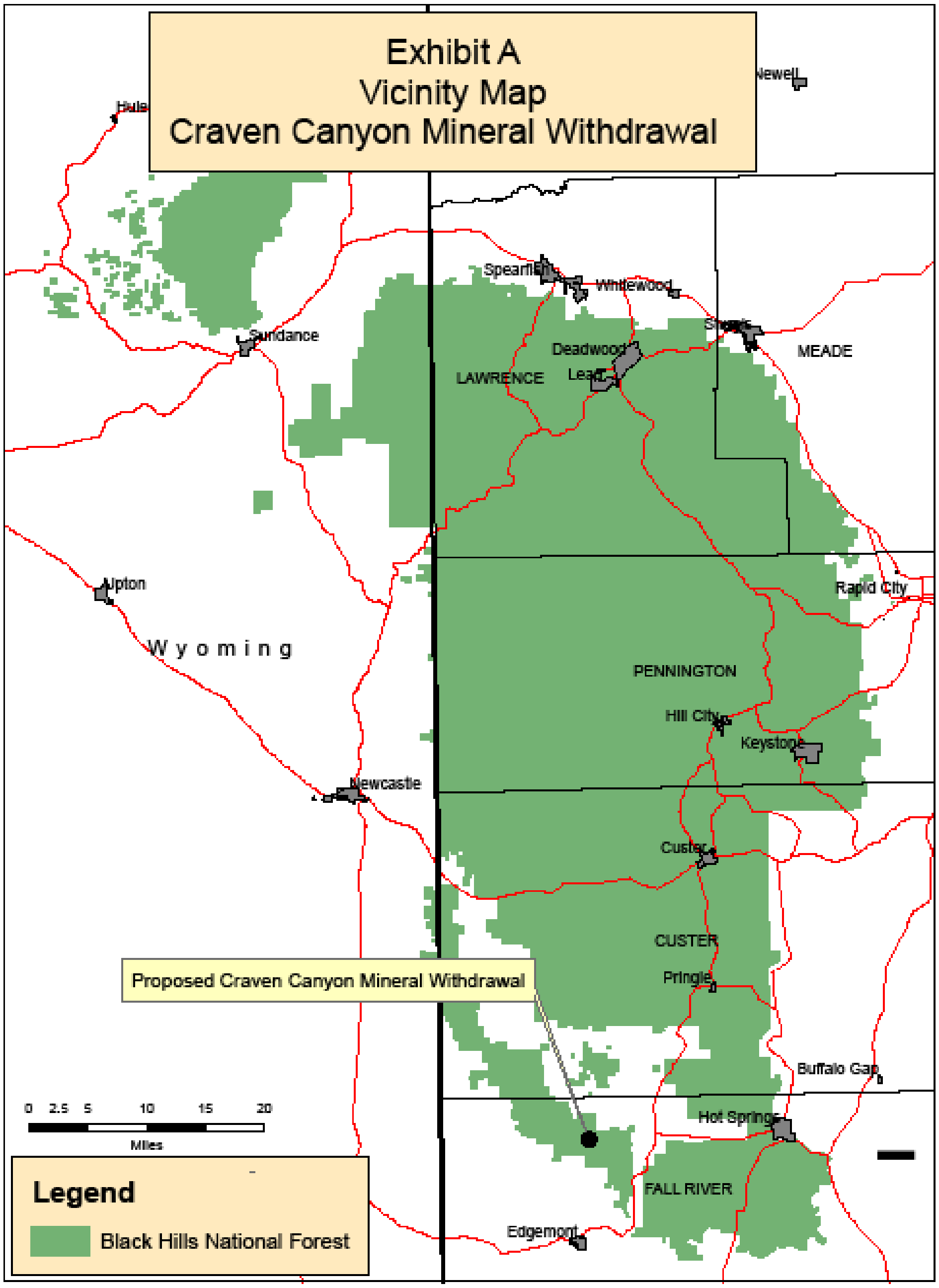


Figure 1. Vicinity Map.

CHAPTER 1. PURPOSE AND NEED FOR ACTION

Document Structure

The Forest Service has prepared this Environmental Assessment in compliance with the National Environmental Policy Act (NEPA) and other relevant Federal and State laws and regulations. This Environmental Assessment discloses the direct, indirect, and cumulative environmental impacts that would result from the proposed action and alternatives. The document is organized into four parts:

- *Chapter 1 Purpose and Need for Action:* This section includes information on the history of the project proposal, the purpose of and need for the project, and the agency‟s proposal for achieving that purpose and need. This section also details how the Forest Service informed the public of the proposal and how the public responded.
- *Chapter 2 Alternatives, including the Proposed Action:* This section provides a more detailed description of the agency‟s proposed action as well as alternative methods for achieving the stated purpose. These alternatives were developed based on significant issues raised by the public and other agencies. This discussion also includes possible mitigation measures. Finally, this section provides a summary table of the environmental consequences associated with each alternative.
- *Chapter 3 Affected Environment and Environmental Consequences:* This section describes the environmental effects of implementing the proposed action and other alternatives. This analysis is organized by resource area. Within each section, the affected environment is described first, followed by the effects of the No Action Alternative that provides a baseline for evaluation and comparison of the other alternatives that follow.
- *Chapter 4 List of Preparers, and Distribution:* This section provides a list of preparers and agencies and persons consulted during the development of the environmental assessment.
- *Appendices:* The appendices provide more detailed information to support the analyses presented in the environmental assessment.

Additional documentation, including more detailed analyses of project area resources, may be found in the project planning record located at the Hell Canyon Ranger District Office in Custer, South Dakota.

Background

The southern Black Hills in general contain an unparalleled diversity of rock art styles spanning the entire breadth of human occupation of the area. The most significant representation of this diversity exists in Craven Canyon. Archaeological investigations, consultation with Native Americans, and oral histories of local ranchers have established that Craven Canyon is an irreplaceable element of the plains Native American cultural fabric.

From an archaeological standpoint, the rock art sites in Craven Canyon are a highly significant cultural resource. They have yielded, and continue to yield, information about ideology, aesthetics, technology, and social organization not found in other types of archaeological sites (Sundstrom 1993; Sundstrom 2004). In addition, recent investigations by Fredlund (1996), and Sundstrom and Fredlund (2007) indicate that rock shelters and lithic scatters in Craven Canyon contain intact and deeply stratified deposits and intact paleosols not found elsewhere in the Black Hills. These sites have the potential to answer questions about paleoenvironmental conditions and human use of the Black Hills throughout the Holocene.

The importance of Craven Canyon from a cultural use perspective cannot be overstated. For peoples‟ whose culture, history, values, morals, and beliefs are largely or wholly oral rather than written, *places* serve as “indispensable aids for remembering and imagining” (Basso 1996:7). Lakota, Cheyenne, Arapaho, Kiowa, and many other plains peoples regard the Black Hills as sacred (La Pointe 1976). These peoples have a special connection to rock art sites in the Black Hills because they are the descendants of the people who made them. The rock art sites in Craven Canyon, and indeed the canyon itself, continue to serve as repositories of history, beliefs, wisdom, and inspiration. When one place or one rock art site is damaged or altered, the corresponding piece of history, moral value, or belief is also threatened because the particular place which served as the heuristic devise for remembering is no longer intact. Thus, any adverse effect in Craven Canyon is rightly viewed as an affront to plains Native American culture and Indigenous human rights.

The Black Hills National Forest Land and Resource Management Plan, as amended (BHNF LRMP) emphasizes the management of cultural resources to protect them from loss or damage until they can be evaluated for significance, to be retained for appropriate uses, to provide opportunities for scientific study about past human behavior and environments, or to offer the public a better understanding of its collective human heritage.

Mining activities such as exploratory drilling, mining, blasting and the operation of heavy equipment can destroy archaeological sites and viewsheds. Furthermore, industrial activities are disruptive to traditional religious activities, many of which are private in nature and require a great sense of solitude.

Management Direction

The project area lies within Management Area (MA) 5.1A Southern Hills Forest and Grassland Areas per the Black Hills National Forest Revised Land and Resource Management Plan (BHNF LRMP, as amended). Forest Plan direction for the Craven Canyon area emphasizes managing for sustainability of the physical, biological and visual values associated with areas of woody vegetation and open grassland. This area is dominated by open grasslands and areas of woody vegetation, with deep sandstone canyons and very little surface water available. Though forested areas exist, they do not produce commercially profitable wood fiber as a result of poor site conditions. Wildlife habitat and forage production for both livestock and wildlife are emphasized.

More specifically, the following Forest Plan goals, objectives, standards and guidelines for the Craven Canyon area were used to develop the proposed action.

Minerals

Standard 1509. For classified lands not withdrawn from operations under the general mining laws (research natural areas, national recreation areas, special interest areas such as “scenic”, “botanical”, and “geologic”, national historical sites, and “scenic” and “recreation” segments of wild and scenic rivers):

a. The status of classified lands with respect to withdrawal must be checked before an operating plan can be approved.
b. Provide for reasonable protection of the purposes for which the lands were classified.
c. Reclaim disturbed lands to a condition suitable for the purposes for which the lands were classified.
d. Pursue withdrawals where appropriate.

Guideline 1510. Developed recreation areas should be withdrawn from locatable mineral entry. Maintain existing withdrawals.

Heritage Resources

Objective 405. Manage all heritage sites listed in the National Register of Historic places in consultation with the State Historical Preservation Officer (SHPO) and the President"s Advisory Council on Historic Preservation (ACHP).

Objective 406. Provide opportunities for the public to participate in heritage management activities, including the monitoring, excavation, and protection of archeological sites.

Wildlife

Standard 3102. Where caves are important nurseries or hibernacula for sensitive and local concern bat species protect the caves and maintain their microclimates when designing management activities. Protect known bat day and night roosts.

R2 Sensitive and SOLC Plants

The Forest Plan (USDA Forest Service 2006) states that Region 2 (R2) sensitive plant species, and plant species of local concern would be protected as follows:

Objective 221. Conserve or enhance habitat for R2 sensitive species and species of local concern (SOLC).

Guideline 4102a. Avoid the use of earth-moving equipment within national register eligible heritage resource sites, known locations of R2 sensitive species and species of local concern plants, BAs, RNAs, or in stream channels, except at designated points and with proper mitigation. Prohibit this use in the Wilderness.

Standard 4304. Treat individual plants or group of plants in areas where R2 sensitive or species of local concern plants occur. Use a treatment method that is the least risk to the species being protected.

Purpose and Need for Action

The purpose of and need for action is to protect and preserve existing Native American cultural resources including rock art of great cultural, scientific, and public interest, and traditional cultural properties with associated viewsheds. This action is needed, because there is potential for damage of the unique values associated with this area from any future mining activities. Lands in most of this area are currently open to mineral entry under the General Mining Law, as amended.

The Black Hills National Forest Land and Resource Management Plan, as amended (BHNF LRMP) emphasizes the management of cultural resources to protect them from loss or damage until they can be evaluated for significance, to be retained for appropriate uses, to provide opportunities for scientific study about past human behavior and environments, or to offer the public a better understanding of its collective human heritage.

The most appropriate use for Craven Canyon and the purpose for its withdrawal from mineral activities are to provide opportunities for scientific study about past human behavior and environments, to continue to serve the religious and cultural needs of Native Americans, and to offer the public a better understanding of its collective human heritage.

This action responds to the goals and objectives outlined in the Black Hills Forest Plan, as amended, and helps move the project area towards desired conditions described in that plan. The resource values and risks for Craven Canyon and surrounding area are described below.

Proposed Action

The proposed action was developed by the Forest Service to meet the purpose and need for action. Specifically, the Forest Service proposes to withdraw approximately 3,968 acres of National Forest System land from mineral entry for 20 years to protect cultural resources, including rock art of great cultural, scientific and public interest. The proposed action would withdraw these lands from mineral exploration and development under the General Mining Law of 1872, as amended. This means that mining exploration and development would not be allowed during the life of the withdrawal (20 years, with option for renewal). The proposed withdrawal area is shown in Figure 2.

Decision Framework

The USDI Bureau of Land Management is a cooperating agency and is responsible for the final decision regarding this mineral withdrawal. Mineral withdrawals fall under the administrative responsibilities of the UDSI Bureau of Land Management (43 CFR 2310.1). Section 104 of the Federal Land Policy and Management Act of 1976 gives the Secretary of the Interior authority to make, modify, extend, or revoke most withdrawals on public or reserved Federal lands. The Forest Service must apply to the Secretary of the Interior for withdrawal actions on National Forest lands (FSM 2761.01). The Forest Service initiates an application with the BLM for a mineral withdrawal. The BLM publishes notice of an application for withdrawal in the Federal Register along with a segregation order. The segregation order prohibits new mineral claims for a period of two years. In those two years, the Forest Service then completes an environmental assessment (EA) and supporting specialist reports to meet the requirements of the National Environmental Policy Act (1969). The notice of application for withdrawal and order of segregation was published in the Federal Register on August 20, 2008, with comments and requests for public meetings due by November 18, 2008. For a period of two years from the August 20th date of publication in the Federal Register, the land identified in this assessment would be segregated from location or entry under the United States mining laws, unless the application to withdraw is denied or canceled or if the withdrawal is approved prior to that date.

This Environmental Assessment is not a decision document. Based upon the effects of the alternatives, the Recommending Forest Service official will transmit a recommendation to the BLM. The Director of the BLM approves the decision on the proposed withdrawal and publishes notice of decision in the Federal Register. Therefore, the Forest Service recommendation is not appealable (36 CFR 215.12(h)). The Recommending Forest Service official for this assessment will be the R2, Rocky Mountain Regional Forester (FSM 2761.04).

The Recommending Official will decide 1) if mineral withdrawal is necessary to protect the culturally significant resources located at Craven Canyon, and 2) if so, what the appropriate size of the withdrawal should be.

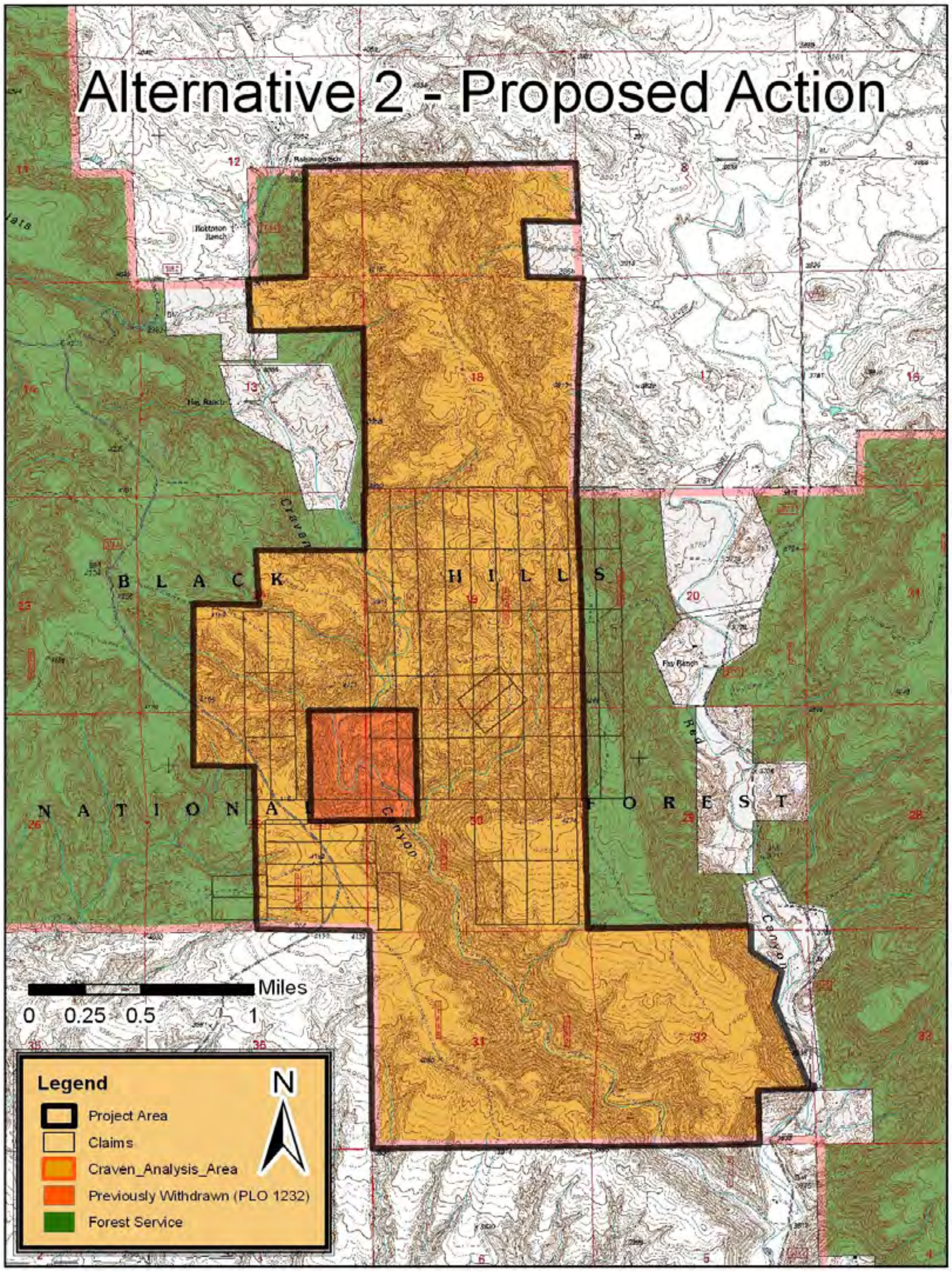


Figure 2. Proposed Action

Public Involvement

Public involvement on this project began prior to the formal scoping period. Scoping as defined by the Council on Environmental (CEQ) includes refining the proposed action, identifying preliminary issues, and identifying interested and affected persons. Notices of the proposed withdrawal and segregation orders were published in the Federal Register on August 20, 2008. The proposal was listed in the Schedule of Proposed Actions in October 2008. The proposal was provided to the public and other agencies for comment during scoping which began on January 12, 2009. In addition, as part of the public involvement process, the agency provided maps and information on the Black Hills National Forest website (www.fs.fed.us/r2/blackhills). At the request of the Fall River County Commissioners, the Forest Service met with the Commissioners on May 15, 2009 to discuss the proposed withdrawal. Using the comments from the public, other agencies, and tribal contacts the interdisciplinary team developed a list of issues to address.

Issues

The Forest Service reviewed input submitted during scoping and separated the issues into two groups: significant (as directed by the Council on Environmental Quality (CEQ) regulations (40 CFR 1500.4(g) and 1501.7)) and non-significant issues. Significant issues were defined as those directly or indirectly caused by implementing the proposed action. Non-significant issues were identified as those: 1) outside the scope of the proposed action; 2) already decided by law, regulation, Forest Plan, or other higher level decision; 3) irrelevant to the decision to be made; or 4) conjectural and not supported by scientific or factual evidence. The Council on Environmental Quality (CEQ) NEPA regulations require this delineation in Sec. 1501.7, "…identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (Sec. 1506.3)…" A list of non-significant issues and reasons regarding their categorization as non-significant may be found in the project record. The Forest Service identified the following significant issue during scoping (Table 1).

Table 1. Significant Issues/Concerns
Issue #1: Protection of existing claims. There is concern that the size of the withdrawal is too large and would have adverse effects on mining opportunities. There are approximately 67 mining claims that exist within the proposed withdrawal area. There is concern that the withdrawal would eliminate opportunities for future exploration and development of mineral resources, and that archeological resources, including rock art sites and viewsheds within the Craven Canyon area, could be protected with existing protection and mitigation measures available through the existing 640-acre Pictograph Withdrawal and through the Forest Service 36 CFR 228 mineral regulations. *This Issue was used to develop Alternative 3 and will be carried forward for analysis.* ***Measures:*** • ***Existing Mineral claims included within withdrawal area.*** • ***Number of culturally significant sites protected.*** • ***Viewshed acres protected.***

CHAPTER 2. ALTERNATIVES, INCLUDING THE PROPOSED ACTION

This chapter describes and compares the alternatives considered for the Craven Canyon Mineral Withdrawal project. It includes a description and map of each alternative considered. This section also presents the alternatives in comparative form, sharply defining the differences between each alternative and providing a clear basis for choice among options by the decision maker and the public. Some of the information used to compare the alternatives is based upon the design of the alternative (i.e., location and size of the withdrawal) and some of the information is based upon the environmental, social and economic effects of implementing each alternative (i.e., the amount of high potential minerals withdrawn).

Alternatives

Alternative 1

No Action

Under the No Action alternative, current management plans would continue to guide management of the project area. No additional areas would be withdrawn to accomplish project goals. The existing mineral withdrawal (PLO 1232 - 160 Acres) would remain in effect. All other areas in the vicinity of Craven Canyon would remain open to mineral exploration and development. Mineral exploration and development would continue to be regulated through the Forest Service 36 CFR 228 mineral regulations.

Alternative 2

The Proposed Action

The Black Hills National Forest proposes to recommend withdrawal of 3,957 acres of National Forest System land from mineral entry for 20 years to protect cultural resources, including rock art of great cultural, scientific and public interest. The proposed action would withdraw these lands from mineral exploration and development under the General Mining Law of 1872, as amended. The proposed withdrawal is intended to provide protection of the unique resources present at Craven Canyon from the adverse effects of all future mining activities. There are currently approximately 67 existing mining claims within the proposed mineral withdrawal area. The proposed action would not change the validity of those existing claims, but would limit any future claims.

The significance of Craven Canyon from a traditional use perspective is not limited to the rock art. Rather, Craven Canyon should be viewed as an Ethnographic Landscape. National Park Service Preservation Brief 36 defines an Ethnographic Landscape as “a landscape containing a variety of natural and cultural resources that associated peoples define as heritage resources” (NPS 1994: 2). As mentioned above, some Lakota were more interested in Craven Canyon as a whole, and are not interested specifically in the rock art. For these individuals, the need for protection of Craven Canyon goes well beyond physical protection of the rock art, and includes a need for protecting the natural landscape features of Craven Canyon. For this reason, the proposed withdrawal includes consideration of the viewshed of the natural landscape as seen from the Rock Art sites. Additionally, archaeological and paleoenvironmental investigations in Craven Canyon indicate that there is still much to be learned about post-Pleistocene deposits and post-Pleistocene human activities. Much of the area north of Craven Canyon along what is known as Long Mountain has yet to be surveyed. Therefore, the proposed action also includes areas suspected to contain additional archeological discoveries on Long Mountain.

Under alternative 2, existing claims would remain but mineral development on those claims would be subject to valid existing rights. Mineral activity on the mining claims within the withdrawal area, including mineral exploration, would require a Plan of Operations under Forest Service 36 CFR 228 regulations. Before a Plan of Operations can be approved, valid existing rights must be verified for each mining claim on which the activity is proposed. Valid existing rights are verified through mineral examinations conducted by a government certified mineral examiner. If minerals have not been found in sufficient quantity and quality to constitute a valid discovery of a valuable mineral deposit on the subject claims as of the date of withdrawal, and any time afterwards through to the date of the examination, then those claims will be declared null and void, and will no longer exist. Therefore, the claims will remain after the withdrawal, but once an operator tries to do anything with them they will find out that indeed there are effects on the claims due to the withdrawal. Also, undiscovered mineral resources will be impacted by remaining lost to future exploration and development during the term of the withdrawal.

Table 2. Components of Alternative 2 – Proposed Action	
Acres to be withdrawn	**3,957 acres**
Archaeological Sites Protected	**46 (100%)**
Acres of the Long Mountain Research Interest Area Protected	**386 acres (100%)**
Unsurveyed Acres Protected	**2,780 (100%)**
Culturally Significant Sites Protected	**9(100%)**
Culturally Significant Site Viewsheds Protected	**16 (100%)**
Total Culturally Significant Viewshed Acres Protected	**621(100%)**
Existing Claims included in withdrawal area	**67 (100%)**

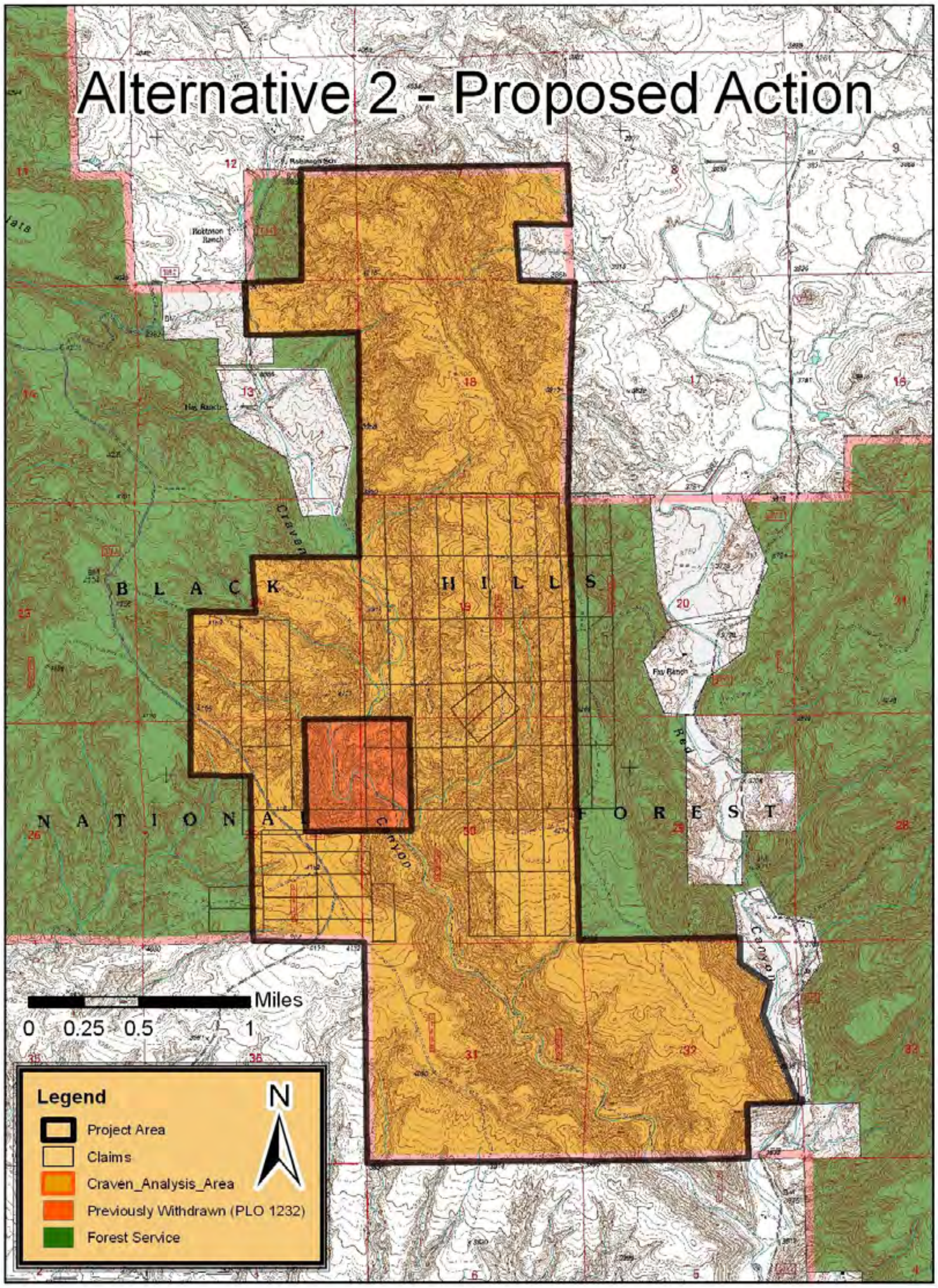


Figure 3. Alternative 2 – Proposed Action

Alternative 3

Alternative 3 was developed in response to an issue raised during public scoping. Some commentors felt that the proposed withdrawal is larger than necessary to protect the resources at risk and would adversely affect mining opportunities. Therefore, the IDT developed Alternative 3 which would only partially withdraw the canyon, rock art sites, and significant associated viewsheds, which are considered part of this cultural site and important to Native populations. This alternative seeks to withdraw all areas of the current analysis area except areas with existing mining claims. Under this alternative approximately 2,649 acres would be withdrawn from mineral entry.

Under this alternative 67% of the analysis area would be included in the withdrawal. This would protect 59% of the archaeological sites, 81% of the Long Mountain Archaeological Research Interest Area would be protected, 57% of areas without previous archaeological survey would be protected, and 89% of the culturally significant sites would be protected. This alternative would withdraw the viewshed for 63% of the culturally significant sites totaling 76% of the total viewshed acres. This alternative would partially cover Heritage Resources at risk, but allows more opportunities for existing and future mineral exploration and development than does Alternative 2.

Table 3. Components of Alternative 3	
Acres to be withdrawn	**2,649 acres**
Archaeological Sites Protected	**27 (67%)**
Acres of the Long Mountain Research Interest Area Protected	**313 acres (81%)**
Unsurveyed Acres Protected	**1,574 (57%)**
Culturally Significant Sites Protected	**8 (89%)**
Culturally Significant Site Viewsheds Protected	**4 (25%)**
Total Culturally Significant Viewshed Acres Protected	**473 (76%)**
Existing Claims excluded from withdrawal	**67 (100%)**

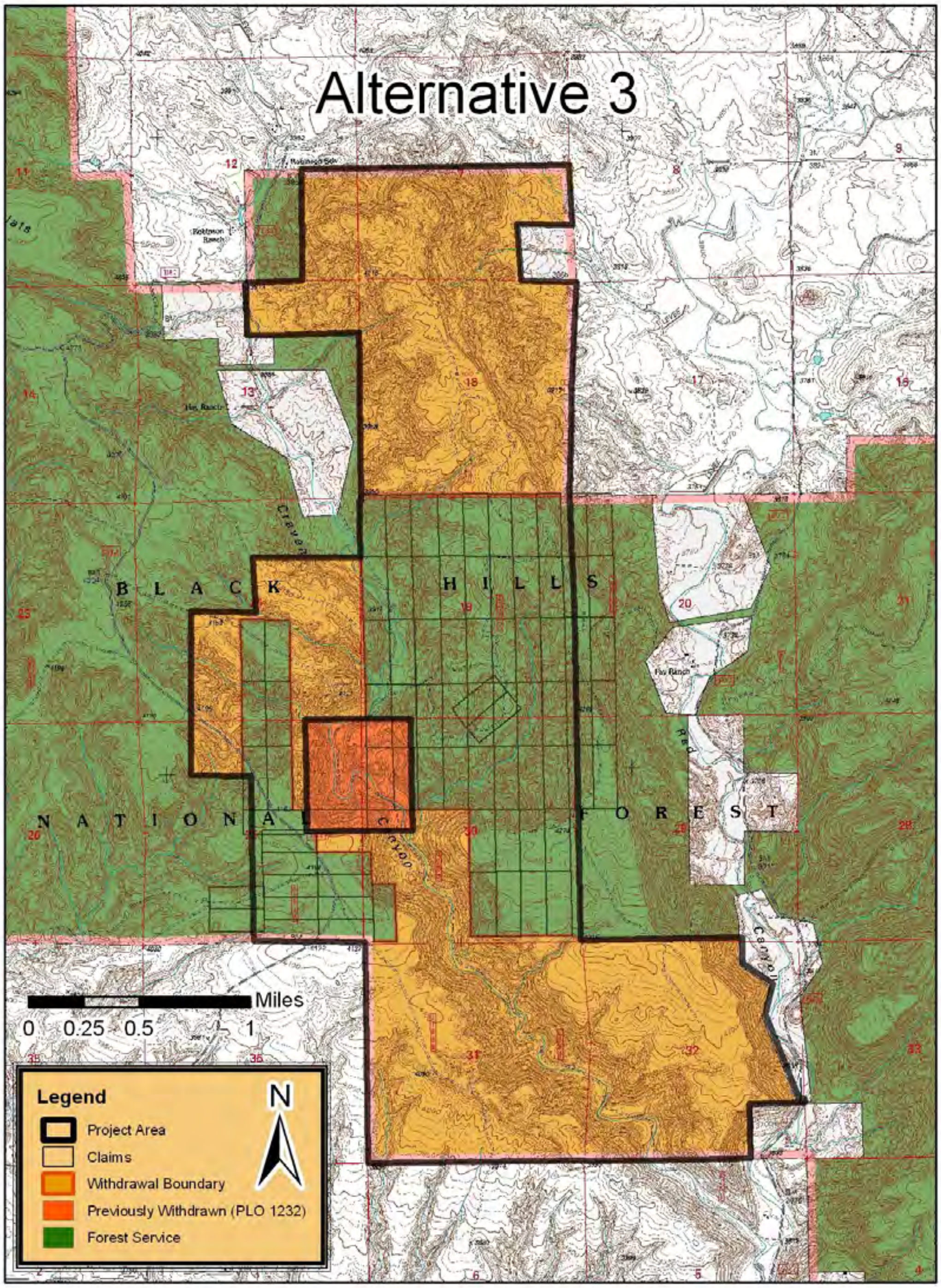


Figure 4. Alternative 3

Comparison of Alternatives

This section provides a tabular summary of the effects of implementing each alternative on the Significant Issues (3) identified for this project. Information in the table is focused on the comparison of each alternative by using the four measures identified to compare the effects of implementing each of the alternatives.

Table 5. Comparison of Alternatives

Issue/Concern	Measures	Alternative 1	Alternative 2	Alternative 3
Size of Withdrawal Area	Acres Withdrawn from Mineral Entry	0 ac	3,957 ac	2,649 ac
Inclusion of Existing (67) Claims	Existing Claims Excluded From Withdrawal (%)	0 %	100 %	0 %
Protection of Archeological Sites and Significant Viewsheds	Heritage / Cultural Resources Protected (# of known sites protected (%))	0 %	46 (100%)	27 (67%)
	Total Culturally Significant Viewshed Acres Protected	0 ac	621 ac	473 ac

CHAPTER 3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This section summarizes the physical, biological, social and economic environments of the affected project area and the potential changes to those environments due to implementation of the alternatives. It also presents the scientific and analytical basis for comparison of alternatives presented in the chart above.

Past, Present, and Reasonably Foreseeable Actions

- Uranium exploration and extraction has occurred in the project area in the past. Uranium exploration and extraction are occurring in areas adjacent to the analysis area at present, and it is reasonably foreseeable that uranium exploration and extraction would occur within the analysis area in the near future. Other activities in the analysis area include recreation, traditional cultural activities, and cattle grazing. While these activities may have a cumulative effect on heritage resources in the form of increased soil erosion, increased visitor use, and vandalism, none of them have the potential to irrevocably harm the cultural resources in Craven Canyon as much as hard rock uranium mining.
- Livestock grazing is expected to continue as managed under the current Allotment Management Plans for the Basin, Long Mountain and Robinson Flats Grazing Allotments.
- Surveys for rare plants, wildlife and heritage resources within the analysis area would be ongoing

Heritage Resources

Affected Environment

The significance of rock art sites in the Black Hills has been established in two previous National Register of Historic Places (NRHP) nominations (Rock Art of the Southern Black Hills, 1980; Prehistoric Rock Art of South Dakota, 1993). All rock art sites in Craven Canyon are already listed, except those discovered after the earlier nominations were submitted.

The southern Black Hills in general contain an unparalleled diversity of rock art styles spanning the entire breadth of human occupation of the area. The most significant representation of this diversity exists in Craven Canyon. Archaeological investigations, consultation with Native Americans, and oral histories of local ranchers have established that Craven Canyon is an irreplaceable element of the plains Native American cultural fabric.

<u>Prehistoric Context</u>

The Black Hills are part of the greater culture area of the Northwestern Plains (Sundstrom 1989). Human occupation of this area has been divided into six broad cultural periods (Frison 1991):

Paleo-Indian	11,500 B.P. to 7,000 B.P.
Early Archaic	7,000 B.P. to 5,000 B.P.
Middle Archaic	5,000 B.P. to 3,000 B.P.
Late Archaic	3,000 B.P. to 1,500 B.P.
Late Prehistoric	1,500 B.P. to 500 B.P.

The significance of prehistoric rock art sites in the Black Hills has been established in two previous NRHP nominations (Rock Art of the Southern Black Hills, 1980; Prehistoric Rock Art of South Dakota, 1993). All rock art sites in Craven Canyon are already listed, except those discovered after the earlier nominations were submitted. Rock art sites in the Craven Canyon District not yet listed, but eligible under the 1993 Prehistoric Rock Art of South Dakota thematic nomination are the following: 39FA1651, 39FA1652, 39FA1653, and 39FA1702.

Archaeological Significance

From an archaeological standpoint, the rock art sites in Craven Canyon are a highly significant cultural resource. They have yielded, and continue to yield, information about ideology, aesthetics, technology, and social organization not found in other types of archaeological sites (Sundstrom 1993; Sundstrom 2004). In addition, recent investigations by Fredlund (1996), and Sundstrom and Fredlund (2007) indicate that rock shelters and lithic scatters in Craven Canyon contain intact and deeply stratified deposits and intact paleosols not found elsewhere in the Black Hills. These sites have the potential to answer questions about paleoenvironmental conditions and human use of the Black Hills throughout the Holocene.

Archaeological and paleoenvironmental investigations in Craven Canyon indicate that there is still much to be learned about post-Pleistocene deposits and post-Pleistocene human activities. Therefore, the affected environment is not limited to known archaeological sites. Instead, the affected environment also includes areas suspected to contain stratified deposits on Long Mountain.

Traditional Cultural Use

The importance of Craven Canyon from a cultural use perspective cannot be understated. For peoples" whose culture, history, values, morals, and beliefs are largely oral rather than written, places serve as “indispensable aids for remembering and imagining” (Basso 1996:7). Lakota, Cheyenne, Arapaho, Kiowa, and many other plains peoples regard the Black Hills as sacred (La Pointe 1976). These peoples have a special connection to rock art sites in the Black Hills because they are the descendants of the people who made them. The rock art sites in Craven Canyon, and indeed the canyon itself, continue to serve as repositories of history, beliefs, wisdom, and inspiration. When one place or one rock art site is damaged or altered, the corresponding piece of history, moral value, or belief is also threatened because the particular place which served as the heuristic devise for remembering is no longer intact. Thus, any adverse effect in Craven Canyon is rightly viewed as an affront to plains Native American culture and Indigenous human rights.

The significance of Craven Canyon from a traditional use perspective is not limited to the rock art. Rather, Craven Canyon should be viewed as an Ethnographic Landscape. National Park Service Preservation Brief 36 defines an Ethnographic Landscape as “a landscape containing a variety of natural and cultural resources that associated peoples define as heritage resources” (NPS 1994: 2). As mentioned above, some Lakota were more interested in Craven Canyon as a whole, and are not interested specifically in the rock art. For these individuals, the need for protection of Craven Canyon goes well beyond physical protection of the rock art, and includes a need for protecting the natural landscape features of Craven Canyon. For this reason, the affected environment is not limited to the physical protection of the rock art itself. The affected environment also includes a consideration of the viewshed of the natural landscape as seen from the Rock Art sites.

Environmental Effects Analysis

Alternative 1

No Action may result in the destruction of cultural resources due to mining activities such as hard rock uranium extraction. Archaeological resources are non-renewable, and ethnographic landscapes cannot be recreated. Taking no action places all 3,957 acres of the analysis area in danger of mineral exploration and development. This in turn threatens 46 known archaeological sites, 386 acres of the Long Mountain Archaeological Research Interest Area, 9 rock art sites of traditional cultural significance, and the view shed from these sites.

Under the No Action alternative the existing 160 acre withdrawal (PLO 1232) would remain in place for the protection of significant rock art sites within a portion of Craven Canyon. However, as discussed above in the affected environment section, there are a total of 46 archaeological sites in the current analysis area, whereas there are only 9 archaeological sites in the previously withdrawn area. Furthermore the current analysis addresses more than just the physical protection of known archaeological sites. There is also consideration of view sheds of traditional cultural importance, areas where no cultural resource inventories have been conducted, and areas where preliminary studies suggest a great deal of archaeological and paleoenvironmental potential--all of which would remain unprotected if the no action alternative is chosen.

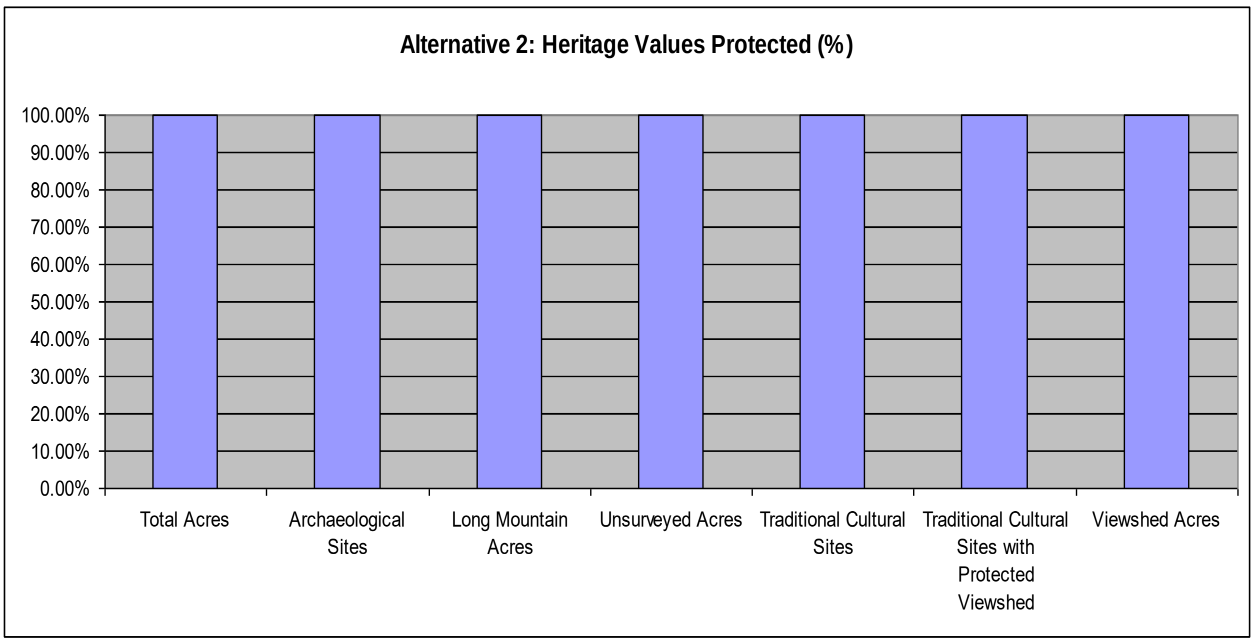
Under the No Action alternative, mining regulations outlined in 36CFR228 could be effective in protecting the archeological sites from physical harm, however, there are 18 archaeological sites located within known claims. Furthermore, the affected environment includes more than just the physical boundary of the 46 archaeological sites. It includes areas with high potential for future research, areas without previous adequate survey, and viewsheds from culturally significant rock art sites--all of which would remain unprotected under the no action alternative.

Alternative 2: Proposed Action

Alternative 2 proposes to withdraw 3,957 acres from mineral entry and development (subject to the rights of existing valid claims). This represents a withdrawal of the entire analysis area.

Under this alternative, all archaeological sites, all areas of the Long Mountain Archaeological Research Interest Area, all areas without previous archaeological survey, all culturally significant sites, and the viewsheds from these sites would be protected from mineral exploration and development. This is the preferred alternative because it meets all aspects of the purpose and need.

- Archaeological Sites Protected: 46 (100%)
- Acres of the Long Mountain Research Interest Area Protected: 386 (100%)
- Unsurveyed Acres Protected: 2780 (100%)
- Culturally Significant Sites Protected: 9 (100%)
- Number of Culturally Significant Site Viewsheds Protected: 16 (100%)
- Total Culturally Significant Viewshed Acres Protected: 621 (100%)

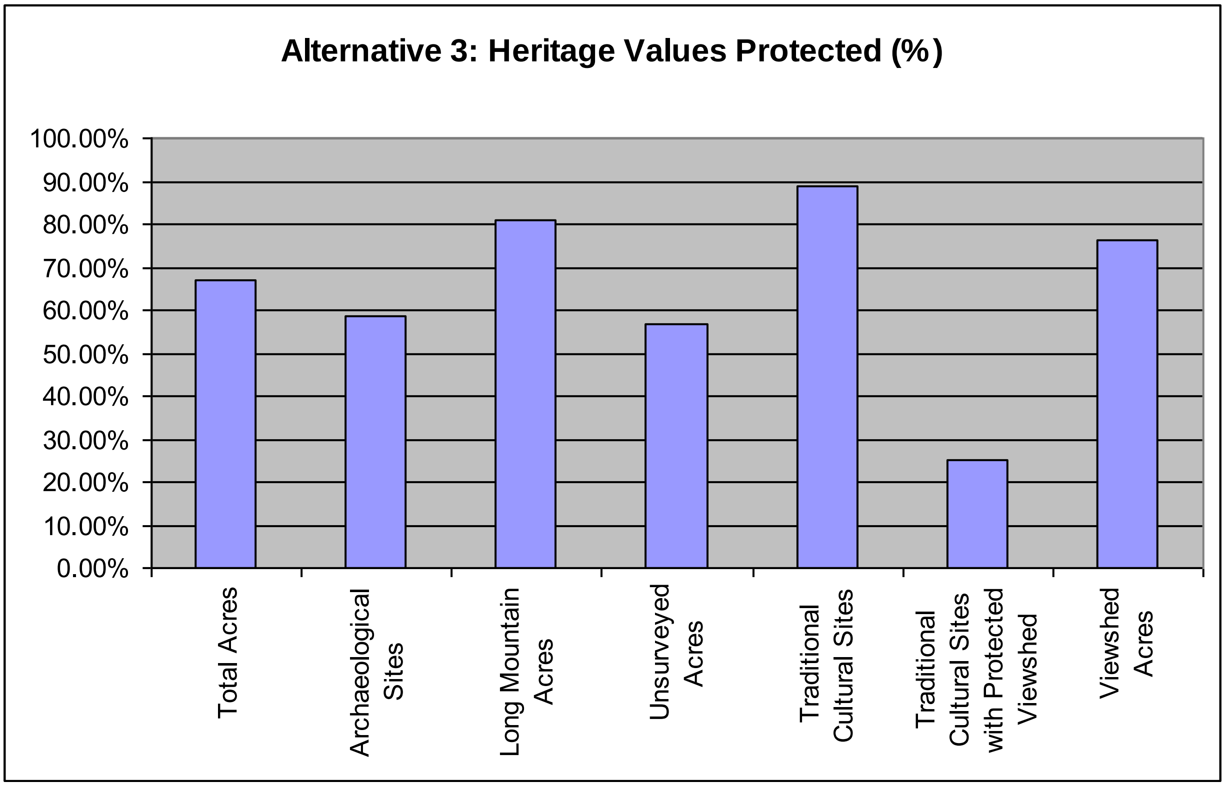


Alternative 3

Alternative 3 proposes withdraw all areas of the current analysis area except areas with existing mining claims. This area totals approximately 2,649 acres.

Under this alternative 67% of the Analysis Area would be included in the withdrawal. This would protect 59% of the Archaeological Sites. 81% of the Long Mountain Archaeological Research Interest Area would be protected under this alternative. 57% of the areas without previous archaeological survey would be protected. 89% of the culturally significant sites would be protected. This alternative would protect the viewshed for 63% of the culturally significant sites totaling 76% of the total viewshed acres. Of the Action alternatives, this is the least favorable for Heritage Resources because it achieves the lowest amount of cultural resource protection, and does not fully meet the purpose and need.

- Archaeological Sites Protected: 27 (67%)
- Acres of the Long Mountain Research Interest Area Protected: 313 (81%)
- Unsurveyed Acres Protected: 1574 (57%)
- Culturally Significant Sites Protected: 8 (89%)
- Number of Culturally Significant Site Viewsheds Protected: 4 (25%)
- Total Culturally Significant Viewshed Acres Protected: 473 (76%)



Cumulative Effects

Archaeological resources are non-renewable. The cumulative effects of taking no action to protect this area from mineral exploration and development is that more and more archaeological sites would be destroyed by mining activity. Over time fewer archaeological resources would be available to learn about past human life-ways. Fewer places would be available for the Lakota and Cheyenne to seek wisdom and inspiration. Eventually, Craven Canyon would lose its essential character as a place of significant Native American history and inspiring natural beauty. That character would be replaced with one of industrial exploitation that has little regard for the natural beauty and human history that once existed there.

Mineral Resources

Affected Environment

The southern Black Hills area is dominated by open grasslands and areas of woody vegetation that is dominantly ponderosa pine intermingled with Rocky Mountain juniper. Deep sandstone canyons run through the area and surface water is limited. Craven Canyon is one of these deep sandstone canyons and water only flows through the canyon intermittently, generally after major storm events. Flat areas such as plateaus, benches, ridgelines, and plains along the canyon bottom are dominantly open grassland with a few trees; whereas, the steeper slopes and more shaded areas become heavily vegetated with trees.

The area proposed for withdrawal is in Fall River County, South Dakota, on the Hell Canyon Ranger District of the Black Hills National Forest about 7 miles (11.3 km) north of the town of Edgemont, South Dakota. The withdrawal is from location and entry under the United States mining laws for a period of 20 years, subject to valid existing rights. There are 295 active lode mining claims within the same two townships as the proposed withdrawal area with 67 of those claims occurring in or partly within the subject withdrawal area. The subject area occurs mainly over outcrops of Early Cretaceous Inyan Kara Group sedimentary rocks with an underlying sequence of Mesozoic and Late Paleozoic sedimentary rocks. The Inyan Kara Group is known for hosting deposits of uranium and because of such, has been mapped in detail. It has been divided into the Lakota and Fall River Formations and further into several members and units. Massive fluvial sandstone from the Chilson Member of the Lakota Formation form high vertical cliffs in Craven Canyon. Craven Canyon lies in the heart of the Edgemont uranium mining district. Mineralization is roll-front-type uranium and vanadium deposits. Several past producing uranium mines occur in and adjacent to the proposed withdrawal area. Those to the east of the canyon occur in fluvial unit 1 of the Lakota Formation and those to the west occur in the lower unit of the Fall River Formation. Several mining companies are actively seeking uranium resources in the area. One company is currently conducting exploration drilling just west of National Forest System land near Dewey, South Dakota. Another two companies have approached the Forest Service about exploration and the potential impacts to their mining claims from the proposed withdrawal. None have yet to submit a Notice of Intent or Plan of Operations. A field investigation conducted for this proposed withdrawal confirmed the presence of uranium mineralization and past mining within the subject area.

Locatable Minerals

Locatable minerals in this report refer to minerals that typically are obtained by the public through filing mining claims on public domain land. The subject proposed withdrawal area is covered by mineral potential designations provided in DeWitt and others (1986). DeWitt has four different mineral potential designations in the general area of the proposed withdrawal labeled M2, N1, O3, and O5. M2 represents large (>10,000,000 tons) bedded sedimentary deposits (high-calcium limestone) in the Minnekahta Limestone. N1 represents medium (100,000 to 1,000,000 tons) bedded sedimentary deposits (gypsum) in the lower part of the Spearfish Formation and the lower part of the

Gypsum Spring Formation. M2 and N1 both are listed has high resource potential (H/D). O3 represents a high potential (H/D) for medium (10,000 to 50,000 ton) stratabound roll-front deposits of uranium and vanadium in the Inyan Kara Group rocks. O5 represents moderate potential (M/C) for medium to large stratabound roll-front deposits of uranium and vanadium in the deeply buried Inyan Kara Group rocks that could be exploited by solution mining (in-situ mining).

The Craven Canyon proposed withdrawal area is covered mostly by Inyan Kara Group sedimentary rocks; the majority of which is fluvial unit 1 of the Lakota Formation. The middle unit of the Fall River Formation makes up the next largest exposure in the subject area. The presence of fluvial unit 1 of the Lakota Formation represents a favorable geologic setting (factor 1). The identification of visible carnotite mineralization in sandstone and the high scintillometer readings indicates roll-front mineralization of potentially economic concentrations (factors 2 and 3) occur within the subject area. Several adits and open pit glory holes occur where mineralization is evident and known production of uranium and vanadium came from these workings (factors 4 and 5). Lastly, DeWitt and others (1986) have given a mineral potential designation of O3 for the subject area (factor 6). O5 designations occur to the southwest of the subject area where upper Cretaceous sedimentary rocks overlie the lower Cretaceous Inyan Kara Group rocks. All six mineral potential determination factors exist for medium (10,000 to 50,000 ton) stratabound roll-front deposits of uranium and vanadium in the Inyan Kara Group rocks. The Minnekahta Limestone, Spearfish, and Gypsum Spring Formations deeply underlie the Inyan Kara Group sedimentary rocks exposed on the subject area. Due to the shallow southwest dip of the strata, their surface exposures occur several miles to the northeast of the subject area. Therefore, no mineral potential determination factors occur within the subject area for high-calcium limestone or gypsum. It is my opinion that the Craven Canyon proposed withdrawal area has a high potential (H/D) for uranium and vanadium roll-front deposits hosted in fluvial unit 1 of the Lakota Formation. There is no indicated potential (O/B and C) for any other locatable mineral resource. Renewed exploration for uranium in the Craven Canyon area is foreseeable if mining industry‟s interest for U.S. uranium resources continues to be strong.

<u>Leasable Minerals</u>

DeWitt and others (1986) also identified mineral resource potential for leasable mineral resources. They have four different mineral potential designations in the general area of the proposed withdrawal labeled OG7, OG8, CO1, and CO2. OG7 represents a high potential (H/D) for small stratabound oil and gas deposits (<1,000,000 barrels of oil (BBL); <400,000 million cubic feet of gas (MCF)) in monocline and anticline structural traps within the Minnelusa Formation at the Barker Dome field. The Barker Dome field has produced from the Minnelusa Formation since 1955. OG8 represents a moderate potential (M/D) for medium-sized deposits of oil and gas (1,000,000 to 20,000,000 BBL; 400,000 to 5,000,000 MCF) in all subsurface Phanerozoic strata. Only 13 test wells on NFS land have been drilled in this zone. CO1 represents a low potential (L/C) for small deposits of subbituminous coal (<50,000 tons) in bedded sedimentary deposits within the Inyan Kara Group rocks. CO2 represents a moderate potential (M/D) for small deposits of subbituminous coal (<50,000 tons) in bedded sedimentary deposits within the Inyan

Kara Group rocks where it has been produced from small mines and by local ranchers for heating.

The Craven Canyon proposed withdrawal area overlies several subsurface Phanerozoic sedimentary rock units with the early Cretaceous Inyan Kara Group representing the majority of the surface rock exposure. A moderate potential coal area is in Coal Canyon and extends eastward to about 1 mile west of the proposed withdrawal area. The Barker Dome structure, with a high potential for oil and gas, trends in a northwest-southeast direction terminating at the northwest corner of the proposed withdrawal area. Therefore, neither area designation (OG7 or CO2) applies to the Craven Canyon area. The Inyan Kara Group and the underlying strata do represent a favorable geologic setting (factor 1) for coal and oil and gas occurrences. DeWitt and others (1986) have designated a moderate potential for oil and gas resources, and a low potential for coal resources for the area covered by the proposed withdrawal (factor 6). I saw no surface evidence to indicate any structural traps extend into the subject area and I saw no evidence of the basal fissile shale known to locally contain coal beds. Therefore, factors 2 through 5 do not apply to the subject area for potential leasable resources. Based on the available information and my field investigation, I concur with DeWitt and others designations. It is my opinion that the subject area has a moderate potential (M/B) for oil and gas resources because of the close proximity to a known structural trap, and a low potential (L/B) for subbituminous coal resources.

Salable Minerals

Because the Cretaceous sedimentary rocks are known to contain silt and mudstone layered in with the sandstone, alluvium in drainages from these units are not considered favorable for sources of sand and gravel. Clay has been mined from the Fuson Member of the Lakota Formation but has generally been of marginal quality for refractory bricks and therefore this mining has been very limited. Sandstone has been quarried from the Fall River Formation near Hot Springs, South Dakota, used for stone in building construction. Many areas of the Black Hills, both on and off the Forest, have a high mineral material resource potential. DeWitt and others (1986) show those areas with the best potential. None of those areas occur within the proposed withdrawal area. Because of the likely unsuitability of the mineral material, the remoteness of the subject area from markets, and the abundance of suitable resources in other areas of the Black Hills, including areas much closer to potential markets, there is unlikely to be an interest to extract mineral material from the subject area other than an occasional small amount for local personal use. Furthermore, because of the potential for archeological resources to occur in Quaternary sediments, the Forest is unlikely to allow mineral material excavations in this area. In my opinion, the potential for occurrences of suitable mineral material resources in Craven Canyon is low (L /C) with the potential for any commercial development being equally low.

Environmental Effects

Based on review of available literature, records and databases, and field investigation, the proposed Craven Canyon withdrawal area has (1) a high potential for small to medium sized roll-front-type uranium and vanadium deposits in sandstone within fluvial unit 1 of the Lakota Formation and the lower unit of the Fall River Formation, (2) a moderate potential for oil and gas resources in subsurface Phanerozoic strata, (3) a low potential for subbituminous coal resources in the basal portion of fluvial unit 1 of the Lakota Formation, and (4) a low potential for mineral materials suitable for sand and gravel, clay, and building stone. Mineral materials and leasable minerals such as oil and gas are still available under all alternatives but at the discretion of the District Ranger. Locatable minerals such as uranium will still be available under all alternatives on mining claims with valid existing rights. Operations on these claims will be managed under Forest Service 36 CFR 228 subpart A and will require special mitigation measures to protect significant archaeological resources and other significant resources.

Alternative 1, No Action

Under the No Action alternative, no changes are proposed to the existing opportunities for mineral exploration and development.

Alternative 2, Proposed Action

Under alternative 2, approximately 3,957 acres are proposed for withdrawal from mineral location and entry. New claims can no longer be located. Existing claims would remain until contested or abandoned, and mineral development on those claims found to be valid may still occur. Mineral activity on the mining claims within the withdrawal area, including mineral exploration, would require a Plan of Operations under Forest Service 36 CFR 228, subpart A regulations. Before a Plan of Operations can be approved, valid existing rights must be verified for each mining claim on which the activity is proposed. Valid existing rights are verified through mineral examinations conducted by a government certified mineral examiner. If minerals have not been found in sufficient quantity and quality to constitute a valid discovery of a valuable mineral deposit on the subject claims as of the date of withdrawal, and any time afterwards through to the date of the examination, then those claims will be declared null and void, and will no longer exist. Also, undiscovered or economically unproven mineral resources will be impacted by remaining lost to future exploration and development during the term of the withdrawal.

Alternative 3

Under this alternative approximately 2,649 acres would be withdrawn from mineral entry. This alternative proposes to exclude all (approximately 67) existing mining claims from withdrawal. These claims would not have to show valid existing rights prior to exploration and development. Exploration to prove out new resources may still occur as always within the un-withdrawn areas. Operators are still required to file a Notice of Intent or Plan of Operations where significant surface resource disturbance might occur and to conduct mitigation to protect those resources. Operators are still entitled to reasonable access even if that access is across withdrawn areas, however, the Forest Service may change the access to avoid the withdrawn areas if that access is still reasonable.

Wildlife Resources

Affected Environment

The Craven Canyon area contains a diverse mix of habitats. There is an upper plateau above the sharply dissected canyon ravines. This has open meadow, ponderosa pine, with rocky mountain juniper. Some of the pine stands are dense, mature (old growth) in character. In the canyon bottom, plains cottonwood, green ash, and other riparian associated species (e.g. rushes) occur. Understory species include: common juniper, currants, silver sage, and cactus. A variety of grasses are present including grammas, needle grasses, bluegrass, buffalo grass, and brome grasses.

The Craven Canyon area provides habitat for a variety of mammal, bird, amphibians and reptile species. Some of these species use the area for breeding as well as foraging habitat. District records list prairie falcons and golden eagles nesting in the steep cliff habitat of Craven Canyon. Spade-foot toads have been recorded breeding in the intermittent ponds that occur after spring rains. The riparian habitat in the canyon bottom contains mature cottonwood trees which provide nesting and roosting habitat from species like Lewis woodpecker, northern flicker, and hoary bat. The scattered stands of mature, dense ponderosa pine provide habitat for the fringed myotis, brown creeper and northern goshawk. Other species that occur in the Craven Canyon vicinity include: prairie dog, badger, various species of bats, hawks, owls, swallows, grasshopper sparrow, meadow lark, rock wren, bobcats, coyote, mule deer, turkey, red squirrel, busy tailed woodrat, and other small mammals.

Environmental Effects

Effects common to all Action Alternatives

Threatened, Endangered, and Sensitive Species

The Fish and Wildlife Service (USFWS) lists identify no T&E species for Fall River County, South Dakota. There are a number of Rocky Mountain Region (R2) Sensitive Species that are known to occur or have suitable habitat in the project area. A separate Biological Evaluation would accompany this report. Since there would be no ground disturbing activities associated with this (administrative) project there would be „No Impact‟. However, allowing additional mining claims in the project area could result in a loss of habitat if mining were to occur.

Species of Local Concern (SOLC)

The four bat species and the bighorn sheep (R2SS) are known or strongly suspected to be present in the project area. Since there would be no ground disturbing activities associated with this (administrative) project there would be „No Impact‟. However, allowing additional mining claims in the project area could result in a loss of habitat if mining were to occur.

Management Indicator Species (MIS)

Black Hills National Forest has selected nine (9) Management Indicator Species (MIS) to monitor effects of projects. They are: beaver, brown creeper, white-tailed deer, ruffed grouse, golden-crowned kinglet, song sparrow, grasshopper sparrow, black-backed woodpecker, and mountain sucker. Of these only the grasshopper sparrow has suitable habitat that could be affected by the project. Alternatives that withdraw acres from mineral entry would maintain the upland grassland habitat used for nesting and foraging habitat by the grasshopper sparrow. Alternative 2 (proposed action) would be expected maintain the best situation for the grasshopper sparrow of all alternatives. Alternative 1 (no action) could allow future mining operations that would likely result in a reduction of grassland habitat in the project area.

Migratory Birds

Historic information has both golden eagles and prairie falcons nesting within the project area. Due to lack of suitable habitat the red-napped sapsucker is not suspected to occur in the Craven Canyon Mineral Withdraw Project Area. Alternative 2 would provide the best outcome for these migratory birds by protecting cliff nesting habitat. Alternative 1 (no action) could allow mining activities to reduce habitat and create human (noise) disturbance.

Botany/Range/Weeds Resources

Affected Environment

Rangeland Resources

The Craven Canyon Mineral Withdrawal Analysis Area includes portions of the Basin, Robinson Flats and Long Mountain grazing allotments (Figure 6).

The area is currently grazed as follows:

Allotment	Unit	Number of livestock	Average length of time	Grazing system
Basin	Red Canyon	65 cow/calf pairs	40 days	2-unit deferred rotation
	North Red Canyon	65 cow/calf pairs	79 days	2-unit deferred rotation
Robinson Flats	Coal Canyon	71 cow/calf pairs	55 days	2-unit deferred rotation
	Elbow Canyon	126 yearlings	90 days	2-unit deferred rotation
	Gravel Pit	126 yearlings	30 days	2-unit deferred rotation
Long Mountain	South	30 cow/calf pairs	43 days	2-unit deferred rotation
	North	30 cow/calf pairs	47 days	2-unit deferred rotation

The area is predominately stony hills, shallow and silty range sites, as defined by the Natural Resource Conservation Service (NRCS) with numerous rock outcrops. Rangeland vegetation is a mixture of mid and short, warm and cool season grasses. Typical cool season grasses include needleandthread (Hesperostipa comata) and western wheatgrass (Pascopyrum smithii). Warm season grasses include little bluestem (Schizachyrium scoparium) and gramas (Bouteloua spp.). Forbs such as sageworts (Artemisia spp.) and scurfpeas (Psoralea spp.) are common. Ponderosa pine (Pinus ponderosa) and Rocky Mountain juniper (Juniperus scopulorum) are scattered throughout the area. Shrubs such as skunkbush sumac (Rhus trilobata) are present, but are not dominant.

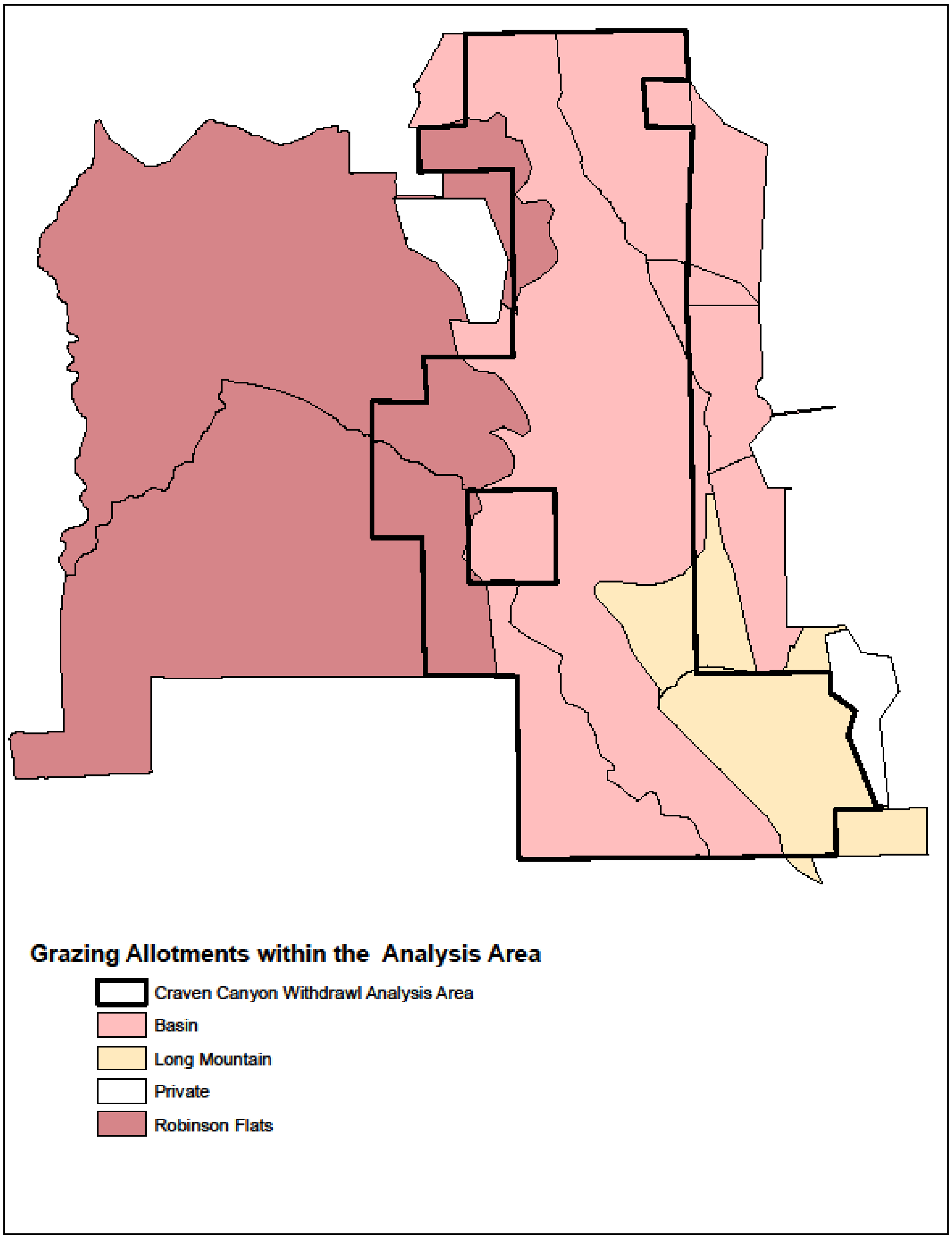


Figure 6. Grazing Allotments

<u>Noxious Weeds</u>

There are some known locations of Canada thistle (Cirsium arvense) in the draw bottoms, but in general, noxious weeds are not currently a problem throughout the analysis area. However, they do have the potential to become an issue with disturbance of the area.

R2 Sensitive and Species of Local Concern

R2 Sensitive Plant Species - R2 sensitive species are species identified by the Regional Forester for which population viability is currently of concern, as evidenced by significant current or predicted downward trends in population numbers or density, or by significant current or predicted downward trends in habitat capability that would reduce a species" existing distribution (USDA Forest Service 2009). Appendix A lists the R2 sensitive plant species that are known to occur or are likely to occur on the Black Hills National Forest.

The Forest Service has established direction in the Forest Service Manual to guide habitat management for proposed, endangered, threatened, and sensitive plant species. The direction establishes the process, objectives, and standards for conducting a Biological Evaluation. This process ensures that these species receive full consideration in the decision making process.

Based on the conditions present (i.e. – elevation, community types, soil types, xeric conditions, etc) in the project area and the fact that most R2 sensitive plant species found in the Black Hills are associated with higher elevations and moister conditions, there are no areas present within the project area that would be considered habitat for most of the current list of R2 sensitive plant species. The exceptions to this generalization are Iowa moonwort (Botrychium campestre) and narrowleaf grapefern (Botrychium lineare).

Rangewide Iowa moonwort is considered a grassland species, associated with sandy grassland habitats in prairies, dunes, railroad sidings, and fields over limestone. The north end of the project area is located within the Red Valley Region. Some of the soils in this region may have formed from limestone parent material.

Typical habitat descriptions for narrowleaf grapefern are problematic because known sites are so different across its currently known range. This species may be a habitat generalist since habitat across the range for narrowleaf grapefern is quite variable and its range stretches from sea level in Quebec to approximately 10,000 feet in Colorado. In the Black Hills area, this species is often found growing in the same locations as Iowa moonwort. No individuals of these two species have been located within the project area.

Plant Species of Local Concern (SOLC)

Species of Local Concern are species that do not meet the criteria for sensitive status. These could include species with declining trends in only a portion of Region 2, or those that are important components of diversity in a local area. The local area is defined as NFS lands within the Forest. (FSM 2620.5 Black Hills Supplement 2600-2005-1).

Forest Service Manual 2622.01 directs us to consider species of local concern during project design and to evaluate the effects to the species from alternatives considered through the National Environmental Policy Act (NEPA) process. Based on known conditions of this project area, it is believed that suitable habitat is lacking for all Black Hills plants species of local concern.

Environmental Effects

Alternative 1: (No Action) – Direct and Indirect effects

Under the no action alternative the area would remain available for mineral entry under the General Mining Law, as amended. If the area remains available to mineral entry and mineral exploration and development occur in the area, there is a potential for decrease in forage available for grazing, increase of noxious weeds as soil is disturbed, and potentially a loss of probable habitat for the two R2 sensitive species which may have habitat in the area. However, all these potential impacts would be addressed as plans of operation for mining are issued for each entry.

Alternative 2: (Proposed Action) – Direct and Indirect effects

Under Alternative 2, if the area is withdrawn from mineral entry there would not be the potential for mining to impact rangeland vegetation in the future as roads are built for exploration and uranium extracted from the area; there would not be the potential for noxious weeds to become an issue due to soil disturbance from exploration and/or mining; and there would be no impacts from exploration and/or mining on the potential suitable R2 sensitive species habitat.

Alternative 3: Direct and Indirect effects

If implemented, Alternative 3 would have the same effects on the rangeland resources, noxious weeds and R2 sensitive species habitat as Alternative 2 except as follows:

Under this alternative 2,649 acres would be withdrawn from mineral entry, so 1,319 more acres have the potential of being impacted from mining and/or exploration (those impacts would be addressed as plans of operation are approved).

Cumulative Effects

The cumulative impact area for this analysis is the Craven Canyon Mineral Withdrawal Project area; activities beyond the project area have a diminished effect on the rangeland vegetation, noxious weeds and rare plant habitat within the project area. The timing limit for the cumulative effects analysis is estimated at 20 years, ten years prior to present and ten years in to the future, which allows for an adequate length of time to record vegetative changes.

Past, present and reasonably foreseeable activities within the Craven Canyon Mineral Withdrawal project area include wildfire, grazing, temporary road construction and maintenance, noxious weed control, wildlife habitat improvement projects, and dispersed recreational use on both the public land and private land in the area.

Any past, present or foreseeable future activity that causes soil disturbance has the potential to introduce and increase the rate of spread of noxious weeds and other exotic plants. This can be detrimental to rare plants and native rangeland vegetation, as invasive species have the ability to out-compete desired native plants. The herbicides used in noxious weed control can also be detrimental to rare plants if the individuals are inadvertently exposed to the herbicides.

When properly managed, livestock grazing can have positive impacts on the rangeland vegetation. The grazing in the Craven Canyon Mineral Withdrawal project area would continue as identified in the Allotment Management Plans for the Basin, Long Mountain and Robinson Flats Allotments.

Aside from the direct impact on the vegetation (i.e. – removal of vegetation, soil compaction and introduction of invasive species), road construction has the indirect impact of making formerly inaccessible areas available to both humans and grazing animals. Opening a new area to grazing can have a positive impact, by helping to distribute grazing animals. It can also have a negative impact by allowing access to areas that may be rare plant habitat. The likelihood of gates being left open (which increases the chance of livestock being in unauthorized areas) increases as the number of roads increase.

In the Craven Canyon Mineral Withdrawal area, the primary impacts from recreational use to the rangeland vegetation and rare plant habitat are the negative direct impacts to the vegetation (i.e. – removal of vegetation, soil compaction, introduction of invasive species) that may result from recreational use. Recreational use in an area increases the likelihood of plant collecting which can have an impact on rare plant populations.

All of the above uses are limited in intensity and duration and therefore when combined with the alternatives analyzed, including the no action alternative, do not result in cumulative impacts to the rangeland vegetation, or to the rare plant habitat.

Economics

Affected Environment

The Black Hills has a rich history of mining and this area is no different. The first discovery of uranium (carnotite) in Fall River County was in Craven Canyon in June 1951. Soon deposits of uranium had been found in the Inyan Kara Group extending from Dewey (about 14 miles (22.5 km) northeast of Craven Canyon) to Chilson Canyon (about 7 miles (11.3 km) southeast of Craven Canyon). The Edgemont mining district was organized in the late 1950‟s. Uranium and vanadium were produced from this district until the 1970‟s. The project area is within the Edgemont uranium mining district. Possible locatable mineral deposits in the Edgemont area include uranium and vanadium roll-front sandstone hosted deposits, and sedimentary rock units containing high calcium limestone and gypsum. Possible leasable mineral deposits include oil and gas in structural traps and minor deposits of subbituminous coal.

Production has come from a number of mines in the Edgemont area many of which were small, one-man operations. The Forest Service has begun reclaiming open pits but essentially little reclamation has been done on the numerous open pits, underground mines, and associated overburden and waste dumps occurring in the area.

Based on BLM‟s LR2000 mining claim data, Forest Service System lands are blanketed with hundreds of active lode mining claims on Inyan Kara Group sandstones from Deadhorse Canyon (4.5 miles (7.2 km) northeast of Edgemont) northwestward to Dewey. Claims are held by both companies and private citizens, and have been recently located starting in 1998 but mostly from 2002 to 2008. The companies are uranium companies and include Powertech Uranium Corp., Strathmore Minerals Corp. and Great Bear Uranium Corp., Tournigan USA Inc., Neutron Energy, and NCA Nuclear Inc. This increase in recent uranium mining claims has occurred throughout the western U.S. likely in response to both increased uranium metal prices and a changing U.S. energy policy. It appears this resurgence in uranium claims was primarily focused in areas of historic uranium activity prior to any new exploration activity.

In addition to the mining industry, there is also interest in the interpretative (recreational) opportunities associated with Craven Canyon. Some individuals have expressed interest in commercial endeavors (tours) that would provide public opportunities for gaining historical knowledge about Craven Canyon and opportunities for viewing the rock art within the canyon.

Environmental Effects

Under all action alternatives withdrawal of National Forest System lands could reduce opportunities for exploration and development of the mineral resources. This could in turn have some impact to local economies. However, mineral exploration and development could also result in adverse environmental impacts as discussed above. In Fall River County, income from mining activities makes up less than 1% on the total income for the county (Bureau of Economic Analysis, U.S. Department of Commerce).

Alternative 1 would have the least economic impact as it pertains to development and extraction of the mineral resources since all areas, except the existing withdrawal, would be available for mineral development subject to the protection and mitigation measures in 36 CFR 228 mineral regulations. All of the action alternatives would have some impact to the potential development of mineral resources and therefore to the local economies.

Cumulative Effects

There are approximately 77,354 acres withdrawn from mineral entry on the Black Hills National Forest. Most mining in the Black Hills occurs on private lands. The Forest Plan EIS (USDA Forest Service 2005) cited very little in the way of expected mineral development in Fall River County or the Black Hills. Mineral development on the Forest was expected to have “little if any effect on the local or national economy” (ibid). Mining operations occurring on private lands in Fall River County and other areas in the Black Hills are likely to have a much larger effect on the economy.

Watershed and Soils

The FEMA DFIRM database was consulted for information on floodplains. The USFWS Wetlands Online Mapper (http://wetlandsfws.er.usgs.gov/wtlnds/launch.html) was consulted for information on wetlands in the project area. There are no floodplains and no wetlands in the project area. There are no ground disturbing activities proposed and no construction associated with this proposed mineral withdrawal.

CHAPTER 4. LIST OF PREPARERS, AND AGENCIES AND PERSONS CONSULTATED

The Forest Service consulted the following individuals, Federal, State, and local agencies, tribes and non-Forest Service persons during the development of this environmental assessment.

ID TEAM MEMBERS AND DOCUMENT PREPARERS:

Patricia Hudson, Interdiciplinary Team Leader

Anthony King, Archeologist

Cissie Englebert, Botanist and Range Specialist

Les Gonyer, Hydrologist

Brad Phillips, Wildlife Biologist

Meagan Buehler, Lands and Special Uses

Dave Pickford, Recreation Specialist

Michael Dunn, Minerals Specialist

FEDERAL, STATE, AND LOCAL AGENCIES:

UDSI Bureau of Land Management

Fall River County Commission

Edgemont Chamber of Commerce

State of South Dakota

South Dakota Department of Agriculture

South Dakota Department of Environment and Natural Resources

South Dakota Department of Game, Fish and Parks

South Dakota Department of Transportation

South Dakota State Historic Preservation Officer

TRIBES:

Cheyenne River Sioux Tribe

Cheyenne/Arapaho Tribes of Oklahoma

Crow Creek Sioux Tribe

Eastern Shoshone Tribe

Flandreau Santee Sioux Tribe

Grey Eagle Society

Lower Brule Sioux Tribe

Mandan Hidatsa & Arikara Tribes

Northern Arapaho Tribe

Northern Cheyenne Tribe

Oglala Sioux Tribe

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Santee Sioux Tribe

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Spirit Lake Sioux Tribe

Standing Rock Sioux Tribe

Three Affiliated Tribes

Yankton Sioux Tribe

OTHERS:

Adjacent Landowners

Association of Professional Archeologists

Biodiversity Conservation Alliance

Defenders of the Black Hills

Mintec Corporation

Scott"s Rock Shop

South Dakota Mining Association

Sierra Club, Black Hills Group

Society for American Archeology

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Advisory Council on
Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005

Memorandum of Understanding
Between the
U.S. Department of Agriculture, Forest Service
and the
Advisory Council on Historic Preservation

WHEREAS, the United States Department of Agriculture, Forest Service manages the National Forest System and among other things, is directed by Congress to develop land use plans for this system under the Renewable Resources Planning Act of 1974 (88 Stat. 476; 16 U.S.C. 1601-1610) as amended by the National Forests Management Act of 1976 (90 Stat. 2947); and

WHEREAS, the Advisory Council on Historic Preservation and the United States Forest Service have met and reviewed the land use planning process of the Forest Service and its relation to compliance with Section 106 of the National Historic Preservation Act (80 Stat. 915, 16 U.S.C. §470f) and Executive Order 11593, May 13, 1971, "Protection and Enhancement of the Cultural Environment," as implemented by the Council's "Procedures for the Protection of Historic and Cultural Properties," (36 C.F.R. Part 800) (hereafter "Procedures"); and

WHEREAS, in order to implement its responsibilities under the Resources Planning Act, the Forest Service prepares a number of plans in order to localize and refine national, regional, and agency-wide goals and policies for land under Forest Service jurisdiction and control and these plans include Area Guides, Forest Land Management Plans, Unit Plans, Resource Plans, and Project Plans; and

WHEREAS, Area Guides, Forest Land Management Plans, some Unit Plans and some Resource Plans, as defined in applicable Forest Service documents, do not directly authorize or result in activities that may have an effect on properties included in or eligible for inclusion in the National Register of Historic Places; and

WHEREAS, some Unit Plans, Resource Plans and Project Plans, may authorize land disturbing activities that may have an effect on properties included in or eligible for inclusion in the National Register of Historic Places; now

THEREFORE, it is mutually understood that:

(1) Area Guides and Forest Land Management Plans do not have an effect on properties included in or eligible for inclusion in the National Register of Historic Places as defined in Section 800.8 of the Council's Procedures.

Tribal Water Alliance
Exhibit 20_____

The Council is an independent unit of the Executive Branch of the Federal Government ...

Proposed Memorandum of Understanding
Between the U.S. Department of Agriculture, Forest Service
and the Advisory Council on Historic Preservation

(2) Unit Plans and Resource Plans that do not directly authorize land disturbing activities do not have an effect on properties included in or eligible for inclusion in the National Register of Historic Places as defined in Section 800.8 of the Council's Procedures.

(3) Unit Plans that directly authorize land disturbing activities which may have an effect on properties included in or eligible for inclusion in the National Register of Historic Places will be subject to review in accordance with the Council's Procedures.

(4) Individual Project Plans and Resource Plans authorizing land disturbing activities will be subject to review in accordance with the Council's Procedures.

(5) The Council, pursuant to its Procedures, may comment on any Area Guide, Forest Land Management Plan or Unit Plan that in its judgment may have an effect as defined in Section 800.8 on properties included in or eligible for inclusion in the National Register of Historic Places and the Forest Service agrees to provide the Council with copies of environmental statements prepared pursuant to the National Environmental Policy Act.

(6) The Advisory Council and the Forest Service agree to consult on changes to the Forest Service Manual and directives to the field that will reflect this Memorandum of Understanding.

(7) The Forest Service and the Council shall review the provisions of this Memorandum on an annual basis to determine whether modification or termination is appropriate. Should the current land use planning process of the Forest Service be revised or suspended, the Forest Service shall inform the Council and they shall mutually determine whether the provisions of this Memorandum shall continue to apply.

Clement M. Silvestro (Date) February 25, 1977
Clement M. Silvestro
Chairman, Advisory Council on Historic Preservation

John R. McGuire (Date) 5/13/77
Chief, Forest Service
U.S. Department of Agriculture

DOCUMENTATION OF THE NORTHERN LONG-EARED MYOTIS, *MYOTIS SEPTENTRIONALIS* ON THE STANDING ROCK INDIAN RESERVATION

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ABSTRACT

Since 2006, the northern long-eared myotis (*Myotis septentrionalis*) has declined by 98 percent in the U.S. Northeast, where white-nose syndrome first appeared. Because of the species' strong association with large blocks of older forests, forest fragmentation, logging and forest conversion (such as clearing trees for agriculture and development) are major threats to its survival. In 2013, the US Fish and Wildlife Service designated the northern long-eared bat as threatened under the Endangered Species Act. The Standing Rock Sioux Tribe (SRST) was awarded a US Fish and Wildlife Tribal Grant to assess all small mammals on the reservation, including bats. Surveying for bat species on the SRST reservation included the use of Pettersson D500x passive terrestrial ultrasonic recorders, one of which was installed at a Moreau Prairie location in Sioux County, North Dakota. On 37 trap nights 143 bats from 10 species were recorded, among them the federally threatened northern long-eared bat. More sampling will be conducted to further investigate the diversity and abundance of bat species on Standing Rock Indian Reservation, and will contribute to the development of crucial conservation management programs on the reservation.

KEYWORDS

Northern long-eared myotis, Standing Rock Indian Reservation, Pettersson D500x, *Myotis septentrionalis*

INTRODUCTION

The northern long-eared myotis, *Myotis septentrionalis,* is a medium-sized bat with a body length of 3 to 3.7 inches and a wingspan of 9 to 10 inches (US Fish and Wildlife Service 2015). Fur color ranges from medium to dark brown on the back and tawny to pale-brown on the underside. As its name suggests, this bat is distinguished by its long ears, particularly in comparison to other bats in the

Tribal Water Alliance
Exhibit 20_____

genus *Myotis*. The northern long-eared myotis spends winter hibernating in caves and mines, called hibernacula. High value hibernacula include draftless areas of high humidity and relatively high and stable temperature. Within hibernacula, northern long-eared bats most often hibernate in small crevices or cracks, often with only the nose and ears visible. During summer, the northern long-eared myotis roosts singly or in colonies underneath bark, in cavities, or in crevices of both live trees and dead trees. Males and non-reproductive females may also roost in cooler places, like caves and mines, and less frequently in structures, like barns and sheds (Henderson and Broders 2008). The northern long-eared bat's range (Figure 1) includes much of the eastern and north central United States, and all Canadian provinces from the Atlantic Ocean west to the southern Yukon Territory and eastern British Columbia (US Fish and Wildlife Service 2015).

Of the six bat species known to be affected by white-nose syndrome, the northern long-eared is among the hardest hit. Since 2006, the northern long-eared has declined by up to 99 percent in the US Northeast, where white-nose syndrome first appeared (US Fish and Wildlife Service 2016). Because of the species' strong association with large blocks of older forests, forest fragmentation, logging and forest clearing are also major threats. Various human activities disturb hibernacula, including the effects of roost disturbance, control of economically important insect pests, exposure to pesticides, long-term monitoring of populations, and the potential consequences of expanding populations (Agosta 2002). In 2013, the US Fish and Wildlife Service determined that the northern long-eared myotis should be designated as threatened under the Endangered Species Act. Under the Endangered Species Act, a threatened species is likely to become endangered in the foreseeable future, while an endangered species is currently in danger of becoming extinct (US Fish and Wildlife Service 2016).

In 2012, the Standing Rock Sioux Tribe (SRST) was awarded a US Fish and Wildlife Tribal Wildlife Grant to assess the diversity and abundance of small

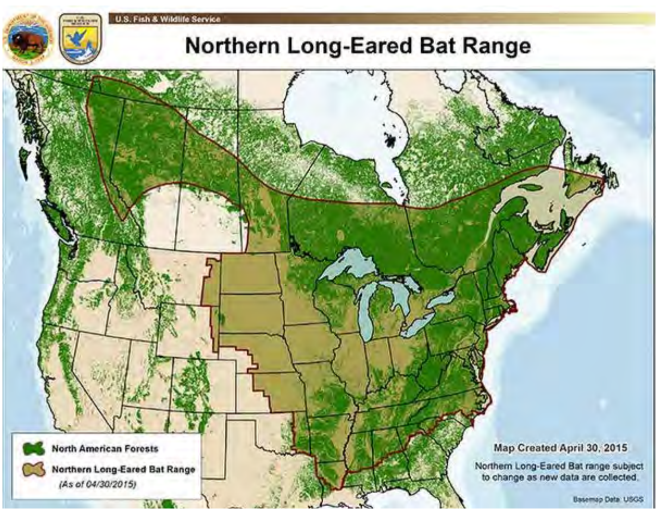

Figure 1. Northern long-eared bat range. Map courtesy of US Fish and Wildlife Service, 2015.

mammals, including bats, on its reservation. The reservation lies within the level III Northwestern Great Plains eco-region, while the specific site where the northern long-eared bat was detected is in the level IV Moreau Prairie eco-region, within a mile or two of the adjacent level IV Missouri Plateau eco-region (US Environmental Protection Agency 2015). The Moreau Prairie is characterized by buttes, badlands, saltpans and grasslands that typically have alkaline soils less suitable for agriculture than the soils of the adjacent Missouri Plateau (Omernik and Griffith 2008). Representative flora within the site of monitoring includes the following: tree stratum: green ash (*Fraxinus pennsylvanica)*, bur oak (*Quercus macrocarpa*) and eastern cottonwood, (*Populus deltoides*); scrub-shrub stratum: chokecherry, (*Prunus virginiana*), coralberry (*Symphoricarpos orbiculatus*) and Missouri gooseberry (*Ribes missouriense*); forbs and grass stratum: blue grama (*Bouteloua gracilis*), white sagebrush (*Artemisia ludoviciana*), curlycup gumweed (*Grindelia squarrosa*) and prairie dropseed (*Sporobolus heterolepis*).

METHODS

We surveyed for bat species on the SRST reservation at a Moreau Prairie location (Figure 2) in Sioux County, North Dakota, known as Unit 41(N 46° 10.18' W 100° 54.51'). Unit 41 is an area of mixed grass prairie that also includes bluffs, woody draws, scrub and short grass steppe. The land is extremely rugged, and has no regular human presence. There are no residences on Unit 41, and no hunting or other human incursion unassociated with managing Unit 41's bison and wildlife assets is allowed.

Figure 2. Map by county of Standing Rock Indian Reservation with an arrow indicating Unit 41 location.

An ultrasonic microphone was installed on a telescoping microphone mast, approximately 6 m high to minimize noise from vegetation and other interference. The data recording device, a Petterson D500x passive ultrasonic recorder (Bat Conservation Management, Carlisle, PA), was placed on the ground at the base of the microphone mast and protected from bison. Data were stored on compact flash cards, and were then processed and analyzed using the bat species identification software, SonoBat 3.2.1 (SonoBat, Deer Fern Ct, Arcanta, CA). Bat presence, in the form of vocalizations, was determined by frequency of occurrence of identified bat calls, thereby allowing us to estimate species presence.

RESULTS AND DISCUSSION

The monitor recorded from August 18, 2015 through September 23, 2015 for a total of 37 trap nights and yielded recordings from 143 bats from 10 different species. Most significantly, the federally threatened northern long-eared myotis was unequivocally documented. This is the first bat survey conducted within the 3,571.9 square mile Reservation, therefore the data gathered are crucial for benchmarking species diversity and abundance. Table 1 shows data from SonoBat 3.2.1 which reveal a total of 19 northern long-eared bat recordings on the device with an estimated likelihood of presence of 0.997494. Results demonstrated a relatively high diversity of bat species. Figure 3 shows the sonogram results from data analysis through the SonoBat program. Given that the northern long-eared myotis had an estimated likelihood of presence of 0.997494 suggests a very high chance of presence (Table 1). More sampling will be conducted to further investigate the diversity and abundance of bat species on the SRST reservation, and will contribute to the development of crucial conservation management programs on the reservation.

Table 1. The number of individual bats recorded from August 18, 2015 through September 23, 2015 at Unit 41 on the Standing Rock Reservation in North Dakota and the estimated likelihood of their presence.

Species	Number	Est. likelihood of presence
Myotis leibii	35	0.999919
Myotis septentrionalis	19	0.997494
Myotis sodalis	4	0.523413
Myotis lucifugus	1	0.192
Perimyotis subflavus	3	0.805231
Nycticeius humeralis	4	0.615933
Lasiurus borealis	11	0.999837
Eptesicus fuscus	20	0.981117
Lasionycteris noctivagans	38	0.999921
Lasiurus cinereus	8	0.998095

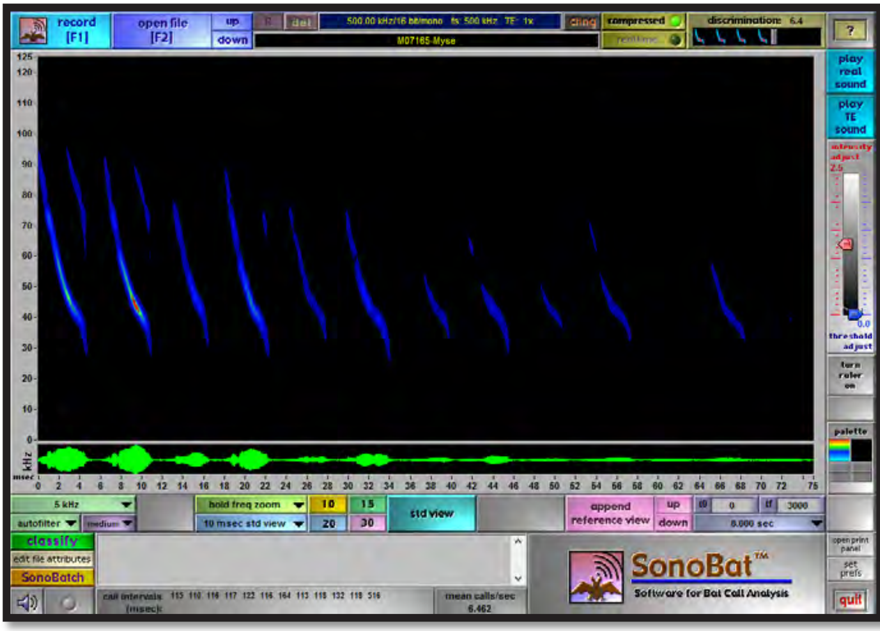

Figure 3. Northern long-eared bat Sonogram from recordings at Unit 41 study site on the Standing Rock Reservation, North Dakota.

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2013

Heavy Metals in Traditionally Used Fruits Among the Lakota

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Tribal Water Alliance
Exhibit 20_____

HEAVY METALS IN TRADITIONALLY USED FRUITS AMONG THE LAKOTA

BY

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HEAVY METALS IN TRADITIONALLY USED FRUITS AMONG THE LAKOTA

This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy in Biological Sciences with Plant Science Specialization degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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For Eugene Buechel

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CONTENTS

ABBREVIATIONS

ANZFA	Australian New Zealand Food Authority (changed to FSANZ)
AAS	Atomic Absorption Spectroscopy
ATSDR	Agency for Toxic Substances and Disease Registry (US Department of Health and Human Services agency)
BMD	Bench mark dose (US EPA)
BMDL	Lower-bound confidence limit of BMD (US EPA)
BONAP	The Biota of North America Program (North America Vascular Flora)
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (US Congressional Superfund Act of 1980)
CDC	Centers for Disease Control (US Department of Health and Human Services)
EC	European Commission (EFSA)
EFSA	European Food Safety Authority
EUR-Lex	European lexicon (a trade name for a business that provides distribution of EC data through a webpage)
FAO	Food and Agriculture Organization (UN)
FSANZ	Food Standards Australia New Zealand
GELs	Generally Expected Levels (of elements, FSANZ, formerly ANZFA)
ICP-MS	Inductively Coupled Plasma-Mass Spectroscopy
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrometry
IRIS	Integrated Risk Information System, US EPA
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LOAEL	Lowest-Observed-Adverse-Effect Level (reference dose, US EPA, IRIS)
MCL	Maximum Contaminant Level (standard set for drinking water, US EPA)

MCLG	Maximum Contaminant Level Goal (goal standard set for drinking water, US EPA)
ML	Maximum Level of Codex Alimentarius Commission permitted in food (WHO/FAO)
ML	Maximum Level of specified contaminant in food (FSANZ, formerly ANZFA)
MRL	Minimum Risk Level (non-cancerous health effect, ATSDR of CDC)
ND	North Dakota
NE	Nebraska
NOAEL	No-Observed-Adverse-Effect Level (without statistical significance, US EPA, IRIS)
NPDWR	National Primary Drinking Water Regulations (or primary standards US EPA)
NPL	National Priorities List (ATSDR)
NRCS	Natural Resources Conservation Service (USDA)
NSF	National Science Foundation (US)
OLC	Oglala Lakota College (Kyle, SD, administrative headquarters location, *Piya Wiconi*
OSPRA	Oglala Sioux Parks & Recreation Authority (Kyle, SD)
OSSPEEC	Oglala Lakota College, South Dakota State University, South Dakota School of Mines and Technology Pre-Engineering Education Collaborative (NSF grant project)
OST NRRA	Oglala Sioux Tribe, Natural Resources Regulatory Agency (Pine Ridge, Reservation, SD)
PEEC	Pre-Engineering Education Collaborative (NSF grant project, see OSSPEEC)
PRG	Preliminary Remediation Goals (US EPA, CERCLA/RCRA, Superfund sites)
PRR	Pine Ridge Reservation

PTWI	Provisional tolerable weekly intake (WHO/FAO)
RBC	Risk-Based Concentration Table (US EPA)
RfD	Oral reference dose (US EPA, IRIS)
RCRA	Resource Conservation and Recovery Act (US)
RSL	Regional screening level (US EPA, CERCLA)
SARA	Superfund Amendments and Reauthorization Act
SD	South Dakota
SDSMT	South Dakota School of Mines and Technology (Rapid City, SD)
SDSU	South Dakota State University (Brookings, SD)
SL	Screening level (US EPA, CERCLA)
SSL	Soil Screening Level (US EPA, CERCLA)
TOSNAC	Technical Outreach Service to Native American Communities
TT	Treatment Technique
UN	United Nations
US	United States
USDA/ NASS	United States Department of Agriculture / National Agricultural Statistics Service
US EPA	United States Environmental Protection Agency
US FDA	United States Food and Drug Administration
USGS	United States Geological Survey
WEERC	Water and Environmental Engineering Research Center laboratory (at SDSU)
WHO	World Health Organization (UN public health division)
WHO/FAO	World Health Organization/Food and Agriculture Organization

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ABSTRACT

HEAVY METALS IN TRADITIONALLY USED FRUITS AMONG THE LAKOTA

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2013

Heavy metals concentrations in soils and plants on and near Pine Ridge Reservation (PRR), SD, are a cause of concern to Oglala Lakota tribal government, particularly because of current and past uranium mining nearby, as well as familiarity with occasional selenium poisoning in livestock. In this study, concentrations of As, Ba, Pb, Se, and U were determined using ICP-OES for selected traditionally edible berries and small fruits, and the soils in which they grow. Results indicated that the heavy metals are likely of natural origin, and ingestion of these culturally important fruits at levels reported in interviews among the Lakota on nearby Rosebud Reservation generally do not exceed US CDC Minimal Risk Levels (MRLs) for chronic oral ingestion, with the possible exception of As in chokecherries and wild rosehips, and U in wild plum and wild rosehips. No US CDC MRL for Pb has been established, because they deem such a standard as inappropriate at the current state of knowledge, with which I agree. However, fruits were compared to the WHO/FAO Maximum Level (ML) permitted for berries and small fruit, with 8.5 per cent of fruit samples from PRR exceeding that standard. Results showed that fruits were generally lower in heavy metals than the soils in which they grew on PRR, with the exception of Se. Some detected concentrations of Se in fruits and other plant tissues at 9 of 15 sites indicated possible bioaccumulation. Wild rosehips on and near PRR were generally higher in heavy metals concentrations than in comparison samples from Brookings County, SD, where Pb concentrations were comparable or slightly higher, and one Se sample was unusually high. Concentrations of heavy metals in soils on PRR ranked substantially lower in As, Ba and Pb and much higher in Se and U compared to USGS arithmetic means and ranges for the conterminous United States established by Shacklette and Boerngen (1984). This study produced preliminary baseline concentrations for fruits and the soils in which they grow on and near PRR and for estimated oral exposure levels based on interviews from nearby Rosebud Reservation, against which other research may be compared.

Key words: ICP-OES, traditional fruits, ethnobotany, soils, Native diet, Pine Ridge and Rosebud Reservations

OVERVIEW OF DISSERTATION

This study began as an outgrowth of my researching heavy metals concentrations in traditionally edible fruits on Pine Ridge Reservation (PRR) in South Dakota from 2011 to 2013, in a project partially funded by the National Science Foundation (NSF). Through interviews with residents of nearby Rosebud Reservation, I estimated the levels of consumption and absorption of the fruits in Chapter 1. Finding that little research existed concerning modern-day uses of traditionally edible fruits and the role they currently play in Lakota culture, another motivation for the Chapter 1 study was to fill that void. Thereby, I updated the ethnobotanical work of others, particularly Melvin R. Gilmore (1919, 1991).

In Chapter 2, I determined concentration levels of heavy metals in traditionally edible fruits and the soils in which they grew on PRR and, thereby, produced estimated baselines for both in a screening study. In addition, I examined possible health implications for those who gather, consume, or otherwise use those fruits and parts of the plants of interest, using data reported in Chapter 1.

CHAPTER 1: ETHNOBOTANY OF THE LAKOTA IN SOUTHWESTERN SOUTH DAKOTA

INTRODUCTION

While some older studies existed concerning the uses of traditionally edible fruits among the Lakota-speaking Teton Sioux, I found scant information about modern cultural practices. The current study provides up-to-date ethnobotanical information from interviews with local residents of Rosebud Reservation concerning their uses of plants of interest. Although particularly focused upon fruits, interviewees described certain other plant parts as foods, beverages, medicines, tonics, religious paraphernalia and crafts, as well as describing the contexts in which they use them currently. Participants also shared preparation methods and short vignettes about their cultural ties to traditionally edible fruits (Appendix A).

Although I recorded interviews on Rosebud Reservation, I collected the actual plant samples on nearby PRR, where permission for interviews remains pending. Residents of the two participating reservations are Teton Sioux (the western Sioux), but they comprise different sub-tribes, *Sicangu Oyate (Brule)* and *Oglala,* respectively.

Concerning the traditionally edible fruit plants selected for this study, they are as follows by common English names and their Latinized species names: buffaloberry (*Shepherdia argentea* [Pursh] Nutt.), buffalo currant (*Ribes aureum,* Pursh var. *villosum* DC.), chokecherry (*Prunus virginiana* L. var. *melanocarpa* [A. Nelson] Sarg.), riverbank grape (*Vitis riparia* Michx.), wild plum (*Prunus americana* Marsh.), and wild roses (*Rosa spp.*).

Other traditionally edible fruits, such as serviceberry (*Amelanchier alnifolia* Nutt.), wild raspberry (*Rubus idaeus* L.), wild strawberry (*Fragraria virginiana* Duchne.), and groundcherry (*Physalis spp.*) would have been of interest, but they were absent or uncommon on PRR. In addition, interviewees on nearby Rosebud Reservation seldom reported those species or their uses in the modern day, due to their scarcity or absence since the locale is too prone to drought.

HYPOTHESIS

The hypothesis of this study is that modern day uses of traditionally edible fruits remain important in Lakota culture (Chapter 1) and increases their risk of exposure to certain heavy metals (restated in Chapter 2).

OBJECTIVES

1. Determine the presence and availability of selected traditionally edible wild fruits among the Lakota in southwestern South Dakota.
2. Determine the extent to which modern Lakota on Rosebud Reservation gather or otherwise obtain those wild fruits.
3. Estimate amounts ingested or other exposures to those wild fruits and related plant parts among the Lakota on Rosebud Reservation, in light of the measured concentration levels of selected heavy metals in such fruits on nearby PRR reported in Chapter 2 of this study.
4. Determine the modern-day uses and cultural importance of the plants of interest among the Lakota on Rosebud Reservation.

BOUNDARIES OF THE STUDY AREA

ROSEBUD RESERVATION

The overall boundaries for the ethnobotanical study encompassed the Rosebud Reservation in south-central South Dakota as depicted in Figure 1. Today's Rosebud Reservation, located in Todd County, South Dakota, is home of a large segment of the *Sicangu Oyate* (*Brule*) Lakota. In addition, the reservation holds trust lands in nearby Mellette, Tripp, Gregory, and Lyman Counties. Historically, in a complicated series of realignments, the boundaries of Todd County changed significantly through time, as noted by Thorndale and Dollarhide (1987).

PINE RIDGE RESERVATION

While I conducted no ethnobotanical interviews on PRR, all of the plant specimens for this study, discussed in Chapter 2, were collected there. Currently, the PRR, home to the Oglala Lakota tribe, comprises all of Shannon County and the southern part of Jackson County with some trust lands in adjacent Bennett County to the east (Fig. 1).

Reservation and county boundaries changed through time, which is of interest because herbarium labels designate plant voucher specimens by county. Therefore, it is worth noting that the boundaries of the reservation in 1910 included all or parts of the following counties: extinct Washington, Shannon, extinct Washabaugh, and Bennett (Long, 2011). According to historian J. Leonard Jennewein, Congress opened nearby

Mellette County for settlement in 1910, although proclaimed in 1911, and "Bennett County was opened at about the same time" (Jennewein, 1961, 440).

By 1920, the PRR boundaries included extinct Washington, Shannon, and extinct Washabaugh Counties. In 1943, Washington County became a part of Shannon County (Thorndale and Dollarhide, 1987), taking effect in 1945 (Long, 1911). Finally, Washabaugh County became part of Jackson County in 1983 (Long, 2011). For purposes of this study, the boundaries for PRR include all of present-day Shannon and the southern part of Jackson Counties. However, in an ongoing dispute with the State of SD, tribal government often includes Bennett County, immediately south of Jackson County, as part of the Greater PRR.

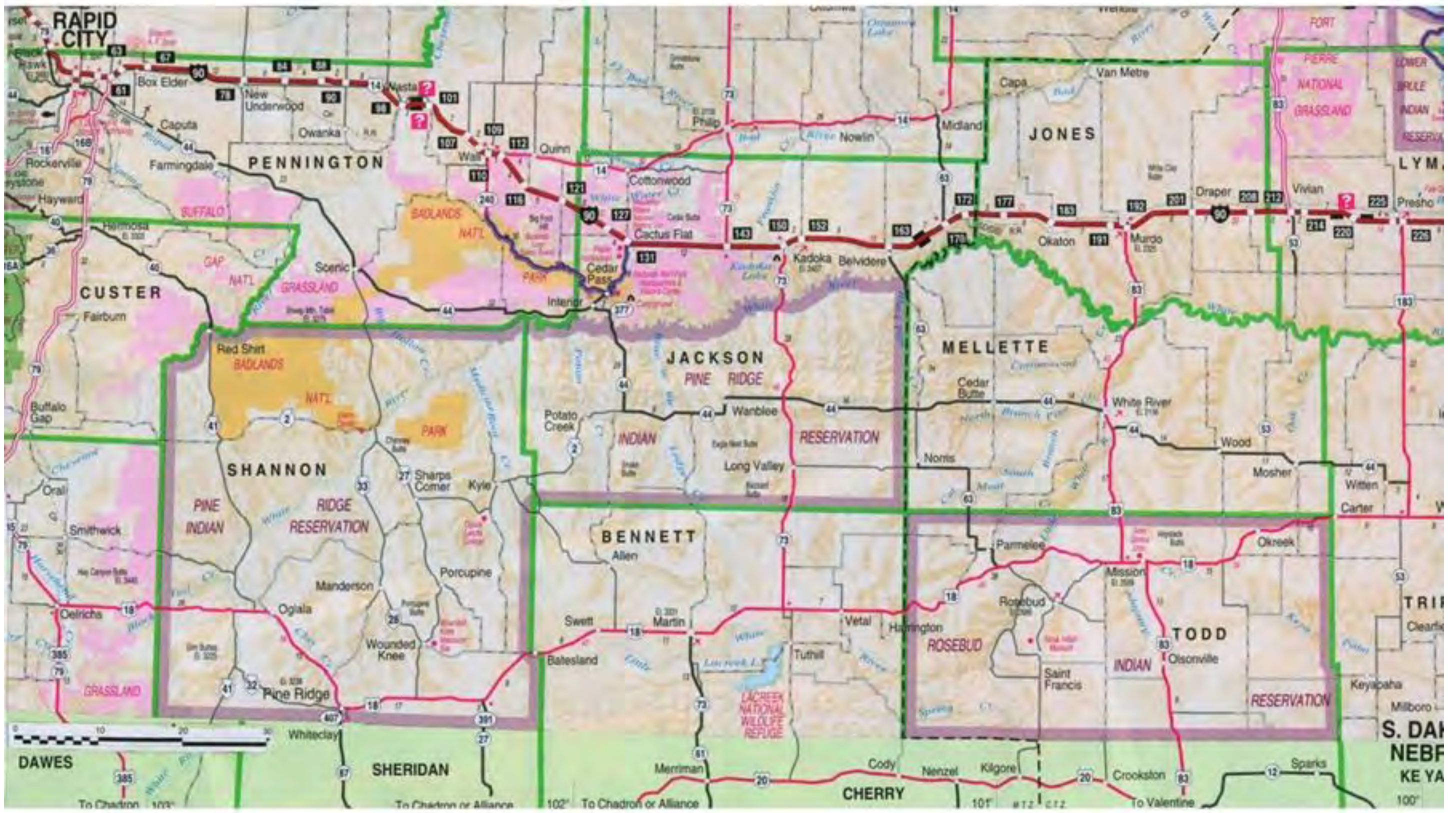


Figure 1. Rosebud and Pine Ridge Reservations from a segment of South Dakota Official Highway Map, 2011. South Dakota Department of Transportation (with permission, State of SD copyright.

LITERATURE REVIEW

In reviewing the literature about the plants of interest on PRR, I began with the current standard book reference for South Dakota, Theodore

Van Bruggen's *The Vascular Plants of South Dakota*, Third Edition (1996). The book was invaluable for identifying plants, but in it Van Bruggen also provided a succinct but detailed history of plant collectors in the state, beginning with the Lewis and Clark Expedition in 1804-1805 to William H. Over's 1932 classic book about the state's vascular plants, with its estimated 1,500 species (Over, 1932, after Van Bruggen, 1996). Van Bruggen also listed herbaria holding South Dakota plant collections, including these: SDSU; University of South Dakota, Vermillion; and Black Hills State College, among others in the state. For those known outside the state, he listed the Smithsonian Institution, University of Kansas, North Dakota State University, and the Missouri Botanical Garden (Van Bruggen, 1996). Since its publication, botanists updated many scientific plant names. Websites used as sources of contemporary scientific Latinized plant names, included the following: the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), "Plants Database," http://wwwplants.usda.gov (USDA, 2013); and The Biota of North America Program (BONAP), "North American Vascular Flora," http://www.bonap.org/ (BONAP, 2013).

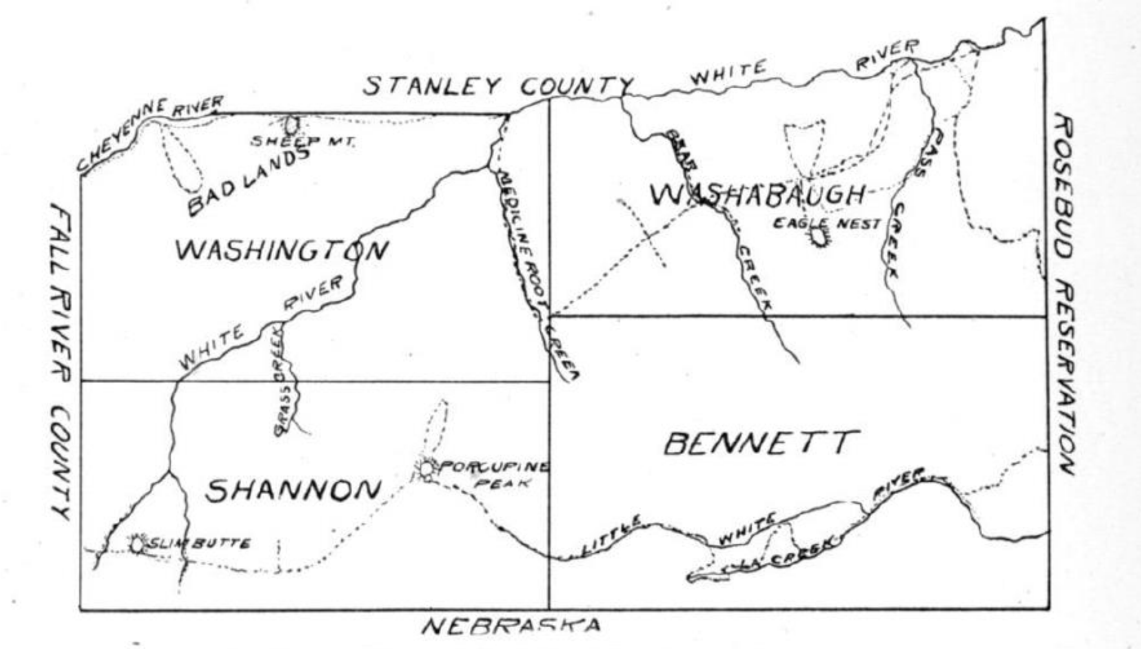
Books used to assist in field identification and to provide contextual information included *Grassland Plants of South Dakota and the Northern Great Plains* (Johnson and Larson, 2007) and *Plants of the Black Hills and Bear Lodge Mountains* (Larson and Johnson 2007). Others of interest included *Atlas of the Flora of the Great Plains* (Great

Plains Flora Association, 1977), *Trees of South Dakota* (Collins and Helwig, ca. 1972), *Plants of South Dakota Grasslands: A Photographic Study* (Johnson, 1970), and *Living Landscapes in South Dakota: A Guide to Native Plantscaping* (USDA NRCS, 2007).

STEPHEN SARGENT VISHER: EARLY BOTANIST ON PINE RIDGE RESERVATION, 1911

Naturalist Stephen Sargent Visher of South Dakota's State Geological Survey, wrote that he collected an estimated 400 species of plants in southwestern South Dakota in the summer of 1911 (1912). About 90 were new to the state's list of plants known to scientists of the day. P. A. Rydberg of the New York Botanical Garden, provided sample specimen identifications for Visher, who published his findings in 1912 and 1913 (Visher, 1912; 1913a-c).

In State Geologist Ellwood C. Perisho's 1912 publication, Visher described his collection as "Plants of the Pine Ridge Reservation," which at that time included Bennett, Shannon, Washabaugh, and Washington Counties as shown in Figure 2 (1912, 109). The latter two counties are currently extinct, and Bennett County is not within the PRR boundaries. Throughout the 1912 and 1913 publications, Visher emphasized his discovering firsts for many plant species in the state. In his section of State Geologist Perisho's multi-topic publication, Visher noted that, "Neither the bad lands nor the sand hills of South Dakota had been botanically explored before, which is an explanation of the large number of species added to the [State of South Dakota's] flora"(1912, 45). Visher and Perisho mapped the locale, delineating the boundaries of Visher's botanical work as shown in Figures 2 and 3 (Visher, 1912; Perisho, 1908 and 1912).



A Sketch Map of the Old Pine Ridge Reservation

Figure 2. Visher's 1911 collection area and the Greater Pine Ridge Reservation. Lines indicate his trek with horses or on foot (Visher in Perisho 1912, 109-110). Washington County is extinct and merged with Shannon. Washabaugh is extinct and merged with Jackson. Bennett is not within borders of the PRR but is often included by locals within what is called the Greater PRR because the tribe owns some parcels of leased trust lands within the county. Courtesy of SDSU Archives & Special Collections, South Dakota State University, Brookings, SD.

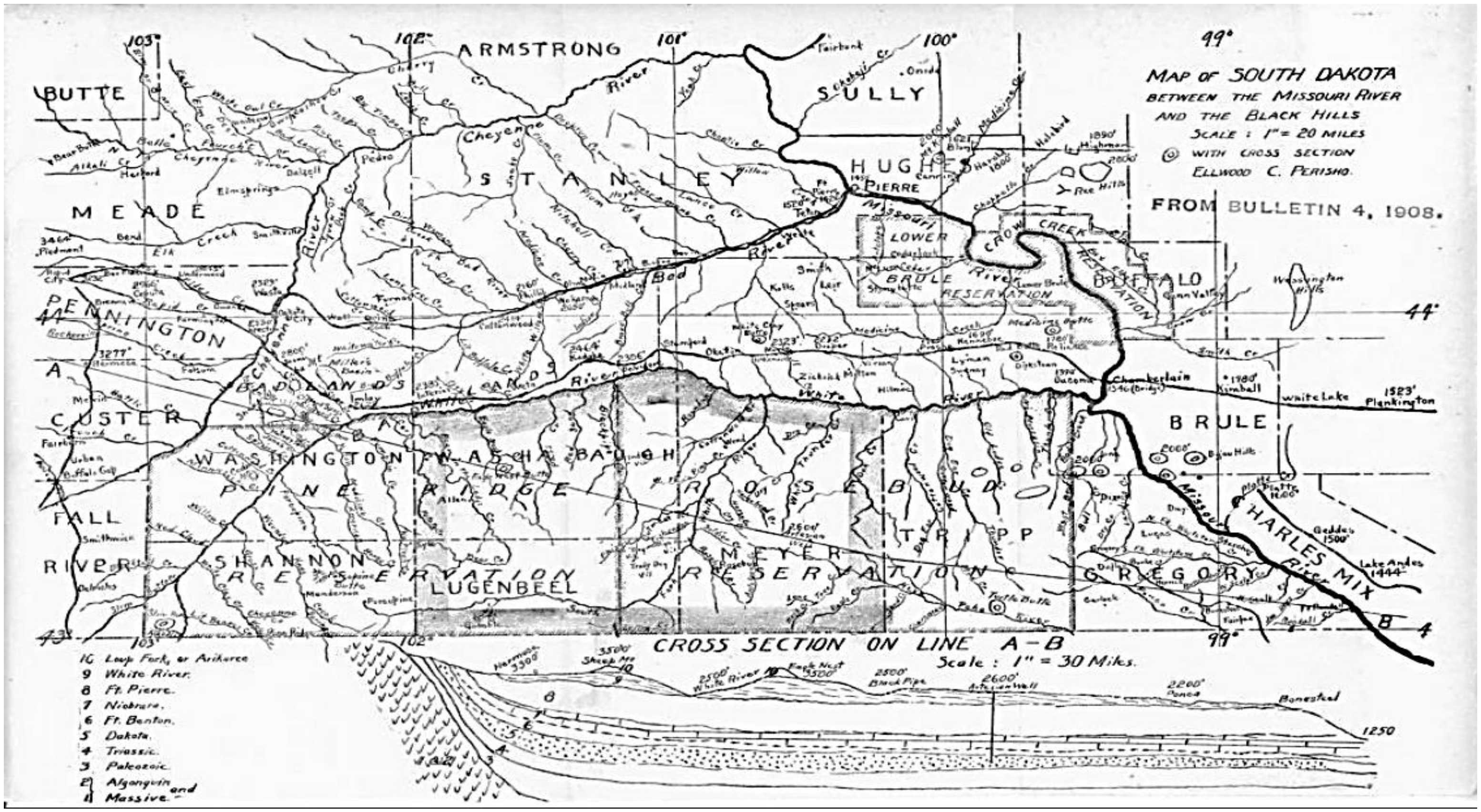


Figure 3. Perisho's map, 1908-1912, Pine Ridge and Rosebud Reservations (1908 and 1912, n.p.). County borders and names, and reservation boundaries changed through time. Not to original scale. Courtesy of SDSU Archives & Special Collections South Dakota State University, Brookings, SD.

Keeping in mind that the plants of interest in the current study are silver buffaloberry, buffalo currant, chokecherry, riverbank grape, wild plum, and wild roses, Visher reported the following concerning his 1911 expedition. Among the estimated 90 new species he added to the state's list, he found buffalo currant, *Ribes aureum* Pursh, (reported by Visher and formerly known as "*Ribes odoratum* Wendl.") and "*Rosa arkansana* Porter, Prairie rose," in Washington County. He collected "Wood rose" (formerly known as "*Rosa maximiliani* Nees.") in Washabaugh County, and "*Rosa suffulta* Greene" (regarded as a synonym of *Rosa arkansana*) in Bennett County (1912, 94-95; 1913c, 48).

In Visher's 1911 overall collection of plants, in the rose section, he reported neither prickly rose, *Rosa acicularis* L., nor smooth rose, *Rosa blanda* Ait.(1912), both of which I collected on the PRR in the current study, although sometimes in an apparently hybridized form. He reported riverbank grape, *Vitis riparia* Michx. as *Vitus volpina* L. in Washabaugh County (Visher, 1912, 99). He collected "Choke Cherry," *Prunus melanocarpa* (A. Nels.) Rydb. [*Prunus virginiana* L.], county not specified, and wild plum, *Prunus americana* Marsh., in Washabaugh County (Visher, 1912, 95). Thus, on Visher's 1911 expedition, he collected most of the plant species in this current study. It is important to note that from the Lakota perspective, local Indian populations knew and used all of these plants for centuries, although, no evidence showed that they distinguished between varieties of wild roses (Kindscher, 1992).

REVEREND EUGENE BUECHEL, S. J.: ETHNOBOTANY AND LANGUAGE STUDY—1917 TO 1923

Although not yet ordained as a Jesuit Roman Catholic priest, Eugene Buechel, (Fig. 4) immigrated to the United States from Europe in 1900, according to Dilwyn Rogers (1980a). Rogers also authored a book about plant uses of the region (1980b). Biographer Reverend Joseph Karol wrote that Buechel was born in Schleida, Thuringia, Germany in 1874 and studied for the priesthood in Germany and in Blyenback, Holland, where he entered the Jesuit order in 1897 (Karol, 1970). Buechel first collected and prepared plant vouchers and assembled ethnographic information, particularly in L dialect (Lakota) language, as a Christian missionary on the PRR (*Oglala* Lakota) and adjacent Rosebud Reservation (*Sicangu Oyate* also known as *Brule*) from 1917 to 1923. Whereas I collected all of the plants in the current study from PRR, Reverend Buechel only collected and vouchered a few plants there. He collected mostly from nearby Rosebud Reservation in present-day Todd County (Rogers, 1980a). His collection remains today on Rosebud Reservation at the local Buechel Memorial Lakota Museum at St. Francis, South Dakota. Buechel's other legacy, a dictionary, included local plant names and uses. He compiled thousands of entries from local residents, but he also included the work of Stephen R. Riggs, Emil Perrig, and Ella Cara Deloria, according to Marquette University's Raynor Memorial Libraries (2013). After Buechel's death in 1954, Reverend Paul Manhart, S. J. [Jesuit, Society of Jesus] edited Buechel's language study, entitled *A Dictionary of the Teton Dakota Sioux Language: Lakota-English: English-Lakota: With Consideration Given to Yankton and Santee Dialects* (Buechel, 1970 and 1983).

Dilwyn J. Rogers, a Professor of Biology at Augustana College in Sioux Falls, South Dakota, wrote Buechel's story and described his botanical collection in a book entitled *Lakota Names and Traditional Uses of Native Plants by Sicangu (Brule) People in the Rosebud Area, South Dakota: A Study on Father Eugene Buechel's Collection of Plants of Rosebud around 1920* (1980a). While still a seminary student, Buechel lived at St. Francis from 1902 to 1904 on Rosebud Reservation. After completing his studies at St. Louis University with ordination in 1906 (Karol, 1970), Buechel returned to South Dakota to Holy Rosary Mission at the village of Pine Ridge on PRR from 1907 to 1916 and again from 1926 to 1929. In the interim and during the remainder of his life, Buechel served as Superior to St. Francis Mission on the nearby Rosebud Reservation (Rogers, 1980a).

Figure 4. Reverend Eugene Buechel with unidentified Natives at Pine Ridge, SD, 1920s. Courtesy Buechel Memorial Lakota Museum Collection, St. Francis, South Dakota.

Buechel mostly collected plant specimens in the vicinity of St. Francis on Rosebud Reservation in present day Todd County, some from nearby Mellette County (non-reservation), and a few from extinct Washabaugh County on PRR (Rogers, 1980a). In addition, Buechel gathered limited data from native informants, mostly from Rosebud Reservation, concerning the uses of the plants for his *Lakota-English Dictionary* (Buechel, 1970; Rogers, 1980a). Rogers characterized Buechel's ethnobotanical work. Buechel corresponded with the famous anthropologist Franz Boas. Buechel determined the taxonomic, Latinized scientific names as best he could, in some cases with the help of the naturalist and museum director William H. Over of the University of South Dakota and from Paul C. Standley, Associate Curator of the Division of Plants, U. S. National Museum, Washington, D. C. In identifying plants, Buechel possibly accessed the three volumes of N. L. Britton and A. Brown's 1913, *An Illustrated Flora of the Northern United States* at St. Francis Mission School (Rogers, 1980a).

Dilwyn J. Rogers examined the plant collection, Buechel's notes, and the *Lakota-English Dictionary* as the basis for his book (1980a). He updated Buechel's scientific names, or lack thereof, based on Theodore Van Bruggen's 1976 book, *The Vascular Plants of South Dakota,* as well as M. R. Gilmore's 1919 book, *Uses of Plants by the Indians of the Missouri River Region*, 1977 edition (Rogers, 1980a). Rogers used parentheses for such updates and other added information in his book (1980a). Buechel reported 293 species in the collection, not counting duplicates, with 245 Lakota names. Buechel noted that 65 other species were named in the *Dictionary* but were not part of the plant collection. Concerning the Buechel collection as a whole, Rogers reported that "quite a few are fruits" (1980a, vi). Buechel included brief notes concerning "Family, Latin Name, Indian Name, Locality, Habitat, Date," and his signature on the specimen sheet labels according to Rogers (1980a, 108-110).

I summarized the plants of interest for the current study based on Rogers' analysis of both Buechel's plant collection and dictionary work (1980a), although pronunciation markings are omitted here. The Buechel collection included buffaloberry, buffalo currant, chokecherry, wild grape [riverbank grape], wild plum, and Woods' rose (Rogers, 1980a). As noted, specimen labels included Lakota names (as in Buechel's *Dictionary*) and some uses such as the following, after Rogers' analysis of Buechel's work. The brackets, below, replaced by commas in the original Rogers' text, indicate Rogers' commentary added to Buechel's work (Rogers, 1980a).

Buffaloberry, reported as "*mastinca pute can*. Means 'rabbit lip tree'. [Fruits are edible.]" (Buechel, 1970, 333; Rogers, 1980a, 44).

Buffalo currant, reported as "*wica gnaskahu*. Means 'male frog stem'. The fruits, *wicagnaska*, are edible. Stems are used for making arrows." Rogers noted that the Lakota name may have been for another species, *Ribes missouriense*-Gooseberry (1980a, 58).

Chokecherry, reported as "*canpa hu*. Means 'bitterwood stem'. Choke cherries, *canpa*, are edible; *canpakaski* refers to mashed, dried cherries; *canpasapa wi* is the month of July when the choke cherries are black ripe. The stems are used for arrows." (Buechel, 1970, 122; Rogers, 1980a, 57).

Wild grape, reported as *Vitis vulpina*, a separate species that ethnobotanists did not originally distinguish from *Vitis riparia*, was probably actually the latter, and was "*cunwi yapehe iyuwi*. Means 'wood used with wind around vine' or 'tangled vine'. [The fruits called *cunwiyapehe* are edible.]" (Buechel, 1970, 124; Rogers, 1980a., 61).

Plum, reported as "*kantahu can*. Means 'plum tree'. The fruits are edible. [*Kanta* is the plum. *Kantasa wi* means 'red plum moon'; this is the month of August when the plums are ripe."] (Buechel, 1970, 112; Rogers, 1980a, 56).

MELVIN R. GILMORE: ETHNOBOTANY AMONG THE LAKOTA

Melvin R. Gilmore collected early pioneering data about traditional plant uses among the Teton Lakota beginning in 1911-1912 (1913). He earned a Ph. D. in botany from the University of Nebraska in 1914. For his "thesis," he enlarged his study to include the Ponca and Pawnee of Nebraska and the Teton Lakota (Cutler 1991, x) of western Nebraska and southwestern South Dakota published in 1919 and posthumously in 1977 and 1991 (Gilmore, 1919, 1977, and 1991).

Gilmore reported that he showed actual plant specimens to those he interviewed to be certain that both he and his informants referred to the same plant. It seems unlikely that he produced plant specimen vouchers during his ethnographic or other botanical work, based on a recent database search by Thomas E. Labedz of the University of Nebraska State Museum's Bessey Herbarium (email from Labedz to Joanita Kant, July 24, 2013).

Gilmore collected ethnobotanical and linguistic information in Nebraska and South Dakota. His work included the Omaha, Ponca, Pawnee, Winnebago, and Sioux (1991, 40). Concerning the Sioux, Gilmore most often included information concerning the "Dakota," and he occasionally listed "Teton dialect," "Santee dialect," and "Yankton dialect" (1991, 68). When Gilmore referred to "the Dakota Nation" (1991, 9) it is uncertain whether he meant the entire Sioux nation, including all of the language dialects or if he simply meant D dialect speakers. Gilmore's charts, summarizing his work, only included "Dakota" words (1991, 103-111) and omitted the other dialects listed with each plant he described (1991, 68).

In the preface of Gilmore's thesis, he described his informants and his "own study of the languages" as follows.

> The information here collated has been obtained at first hand from intelligent and credible old persons, thoroughly conversant with the matters which they discussed. The various items have been rigorously checked by independent corroborative evidence from other individuals of the same tribe and of different tribes through a protracted period. The work of the interpreters employed has also been verified by comparison and by my own study of the languages of the various tribes interviewed (Gilmore, 1991, xvii).

Since Gilmore referred to the "Teton" in his preface, and thanked "Fast Horse and wife, Joseph Horncloud, Otto Chief Eagle, and Short Bull," identifying them as "Teton Dakota" (1919, 4; 1991, xviii), he likely collected information among L dialect speaking Lakota. Concerning the word "Teton," authors of *A New History of South Dakota*, (Thompson, General Editor, 2009, 44), noted that in older literature, "Teton sometimes was used to identify only Oglalas and Brules (the two southern Lakota tribes)… ." Possibly, Gilmore also used the term Teton to mean Oglalas and Brules.

Gilmore also referred to the "Dakota Nation" (1991, 9), possibly simply meaning all of the Sioux, or he could have meant only D dialect speakers, the eastern Sioux. Lakota is the language division for the western Sioux. The eastern and middle Sioux (Santee, Yankton, and Yanktonnais) speak D dialect Dakota. Despite the common historical lapse, probably begun by well-meaning missionaries, who referred to the

Yankton and Yanktonnais as N dialect speakers of Nakota, a dialect that likely never existed according to Parks and DeMaillie (1992, 1-4; 2001, 94-114).

The authors of *A New History of South Dakota* continue to list "Nakota" as a legitimate entity (Thompson, 2009, 44). Gilmore probably believed that the N dialect existed, since he included a "Yankton dialect" word for wild gooseberry (1991, 32). Thus, a dispute among experts concerning whether there were two dialects or three is far from settled.

Below, I compared some of Gilmore's published data (1991) that included various Sioux dialects collected in 1911 and 1912 with that of Reverend Eugene Buechel's that included mostly L dialect, collected beginning in 1917 and continuing into the early 1920s (Rogers 1980a). I omitted their pronunciation markings in the quotations for convenience.

For buffaloberry, Gilmore listed "mashtin cha-pute (Dakota)" meaning "rabbit nose" (1991, 54) rather than Buechel's "mastinca pute can" meaning "rabbit lip tree" (Rogers, 1980a, 17, 44).

Gilmore noted that they ate buffaloberry raw or dried it for later use. Buffaloberry occasionally substituted for chokecherry, among the Dakota in a girl's puberty ceremony (Gilmore, 1991, 36, 54).

Among plants used by the Dakota, Gilmore omitted buffalo currant.

Concerning chokecherry, Gilmore included a photo of a "Teton Dakota" woman pulverizing the fruits [drupes] for drying (1991, 32b). Gilmore recorded the Dakota word for chokecherry as "Chanpa" (1991, 36, 110); whereas, Buechel recorded the Lakota word as "canpa" (Rogers, 1980a, 57). In addition, Gilmore's word for the month when chokecherries ripen differed from Buechel's. Chokecherries, Gilmore wrote, were highly prized by all tribes of the Missouri River region. Gilmore recorded that the Dakota and many tribes used them for "food . . . , old-time ceremonies and rituals as well as . . . stories, songs, and myths" (1991, 36). Gilmore noted that the natives travelled to their favorite spots where the cherries were plentiful. The natives pounded large quantities of chokecherries, pits and all, and formed them into small cakes to dry. The Dakota mixed the final product with dried meat to produce *wasna*, pemmican (Gilmore 1991, 36). Figure 5 shows the process.

Figure 5. Lakota Woman making chokecherry patties, ca. 1920s-1930s, Standing Rock Reservation. Denver Public Library, Western History Collection (catalogue number X-31710). Denver Public Library Digital Collections webpage. Used with permission <http://cdm16079.contentdm.oclc.org/cdm/singleitem/collection/p15330coll22/id/27221/rec/1>.

According to Gilmore, natives called wild grapes "*Hastanhanka* (Dakota); Teton dialect *Chan wiyape*," and the Teton version literally means "tree twiner." They ate wild grapes fresh or dried them for future use (1991, 50). Originally, botanists did not differentiate the two species of wild grapes in the region, but wild grapes in the locale of interest are all probably *Vitus riparia* Michx., not *Vitus vulpina* L., the species recorded by Gilmore.

The Dakota word for plum, Gilmore reported as "*Kante*" (1991, 35), rather than "*Kanta,*" Buechel's Lakota version (Rogers, 1980a, 56). Informants told Gilmore that they pitted the plums before they ate them freshly picked, cooked, or pounded and dried for future use. He also wrote that the Teton Dakota produced prayer wands using plum sprouts and branches. In a ceremony, the wand aided those interceding for the ill according to Dr. J. R. Walker, a Pine Ridge physician interviewed by Gilmore (1991, 35).

In addition, Gilmore recorded the name for wild rose (*Rosa spp.*) as "*onzinzhintka* (Dakota). *Onzhinzhintka-hu*, rosebush" (1991, 33). The only specific use for wild rose, attributed to the Dakota by Gilmore, was in a "Song of the Wild Rose," the translation of which Gilmore attributed to "Dr. A. McG. Beede" (1991, 33). The song lyrics described a time when a Dakota bride attached wild roses to her wedding dress and placed wild roses in her hair. In addition, the song celebrated Mother Earth's many songs including that of the wild rose (1991, 33-34).

OTHER AUTHORS

Of the plants of interest in this study, Kelly Kindscher recorded information about chokecherries and all the relevant wild roses among prairie tribes (1992, 189-193). He wrote that chokecherry was the "most important wild fruit to the Indians of the Prairie

Bioregion” including the Sioux (1992, 171, after Kindscher 1987, 177-182 [possibly after Gilmore 1991, 36]). Kindscher noted that Blankenship reported that the “Sioux” made tea from rose plant bark for intestinal ailments, and they masticated the dried roots to treat wounds and to control bleeding (Kindscher, 1992, 171; after Blankenship 1905, 19). Kindscher noted that wild roses frequently hybridize, and that there is no evidence to show that American Indians made distinctions between species (1992, 190), a reason I decided not to differentiate them in this study.

Daniel E. Moerman compiled all of the known uses of plants by Indians in America in a 927-page book entitled *Native American Ethnobotany* (1998) with a condensed version in 2010, *Native American Food Plants: An Ethnobotanical Dictionary*. Moerman included some of the plants in the current study, but I failed to find new information. While neither book helped in that regard, his books helped me to check for major gaps in my literature review.

S. K. Kraft’ s 1990 M. S. thesis, a dietary study on the Standing Rock Reservation of northern South Dakota and southern North Dakota confirmed the frequency of Lakota participants’ eating traditionally edible fruits in the modern day.

Morgan L. Ruelle and Karim-Aly S. Kassam (2011) confirmed the variety of opinions concerning plant knowledge among Elders on Standing Rock Reservation in northern South Dakota and southern North Dakota. The article was a good source of current information on the topic of modern Lakota ethnobotany, confirming that there was considerable diversity of opinions about the uses for traditional reservation plants (2011, 295-307).

Various authors compiled stories and legends that included traditionally edible plants among the Sioux. Examples included “The Story of a Hard Winter” in which a woman picked “rose berries” and gooseberries in the snow to keep from starving (South Dakota Writers’ Project 1987, 77), a story that reinforces the idea of rosehips as an emergency food. Another tale was “Maiden’s Isle,” in which a pelican brings fish and berries to a young woman stranded on an island (1987, 124). Other examples included “The White Fox,” a trickster who might steal buffaloberry jam (Yellow Robe 1979, 43).

RONALD L. MCGREGOR HERBARIUM COLLECTIONS, UNIVERSITY OF KANSAS: COLLECTORS ON PINE RIDGE RESERVATION FROM 1943-1974

Over the years, several persons collected plant specimens on and near PRR. The Ronald L. McGregor Herbarium at the University of Kansas in Lawrence, Kansas, has extensive collections of plants from the Great Plains, including PRR. Collection Manager Caleb A. Morse provided a list of relevant plants currently databased there, although he noted that there is no way to know how many of interest in their collections remain to be processed and databased (e-mail to author November 17, 2011). Morse sent their database records of collections from Bennett, Jackson, Shannon, and Washabaugh Counties at my request (Ronald L. McGregor Herbarium, 2011). Of 297 entries for individual plants, including locations, remarks, date collected, and collectors, 139 were probably from within the current boundaries of PRR. None of those from within the reservation boundaries included the plants of interest for this dissertation. However, other records of general interest included 70 entries for northern Jackson County and 88 in Bennett County, both outside the reservation boundaries. Their database showed that in

1970, Steve Stephens and Ralph E. Brooks collected buffalo currant (*Ribes aureum* var. *villosum* DC.) in Bennett County, just south of the PRR boundary, north of Allen, South Dakota. Buechel's name is not included as a collector of plants in their database (Ronald L. McGregor Herbarium, 2011).

HIGH PLAINS HERBARIUM COLLECTIONS, CHADRON STATE COLLEGE, CHADRON, NEBRASKA

The High Plains Herbarium at Chadron State College in Chadron, Nebraska contains close to 60,000 plant specimens. Steven Rolfsmeier, who recently succeeded the late Ronald Weedon as Curator of High Plains Herbarium, summarized their PRR holdings as follows:

> Our database shows about 110 specimen records from the Pine Ridge Reservation, with 27% of our collection entered. Our most prolific collectors (16-21 records apiece) are Claire Furman (1977), Lisa Smoke (1998) and Ronald Weedon (1978-1998). The next most prolific (6-13 apiece) are Dawn Holguin (1999), Frank Martinez (1976), Adedoyin Oduye (1974), Brandon Rock (1994) and Bill Tuma (1987). Other minor collectors were Joyce Hardy (1978), and Kyle Metzger (1987). We have 13 collections by J. Sipes (1969) and 7 by Fred Hagmann (1970) that are attributed to Shannon County, though most of Sipes collections were labeled simply "Pine Ridge" and were probably made in Nebraska, and some of Hagmann's localities are questionable too (E-mail Steven Rolfsmeier to author, September 11, 2013).

Within their current database, Rolfsmeier found only three specimens of the plants of interest for PRR, all in Shannon County, including buffalo currant, as "*Ribes odoratum*" [*Ribes aureum*] collected in 1998 by Lisa Smoke, and by Dawn Holguin, J. Holy Rock, and W. Mesteth in 1999. The latter three persons also collected buffaloberry, *Shepherdia argentea*, in 1999.

C.A. TAYLOR HERBARIUM AT SDSU AND OLC COLLECTIONS

Gary Larson, Curator of SDSU's C. A. Taylor Herbarium, reported that few plants from Pine Ridge Reservation were databased there. During the present study, I and student interns added voucher specimens of the plants of interest for their collections, and we provided duplicate copies for the newly established Oglala Lakota College (OLC) herbarium at *Piya Wiconi* campus near Kyle, South Dakota.

CYANIDE POISONING IN PLANTS OF INTEREST

Of the plants of interest in this study, some contain poisonous cyanide, particularly in the pits or achenes. Those include chokecherry, plum, and wild roses. John Kallas found that cyanide can be a concern, as follows.

> The body gets rid of cyanide by exhaling it from the lungs. Many plants you eat contain some cyanide. Eating small amounts is harmless because our body moves it to the lungs where you breathe it out. Ingest too much cyanide, however, and you overwhelm your lungs' ability to clear it, so it builds to harmful levels—harmful enough that it can kill you (2010, 40).

Dilwyn J. Rogers noted that while some plants, such as chokecherry, contain cyanide, "pounding and drying or cooking" render them harmless. He confirmed what has long been known, however, that cyanide-laden twigs and leaves of chokecherries can be poisonous to livestock (1980b 4, 90) David Ode recorded that cyanide, particularly common in the rose family and many others, "will poison livestock only if they are consumed in large amounts without prior exposure." In addition, Ode noted that "many animals can detoxify cyanide-containing compounds . . . if they consume small amounts of it over an extended period of time" (2006, 155).

METHODS AND MATERIALS

The interview instrument included both quantitative and qualitative, structured, and open-ended, pre-determined questions (Appendix B) in which paid informants participated in hour-long oral interviews. The use of quantitative questions helped to determine the estimated amounts and routes of exposure (ingestion and absorption) of the traditionally edible fruits of interest for use in Chapter 2 of the study. I asked participants to respond in quantities of “measuring cups” (one cup equals 240 mL or 0.23659 L by volume) as a handy common household unit of measure, after considering their advice about the best measurement to use.

B. L. Berg’s spiraling qualitative research method undergirds the research, allowing flexibility, reassessment, and changes in a continuous process until developing a suitable research plan (2004). Thereby, I adapted methodological triangulation as central to the plan, whereby multiple lines of sight allowed a greater depth of understanding of the native perspective about the role of traditionally edible fruits in the modern day. Specifically, in the spiraling method, I determined the basic facts of the situation and then introduced more details, maintaining flexibility in a partnership with interviewees. Their opinions mattered, concerning the direction of the research, including ethical behavior and cultural sensitivities, particularly when discussions involved spiritual beliefs. The technique of triangulation of various perspectives added more depth of understanding by incorporating the variety of native viewpoints by asking each interviewee to tell me about traditionally edible fruits in their lives and by making their “stories” an integral part of the research.

Thus, my concern was how and why interviewees collected and used the fruits in the modern day. Further refinement, as proposed in Berg's methodological qualitative spiral (2004), resulted in the final qualitative question, "Do you have a related story that you want to tell?" (Appendix B). The literature review and a conversation with Cornelia White Feather, the first local informant, heavily influenced the adding of that final question. Those stories provided rich context for the role these fruits play in Lakota culture in the modern day. Their personal stories humanized the study, provided a particularly unique local viewpoint, and allowed unstructured native participation, where they added legacy information for future generations.

DATA COLLECTION

I conducted some interviews at St. Francis Mission guest house which served as field headquarters from August 20 to 26, 2012. Geraldine Provencial offered the use of the family's home and their food concession booth at the Rosebud Fair, where I conducted other interviews. In the process of data collection, I showed the participant the list of questions, asking for responses in that order (Appendix B) and recorded responses by typing them into a Word document on a personal computer, since most participants declined being tape recorded. I provided color photographs of the plants under discussion in case a participant was unsure of the identity of the plant in question. This rarely happened.

Concerning data collection, ethical boundaries existed for the study. As a part of the Institutional Review Board/ Reservation Review Board (IRB/RRB) process, NSF-supported Principal Investigator, Dr. Bruce Berdanier, and NSF-supported graduate student, Joanita Kant, obtained training and certification in the ethical treatment of human subjects through the National Institutes of Health (NIH), and/or through the Collaborative Institutional Training Initiative (CITI) subscription services providing on-line education.

Rosebud tribal government granted permission to conduct interviews and to collect stories, but all activities were wholly dependent upon permissions from their Reservation Review Board (RRB), facilitated by Elders serving on their Historical Preservation Commission. Rosebud tribal government required National Institute of Health (NIH) certification and standardized protocols prior to conducting research within their jurisdiction. As a result, I provided interviewees with documents explaining their rights. In addition, Rosebud tribal government's RRB and SDSU's IRB officers required detailed explanations of the proposed plan as shown in Appendix B. After receiving the necessary approvals, I conducted the interviews.

I requested permission to conduct oral interviews on PRR in 2012 and 2013, but at the time of this writing, the requests remained pending.

Interviewees on Rosebud Reservation signed and received copies of the following forms: Information Sheet and Consent Form (Appendix B), a W-9 Request for Taxpayer Identification Number and Certification, and a payment voucher from the South Dakota Humanities Council grant. The information sheet and consent form complied with the IRB/RRB and with general ethical concerns for studies of this type. Each interviewee received a 60 dollar check for their time and services, with funding provided by a grant from the South Dakota Humanities Council and administered by the South Dakota State University Foundation. I advised each interviewee that this study relates to my heavy metals analysis of traditionally edible fruits on PRR, including assays for arsenic, barium, lead, selenium, and uranium.

The Cultural Review Board's Elder Advisory Council for the Tribal Historic Preservation Office granted preliminary permission to use the interviews, acting for the Rosebud tribal RRB, through the efforts of Susie Blacksmith of the *Mni Wiconi* Program at Rosebud, SD. The Elders required a meeting where I explained the proposed project and required forms. Within a month of taking interviews, Rosebud Elders, acting for the Rosebud RRB, received an edited copy. They gave tentative approval but required that the entire dissertation, of which the interviews are a part, be subject to their review and approval before considering granting final permission to use the interviews.

Geraldine Provencial and Cornelia White Feather helped recruit participants. In addition, two interviewees served on the Elder Advisory Council for Tribal Historic Preservation, since they expressed interest when we met during the RRB process. They participated in those two interviews by telephone on September 12, 2012, and on October 4, 2012 by United States Postal Service mail; whereas, all others were face to face at various places on Rosebud Reservation in August 2012.

DATA PREPARATION AND ANALYSIS

Interviews numbered 32. I recorded participants' names, except for those who requested anonymity, and I extracted or estimated the ages of participants from the interviews. I recorded the quantity of each traditionally edible fruit and the intended use. In order to produce a final document (Appendix A), I edited interviews as soon as possible after collection. I searched the edited interviews and extracted data needed to meet the objectives of this study.

Of the 32 participants interviewed, 18 were women and 14 were men. Twenty-five per cent selected anonymity. Twenty-eight participants self-identified as enrolled members of the Rosebud. Others reported as follows: one Lakota at the Cheyenne River Reservation in South Dakota, one Santee Dakota enrolled in Nebraska, one Lakota who cannot obtain enrollment because she lacks the documentation, and a non-native who lives near the reservation in Nebraska but who is a life-long laborer on the Rosebud Reservation and who considers himself culturally integrated.

The estimated age in years of more than 78 per cent of those interviewed was from their 40s to their 60s with a mean of about 50 years. Five participants were in their 20s or 30s, 25 in their 40s, 50s, or 60s, and only two in their 70s or 80s. The age factor in the study was likely influenced by the method of attracting participants by word of mouth, probably creating the expectation that only those with significant interest and experience with traditionally edible fruits should come forward. As noted, results indicated that the subject of traditionally edible fruits was more important to the middle age and older participants rather than to the younger. The study also probably attracted fewer elderly participants (70s and older) because of the necessity of their travelling to a site where the interviews were being conducted, in most cases, possibly presenting a hardship. In recruiting participants, I obtained as wide a range of adult ages as circumstances allowed and tried to interview an equal number of each gender. The study was not meant to be a history, although interviewees consistently reported that their current uses of traditional fruits were affected by historical customs. During interviews, I often redirected the focus of participants to the uses of the plants in the present day.

RESULTS

PRESENCE AND AVAILABILITY OF FRUITS

I confirmed that the traditionally edible fruits selected for this study are widespread on both Rosebud and Pine Ridge Reservations where local residents continue to collect and to use them. The plants of interest grow wild throughout both reservations, and local residents commonly harvest them at no cost. The plants of interest are so widespread that I often viewed them from a truck while driving on paved highways throughout both reservations. All of the fruits grew sporadically in road ditches. Most often, I found all of the plants of interest along the edges of wooded draws, floodplains, rivers, creeks, and intermittent drainages. Wild roses grew in such settings, but wild roses also abundantly inhabited treeless badlands and pastures. Buffaloberries sometimes dotted the pasture landscapes or grew at a short distance from hardwoods fringed with chokecherry and plum bushes. Riverbank grapes clung to hardwoods and bushes, and they generally avoided growing in treeless grasslands lacking shrubs.

The plants of interest did not necessarily set fruit each year, influenced by the age, health, and gender of the plant (as in the case of buffaloberries), precipitation, weather, pollination problems, and destruction by cattle or deer. Interviewees reported that their families had secret places where they collected the best fruit, and the locations were not to be shared with others.

Interviewees reported that occasionally some raw fruits were sold at fairs, *wacipis* (dances), and other events. One interviewee sold bottled plum juice at the Rosebud Fair in 2012. One participant reported that Hutterites from eastern South Dakota traded chickens for permission to pick wild grapes on her land in the recent past. In their ethnobotanical study on Standing Rock Reservation, Ruelle and Kassam also reported that Hutterites came to the reservation to buy wild grapes (2011, 301). Several participants reported that they would buy traditionally edible fruit products in local grocery stores if they were available. One interviewee noted that she bartered in exchange for wild fruits. Thus, although limited, traditionally edible fruits are part of the economy in Lakota culture.

INGESTION, EXPOSURE, AND MODERN DAY USES

Participants reported consuming traditionally edible fruits by mouth either as food, beverage, tonic, or medicine—or some such combination—within the previous five years. Although some reported topical absorption exposures such as face painting or the dying of porcupine quills with the fruits in the past, no one reported such present day uses. Exposure to the fruits through skin absorption was reported as minimal. Their current skin exposure to the traditional fruits occurred when picking fruits and preparing them for immediate or later use. In addition, a few participants reported occasionally making small craft or religious items with peeled twigs and branches from chokecherry or plum bushes, but not often, and production was low. Those chokecherry branch items most often included frames for dream catcher wall hangings as shown in Figure 6 or, in one case, for pipe tampers and vision quest sticks. Some reported experiencing significant skin exposure to chokecherry plant juices, in particular, because the berries are often ground, formed into patties by hand, and dried for later use.

Figure 6. Scraped chokecherry branch wall-hanging produced by a Lakota craft worker and offered for sale at an outdoor craft booth near Wounded Knee, PRR, 2013.

Concerning amounts of ingestion, some participants collected and used all of the traditionally edible fruits in the study, while others use only a few. The most common use was simply for food, followed by beverage, medicine (spiritual or physical), and tonic (health supplement or disease preventative).

Interviewees estimated of amounts of each fruit they ingested, along with their uses as food, beverage, tonic, or medicine (Tables 1 through 6) in response to the question “How much, in measuring cups, would you estimate that you eat of each of the following traditionally edible fruits in one year’s time in an average year over the past five years.” I explained that I meant a year of sufficient rainfall in a year of good production of fruits. They reported that the fruits used the most were chokecherry and wild plum. Tables 1-6 indicate use by fruit type ranged from no use to 100 cups (23.66 L) per year of buffaloberry with an average of 2.77 cups (0.60 L), from no use to 100 cups (23.66 L) per year for buffalo currant with an average of 2.55 cups (0.60 L), from one to 150 (35.49 L) cups per year for chokecherry with an average of 16.88 cups (3.99 L), from no use to 80 cups (18.93 L) per year for riverbank grape with an average of 4.28 cups (1.01 L), from 0.50 cup (0.12 L) to 150 cups (35.49 L) per year for wild plum with an average of 15.28 cups (3.62 L), and from no use to 64 cups (15.14 L) per year for rosehips from wild roses with an average of 3.39 cups (0.80 L) (or much less frequently, as wild rose leaves for tea). There is such variation in the amounts of ingestion that it is more instructive to consider exposure on a case by case basis. The means, medians, and standard deviations, above, as shown in Tables 1 and 2 for buffaloberry and buffalo currant, respectively, do not include interviewee 18 as extreme outliers at 100 cups.

Table 1. Buffaloberry use by participant in cups in a good production year within the last five years. Key: * statistics not including No. 18, extreme outlier.

Participant Name	Number	Buffaloberry in Cups	in Liters	Used As
Cornelia White Feather	1	0	0	
Carole A. Provencial	2	0	0	
Byron Provencial	3	0	0	
Melvin Guerue	4	12	2.84	T
Anonymous	5	1	0.24	F
Michael White Buffalo Chief	6	2	0.48	FB
Anonymous	7	4	0.96	F
Sidney Reddest, Jr.	8	2	0.48	F
Leston Brewer	9	2	0.48	F
Keith Murray	10	5	1.18	F
Nicol Burow	11	0	0	
Maria Iyotte	12	0	0	
Leana Long Pumpkin	13	2	0.48	FB
Carol Black Elk	14	4	0.96	F
Nellie Eagleman Black Owl	15	2	0.48	F
Stanley Little Thunder	16	5	1.18	F
Sam High Crane	17	1	0.24	FM
Anonymous*	18	100	23.66	F
Anonymous	19	4	0.96	F
Anonymous	20	1	0.24	F
Altine Black Lance	21	5	1.18	F
Sylvan White Hat, Sr.	22	0	0	
Anonymous	23	0	0	
Larry Black Lance	24	1	0.24	F
Aloysius Running Horse	25	1	0.24	F
Clayton High Pipe	26	3	0.71	F
Greg P. Quigley	27	16	3.79	TM
Anonymous	28	0	0	
Audrey Bear Dog	29	4	0.96	FBTM
Anonymous	30	8	1.89	F
Delores Kills In Water	31	0	0	
Violet Little Elk	32	1	0.24	F
mean*		2.77	0.66	
median*		2.00	0.48	
standard deviation*		3.59	0.85	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 2. Buffalo currant use by participant in cups in a good production year within the last five years. Key: * statistics not including No. 18, extreme outlier.

Participant Name	Number	Buffalo Currant in Cups	in Liters	Used As
Cornelia White Feather	1	2.00	0.48	F
Carole A. Provencial	2	0.00	0.00	
Byron Provencial	3	2.00	0.48	F
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	1.00	0.24	F
Michael White Buffalo Chief	6	2.00	0.48	FB
Anonymous	7	6.00	1.44	FM
Sidney Reddest, Jr.	8	3.00	0.72	F
Leston Brewer	9	0.00	0.00	
Keith Murray	10	5.00	1.18	F
Nicol Burow	11	0.00	0.00	
Maria Iyotte	12	4.00	0.96	FB
Leana Long Pumpkin	13	2.00	0.48	F
Carol Black Elk	14	4.00	0.95	F
Nellie Eagleman Black Owl	15	1.00	0.24	F
Stanley Little Thunder	16	2.00	0.48	F
Sam High Crane	17	4.00	0.95	FM
Anonymous*	18	100.00	23.66	F
Anonymous	19	0.00	0.00	
Anonymous	20	0.00	0.00	
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	0.00	0.00	
Anonymous	23	0.00	0.00	
Larry Black Lance	24	0.00	0.00	
Aloysius Running Horse	25	1.00	0.24	F
Clayton High Pipe	26	0.00	0.00	
Greg P. Quigley	27	4.00	0.96	TM
Anonymous	28	0.00	0.00	
Audrey Bear Dog	29	8.00	1.89	FBTM
Anonymous	30	16.00	3.79	F
Delores Kills In Water	31	0.00	0.00	
Violet Little Elk	32	1.00	0.24	F
mean*		2.55	1.36	
median*		2.00	0.48	
standard deviation*		3.30	4.14	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 3. Chokecherry use by participant in cups in a good production year within the last five years.

Participant Name	Number	Chokecherry in Cups	in Liters	Used As
Cornelia White Feather	1	5.00	1.18	F
Carole A. Provencial	2	8.00	1.89	F
Byron Provencial	3	12.00	2.84	F
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	10.00	2.37	FB
Michael White Buffalo Chief	6	3.00	0.71	FBM
Anonymous	7	12.00	2.84	FBM
Sidney Reddest, Jr.	8	12.00	2.84	F
Leston Brewer	9	2.00	0.48	F
Keith Murray	10	9.00	2.13	F
Nicol Burow	11	2.00	0.48	F
Maria Iyotte	12	2.00	0.48	FB
Leana Long Pumpkin	13	80.00	18.93	FBTM
Carol Black Elk	14	2.00	0.48	FBM
Nellie Eagleman Black Owl	15	2.00	0.48	FB
Stanley Little Thunder	16	5.00	1.18	FB
Sam High Crane	17	6.00	1.42	FBM
Anonymous	18	16.00	3.79	F
Anonymous	19	8.00	1.89	F
Anonymous	20	8.00	1.89	F
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	6.00	1.42	F
Anonymous	23	5.00	1.18	F
Larry Black Lance	24	1.00	0.24	FM
Aloysius Running Horse	25	30.00	7.10	FB
Clayton High Pipe	26	16.00	3.79	FM
Greg P. Quigley	27	16.00	3.79	TM
Anonymous	28	150.00	35.49	F
Audrey Bear Dog	29	80.00	18.93	FBTM
Anonymous	30	16.00	3.79	F
Delores Kills In Water	31	4.00	0.95	FB
Violet Little Elk	32	1.00	0.24	F
mean		16.88	3.99	
median		7.00	1.66	
standard deviation		30.19	7.14	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 4. Riverbank grape use by participant in cups in a good production year within the last five years.

Participant Name	Number	R. Grape in Cups	in Liters	Used As
Cornelia White Feather	1	5.00	1.18	F
Carole A. Provencial	2	1.00	0.24	F
Byron Provencial	3	0.00	0.00	
Melvin Guerue	4	6.00	1.42	FT
Anonymous	5	1.00	0.24	F
Michael White Buffalo Chief	6	4.00	0.95	F
Anonymous	7	5.00	1.18	FB
Sidney Reddest, Jr.	8	0.50	0.12	F
Leston Brewer	9	2.00	0.48	FB
Keith Murray	10	2.00	0.48	F
Nicol Burow	11	0.00	0.00	
Maria Iyotte	12	0.00	0.00	
Leana Long Pumpkin	13	80.00	18.93	F
Carol Black Elk	14	2.00	0.48	F
Nellie Eagleman Black Owl	15	0.00	0.00	
Stanley Little Thunder	16	2.00	0.48	FB
Sam High Crane	17	0.50	0.12	FM
Anonymous	18	0.00	0.00	
Anonymous	19	0.00	0.00	
Anonymous	20	0.00	0.00	
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	0.00	0.00	
Anonymous	23	0.00	0.00	
Larry Black Lance	24	1.00	0.24	F
Aloysius Running Horse	25	0.00	0.00	
Clayton High Pipe	26	1.00	0.24	FM
Greg P. Quigley	27	0.00	0.00	TM
Anonymous	28	0.00	0.00	
Audrey Bear Dog	29	16.00	3.79	F
Anonymous	30	2.00	0.48	F
Delores Kills In Water	31	0.00	0.00	
Violet Little Elk	32	1.00	0.24	F
mean		4.28	1.01	
median		1.00	0.24	
standard deviation		13.94	3.30	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 5. Wild plum use by participant in cups in a good production year within the last five years.

Participant Name	Number	Wild Plum in Cups	in Liters	Used As
Cornelia White Feather	1	5.00	1.18	F
Carole A. Provencial	2	4.00	0.95	F
Byron Provencial	3	6.00	1.42	F
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	4.00	0.95	FM
Michael White Buffalo Chief	6	10.00	2.37	FBM
Anonymous	7	12.00	2.84	FM
Sidney Reddest, Jr.	8	6.00	1.42	F
Leston Brewer	9	1.50	0.35	F
Keith Murray	10	0.50	0.12	F
Nicol Burow	11	1.00	0.24	F
Maria Iyotte	12	4.00	0.95	F
Leana Long Pumpkin	13	16.00	3.79	F
Carol Black Elk	14	1.00	0.24	F
Nellie Eagleman Black Owl	15	3.00	0.71	B
Stanley Little Thunder	16	4.00	0.95	F
Sam High Crane	17	12.00	2.84	FM
Anonymous	18	80.00	18.93	F
Anonymous	19	8.00	1.89	F
Anonymous	20	3.00	0.71	F
Altine Black Lance	21	5.00	1.18	F
Sylvan White Hat, Sr.	22	6.00	1.42	F
Anonymous	23	5.00	1.18	F
Larry Black Lance	24	3.00	0.71	F
Aloysius Running Horse	25	30.00	7.10	F
Clayton High Pipe	26	10.00	2.37	FM
Greg P. Quigley	27	32.00	7.57	TM
Anonymous	28	150.00	35.49	FBM
Audrey Bear Dog	29	32.00	7.57	F
Anonymous	30	16.00	3.79	F
Delores Kills In Water	31	12.00	2.84	F
Violet Little Elk	32	1.00	0.24	F
mean		15.28	3.62	
median		6.00	1.42	
standard deviation		28.45	6.73	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Table 6. Wild rose use by participant in cups a good production year within the last five years. Most often rosehips were used, but, occasionally, leaves were used for tea.

Participant Name	Number	Wild Rose in Cups	in Liters	Used As
Cornelia White Feather	1	0.00	0.00	
Carole A. Provencial	2	0.00	0.00	
Byron Provencial	3	0.00	0.00	
Melvin Guerue	4	6.00	1.42	T
Anonymous	5	2.00	0.47	B
Michael White Buffalo Chief	6	1.00	0.24	FB
Anonymous	7	2.00	0.48	B
Sidney Reddest, Jr.	8	0.00	0.00	
Leston Brewer	9	0.00	0.00	
Keith Murray	10	0.00	0.00	
Nicol Burow	11	0.00	0.00	
Maria Iyotte	12	0.00	0.00	
Leana Long Pumpkin	13	2.00	0.47	BTM
Carol Black Elk	14	2.00	0.47	BM
Nellie Eagleman Black Owl	15	2.00	0.47	F
Stanley Little Thunder	16	0.00	0.00	
Sam High Crane	17	0.00	0.00	
Anonymous	18	16.00	3.79	F
Anonymous	19	0.00	0.00	
Anonymous	20	0.00	0.00	
Altine Black Lance	21	10.00	2.37	B
Sylvan White Hat, Sr.	22	0.00	0.00	
Anonymous	23	0.00	0.00	
Larry Black Lance	24	0.00	0.00	
Aloysius Running Horse	25	0.00	0.00	
Clayton High Pipe	26	0.50	0.12	T
Greg P. Quigley	27	64.00	15.14	TM
Anonymous	28	1.00	0.24	B
Audrey Bear Dog	29	0.00	0.00	
Anonymous	30	0.00	0.00	FB
Delores Kills In Water	31	0.00	0.00	
Violet Little Elk	32	0.00	0.00	
mean		3.39	0.80	
median		0.00	0.00	
standard deviation		11.38	2.69	
F=Food, B=Beverage, T=Tonic, M=Medicine				

Participants stated that, generally, they ate more fruit at the time of harvest in mid-summer and early fall when fruit was freshly picked. The majority of participants consumed the fruits year round, however, since it is often dried, frozen, or canned for later use.

They reported not eating ground plum pits, and they usually discarded the achenes (seeds) of rosehips, as well. Concerning the other fruits of interest, they reported sometimes grinding the pits, seeds, and achenes and including them in the dish being prepared, although occasionally they strained and discarded them. In the case of chokecherries, except when eaten raw during harvesting, they often ground the pits during preparation, giving the food a gritty texture, but more flavor. Others reported discarding the chokecherry pits when preparing food and beverages.

Participants reported using the fresh fruits raw, as well as frozen or dried. The various types of uses included a pudding (*wojapi*), a type of trail mix or side dish or pemmican (wet or dry *wasna*), jam, jelly, syrup, juice, candy, popsicles, and rose tea. Some made or consumed rose tea made only from water and tea leaves and others made from rosehips. In addition, they made and used various medicines or tonics from all the fruits. Interviewees reported the final forms of the products made from traditionally edible fruit plants in the past five years on Rosebud Reservation (Table 7).

Table 7. Forms of final product used on Rosebud Reservation.

Plant Common Name	Forms of Final Product
buffaloberry	raw, *wasna, wojapi,* jam, jelly, and juice
buffalo currant	raw, *wasna, wojapi,* jam, jellly, juice, twigs for crafts, and story
chokecherry	raw, *wasna* , *wojapi* , jam, jelly, juice, syrup, dried snack, taffy, lotion for poison treatment, twigs for the following: crafts, pipe tampers, and religious ceremonies
riverbank grape	raw, *wojapi* , juice, syrup, wine, and popsicles
wild plum	raw, *wasna* , *wojapi* , jam, jelly, syrup, plum buttter, dried fruit addition to roasting meat
wild rose	Rosehips as follows: raw, *wojapi* , jelly, juice, tea, and addition to roasting meat, powdered for poison ivy treatment; twigs for crafts; leaves for tea; entire plant for stories

CULTURAL IMPORTANCE

The interviewees on Rosebud Reservation indicated that traditionally edible fruits remain an important part of cultural life. Among interviewees, the percentages of those using buffaloberry, buffalo currant, chokecherry, riverbank grape, wild plum, and rosehips or rose leaves, respectively, were 72, 66, 100, 59, 100, and 37. Participants often reported the collection, preparation, and use of traditionally edible fruits as important for cultural identity, on a par with Lakota language and Lakota spirituality. The majority of those interviewed reported an obligation to pass on these practices to the next generation. Results showed that traditionally edible fruits and certain plant parts remained a part of Lakota folklore, storytelling, and rituals, and their use happily reminded many of their younger years and their ancestors. Most of those interviewed noted that traditionally edible fruits play a key role in cultural cohesion and in the embeddedness of Lakota spiritual life. They reported the fruits used at spiritual, healing, and naming ceremonies; funerals and wakes; and at dinners and meetings where important decisions were made. In addition, many used the fruits to honor the Elders, to cure ailments, to improve health, or to share as reciprocal gifts.

DISCUSSION AND CONCLUSIONS

The interviews from Rosebud Reservation provided new information about the continued presence and availability of traditionally edible fruits there. While traditionally edible fruits and their plant parts constituted a valuable resource among the Lakota in the past, the present study provided details concerning the fruits' importance in Lakota culture in the modern day. Although participants did not report the fruits of interest as a main staple of their daily diets, results indicated that considerable gathering and using of the plants of interest continues, although less so than in the last century. S. K. Kraft confirmed, in a 1990 M. S. thesis for the University of North Dakota, that the fruits did not constitute a staple of the daily diet in research among the Lakota on Standing Rock Reservation.

Generally, the older participants on Rosebud Reservation reported more interest and more usage than those younger, although results showed that the fruits are not a major component of the daily diet for most participants of any age. Most reported that they expected the fruits to be served at important events, particularly at wakes, funerals, and spiritual ceremonies. The most ingestion occurred around harvest time in July and August, although they generally reported eating dried, frozen, and canned fruits throughout the year. They reported the fruits and plant parts as intertwined with Lakota spirituality and identity, describing specific uses as foods, beverages, medicines, and tonics, with limited uses for crafts, utilitarian, and religious paraphernalia. I found considerable diversity in opinions about the general topic of traditionally edible fruits on Rosebud Reservation. That finding confirmed trends reported by Morgan L. Ruelle and Karim-Aly S. Kassam in their ethnobotanical research among the Lakota on Standing Rock Reservation (2011, 295-307).

Interviewees estimated the amounts ingested for each of the fruits of interest as highly variable from individual to individual, in the most extreme cases, by as much as 145.5 cups (34.42 L) per year for some fruits of interest. From interviewee data, I estimated exposure levels to certain estimated heavy metals concentrations detected in traditionally edible fruit and plant samples from nearby PRR, the focus of Chapter 2.

RECOMMENDED FUTURE RESEARCH

Since results indicated that traditionally edible fruits do not constitute a major component of the daily diet for most of those interviewed on Rosebud Reservation, I recommend total dietary studies in the future. Such studies may provide a more accurate estimation of heavy metals exposure through diet, in light of pockets of elevated heavy metals levels in plants and the soils in which they grow on nearby PRR.

Researchers might consider investigating the potential for economic development of traditionally edible fruits, since interviewees reported them as a valuable commodity with limited current sales or bartering. Furthermore, interviewees indicated a desire to purchase such products if available.

CHAPTER 2: HEAVY METALS ON PINE RIDGE RESERVATION

INTRODUCTION

Pine Ridge Reservation residents expressed concern about heavy metals because they live in a locale where levels are naturally high, particularly for uranium and selenium. Heavy metals selected for the study included arsenic (As), barium (Ba), lead (Pb), selenium (Se), and uranium (U), since they were of particular interest to the Oglala Lakota Sioux Tribe's Natural Resources Regulatory Agency (OST NRRA). Residents were especially interested in this study to help build a database of preliminary baselines for soils and plants on the reservation to help manage their resources. While they were aware of some soil and plant baselines for heavy metals for the conterminous United States, the OST NRRA sought more detailed information from samples unique to PRR. As Gustavsson et al. (2001) noted, soil sampling databases and geochemical mapping are important tools in detecting geochemical variations, anthropogenic disturbances, mineral deposits that might be extracted, and potential health effects, among others. The United States Centers for Disease Control (US CDC) and the United States Environmental Protection Agency (US EPA), as well as others, provide heavy metals standards to help assess potential toxicity in edible plants. The US CDC reports that oral intake standards help professional health risk managers to assess "where to look more closely" (US CDC, 2013 b).

The scientific community lacks a commonly agreed upon definition for the phrase "heavy metals," but the phrase is widely used, in the medical sense, to refer to a variety of elements and their compounds that have the potential for toxicity in humans and animals. Writers of both popular and scientific literature often use the term in referring to elements that may be neither metals nor heavy in terms of density, atomic weight, and number.

HYPOTHESIS

The hypothesis of this study is that modern use of traditionally edible fruits by the Lakota increases their risk of exposure to certain heavy metals, potentially to the point of toxicity (as stated in Chapter 1).

OBJECTIVES

1. Produce preliminary baseline concentration levels of selected heavy metals in certain traditionally edible wild fruits and the soils in which they grow, on (PRR) in a screening study.
2. Compare and contrast observed concentration levels in traditionally edible fruits with a variety of heavy metals standards, guidance, and risk assessments.
3. Determine if ingestion or absorption of traditionally edible fruits increases human exposure to heavy metals to the point of potential toxicity, using exposure data collected in Chapter 1.

BACKGROUND

The background includes (1) concerns about possible uranium contamination among some local residents of PRR and (2) boundaries and geography for the study. The literature review includes (3) other heavy metals studies in soils and sediments in South

Dakota; (4) overviews of the heavy metals of interest; (5) an overview of spectrometry as a common technique for analyses of elements in foods; (6) general health effects of heavy metals toxicity; and (7) selected standards, guidance, and risks assessments for heavy metals in foods and the soils in which they grow.

CONCERNS OF PINE RIDGE RESERVATION RESIDENTS

The Oglala Lakota Sioux Tribe's government is well-aware that the reservation is a locale with high levels of certain heavy metals, particularly uranium and selenium. There has long been concern about the safety of nearby uranium mining among residents of PRR. Uranium is or was extracted in two counties adjacent to the reservation on the west and south. In the 1970s, uranium was mined in Fall River County, SD, and there are current plans to resume operations there. In addition, for over 20 years, Crow Butte uranium mine has operated in bordering Dawes County, Nebraska, near the small town of Crawford. Both mine locations are upstream from the Cheyenne and White Rivers, respectively, that border or flow through the reservation from southwest to northeast, raising the issues of potential surface and groundwater contamination, in particular.

Nebraska Public Broadcasting's Net Radio news caster Fred Knapp reported both sides of the uranium issue on July 7, 2011. Ken Vaughn, who represented Cameco, a Canadian company that owns the Crow Butte mine, assured listeners that the mine operated safely with its injection well technology and land restoration activities. A critic of the mine, geologist Hannan LaGarry, expressed skepticism when interviewed by Knapp. LaGarry, then head of the Math and Science department at the tribally controlled Oglala Lakota College on PRR, expressed concerns about Crow Butte mine safety as follows:

> 'They're forcing oxygenated water down into the ground to force a chemical reaction that wouldn't normally occur . . . and in the process freeing trapped accessory minerals that co-occur with the uranium. And then this becomes a heavy-metal laden soup.
>
> . . . Eventually, it's likely that there will be communication of mining fluids outside of their mining area . . . . There could be what's called an excursion outside their monitoring wells and potentially contaminate the overlying surficial deposits (and) the White River.'

Thus, there is disagreement concerning whether or not uranium mining poses a contamination risk in the locale.

Concern about uranium among residents of PRR is fueled by recent newspaper articles in the Rapid City Journal (2013a and 2013b) and the Sioux Falls Argus Leader (2013). Powertech, a mining company, requested a state permit to mine uranium near Edgemont, SD, in Fall River County, bordering PRR on the west. Lilias Jarding of Rapid City of the grassroots environmental organization, Clean Water Alliance, has been a vocal critic of uranium mining in both Nebraska and South Dakota.

Also drawing attention to the subject of uranium on PRR is the movie *Thunderheart*, produced in 1992 and still available for viewing. The film was shot partially on-location on PRR. The movie kept the uranium issue brewing with its fictionalized story in which residents fought against a conspiracy to harm the reservation through uranium poisoning. Thus, uranium has been viewed by some residents of PRR as an uncertain, potential threat for decades.

In addition, PRR has a history of long-standing concern about potential chemical residue on a World War II era conventional weapons bombing range in the northwest quarter of PRR shown on the maps in Figures 7 and 15. Known locally as the “Bombing Range,” it was a place where United States military aircraft conducted practice bombing runs with wrecked car bodies as targets. A road sign at “Bombing Range Road,” east of the village of Potato Creek, remains as a daily reminder of 1940s Department of Defense activities on the gunnery range (Fig. 8).

In 1998, Mike Lambert of the Hazardous Substances Research Center evaluated potential toxicity of uranium and selenium on the gunnery range on PRR. Lambert’s evaluation was part of Technical Outreach Services to Native American Communities (TOSNAC), a program based on unbiased evaluations presented to native communities concerning activities at former Department of Defense sites (Lambert, 1998).

More recent research suggests that even low levels of naturally occurring uranium can pose health risks. At the time of Lambert’s report, he noted that the highest concentration of “natural uranium” in soils in “southern South Dakota” was 11 ppm in 1998 (probably after Shacklette and Boerngen, 1984). However, the current study indicated the highest concentration of uranium in soils for PRR at 35.94 ppm at Site 8 near Potato Creek village along the southeast border of the former US military gunnery range on PRR.

Lambert compared uranium concentrations of 11 ppm, as above, to 230 ppm from the US EPA Region III’s Risk-Based Concentration (RBC) “table [that] sets a limit of uranium in residential soil of 230 ppm” (Lambert, 1998). The RBCs in Lambert’s report were predecessors of today’s US EPA Regional Screening Levels (RSLs), also known as Preliminary Remediation Goals (PRGs) (Hubbard, 2008). RBCs or PRGs are not meant as stand-alone levels that imply safety. They are, instead, only a first step in clean-up efforts at anthropogenically caused pollution at Superfund Sites or should be used to assess sites not yet on the National Priorities List for Superfund Sites. If naturally occurring background levels exceed PRGs, clean-up is not undertaken at Superfund Sites (US EPA, 2012). Thus far, there is no scientific evidence to show that heavy metals levels on PRR are other than naturally occurring in soils; however uranium concentrations in soils on PRR in the current study are higher than those cited by Lambert.

Lambert (1998) reported that selenium was not a component used in manufacturing conventional bombs during the active period of the gunnery range. He concluded that selenium does not pose a health risk on the bombing range, with the exception of naturally occurring selenium in livestock forage. In particular, Lambert identified loco weed, goldenweed, and prince’s plume as plants naturally high in selenium.

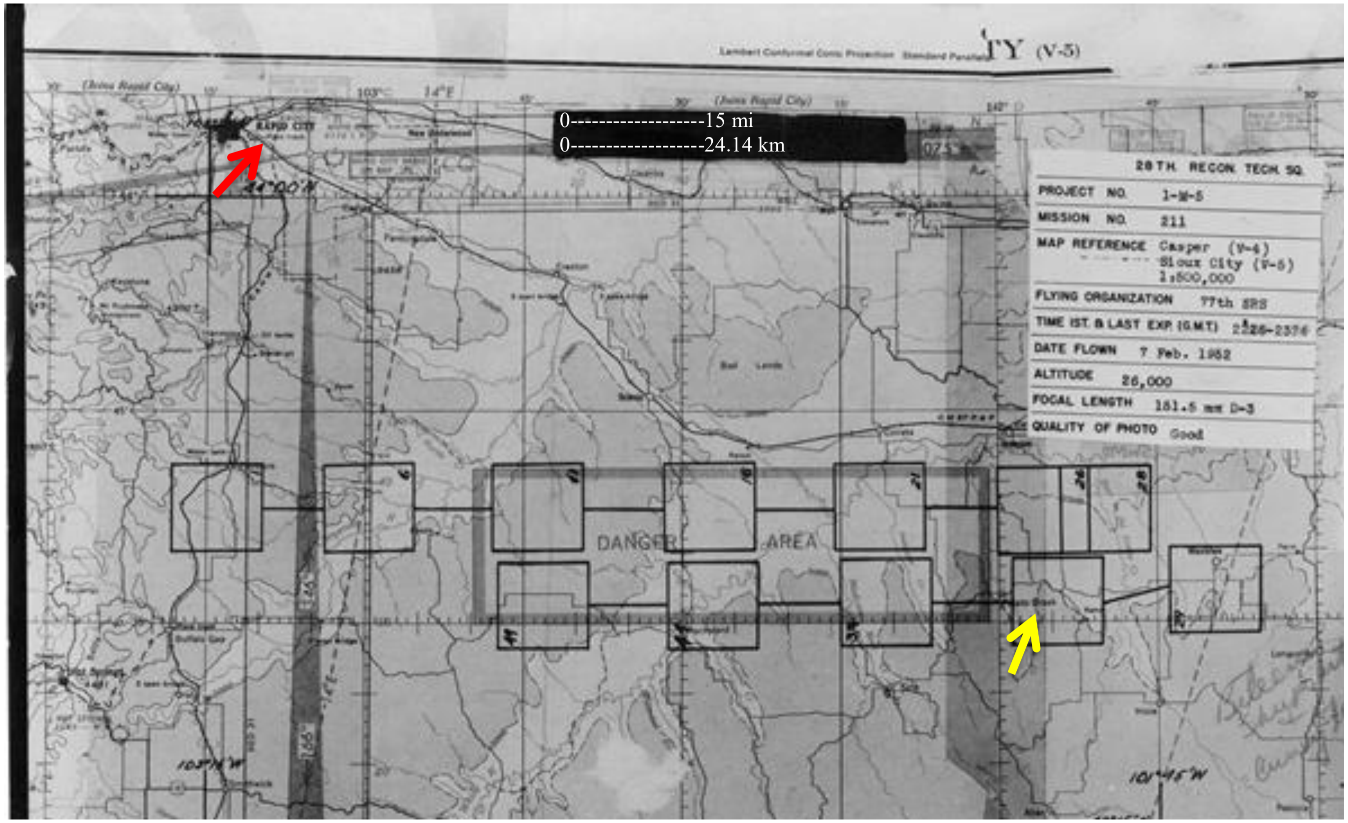


Figure 7. World War II gunnery range map, Department of Defense, 1952. While its borders extended beyond the west border of PRR, within reservation borders, it extended roughly north and west of the village of Potato Creek, SD (modified after South Dakota State Archives, Pierre, SD). Rapid City is marked with a red arrow and Potato Creek village with a yellow arrow. Borders of the gunnery range are shown in Figure 15 in the context of the entire study area. Scale of miles added.

Figure 8. Bombing Range Road sign on PRR, named for the World War II era US Department of Defense bombing range test site.

The heavy metals of interest in this study, arsenic, selenium, lead, barium, and uranium, were of particular interest to the Oglala Sioux Tribe, including Director Michael Catches Enemy and associate Kathryn Converse of the tribe’s NRRA in 2011 when this study began. They were in the process of building a database from which to manage the environment. They encouraged my research and provided a letter of endorsement and introduction.

BOUNDARIES AND GEOGRAPHY OF THE STUDY AREA

The study area, PRR, home of the Oglala Lakota, is in Shannon County and the southern half of Jackson County on the Great Plains of southwestern South Dakota (Fig. 9). As part of the larger Missouri Plateau in western South Dakota, Shannon County is further subdivided into the Southern Plateau with the Pierre Hills along the western border. Southern Jackson County is wholly classified as Southern Plateau (Hogan and Fouberg, 2001; after Flint, 1955). Hogan and Fouberg have described the Southern Plateau as follows:

> This area is comprised of young rock formed by the debris produced by the erosion of the Black Hills and Rocky Mountains and carried eastward by wind and water. Today, this is a region of wide, flat areas of land between streams and contrasting deep, narrow stream valleys and canyons. It is also a region of badlands, buttes, and tables. The Southern Plateaus are dominated by rocks formed from sands and clays, occurring in a variety of colors. Streams have cut deep into the landscape, exposing the sub-surface rocks.
>
> The northern part of the Southern Plateaus is noted for its badlands topography. Of the several badlands areas found here, the largest and most famous is the Big Badlands, which follow the White River for over 100 miles. . . . Badlands result from a combination of geologic and climatic factors: falling and running water; the sands, clay and volcanic ash that form the soil and rock materials; and elevation that results in rapid downcutting by streams.
>
> The bulk of the land in the northern part of this subregion is composed of level plains. The land is today covered with grasses or is farmed. . . .
>
> The southern section of the subregion is locally known as the "Tables." It is comprised of large, wide-topped buttes and mesas. Among the more notable tables are Cuny Table, Sheep Mountain Table, and Hart Table. They stand over 400 feet above the surrounding landscape. . . (2001, 24).

Furthermore, Hogan and Fouberg have described the Pierre Hills as follows:

> They comprise a mature geologic subregion of smooth, rounded, contoured hills. The area is a result of erosion of dark Pierre shale bedrock, which breaks down into sticky clay called "gumbo." When

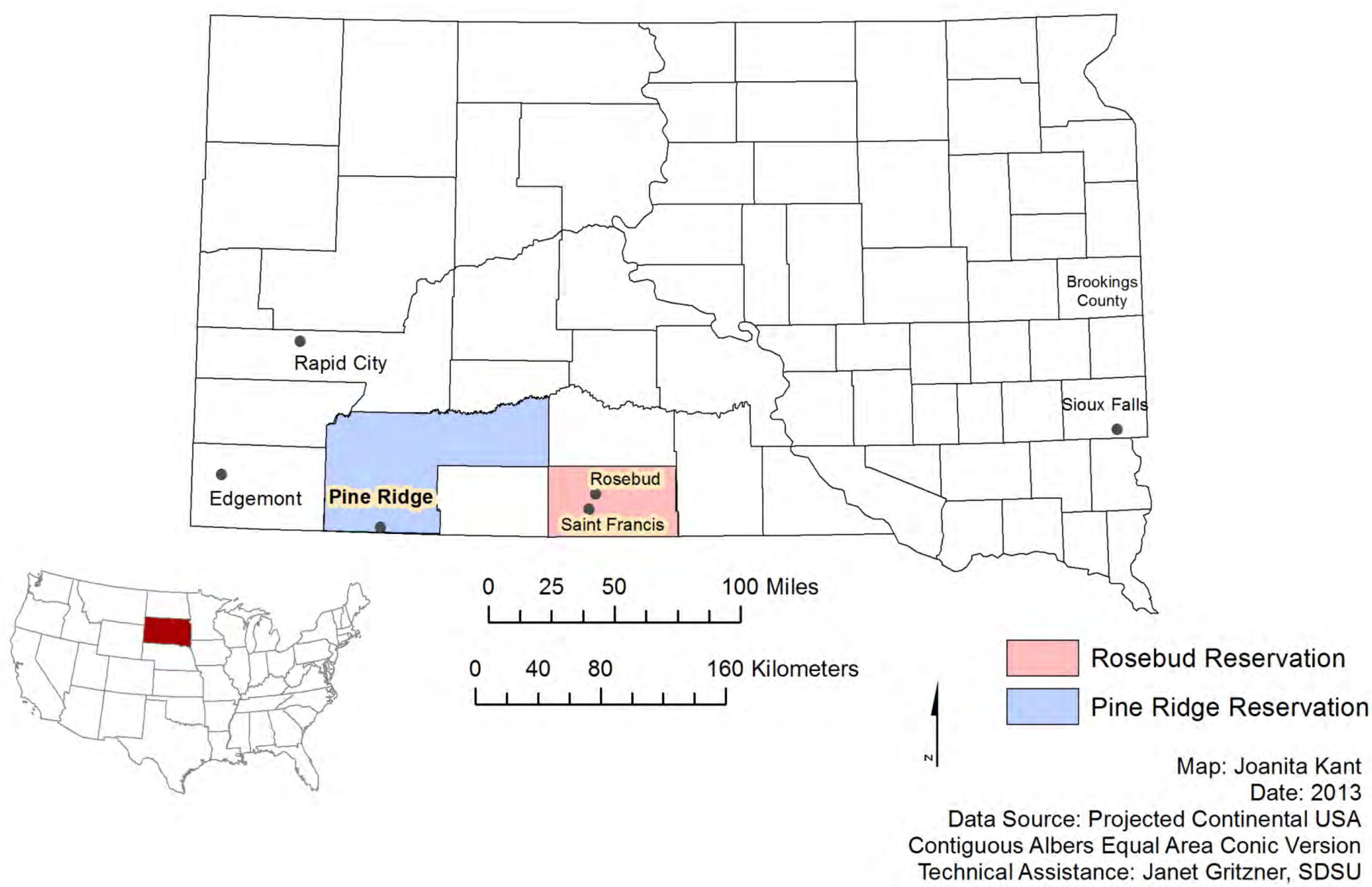


Figure 9. Rosebud and Pine Ridge Reservations borders, after South Dakota Official Highway Map, 2011. South Dakota Department of Transportation (State of SD copyright, with permission).

> wet, the clay resists water absorption and when dry, it tends to cake, flake, and decompose. . . .
> During wet periods, water that is unable to saturate the "gumbo" rapidly runs off the land, cutting deep into the land. In other places, valley water holes and intermittent standing pools collect the runoff. It then evaporates or very slowly seeps into the land.
> . . . Alkali spots contain a salt in the soil, resulting in a surface that is essentially devoid of vegetation (2001, 23).

As noted by Hogan and Fouberg, Westin (1977) divided the soil types in South Dakota into three types: Chernozem, Chestnut, and Gray Wooded, names used infrequently in the modern day. Chestnut soil type included the PRR and the remainder of the area west of the Missouri River, with the exception of the Black Hills. Chestnut soils formed in short grass steppes and exhibit shallow upper horizons from two to four inches (5.08 to 10.16 cm). These areas are generally marginal for crop production but can be fertile with adequate rainfall, requiring conservation techniques to reduce erosion risk (Hogan and Fouberg, 2001). While there are other modern soil classification systems, Brady and Weil (2008) introduced a common one used by Malo (2012) at South Dakota State University. Brady and Weil divided South Dakota soils orders into the following: Mollisols, Alfisols, Entisols, Vertisols, and Ardisols. Of those, PRR included Mollisols in the north and Entisols in the south. After Brady and Weil, Malo described Mollisols as, "Prairie derived, high humus . . . A horizon, deep dark colored surface, high fertility" with a formative element of Haplustoll. In addition, Malo described Entisols as, "Soils with no well developed [*sic*] pedogenic horizons" with formative elements of Udifluvent (Malo, 2012, 195-196; after Brady and Weil, 2008). Concerning major vegetation types, PRR, mostly included northern wheatgrass-needlegrass plains (Johnson and Larson, 2007).

The two major watersheds for PRR are the White River and the Cheyenne River, both of which flow east to northeast. Those rivers eventually converge with the Missouri River which flows south to the Gulf of Mexico.

The climate in South Dakota, west of the 100th Meridian (roughly west of the Missouri River) is dry continental. It is an area of low humidity with hot summers and the potential for bitterly cold winters. Summer temperatures occasionally exceed 100 degrees F (37.8 C) and winter temperatures often dip to below zero F (-17.8 C), with record-breaking extremes in the 1930s reported at 120 degrees F (48.9 degrees C) and -38 degrees F (-38.9 C) (South Dakota State Climatologist, 2013a).

The Porcupine, SD weather station on PRR reported temperatures from 1971 to 2000. Results indicated that temperatures for the months of January and February averaged 20 degrees F (-6.67 C) and 25.6 degrees F (-3.36 C), and for the months of July and August averaged 72.9 degrees F (22.72 C) and 71.4 F (21.89 C) during the same period, respectively (South Dakota State Climatologist, 2013b). Precipitation can be quite variable.

The average annual precipitation for South Dakota ranges from about 16 inches (40.64 cm) west of the Missouri River to about 26 inches (66.04 cm) in the southeastern corner of the state, reported by the South Dakota State Climatologist, in the *South Dakota Agriculture 2011* (USDA/NASS, 2012) report. The Porcupine, SD, station report noted that for 2010, the growing season precipitation for PRR (from April through September) was less than 15 inches (38.1 cm) with the exception of a small area in the northwestern corner; whereas, it ranged to above 30 inches (76.20 cm) for the southeastern part of the state. Growing season precipitation averages from 1971 through 2000, PRR (Shannon and the southern half of Jackson Counties) were from 12 to 16 inches (30.48 to 40.64 cm) (USDA/NASS, 2011).

South Dakota Agriculture 2011 listed Shannon County as having a 2010 Census population of 13,586. In addition, the report listed a land area of 1,340,131 acres (3,311,598 ha) with 1,333,708 acres (3,295,726 ha) in farms, including only 104,917 acres (259,260 ha) in cropland, ranked it 62nd of 66 counties in the state for the latter. Farm crops consisted mostly of non-alfalfa hay, alfalfa hay, corn, and oats. Cattle numbered 37,500 in the county as of January 1, 2011. In 2007, bison numbered 1,000, and horses, 2,509 (USDA/NASS, 2012).

As noted, PRR includes only the southern half of Jackson County. *South Dakota Agriculture 2011* listed data by county, not by reservation. Jackson County included a 2010 Census population of 3,031, and a land area of 1,196,347 acres (29,644,173 ha) with 1,184,156 acres (2,926,168 ha) of land in farms that included only 228,994 acres (565,867 ha) of cropland, ranking it 45th of 66 counties in the state for the latter. Farm crops most often reported included alfalfa hay, non-alfalfa hay, and oil sunflowers. Cattle numbered 51,000 as of January 1, 2011. In addition, horses numbered 2,080, placing both Shannon and Jackson Counties in the top eight of 66 counties in that category (USDA/NASS, 2012).

PREVIOUS HEAVY METALS RESEARCH IN AND NEAR THE STUDYAREA

Some other studies of heavy metals in South Dakota in recent years included two M. S. theses at SDSU by Faris (2012) and by Decoteau (2013). Faris studied heavy metal concentrations from snowfall and precipitation runoff for six bridges in Brookings County, South Dakota. Arsenic, lead, selenium, and other heavy metals concentration levels were reported in excess of US EPA Primary Drinking Water Standards. In Faris' study, a possible primary source of contamination could have been ash added to the deicing treatment obtained from a coal-fired electrical production plant in northeastern South Dakota (Faris 2012).

In Decoteau's heavy metals study, he reported collecting and analyzing river water and sediment samples in 2011 in northwest Nebraska and southwest South Dakota. He examined the White and Cheyenne River watersheds, south and west of PRR, as well as four sites along the White River within reservation boundaries. Results showed concentration levels of several heavy metals, including arsenic, barium, lead, selenium, and uranium, in excess of US EPA Primary Drinking Water Standards. The study concluded that the sources are probably naturally occurring and not necessarily the result of point source pollution caused by mining operations near the reservation (Decoteau 2013).

DeBoer, et al. (2005, 29) reported no significant difference in selenium levels between high selenium soils in Charles Mix County, South Dakota, when soils described as "derived from glacial till and collapsed drift geologic materials" were compared with unglaciated soils. Selenium levels increased with depth for both total concentration and highly available [inorganic] concentration. They reported average concentrations of total selenium at 0.929 ppm from the surface to 1.6 feet (0.49 m), and at 1.684 ppm at 6.6 to 9.9 feet (2.01 to 3.02 m). The average for highly available [inorganic] selenium ranged from 0.072 ppm at the surface to 0.662 ppm at greater depths. For comparison purposes, it is important to note that PRR is not in a glaciated area of the state. The current study results indicated much higher overall average concentrations of selenium in soils at 6.09 ppm.

Williamson et al. (1996) reported levels of heavy metals in sediment, plants, and fish in Rapid Creek at Rapid City, South Dakota during 1993-1994. While primarily interested in silver (Ag), cadmium (Cd), copper (Cu), and zinc (Zn), they found that levels in Rapid Creek water and plants were generally higher downstream from the local wastewater treatment plant. Levels did not consistently follow that pattern concerning fish livers, however. Their primary findings showed that water, bed sediments, plants, and fish bioaccumulated heavy metals, but there was no evidence of biomagnification:

> Based on the limited sampling during this study, there is evidence that the selected metals present in both the water and bed sediments are bioaccumulating in the plant and fish species. Results also indicate that biomagnification in the plants and fish is not occurring; that is, the concentrations found in the sediment, plants, and fish are all at about the same order of magnitude (1996, 1).

Williamson et al. (1996, 26-27) reported that bed sediments for arsenic (As) along Rapid Creek ranged from 10 to 20 micrograms per gram [ppm], lead (Pb) from 36 to 49, and uranium (U) <100.

Including soil samples from PRR, Gustavsson et al. (2001) reported baseline estimations for a variety of element concentrations in soils. The study is the most comprehensive for the conterminous United States based on samples taken by United

States Geological Survey teams in the 1960s and 1970s. The baselines developed by Gustavsson et al., based on reworked research by Shacklette and others (Shacklette et al., 1971; Boerngen and Shacklette, 1981; and Shacklette and Boerngen 1984) are among those used for comparisons in the current study.

HEAVY METALS OF INTEREST

As noted, heavy metals of interest included arsenic (As), barium (Ba), lead (Pb), selenium (Se), and uranium (U). While they are referred to as "heavy metals," technically speaking, they are elements on the periodic table, more properly described as follows: As is a metalloid; Ba is an alkali earth metal; Pb is a metal, Se is a nonmetal; and U is an actinide (with an atomic number of 92, within a group of radioactive metallic elements with atomic numbers ranging from 89 to 103). Heavy metals and other inorganic compounds are widespread and naturally occur in the environment. Although capable of building to toxic levels, some, such as selenium, are necessary micronutrients for good health.

Capable of high mobility in the environment, inorganics adsorb particularly to organic matter, mud, and clay. Inorganics are particularly soluble depending upon conditions in which they occur. Variability in hardness, pH, moisture, accompanying compounds, and other factors affect their solubility (US EPA, 2013e). Burckhard (1997) reported that organic acids in the presence of heavy metals influence adsorption rates in vegetation, with oxalic acid related to increases and citric acid related to decreases.

Of the heavy metals of interest, Cai (2003) noted that the US EPA considers two of them, arsenic and selenium, to be among the three heavy metals of particular interest to the US EPA in studying the chemistry of all things, both living and non-living. The other of the three is mercury. All three can be very toxic, causing harmful effects.

All the heavy metals of interest can cause adverse health effects when ingested as contaminants in drinking water. Living in areas with high naturally-occurring levels of heavy metals in soils may also be harmful to health.

ARSENIC

Arsenic, As, with an atomic number of 33, is a metalloid that mostly occurs in its natural state with other minerals and metals. Less often, As occurs as an element in pure crystalline form.

Anthropogenic activities can add to natural levels of As in the environment. As is particularly associated with wood preservative in industrial settings, pesticides, metallurgy, and mining residues. On a worldwide level, arsenic is a major problem in drinking water, particularly well water; also in rice, sea fish, apple juice, and some other fruit juices (US CDC 2013d and 2007a; and US EPA 2013e). Worldwide, regulatory agencies are currently reassessing and/or revising standards for safer levels that are economically feasible. Gebel (2000) found that arsenic, as a contributing factor in cancers, may vary between genetic sub-groups such as Mexican or Taiwanese populations. Therefore, he reported, that "Unfortunately, a toxicologically safe risk assessment and standard setting, especially for long-term and low-dose exposures to arsenic, is not possible" (Gebel, 2000).

BARIUM

Barium, Ba, with an atomic number 56, is a metallic alkaline earth metal. In nature, Ba is not found in a free state, but rather as one of its compounds, many of which are potentially toxic.

Anthropogenic activities can add to natural levels of Ba compounds in the environment. The workplace can be an important source of exposure. Others sources include drill bit lubricants that include barium compounds in the gas and oil industry, pigment in paints, medical x-rays, fireworks, rubber, fluorescent bulbs, pesticides, ceramics, plastics, and glass (US CDC, 2013d and 2007b; and US EPA 2013e).

LEAD

Lead, Pb, is classified as a metal, with an atomic number 82. It mostly occurs in nature in ores, especially copper, silver, and zinc.

Anthropogenic activities can add to natural levels in the environment. It is particularly problematic in water and sewer pipes, solders and lead-based paints, and in old construction projects. It is commonly used in automobile batteries, radiation shields, dishware and ceramic glazes, weights, and ammunition. In recent years, lead shot has been replaced by steel shot for waterfowl hunting in an effort to reduce contamination levels. Pb release into the environment is associated with metallurgy and mining. Worldwide, regulatory agencies are reassessing and/or revising standards for safer levels that are economically feasible. Pb may pose health risks at very low levels, particularly for children. Pb is considered a worldwide concern in drinking water for humans (US CDC, 2013d and 2007c; and US EPA 2013e).

SELENIUM

Selenium, Se, is classified as a nonmetal, atomic number 34. Se most often occurs in nature in metal sulfide ores, particularly in copper mining, rather than in a pure state as an element or a compound. Se naturally occurs in fossil fuels, as well as igneous and sedimentary rock (Ohlendorf, 1989).

Anthropogenic activities such as mining can add to natural levels in the environment. Particular contaminant sources include agricultural and industrial runoff and ash from coal burning (Ohlendorf, 1989). In addition, Se is often used in electronics, rubber, glassmaking, pigments, metallurgy, fungicides, and medical imaging procedures. Food supplements containing Se are commonly sold, since trace amounts are essential in human and animal diets (US CDC, 2013d and 2013c; and US EPA, 2013e).

Veterinaries, ranchers, and farmers recognize Se as potentially problematical for livestock which graze plants or eat hay contaminated with high Se from soil uptake. Se can be toxic for humans and livestock at unusually variable concentrations, resulting in symptoms of selenosis. Other researchers, including Ohlendorf (1989), report that selenium is capable of bioaccumulation and biomagnification.

Certain plants require or tolerate large amounts of selenium. Johnson and Larson (2007) reported that some plants are indicators of Se soils, including plants commonly found in pastures in western South Dakota. Those involve some species in the

Brassicaceae, such as prince's plume (*Stanleya pinnata*), and some Fabaceae, e.g. species of *Astragalus,* the poison vetches.

Human studies have shown that up to 0.853 mg/day is sometimes tolerated by certain individuals but not by a subset of particularly sensitive individuals (Yang, et al, 1989 and Longnecker et al., 1991).

URANIUM

Uranium, chemical symbol U, is an element classified as an actinide. Its atomic number is 92 within a group of radioactive metallic elements with atomic numbers ranging from 89 to 103. In nature, U often occurs in mineral form, such as uraninite. Found in low concentrations in water, soil, and rock, U is highly inorganic with no organic form in nature (Emsly, 2001).

Anthropogenic activities add to natural levels of U exposed in the environment. Of most importance is uranium mining. Uranium's most important uses are as fuel for power-generating nuclear reactors and for nuclear weapons. The inorganic form normally used in nuclear reactors, is isotope U235, although U238 is used in fast reactors.

LITERATURE REVIEW

OVERVIEW OF SPECTROMETRY TESTING IN FOODS

Among researchers worldwide, it is common practice to detect trace element concentrations using spectrometry methods, particularly inductively coupled plasma optical emission spectrometry (ICP-OES), atomic absorption spectroscopy (AAS), and inductively coupled plasma mass spectroscopy (ICP-MS). Each technique has unique advantages and disadvantages. ICP-OES was appropriate for the current study, with a goal of establishing a preliminary baseline of heavy metals, because it is effective in terms of time and cost and capable of detecting a wide variety of elements in a single sample. AAS requires five separate runs for every sample and only detects one element at a time. MS is capable of detecting specific isotopes, although at a higher cost, if there is some reason to look more closely in follow-on studies. Spectrometry has been used for decades to detect heavy metals concentrations in environmental samples including foods, plants, aqueous solutions, sludge, soil, sediment, and oil. Its use has surged since the 1980s, although the basic principles were understood much earlier.

The current research samples were processed using ICP-OES. The method involves an atomic emission occurring when certain atoms are passed into a flame. Metals are differentiated from one another based on the wavelengths of the atomic emission. Since ground state metals are known to absorb light at particular wavelengths, when light is supplied to the sample, the absorbed light is compared to a standard curve to identify the quantified "signature" of the isotopes or element concentrations. Atomic absorption spectrometry is based on Gustav Kirschoff's law, "Matter absorbs light at the same wavelength at which it emits light," discovered in the 1800s (Haswell, 1991).

Table 8 presents a sampling of spectrometry research studies in foods, including results and the country of origin. A search of the literature showed that spectrometry testing is worldwide, with research interests in a broad range of elements and food types in both human and animal studies. While only five heavy metals, arsenic, barium, lead, selenium, and uranium, are of concern in the current study, many other research studies do not include all of them. Food studies including arsenic and lead were common. Such studies have proliferated since the 1970s resulting in a vast amount of data. In response, various worldwide agencies increasingly establish baselines, summaries, assessments and evaluations drawing conclusions for guidance and regulations. Those are presented later in this chapter.

Table 8. Spectrometry research studies in foods: Detecting heavy metals and other elements.

Elements	Tested	Result	Country	Reference
Ca, Mg, Na, K	meat, fish, dairy, & vegetables	Focus was using simultaneous techniques with an individual sample using spectrometry to analyze nutrients and elements in food	France	Chekri et al., 2010
Cu, Cd, Zn	watermelons	Levels excessive and a threat when plants are irrigated with urban wastewater, although water-melons fruits have a natural filtering mechanism; warned that spectrometry in general is prone to errors	Iran	Khanjani et al., 2008
Al, Cd, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Ti V, Zn	berries and mushrooms	These elements are not subject to bio-accumulation from heavy metals contamination in wood ash	Finland	Moilanen et al., 2006

Table 8. Spectrometry research studies in foods: Detecting heavy metals and other elements (continued).

Elements	Tested	Result	Country	Reference
As, Cu, Mi, Mn, Zn, Se	water, vegetables, cereals, and bakery items	As, in particular, was high in local water sources; thereby, it contaminated local foodstuffs	India	Roychowdhury, et al., 2003
Ag, Cd, Cu, Zn	plants and fish	Bioaccumulation of certain metals likely, based on small sampling in Rapid Creek	United States (South Dakota)	Williamson, et al., 1996
Pb, Cd, Cu, Zn	various market fruits and vegetables, including strawberries, cucumbers, dates, and spinach	In comparing these with others around the world, they were within WHO/FAO accepted standards for daily intake estimates	Egypt	Radwan and Salama, 2006
Cd, Cu, Pb, Zn	various green vegetables	Some plants grown along rivers exceeded WHO/FAO standards	Tanzania	Bahmuka and Mubofu, 1999

Table 8. Spectrometry research studies in foods: Detecting heavy metals and other elements (continued).

Elements	Tested	Result	Country	Reference
Cr, Co, Cu, Ni, Pb, Zn	various vegetables, spinach, onion,	All showed detectable levels, but all were within standards set by the National Agency for Food and Drug Administration Control (NAFDAC)	Nigeria	Lawal and Audu, 2011
Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn	various market fruits: oranges, bananas, pomegranates, lemons, pears, Chiku fruits, apples, mangoes, guavas, grapes, mandarins	All exceeded legal safety levels of the Indian Food Adulteration Act of 1954, less stringent than other European Union Standards	India	Mahdavian and Somashekar 2008
Cu, Zn, Pb, Cr, Cd, Mn	green leafy vegetables: palak and coriander	Many exceeded WHO standards, Pb particularly high	India	Ramesh et al., 2012
As, Cd, Pb, Zn, Cu	commercial and residential vegetable gardens: lettuce, spinach cabbage, leek rhubarb, beetroot parsley, mint	Some exceeded Australian, New Zealand, European, and Codex Alimentarius Commission standards, particularly near smelters	Australia	Kachenko, et al., 2006

HEALTH EFFECTS OF HEAVY METALS TOXICITY

Health concerns from exposure to toxic concentrations of heavy metals, through ingestion, inhalation, and dermal contact, are widely acknowledged in scientific literature. Research on the topic is rapidly expanding, as noted. Overviews of health effects for each heavy metal of interest follow. A selection of recent worldwide trace metal toxicity studies and health effects for the heavy metals of interest are presented in Table 9.

Inorganic arsenic is particularly toxic, occasionally fatal, with the potential to accumulate in cells of the body and increasing the chances of cancers including those of the bladder, liver, lung, and skin. In addition, inorganic arsenic may adversely affect the following systems or organs in humans: cardiovascular, blood and bone, gastrointestinal, kidney, pancreatic, brain, and others (US CDC, 2013d and 2007a; Vigo and Ellzey, 2006; and Oluwole, 2011). Very little is known about the effects on human health for organic arsenic (US EPA 2013e).

Barium toxicity is directly related to its ability to dissolve in water and in human intestines. Barium toxicity particularly affects the human gastrointestinal and muscular systems. Long-term exposure to soluble barium may cause disturbances in the lungs and cardiovascular system (US CDC 2013d and 2007b; and US EPA 2013e). Barium potentially accumulates in fish and aquatic organisms (Eisler, 1988). The US EPA reported that barium is unlikely to be a human carcinogen (US EPA, 2013e).

Lead toxicity affects nearly every organ system of the human body. In particular, lead adversely affects the human nervous system. High exposure levels target the brain, kidneys, blood, and reproductive system. Lead is a probable human carcinogen (US CDC, 2013d and 2007c; US EPA, 2013e; Knobeloch et al., 2006; and Leonardi et al., 2012). Eisler (1988) reported adverse effects in plants; however, inorganic lead contamination in food has mostly been associated with lead-based paint, lead shot, and lead weights.

Selenium enters the food chain through sediments and in water. The US EPA (2013e) lists the following health concerns for selenium toxicity: "loss of equilibrium and other neurological disorders, liver damage, reproductive failure, reduced growth, reduced movement rate, chromosomal aberrations, reduced hemoglobin and increased white blood cell count, and necrosis of the ovaries." The US CDC specifically includes symptoms of selenosis: hair loss, fingernail and toenail irregularities, and tingling sensations in the extremities. In addition, the CDC reports that selenium intake may actually decrease cancer risk (US CDC 2013d and 2013c).

Uranium toxicity targets human kidneys in both the natural or depleted forms of the element. As with other heavy metals, soluble forms of uranium produce damage at lower concentrations than insoluble forms. According to the US CDC, although natural uranium is mildly radioactive, adverse health effects are caused by the chemical exposure, not the radiation. Human food exposure is often through root vegetables and the soils in which they grow. Concerning cancer causing potential, the US EPA has not classified uranium (US EPA 2013e and US CDC 2013d and 2007d).

Uranium toxicity health effects were also compiled by Craft, et al. (2004). Adverse effects were noted in animal and human studies. Human body systems negatively affected include renal, brain and central nervous system, DNA (associated cancers), reproductive, gastrointestinal, immune system, and cardiovascular. Table 9 presents a survey of studies estimating potential health risks from heavy metals toxicity.

Table 9. Potential health effects of heavy metals toxicity

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Arsenic	persistent arsenicosis	groundwater aquifers as drinking water and	Bangladesh	Mukherjee and Bhattacharya, 2001
Arsenic	skin lesions	drinking water	Chile	Smith et al., 2000
Arsenic	liver disease non-cirrhotic fibrosis	drinking water	India	Santra et al., 2000
	skin lesions	water	Bangladesh	Hall et al., 2006
Arsenic	cardiovascular degeneration	water	Taiwan, Bangladesh, India, Argentina, Australia, Chile, Australia, Chile, China, Hungary, Peru, Thailand, Mexico, USA	Balakumar and Kaur, 2009
Arsenic	Ischemic heart disease	artesian drinking water	Taiwan	Tseng et al., 2003
Arsenic	may increase risk of Type 2 Diabetes	drinking water	USA	Navas-Acien et al., 2008
Barium	reduced life-span, reproduction, development (size), and motor skills in soil nematodes	deliberate exposure to barium in laboratory	China	Wang and Wang, 2007

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Barium	reduced weight ratios in liver, brain, kidney, ovary (and survivability in females in amounts over 300 mg/kg, 1 to 10 day gavage; no changes at levels below 209 mg/kg. in lab rats	deliberate exposure $BaCl_2$ in laboratory	USA	Borzelleca et al., 1988
Barium	hypertension if in 95th Percentile of "established reference dose"	ceramic glaze in dishes	USA	Assimon et al., 1997
Barium (reactive salts)	multiple sclerosis, transmissible spongiform encephalopathies, amyotrophic lateral sclerosis	workplaces/environment various	Colorado, Guam, Massachusetts, Sardinia, Scotland, Saskatchewan	Purdey, 2004
Barium Sulfide	"produces characteristic gastrointestinal symptoms, periorbital and extremity paresthesia, hypertension, and progressive flaccid muscular paralysis. Profound hypokalemia also may be induced. Overdose may be rapidly fatal unless the ingestion is recognized and appropriate treatment. . . immediately."	shaving cream ingestion, suicide	USA	Downs and Nichols, 1995

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Lead	impaired neurological development; harm to nearly all organ systems, genotoxic, particularly in children	naturally occurring in environment; anthropogenic introduction in various products: car battery, paint, solder, ceramics, ammunition; industrial waste	USA Israel	Sanders, et al., 2009
Lead	death of condors	ingesting lead shot from hunting gut piles	USA	Green et al., 2008
Lead	kidney toxicity	various environmental and anthropogenic sources with increased incidence when co-occurring with poverty, obesity, and diabetes	USA	Ekong et al., 2006
Lead	Burton's Line, blue line along gums; children: "irritability, loss of appetite, weight loss, sluggishness, behaviour (continued)	various environmental and anthropogenic sources	UK	Pearce, 2007

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
	abdominal pain, vomiting, constipation, anaemia and renal failure." Adults: pain, numbness or tingling of the extremities, muscular weakness, headache, abdominal pain, memory loss, anaemia and renal failure, male reproductive impairment."			
Lead	reduced brain size in adults with history of childhood lead exposure, resulting in cognitive impairment	various environmental	USA	Cecil, et al., 2008
Selenium	possible increase diabetes in adults	not specified	USA	Bleys et al., 2007
Selenium	slowed growth; enlarged livers; and mortality for 97.5%-100% of mallard ducklings at maximum dose	10 to 80 ppm/d in controlled setting	USA	Heinz et al., 1988

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Selenium	deficiency of is associated with Ketogenic diet in epileptic children	Ketogenic diet for epileptic children	USA	Bergqvist et al., 2003
Selenium	reproductive failure; deformities; mortality, irregularities in blood, eyes, liver, heart, kidney in fish	coal wastewater	USA	Lemly, 2002
Selenium	diarrhea, fatigue, hair loss, finger-nail disfiguration joint pain, nausea	dietary supplement at over 750 x recommended daily allowance	USA (10 states)	MacFarquhar et al., 2010
Uranium	depending upon the species, soluble uranium is of most interest and increases kidney disease, and increases risk of various forms of cancer	eating and/or breathing from industrial sources or environment	USA	Argonne National Laboratory, 2012
Uranium	lung cancer among Navajo 1969-1993	working in uranium mine	USA	Gilliland et al., 2010

Table 9. Potential health effects of heavy metals toxicity (continued).

Elements	Potential Health Effects after Exposure	Probable Source	Country	References
Uranium	slight increase of leukemia for men and kidney and lung cancers for women	drinking water, mostly below 20 µg/L [0.020 ppm]	Germany	Radespiel-Tröger and Meyer, 2012
Uranium	potentially toxic as an element, causing "non-malignant respiratory disease (fibrosis, emphysema) and [probably 'reversible'] nephrotoxicity"; but no studies show that uranium causes cancers because of its radioactivity, as is commonly believed.	working in mines, mills, and uranium facilities	USA	Gehle, 2012 for US Health and Human Services continuing medical education website
Uranium	"Intakes of uranium exceeding EPA standards can lead to increased cancer risk, liver damage, or both. Long term chronic intakes of uranium isotopes . . . can lead to internal irradiation and/or chemical toxicity. . . ."	"food, water, or air"	USA	United States Environmental Protection Agency, 2013b

STANDARDS AND RISK ASSESSMENTS FOR HEAVY METALS

US EPA NATIONAL PRIMARY DRINKING WATER REGULATIONS FOR SELECTED HEAVY METALS

United States Environmental Protection Agency (US EPA, 2013a) establishes National Primary Drinking Water Regulations (NPDWR or primary standards) for contaminants including heavy metals of interest in this study. The primary standards are based on inorganic forms of arsenic, barium, lead, and selenium, rather than totals of organic and inorganic. The NPDWR sets unenforceable Maximum Contaminant Level Goals (MCGLs) below which negative health effects are not expected. In addition, they establish MCLs (Maximum Contaminant Levels) that are both enforceable and achievable in terms of technology and price (2013a).

The NPDWR are widely referenced because they are easily accessible and simple to understand. US EPA National Primary Drinking Water Regulations for the heavy metals of interest are presented in Table 10. They include MCLs and MCLGs, as well as summaries of adverse health risks. They are useful for reference, but it is important to remember that drinking water is ingested on a daily basis, and in many countries it is used for bathing; whereas, exposure to a particular food may be much less frequent. Thus, foods require their own standards, and they may or may not exist for many of the heavy metals in question. Also, existing standards may not apply to particular foods of interest.

Table 10. US EPA National Primary Drinking Water Regulations: MCGLs and MCLs, potential health effects, and sources of contaminant (directly quoted and extracted from US EPA, 2013a)

Contam-inant	MCLG [mg/L]	MCL or TT[1] (mg/L)[2] [except U]	Potential Health Effects from Long-Term Exposure Above the MCL	Sources of Contaminant in Drinking Water
As_i	0	0.010 as of 01/23/06	Skin damage or problems with circulatory systems, and may have increased risk of cancer	Erosion of natural deposits; runoff from orchards, runoff from glass and electronics production wastes
Ba_i	2	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Pb_i	0	TT[7]; Action Level =0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities	Corrosion of household plumbing systems; erosion of natural deposits
Se_i	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems from mines	Discharge from petroleum refineries; erosion of natural deposits; discharge
U	0	30 ug/L as of 12/08/03 [=0.03 ppm]	Increased risk of cancer, kidney toxicity	Erosion of natural deposits”

[Selected]Notes:

“1 . . . Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs [Maximum Contaminant Level Goals] as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards. . . .

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.

7 Lead and copper are regulated by a Treatment Technique [TT] that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.” Superscripts 3-6 were omitted because they are not applicable to the elements of interest. Subscript “i” indicates “inorganic.”

SELECTED STANDARDS, RISKS ASSESSMENTS, AND GUIDANCE FOR FOOD AND SOIL

CAUTIONS IN USING STANDARDS AND RISK ASSESSMENTS

Duffus (2002) noted that “heavy metals” do not necessarily equal toxicity. He explained that,

> “Understanding bioavailability is the key to assessment of the potential toxicity of metallic elements and their compounds. Bioavailability depends on biological parameters and on the physic-chemical properties of metallic elements, their ions, and their compounds. These in turn depend upon the atomic structure of the metallic elements, which is systematically described by the periodic table. Thus, any classification of the metallic elements to be used in scientifically based legislation must itself be based on the periodic table or some subdivision of it.
> . . . If metallic elements are to be classified sensibly in relation to toxicity, the classification must relate logically to the model adopted for carbon and each metal species and compound should be treated separately in accordance with their individual chemical, biological, and toxicological properties (2002, 804).

Many studies of heavy metals do not differentiate between their inorganic and organic forms (Yong Cai, 2003). Instead, researchers often report combined totals. Since the inorganic form is most readily absorbed in humans and animals, it is of most concern. By reporting total concentrations of heavy metals, researchers may overstate the risks. Until such time when researchers routinely differentiate between inorganic and organic, allowable concentrations of heavy metals established by standard-setting agencies are not as useful as they could be because of lack of equivalency in comparisons.

When drawing risk conclusions based on established concentration standards for heavy metals, it is important to take into consideration the toxic potential of the element, the amount of exposure, the body weight of the human or animal, age, condition of health and overall nutrition, possible genetic predisposition related to sensitivity or lack thereof, possible tolerance buildup through gradual exposure, and the presence or absence of other elements, as well as many other factors. Maines noted, in published chart form, individual differences in exposure to toxic metals may include “protein binding, sex, genes, pregnancy, occupation, drugs, season, diet, exercise, duration, chemicals, stress, disease state, gastrointestinal function, renal function, temperature, [and] age” (1994, 22). In addition, Maines reported that individual organs may respond to heavy metals in various ways based on “metal binding proteins, organ region, blood perfusion, drugs/chemicals, steroids, transport protein receptors, metal/metal interaction, organelle, cell type, GSH[glutathione]/cysteine, [and] oxidative stress” (1994, 23).

FOOD STANDARDS FOR HEAVY METALS

It is of interest to note that the media plays a role in calling attention to heavy metals that can lead to advocacy for standards. Of particular recent interest in the news are levels of As in rice, and levels of As and Pb in fruit juice. The US FDA came under increasing pressure in 2012 from Representatives Frank Pallone (Democrat, New Jersey) and Rosa DeLauro (Democrat, Connecticut) to consider establishing standards for As and Pb in certain fruit juices. Lawmakers are pressing for US FDA standards for heavy metals, including As and Pb, for all food products under their jurisdiction (Bottemiller, 2012).

While many countries have their own standards for contaminants in food, the following sections discuss selected standards for the United States, Australia and New Zealand, the World Health Organization (WHO), and the Government of Hong Kong.

US EPA'S REFERENCE DOSES (RFDS) INCLUDE FOOD

The current study reports concentrations of combined totals of organic and inorganic forms of arsenic, barium, lead, and selenium; and total uranium. Typically, the published standards and much of the guidance for comparison are for inorganic forms or specific isotopes only. The United States Environmental Protection Agency's Integrated Risk Information System (US EPA's IRIS) (2013c) chronic, oral, daily reference dose (RfD) levels were searched for the heavy metals of interest. An IRIS RfD is a usually non-carcinogenic "estimate … of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime" often determined from lowest-observed-effect levels (LOAELs) and no-observed-effect levels (NOAELs) or, since 1995, benchmark dose (BMD) and lower-bound confidence limit (BMDL) (US EPA, 2013d). When an RfD includes a carcinogenic estimate, it is included as Part II of the IRIS explanatory data (US EPA, 2013c), as discussed elsewhere in this research.

The search for standards and guidance included arsenic, barium, lead, selenium, and uranium. RfDs established by the US EPA are presented in Tables 11-14. The RfDs are specifically for inorganic arsenic, for barium and compounds, and for selenium and compounds. While the US EPA set an RfD for "uranium soluble salts," based on uranyl nitrate hexadyrate in food converted to urnium for the lowest-observed-adverse-effect level (LOAEL) needed to extrapolate an RfD, they established none for "natural uranium."

Table 11. Food: Chronic oral reference dose (RfD) for inorganic arsenic established by US EPA (after US EPA, 2013c).

Element	Critical effect	Dose NOAEL mg/kg/bw/day	Dose LOAEL mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Data last revised
Inorganic arsenic	Hyperpigmentation, keratosis and possible vascular complications Human chronic oral exposure (Tseng, 1977; Tseng et al., 1968)	0.0008	0.014	0.0003	55 kg	2/1/1993

Table 12. Food: Chronic oral reference dose (RfD) for barium established by US EPA (after US EPA, 2013c).

Element	Critical effect	Dose BMDL Statistical lower confidence limit on benchmark dose BMD, 5% extra risk mg/kg/bw/day	Dose BMD Maximum likelihood estimate of dose, 5% extra risk mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Date last revised
Barium and compounds	Nephropathy 2-year drinking water study in mice (NTP, 1994)	63	84	0.20	55 kg	7/5/2005

Table 13. Food: Chronic oral reference dose (RfD) for selenium and compounds established by US EPA (after US EPA, 2013c).

Element	Critical effect	Dose NOAEL mg/kg/bw/day	Dose LOAEL mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Data last revised
Selenium and compounds	Human epidemiological study, clinical signs of selenosis in 5/349 adults in high selenium soils area (Yang et al., 1989)	0.015	0.023	0.005	55 kg	9/1/1991

Table 14. Food: Chronic oral reference dose (RfD) for uranium soluble salts (after US EPA, 2013c).

Element	Critical effect	Dose NOAEL mg/kg/bw/day	Dose LOAEL mg/kg/bw/day	RfD mg/kg/bw/day	Body weight (bw)	Data last revised
Uranium soluble salts as uranyl hexadyrate	Initial body weight loss; moderate nephrotoxidity 30-day oral rabbit bioassay (diet) (Maynard and Hodge, 1949)	none	2.80	0.003	55 kg	32782

US EPA IRIS CANCER RISK ASSESSMENTS

In addition to the non-cancerous RfDs above, the US EPA Integrated Risk Information System IRIS (US EPA, 2013c) assesses cancer risks associated with the heavy metals of interest. The weight of evidence for inorganic arsenic shows increased lung cancer, internal organ cancers, and skin cancer. Barium and its compounds were not assessed for cancer risk by the US EPA, and the weight of evidence shows that Ba is not classified as a human carcinogen. Inorganic lead and its compounds were assessed for cancer risk. They are probable human carcinogens, and the weight of evidence shows that in animals lead and associated compounds are related to renal tumors and are expressed through their influence on gene expression. Selenium and compounds were not classifiable as human carcinogens by the US EPA, but there were conflicting research results. However, in the weight of evidence narrative, selenium sulfide is a probable human carcinogen. Natural uranium was not assessed as a carcinogen by the US EPA, or the information was withdrawn (US EPA, 2012c).

US CENTERS FOR DISEASE CONTROL (US CDC) MINIMAL RISK LEVELS (MRLS) FOR ORAL AND INHALANT EXPOSURE ROUTES

The US Centers for Disease Control and Prevention (US CDC), Agency for Toxic Substances and Disease Registry (ATSDR) provides continuously updated risk assessments for potentially toxic substances. The US CDC publishes a Priority List of Hazardous Substances, identified in cooperation with the US EPA in compliance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and amended in the Superfund Amendments and Reauthorization Act (SARA) (US CDC/ATSDR, 2011). Of the 275 substances on the updated 2011 priority list, arsenic, barium, lead, selenium, and uranium ranked, respectively, as 1, 126, 2, 146, and 97. These are not necessarily the “most toxic” substances, but for National Priority List (Superfund) sites, their ranking is based on “frequency, toxicity, and potential for human exposure” (US CDC/ASTDR, 2011). In addition, ATSDR provides minimum risk levels (MRLs) based on NOAELs for potentially toxic substances, including oral routes of exposure listed in Table 15 (2013a and 2013b) (although none no MRL is established for lead). ASTDR defines MRLs and appropriate uses, as follows:

The ATSDR Minimal Risk Levels (MRLs) were developed as an initial response to the mandate [CERCLA and Superfund law]. Following discussions with scientists within the Department of Health and Human Services (HHS) and the EPA, ATSDR chose to adopt a practice similar to that of the EPA's Reference Dose (RfD) and Reference Concentration (RfC) for deriving substance specific health guidance levels for non-neoplastic endpoints. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure. These substance specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors and other responders to identify contaminants and potential health effects that may be of concern at hazardous waste sites. **It is important to note that MRLs are not intended to define clean up or action levels for ATSDR or other Agencies (**emphasis theirs; US CDC/ATSDR, 2013b).

Table 15. Oral and inhalation minimal risk levels (MRLs) established by the US CDC. Inhalation exposure MRLs are expressed for particles (after US CDC/ATSDR, 2013b). Key: acute =1 to 14 days; intermediate = 15 to 364 days; chronic= > l year. None established by US CDC for lead.

Analyte	Route	Duration	MRL as daily human dose, non-carcinogenic	Endpoint	Date
Arsenic	oral	acute	0.005 mg/kg/day	gastrointestinal	Aug. 2007
	oral	chronic	0.0003 mg/kg/day	dermal	Aug. 2007
Barium	oral	intermediate	0.20 mg/kg/day	renal	Aug. 2007
soluble salts	oral	chronic	0.20 mg/kg/day	renal	Aug. 2007
Selenium	oral	chronic	0.005 mg/kg/day	dermal	Sept. 2003
Uranium	inhalation	intermediate	0.001 mg/m^3	renal	Feb. 2013
soluble salts	inhalation	chronic	0.00004 mg/m^3	renal	Feb. 2013
	oral	acute	0.002 mg/kg/day	developmental	Feb. 2013
	oral	intermediate	0.0002 mg/kg/day	renal	Feb. 2013
Uranium	inhalation	intermediate	0.002 mg/m^3	renal	Feb. 2013
insoluble compounds	inhalation	chronic	0.008 mg/m^3	respiratory	Feb. 2013

OTHER FOOD STANDARDS

Research was conducted to determine other world standards for all of the elements of interest applicable to food. Also, generally expected levels (GELS) from Food Standards Australia New Zealand (FSANZ) are included in the following sections. GELs are defined as “a range of contaminant levels that would normally be expected in particular foods” (FSANZ, 2001, 3).

ARSENIC: OTHER FOOD STANDARDS

FSANZ (2013) established maximum levels (MLs) of certain metals and their compounds in those foods deemed significant in the diets of persons in Australia and New Zealand. In many cases, FSANZ did not include fruits, or there was inconclusive or insufficient scientific evidence to include other food categories. FSANZ established “total arsenic” ML concentrations of 1.0 mg/kg for only one class of foods, cereals. Inorganic arsenic MLs were set for crustacean, fish, mollusks, and seaweed ranging from 1 to 2 mg/kg, since fish consumption is high and the inorganic form of arsenic is potentially more toxic (FSANZ, 2013).

In 2001, FSANZ (2001 and 2013) reviewed and revised all GELs for metal contaminants in light of increased research data. FSANZ proposed a GEL for “total arsenic” guidance, only for meat, but not for other any other food categories, with GEL medians ranging from 0.01 to 0.20 mg/kg and 90^{th} percentiles ranging from 0.02 to 1 mg/kg (2001).

The Government of Hong Kong (Choi, 2011) set a standard for inorganic arsenic at 1.4 mg/kg for solid food, 0.14 mg/kg for liquid food, 6.00 mg/kg for fish, and 10 mg/kg for shellfish.

WHO/FAO's Codex Alimentarius (as amended, 2012) assessed inorganic arsenic in food as presented by the Joint FAO/WHO Expert Committee on Food Additives (JECFA). Inorganic arsenic (shown in the JECFA table as "arsenic," but footnoted as based on "inorganic arsenic") standards for oils, fats, and natural mineral water were set at 0.10 ppm, and salt at 0.50 mg/kg.

In addition, US FDA (2009a) set MCLs for inorganic arsenic in bottled water, equivalent to US EPA Primary Drinking Water Regulations at a concentration of 0.01 mg/L.

BARIUM: OTHER FOOD STANDARDS

Few food standards were found for barium. Bottled water is regulated as a food by the United States Food and Drug Administration (US FDA). The US FDA follows the US EPA's primary drinking water standard of an MCL of 2 mg/L and a maximum contaminant goal level (MCGL) of 2.9 mg/L for bottled water (US FDA, 2002 and US EPA, 2013).

LEAD: OTHER FOOD STANDARDS

Concerning lead, while US EPA set no RfD (2013c), the World Health Organization/Food and Agriculture Organization of the United Nations (WHO/FAO), and FSANZ, set maximum levels (MLs) for fruits. The WHO/FAO Codex Alimentarius

(2012) set a lead concentration ML at 0.20 mg/kg for berries and small fruit, at 0.05 mg/kg for fruit juice, and at 0.10 mg/kg for pome and stone fruits, and 100 Bq/kg for infant foods. In addition, WHO/FAO (2000) approved a provisional tolerable weekly intake (PTWI) of lead as 0.025 mg of lead per kg of body weight per week (expressed as mg/kg/bw/week) approved by the 53rd meeting of the Joint FAO/WHO Expert Committee on Food Additives.

In 2001, FSANZ withdrew and revised former GELS, and none were approved for lead. FSANZ noted that GELS are not appropriate for lead because of the high potential for human toxicity at extremely low levels, particularly for infants and children. They advise that lead levels should be kept as low as possible and that there may be no safe level, particularly for vulnerable individuals (FSANZ, 2001). FSANZ (2013) set the lead ML for fruit at 0.10 mg/kg with other foods ranging from 0.10 to 2 mg/kg.

The US FDA MCL for lead in candy and candy wrappers is 0.10 mg/kg (US FDA, 2006). Concerning bottled water, US FDA MCLs are less stringent than US EPA domestic drinking water standards, since lead pipes are a not generally problematic in bottled water. Thus, US FDA set MCLs at 0.005 ppm for bottled water, when lead occurs consistently in test samples (US FDA, 2002 and Sharfstein, 2009), as compared to 0.015 ppm for National Primary Drinking Water Regulations of the US EPA (US FDA, 2013a). Otherwise, US FDA (2006) handles heavy metals toxicity issues in food on a case by case basis if a reason for concern has been identified.

SELENIUM: OTHER FOOD STANDARDS

FSANZ (2001) established a GEL for selenium for crustacea, mollusks, and edible offal and meat from cattle, swine, sheep, and fish with medians ranging from 0.50 to 1.0 mg/kg and 90th percentiles ranging from 0.2 to 2.0 mg/kg. FSANZ (2013) set no MLs for selenium.

URANIUM: OTHER FOOD STANDARDS

Food standards for uranium, as set by the WHO/FAO Codex Ailmentarius (amended 2012), apply to catastrophic releases of radionuclides. However, FSANZ (2013) set no MLs for uranium.

SOILS: HEAVY METALS BASELINES FOR COMPARISON

Many countries set their own standards for heavy metals contamination in soil and sediment. Selected baselines or standards that follow include some from the United States and Brazil.

Gustavsson (et al., 2001) and others produced baselines with color-coded maps representing concentration levels for comparisons of elements in soils for the conterminous United States, including PRR. Their new baselines resulted from revised and extracted data from United States Geological Survey (USGS) research by Shacklette et al., 1971; Boerngen and Shacklette, 1984, and Shacklette and Boerngen, 1984. In the original research by Shacklette and others, a USGS team collected soil samples at sites about every 80 km across the conterminous United States from 1961 to 1975 (Fig. 10). Results included slightly over 1,300 samples that were analyzed for a variety of trace elements. The reworked results by Gustavsson et al. (2001) comprise the largest comprehensive database and color-coded maps of element concentrations for the conterminous United States available to date. The publication by Gustavsson et al. included arsenic, barium, lead, and selenium, although the original research by Shacklette and others also included uranium. Gustavsson et al. (2001) applied moving weighted-median and Bootstrap statistical processes that smoothed the 1960s and 1970s results of Shacklette and others, not including uranium. The statistical technique involves random resampling of the original database and replacing some of the values using computer programs. Such statistical manipulation is useful for massive databases where only a few samples represent a large area.

A comparison is presented in Table 16 of the statistically reworked data, as described above, reported by Gustavsson et al. (2001) based on original fieldwork reported by Shacklette and Boerngen (1984) and others. In the case of PRR, results are based on about four sites (Fig. 10) sampled and reported by Shacklette and Boerngen others from 1961 to 1975 (1984). Baseline distribution maps for the conterminious United States for arsenic, barium, lead, and selenium are reproduced in Figs. 11-14 after Gustavvson et al. (2001) with no map available for uranium.

Table 16. Soils: USGS baselines for comparison with natural or anthropogenically-influenced geochemical variations (modified after Gustavsson et al., 2001, who modified after Shacklette and others), USA conterminous, 1961-1975, 24 cm.

Element	Weighted-median and Bootstrap-based (Gustavsson et al., 2001) range, ppm	(Shacklette and Boerngen, 1984) range, ppm	arithmetic mean, ppm
Arsenic	3.10-11	<0.10-97	7.20
Barium	241-945	10-5,000	580
Lead	10.30-30.10	<10-700	19
Selenium	0.17-0.74	<0.10-4.30	0.39
Uranium	NA	0.29-11	2.70

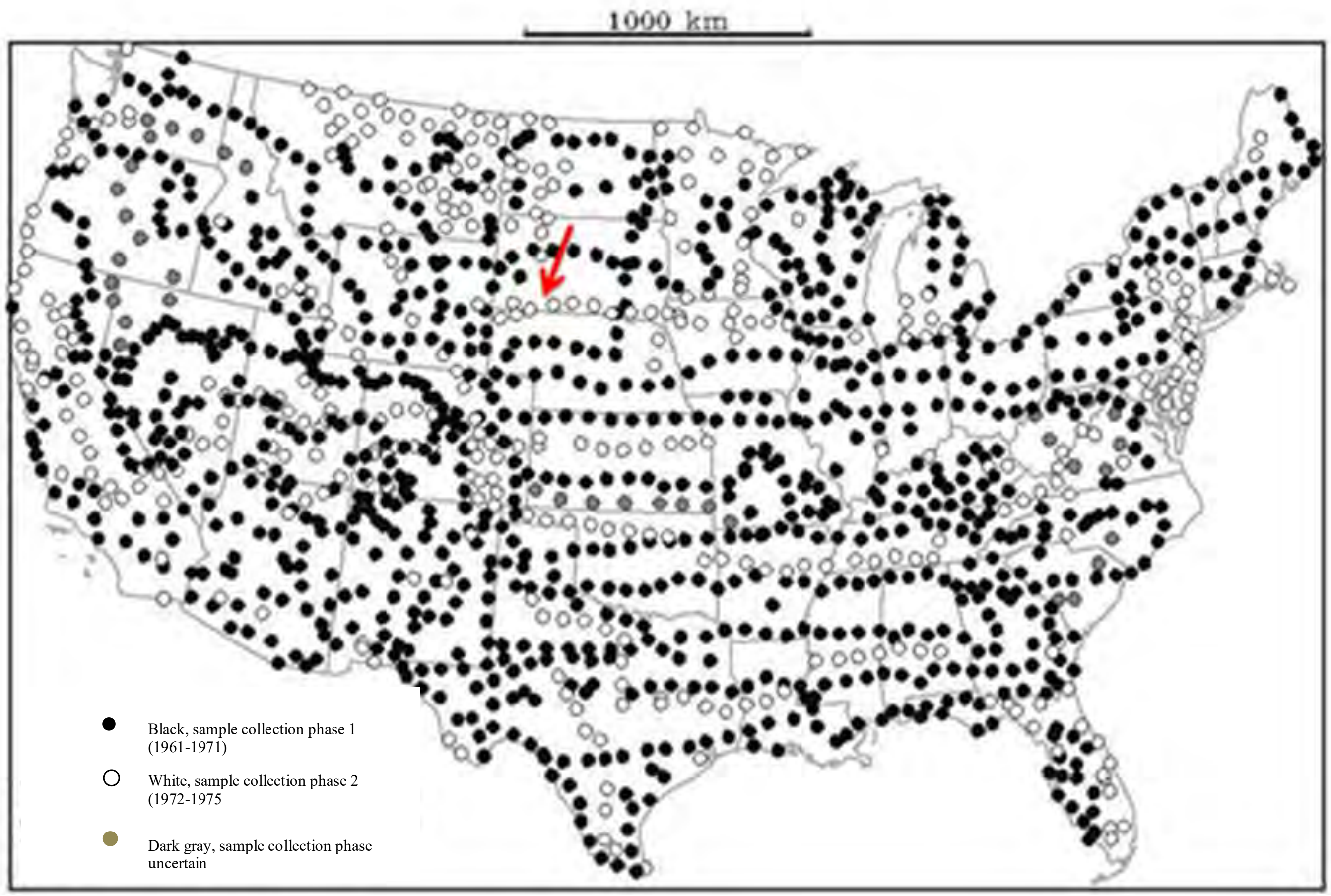


Figure 10. USGS soil sample sites for 22 elements from 1961 to 1975 with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 3).

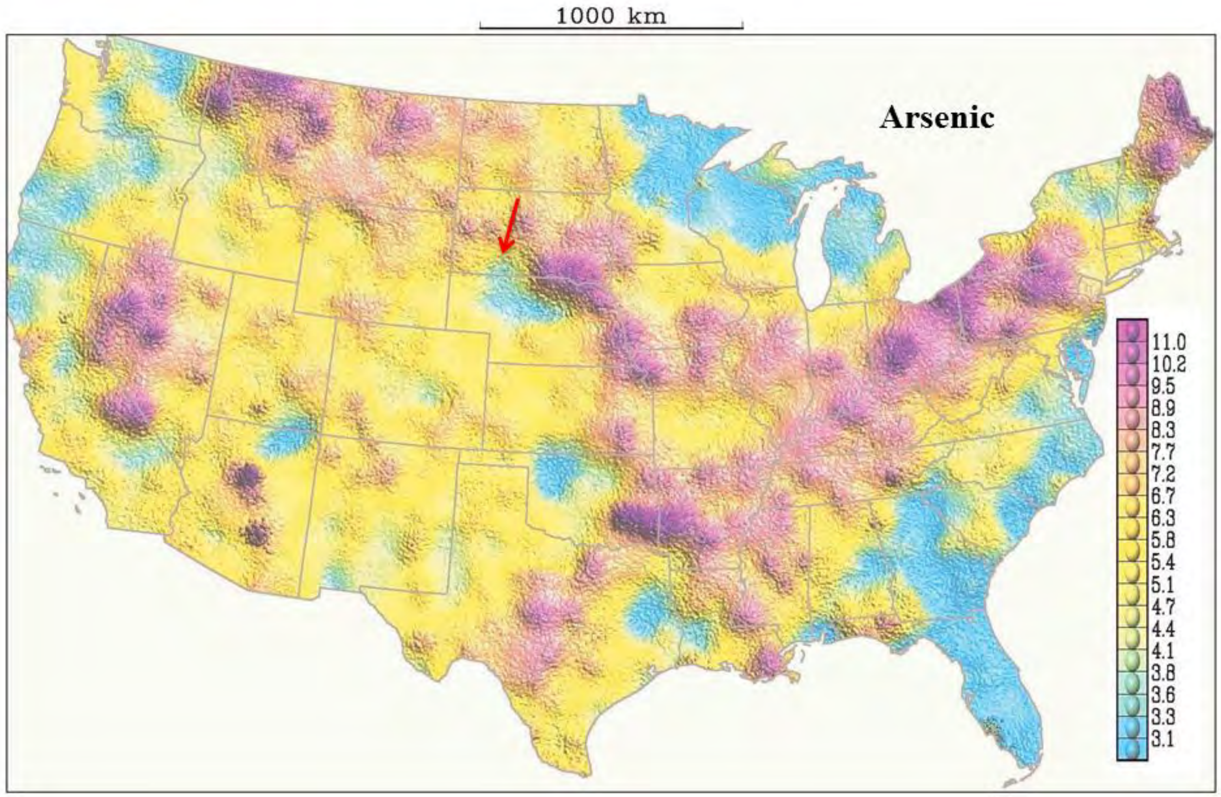


Figure 11. USGS-based arsenic distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 9).

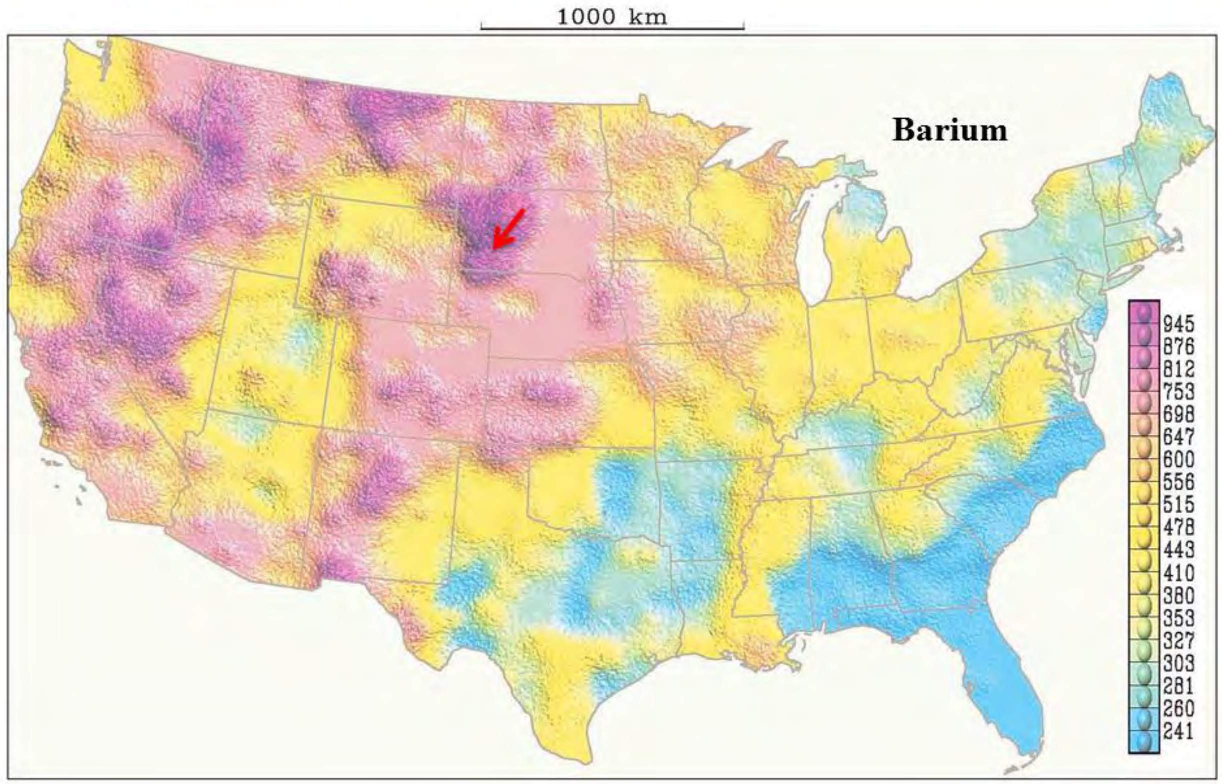


Figure 12. USGS-based barium distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 10).

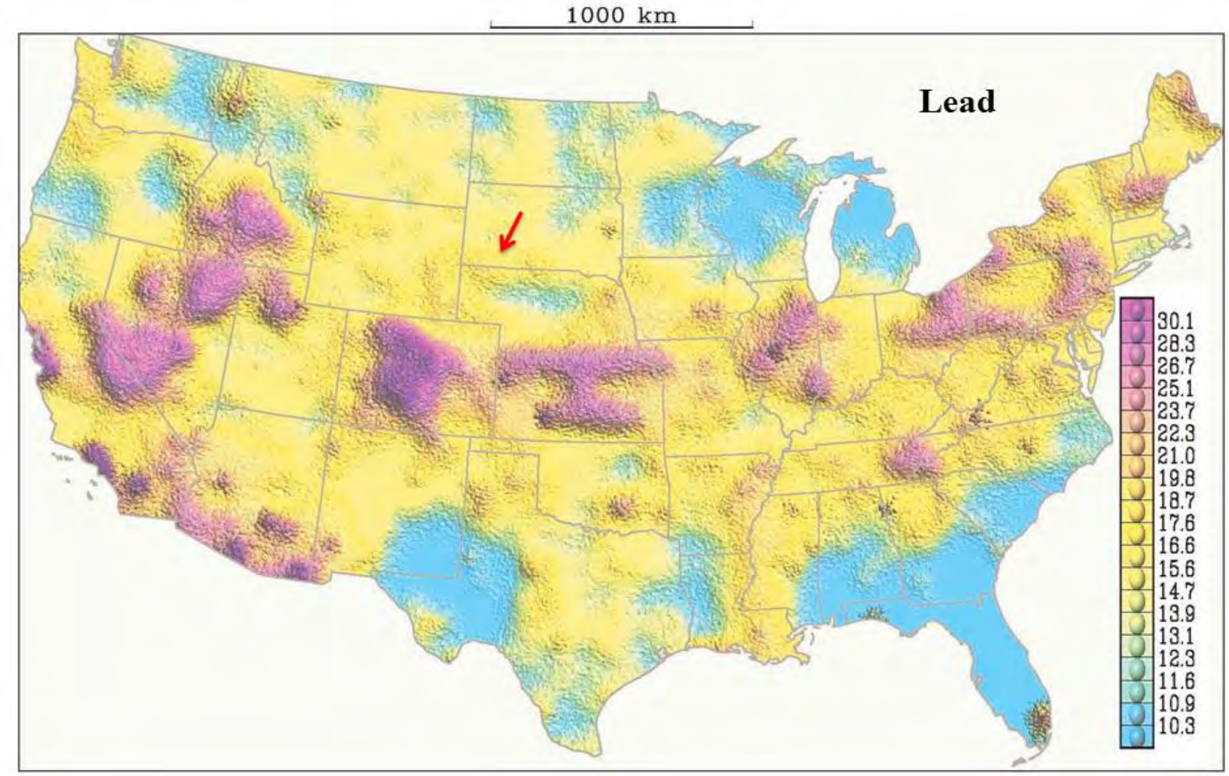


Figure 13. USGS-based lead distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 22).

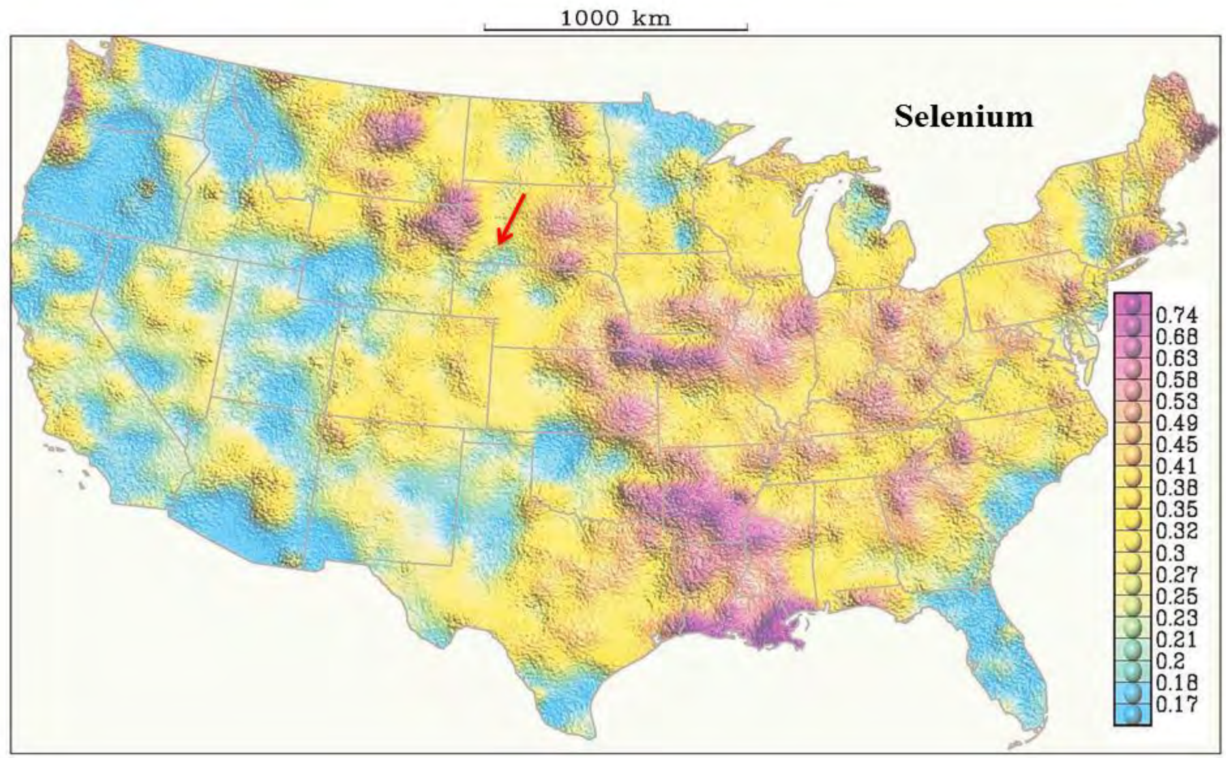


Figure 14. USGS-based selenium distribution in soils and other surficial materials in the conterminous United States, 1961-1975, with Pine Ridge Reservation, South Dakota, at red arrow (modified after Gustavsson et al., 2001, 23).

OTHER SOIL AND SEDIMENT GUIDANCE

Other sources for guidance included the Primary Remediation Goals (PRGs) of the US EPA for Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (Table 17). CERCLA guidance is for initial cleanup of Superfund sites concerning non-cancerous human health risks (unless stated), and is not meant to be used for development of stand-alone baselines. PRGs are not meant to imply a safe level of contamination (US EPA, 2012b). In addition, US EPA's CERCLA guidance lists typical exposure routes (ingestion and absorption), for contaminants, including the heavy metals in the current study, for residential land use as follows:

- Groundwater and surface water, "[i]ngestion from drinking, [i]nhalation of volatiles, and [d]ermal absorption from bathing."
- Surface water, swimming and eating fish.
- Soil, "[i]ngestion, inhalation of particulates, [i]nhalation of volatiles, [e]xposure to indoor air from soil gas, [e]xposure to ground water contaminated by soil leachate, [i]ngestion via plant, meat or dairy products, [and] [d]ermal absorption" (2012b, 4).

Table 17. Soils, US EPA preliminary remediation goals (PRGs), Superfund sites (After US EPA, 2012b).

Analyte	Screening Levels		Protection of Ground Water SSLs	
	Resident Soil mg/kg [ppm]	Key	Risk-based SSL mg/kg [ppm]	MCL-based SSL mg/kg [ppm]
Arsenic, Inorganic	0.39	c*	0.0013	0.29
Barium	15000.00	n	1200.0000	82.00
Lead and Compounds	400.00	L	NA	14.00
Selenium	390.00	n	0.4000	0.26
Uranium (Soluble Salts)	230.00	n	21.0000	14.00

Key: c*= if value were multiplied by 100, non-cancer PRGs would be exceeded; n=noncancer; L=see user guide for lead model; SSL=soil screening level; MCL=maximum contamination limit.

Another standard for soils established by the US EPA (Bastian, 1995) are regulatory limits for concentrations of heavy metals when sludge is applied. The regulations also include the maximum annual as well as the cumulative loading rates for such pollutants, as shown in Table 18.

Table 18. Sludge, US EPA maximum pollutant concentrations for heavy metals when applied to soils (After Bastian, 1995).

Element	Maximum concentration in sludge mg/kg or ppm	Maximum concentration annual pollutant loading rate kg/ha/yr	Maximum cumulative pollutant loading rate kg/ha
Arsenic	75	2	41
Lead	840	21	420
Selenium	100	5	100

Concerning sediment contaminants, the [Brazilian] National Council on the Environment (Conselho Nacional do Meio Ambiente-CONAMA, 2004) established Threshold Effect Levels (TELs) and Probable Effect Levels (PELs) for potentially toxic concentrations. The TELs are defined as “concentrations below which value are rarely associated with biological effects.” CONAMA PELS are defined as “concentrations above which value are frequently associated with biological effects” (National Council on the Environment, 2004). The standards are based on specific isotopes, rather than totals of organic and inorganic concentrations. Concerning analytes related to my study, they listed, for example, ^{75}As (a highly stable, inorganic form), ^{137}Ba, and ^{206}Pb (Table 19).

Table 19. Sediment, CONAMA (Brazil) Threshold (TEL) and Probable Effect Level (PEL) (After [Brazilian] National Council on the Environment, 2004).

Analyte	Limits of Detection ICP-MS mg/kg (ppm)	TEL mg/kg (ppm)	PEL mg/kg (ppm)
Arsenic, ^{75}As	0.026	5.900	17.000
Barium, ^{137}Ba	0.012	no reference value	no reference value
Lead, ^{206}Pb	0.045	35.000	91.300

METHODS AND MATERIALS

The methodology included selecting most of the 15 sites for which permission was obtained from local tribal government and approved by South Dakota State University (SDSU). SDSU’s Institutional Review Board (IRB), Oglala Lakota College’s (OLC’s) IRB, and the Oglala Lakota Sioux Tribe’s (OLST’s) Reservation Review Board (RRB) established certain conditions under which I conducted research. SDSU’s IRB declared the project “exempt” from review but required that I comply with regulations of IRBs/RRBs on PRR. As a result, the Oglala Lakota Sioux Tribe’s (OLST’s) Natural

Resources Regulatory Commission (NRRC) allowed the collection of plant and soil samples on the reservation in public road ditches or within strictly specified areas of tribally owned, non-leased land adjacent to paved roads. The NRRC provided aerial photographs delineating the locations where they allowed sample collecting for the research. Since the plants of interest, traditionally edible fruits, often grow along the perimeters of wooded drainages, we collaborated in examining the NRRC's aerial photos in order to request permission at likely locations. Thereby, NRRC granted permission to collect samples within reservation boundaries, where I gathered samples at Sites 1 through 10 in 2011 and at Sites 12, 14, and 15 in 2012. In addition, I collected samples at Sites 11 and 13 immediately outside reservation boundaries in 2012 (Fig. 15 and Appendix I). I revisited the sites in 2013 collecting more fruit samples to determine weights.

The plan included collecting plant and soil samples and testing them for heavy metals concentrations. The method for analysis was closed capsule microwave digestion and inductively coupled plasma optical emission spectrometry (ICP-OES).

For purposes of comparison of heavy metals concentrations from a different area, 30 sites were sampled (Fig. 16 and Appendix I) in Brookings County, SD, collecting rosehips, but not soils, in the fall of 2011. Rosehips were selected as the fruit of interest, since they comprised the only fruit consistently present at all 15 sites on and near PRR from 2011 and 2012 (Fig. 15 and 16, Appendices D-G [uranium ND], and I).

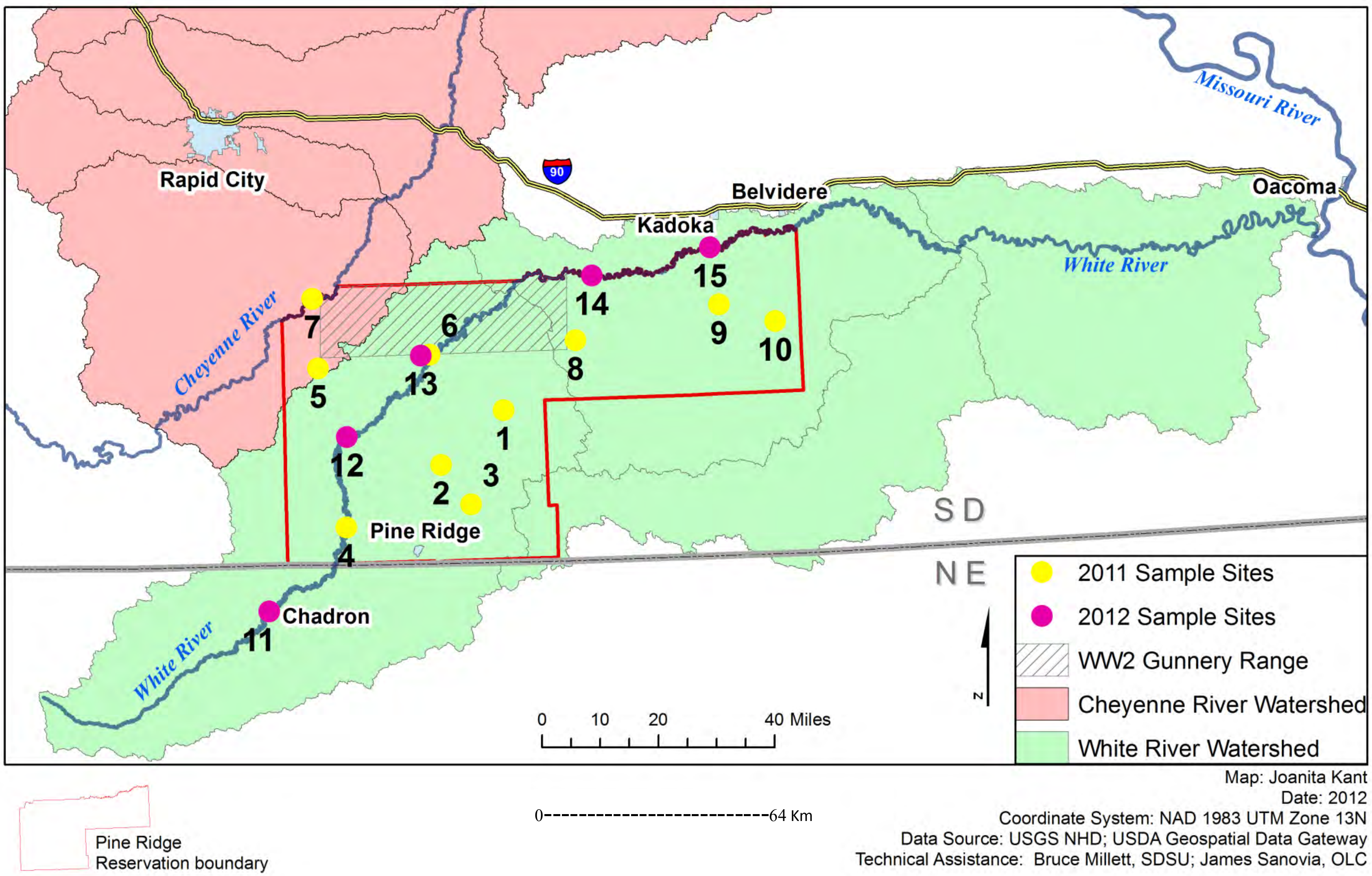


Figure 15. Map of study area and sites with boundaries of Pine Ridge Reservation in red.

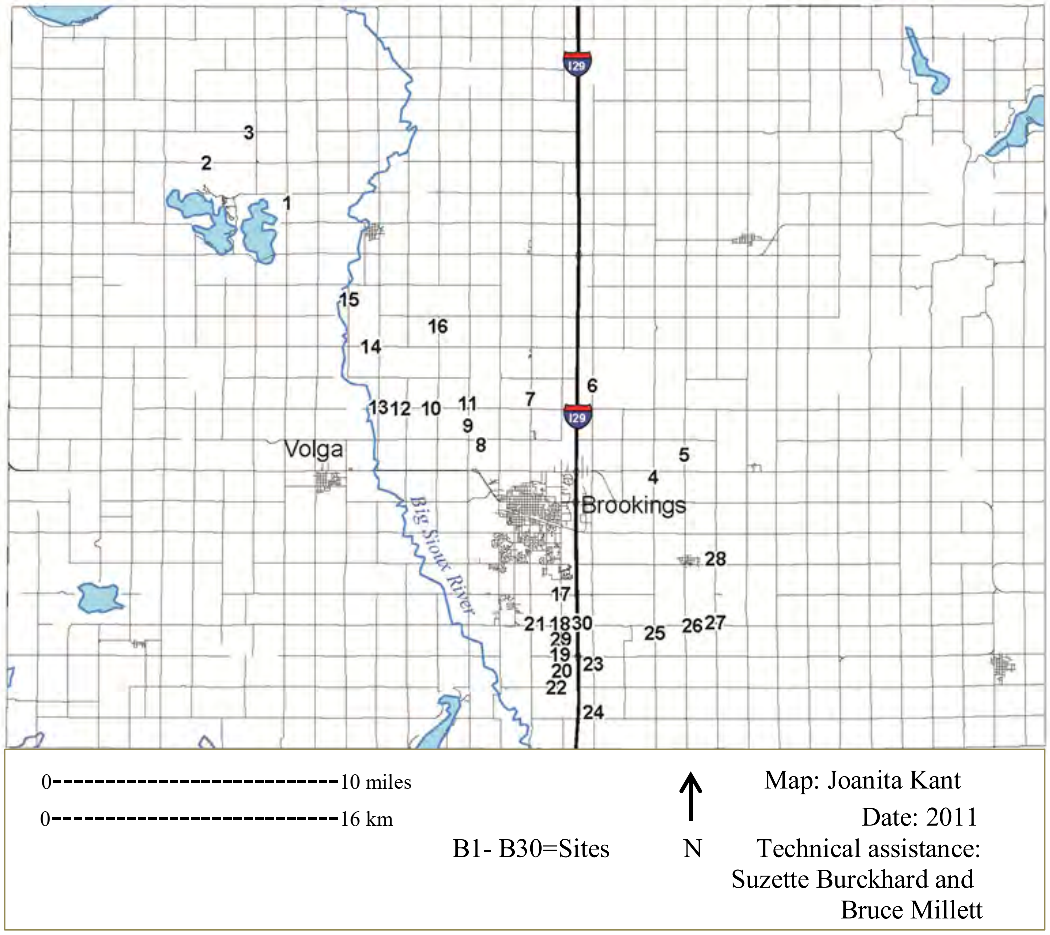


Figure 16. Map of Brookings County, SD comparative rosehip sites, 2011. Brookings sites are numbered with a "B" prefix throughout the manuscript to distinguish them from PRR sites.

DATA COLLECTION

During the 2011 summer season, the sampling plan was as follows. Sites 1 through 10 were selected ranging widely across PRR, shown in yellow in Figure 15. Samples were collected at each site including any of the traditionally edible plants of interest that were available in sufficient quantities, including buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and four species of wild roses or naturally hybridized forms. Sample plant parts of particular interest and highest priority included ripe and green fruits. Precipitation in the year 2011 was higher than average at 21.6 inches (54.864 cm), and 2012 considered by local residents to be a dry year. In comparison, the 31 year average is 19.01 inches (48.285 cm) with a 31 year range of 11.95 to 26.21 inches (30.353 to 66.573 cm) with no data available for 2012 from the Porcupine, SD reporting station on PRR (SD State Climatologist, 2013a). The plants of interest do not necessarily set fruit each year, and fruits were not abundant in either 2011 or 2012. In addition, birds, deer, and other wildlife competed for the fruits. When desirable fruit samples were not available, other plant parts were collected such as flowers, barely formed fruit, and new leafy growth. All plant parts were coded by type.

At Sites 1-10, soil samples were collected at each site in a column at ground surface near the plants of interest and at depths of 10 inches (25.4 cm), 20 inches (50.8 cm), and 30 inches (76.2 cm), with the exception of Site 9 where bedrock was reached at 20 inches (50.8 cm). Soil samples were collected from greatest depths to surface to avoid cross contamination. If plants of interest were more than 50 feet (164 m) apart at Sites 1-10, a second soil column was tested near the second group of plants. At Sites 11-15 along the White River two soil columns were tested, one at the base of the plant, "a," and another, "b," nearby at water's edge on the bank of the White River. In the fall, sites were visited again to collect more ripe fruit, particularly rosehips and grapes.

No permissions were required for collecting throughout Brookings County's comparison sites, numbered B-1 through B-30, in road ditches and public areas. Although an attempt was made to collect from all parts of the county, local wildlife had heavily grazed the plants of interest in certain areas, particularly in the floodplain of the Big

Sioux River, south of Brookings, SD. The samples collected represent the same four species of wild roses and their apparently naturally hybridized forms as those on PRR.

In the 2012 field season, a drought year, my attention turned to the White River trench that bisects the reservation with flow from southwest to northeast. Since an active uranium mine, Crow Butte, operates near the headwaters of the White River west of Crawford, Nebraska, (near Chadron, NE) a comparison of results along the river was of interest. The objective in 2012 was to compare rose plant and surface soil samples at sites along the river (Sites 11-15, shown in red in Fig. 15), with samples generally distributed across the reservation that were collected the previous year (Sites 1-10). Sites 11-15 ranged from west of Crawford and Chadron, NE, to south of Kadoka, SD (Fig. 15). Neither 2011 nor 2012 were years of abundant fruit production at the sample sites.

Wild rosehips were selected because they were the only fruit present at every site tested in the prior year's fieldwork. In addition, roses were unique, as noted along cut banks, for their deep rooting to 20 feet or more or until reaching bedrock. Therefore, roses serve as an environmental indicator with capabilities for absorption and adsorption of heavy metals in soils to greater depths than other plants of interest in the study. Selecting unique local bioindicators has been useful in other heavy metals research, as, for example, Batarseh et al., 2008).

The plan for the 2013 summer season was to collect one-cup (240 mL or 0.24 L by volume) samples of all of the fruits of interest, only to determine fresh and dry weights to coordinate with the self-reported ingestion amounts in Chapter 1. Weights were needed to compute US CDC MRLs.

Buffaloberry was not collected because it did not set fruit in 2013 at Sites 1-15, and sample quantities of ripe fruit were not sufficient for to establish weights in 2011 or 2012. Since a household measuring cup was the standard measurement that was the most meaningful term in conducting interviews, estimates of usage were given in cups and were converted to L. Fresh and dry sample weights were measured in grams.

SAMPLE PREPARATION

Plant and soil samples were collected in the field and placed in plastic Ziploc brand storage bags with labels. Plant clippers, tiling spades, scoops, and augers were thoroughly washed in three rinses of tap water and three rinses of distilled water and air dried before use. Sampling tools were dry brushed and passed through the same rinsing process during use in the field.

Plant and soil samples were placed in coolers with ice until they could be processed later in the day. The plants were divided by plant part and site and were coded, thoroughly rinsed three times in tap water and three times in distilled water, and were air dried in paper sacks. Soils were coded and air dried in paper sacks.

Once we returned to the SDSU laboratory in 2011 and 2012, plant samples were dried for three days at 60 degrees C or less (about 102 degrees F) and were ground and sieved through a 2 mm stainless steel screen. Soil samples and sediments were also oven dried, then pulverized with a mortar and pestle. They were sieved through a 2 mm stainless steel screen.

HEAVY METALS ANALYSIS

All 2011 and 2012 samples were microwave digested in closed vessels, using US EPA Method 200.7 (US EPA 2013b) for soils and plants, in CEM company's MARS 5 equipment. Some soil samples were filtered after microwave digestion, as needed, using Whatman 42 paper. Samples were then subjected to Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) in Varien, Inc., 720 Agilent equipment at the Water and Environmental Engineering Research Center (WEERC) laboratory at SDSU.

For plant samples, 0.25 g of each ground samples was placed in a microwave digestion tube. For soils samples, 0.50 g of each was pulverized, and each sieved sample was weighed and placed in a microwave digestion tube. For plant and soil samples, 10 mL of trace metal grade nitric acid (HNO_3) was added to each by pipette. For microwave and ICP spectrometry runs, each had known values of reference standards and outside source check standards with 32 known elements of interest, called lab standards. For quality control, there were spikes and duplicates, as well as laboratory blanks (Nanopure filtered deionized water with added known amounts of standards). These provided quality checks required by the methods.

Samples were microwaved, cooled, and brought to volume in flasks using Nanopure filtered deionized water. Plant samples were brought to 25 mL volume, and soils to 50 mL. Then each sample was poured into a 50 mL centrifuge tube and capped, labeled, and refrigerated until they were run through the spectrometer. Samples were poured into test tubes in racks for the spectrometer runs. The racks were set up with reference standards and check standards, as noted. The spikes for the blanks were copper or yttrium for the 2011 samples (Sites 1-10) and yttrium for 2012 (Sites 11-15) samples.

The check standards were in the 95^{th} percentile or better. Reference standards were generally at the 90^{th} percentile or better, and duplicates were accepted at the 80^{th} percentile or better. US EPA Method 200.7, item number 6.10 was followed for quality control (2011a).

In 2013, one cup each of the fresh fruit samples was weighed. Each cup was then dried for four days at 60 degrees C (about 102 degrees F), and the dry weight was recorded. The weights were collected for comparison with amounts reported by interviewees in Chapter 1 in Tables 1-6.

The labware cleaning procedure was to wash the item with trace metal grade detergent solution, rinse with tap water, and soak for four hours or more in 20 per cent trace metal grade nitric acid (HNO_3) in solution with Nanopure filtered deionized water. Alternatively, the method allowed the use of nitric acid (HNO_3) or a mixture of nitric acid and trace metal grade hydrochloric acid (HC1) (1+2+9), followed by rinsing with Nanopure filtered deionized water and storing in a clean area. An acceptable alternative procedure included an extra step of rinsing with Reverse Osmosis (RO) deionized water three times and then Nanopure three times after the acid wash. Occasionally, the labware was soaked overnight in the detergent solution before the final rinses to accommodate personnel schedules.

RESULTS AND DISCUSSION

FRUITS

Figure 17 compares ICP-OES detected concentrations of heavy metals of interest for wild rose plant parts for all PRR locale sites in 2011 (Sites 1-10) and 2012 (Sites 11-15) (map, Fig.15; Appendices D-H: Figs. D-6, D7, E-6, E-7, F-6, F-7, G-6, G-7, H4, and H-5). When a site number includes an “a” or a “b,” the site has two soil sample columns because multiple species of plant samples were collected at the site, and the species were more than 50 feet (15.24 meters) apart. Plant and soil samples were linked in this scheme. A site number lacking an “a” or a “b” has only one soil column. If a site number is repeated more than once or if a site has more than one column, it simply represents another sample. (See Fig. 18 for soil concentrations presented in the same manner.)

Wild rose comprised the only plant in the study that consistently was present at every site, including over 28 per cent of the total of 98 samples of the various plants of interest. Figure 17 presents heavy metals concentration results for wild rose plant tissue samples, divided into the following categories: fruit, leaves, and “other” (a mixture of flowers and immature fruits). Heavy metals were detected in rosehip fruits more often than in other tissues of wild roses.

In comparing wild rose samples at Sites 1-10 in the 2011 series (Fig. 17), arsenic concentrations in all three plant part categories. A sample in the rosehips fruit category at Site 10 indicated the highest concentration of arsenic at 3.20 ppm, with Site 2 highest for leaves at 3.05 ppm, and only a single sample at Site 7 indicated arsenic in the “other”

Figure 17. Comparison of all wild rose sample concentrations at all PRR sites (2011 and 2012). Key: Other = mixture of flowers and immature fruit (Appendices G-H: Figs. D-6, E-6, F-6, G-6, and H-4). Backup sample 14b replaced 14a due to lab error.

category at 2.20 ppm. Results showed that arsenic in wild rose tissue was undetected at sites 4 and 8.

Continuing the comparison for wild rose tissues among Sites 1-10 (Fig. 17), results indicated that barium concentrations in all three plant tissue categories. Barium concentrations were highest at Site 1 for rosehips at over 200 ppm. Overall, barium concentrations were generally less than 100 ppm, most often below 50 ppm, and undetected at Site 9.

Lead concentrations were seldom detected in the established wild rose plant tissues for Sites 1-10 (Fig. 17) with the highest occurrence at Site 6 at 1.02 ppm. In rosehips, lead was only detected at Sites 8 and 10 at less than 0.15 ppm, and lead was undetected at Sites 2, 3, 4, 5, 7, and 9.

Selenium concentrations at Sites 1-10 (Fig. 17) in the wild rose plant tissues were highest in fruits rather than leaves or "other," with the highest concentration at Site 8 at 8.94 ppm. The next highest concentration of selenium was for the wild rose plant tissue category of "other" at Site 1 at 6.57 ppm, followed by leaves at 6.52 ppm at Site 7. Selenium was detected in wild rose tissue at every 2011 site, including Sites 1-10.

In comparing Sites 1-10 (Fig. 17), uranium was undetected in wild rose tissues at Sites 3, 4, 5, 7, 8, 9, and 10, but it was detected in each of the plant part categories for wild roses at Sites 1, 2, and 6 at 13.59 pm (fruit), 0.428 ppm (leaves), and 0.564 ppm ("other").

In the 2012 season, only rosehips (fruit) were collected along the White River, for the purpose of comparing samples with the 2011 season's Sites 1-10 rosehip samples. The 2011 sites were generally distributed across the PRR with only one site, Site 4, along the White River (map, Fig. 15). For purposes of comparison, 2012 sites were all established along the White River from upstream to downstream, with Site 11 near Crawford and Chadron, NE, (near an active uranium mine), to Site 15 south of Kadoka, SD. Site 4 (2011) was located between Sites 11 and 12 (2012) (Fig. 15).

In making the comparisons and reviewing Figure 17 by year of sampling, results showed that concentrations of the heavy metals in wild rose tissues at Sites 11-15, with the exception of selenium, were generally equal to or greater than concentrations at Sites 1-10. Site 4 results indicated much lower concentration levels of arsenic, generally comparable levels of barium, much lower levels of lead, much higher levels of selenium, and much lower levels of uranium. Site 4 was sampled after the highway and culvert were washed away by a flash flood in 2011, and the disturbance may help to explain the differences.

The levels of uranium and lead in wild rose tissues at Site 4 are low compared to other White River Sites (Fig. 17). Many variables influence uptake of heavy metals, including uranium, a key difference in comparing uranium (and other heavy metals of interest) concentrations at Site 4 with concentrations in wild rosehips at Sites 11-15 may be precipitation differences in 2011 and 2012 a wet year and a drought year, respectively.

Site 1 is conspicuous for elevated levels in three of the five heavy metals of interest, including barium, selenium, and uranium in wild rose tissues.

Table 20 includes averages and ranges of concentrations of heavy metals in fruits of interest. The exception is buffaloberry, where only one fruit sample was collected, as already noted.

US CDC MRL exposures (Table 21) were determined for the heavy metals of interest in the fruits of interest, with the exception of buffaloberry, since buffaloberry did not set fruit in 2013 when samples were taken to obtain wet and dry weights that were essential for MRL calculations (Appendix K, Table K-1). In addition, the study included only 1 buffaloberry fruit sample because of lack of availability of the fruit in 2011 and 2012. Buffaloberries remained in the study because there were 7 samples of leaves and one sample of "other" (immature fruit and flower parts) in which heavy metals were detected. Those samples remain useful for this screening study in establishing a baseline against which other data may be compared in the future.

Reported exposure quantities in Chapter 1 were used to estimate yearly intake of the fruits in cups (0.24 L volume) in column C, with conversions of fresh "wet" weight to dry weight in column D. Heavy metals concentrations detected in the other fruits of interest on and near PRR at 15 sites were analyzed to find arithmetic means and ranges in mg as shown in Table 21 (Table K-1 in columns G and H). Other factors used in calculations included standard body weight of 55 kg, and 364 or 365 days of chronic exposure. Since a 365-day exposure category was not set for uranium by US CDC, the next best available choice their category of up to 364 days.

In Table 21 (Table K-1), US CDC conversions were calculated in column L as mg of heavy metal concentration in dried fruit multiplied by kg of body weight multiplied by 365 days (or 364 in the case of uranium). Then comparisons were made to see if a potential yearly "dose" exceeded the MRL. For example, the US CDC MRL formula is mg of heavy metal/kg of body weight/days of exposure; thus, for buffalo currant and arsenic, the first line of Table K-1 equals 6.0225 mg, the maximum allowable yearly dose for this standard, as below,

$$\frac{0.0003\,mg\ As}{kg\ \cdot day} \times 55\ kg\ \times 365\ \frac{days}{year}\ = 6.0225\ \frac{mg\ As}{year\ .}$$

The potential yearly dose from Chapter 1 data for arsenic concentration in buffalo currant equals 2.7273 mg, based on the arithmetic mean, as below,

$$\frac{100\ cups}{year} \times 0.02117\ \frac{kg\ dry\ fruit}{cup} \times 1.288\ \frac{mg\ As}{kg\ dry\ fruit} = 2.73\ \frac{mg\ As}{year\ .}$$

The potential yearly dose based on the maximum concentration observed equals 5.4555 mg, as below,

$$\frac{100\ cups}{year} \times 0.02117\ \frac{kg\ dry\ fruit}{cup} \times 2.5770\ \frac{mg\ As}{kg\ dry\ fruit} = 5.46\ \frac{mg\ As}{year\ .}$$

Thus, in this case, since 6.0225 mg exceeds 2.7273 mg and 5.4555 mg, both doses are below the MRL standard.

In Table 21 (Appendix K, Table K-1), calculations that exceeded MRLs are marked in red and yellow.

Final results were extracted from Table K-1 and summarized in Table 21, emphasizing US CDC MRLs. Reported exposures were calculated for the mean and the highest score in the range to determine a “dose” that exceeded neither, then checking to see how many individuals in certain categories still exceeded that dose (shown in yellow in Table 21). Exposure to heavy metals potentially exceeded MRLs for some fruits. In particular, those included arsenic for 4 persons (12.5 per cent) consuming chokecherries at a maximum of 16 cups per year. In addition, those included arsenic for 1 person (3 per cent) consuming wild rosehips at a maximum of 16 cups per year. Also potentially exceeding US CDC MRLs for uranium in particular were 2 persons (6 per cent) at a maximum of 32 cups per year of wild plums, and for uranium, four persons (12.5 per cent) at a maximum of 2 cups of wild rosehips per year of wild rosehips.

The potential for exceeding MRLs increases when multiple fruits are ingested by an individual creating a cumulative total as the yearly dose. It is important to keep in mind that the standard for uranium MRLs is "uranium soluble salts," and the study only detected "total uranium," so that identical comparisons could not be made. While using the fruits may increase exposure to heavy metals in the PRR community, the risk of exceeding US CDC MRLs from use of these foods, alone, is relatively low (Table 21). Further studies, comparing equivalent analytes, as well as total dietary studies could provide a clearer view of true uptake potential.

Comparisons of concentrations of heavy metals detected in PRR area rosehips with those from 30 sites (Sites B-1-B30, 2011) in Brookings County, SD are presented in Table 22 with calculations in Appendix K, Table K-2. Results indicated that heavy metals concentrations were generally lower in the Brookings County samples with the exception of lead and selenium which were comparable or slightly higher. The highest concentrations for individual samples for lead and selenium in Brookings County may be outliers. However, increased lead concentrations in Brookings County may be related to greater population density and the use of leaded gasoline before the advent of emissions controls on vehicles.

Table 20. Fruit, ranges and arithmetic means for heavy metals concentrations, Sites 1-15, near and on PRR. Calculations do not include for buffaloberry, since only one fruit sample was collected, although other buffaloberry plant tissues are included in the study.

Fruit	Heavy metal	Only one sample mg/kg	Arithmetic mean mg/kg	Range (ND=none detected) mg/kg	ND ratio	ND %
Buffaloberry	arsenic	0.68	NA	NA	NA	NA
	barium	27.39	NA	NA	NA	NA
	lead	ND	NA	NA	NA	NA
	selenium	5.72	NA	NA	NA	NA
	uranium	ND	NA	NA	NA	NA
Buffalo currant	arsenic		1.29	ND-2.58	1 of 2	50
	barium		10.15	4.97-15.34	0 of 2	0
	lead		ND	ND	2 of 2	100
	selenium		2.26	2.21-2.30	0 of 2	0
	uranium		ND	ND	2 of 2	100
Chokecherry	arsenic		0.32	ND-1.93	6 of 9	67
	barium		27.39	ND-58.71	1 of 9	11
	lead		0.01	ND-0.07	7 of 9	78
	selenium		2.84	ND-7.42	3 of 9	33
	uranium		ND	ND	9 of 9	100
Wild grape	arsenic		0.42	ND-1.11	2 of 4	50
	barium		54.77	31.05-77.23	0 of 4	0
	lead		1.76	ND-0.29	3 of 4	75
	selenium		1.76	ND-4.12	2 of 4	50
	uranium		ND	ND	4 of 4	100
Wild plum	arsenic		0.26	ND-1.03	3 of 4	75
	barium		69.19	23.45-178.24	0 of 4	0
	lead		0.00	ND-0.01	0 of 4	0
	selenium		5.14	2.35-8.90	0 of 4	0
	uranium		0.72	ND-2.90	3 of 4	75
Wild rose	arsenic		0.41	ND-3.20	17 of 27	63
	barium		34.94	ND-211.51	3 of 27	11
	lead		0.06	ND-0.69	21 of 27	78
	selenium		1.94	ND-8.94	6 of 27	22
	uranium		1.46	ND-13.59	21 of 27	78

Table 21. Fruit, US CDC MRL calculations for heavy metals, Sites 1-15 on and near PRR.

A	B	C	D	E	F	G	H	I
Fruit	Heavy metal species in US CDC standard	Number of cups per year, cups fresh, volume (1 c.- 0.24L) per year, cups	Yearly "dose" based on arithmetic mean mg	Yearly "dose" based on highest score in range mg	Body weight standard kg	Days of chronic oral use	Exposure in mgs of heavy metal/ kg of body weight/ 365 days (except uranium/365 days)	# persons/% above lowest MRL dosage*
Buffalo currant	arsenic	100	2.73	5.46	55	365	6.02	
	barium soluble salts	100	21.50	32.48	55	365	4015.00	
	selenium	100	4.78	4.86	55	365	100.38	
	uranium soluble salts	100	ND	ND	55	364	4.00	
Chokecherry	arsenic	150	2.47	14.96	55	365	6.02	
	arsenic	80	1.32	7.98	55	365	6.02	
	arsenic*	16	0.26	1.60	55	365	6.02	#4/ 12.5%
	barium soluble salts	150	212.00	454.50	55	365	4015.00	
	selenium	150	21.98	57.42	55	365	100.38	
	uranium soluble salts	150	ND	ND	55	364	4.00	
Wild grape	arsenic	80	1.24	3.28	55	365	6.02	
	barium soluble salts	80	161.95	228.34	55	365	4015.00	
	selenium	80	5.19	12.18	55	365	100.38	
	uranium soluble salts	80	ND	ND	55	364	4.00	
Wild plum	arsenic	150	0.96	3.83	55	365	6.02	
	barium soluble salts	150	256.34	660.36	55	365	4015.00	
	selenium	150	19.05	32.96	55	365	100.38	
	uranium soluble salts	150	2.68	10.72	55	364	4.00	
	uranium soluble salts	80	1.43	5.72	55	364	4.00	
	uranium soluble salts*	32	0.57	2.29	55	364	4.00	#2 / 6%
Wild rose	arsenic	64	1.40	11.00	55	365	6.02	
	arsenic*	16	0.35	2.75	55	365	6.02	#1 / 3%
	barium soluble salts	64	119.96	726.09	55	365	4015.00	
	selenium	64	46.64	30.70	55	365	100.38	
	uranium soluble salts	64	5.01	46.64	55	364	4.00	
	uranium soluble salts	16	1.25	11.66	55	364	4.00	
	uranium soluble salts	10	0.78	7.29	55	364	4.00	
	uranium soluble salts	6	0.47	4.37	55	364	4.00	
	uranium soluble salts*	2	0.16	1.46	55	364	4.00	#4 / 12.5%

Key: red= yearly "dose" in mgs where interviewees exceeded mean or highest score in reported range; yellow*= yearly "dose" (Column C) where some interviewees still exceeded the MRL dosage (Column H), with numbers/percentages of interviewees represented in that category, Column I; and Column H=do not exceed level based on MRL.

Table 22. Wild Rosehips comparison of heavy metals concentrations, on and near PRR Sites 1-15; and Brookings County, SD, Sites B1 through B30 (see Appendix K, Table K-2 for calculations). Key*= possible outliers.

Element	Location	Range (ND=none detected) mg/kg	Arithmetic mean mg/kg	ND ratio	ND %
arsenic	PRR study area	ND-3.20	0.41	17 of 27	63
arsenic	Brookings Co., SD	ND-2.56	0.26	24 of 30	80
barium	PRR study area	ND-211.51	34.94	3 of 27	11
barium	Brookings Co., SD	0.45-23.31	6.94	0 of 30	0
lead	PRR study area	ND-0.69	0.06	21 of 27	78
lead	Brookings Co., SD	ND-1.67*	0.08	24 of 30	80
selenium	PRR study area	ND-8.94	1.94	6 of 27	22
selenium	Brookings Co., SD	ND-10.25*	2.73	6 of 30	20
uranium	PRR study area	ND-13.59	1.46	21 of 27	78
uranium	Brookings Co., SD	ND	ND	30 of 30	100

Johnson and Ademoyero warn that risk assessments need to be improved and that creating risk assessments based on inadequate data should be avoided, as follows:

> In the absence of adequate scientific information, a risk assessment should not be done. All risk assessments acquire a certain degree of permanency, and those that are developed using less-than-adequate database are difficult to retract and lead to diminished credibility of the risk assessor. Rather than developing a risk assessment predicated on an insecure foundation, it is better to identify and conduct the key research needed to perform a specific risk assessment" (1994, 10-11).

Therefore, in heeding their advice, the current study purports to add to the overall database of detected levels of selected heavy metals and routes and amounts of ingestion of traditionally edible fruits in certain populations, determining if cultural norms tend to increase exposure to naturally occurring heavy metals. Specific risk assessment for disease, per se, is beyond the scope of the current study. The comparisons to US CDC MRLs that follow for arsenic, barium, selenium, and uranium are meant to guide health professionals concerning where to look more closely. In comparing lead concentrations to standards set by WHO/FAO and FSANZ, the same applies.

Concentrations of heavy metals in fruits were compared to US CDC MRLs, with the exception of lead, since no lead MRL has been established. The US CDC does not set levels because they have concluded that there is no "safe" level, and that might be implied by setting an MRL. Lead exposure should be kept as low as possible. Lead is considered later and is compared to other standards. Calculations began with the highest number of cups reported by an individual as reported in Chapter 1. Buffaloberry was not included because it did not set fruit in 2013, the year fruits were collected for weighing. Collecting fruit for the purposes of establishing weights was delayed in 2011 and 2012 because fruit production was limited in each of those years, probably due to weather and lack of pollination.

When calculating MRLs based on arithmetic means of heavy metals concentrations in fruit, Sites 1-15 were below the standard based on maximum cups reported in interviews, with one exception. That exception was for uranium in wild rosehips on and near PRR based on a maximum reported use of 64 cups per year. It is important to note that the current study measured total uranium, and the US CDC standard is for "uranium soluble salts." The yearly mean dose reported in interviews in Chapter 1 at 5.0091 mg was only slightly higher than the MRL of 4.0040 mg. for uranium soluble salts. Thus, it is possible that samples could fall within MRL limits if equivalents could be compared. However, a maximum of 16 cups (3.79 L) of wild rosehips could be ingested to remain below the MRL.

A second calculation was made, using the most extreme score of detected concentrations of heavy metals in fruits, calculating MRLs based on the highest scores in each range. The point was to create the worst case scenario for ingesting heavy metals based on samples in the study, however unlikely.

When calculating MRLs based on the highest score in the ranges of heavy metals concentrations in fruit, only arsenic in chokecherries and wild rosehips, and uranium soluble salts were exceeded for wild plum and wild rosehips. MRLs were exceeded for arsenic at 80 cups (18.93 L) per year of chokecherries, with a maximum of 150 cups (35.49 L) reported by an interviewee in Chapter 1. Also for arsenic, MRLs were exceeded at 64 cups (15.14 L) (the maximum reported) for wild rosehips. MRLs were exceeded for uranium soluble salts at 80 cups per year for wild plums, with a maximum of 150 cups (35.49 L) reported. MRLs were exceeded for uranium soluble salts (although total uranium and not uranium soluble salts was measured in the fruits) at 6 cups per year for wild rosehips, with a maximum of 64 cups (15.14 L) reported. Despite those excesses, 4 of 32 persons ingesting arsenic in chokecherries and 1 of 32 persons ingesting arsenic in wild rosehips exceeded the MRLs. In addition, 2 persons ingesting uranium soluble salts in wild plums and 4 persons ingesting uranium soluble salts in wild rosehips exceeded the MRLs. The risk, therefore, based on US CDC MRLs, is low when basing calculations on the highest score in the range of values for heavy metals in traditionally edible fruits.

For those individuals consuming several or all of the fruit types, the cumulative load of each of the heavy metals could potentially exceed the MRLs for a few based on the highest score in the range. For example, the MRLs may be exceeded for arsenic and uranium if the maximum amount reported of each of the fruits were ingested per year. The load would be calculated by adding the "dose" per year for arsenic from each type of fruit and checking to see if it exceeds the total MRL allowable. For example, the yearly maximum dose for arsenic in buffalo currant based on the arithmetic mean is 2.73 mg; and for chokecherry, 2.47 mg; and for wild grape, 1.24 mg; and for wild plum 0.96 mg; and for wild rose, 1.40 mg; for a total of 8.8 mg, while the MRL is 6.02 mg. Such calculations might suggest looking more closely at ingestion of fruits at such levels as 100 cups (23.66 L) for buffalo currant, 150 cups (35.49 L) for chokecherry, 80 cups (18.93 L) for wild grapes, 150 cups (35.49 L) for wild plum, and 64 cups (15.14 L) for wild rosehips (Table 21), especially in combination.

The wild rosehips results for Sites 1-15 on and near PRR were compared to wild rosehip results at Sites B1-B30 in Brookings County (Table 22). Calculations were determined based on arithmetic means, as above, and all samples were lower than MRLs. However, when calculations were based on the highest score in the range, arsenic (possibly an outlier) exceeded the MRL standard of 6.0225 mg with a result of 8.7880 mg, again representing an unlikely worst case scenario. In addition, the selenium range to 35.18 mg is likely an outlier with the next lower score at 6.810 mg. With that in mind, generally, all means and ranges were substantially lower than those for PRR (Table 21, and Appendices K and I: Tables K-2, and I-5).

WHO/FAO Codex Alimentarius (2000) set a lead concentration for maximum level permitted (ML) at 0.20 mg/kg for berries and small fruit and 0.10 mg/kg for pome and stone fruits with lower levels for infant foods. In addition, FSANZ (2013) set the lead ML for fruit at 0.10 mg/kg. Results indicated that for lead concentration levels detected in all fruit samples at Sites 1-15 in the PRR locale, 5 of 47 (11 per cent) exceeded 0.10 mg/kg, and 4 of 47 (8.5 per cent) exceeded 0.20 mg/kg (Appendix I, Table I-1 and I-2). By way of comparison, 5 of 30 (17 per cent) wild rosehip samples in Brookings County exceeded 0.10 mg/kg, and 3 of 30 (10 per cent) exceeded 0.20 mg/kg (Appendix I, Table I-5).

While the US EPA (2013a) has set primary drinking water standards for lead as a "treatment technique," (TT), meaning that action is required if samples are consistently above certain levels, US governmental agencies have not set levels for food, with the exception of bottled water (US FDA 2009a). Food is handled on a case by case basis.

The US CDC (2007c) has not set lead standards because they do not want to convey that any level of lead is "safe," especially for vulnerable populations such as fetuses, infants, children, the malnourished, and those in poor health, among others. Their position is simply that lead needs to be kept at the lowest possible levels that are economically feasible.

SOILS

Figure 18 compares ICP-OES detected concentrations of heavy metals of interest in soils at Sites 1-10 on PRR in 2011 at the surface, 10, 20, and 30 inches (surface, 25.4, 50.8, and 76.2 cm) levels, and at Sites 11-15 on and near PRR in 2012, at the surface (also see Figs. D-8, E-8, F-8, G-9, and H-6). The purpose of testing Sites 11-15 in 2012 was to determine if concentrations of heavy metals in soils at sites along the White River varied from those distributed across PRR, including Site 4 along the White River.

The variability of heavy metals concentrations at the same site is apparent in comparing detected levels at “a” and “b” paired sites, such as 4a and 4 b, for example. Most “a” and “b” soil columns are within 100 feet (30.48 meters) of one another. As noted, a second soil column was established only if necessary as in cases where plants of interest were more than 50 feet (15.24 meters) from soil column “a” at each site (Fig. 18).

Year 2012 White River Sites 11-15 were generally higher in concentrations of arsenic in soils at the surface level than other PRR sites with the exception of White River Site 4. Compared to the 2012 White River sites, the 2011 sites were generally comparable in soil concentrations of barium and lead at the surface level but much lower in selenium and much higher in uranium, with the exception of Site 8, with the highest concentration for uranium of any site in the entire study at 35.94 ppm.

In comparison with one another, Sites 1-10 from the 2011 series, revealed arsenic concentrations in soils at all sites but not at all depths in the study. Arsenic concentrations in soils were highest at Site 4 at 12.30 ppm at a depth of 50.8 cm. Concentrations of arsenic in soils were generally below 8 ppm.

Continuing the comparison, soil concentrations of barium were detectable in all samples at Sites 1-10. Site 3 had the highest concentration of barium at about 1,300 ppm at a depth of 76.2 cm. Barium concentrations in soils were reported at all sites and most depths, usually in concentrations below 400 ppm, but increasing to over 600 ppm at sites 2, 4, 9, and 10. In general, most soil concentrations of barium were well below 800 ppm.

Lead concentrations detected in all soil samples at Sites 1-10 indicated that the highest concentration of lead was at Site 4 on the White River, at 28.44 ppm at a depth of

50.8 cm. The next highest concentrations were at the surface level at Sites 1, 2, 4, 5, 6 and 9 from about 10 to 20 ppm.

Selenium was detected in all soil samples for Sites 1-10, ranging from below 2 ppm at a few sites to a high of more than 12 ppm at Sites 3 and 4. Potential bioaccumulation of selenium in plant tissue is discussed elsewhere.

Although detected in most soil samples at Sites 1-10 (2011), uranium showed variable concentrations at all depths with the largest concentration of 29.35 ppm at a depth of 20 inches (50.8 cm) at Site 7, and 35.94 ppm at the surface level at Site 8. In general, uranium concentrations were below 32 for Sites 1-10 (Fig. 18).

Figure 18. Comparison of all soil sample concentrations at all PRR sites (2011-2012). Site 9 lacks 76.2 cm sampling because of bedrock at that level (Appendices D-H: Figs. D-8, E-8, F-8, G-9, and H-6). Backup sample 14b replaced 14a due to lab error.

SOILS COMPARED TO USGS BASELINES

Soil concentration results from the current study were also compared with results from two USGS baselines for the conterminous United States. For both, samples were collected by USGS teams from 1961 to 1975 by Shacklette and others (Shacklette et al., 1971; Boerngen and Shacklette, 1981; and Shacklette and Boerngen, 1984) and the data was later reworked by Gustavsson et al., 2001.

Since the USGS samples were collected at a depth of 24 cm, samples from the current study at the closest depth, 25.4 cm, were extracted for comparison (Table 23). In addition, all soil sample results from the current study, collected in the summers of 2011 and 2012, were extracted for comparison (surface, 25.4 cm, 50.8 cm, and 76.2 cm) for all 15 sites (Appendix I, Tables I-3 and I-4). Arithmetic means and ranges were determined, and comparisons are presented in Table 24.

Table 23. Soil sample concentrations from PRR, depth of 25.4 cm, 2011.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm
1a	3.55	257.11	7.67	7.33	5.08
1b	2.80	224.02	9.01	2.05	11.16
2a	1.31	220.40	8.74	6.65	4.97
2b	2.67	216.05	7.34	8.63	0.00
3a	0.27	182.35	6.80	12.52	7.71
3b	0.52	210.72	5.84	3.86	0.00
4a	6.30	312.74	8.66	3.30	15.35
4b	2.74	320.25	8.60	11.58	10.22
5	2.18	189.82	13.17	5.31	16.96
6	5.73	253.55	10.45	9.66	13.83
7a	4.30	139.53	6.35	9.73	1.90
7b	1.89	176.20	3.91	6.93	1.28
8a	6.06	247.69	6.04	8.31	6.20
8b	5.01	254.48	7.13	9.94	27.95
9	5.14	458.75	12.51	5.19	18.25
10	0.64	619.23	11.09	6.78	16.40
arith. mean	3.19	267.68	8.33	7.36	9.83
range	0.27-6.30	140-619	3.91-13.17	2.05-12.52	0-27.95
std. dev.	1.97	115.64	2.42	2.87	7.64
# ND	0	0	0	0	2
% ND	0	0	0	0	12.5

Table 24. Soils, USGS baseline concentration comparisons with PRR locale Sites 1-10 at similar depths and at various depths (gray for emphasis of arithmetic mean and range comparisons at similar depths, as distinguished from median-derived and Bootstrap-determined baselines or other depths).

	A	B	C	D	E	F	G	H
Element	USA conterminous	PPR range at 24 cm	USA conterminous		PRR locale			
	range at 24 cm		range at 24 cm	arithmetic mean at 24 cm	range at 25.4 cm	arithmetic mean at 25.4 cm	range at surface, 25.4, 50.8, and 76.2 cm	arithmetic mean at surface 25.4, 50.8, and 76.2 cm
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Arsenic	3.10-11	4-8	0.10-97	7.20	0.27-6.29	3.19	ND-12.30	3.32
Barium	241-945	800-945	10-5,000	580	139.53-619.23	267.68	139.5-1311.9	308.49
Lead	10.30-30.10	15-20	<10-700	19	3.91-13.17	8.33	3.91-28.44	8.98
Selenium	0.17-0.74	0.17-0.41	<0.10-4.30	0.39	2.05-12.52	7.36	ND-12.69	6.17-7.03
Uranium	NA	NA	0.29-11	2.70	ND-27.94	9.83	ND-35.94	13.46

Key: A=1961-1975, weighted-median and Bootstrap-based by Gustavsson et al. (2001) representing about 1,318-1,323 statistically reworked samples after Shacklette and Boerngen (1984) and others. B=1961-1975, weighted median and Bootstrap based, PRR data extracted by Kant from Gustavsson et al., 2001, after Shacklette and Boerngen (1984) and others, representing about four sites. C and D=1961-1975, representing 1,318-1,323 samples from Shacklette and Boerngen (1984) and others. E and F=Kant, 2011, representing 16 samples, Sites 1-10. F=Kant, 2011, representing 16 samples, Sites 1-10. G and H= Kant, 2011-2012, representing 73 samples, Sites 1-15.

USGS baseline studies were selected for comparisons with soils in the current study, although US EPA PRGs, US EPA sludge standards, and Brazilian CONAMA sediment standards were presented in the literature review to show the variety of guidance concerning soils that is available for researchers.

Of the heavy metals of interest in this study, average soil concentrations of arsenic, barium, and lead (at depths of about 24 to 25 cm) are lower than baselines for the conterminous United States established by Shacklette and Boerngen (1984) in USGS studies (Table 24). However, average soil concentrations of selenium and uranium are much higher, as much as 18 times for selenium and 3.6 times for uranium for samples from the PRR locale (Table 24, columns C-F).

While it is of interest to compare current study results with the soil baselines established by Gustavsson et al. (2001), their results were based on weighted moving medians that were statistically bootstrapped (Table 24, column A). Data in the current study is based on ranges and arithmetic means; thus, comparisons with the baselines established by Gustavsson et al. are not as useful for comparisons as the arithmetic means and actual ranges for the conterminous United States estimated by Shacklette and Boerngen (1984) (Table 24, columns C-D).

The maps by Gustavsson et al. (2001) were relevant for comparison (Figures 11-14), since they depict, by color coding, relative concentrations of arsenic, barium, lead, and selenium (not including uranium) distribution in soils for the conterminous United States. Their maps by Gustavsson et al. (2001) indicate that for the PRR area, arsenic is generally in the low range, barium in the high range, lead in the medium range, and selenium in the low range.

The low selenium determination for the PRR locale as shown on the map (Fig.14) by Gustavsson et al. (2001) is likely an anomaly caused by statistical procedures. In checking the maps of Shacklette and others (1984), upon which the Gustavsson et al. maps were based, results for the PRR locale were probably based about four sample sites on PRR, statistically manipulated to the number of samples in the original study when the data was reworked. Thus, the PRR locale, known for its selenium indicating plants, escaped detection. The Gustavsson maps remain valuable as the most comprehensive baseline available for the conterminous United States, although they may have limited precision at the local scale.

In Figure 14, the selenium distribution map by Gustavvson et al. (2001), with its statistically smoothed data, some of the highest levels of selenium in the conterminous United States are indicated in soils northwest of PRR, in the Black Hills, northeast Wyoming, and southwest Montana (median-weighted and bootstrapped ranging from 0.17 to 0.74 ppm). However, in the current study, selenium concentrations in soils, on and near PRR ranged from none detected to 12.69 ppm with an average of approximately 6 to 7 ppm at a depth of 25.4 cm (Table 24). Shacklette and Boerngen (1984) reported a range of <0.10 to 4.30 ppm with an arithmetic mean of 0.39 ppm for the conterminous United States (Table 24). Thus, by comparison, the PRR locale is a place of high concentrations of selenium.

Uranium was not included when Gustavvson et al. (2001) revised and statistically manipulated the data of Shacklette and others. However, Shacklette and Boerngen (1984) originally reported an actual statistical range (not a modified median as in Gustavvson et al. 2001) of uranium concentration in soils for the conterminous United

States at 0.29 to 11 ppm and an arithmetic mean of 2.70 ppm (Table 24, column D). Uranium results from the current study, when including soil samples at a depth of 25.4 cm ranged from none detected to 27.94 ppm with an arithmetic mean of 9.83 ppm (Table 24, columns E-F). Thus, uranium concentrations in soils on and near PRR are much higher than the maximum range reported by Shacklette and Boerngen (1984) for the conterminous United States. For the PRR locale, results at 25.4 cm indicated that the highest concentration in the range was more than twice that reported by Shacklette and Boerngen (1984) for the conterminous United States, and the PRR arithmetic mean was nearly three times higher (Table 24, columns E-F). Thus, PRR is a place of high concentrations of uranium when compared to the conterminous United States.

SOILS AND US EPA PRG COMPARISONS

In comparing US EPA PRGs (2012b) with results from the current study (Table 17), it is important to note the species of the element compared and that soil screening level PRGs are meant as initial clean-up goals at Superfund sites. In addition, PRGs are not applicable where natural background levels exceed US EPA screening levels, as is likely the case on and near PRR.

With that in mind, the average concentration levels of arsenic are well above the US EPA PRGs (2012b) for residential soils and ground water protection. The US EPA species is inorganic arsenic, not the total arsenic as in the current study. Concerning barium, average concentration levels were well below soil screening level PRGs for residential soils, and well above for one category of ground water protection, and well below for the other. Average concentrations for lead were well below soil screening level PRGs for residential soils and protection of ground water. Average concentrations for selenium concentrations were well below soil screening level PRGs for residential soils but well above for protection of ground water in both categories. For uranium, average concentrations were well below soil screening level PRGs for residential soils and below for protection of ground water in both categories.

BIOACCUMULATION OF SELENIUM

Comparing heavy metals levels in all wild rose plant tissues in Figure 17 with those of all associated soil samples in Figure 18, the study indicates that plants of interest at Sites 1-10 accumulate certain heavy metals from the soils in which they grow. The degree of uptake is not necessarily in direct proportion to the amount of heavy metals of interest in the soils, however. Bioaccumulation of selenium may occur in wild rose plant tissue at Sites 1, 3, 7, 8, 9 (Appendix G, Figs. G6-G8) where concentrations in the plant tissues sometimes exceeded the lowest concentration of selenium in the soils in which the plants grow (Figs. 17 and 18).

There is also potential selenium bioaccumulation in the fruits of wild roses at some of the 2012 sites on the White River (Fig.19). Although surface soil samples show low or undetectable levels of selenium concentration, rosehip concentrations were in excess of soil levels at Sites 11, 13, and 15. The rosehips may uptake selenium from higher concentration levels at greater soil depths or through delivery of selenium to the plants during periodic flooding along the White River. Only surface soil was sampled during the 2012 field season at Sites 11-15.

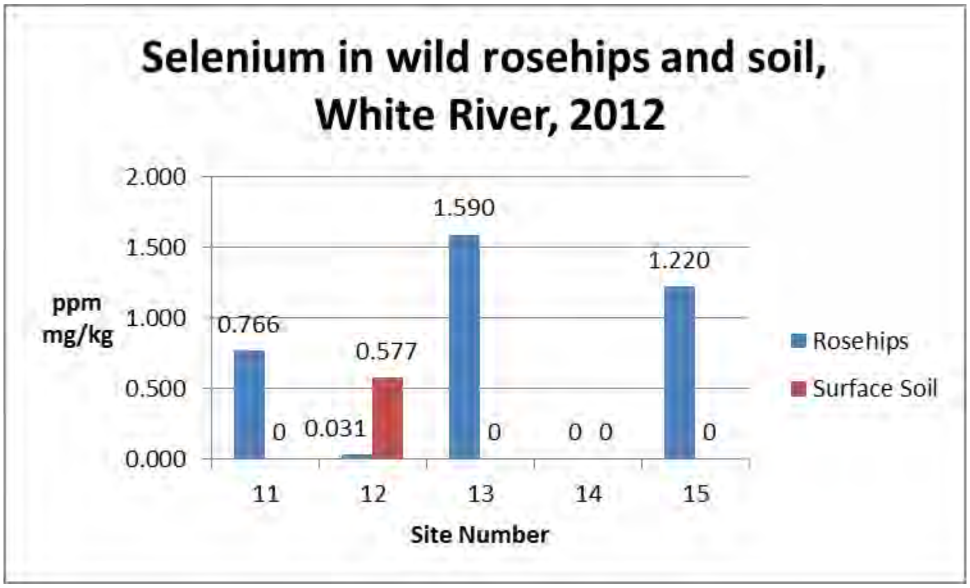


Figure 19. Paired columns comparing detected concentrations of selenium in rosehips and surface soil samples at Sites 11-15 (2012) indicated potential bioaccumulation of selenium in rosehips because of higher levels in some plant samples than the soils in which they grow.

Overall results for all plant tissue and soil samples in the study suggested selenium bioaccumulated in some fruits and other plant tissues. Of 104 total plant samples tested at Sites 1-15 (Sites 1-10 in 2011 and Sites 11-15 in 2012), identified as either fruits, leaves, or "other" (non-root, mostly flower parts and immature fruits), selenium concentrations were detected in 74 samples. Forty-one plant tissue samples (33 per cent), showed concentrations of selenium greater than at least one of the soil samples in which the plant grew. Sites involved included 1, 3, 4, 7, 8, 9, 11, 13, and 15 and at least one sample of all species of plants of interest in the study. A few samples showed higher concentrations of selenium than any of the soil samples at the site, including a plum fruit sample at Site 3, a buffaloberry leaf sample and a buffalo currant leaf sample at Site 4, and a buffalo currant "other" sample at Site 9 (Appendix I, Tables I-1, I-4; I-2 and I-3). Bioaccumulation was not analyzed for Brookings County, SD comparison sites, since no soil samples were collected.

CONCLUSIONS

This screening study identified areas where researchers should look more closely to see if health or toxicity risks exist. Generally, results indicate that modern day uses of traditionally edible fruits on PRR may increase the community's risk of exposure to certain heavy metals. However, more studies would be needed to assign definitive risk levels to specific ingestion quantities.

All ICP-OES sample results for this study did not differentiate between organic and inorganic forms of arsenic, barium, lead, or selenium, or specifically between "uranium soluble salts" and total uranium. Current standards and risk assessments from various regulations and guidelines cited in this study are based on specific forms of the elements of interest. For example, US CDC MRL (2012b) element forms are as follows for fruits: "arsenic, barium soluble salts, selenium, and uranium soluble salts." The WHO/FAO (2000 and 2012) standard for lead in fruit is specifically for "lead." USGS forms of elements reported by Shacklette and Boerngen (1984) for soils are listed as "arsenic, barium, lead, selenium, and uranium." With that in mind, significant findings are presented below.

1. In general, US CDC MRLs for reported annual oral intake doses of heavy metal containing fruits were not exceeded at the calculated mean heavy metal concentration dose. When based on the highest dose in the range for heavy metals concentrations in fruit samples, MRLs may have been exceeded for arsenic in

chokecherries and wild rosehips, and for uranium in wild plum and wild rosehips in 3 to 12.5 per cent (1 to 4 of 32 individuals interviewed) of those potentially ingesting the fruits on PRR, based on amounts reported by interviewees on nearby Rosebud Reservation.

2. Concentrations of lead in 8.5 per cent of fruit samples on and near PRR exceeded the WHO/FAO ML in the food category of small fruits. No samples of wild rosehips at comparison sites in Brookings County, SD, exceeded the WHO/FAO ML established at 0.20 ppm for small fruit. As noted in this study no MRL has been established for lead by the US CDC.

3. Selenium in fruits and other plant tissues was higher than the concentration detected in soil in which the plants grow at 9 of 15 sites in the PRR locale, indicating possible bioaccumulation in plants.

4. When plant tissue samples at sites along the White River were compared by year of collection (2011 or 2012), there were marked differences in uptake of certain heavy metals. One probable cause may have been in comparing a wet year with a drought year. Uptake was higher in the wet year as compared to the drought year for lead and uranium.

5. The database for the current study establishes preliminary baselines against which other research may be compared for small fruits on PRR and in Brookings County, SD, and for soils on PRR.

6. USGS baseline means and ranges for the conterminous United States for selenium and uranium in soils established by Shacklette and Boerngen (1984) were exceeded on PRR. The mean for selenium in soils on PRR was more than 18 times

higher, and the mean for uranium was more than 3 times higher than for the conterminous United States.

7. Lambert's (1998) conclusions that uranium levels are within US norms for the former PRR gunnery range are not sustained by the results in the current study, although there is no current evidence that heavy metals concentrations in soils or plants on PRR are anthropogenically caused.

8. There are a variety of worldwide standards for foods and soils that are neither uniformly updated nor accessible when making selections for comparisons in determining risk from exposure.

RECOMMENDED FUTURE RESEARCH

1. In order to determine heavy metals risks for residents of PRR and Rosebud Reservations, a study should include all possible routes of exposure: oral, inhalation, and dermal, using guidance available from US EPA and US CDC, as well as other sources. A total dietary study could provide a clearer view of true uptake potential.

2. Since small plot vegetable gardening is a current trend on PRR, researchers should consider a study of heavy metals in root vegetables such as potatoes; carrots; turnips; and Lakota *timpsila*, also commonly called "prairie turnip" or "prairie potato" in the Fabaceae family.

3. A controlled general study of high selenium soils and bioaccumulation in plants should be conducted.

4. A remote sensing study should be conducted to determine the use of known bio-indicator plants for identifying areas of most concern for high selenium soil bioaccumulation.

5. Since mercury is of key interest in environmental studies and was beyond the scope of the current study, a study of mercury concentrations in plants and soils should be conducted and could prove invaluable in managing resources on and near PRR.

6. Ground water studies on PRR may prove of great value for monitoring levels of heavy metals in general, and in monitoring potential sources of contamination. Such studies should include public education about the importance of using the already available rural water system in cases where well water may be preferred because of taste. Water has much more potential than wild fruits as a major, daily route of exposure to heavy metals if present.

7. Food standards are in the early stages scientific development and need to be expanded and unified in an increasingly complex worldwide food distribution system. There should be a clearinghouse website including all heavy-metals-standard-setting agencies in the world with the most current information available.

8. USGS baseline studies should be updated and densified to properly reflect the concentrations of selenium and uranium in PRR soils, since the concentrations are higher than any reported for the conterminous United States.

APPENDICES

APPENDIX A: INTERVIEWS FROM ROSEBUD RESERVATION, 2012

AN INTERVIEW WITH CORNELIA WHITE FEATHER (1)

In recent years I collect the following fruits on Rosebud Reservation to use as food: buffalo currant, chokecherry, wild grape, and plum. I mostly use them for dinners for the family, although we eat them raw when we go to pick them, too. For all of those fruits, we eat them raw or make them into *wojapi*, a type of pudding. We don't make jelly. Occasionally, I grind the chokecherries, pits and all, to prepare them for use. For the plums, the pits are always discarded.

My grandparents were traditional type people. Concerning these fruits, I do the things they taught me how to do when I was younger. We took a sheet and placed it under buffaloberry trees that had ripe fruit. Then we would shake the tree and the berries would fall.

When I first started collecting the fruits again, ten years ago, I took my nieces and nephews. I would tell them that we would collect these wild plants as each matured in the summer: turnips, currants, chokecherries, plums, and grapes. There is a Lakota name for the chokecherry time.

When I was out walking around, I found a good spot for wild turnips. As it turned out, the fruits I wanted were nearby, too. We don't tell people where I go. It is something children should do for exercise and fun and as a part of our traditions. The fun of going and getting it is the most important. It's the way I grew up. I wish my grandkids would do this. Next year we should go out. They should learn how. We need our plants for oxygen and everything. Hopefully the plants will still be around in the future. I want my grandchildren to pass this on. It is really important that we not lose that part of our culture.

Traditionally edible fruits are important at family dinners, wakes, and funerals. It would be unusual if they were missing at important events. If I went to a funeral, for example, and there were no traditional fruits there, I would wonder, "All right, who didn't freeze the fruits this year?" (Laughs.) There are a lot who don't pick the fruits, turnips, and other plants-- or prepare them anymore. It's important to take the time to do it and make it fun.

My mom's from here. I am enrolled at Eagle Butte (Cheyenne River Reservation), but I live on Rosebud Reservation. I think that Rosebud is named for the wild rose. I have a daughter named Chastity Rose.

AN INTERVIEW WITH CAROLE A. PROVENCIAL (2)

In recent years, I use the following traditionally edible fruits: chokecherry, wild grape, and wild plum. I eat them raw or make jelly, syrup, and *wojapi* (pudding). I also eat *wasna,* a spiritual food-- pounded together like sand. The dried ingredients include chokecherries, sweet corn, buffalo or other meat, and sugar. That is mixed together with any kind of fat, lard or shortening.

I use these fruits because I did it when I was young. I grew up that way. It's a different taste than what you can buy in a store. It's fun and I want to carry on the tradition and teach my children. It would matter if it didn't get carried on; plus it's family recreation. It gives us something to do as a family. It provides cultural identity. Now that I stand back and look at it, it is special. When I was young, it was just fun. I think it's important to save and teach these things so they don't disappear. My children need to pass them on. This is how we lived off the land. Should times get really hard, we can take these and eat them and live. The idea is that Mother Earth feeds us, rather than a supermarket. We have these resources here as part of the land. I think they should plant more of these just to save the bushes. We had a bad fire this summer on the reservation. Weather and forest fires, can burn out plants. By planting them in the yard, for example, you have them.

I was born in 1961 and I grew up in the 60s. Grandmother was in her 70s, and she raised me. She was traditional, although she didn't look that way. One of her traditional practices was getting berries and preparing them. And she had gardens. She canned chokecherry jelly and plum and buffaloberry. She also canned the juice to make things later on. She had a buffaloberry tree in her back yard. She would put a sheet under the tree and shake it. She had a big smooth grinding stone and another smooth stone held by hand. Uncles picked for her because she was old. She would pound the chokecherries with the stones and put them out to dry on screens or old curtains. They looked like hamburger patties as they dried in the sun. She hung the dried patties in cloth bags in the porch for the winter. Then they were handy so she could use them throughout the winter. She would boil them to rehydrate them. She would make *wojapi* (pudding), and jelly with the ground pits included. She also used the dried berries to make *wasna*, but back then it was just food. The berries were pounded down and ground. Sometimes we would just eat that. Her *wasna* included ground up berries; meat, (sometimes buffalo) dried or roasted; sweet corn; lard; or fat.

In my late thirties, I started doing this, myself. We make jellies with it. I store and preserve the chokecherries and plums by cleaning, pouring into gallon Ziploc bags, and freezing. We give them away in those bags. When someone dies, we give to them to make *wojapi* (pudding) or *wasna*. Both might be served at a wake or a funeral. I give my jellies and homemade bread as gifts at Christmastime.

Mainly, we pick and prepare the fruits every August. We do it as a family, with helpers from about age three and older. When it comes to wild berries, we take what we can find. Turnips are important too. It gives us something fun to do. One fall we all went turnip hunting for the weekend. We have our private spots that we keep location to ourselves for our little group.

I just know that when I was growing up it was lot of fun and I liked to help out. I didn't even realize I was learning this stuff, until one day when I decided to do it again. I don't have a grinding stone anymore. We use metal grinders when we need to. We pick and store. It reminds me of my relatives, including my grandma, Ada Whipple.

I know people named Rose. It's a bit of an old fashioned name today. I don't think there are more people here with that name because of the name of the Rosebud Reservation. People associate the name Rose with the Rosebud Reservation because it has many wild pink roses. It's just filled with them. I am enrolled here.

AN INTERVIEW WITH BYRON PROVENCIAL (3)

Lately, I collect and eat these traditionally edible fruits on the Rosebud: buffalo currant, chokecherry, and wild plum. I have always used traditionally edible fruits. My mother picked them. Our grandparents used them. It was just what we were told-- to keep it up. They showed us different ways of doing things and how to make different things with berries. The taste matters, but so does collecting and preparing the berries as a family. They used to use corn for soups and stews, and that was good. I have had chokecherry jelly both ways, with and without the pits ground into it. I like it without. With *wojapi* (pudding) it is good both ways. With the pits ground up in it, it feels gritty going down, but it has more taste that way.

I would miss it if the tradition were lost. I have eaten it since I was a small child. It would be strange to go to a funeral without seeing traditionally edible fruit dishes served. At a ceremony, I would expect to see it. Some examples would be the Sundance, powwows, and traditional weddings. *Wasna* is the mourning food for the Native American Peyote Church. Sometimes the berries are sold at booths at certain special events.

I have eaten buffalo currants in cake. In addition, I have eaten chokecherries in jelly, syrup, and as a seedless, sweetened paste that covered wild game meat as it roasted in the oven. All I could taste was the meat and berry---the sweetness was not there. It was used on deer and elk. My aunt made chokecherry wine and gave it to friends at Christmas and Thanksgiving. That was within 18 to 20 years. Mom made ground and dried patties with chokecherries. She would rehydrate sometimes and make things. She mixed chokecherries with plums and made *wojapi* (pudding) or jelly. She also made straight chokecherry or plum jelly. She used Sure-Jell brand thickener. She sealed the jelly jars with wax. They canned the juice to use later. If she needed to strain the crushed fruits, she used cheesecloth. The chokecherries, in particular, would cause a permanent stain in the cloth.

We had plum and chokecherry bushes all over by the river. We would get buckets or pillowcases and pick the berries. She would clean the berries and separate them into each bucket and bag them up to freeze them. She would start boiling it and making jelly and jam. I remember that was about 1977 or 1978.

I have felt an obligation to keep it going so the future children can learn what we had. We want them to do the same thing we did. They need to know about *wasna* for ceremonial use. Of course, they could make it from chokecherries and plums. Ours was almost like *wojapi* (pudding), but not exactly, more like fruit leather. She would sugar that up and put it in a bowl. She would add raisins and mix it up. It was a really thick, a sweet side dish. Although it was dehydrated, it would still pull apart. She made that when I was eight or nine years old. I was born in 1969 and am an enrolled Rosebud member. It would be nice if the information were saved so that people in the future know what we did, what we used it for, and how it was prepared. It will help them follow and do the same things we did.

There are quite a few people with middle or first names of Rose on the reservation. You would not be likely to select it today because it’s a little old fashioned. When I was growing up it was used more.

AN INTERVIEW WITH MELVIN GUERUE (4)

Currently, I eat the following fruits collected on Rosebud Reservation: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips. The chokecherry can be used as medicine for poison ivy problems. For the buffaloberries, I pick one and taste it to see if they are good. If the berry pops, it is good. If they are, I pick some and take them to use as a dessert when I have soup or fry bread. I don't go to extremes when eating them. I don't eat more than seven berries at a time. I don't eat all that I pick in one day, either. That would upset my stomach.

It is best to pick berries before sunrise. If I go to pick berries in the evening and a frost comes up and kills them, they are no good. If I try to get more, there's a frost that will kill them. It is the same way with buffalo currants.

When it comes to chokecherries, I usually say that my great-grandma and grandma showed me how to use them. I watched them. They don't use a hammer or grinding stones. They grind the berries with solid bricks. They made a big patty to dry. The crushed chokecherry patties were spread on canvas to dry and then hung on a clothesline for a total of about three days. She stored them, dried. She used them to make *wojapi* (pudding). Even plums and other wild berries could be used. She added corn starch or a little flour, and sugar. There is no meat or grease in *wojapi*, because it's a sweet pudding. Each flavor is separate. You don't mix chokecherries and buffaloberries, for example. All of the fruits involved include the pits in the recipes, with the exception of plums. The large plum pit is always removed and not part of the food. They also used powdered dry milk, when available, in their recipes.

They used rosehips and their seeds for flavor in rose *wojapi* (pudding). For rose tea, they would go into the valley and smell the leaves to be sure they had the right odor. They used early leaves but no rose petals or rosehips for the beverage.

My uncle would tell us how to collect plums. We put a sheet or canvas or table cloth under the plum trees. He would shake the tree and the plums would fall to the ground where we could collect them. We had to be careful of poison ivy when picking berries. We put on boots and gloves. We would fill large buckets with fruit.

The chokecherries make a good medicine for someone who has caught poison ivy. You can steam it up and use it like lotion. You avoid scratching. Let it go. It will dry up. The other one was plum. My cousin was scratching away, and dad said poison ivy got on him. He went and got flour and browned it and made a powder to apply for poison ivy.

Wasna can be made with chokecherries. You dry the chokecherries and crush them. Then you mix them with corn meal, powdered milk, and a little bit of lard. Set it aside for an hour. It is ready to eat when it is dry and grainy like crushed up cereal.

The buffaloberry is a tonic because you drink it straight. Tonic is important to us to help avoid infection or illness or abdominal upset. It must be used in moderation, though, because it can cause stomach upset if not kept within limits. It is best to limit sugar in these traditional recipes to limit diabetes problems.

My grandma told us to do this and that. I can still remember what she told me. I am 60. Grandma's name was Mabel Hollow the Hawk. The fruits grew just like money on trees. She was elderly then and did the cooking. I would help her and watch her and catch on. So, now if I do cooking I know how to do it. She didn't go by measurement. She knew what to do.

If I don't have anything to do, I walk, and I know where the fruits are. I take friends along. I let them go first in case there are snakes! (Laughs.) I pick one relative of mine and send them in there. I tell him not to tell everybody about this private place. I tell him not to bring anybody else. In our household, I use all of the fruit that I collect.

I make God's Eyes wall decorations. The frames are chokecherry twigs. I take a potato knife and scrape the outside down to bare wood for the circular frame. I add feathers and I have them in the house. I don't sell them. I keep them where there are no kids around. When a relative dies, I give them away at the funeral. I make them from six to 18 inches, in matching colors.

My uncle, Moses Big Crow, was an instructor for St. Francis Indian School, the boarding school, and he was trying to get us to dance, but we weren't interested. But he showed us how to do art and beadwork projects. I attended the boarding school there from 1965 to 1967 and lived in a dorm. He also talked about how to use traditionally edible fruits. I told other students ahead of time because I knew from my grandma. My uncle talked to us in Lakota.

When summertime comes, we pick traditional fruits off the tree. It's the Indian way to pick them up. It's a traditional way. It's money saving. The children catch on. It's important to continue as a tradition. When winter comes, we get more store bought foods.

AN INTERVIEW WITH ANONYMOUS (5)

In recent years, I have used the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

My mother used to make traditional foods from the fruits, and I helped. Concerning buffaloberries, we made them into jelly and put it on bread. We ate a lot of them raw, too. Mom would want the berries to can them, but we would pick and eat. She would say, "There is not enough for winter. Those are the hard times." We also picked and ate ripe buffalo currants. Mom froze them, and we have them for snacks. We didn't make jelly. She juiced all of the berries and used them in place of Kool-Aid. She used another wild berry, too. It looked like a raspberry, and she would add it to muffins. There are purple and red ones, but I don't know the name. She would make juices out of those, too.

To process chokecherries, Mom and I put them through a metal meat grinder. Then we put them into patties and put them on a screen to dry outside for about three days. In the wintertime, we made *wojapi* (pudding) by rehydrating the dried chokecherries with boiling water. We used the dried chokecherries for *wasna*, too. We hardly had sugar, so we used corn syrup from commodities (when we needed to), and a flour and water mixture to thicken *wojapi*. Ingredients for *wasna* don't include grease--just sugar and ground raw berries. She bakes it. When it's done, it's kind of wet. She pours the fruit's juice over the mixture when it comes out of the oven. It's served in a bowl and is the consistency of raw hamburger. You dip it out of the bowl with a spoon. Mom used to crush the berries with rocks (mortar and pestle), until she met my step-dad. Now she uses a metal meat grinder and prefers that.

Concerning wild grapes, we just pick them and eat them fresh. Mom used them for juices. She canned or made them into jelly, too. She strained the seeds out and used just the pulp and skin. She used corn syrup. It looked a bit like pancake syrup.

Mom canned plums. She would get five gallon buckets of the fruit. She pitted half of them. She froze them, too. I think she used those for medicine in the wintertime. She puts another ingredient in with them. I don't know what that was. She made a medicine that we had to take in the wintertime. She used plums for *wojapi* (pudding), too.

When it comes to rosehips, formerly, we picked the little miniature “apples” and ate them. We spit out the seeds. Mom and those folks used rosehips tea for ceremonies. I think she used leaves for the tea. Today, I don’t use tea at all. We don’t use rosehips today. Mostly it is just buffaloberry, buffalo currant, chokecherry, and plum. We collect turnips, too, starting in June.

Then Mom used to make another tonic for everyone to keep them healthy. It included chokecherries or plums, and maybe cod liver oil, or maybe something else. She made us drink that as a tonic. It was really gross. When we saw her making it, we all took off running. I don’t give that to the kids today. I say, “You guys have what you need when you get sick. We had it hard.” I also don’t like sage juice for stomach aches. That stuff is bad. My mom gave some to my kids when she was still alive. They were staying with her. After six months, the kids said they didn’t want to stay with grandma anymore. They said, “Grandma gave us a tonic. She boiled it and said it was tea. When we ate we had to drink it.” She told me that she gave it to them to cure constipation and not at every meal. Now my daughter says, “When my boys get stomachaches, I am going to give them sage water!” She doesn’t mean it, of course.

I remember that back in the day, my grandma made chokecherry patties and they were drying. My uncle was gone a lot on farm places. He came back with his co-worker. My grandma had patties drying outside, and her corn was drying, too. In addition, meat was on the line drying out. My uncle grabbed one of the chokecherry patties. They cut the bread and put the patty in it. They ate it, because they thought it was hamburger. Grandma got upset. She took her chokecherry patties inside when they weren’t really dry. They rotted because they were too moist—so she lost her chokecherries that year to mold. My uncle had to stay at the ranch, and she had him pay for those chokecherries they lost.

One of my ancestors, Albert Black Mountain Sheep, was a medicine man, and he stayed away from the public. He lived in a car body away from other people. He walked the hills a lot. Because of his spirituality, he remained away from others unless they came to get his help. He knew they were coming, even though there was no way to communicate with them. My mother tells me stories about him. She picked plants (not fruits) for him for medicine. Mother said that Bessie, Albert's wife, taught her to work with chokecherries and plums. They dried everything because they had no way to freeze products. Albert helped people look for someone who had lost a son. So he was gone for days helping them. He needed the plants for a ceremony that he would use to help them. He told them their son was in a basement of a house in California. They should go get him. He said he would put up red flags for them to follow to get him. They got him and returned him to his reservation (probably Pine Ridge) and did a thank you ceremony.

My girls participate in the Sundance. I was brought up in Lakota religion, so I know all about it. I chose not to go and Sundance. I sweat and go to ceremonies. I know how hard it is, so I don't Sundance. There are foods that are served there that have to do with the traditionally edible fruits. Chokecherry juice and buffaloberry juice are for Sundancers if they are dehydrating, and for ceremonial reasons.

AN INTERVIEW WITH MICHAEL WHITE BUFFALO CHIEF (6)

In recent years, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

Concerning buffaloberry, the berries are boiled, and sugar and cornstarch are added to make a pudding, *wojapi*. When it comes to buffaloberry, we have *wasna* with corn. It's only supposed to be for religious ceremonies because spirits are more attached to the corn. The buffaloberries are also made into jam that is thickened with Sure-Jell.

When it comes to beverages made with buffaloberry, buffalo currant, chokecherry, wild plum, or wild rose plant parts, we add sugar to some. We limit sugar now because some have diabetes. Sometimes it is just the fruit boiled in water and strained and put into a container. In native religion, we can it and put it in containers and make beverages for Sundancers to prevent dehydration. We take a dancer into a sweat lodge and feed this to him to help keep his strength up. When done with four days of the Sundance ceremony, we give the dancers a drink of buffaloberry juice before they go into a sweat lodge. The participant can have Gatorade or coffee, pop, or Kool-Aid and the like—but not water. They cannot even touch water because it might cause the Thunder Gods to come down, and that usually brings storms and rain and lightning in four directions. Or the lightning could hit the Sundance tree, too. If lightening hits it, the Sundance is over. Their family members bring that juice to them. The dancers can't touch water for eight days while in the ceremony. They pray with the water. I can offer them water to drink because I am "a backwards" or *heyoka*—so I can do that. That's my role.

Grandmother showed me how to do the stuff. She explained how these things will be used with the native religion. I know how to can for winter, but in the old days, they had to dry fruits because we didn't have freezers.

The *wasna* that we give them in the Sundance is the corn type. When they come back from their vision quests, we have a container of dry meat, bacon or lard, plus chokecherries, and if they are lucky, they have plum juice when they are done eating.

For roses, we just use the leaves for tea. We can't use the little rosehips because only the elderly can deal with that. Grandmother said not to touch the rosehips until you are an elder.

Grandma, Hattie Black Mountain Sheep, used Iktomi verses to prepare the food and get ready for winter or religious ceremonies. She said what to do and what not to do. I like doing all that instead of looking for things on shelves. If I go in the wilderness, I can pick them, but I have to have an elder to deal with rosehips, but I can deal with the rose leaves. We took tobacco out and threw it down as an offering when we picked parts of the rose plant. If I needed to get rosehips, I broke the branch off and took it to her with the rosehips attached so that she could take them off.

We pick chokecherries and put them in bags in the refrigerator. We don't freeze any fruits. It tastes better dry.

I was born in 1962. I am a member of Rosebud. My wife is Winnebago Indian, and they tend to do things differently than the Sioux. I have been trying to learn their ways from my wife, but it is hard to pick it up, as to how they do theirs. Her mother was showing us how they prepare food. I told her we do it differently. I explained how we do canning and all that stuff. We do it my way at our house.

When deer season comes, I try to get some meat from a friend, and I slice it and dry it for the winter. We can grab a piece of that dried meat with some dried sweet corn, sliced salt pork, and water. In addition, I make a six foot braid of turnips that lasts all winter. We add it to soup—even at Sundance. A bowl of *wojapi* (pudding) and fry bread often goes along with it. The elders really like that around here.

My grandpa, William Points At Him, told me quite a few Iktomi (Spider/Trickster) stories. He used that to kind of teach us kids how to behave ourselves. One story he told involves chokecherries and wild roses. Iktomi and coyote were walking and came upon a bush with chokecherries. Iktomi was eating them. The chokecherry plant turned around and said, "If you eat me, you will itch." He ate more anyway and took some in a container. He was scratching, and he found a rosebush with thorns and started scratching himself with it. The more he scratched, the more he saw wild rice falling out. The coyote took the rice and the chokecherries. They came to a pond with some ducks. Iktomi went over there to get them. He packed wood and went down there. They saw him coming. The ducks said, "Come and sing for us." Iktomi said, "No, I am in a hurry." The ducks begged for him to come back. He told the ducks, "You have to stand in a circle, and I will sing a song. You need to close your eyes. I am singing a sacred song." So they did. As they came closer, he hit the ducks on the head and threw them in a bag. Some took off in flight. One turned around and looked at Iktomi. He told the ducks, "You turned and looked at me, so you will have red eyes now, forever." So they have red eyes. So Iktomi and coyote sat down and ate berries and ducks. So, they had a full belly and they lay down under the tree and slept.

My wife's Winnebago name is Picks Berries. Mine is Eagle Shield. My first Indian name as a little child was "Women Comes Looking For Him." I was told that when I was born, all the women came over to see me. So grandma gave me that name. My grandpa said, "Now women cannot come looking for you—you are married." So, I had to go to the sweat ceremony to get a new Indian name. Grandpa shook my hand and said, “Here is your new name, Eagle Shield.” I asked, “What happened to my old name. He said “We took it away because you are now married.”

AN INTERVIEW WITH ANONYMOUS (7)

In recent years, when rainfall was normal, I collected and ate the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

I was brought up with no electricity, no running water, and an outhouse. While the men were sweat lodging, I helped grandma get the meal ready for them, and it would include some kind of traditionally edible fruit, such as chokecherry jelly and *wasna*.

With buffaloberries, I make *wojapi* (pudding). My grandmas used that for jelly, and I still do, along with jam. We spread it on bread. When we picked buffaloberries with Grandma, we held sheets or blankets under the trees, and she hit it with her cane to make the berries fall. We avoided sharp thorns. I wondered why my sister and I had to hold this blanket. Of course, we could catch more berries that way. She would direct us so we didn’t miss any.

The buffalo currants we just eat fresh. My Grandma made jelly, but I don’t because I think plum and chokecherry are better. Concerning chokecherries, we eat them raw with salt, make jelly (with pits), or grind them with a metal grinder and make patties and dry them out. We rehydrate the berries later and make other things.

My Grandma canned plums and chokecherry juice and made jellies later with it. For ceremonies involving healing or prayers for the sick, we use chokecherry juice with sugar. For a funeral you would have wet *wasna*. It can be made in different ways, but it is always baked and then drizzled with chokecherry juice. It is served in a bowl and is the texture of raw hamburger.

With wild grapes, Grandma made jelly and jam and juice. I make that jelly and juice also, including frozen popsicles with added sugar. For jam and jelly, one requires ground berries with pits and the other calls for cheesecloth to strain the juice. I make baking powder bread. The ingredients are flour, milk, baking powder, and a little sugar. I don't knead it—just pat it instead. It is formed into patties the size of my hand, and then deep fried. We put jelly on it. The kids make holes in bread for the jelly to seep in.

Concerning wild plums, we eat them raw with salt, or I make jam and jelly. I also make *wasna* for religious or healing ceremonies or for funerals. In addition, I make *wojapi* pudding to eat or use for ceremonies or for honoring. Sometimes for powwow we have it for dessert. We picked plums last week, but they are not as big as usual. They were very small. I am going to make jam with them. I have many children, but the five girls went along. I will use sugar, Sure-Jell, and plums. For wojapi (pudding), I use flour to thicken it. Sometimes when making roast of meat, I put in a cup of dried plums. That will make the gravy lumpy—so I strain the gravy. Sometimes my daughter and I would pick berries on horses.

We don't use rosehips, the little apples on rose plants. We only collect this year's tender rose leaves for making tea. We steep the leaves in hot water.

One of my ancestors, Francis Quick Bear, Sr. used chokecherry twigs for ceremonies. He used them for vision quest. In that case, he would have four stakes about five feet long. They were made of chokecherry branches stripped of their leaves. He would put them around the participant and attach cotton cloth strips of the four colors: red, yellow, white, and black (or blue or green). That is still practiced today.

Concerning the Sundance, first they have a sweat to get prepared. Then they go at 5:00 a.m. to their vision quest site, where they stay for four days to fast and pray. A traditional fruit beverage is given here if they are getting dehydrated. Then they come back to the Sundance tree and get prayed over by a medicine man. Then they are pierced. They go back to camp and wait for all the dancers to get done. They have a last sweat. Then they eat traditional foods at the end, including traditional fruit dishes.

I am enrolled at Rosebud as a full-blood, am middle-aged, and going to school at Sinte Gleska.

AN INTERVIEW WITH SIDNEY L. REDDEST, JR. (8)

In recent years when there is normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

I collect buffaloberries on horseback and eat the fruit raw. They are hard to pick. So I don't collect them by the bucket. Concerning buffalo currants, I just eat them raw as I find them by going from meadow to meadow. I pick more chokecherries in larger amounts and grind them for *wojapi* (pudding) and *wasna*. I pick them in ice cream buckets and pour those into five gallon buckets. If it is a hot day, adults do the picking because it is not a good time to take kids along. It can be a family event if the weather is nice. Sometimes when I am on horseback, I simply see some berries and stop and pick them. There have been times when I have collected them in my hat, for example.

Concerning wild grapes, I hardly ever see them. I would pick them if I found some and they were still good and juicy. When Grandma Sara High Pipe was around, we would go as a group to get plums. Now we go by ourselves and get what we need. We don't pick or use rosehips or rose leaves.

Buffaloberries or buffalo currents make good *wojapi* (pudding). It is cooked slowly, and for sweetener you can also use honey. Back with grandma, she made jelly or jam with it. We don't, now. We don't can or jar them. Since Grandma's time, we don't make it as much.

With chokecherries, we make *wojapi* (pudding) and jam. The taste of chokecherries is between bitter and sweet. We grind the chokecherry pits into it. Nowadays, to keep them until needed, we use a metal meat grinder to crush the chokecherries. Then we put them in freezer bags with juices as one big lump. In contrast, Grandma ground the berries on a large flat rock with a fist-shaped rock held by hand. Grandma used to get up early and take six, five gallon buckets and get all the fruits they could find. They went to various places to collect. Sometimes fruit is only good to collect every other year. Now, working with chokecherries brings back memories of picking them a long time ago.

After we collect plums, we just pit and freeze them. At that point, they are ready to use. For plum *wojapi* (pudding), we add corn syrup and corn starch.

I like to go on horseback to pick berries with eight or nine cousins. We like to go where the water hole is. Even the windmill would work. Those are the best times I had with my cousins. If we were gone for so long that we missed a big meal, Grandma Sara High Pipe would save it for the next meal. She always had traditionally edible fruits. We would go in her house, and it would look like there was nothing much there, but she could make a good meal. She could make fresh bread, too. She lived on the west end of the county. We all grew up there. Lots of times we had horses that got away, so we would catch one or two and chase after the others. We would come across these fruits in the meadows and draws. Through hunting and so on, we know where to find the best places to pick berries. We also dug turnips.

Now, every time we go out to pick berries is a good time. I have kids, too. One is in college now and the youngest is one year old. With the younger ones, I did more turnip digging.

The berries and turnips are often served at ceremonies, dinners, funerals, wakes, and traditional events. The fruits could be for sale, here at the Rosebud Fair. Sometimes they offer chokecherries, plums, or turnips. A braid of turnips might cost twenty-five dollars. Five gallons of chokecherries would be about twenty-five dollars. The plants are not cultivated. They grow wild. Water from the water towers is not best for irrigating these plants. Maybe it is the chlorine. Chokecherries need fresh water to do well. They grow well near natural water sources or in draws that catch the snow.

AN INTERVIEW WITH LESTON BREWER (9)

I am not an enrolled member of Rosebud Reservation, but culturally I am a part of the locale because I have been around here all of my life. I live just over the state line in Nebraska. In a recent, normal year with average rainfall, I collect and eat buffaloberry, chokecherry, wild grape, and wild plum. Concerning all those fruits, I eat them made into jellies. They are made by cooking and straining the berries, sweetened with sugar, and thickened with Sure-Jell. I also like wild grape juice.

As kids we'd have berry fights, just for fun. Of course, we collected them to eat and make jelly. Basically, we did it with mom and grandma and the kids. I just kept it up as I got older. Today, when I am out working cattle, I might see berries growing and just eat some of them raw.

I was diagnosed with Hodgkins, and it hadn't turned to melanoma yet. So, I started reading on the subject. I read anything I could get my hands on that wasn't American Medical Association approved. I knew some of the names and some uses of traditional plants from native lore that were talked about in the range programs in Future Farmers of America meetings. So, I went out and got the herbs and made tinctures. I took just a little—not too much. In a month or so, I was out of pain. The plant identifiers had passed down the native lore. None of these plants are fruits. The medicinal plants include purple prairie coneflower (echinacea), mullein tea, leadplant, and others. I think there is something to be learned from native medicinal practices that are ignored by modern medicine and the pharmaceutical industry.

AN INTERVIEW WITH KEITH MURRAY (10)

In a recent year with normal rainfall, I collect and eat buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum. I like to eat all of those raw.

For chokecherries, I eat *wojapi* (pudding), but not the jelly. Concerning plums, I eat some jelly, as well as the dry *wasna* made with meat, corn, berries, sugar, and lard.

Women make the prepared foods. They grind chokecherries (including pits) in a metal meat grinder and dry them, storing them in cloth sacks to stay dry. They don't can them.

I was nine when I picked chokecherries with my grandma, Sarah High Pipe, and my uncle, Omer High Pipe. We climbed the trees and got the ones at the top. We often got five gallons. I watched her get them ready to dry in patties. Her *wojapi* (pudding) was the best dish she made from chokecherries. She also made it with plums. I miss going out to get the fruits as a group. It brings back memories of the old days when I eat it and the taste is just right. Everyone makes it differently. It's becoming a lost art. I personally don't know anyone who makes it. There are still places where people serve *wojapi* (pudding) and fry bread with jelly.

I will go out of my way to pick wild fruits if I see them. Plums are my favorite because they are the sweetest. Normally people don't grow them in their yards. It's fun to pick them in the wild. Of all of these berries, raw chokecherries are the most likely to be sold here today at the Rosebud Fair.

AN INTERVIEW WITH NICOL BUROW (11)

In a normal, non-drought year, I eat and pick chokecherries and wild plums. Concerning chokecherries, I eat them raw or dried as a snack. Sometimes I mix them with unsalted nuts. I eat plum *wojapi* (pudding) sometimes. I have only made it once, but I eat it at other events. It is made with pitted boiled plums, sugar, water, and cornstarch. Personally, I don't can, freeze, or dry the berries. I use them fresh when I have them.

I was in about second grade when I started picking the berries with friends. I am now 24. Every once in a while we pick them, but it's not as common as in earlier generations. I eat those foods at funerals and ceremonies. I expect to see them there.

Sometimes we take our kids on outings so they will know what to look for and what to pick when they get older. We only collect turnips, chokecherries, and plums. I have never been taught how to can the juice, freeze the berries, or dry them. It doesn't bother me not to know how. It's not high on my priority list. We don't have a specific place or have outings as a regular part of my family. I don't remember any stories about traditionally edible fruits. My family was not all that traditional. Grandma didn't make chokecherry jelly or plum jelly. So, we ate the berries as snacks or if someone else served them, but that was about it.

AN INTERVIEW WITH MARIA IYOTTE (12)

In an average recent year, I collect and eat buffalo currant, chokecherry, and wild plum. I am not an enrolled member of Rosebud Reservation, but I live here. I know that I am Lakota, but I don't know which tribe. So, I am not enrolled because I cannot get enrolled since I don't have the papers to prove it. Culturally, I am Lakota with my heart and soul.

With the buffalo currants, chokecherries, and plums, I make juice, jam, jelly, syrup, and *wojapi* (pudding). The other ingredients in *wojapi* are water, sugar, corn starch, and flour. I use Sure-Jell to thicken the jam and jelly. I have never made *wasna* yet.

Here is how I prepare buffalo currants. Remove the stems and boil the berries in water for a long time. Strain the mixture in a metal sieve. Add sugar. For juice, just dilute it with water.

Concerning chokecherries, for syrup, cook the berries with pits in water for a long time. Strain through a metal colander. For juice or syrup, cook the whole chokecherries with a little water for a real long time; strain through a colander; and add sugar to the juice. For jelly, add Sure-Jell to thicken it. If it remains too thin, it is syrup! With the leftover pulp, put it in the blender and make *wojapi* (pudding) by cooking that pulp with sugar, water, and corn starch or flour to thicken it. I put it in jars in a water bath to can it. I sell it door to door.

For wild plum syrup, I use 1200 grams of the fruit with 1 kilogram of sugar and a little lemon juice. The process for syrup is to boil the fruit with a little water, cool, remove the pits, and add sugar to thicken it. To make jam, boil the plums, cool, remove the pits, puree it in the blender and boil it again and add Sure-Jell. To make *wojapi* (pudding), do the same, but also add flour or cornstarch.

I was one of the Lakota "lost ones." I was adopted as a baby in l962. My adopted mother is from Prague, Czechoslovakia. We moved to Vienna, Austria with my adopted father in 1967. I grew up in Austria. I always felt different, and I didn't know why. I was a tomboy. We played cowboys and Indians. Kids picked on me in school. I had to learn to fight. I took up Judo. I got my self-confidence. I was fifteen when my adopted mother told me I was adopted and Lakota. My response was like falling into a black hole. It was devastating. My world crashed around me. I tried to fit in, but I could not. It was impossible. If you are Lakota you are Lakota.

I met my Lakota husband in Austria in 1999 when he was in a rock band. I was there to support Native Americans and bring them to our group if they had problems. We married in 2000. First we lived on Pine Ridge, now on Rosebud. Together we have one young son—and six other children from previous marriages. Both my husband and our son are enrolled at Rosebud. I am working on obtaining citizenship. We have 20 grandchildren.

One time I found berries on the reservation, and I just wanted to make plum jam. My husband liked it so much, I thought of selling it. I go from door to door and make products from the fruits listed above. I plan to expand to other traditional fruits, too. I make jam, jelly, juice, syrup, *wojapi* (pudding) and homemade bread for jelly. I am selling the plum syrup at the Rosebud Fair. I would be interested in expanding the business in a way that would create jobs and product branding on the reservation.

AN INTERVIEW WITH LEANA LONG PUMPKIN (13)

In a recent year with normal rainfall, I pick and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

I make buffaloberry jam, using the whole berries with Sure-Jell and sugar. I use a blender to puree the fruit, although I tried the rock grinding, and that's hard to do, but it works. I learned that from a friend. I can the final product with sealed lids.

I eat raw buffalo currants, or sometimes a friend gives me jam and makes *wasna*. I don't dry the berries, and sometimes I make *wasna*.

With chokecherries I make the *wasna* and juice recipe. It's the same basic recipe when using buffalo currants. We just drink juice, but we don't sweeten it. I save some of the chokecherries by freezing them in case I want them for funerals or other ceremonies. They can be used for *wasna*. That would include chokecherries that are stone ground and dried (or if frozen, they are pureed in the blender). They are mixed with dried buffalo or beef meat. For buffalo, the dish just includes chokecherries and dried buffalo meat with a little bit of buffalo fat. It makes a dry wasna. There is also sweet corn meal *wasna* if someone gives me dried corn. In that dish, it includes dried meat, corn, raisins, kidney fat (buffalo or beef), sugar, and no other fruit. We also have *wojapi* (pudding) made from chokecherries.

Wild grapes are eaten raw or frozen. The frozen ones I want to dry with a dehydrator, but I don't have one. I want to try grapes in *wasna*.

We eat raw wild plums or make *wojapi* (pudding). We don't make juice or jelly from grapes. For the *wojapi*, we boil plums in a little water, take the pits out, add sugar, boil, and add flour to thicken the mixture. We don't can it because it is used right away as dessert.

We make tea with dried rose leaves in spring. We steep the leaves in boiling water. I have picked red rosehips and made a tonic with the whole hip. I drank it because I didn't want to get the flu or a cold. It is a tonic.

I took a Lakota botany class at Sinte Gleska school, and we talked about the different plants and harvesting seasons. I remembered the happiest times of my life in first grade. My aunt would take all of her equipment, and we would go pick berries. We took our buckets and had long sleeves and long pants. Our shoes had to be boots. I never saw grandma or my aunt in those types of clothes, otherwise. They wore pants, but they wore dresses and aprons over that. They borrowed men's shirts. It was poison ivy protection, I guess. We collected on the Six Mile Road, near Rosebud and farther up the road from Rosebud Dam. We got up early and picked chokecherries. It was cool. The afternoon was so hot. My teeth were temporarily stained brown from eating chokecherries. We had buckets, water, chairs, and flour sack towels. We collected berries in flour sacks.

I remember all of that. So, I started taking my grandkids to pick berries about five or six years ago. My oldest are eleven and nine now. I'm 53. I have fifteen grandchildren. My grandma's name is Frances Sires, and my aunt's name is Angeline Kills In Sight (married name Long Pumpkin). Those two influenced me the most when it comes to harvesting. I want to pass it on because it makes me happy. At the time it was a serious thing because they were preparing for the winter. You had to do it the way they told you. They would punish you by making you go sit in the car for goofing off. So, I began harvesting a lot. I start with turnips and go on through to roses. The weather influences success a lot. I want to make the tool to dig the turnips. It's like an awl, but it is like a shortened crowbar.

I tell my kids why I make *wasna*. The cornmeal we use in ceremonies or to feed our living elderly. It's a spirit food. Now I am learning more about all the whys and wherefores concerning how our ancestors did these things. We never questioned it; we just did it. Now I can explain it better. I would like to teach it in school. Grandkids ask why. They have a hundred questions. I am trying to learn the answers and how to teach the reasons for the young today who question our way of life.

It would seem very serious at a feed if the *wojapi* (pudding) were not just right. I would think, "No one gathered it." One year it was all just canned food. I thought, "What's going on? Are we teaching our children to harvest?"

It helps us to take our culture and keep it, in the same way that language and ceremonies do. I would like to bring back a woman's society where we'd teach young girls to be women. They would go through a rite of passage. "If we don't harvest, our plants will go away." A medicine man told me that.

AN INTERVIEW WITH CAROLYN BLACK ELK (14)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

With buffaloberries, I make jelly, syrup, and *wojapi* (pudding). I preserve or freeze a few gallons for special events. I donate some to other people. I prepare the jelly with Sure-Jell or pectin, and I can them but don't water process them because they are used so quickly. I recycle the jelly jars. They reseal one more time—but I check them. They are meant just for use right away, not for long term storage. I use the colander to get rid of seeds and some of the skin. My husband's uncle made buffaloberry ketchup. We never got the recipe, and he died before we could.

We eat most of the buffalo currants right away as raw fruit. I also make jam or jelly. I cook the berries and thicken them and serve them to friends. I use the same process to make jelly as described for buffaloberries, but I use smaller jars, usually about a half to one cup. They are not preserved, so they are used right away.

Concerning chokecherries, I eat them raw with no sugar when they are fresh. I make some *wojapi* (pudding), or I freeze them. I can the juice, and it is used quickly. With the juice, I make *wojapi*, jelly, and jam. The best jelly is produced by grinding chokecherries and then extracting the juice with a colander. There is more flavor that way from the pits. Sometimes I need some canned juice for ceremonies. I do the same with the frozen chokecherries. When I make *wojapi* (pudding), I grind the cherries and add sugar and flour, or cornstarch. I serve it in a bowl. The kind of chokecherry *wasna* I make is moist rather than dry. The following are the ingredients: dried meat, mostly deer (or beef), kidney fat (sometimes), juicy chokecherries including the pits that are ground in a metal meat grinder (not fine). I use a metal hammer to break up the dried meat to the consistency of sand. I also add kidney fat. If the taste if not sweet enough, I add a little sugar. I eat fresh wild grapes, or make them into grape jelly, or freeze the berries to eat later. Mostly, I make juice after eating some fresh wild grapes.

We pick a lot of wild plums just to eat fresh. I make *wojapi* (pudding), jelly, plum butter, and juice. Some are frozen for later use. I have dried plums before, but they lose some taste that way. The pits are discarded. We don't eat the pits. For plum butter, I use pectin or cook it down to reduce and thicken it. I don't sweeten it until the end because that will cause it to burn. The amount of sugar I use depends on how sweet the plums are naturally. If they are sour, I add more sugar.

I pick and dry red rosehips to make tea. My relatives use the rosehips for *wojapi* (pudding). I don't pick rose leaves for tea or have an interest in them. When drying the rosehips, I pound them with a hammer. I steep the crushed rosehips (including their seeds) in hot water, strain the tea, and drink the beverage.

When picking buffaloberries, my grandma, Millie Arrow Side, had a canvas with hooks for the corners. That way, we caught the berries that dropped to the ground. She had equipment. Buffaloberries were especially important. When picking those, we would get wood for the stove and mint leaves for tea. We picked whatever was in season, so that we didn't waste a trip. We went out with a team of horses and a wagon until the late 1960s. A story that she told me was that there was an old lady who lived not too far from them. That neighbor would holler to Grandma, "Those are my cherries!" Grandma would yell back, "They belong to everybody!" They belong to whoever is there first, I guess. We picked buffaloberries and chokecherries, but I don't remember other fruits.

Mostly grandma dried the fruits. She also baked a lot. You didn't talk unless you were going to eat or there was something you needed to say. Chatting was discouraged. We lived close to a river, and we had the garden nearby. Morning and evening, my brother and I hauled water in coffee cans to the garden.

Wild fruits were not part of the garden. Grandma showed me where the wild fruits were. We drank river water, and later they told us we should go to a spring or well and get our water there. Now, the spring's still there, but the cattle have damaged it. The water just runs down the hill.

After I grew up, I learned from my mother-in-law, Ellen Pratt Moran. She did picking, canning, and drying. She was a small lady. She'd climb the grapevines up in the trees. Everyone was scared for her at around 98 pounds.

I went to many preservation or Extension office programs. I even taught how to make jelly and salsa, and how to preserve food by drying or canning, for example. I went to Bootstrap meetings to see how people were trying to help themselves or to preserve culture. Every couple of years something of that sort comes about. Among my friends, they don't have much interest in it. Everything is so instant in this day and age. It takes time in the summer when the fruits are in season.

I married into the Moran family. They are ranchers and farmers. So they were into gardening. I would like to garden the traditionally edible fruits. It's not a money maker, but it could be. I think we should try to plant sage, too. That could also be a business. You pay for a business site from the tribe. My cousins and aunt are coming to the fair. They have good stories.

AN INTERVIEW WITH NELLIE EAGLEMAN BLACK OWL (15)

In recent years, with adequate precipitation, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild plum, and rosehips.

For buffaloberries, I eat them fresh or make *wojap*i (pudding) and jelly. The process for *wojapi* is to boil the berries with water, strain them in a colander, add a little sugar, and thicken the mixture with corn starch. I make jelly without Sure-Jell. I grind the berries in a blender, boil in water, strain in a colander, and add a little sugar. For *wojapi*, I thicken the mixture with corn starch. I eat fresh buffalo currants or make *wojapi* the same way as that made with buffaloberries.

Concerning chokecherries, I make jam and wojapi (pudding), as well as juice with sugar to serve to the elderly to honor them. The chokecherry *wojapi* is made the same way as above, but the fresh berries are crushed with rocks. They are formed into patties and dried outdoors on cloth for about three days. The dried chokecherries are reconstituted later by adding water. They are not canned. I teach my grandchildren to drink the juices of all of these fruits. In addition, I make *wasna* using the following dry ingredients: beef, chokecherries, flour, and raisins. We eat it like trail mix and store it in Ziplocs. We carve some chokecherry sticks to make the circular frames for dream catchers, a kind of wall ornament, but we don't make many.

With wild plums, I make *wojapi* (pudding) and jelly. I cook the plums a little and remove the pits. I use the skins in the jelly. I freeze plums for later use, but I don't freeze the other fruits.

I make rosehip jelly but not tea. The rosehips are picked when red and are then boiled in water until they are the right color. Some people don't like the taste of the tea.

My mom died when I was seven. I was raised by Auntie Katherine Bone Shirt. She liked the traditional fruits. We were in boarding school and went home in summer on break. She sent us out to get fruit. At the home place where she lived, there were 25 adults and children when we weren't in school. It was a *tiospaye* (family group). Some lived in tents, others in trailer houses, and some in her transitional house in the late 1960s. Sometimes the guys went hunting deer or fishing at the creek by the trees. The kids would go along and check for berries and swim at the spring. I picked berries down by the creek where Grandpa Tom Bone Shirt lived. They'd tell us to pick berries because they made *wojapi* (pudding) to serve after a soup meal. She'd boil the berries right away and use flour in hers. It tasted good.

That's what I want to teach my grandchildren now. They pick for a while and eat it. I say, "We have to fill up this bucket." They get thirsty when they eat too many raw chokecherries. The currants are the juiciest ones. They like those. We all own a piece of land, and I have 2.5 acres. I want to plant a garden there near the chokecherries and buffalo currants. There are plums near my homestead, but there are none there this year.

I do want the grandchildren to know that I go picking turnips, and I am showing them how they look. I have to get them when they are just right. This year we are doing pretty well. I dried those for winter. I braid them. I cut them in half and use them for soup. I want to show the grandchildren what we used traditionally, including mint tea, sage, and prairie cone flower. Some say we shouldn't look to the past. But I think our culture is important. I want people to know that our tradition and our Lakota language won't be lost. It is taught in school, and I teach at home when I can. It's fun when my grandchildren know what I am saying in Lakota.

AN INTERVIEW WITH STANLEY LITTLE THUNDER (16)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

I help pick those fruits. Women cook them. I don't know what they add when they prepare them. I help dry them. I eat buffaloberries raw or made into *wojapi* (pudding). We freeze them, too. I eat fresh buffalo currants, as well as jelly and jam. We also dry them. Later they are rehydrated and used.

Concerning chokecherries, I eat them raw or dried, as well as in jam, jelly, juice, *wojapi* (pudding), and *wasna*. Some chokecherries are frozen, and others are dried. I help grind them and make patties. We dry them outside and place them on cloth. After three days of drying, they are wrapped in cloth. Some berries are ground and then frozen in Ziploc bags. I don't make crafts from chokecherry wood.

I eat fresh wild grapes, as well as in jelly, jam, and juice. For wild plums, I eat them in jelly, jam, syrup, and *wojapi* (pudding).

I started picking wild fruits at about age seven in about 1965 or 1967. We picked buffaloberries, buffalo currants, chokecherries, grapes, and plums. I would ride horses or walk around to collect the fruit. I went with Mom and Grandma, my brother, uncles, and sister. They let me help pick. We often got three or four, five gallon buckets of berries. They put down boards to avoid poison ivy when picking. We went by wagons and horses in the first days. After that, we went in trucks and cars. I kept on collecting wild fruit and never did quit. I show others how to do it because it's important. It would be a strange funeral without *wojapi* (pudding), in particular.

Of course, the berries are free and have different flavors. When I am collecting food from wild plants, I start with turnips and go through the season and see which berries are ready. It would be good if it were commercialized. I would buy chokecherry jelly and traditionally edible fruit products if they were available. My favorite berry is chokecherry because they easy to pick and taste best. I like the *wojapi* (pudding); it is better than jelly.

AN INTERVIEW WITH SAM HIGH CRANE (17)

In a recent year with normal rainfall, I collect and eat buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

After we collect wild berries, about half are used fresh and the other half are frozen to use later. I eat fresh buffaloberries, freeze some for later, and make *wojapi* (pudding) and jam after freezing bunches in Ziploc bags. When I worked for the St.

Francis Mission, I taught kids to pick buffaloberries and to make *wojapi* and jam.

Concerning buffalo currants, I eat them fresh, freeze some for later, and make *wojapi* (pudding) from frozen berries. I don't make jam or jelly. I don't dry buffaloberries or buffalo currants. We make dream catchers with buffalo currant twigs. Kids take them home for wall ornaments. They make little ones for windows or cars.

I eat fresh chokecherries. That dries out the mouth and makes teeth temporarily brown. They're supposed to be good medicine. After picking chokecherries, in recent years, we take them home and smash the fresh berries by putting them through a metal meat grinder. When I was a kid, we pounded them on a wood table with a wood mallet. Some used rocks to smash them at that time; however, we used a cone shaped piece of wood that was hard--like oak. We formed the crushed berries into patties and dried them on screens or canvas for a couple of days, depending on the weather. Then we put them into a cloth bag and stored them. We don't freeze the dried patties. We canned chokecherry juice in the old days but not as much now. At my house, we turn the dried chokecherry patties into *wojapi* (pudding) and juice. We don't can, but we process them right away. We take them out of the freezer to go to a ceremony. We mash it all up and get the juice out and take it to a ceremony for medicine. We collect only so much to make *wojapi*, and then we bag and freeze the berries. Later, we make whatever we want. It could be used for jam, juice, or *wojapi*.

I don't like to pick wild grapes because they make my lips itch and puff up. In my younger days, they picked them to make jam. They tried to make wine. That's about it. I never really got into grapes.

Concerning wild plums, I eat them fresh and make *wojapi* (pudding) and jam. I rank buffaloberries and plums at the top for taste. I like chokecherries in syrup form—but I like the others better. We also remove the pits and dry the wild plums to use later on. The branches of plums don't break very easily. You can use them for dream catcher frames, too.

I never used wild roses or rosehips. My grandmother would go and get rose leaves and mash them and put them on a cut or sore. I had a big cut on my thumb in the late 1940s, and she used that.

My great-grandmother was blind, but she taught me well. I think she was born in the 1860s. She said she was about nine years old when she ended up at Custer's Last Stand. She died in the early 1970s. Her maiden name was Laura Hollow Horn Bear. She was the daughter of Chief Hollow Horn Bear. Her married name was High Crane, but when she got into enrollment the name became Kills In Sight.

When I was a child, my grandfather, Noah Kills In Sight, taught me how to make arrows out of chokecherry wood. We put a bunch of small, green chokecherry branches together while they were drying, to keep them straight. Then, when they were dry, we used an arrow shaft straightener to finish up.

I was told a traditional Lakota story about chokecherries, wild roses, and Iktome. The point of the story is that when people sometimes tell you things to help, you should listen, because they are telling the truth to help you avoid pain. Ikto, a short form of the name, is a liar and cheater. Way back in time, when the Lakota first came out of Wind Cave, Ikto was there. He was one of the ones who got the people from beneath the surface of the earth. Because the people believed in him and followed Ikto, today everyone has a little part of Ikto in them. Ikto could be on the bright side, and in the flip of the moment he can be something else---like people are. Even the best people, they flip, you know. They lie, cheat, or whatever the case may be. We all have a little Iktome in us. Don't be like Ikto and try to outdo the other person by lying or outdoing the other person at what he does best. The following is the story.

> Iktomi (Ikto for short) was walking along, and he came to a chokecherry bush. He asked the chokecherry brush, "What do they call you?"
> The bush said, "I am the chokecherry."
> "What good are you?"
> The chokecherry said, "Well, when you eat me you get your insides doctored."
> "What else?"
> The chokecherry replied, "Well if you eat enough of me, you would plug yourself up."
> So, Ikto said, "What nonsense. See if I get all plugged up!"
> So, he ate a whole bunch. He walked along and came to the rosebud bush and told it, "What are you? What do they call you? Why all the thorns?"
> The bush told Ikto, "It is to protect me from harm."
> Ikto told the rosebud bush, "What are you good for?"
> The rose said, "If you have open wounds, you can use me to doctor yourself. You mash up the rose leaves."
> Ikto said, "What else can you do?"
> The rose said, "Well if you eat enough of me, you will get an itchy butt."
> Ikto says, "That's nonsense! See if I get an itchy butt if I eat a whole bunch."
> Ikto talked to a third kind of fruiting plant, and it told him that eating too much of it would cause stomach gas. So, anyway, Ikto was all filled up with these three fruits: chokecherries, rosehips, and one other kind.
> He went home and lay around. Soon he began passing gas and had to go to the bathroom, but he could only pass gas and had an itchy butt. Soon he ran out along the river, and he rubbed his butt into the sand. That didn't help, so he got on the branch of a tree, and he kept scratching and passing gas. He could not make it stop. He had all the problems at the same time, because he wouldn't listen to the plants and believe them. That's the end of the Ikto story.

I think the wild plants work as a medicine. My great-grandmother told us that all the flowers and fruits are medicine. So, throughout the whole year, that's why they preserve all these, so that they can use them through the winter. When my great-grandmother took water from a stream, she took some in her hand and put it on the ground and asked that the plants could grow and that we could grow strong. I live through those kinds of beliefs.

There was a time when I came to a St. Francis Catholic boarding school. I had never experienced the White side of life until that time. Once in a blue moon, we would have some kind of *wojapi* (pudding) stuff that was cooked. Most of the time, we had a big garden, and we used to pick corn, potatoes, carrots, onions and other garden produce. We'd haul it back and put it in the cellar. That is what we ate. They had milk cows. The boys milked, and the girls made the butter from that. We had the milk too, of course, but it was watered down. The big pile of cement near here is the barn footing. I learned carpentry and bakery work (mostly biscuits).

The *Wasicu* (Whites) had a lot of control over us in boarding schools. When they told us things, it was like with force. We were forced to believe their way and forget our way of life. So, nobody talked about our Lakota ways because the *Wasicu* said it was bad and the worst thing you could ever believe in. They talked about being bad and getting into trouble--by maybe talking Lakota. I know I experienced some very powerful things that even today, I guess, traumatized me. They used to make us box during half-time at a basketball game. I was only in fourth game. They blindfolded us. We were half-time entertainment. Our parents couldn't say anything about it because the government gave the schools complete control (Episcopal or Catholic, for example). I talked to Father about it. I told him, "With all the money you spent in making us into *Wasicu* ways, why don't you use it in helping our children learn about Lakota ways?" So I got hired at St. Francis Mission to explain the Lakota ways. When cuts were made because of financial issues, my position was one of the many cut—but not one of the first ones. I have an AA degree and a BA degree from Sinte Gleska. I did two semesters in Human Services to work on a graduate degree. I had health problems, so I left school.

Lakota does not have a religion. It is a way of life. Some say, when you carry the pipe, you get religion. But you don't. You can pray anywhere you want. You can go way out in the boonies and be in connection with *Tunkasila* (the Great Spirit—grandfather of all –*Tun* is the oldest of the living beings—grandparent-like). *Wakan Tanka* came from Christianity as "God." When people go up on the hill and fast and sing, they make a spiritual connection to *Tunkasila*. When you go back far enough, we are all related to the first human; so we are all related. I think everybody believes that there is a Greater Power—the Great-grandfather exists. And we all came from there in different tones. Maybe we were all one at some past point in time when we all changed our ideas and ways of lives. I think that, because we have the four colors (white, red, yellow, and red) along with blue for sky and green for earth. So, how much more connected could we all be with the environment and the earth?

I was born in 1944 and was taught that we give an offering for whatever we take from Mother Earth. So, we carried tobacco, Bull Duram brand, to give back for whatever we took from her. For example, when we picked fruits, we could spread a small pinch of tobacco on the ground.

I would go pick herbs as a child. Great-grandmother would tell me what to look for. She would smell it and say if I had the right one when I got back. I say, "smell" because she was blind. So, I used to know which herbs would work good for healing or health. For example, I picked puff balls. They have a little hole and when you squeeze the ball, a powder came out. We used the powder. I put it on sores. I use it at Sundance, too. It is called *hoksi cekpa* in Lakota. That means little infant, belly button.

It's important to have an instructor in the schools to talk about the traditional ways. I used to do public service announcements on the radio during a period of high suicide rates on the reservation. I got on the radio and did a talk show about our ways back when I was a little kid. I was trying to give kids their identity, so they wouldn't be committing suicide. I talked about things they could be proud of and who they are. That was about six years ago in 2006. About four or five years ago, I got sick, and so I put it off and never went back.

AN INTERVIEW WITH ANONYMOUS (18)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild plum, and rosehips.

The women cook the fruits, and we usually get them every year. I eat buffaloberries and buffalo currants raw. The buffalo currants taste best, and then the gooseberries. I also eat raw chokecherries and like the taste. I go drink river water when I eat them during picking, because they dry out the mouth. I also eat *wojapi* (pudding) made with chokecherries or plums. Usually, though, I eat the plums raw. We don't can or dry the plums. To make plum *wojapi*, we pit them and cook with a little water with sugar and flour thickening. We just eat rosehips when they are ripe, and we spit out the seeds. I also pick raspberries. They are red or purple. We don't freeze the fruits.

I am 42 years old, and in earlier years, I watched my grandma and great-grandma make chokecherry patties for *wojapi* (pudding) and *wasna*. They had grinding rocks just for that. They dried the patties in the sun. I watched them every summer until about age 26. We used to collect wild fruits all over the place. Dad had a spot by the river, and I like to look for berries by a river. Sometimes there are bushes away from water. I fill buckets with the fruits now, and I sell some. I get ten dollars for a gallon of plums. For chokecherries, I get twenty dollars a gallon. There might be a possibility of a commercial venture involving these fruits on the reservation. There's already fry bread mix in the grocery stores.

I am most likely to see and eat *wojap*i (pudding) and *wasna* at powwows, ceremonies, and funerals. It would be unusual to go to a funeral and not be served traditionally edible fruit dishes. I like how they taste. I grew up with them. It was just part of life. I never thought of it as a traditional. Although the fruits are still important to young people, I think they are more important to older generations. My daughter is 22 and she wants to pick fruits. I pick her up, and we go picking. I go out with other family members now to pick them. If I get the munchies, I go pick the fruits in season. There are too many snakes and too much poison ivy; so we don't always take kids. Kids should be five or six before they start picking.

AN INTERVIEW WITH ANONYMOUS (19)

In a recent year with normal precipitation, I pick and eat the following traditionally edible fruits: buffaloberry, chokecherry, wild grape, and wild plum.

I just eat buffaloberry fresh, and I don't freeze or dry them. Concerning chokecherries, I eat them fresh with salt, or as *wojapi* (pudding), or syrup, but not as *wasna*. For the *wojapi*, I cook the crushed, fresh berries with water, corn starch, and sugar. I eat it right away while it is warm. I freeze chokecherries for later use.

For grapes, I make wine and jelly, although I freeze some so that I can use them later. I don't can the fruits. I eat raw plums, but I don't make *wojapi* (pudding), jelly, or jam with them. The plums are most important because of taste. They are sweet. I've never seen any for sale.

I am 29, but when I was about age seven or eight, I went with my brothers and sisters to pick wild fruit. We collected buffaloberries and chokecherries. We got as many as we could and made all kinds of stuff from the fresh berries. Poison ivy was there, but we walked right through it. Buffaloberries mostly grew by the river. They grow wild all over. We went deeper into the woods to get the bigger fruits that no one got to. We took salt with us and lay under chokecherry bushes and ate them while fresh. We took water with us because they made our mouths dry. I picked mostly with my family, including cousins. We never tried to cultivate the plants. The chokecherries are most important emotionally as a brand or symbol of the culture. I would buy chokecherries if I saw them in a grocery store, for example. No one dyes with natural dyes, like chokecherries, that I know of.

It's important for my children to know about them. My oldest is ten, and he's picked since age five. We pick fruits when we go to Auntie's house. It makes my teeth brown, temporarily, and my mouth feels kind of raw. The salt kills the bitter taste.

We pick mint leaves for tea, although we don't dry it. We get sage to keep and dry for ceremonial or religious purposes.

I would expect the *wasna* and buffalo meat to be at a funeral. If they didn't have buffalo, I'd assume they could only get beef. I might also expect that *wasna* might be served at some tribal council meetings or at gatherings where they make a decision. At an event such as the powwow at the Rosebud Fair, it might not be served, because there are too many people to have enough for everyone.

My mother always went out to pick fresh stuff to make food dishes and to eat. I live in the country, and there are wild fruits nearby. Really, they are everywhere. We will go check the chokecherry bushes to see their condition. Then we go back when they are ready to pick.

AN INTERVIEW WITH ANONYMOUS (20)

In a year with normal rainfall within the last five years, I pick and eat the following traditionally edible fruits: buffaloberry, chokecherry, and wild plum.

I eat buffaloberries when they are freshly picked. Concerning chokecherries, my husband showed me how to smash them with a hammer on a table. I cook them by adding boiling water, corn starch, and sugar. We eat the dish right away. I don't make jelly, jam, or syrup, and we don't freeze or dry the berries. We pick and eat raw plums. I don't make pudding, *wasna*, or any craft items with wild plums.

I am 38 years old, and when we were kids, we looked around for buffaloberries because they didn't grow much where we were. If we couldn't find them, we went swimming instead. We used to pick chokecherries and tried to fill a five gallon bucket. Grandma would pay us for them. That is how we got money for pop and chips. That was in the early 1980s. I've never sold other berries.

I only made chokecherry *wojapi* (pudding) once, and my husband had to tell me how to do it. He told me, and everything I did was wrong. (Laughs.) He'd say, "No, like this." It turned out good. My mom showed me how to make bread and other *wojapi* with canned stuff, like peaches and canned blueberries. I boil water and then put in the fruit and sugar. I cook it until it boils, and then put in cornstarch mixed with a little cold water. That thickens the dish. We don't preserve that. We eat it right away. I don't know why it isn't for sale at the Rosebud Fair. It would be good. It is okay to make the *wojapi* with store fruit for a funeral, for example. I think it's important to pass it on to future generations. I only learned how a year ago.

Lately I haven't picked wild fruit. It's too hot and I am afraid of snakes right now. It's hard to take babies and toddlers along because of heat, poison ivy, and snakes. I don't see snakes that often, but the fear is still there.

AN INTERVIEW WITH ALTINE BLACK LANCE (21)

In a recent year with ordinary precipitation, I collect and eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rose (leaves only).

I pick and eat these fresh wild fruits: buffaloberries, buffalo currants, grapes, and plums. While I haven't done it lately, I have ground chokecherries with a meat grinder to make *wojapi* (pudding), a boiled dish that includes those berries, water, sugar, and flour. With the wild roses, I pick the wet green leaves and steep them for tea. They are good anytime in summer. Concerning buffaloberries, we used to wait until they got really ripe. We would put blankets down, and with some shaking, the fruits would fall onto them.

The yellow ones are the sweetest. We're from Soldier Creek, and there aren't many buffaloberries this year. There are lots of currants, though. Grapes are hard to find. They are getting ripe right now. There are not many plums this year. We have to go way out to find them. Before, we would pick right along the road. Now we go much farther to get grapes and buffaloberries. This summer, we just picked and ate the fruits.

The chokecherries are everywhere. The chokecherry *wojapi* (pudding) is good, and with *gabubu* bread is delicious. You dip the bread in the *wojapi*. It is baking powder skillet bread and is not deep fried. It is pan fried in lard which tastes better than soybean oil.

There is an old saying that if big winds come, tie yourself to chokecherry bushes, and it will hold you. I haven't tried it. I heard it all the time growing up. My cousins used to make little whips that they used to gently get the horses going when they would ride. We don't make craft items with any of these fruits or their branches.

Mom used to make *wojapi* (pudding) out of plums. I didn't pay attention then. I am 54. I think she boiled them, took pits out, and finished the dish. I would serve *wojapi* and skillet bread for an important meal—like Sundance. I'd make regular beef, potato, corn, wild turnip soup. Raw turnips are good too. I'd serve it with Lipton tea.

In days gone by, we would walk five miles to find the best berry bushes. Nowadays, we go by car. My cousins rode their horses in the old days. For a ride home on a horse, we had to share our berries with them. They took horses to the river and swam and had fun while we worked hard picking. So that's how we got home with empty containers sometimes in the 1960s. We ate berries at the picking sites, too. So, if berries made it home, we ground them in the metal meat grinder. If Mom didn't use them right away, she would freeze the un-dried patties while still wet. We never ever canned.

I went to St. Francis boarding school from Kindergarten through eighth grade. I still see some of my classmates, and we lived by the nuns. I think they were Benedictines. There were about ten with whom I had daily contact. They taught cooking, including fry bread, but not traditionally edible fruits.

AN INTERVIEW WITH SYLVAN WHITE HAT, SR. (22)

In a recent year with normal precipitation, I eat the following traditionally edible fruits: chokecherry and wild plum. I eat both of those kinds of berries raw and in jelly and *wojapi* (pudding) that is prepared by women. They probably use Sure-Jell to thicken the jelly. For the *wojapi* (pudding), they grind chokecherries, pits and all, but for the plum *wojapi*, they discard the pits. If they have time, they pound the chokecherries on rock, rather than using a metal grinder with a crank-style handle. They cook the berries and thicken them with sugar and cornstarch. Sometimes they freeze the dry chokecherry patties. The chokecherry *wojapi* is a little bit gritty because of the ground pits. I don't make any crafts with these plants.

When I was young, we didn't have all the technology of today. We just played cowboys and Indians all day. Everybody wanted to be a cowboy! There were hills in my community, and we ran those all day long. We jumped in the river and snacked on the wild berries. Plums also come in different sizes. Along the river banks they can be bigger and yellower. Those are sweeter. Others are smaller and redder. Some purple berries grew near the natural springs, but I don't know the name of them. They make *wojapi* (pudding) with both. They were dessert after supper on special occasions.

The Little White River was clearer before there were so many cattle here. So we could drink river water, then. When there was no electricity, we hauled our wood and water. There was a natural spring for bathing and drinking. They put a pipe in it. I picked and sold chokecherries and plums. I was young enough that I could pick them quickly. I picked turnips, chokecherries, and plums, but I don't today because of lack of time, and I am not as young as I was.

I went picking with my mother in the 1950s. She showed me what to pick, mostly chokecherries and plums, and what not to pick. We tried the wild grapes, but they are sour. We avoided poison ivy the best we could. In the morning and evening, poison ivy gives off a mist. So, it is even more dangerous then. We really watched for rattlesnakes. There were a lot of bullsnakes. I don't kill bullsnakes because they are territorial and usually there are not rattlers where the bullsnakes are.

I didn't get into my culture until later in my life. I was raised in the Episcopal church teachings. My mother wanted me to marry a native girl, so I could have native grandchildren. She said that after she was gone, I could get involved in Lakota culture. She said that religion is nothing to toy with. Her request was that I stay away from our traditional religion while she was alive. I learned about those traditions after her death. She got her wish, Lakota grandchildren.

Part of being involved in these fruits is keeping my culture. These fruits are served at many traditional activities, such as a powwows or naming ceremonies. When there are too many people at an event, sometimes they cannot serve the traditional foods because they might not have enough for everyone. They are served at the Sundance or a sweat (*inipi*). They are also served at funerals and *yewipi* healing ceremonies where traditional fruits might be served. For health we use bitterroot and sage. I have a friend from Pine Ridge who is a medicine man, and he looks for those.

I am grateful that I got the education I got on the Rosebud at Sinte Gleska. I do a lot of public service announcements for the university. I translate to Lakota and put it on the air. I get support from Elders, and they complement me on how well I got my message across to them in Lakota language.

AN INTERVIEW WITH ANONYMOUS (23)

In a year with normal rainfall in the past five years, I have collected and eaten the following traditionally edible fruits: chokecherry and plum. I eat both kinds of berries in their raw state. I also eat chokecherry *wojapi* (pudding).

I don’t make *wojapi*, but my sisters do. They probably thicken it with flour. I am not sure what they do with the pits because I never saw how they handled that. No one showed me how to make it. Sometimes we put it in the refrigerator. The berries are used fairly quickly after they are picked. I don’t make craft items from the plants.

When I would go swimming, I would pick them to have something to snack on. The berries are good for you, and they grow all over the place. We take our kids out and pick them. The berries are not available in the same place every year. We pick ice cream buckets full of the berries. Most of the time, there’s no poison ivy where we pick them at Dad’s place. If we see poison ivy where we pick, we take the kids home, although sometimes they do get into it. We put on calamine lotion and give them children's Tylenol.

Mostly, the wild berry dishes are served at ceremonies, sweats, and wakes. Sometimes people have them for regular supper or dinner. It is really important to keep for our traditions. If you don't know how to live off the land, it's a waste. It's as important as language and native religion because our grandmothers and mothers had those traditions. I don't know of anyone who uses traditional plants for dyes.

We moved here from Denver when I first found out about the uses of traditional fruits. We were just walking around and swimming, and my sisters and cousins told us about the berries. I was about eleven or twelve at the time. I am 26 years old. As I get older, I will pay more attention to the traditional fruits. At the present time, my older sisters collect and cook them. I will learn from them. I intend to pass on to my children the picking of fruits and the making of traditional foods. They are ages seven, six, and four, and the baby is one. It's important that our kids remember what to look for, what to pick, and family time to get together. That part of traditional knowledge needs to keep going on. It's stupid to say that we need to forget the past and history. It's still here, and we can find it and do something about. It's pretty much guaranteed that some family member would bring traditional fruit dishes to a funeral.

AN INTERVIEW WITH LARRY BLACK LANCE (24)

In a recent year with normal rainfall, I collect and eat the following traditionally edible fruits: buffaloberry, chokecherry, wild grape, and wild plum. For the most part, I eat them fresh, just after picking. Occasionally, I eat chokecherry or plum *wojapi* (pudding) when I am visiting others at their homes.

I pick and eat these fruits when I am out walking. With the exception of wild plums, I don't take the berries home in buckets. I leave plums in the house until it is all eaten. I don't have the sweet tooth I had when I was younger.

We are losing some of this part of our culture. I would go with Grandma Rose Kills Plenty to pick berries and stuff at nine or ten years of age. When we got home, she had a big stone that was round and indented and also an upright pestle stone that fit her hand. She would grind the berries, form them into patties, and put them on paper to dry in the sun. Then she hung the patties on a clothesline near the house. My sister's name is also Rose, but it is a name you don't hear much anymore on the Rosebud.

Grandma took me along to pick ripe buffaloberries. She placed a sheet on the ground under the tree, and she shook the branches. The berries fell to the ground. We'd gather big buckets of berries in that way. It was really fun. All the grandkids were there. That was around the 1970s. It was a family thing, not something that included friends. There were lots of spots where we lived. There's a spot where plums are really large. The plums there are the size of ping pong balls. Sometimes Grandma made *wojapi* (pudding) with canned fruit, too.

I went away to Idaho at age eleven. I'd go away for a year and come back here for a year. Grandma passed in 1982. We flew back for that. She wanted to see me before she died. We haven't really gotten into it since she passed. It makes me think of her when we go picking. It would be important for her to know that we are carrying it on. We learned from her. We explored out in the hills. We'd get hungry and know what to eat. At her house, she had a propane cook stove; however, there was an old-time cook stove outside. She'd cook out there in the summer. So I had to get firewood for that. Every day she made biscuits to eat. She made mostly chokecherry and buffaloberry jelly to spread on the bread. I liked the chokecherry best.

AN INTERVIEW WITH ALOYSIUS RUNNING HORSE (25)

In a year with normal rainfall, I use the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, and wild plum.

I eat the raw buffaloberries, buffalo currants, and plums when they are freshly picked. Concerning the chokecherries, I eat them raw with salt, and we make juice and grind them into patties that are dried. They are stored in cloth bags, so they don't mold. We also freeze them. Eventually, those patties are made into *wojapi* (pudding). I don't cook, but I help, up to that point. I don't make crafts from any parts of those plants.

Mom and Dad took me and my brother and sisters to pick chokecherries in the late 1960s. It was fun. We also went swimming. We would have to drink water because the chokecherries would dry out our mouths. We would look for a clear spring.

They'll never stop collecting wild berries. It's the traditional way. It matters. My mom's parents collected berries a long time ago; so she passed it on. I always tried to keep traditional foods at the level of importance of native religion and language.

These foods show up mostly at ceremonies. For example, at *yewipi* (healing) ceremonies, I expect to see chokecherry *wojapi* (pudding). Once in a while it would be plum *wojapi.* I don't remember those foods being served at funerals that I attend.

I went out by myself to pick berries last summer and this year. It's good to hike, to think, and to be in nature. I was riding a horse and looking for other horses and saw a good patch of chokecherries and said, “I’m going to pick some.” I collected about two gallons. I sell them for ten dollars for an ice cream bucket full. I carry them around and let people know I have them. I don’t collect other plants.

The older people seem to be more interested in these matters. Today, you don’t see as many children, teens, and twenty-somethings involved with the fruits. I think it is important for them to know what to collect, where to go get it, and how to prepare it. For example, at a healing ceremony, raw chokecherries are served to everybody there, including the sick. We spit out the pits.

If the traditional fruits were made into foods or beverages and available at a grocery store, and made on Rosebud, I’d buy them. I would rather have such foods made by Lakota so that the taste is right. I would want the product to be like I expect it to be.

AN INTERVIEW WITH CLAYTON HIGH PIPE (26)

Recently, in a year with normal rainfall, I use the following traditionally edible fruits: buffaloberry, chokecherry, wild grape, wild plum, and rosehips.

I eat all of those fruits raw when they are freshly picked—some more than others. Concerning chokecherries, my mother, Emma High Pipe, makes jam, cans juice, and dries the ground patties outside for a week. Then she freezes the patties. The berries are pulverized with a metal meat grinder. She makes chokecherry *wojapi* (pudding). Sometimes I use the chokecherry wood for frames for dream catchers. They are not made to sell, but rather for family and friends.

For plums, Mom removes the pits and makes jelly, jam, and *wojapi* (pudding). She doesn't freeze or dry the plums. I occasionally pick and eat red rosehips when walking through the prairie.

I am 45 years old. I don't know how to put this, but when I was growing up on the reservation, I had nothing in my life, not even electricity. We just had a wood stove. We cooked fish, turtles, and frogs, and we collected all the berries we could see. They were energy. We needed the food. It was survival. In the 1970s, we lived on the prairies with no car and no horses. We had no lights. All they had were candles. Mom cooked outside on a bonfire. We had no propane. Mom would say, "Go fishing." Do you know what a safety pin is? Well, we used those for fishhooks. We dug our own worms for fishing. We would wrap string around a stick and use a rock for a fishing weight. Nine kids lived in our home with mom. My brother and I were the youngest.

Then I went to live at the Bureau of Indian Affairs dormitory at Mission. I only stayed there for two years, and then Mom got a house. Things were better at the house. Then I learned to make *gabubu* bread, fry bread, *wojapi* (pudding), *wasna*, jelly, and jam. She said to me, "You are going to be a man someday and have to take care of your family. You need to know that." She knew I would have children and would take care of them. "Don't be a crook, just be a cook," is my saying.

I think it's better in life if you take care of your health, and that can include traditional fruits. It should be taught in schools. They need to know where to go to collect the foods, when the plants are ready to harvest, how to prepare, and how to cook them. It would be good for parents and grandparents to take kids and show them. There are some plants that will make you sick, but not the ones we are talking about here. So they need to know the difference. Other plant parts to collect are turnips, the fleshy red part on cactus, raspberries, and mint tea. I would choose to go through my early life experiences again, because the experience brought me intuition and taught me how my mind works and how life really is.

AN INTERVIEW WITH GREG QUIGLEY (27)

In a year with normal rainfall, I use the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild plum, and rosehips.

It is common for me to eat the fruits raw. We freeze all of those that are not used fresh. The chokecherries can be ground after they are frozen and thawed. We can the juice to use year round. Mostly, I make the *wojapi* (pudding) from either chokecherries or plums, and I make *wasna* from chokecherries. For the chokecherry *wojapi*, I put the pits and berries through a metal meat grinder, and then I boil it with sugar and flour. The women make the jam and jelly from the fruits. The only thing we make from the rosehips and rose leaves is a tea beverage.

My grandma, Lucy Bear Shield, and my grandpa, Thomas Red Bird, taught me what to do with traditionally edible fruits. Presently, I am 48 years old. When I was four, they taught me about how healthy these fruits are. They took me along picking berries. They taught me how to process them, because they did all that. I learned from them about the ways of long ago. When my mom was alive, she taught me and said, “Don’t lose those traditions, or you will lose your life.” I didn’t give them up.

I was about twelve or fourteen years old when I went out and got chokecherries and plums with other kids. We also went swimming. We kept eating the fresh berries until we had overdone it. We all got very sick to our stomachs. We still tell that story when I am around them. Sometimes I still eat too many, and it makes my stomach upset. I eat that many because they taste so good. I didn't learn from my young experience. I like them that much.

There are religious stories about chokecherries and buffaloberries that we don't talk about because they are sacred in nature. I know many of those stories, but they are not to be recorded. We expect to see some of traditional fruit dishes at certain events such as ceremonies like sweat lodges, Sundances, funerals, healing ceremonies, and others.

AN INTERVIEW WITH ANONYMOUS (28)

In an average year, recently, I use the following traditionally edible fruits: chokecherry, wild plum, and rosehip. While I live on the Rosebud Reservation, I am enrolled as a Santee in Nebraska.

For chokecherries and plums, I eat them raw or dried with salt. Sometimes I make them into jam, syrup, or *wasna*. With plums, I also make *wojapi* (pudding). Dried rosehips are used for tea by steeping them in boiling water.

To prepare the chokecherries, the berries and pits are ground in a metal meat grinder. They are then dried or frozen. They can be used wet when they are freshly ground, too. The plums are not dried. The pits are removed if they are used right away. If they are to be used later, they are frozen and then boiled and the pits removed at the time of use.

My *wasna* is dry like mueslix. I use ground and dried chokecherries or pitted plums with water, sugar, corn starch, and usually raisins. I dry it in the oven for ten minutes at 350 degrees. I store my *wojapi* (pudding) by freezing. For jams, I use Sure-Jell and corn syrups. I do not can the foods I make. I would buy chokecherry jelly, for example, if it were for sale at a grocery store.

I love to pick buffaloberries and chokecherries with grandchildren. We used to go to Little White River by Old Ring Thunder. They'd swim too. There are lots of plums and chokecherries out there. We take ice cream buckets for collecting, along with a lunch. I show kids where poison ivy is, so they stay away. I wear a long sleeved shirt. I put all the chokecherries and plums in water to rinse them off. The kids eat while we pick. It turns their teeth brown, temporarily.

I went riding horses in the 1980s, and we used to pick the berries and plums, and we brought them back home. When kids and nieces and nephews would say they were hungry, I'd say, "Let's go picking berries." It was a family outing involving hiking.

My mom told me that a long time ago they'd pick chokecherries and buffaloberries down by river, and she said how long it took them. She's traditional. Mom would go picking all day in the 1950s. I went picking with Mom and my aunties after that.

I would expect to see traditional fruit dishes at wakes and funerals. They might show up at birthdays or any ceremony, too. It is important to save the traditions, about as important as saving Lakota language. It's family. It's part of the Indian way for grandkids to learn about the fruits and eat it. About age five is a good time to get them started. It is good to show them where to find the fruits, what colors to look for, and when it is ready to eat. They need to know how to save it and prepare it. It makes me happy to know about those ways. It is respect for my mom and grandmas and aunties and sisters.

AN INTERVIEW WITH AUDREY BEAR DOG (29)

In an average year in the last five years, I used the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, and wild plum.

I eat buffaloberries raw, but not salted. I also make *wojapi* (pudding) but not jam, jelly, or syrup. If I get too many berries, I grind them with a metal meat grinder. Buffaloberries are hard to get, though, and it takes a while to pick them. I would freeze the extras and grind those later if I want to. I don't know how to can but want to know how.

With buffalo currants, I eat them raw and also make *wojapi* (pudding). I mash them and then cook them with water and sugar. Then I thicken the mixture with flour or corn starch. That is eaten right away.

Concerning chokecherries, I eat them raw without salt. I also wash some and freeze them. Then I take some of those and grind them in a metal meat grinder. The ground berries are dried outside. I also dry sweet corn. I make *wasna* with ground berries, dried meat (beef, buffalo, or deer) that is all smashed with a mortar and pestle from Mexico, although I got it in Utah. I also add kidney fat, sugar, and raisins. The grease moistens it. For chokecherry *wojapi* (pudding), I combine ground berries, water, sugar, and flour or corn starch. I boil that down, like pudding. I don't make jam, jelly, or syrup, but I make juice and drink it. I have the last of my chokecherry taffy candy in my backpack, but I don't make that. The chokecherry twigs are good for making frames for dream catchers wall hangings.

For wild grapes, I rinse and mash them and cook them with sugar to make *wojapi* (pudding). They are too bitter to eat raw. I don't make grape juice. If I have extra, I freeze the grapes in case I want to make *wojapi* later. I also make *wojapi* with wild plums, and I eat those raw because they are sweet.

I am often out picking because it's a family tradition. For those who aren't afraid of poison ivy, poison oak, or snakes, I suggest they go up into the canyons and pick. They will have a supply of food for the winter.

I always like to tell this bedtime story to little kids. It is about the beginning of time, and maybe these fruits lived in the water. Who knows, at the beginning of time? The story includes beaver and brother spider. They got bored, and between the two, the beaver is the hardest worker in the world. It was the spider who told the beaver to take this mound of dirt and add it to another pile, until the dirt came up above the water level. Brother spider told brother beaver, "I will tell you long, short, and other stories as long as you keep picking up mounds of dirt and adding it to the pile." They created a new world that way above the water. Soon they got bored again, so they went back into the water and got their brothers to join them in the new world they made. (By that time the kids are usually sleeping.) The point of the story is that they had to bring the food up out of the water to have it above ground.

Keeping the food traditions is important, like our language and religion. They use those foods in ceremonies or honoring things or healing. They are for big dinners, too.

They have always been known and passed down. They are sacred, and that is why they are used in ceremonies. Not all foods are ceremonial, but they can be.

I use them as a preventative to keep me strong and healthy, and they taste good, of course. I think they are useful for colds and flu because they have a lot of vitamins. All food comes from Mother Earth and has a kind of spiritual connection because of that—not just these foods. It is from ancient tradition that these are served at funerals—things that those who left before us always enjoyed and used. It honors them. It wouldn't be unusual for buffaloberries, buffalo currants, chokecherries, or wild plums to be served at a funeral. Chokecherry is the most likely.

For young people I would say that from the beginning of time our people lived this way, making use of these. So, they should too. They should think of their health and the unique taste the berries have. I encourage them not to lose the tradition.

When I pick today, I take along one or two grandkids or my cousin. She has a car. Otherwise, I walk near my place and get the berries there. My sons and cousin also dig wild turnips. I pick wild mint for tea and another wild green plant for tea—perhaps that is leadplant. I am not sure what you call that. I used to pick sandcherries, but not now.

AN INTERVIEW WITH ANONYMOUS (30)

In a recent year with average rainfall, I eat the following traditionally edible fruits: buffaloberry, buffalo currant, chokecherry, wild grape, wild plum, and rosehips.

I eat buffaloberries raw, but I also make *wojapi* (pudding) with them, as well as with buffalo currant, chokecherries, and plum. I don't mingle the different kinds of berries. I boil the berries, and add sugar and flour. I don't can or freeze *wojapi*.

For chokecherries, I also eat them raw or dried. I grind the fresh berries and form them into the shape of hamburger patties. I put them outside to dry and put them in pillowcases to store them for later use.

For the wild grapes, I eat them raw or in jam or syrup. When making the jam, I boil the berries, strain out the pits, sweeten it, and thicken it with Sure-Jell. I put it in jars with wax on top.

I eat wild plums when they are fresh or dry. I make plum *wojapi* (pudding), as mentioned, as well as *wasna*. I freeze the whole plums, including the pits. They are pitted when they are later thawed and used.

I eat raw rosehips when they are ripe. For tea, I use both the hips and the rose leaves. I dry them and steep them in hot water for tea.

My grandpa, uncle, and the family used to paint faces with chokecherry juice to dance. It washed off easily. My grandma told me that she died porcupine quills with chokecherry juice. They would teach us kids and tell us what to do to smash the chokecherries on a big bowl-shaped rock. We had a round rock that was hand held to smash the chokecherries. Then we'd dip our fingers in the juice and mark our faces with it. All the kids had a good time doing that in the 1960s. We also ate the crushed berries. There was no sugar added because we never had sweets. It was our treat.

All of us kids and the family would go out and look for berries. Mom and Dad would say, "Here's a tree and there is your bucket." Then they'd go home. They would tell us to pour the berries into five gallon buckets and go pick more berries. The grandmas were at home grinding the chokecherry patties and drying them. They kept some for *wasna* and some for *wojapi* (pudding). None got wasted. We picked wild plums and chokecherries in the 1960's that way, too. We did not crush plums. We were heavily into drying the wild fruits—not using freezers. It was part of getting ready for winter. They got sweet corn ready, too, by drying it and crushing it. We did not can.

We also collected wild turnips, onions, raspberries, and mint leaves for tea. We hung the tea around the porch in bundles. When it was dry, the leaves were crushed and stored in coffee cans.

I go out with my kids today. They are teenagers now. This summer we looked once and didn't find much. We got about a gallon of plums, and we got about a quart of chokecherries. That's because it's a drought year. Usually we get 30 or 40 gallons of plums a summer and 25 gallons of chokecherries.

Some years, the fruits are abundant and other years not. I hope that future generations will go out and pick. It is healthy food. A lot of people are diabetic today. We should look at how we used to eat and encourage that.

AN INTERVIEW WITH DELORES KILLS IN WATER (31)

In a year with normal rainfall in the past five years, I consume chokecherries and wild plums.

I eat the chokecherries raw, near the time they are picked. You need to watch how many you eat because they make your mouth brown, and then you need to brush your teeth! I don't make jelly or jam with them, but my mother did, and she canned them with help from cousins in the neighborhood. I dry chokecherries and use the patties to make *wojapi* (pudding). Sometimes, if I really feel like it, I make *wasna*. I only made that once, because I have a relatives who makes it all the time. So, when she's out of dried chokecherry patties, I share mine with her, and she gives back. We pound and dry the chokecherries, including the pits. I have a stone mortar and pestle that was Grandma's and Mom's, and now it is mine. We dry the patties, and hang them in a clean sack in the corner of the kitchen.

I also make six-inch tampers with scraped chokecherry twigs, and we use them when smoking the pipes. When the ashes go out, we poke them with the stick so that we can continue to smoke. We do that all the time.

Concerning wild plums, I make *wojapi* (pudding), and I also eat raw plums. When I make *wojapi* with either chokecherry patties or with pitted plums, I boil the fruit, and add a flour and water mixture to thicken it. I stir it until the lumps are out. In the early years, we hardly had much sweet food, so I don't use too much sugar, currently. In a two quart pot, I might add two cups of sugar now. We did not know about diabetes in the early days, and we didn't have a craving for sweets, then.

There are three types of *wasna*: jerky, chokecherry, and corn. My mom's recipe for jerky called for a dried piece of beef about the width of a hand and about ten inches long and eight inches wide. Buffalo would also work, but it is hard to get. We always had tallow fat, or kidney fat could be used. Mom dried the meat properly because when it is not done correctly, the food has a spoiled taste. She said that when preparing food, everything must be clean because people will eat it. She would wash her hands and the ingredients. We didn't have running water. So, she boiled the bedding and the kitchen towels. They were always clean. She took a towel and dried the meat before slicing it up to dry in the sun. She tended to the drying meat by covering it with thin cheesecloth, although I use curtains. It is important not to have flies on the meat.

To dry a large piece of meat, she would boil water and add the 8 x 10 inch slab of beef to boiling water where it remained for from two to three minutes. She then removed it from the water and put in a bread pan in a hot oven. She turned it. That moisture from the water helped the dried meat while it was baking. The meat was turned. Then it was taken out of the oven. Mom asked Dad to pound it. He shredded that piece of dried meat until it was very fine, but not powdery. I don't want to share her exact secrets of making *wasna* because someone might take the recipe and make good *wasna* and sell it.

We haven't had many chokecherries or buffaloberries lately. There are cattle all over at the places where we used to pick them. The cattle harm the trees and step on the young branches. We had plums in 1979 when I moved back to the Rosebud Reservation, but the cattle ate them. The deer ate my chokecherries. So, I told the deer, "Eat all you want. When my grandson shoots you this winter, I will have cherry flavor venison!" So, the berries come and go. There are no currants around with this drought (2012). I had all my fruit in the yard. Plums bloomed but didn't produce fruit. The wild grapes produced heavily, but the Hutterites came out about 3 years ago and traded me chickens for them. When the Hutterites don't come, I don't pick the grapes. I just let them die on the branches because I don't want the grapes. I noticed that the chokecherries next to the grapevines do not produce as well as those farther away. The vines may choke the bushes around them. Concerning wild rose plants, I don't use the hips or the leaves at all.

We also used to collect sandcherries. We picked them in Spring Creek community about seven miles south of my community, Grass Mountain. We collected in the 1960s when we visited relatives there. Dad's four brothers would hire out of a ranch at Spring Creek. They asked us to take them to the ranch during haying season. They did other work for the rancher, but this was in July and August. We would go to the sandhills and take the wagon roads and find gallons of sandcherries. They grow close to the ground, unlike the other fruits, and are about the size of plums. They are fleshy and have seeds. The Indians called them *aunyapi*. When we picked those cherries, we faced the wind because if we didn't, the fruit was sour.

My mother used to take me picking berries when I was thirteen or fourteen years old. It was hard work in July going up and down ravines. She would buy us firecrackers; so we would go. I am surprised that I didn't accidentally cause a fire. I could not tolerate canning on a hot day. Mom loved it. She canned inside our log house. One year, my dad and uncle moved a heavy cook stove outside and made an arbor, and Mom canned all the fruits we picked outside that year. One year she canned 42 quarts of juneberries. She never dried those. We picked them in June so we called them that. There was one ravine that had juneberries, chokecherries, plums, and raspberries. At that location, ranchers later leased it, and cattle destroyed those plants.

My mother sent me to all kinds of schools. So I got an education. I graduated from St. Francis in May 1949. They didn't teach us about traditional fruits there. They were trying to save our souls with basic curriculum. We had a religion class, although I am not Catholic. We learned sewing and did kitchen work. They did not can foods.

I was 25 years old when my husband came out of the military service. We relocated to take jobs picking potatoes in the 1950s. Later in my life, we moved back to the Rosebud Reservation so my two young children could graduate from St. Francis. In

1979 when we came back to the Rosebud Reservation, cattle had harmed the traditionally edible fruit plants near where I live now. I don't want to go someplace farther away to pick because it was a hard life doing all that picking.

In my lifetime, my grandmothers and mother died in their sixties. I was 24 when my mother died. She was a hard working lady, known as Grandma Winnie or Auntie Winnie. It was nothing for her to take her daughter out to pick berries. She didn't have a large family, just me and my brother. She shared what she had with her neighbors and relatives. There was an elderly man who lived two miles away. He called my mother Mom. She would share our food with his family. He would say that they were hungry for something sweet—jelly and jam. She would share flour and baking powder, too. She prepared all these goodies for him, sharing all the hard work of picking berries and cooking these foods. She enjoyed giving by preparing food in both summer and winter.

Today, people are more mobile. Some would rather have someone else pick and sell them the traditionally edible fruits. It doesn't happen too often because sometimes a person doesn't have the money to buy. Sometimes, five gallons of chokecherries could cost twenty dollars in this day and age. I think people would want it, if they could buy it. If you know someone to pick for you, you can trade yardage of material for it, too, if they will agree.

It's very rare to get *wojapi* (pudding) now. At a powwow I attended, ladies were cooking. We had traditional soup. They were going to serve us elders. I pointed at a dish that looked like *wojapi*, and I told my daughter to get me an extra serving of that. She looked at me funny and brought me an extra bowl of pork and beans! From a distance it looked like *wojapi*! It is a real treat when someone makes plum or chokecherry *wojapi*, nowadays. Furthermore, buffaloberry is a very rare dish, today, and it is hard to find.

AN INTERVIEW WITH VIOLET LITTLE ELK (32)

In a recent year with average precipitation, I use the following traditionally edible fruits as food: buffaloberries, currant, chokecherries, wild grapes, and wild plums. I don't use rosehips.

Today, I freeze and use wild plums and chokecherries. I have become modern with time, since I am not my Grandma. I use those fruits to make *wojapi* (pudding) for feasts, wakes, or whatever. I enjoy helping other people. I use the same techniques as my grandma. I measure by hand. To me all fruits are food. We also go *tinpsila* hunting for the wild turnips in the prairie.

I am an enrolled member of Rosebud Indian Reservation residing in my community named after a chief, Two Strike. I am proud to be an original member of the Two Strike Community. I grew up with my grandparents. Ever since I can remember, we always went picking fruits in July and August. I heard my grandparents tell when the fruits were ripe. As a little girl—I knew how to pick chokecherries, plums, buffaloberries, and currants. I never picked wild grapes, but my grandma did that. Her fingers turned purple from picking them. She would wear gloves, sometimes. When it was time to go picking, my grandpa would hitch the team, and off we would go—not just me— but also my other siblings. Grandma would pack a lunch, and we came home towards the evening.

My grandma canned her fruits. I remember that when I was a little girl, she used to work in a cannery in the town of Rosebud. I remember, too, that we had a big garden every year. It seemed like we lived on that all summer long. She canned whatever could be canned. For a measurement, she used her hand. So, for me, that's a cup. At that time, I don't remember any measurement utensils. As far as I can remember, mostly all the fruits can be used for *wojapi* (pudding) and all of them can be made into jam. My grandma used them that way.

APPENDIX B: FORMS FOR INTERVIEWS

INTERVIEW QUESTIONS, ROSEBUD RESERVATION

Date:----------

Interviewee: Number from 1 to 32 ----------------

Interviewer: Joanita Kant

Participant Name-------------------------------- Anonymous? No----- yes------

1. How much, in measuring cups, would you estimate that you eat of each of the following traditionally edible fruits in one year's time in an average year over the past five years?

2. How many cups of each, below, do you personally use, and are they as food, beverage, tonic or medicine?

Buffaloberry----------------------------

Buffalo currant--------------------------

Chokecherry----------------------------

Wild Grape-----------------------------

Wild Plum------------------------------

Rosehips (if leaves, specify-----------

3. How do you use those fruits?

4. How do you prepare them?

5. Why do you collect and use those wild fruits in this modern day?

6. Do you have a story or stories that you would like to tell about any of those fruits?

INFORMATION SHEET/CONSENT FORM

Participation in a Research Project: "Modern Uses of Traditional Fruits on Rosebud Reservation"

(distributed to participants)

South Dakota State University and the South Dakota Humanities Council

SDSU Project Directors: Bruce Berdanier and Joanita Kant

Department of Civil and Environmental Engineering, Crothers Engineering Hall 109 SDSU, Brookings, SD 57007 (605-688-5427)

E-mails: Bruce.Berdanier@sdstate.edu and Joanita.Kant@sstate.edu

Prepared: August 17, 2012

Date Please read ------ (listen to) ------ the following information:

1. This is an invitation for you to participate in a research project under the direction of Bruce Berdanier, Department Head, Civil and Environmental Engineering; and Joanita Kant, a graduate student at South Dakota State University. Information (stories and recipes) you provide may be used in a research paper being prepared by Kant as a Ph. D. dissertation and in programs of the SD Humanities Council. It will be available to the general public. Your name will be used if you give permission, or your name will be removed from your information if you select that option. Please initial one of the following concerning confidentiality: (A.) Concerning my story (initial one or the other) I give consent to use and publish my name--------------. (B.) I do not give permission to use and publish my name and want it removed from my story as soon as possible, so that mine is anonymous ---------------.

2. Participants will be adults who live on Rosebud Reservation and whose stories are of

interest to the graduate student collecting the stories. She will make the selections.

3. The purpose of the research is to collect stories about modern uses of traditionally edible fruit on the Rosebud Reservation and their role in cultural lore and the value of history. Since the graduate student is also studying certain nutritional aspects (heavy metals) of such fruits, participants will be asked about how much of each fruit they consume in an average year (buffalo berry, buffalo currant, chokecherry, grape, plum, and rosehips).

4. Participation is voluntary and the participant may withdraw without penalty.

5. The participant will visit with the graduate student for one hour, while she asks questions and takes notes. In order to make corrections, the participant will be given the opportunity to read the notes or have them read to him/her immediately after the interview.

6. The participant will complete a voucher in order to receive a check for $60 in the U. S. Mail, and will also complete a W9 form with his/her social security number in order to receive payments which will be processed by South Dakota State University Foundation. Funds are made possible through a grant from the SD Humanities Council, Brookings, SD. No payments are available for mileage or for others (not selected to be interviewed) who are in the room while the interview is being conducted.

7. The potential benefit to the Rosebud Reservation community is to produce a record of modern cultural practices concerning traditionally edible fruits that have historical connections. A copy of the stories will be made available to the local Historical

8. There are no known risks in participating.

9. The graduate student interviewer may remove any participant from the study if, in her

opinion, it is in their best interests.

10. A copy of this form will be left with the participant so that they can contact the project directors if they need to do so.

DATE PARTICIPANT NAME PROJECT DIRECTOR NAME

If you have questions regarding this study, you may contact the Project Director. If you have questions regarding your rights as a participant, you can contact the SDSU Research Compliance Coordinator at 605-688-6975 or SDSU.IRB@sdstate.edu. This project has been approved by the SDSU Institutional Review Board, Approval No. IRB-115010-EXM.

APPENDIX C: PHOTOGRAPHS

Figure C-1. Site 1, southwest of Oglala Lakota College administrative center, School Road (gravel), 2011.

Figure C-2. Site 2, north edge of the village of Manderson, SD, BIA Highway 28, 2011, Sadia Malik, Willis Zephier, and Laura Henery.

Figure C-3. Site 3, west of Wounded Knee Battleground and Cemetery, BIA Highway 28, 2011, Willis Zephier and Sadia Malik.

Figure C-4. Site 4, on the White River, west of Pine Ridge, SD, BIA Highway 32, 2011. The culvert washed out the road at the site in a flash flood.

Figure C-5. Site 5, badlands north of the USDA Landfill, BIA Highway 41, 2011, Laura Henery and Sadia Malik.

Figure C-6. Site 6, near Badlands National Monument visitor center, BIA Highway 2, 2011.

Figure C-7. Site 7, near Redshirt, SD, BIA Highway 41, 2011, Laura Henery and Sadia Malik.

Figure C-8. Site 8, near Potato Creek village, SD, BIA Highway 2, 2011.

Figure C-9. Site 9, badlands south of Kadoka, SD, State Highway 73, 2011, Laura Henery and Sadia Malik.

Figure C-10. Site 10, near Brunsch Ranch, State Highway 44, 2011.

Figure C-11. Site 11 on the White River, northeast of Chadron, NE, U. S. Highway 385, 2012.

Figure C-12. Site 12 on the White River, west of Oglala, SD, U. S. Highway 18, 2012.

Figure C-13. Site 13, on the White River, west of Badlands National Monument visitor center, north of Rockyford, SD, BIA Highway 2, 2012.

Figure C-14. Site 14, Carlbom Ranch on White River, south of Interior, SD, State Highway 44, 2012.

Figure C-15. Site 15 along the White River, south of Kadoka, SD, State Highway 73, 2012.

Figure C-16. Silver buffaloberry. From a distance, it looks like Russia olive because of the similarity in leaf color. Of all the fruits of interest, silver buffaloberry mostly failed to set fruit in 2011 and 2012.

Figure C-17. Buffalo currant is also commonly known as golden currant because of showy yellow flowers.

Figure C-18. Chokecherry, with remaining bloom remnants, are starting to set fruit. Among the Lakota, chokecherries are probably the favorite, followed by plums.

Figure C-19. Wild grapes beginning to set fruit. When ripe, the fruits are purple with a white dusty haze.

Figure C-20. Wild plum thicket at Potato Creek Site. David Fisher of OLC and Sadia Malik of SDSU collect a soil sample.

Figure C-21. Wild rose in full bloom. This is the tallest of the wild rose species on PRR and one of the most common, Woods' rose.

APPENDIX D: ARSENIC, ICP-OES RESULTS

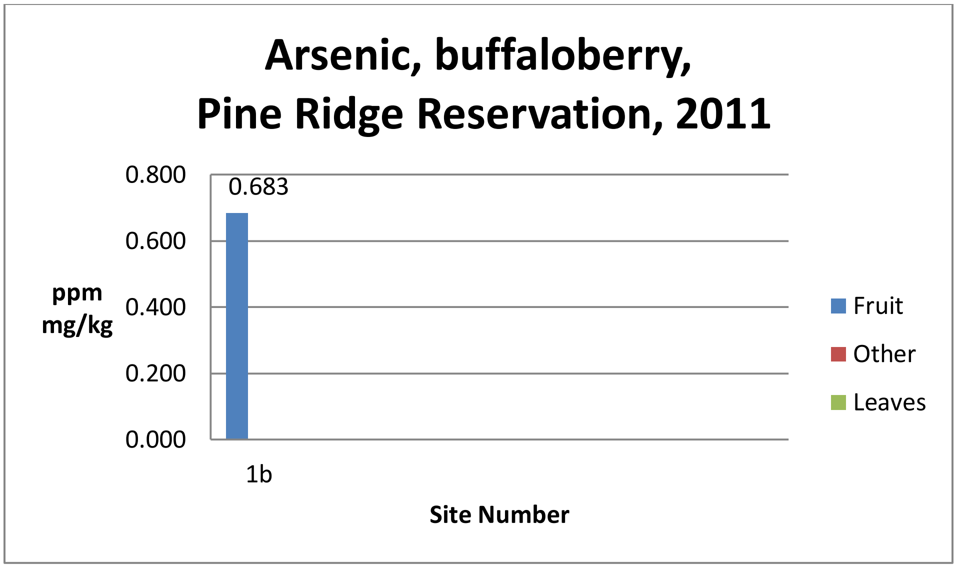


Figure D-1.

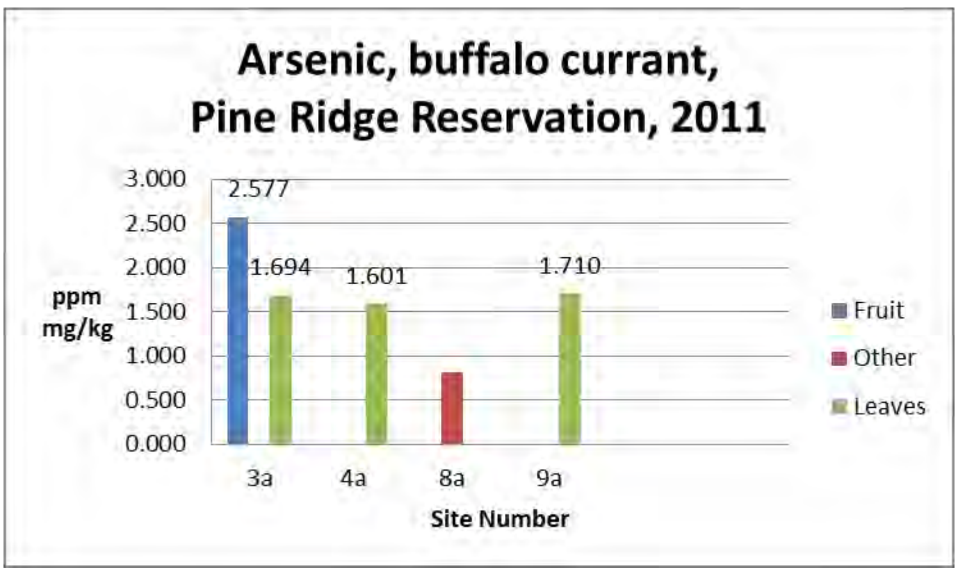
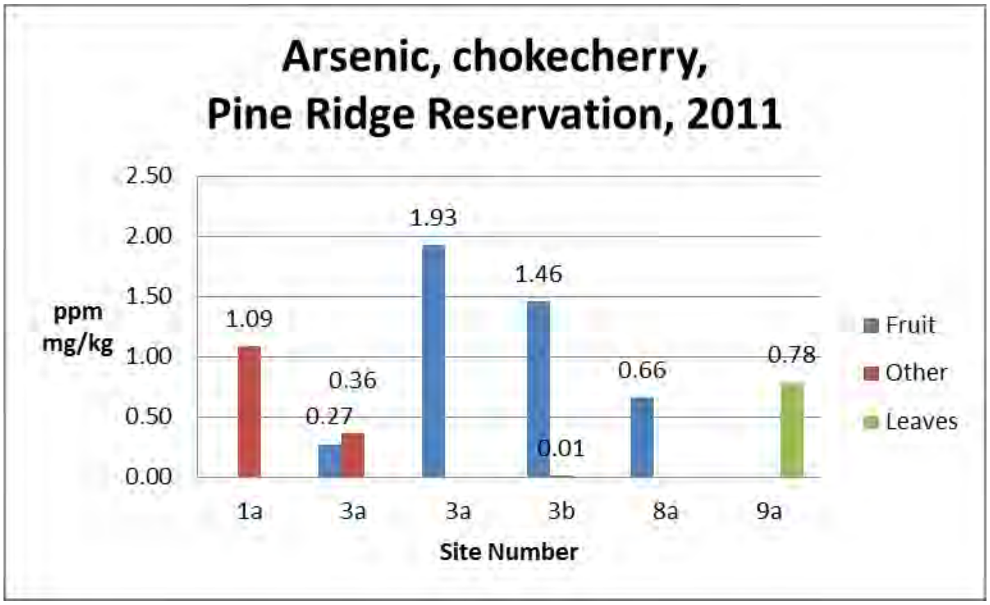


Figure D-2



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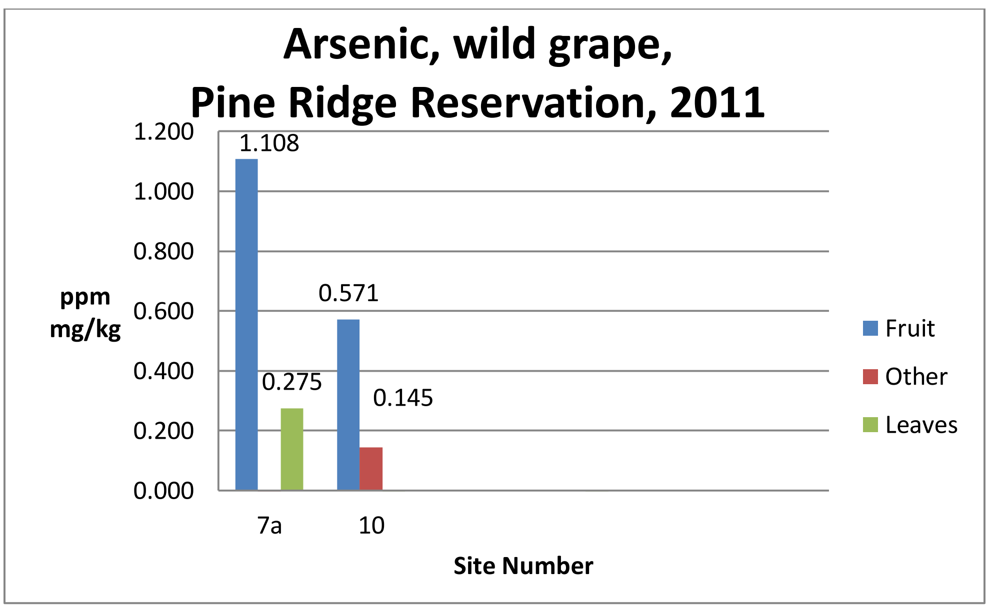

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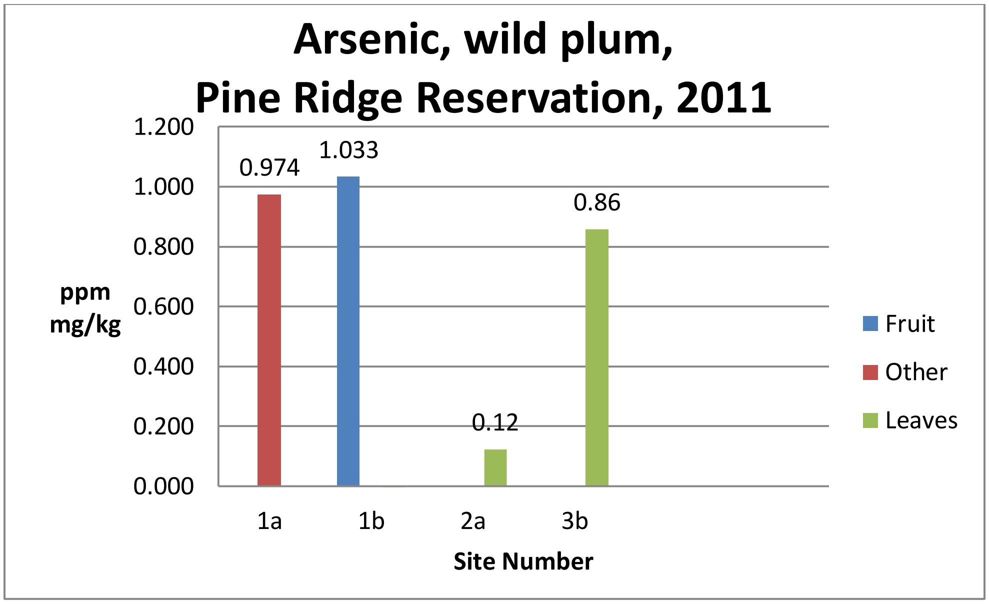

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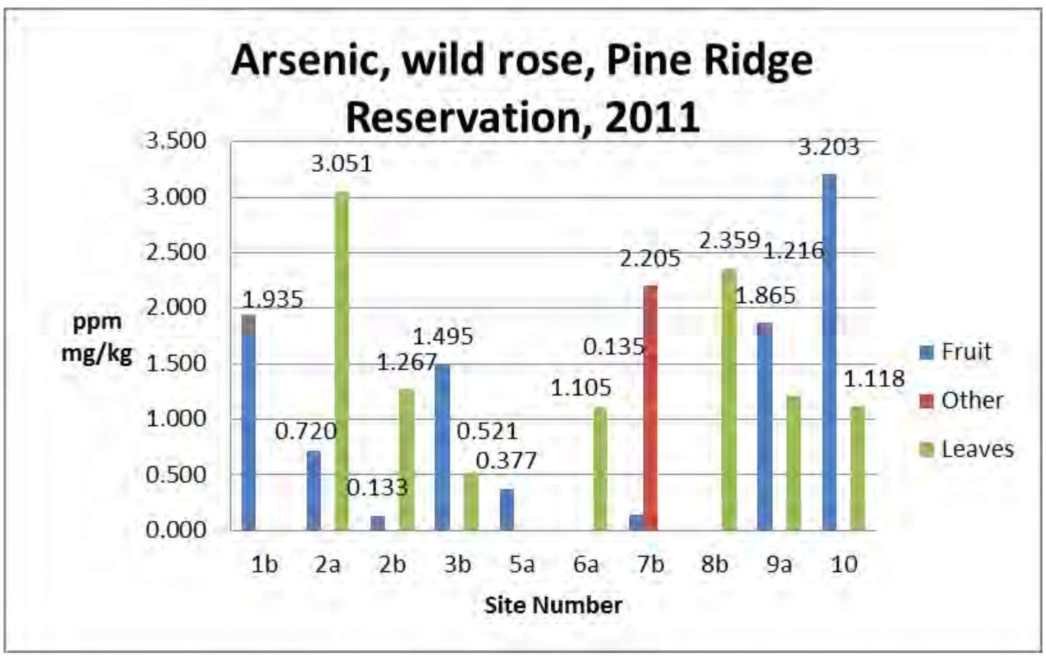


Figure D-6.

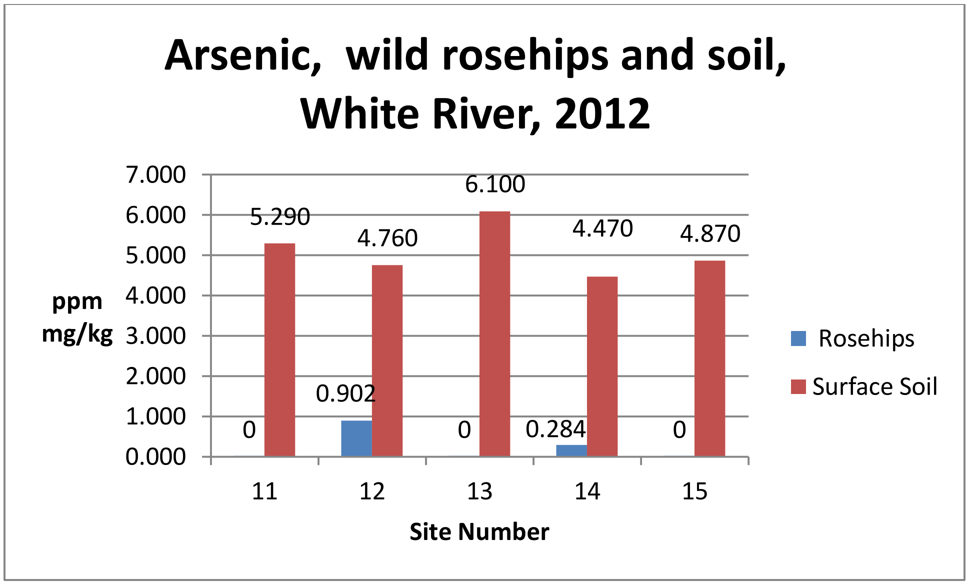
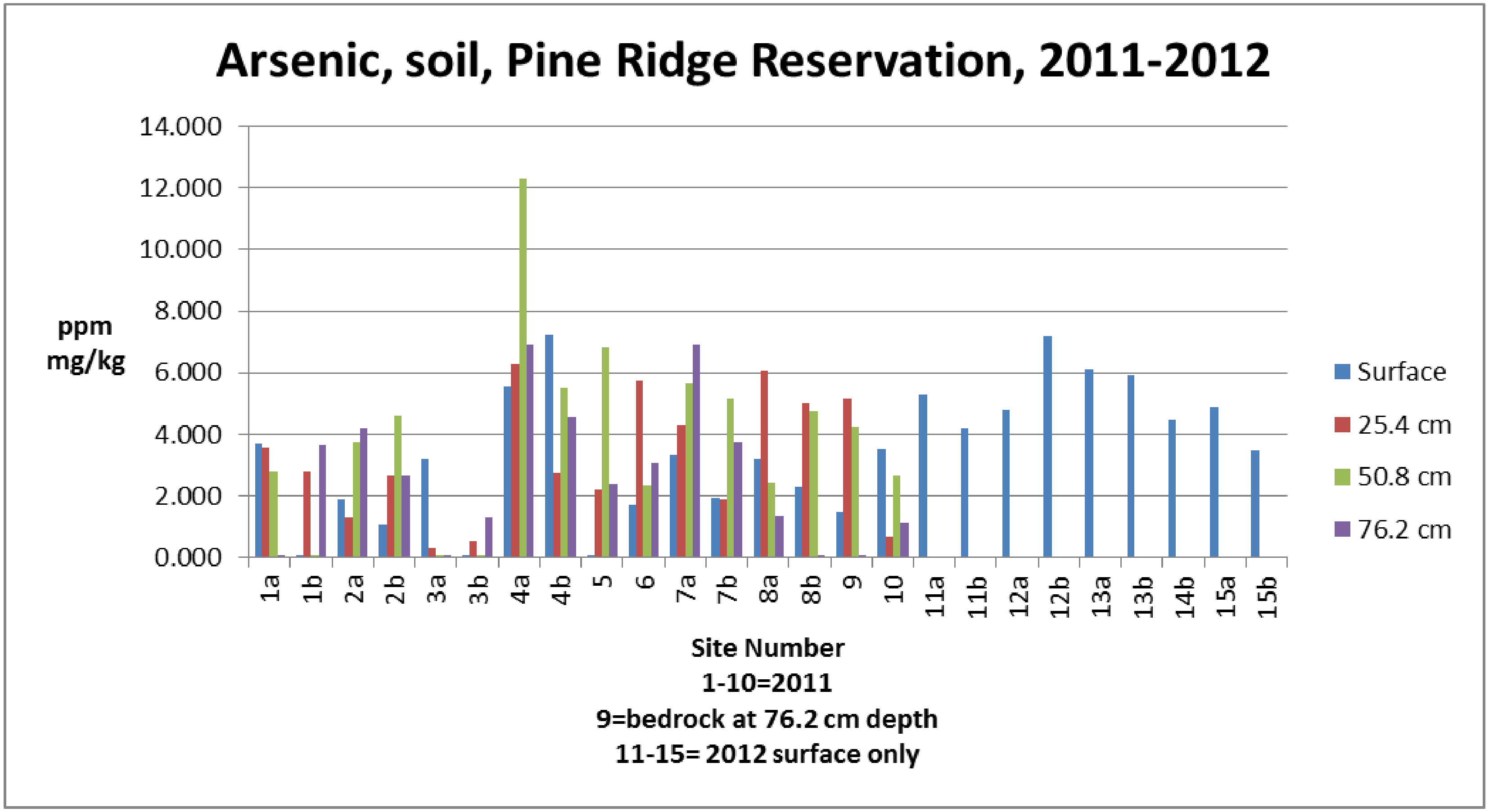

Arsenic, wild rosehips and soil, White River, 2012
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
ppm mg/kg
5.290
4.760
6.100
4.470
4.870
0
0.902
0
0.284
0
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure D-7.



Arsenic, soil, Pine Ridge Reservation, 2011-2012
ppm
mg/kg
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15= 2012 surface only
Surface
25.4 cm
50.8 cm
76.2 cm

Figure D-8.

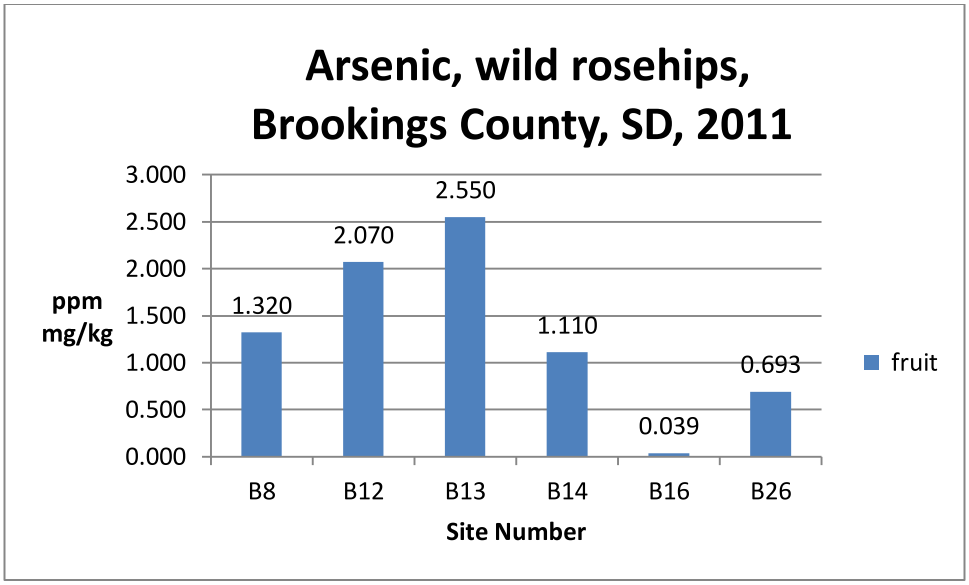

Arsenic, wild rosehips, Brookings County, SD, 2011
3.000
2.500
2.000
1.500
1.000
0.500
0.000
ppm mg/kg
1.320
2.070
2.550
1.110
0.039
0.693
B8
B12
B13
B14
B16
B26
Site Number
fruit

Figure D-9.

APPENDIX E: BARIUM ICP-OES RESULTS

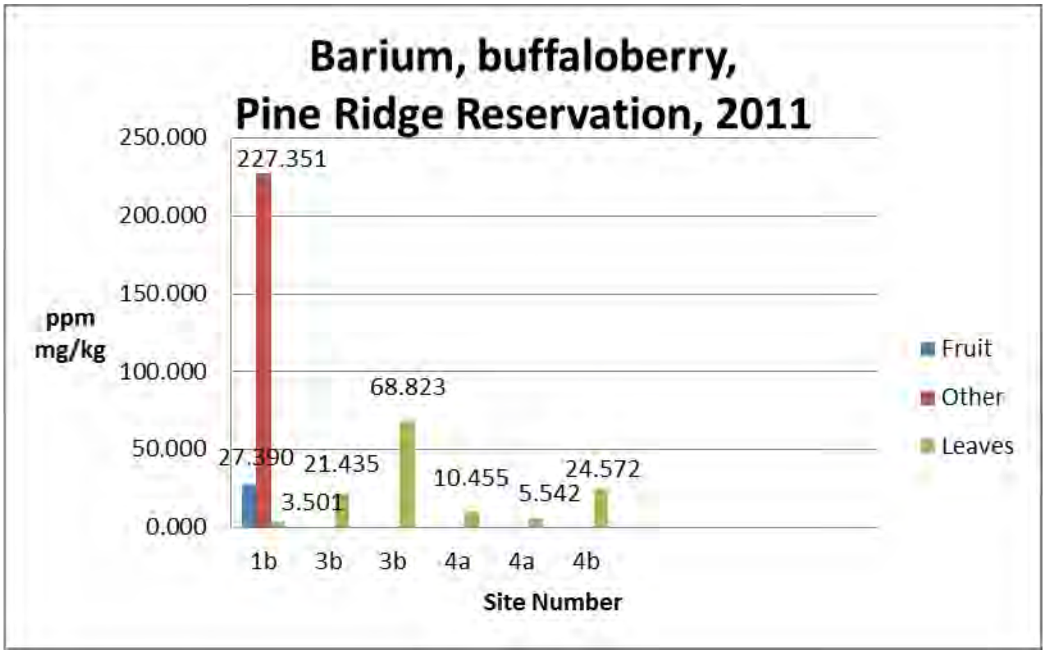


Figure E-1.

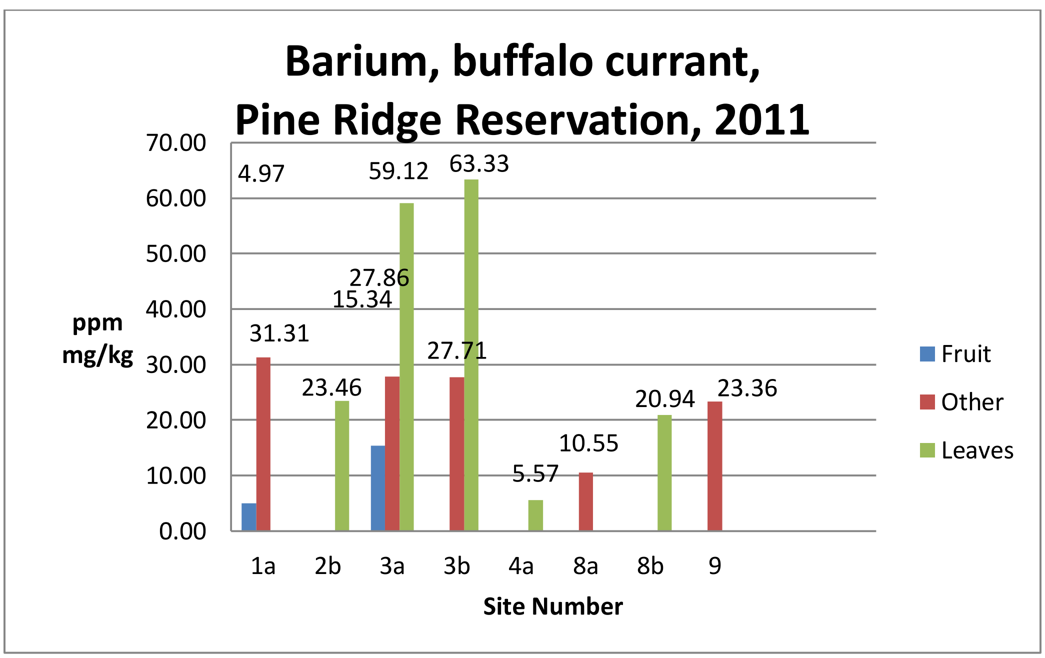


Figure E-2.

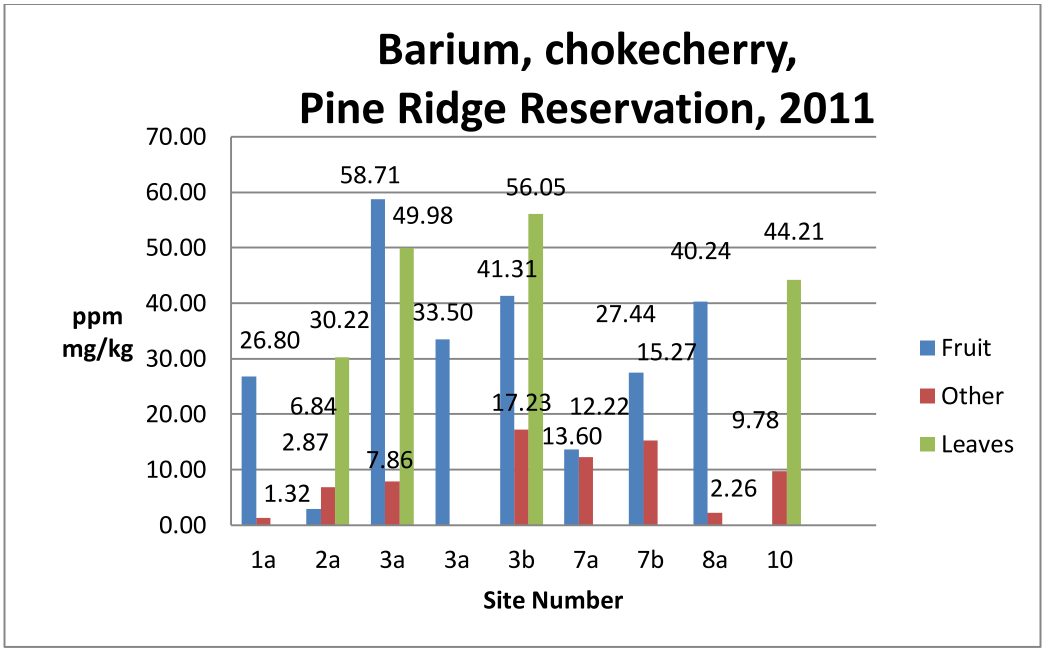


Figure E-3.

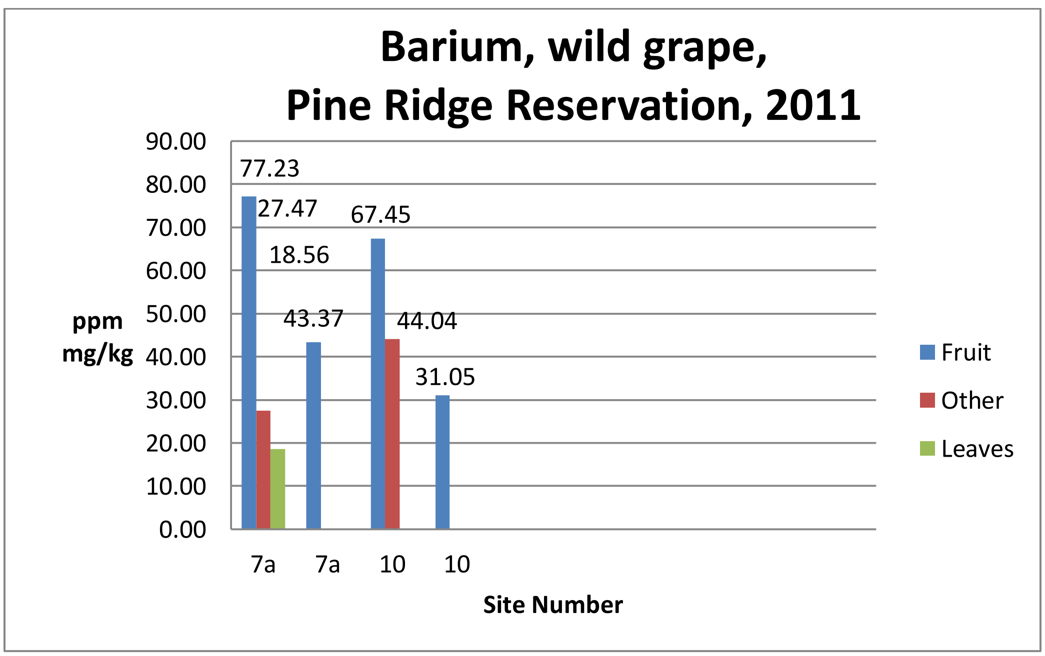


Figure E-4.

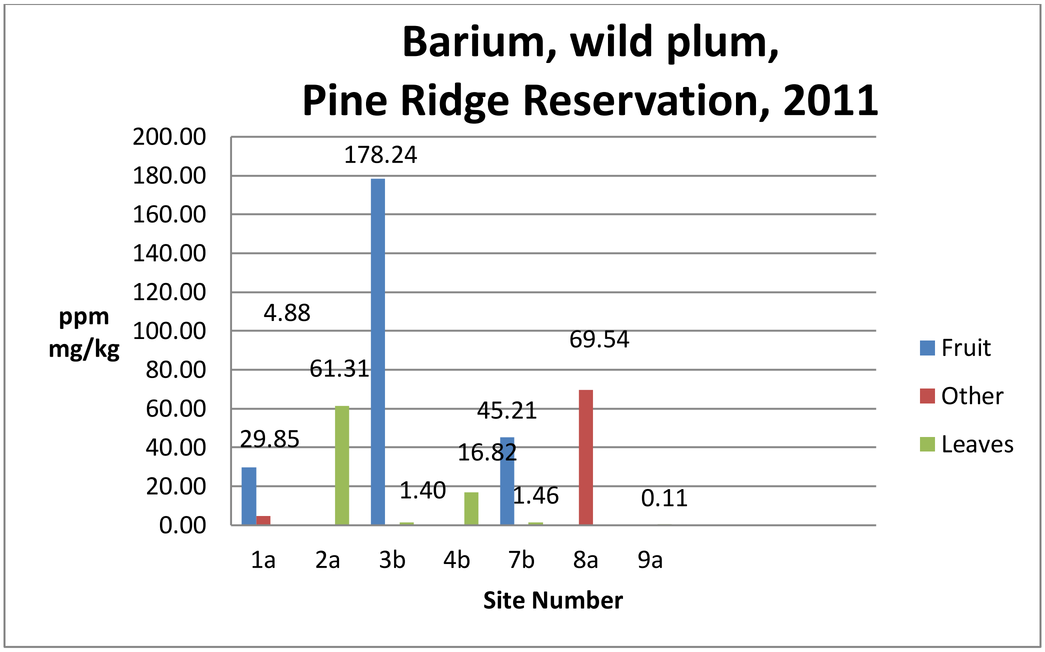
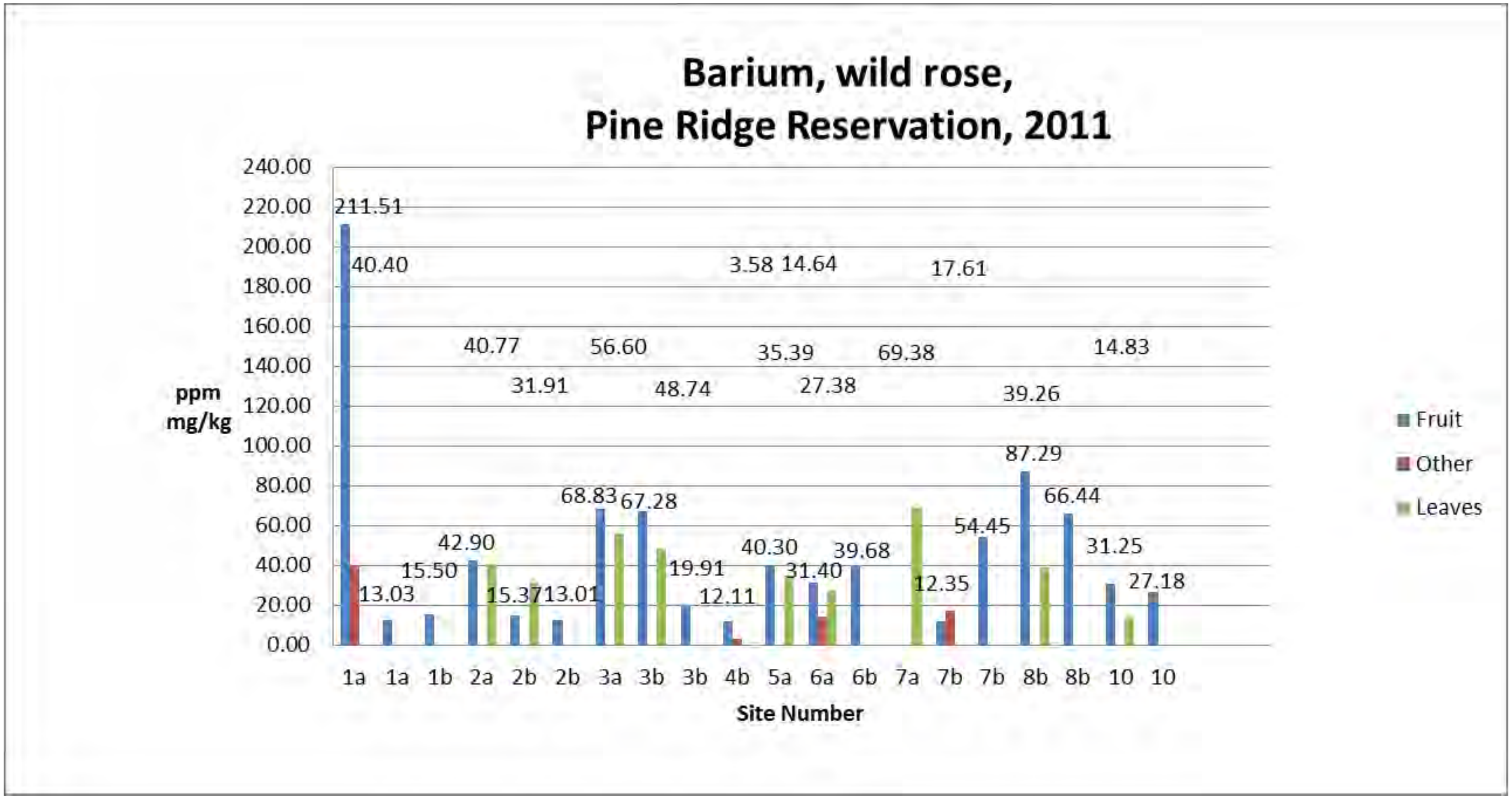

Barium, wild plum,
Pine Ridge Reservation, 2011
ppm
mg/kg
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
178.24
4.88
61.31
29.85
1.40
16.82
45.21
1.46
69.54
0.11
1a
2a
3b
4b
7b
8a
9a
Site Number
Fruit
Other
Leaves

Figure E-5.



Barium, wild rose,
Pine Ridge Reservation, 2011
ppm
mg/kg
240.00
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
211.51
40.40
13.03
15.50
42.90
40.77
15.37
31.91
13.01
68.83
56.60
67.28
48.74
19.91
12.11
3.58
40.30
35.39
31.40
14.64
27.38
39.68
69.38
12.35
17.61
54.45
87.29
39.26
66.44
31.25
14.83
27.18
1a 1a 1b 2a 2b 2b 3a 3b 3b 4b 5a 6a 6b 7a 7b 7b 8b 8b 10 10
Site Number
Fruit
Other
Leaves

Figure E-6.

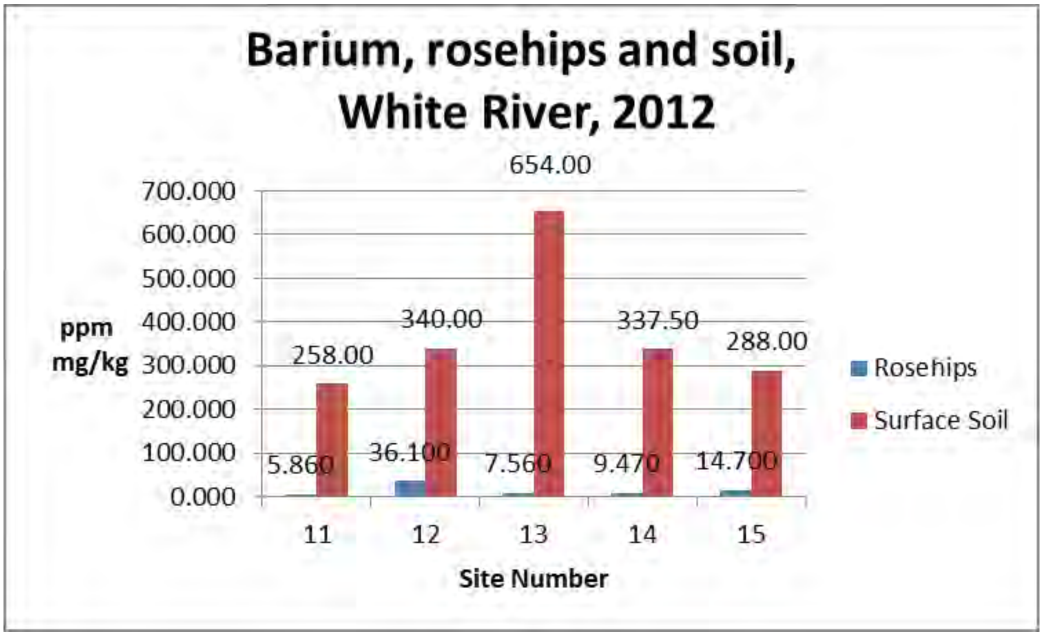

Barium, rosehips and soil, White River, 2012
654.00
700.000
600.000
500.000
ppm
mg/kg
400.000
300.000
200.000
100.000
0.000
340.00
337.50
288.00
258.00
5.860
36.100
7.560
9.470
14.700
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure E-7.

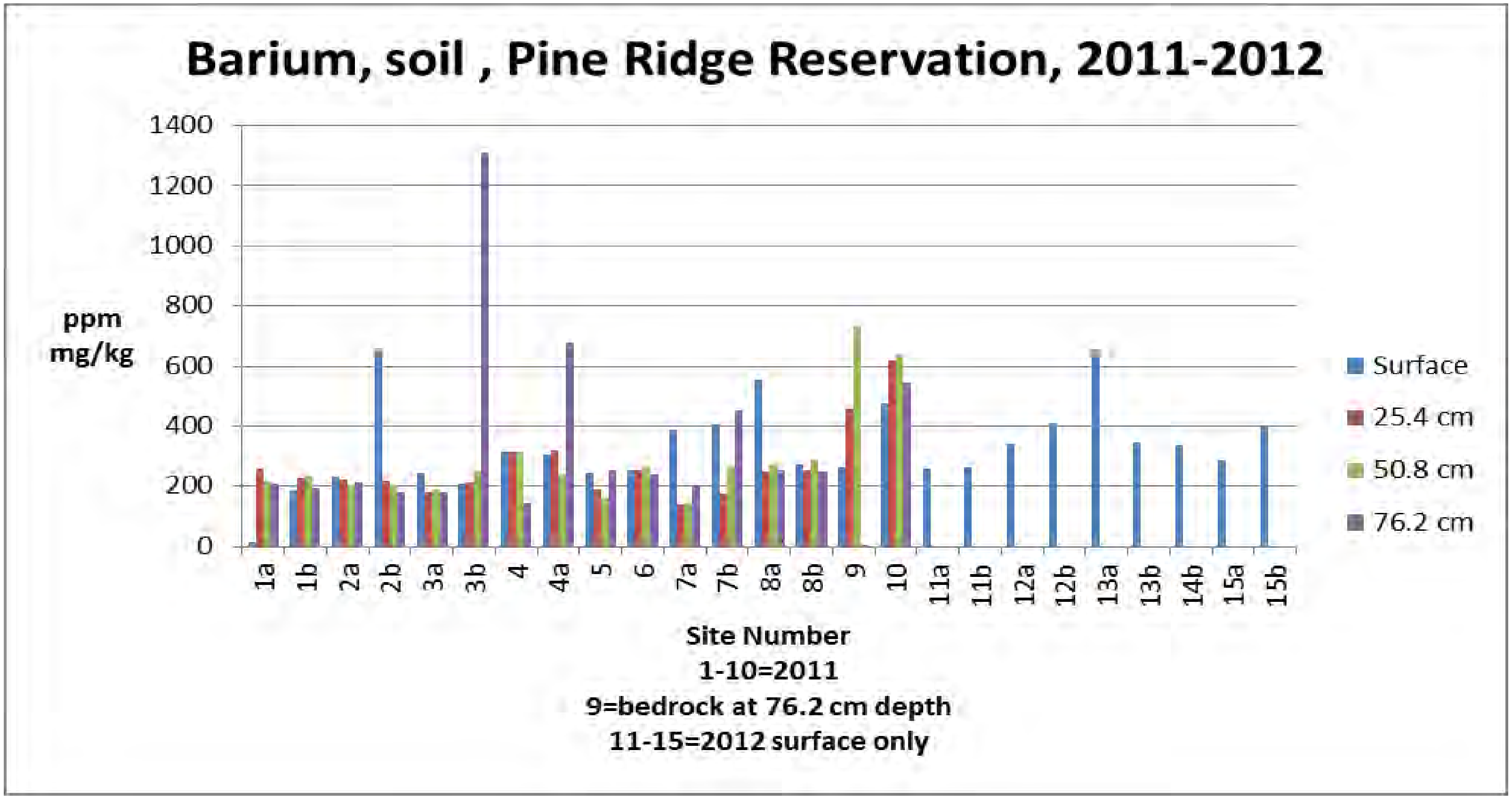
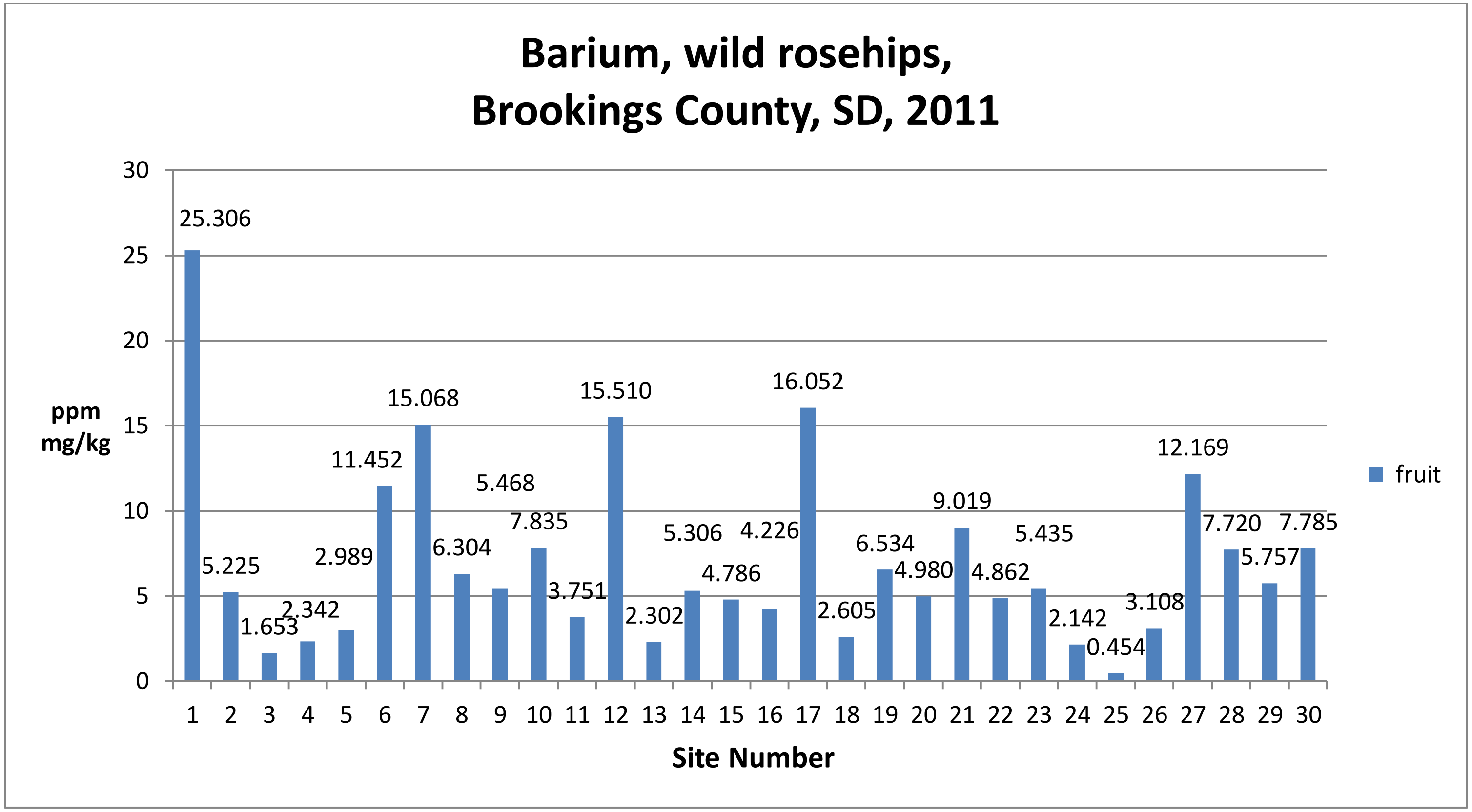

Barium, soil , Pine Ridge Reservation, 2011-2012
ppm
mg/kg
1400
1200
1000
800
600
400
200
0
1a
1b
2a
2b
3a
3b
4
4a
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Surface
25.4 cm
50.8 cm
76.2 cm
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15=2012 surface only

Figure E-8.



Barium, wild rosehips,
Brookings County, SD, 2011
ppm
mg/kg
30
25
20
15
10
5
0
25.306
5.225
1.653
2.342
2.989
11.452
15.068
6.304
5.468
7.835
3.751
15.510
2.302
5.306
4.786
4.226
16.052
2.605
6.534
4.980
9.019
4.862
5.435
2.142
0.454
3.108
12.169
7.720
5.757
7.785
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Site Number
fruit

Figure E-9.

APPENDIX F: LEAD ICP-OES RESULTS

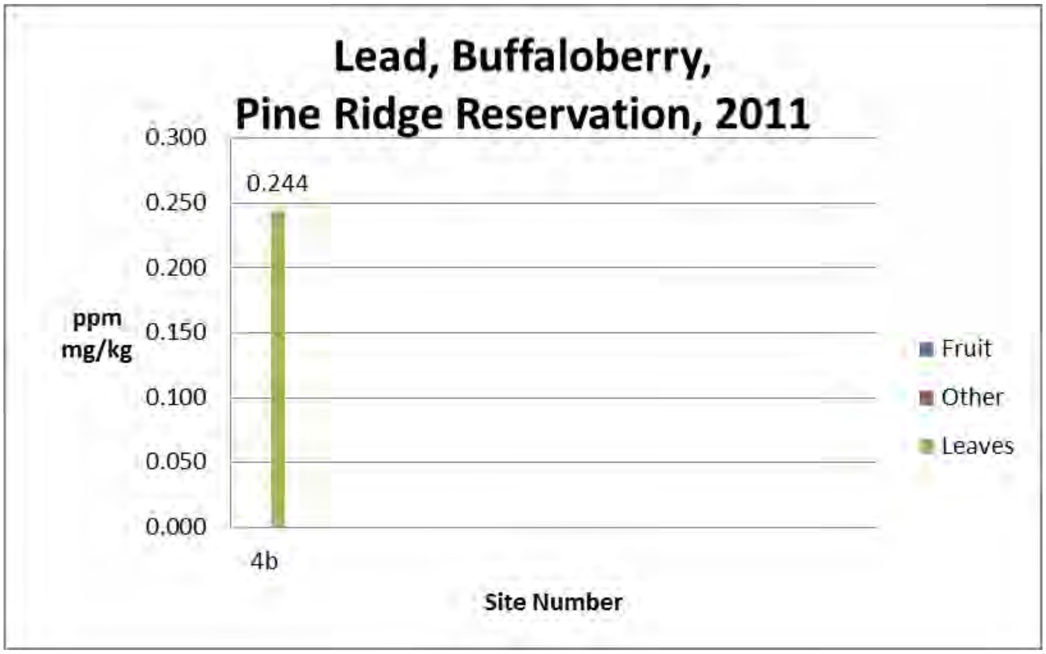


Figure F-1.

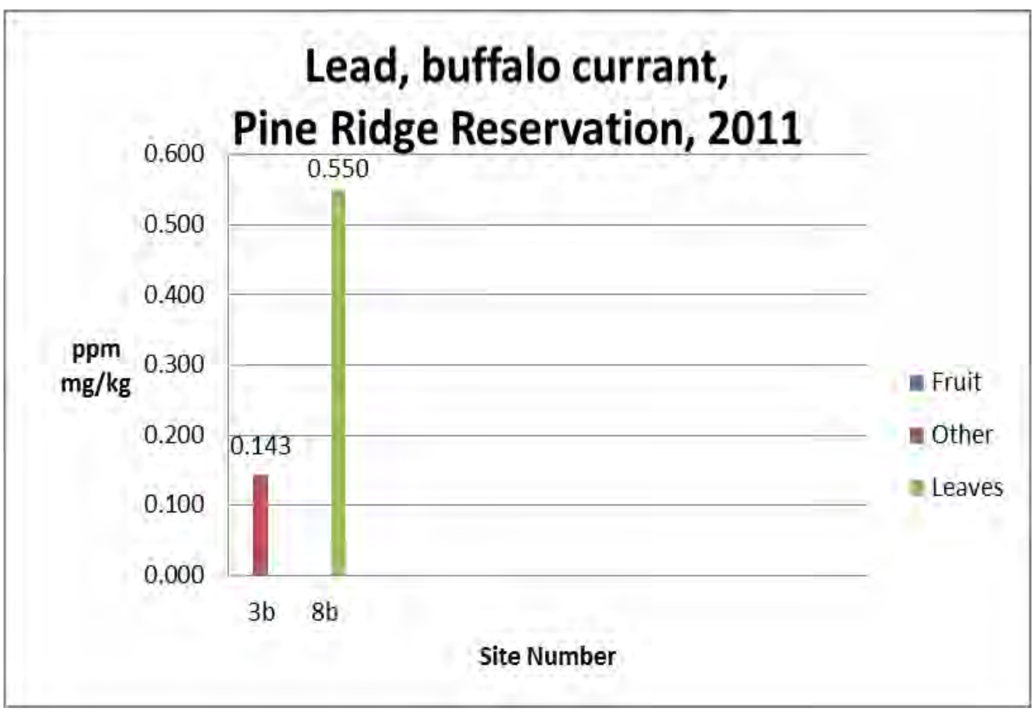


Figure F-2

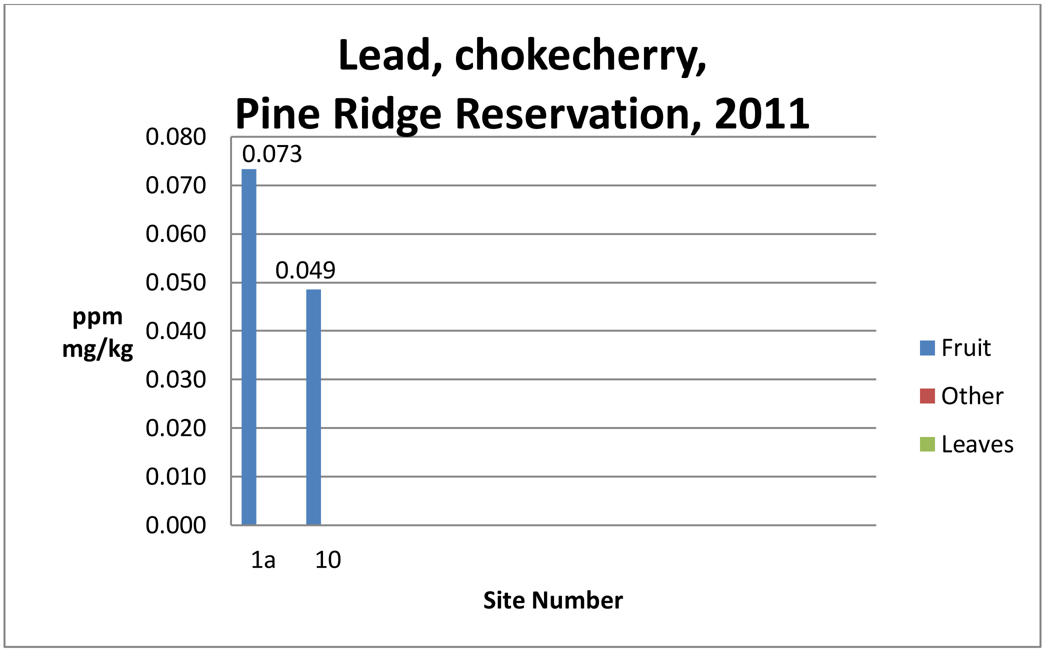


Figure F-3.

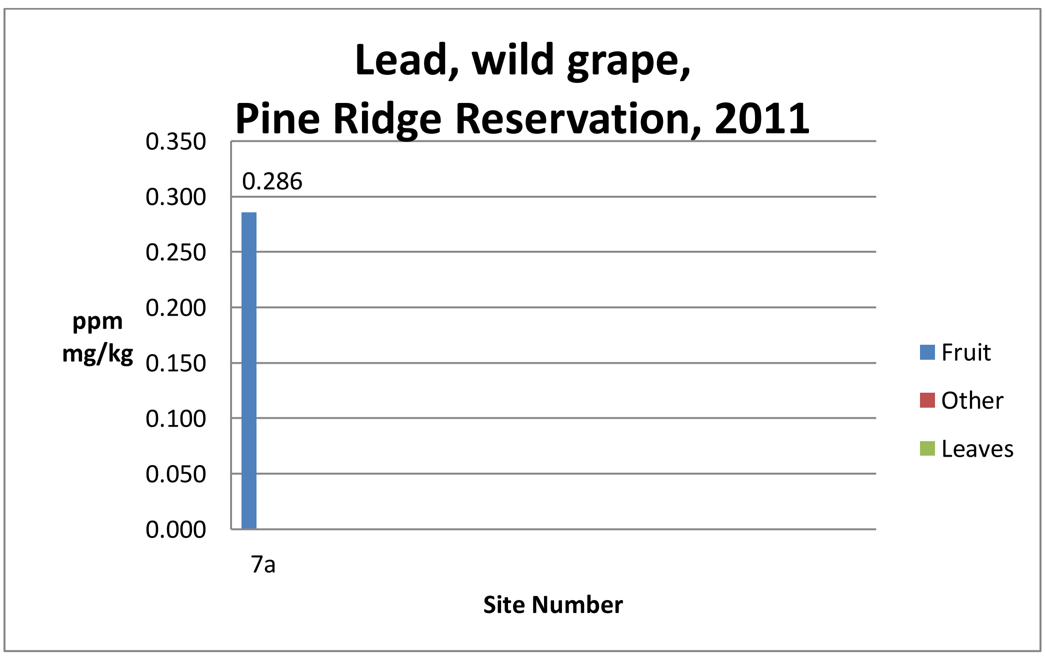


Figure F-4.

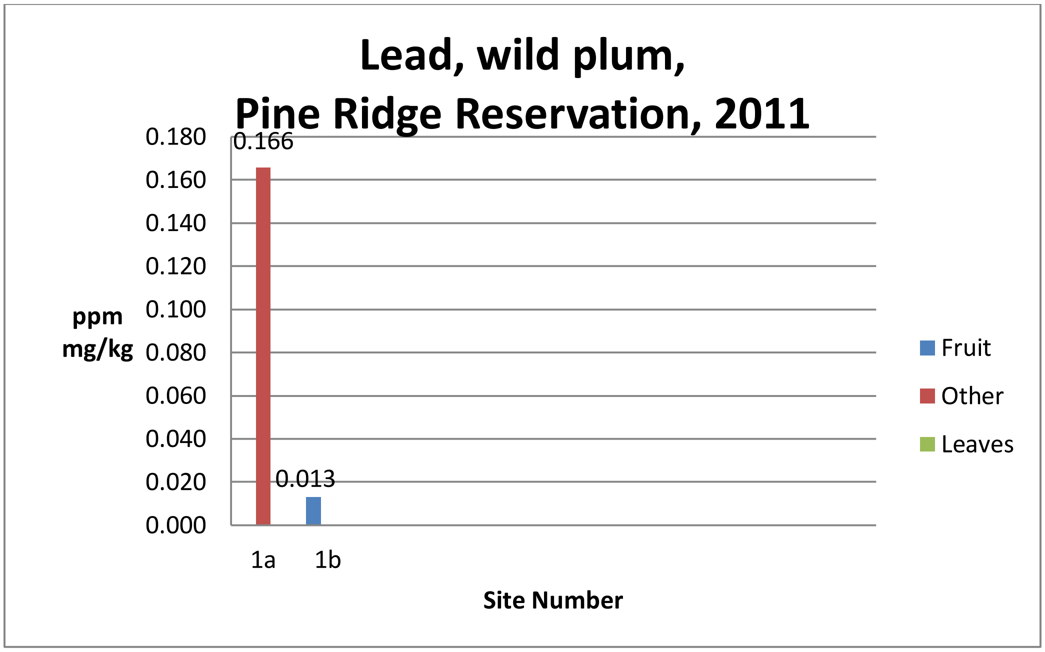


Figure F-5.

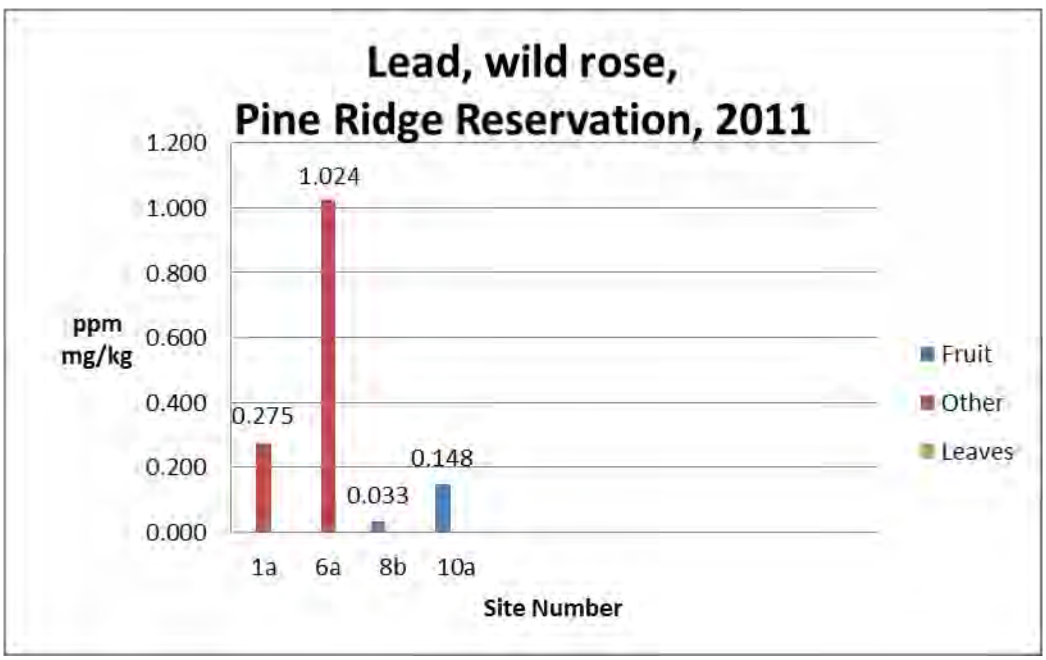


Figure F-6.

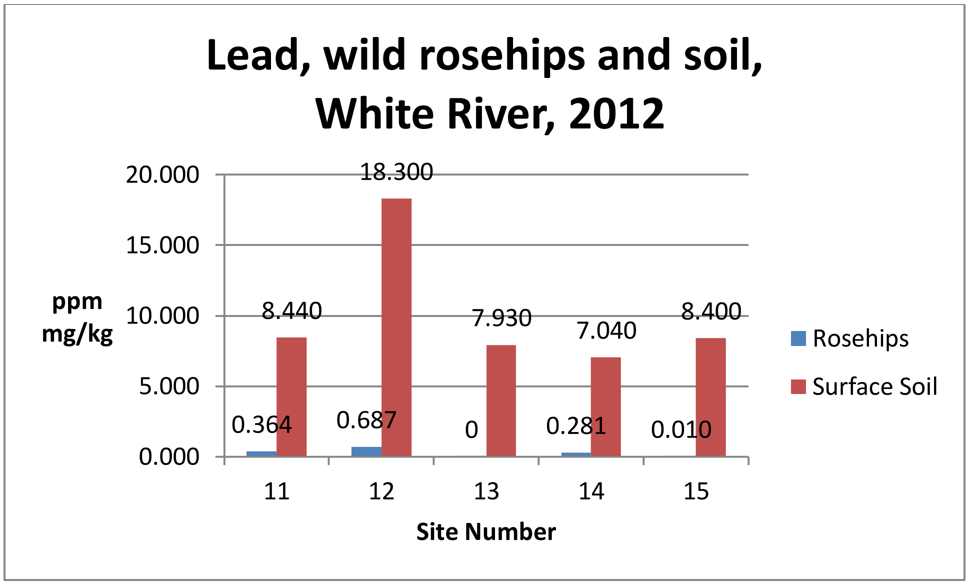

Lead, wild rosehips and soil, White River, 2012
20.000
15.000
10.000
5.000
0.000
ppm mg/kg
18.300
8.440
7.930
7.040
8.400
0.364
0.687
0
0.281
0.010
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure F-7.

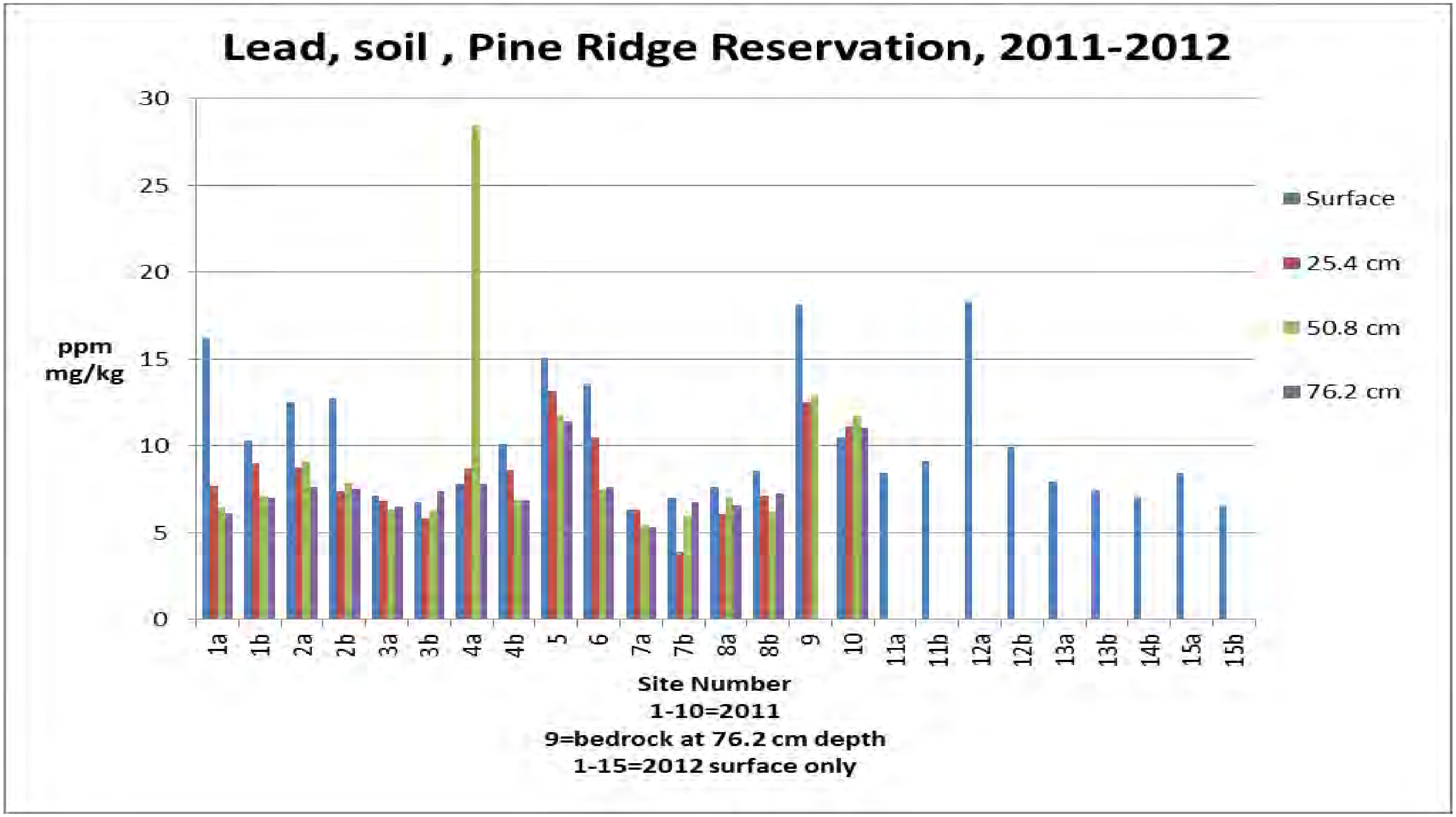

Lead, soil , Pine Ridge Reservation, 2011-2012
30
25
20
15
10
5
0
ppm
mg/kg
Surface
25.4 cm
50.8 cm
76.2 cm
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
1-15=2012 surface only

Figure F-8.

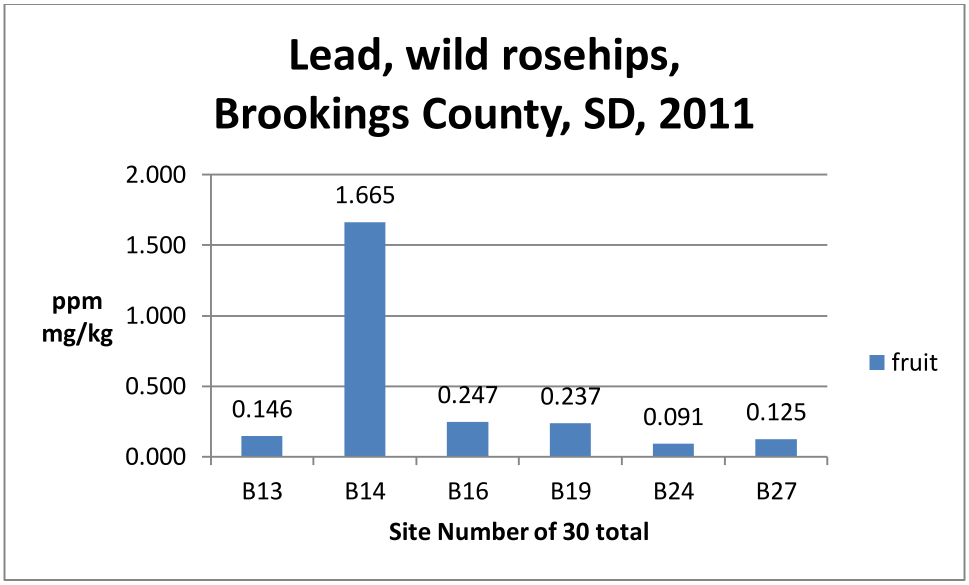

Lead, wild rosehips,
Brookings County, SD, 2011
ppm
mg/kg
2.000
1.500
1.000
0.500
0.000
1.665
0.146
0.247
0.237
0.091
0.125
B13
B14
B16
B19
B24
B27
Site Number of 30 total
fruit

Figure F-9.

APPENDIX G: SELENIUM ICP-OES RESULTS

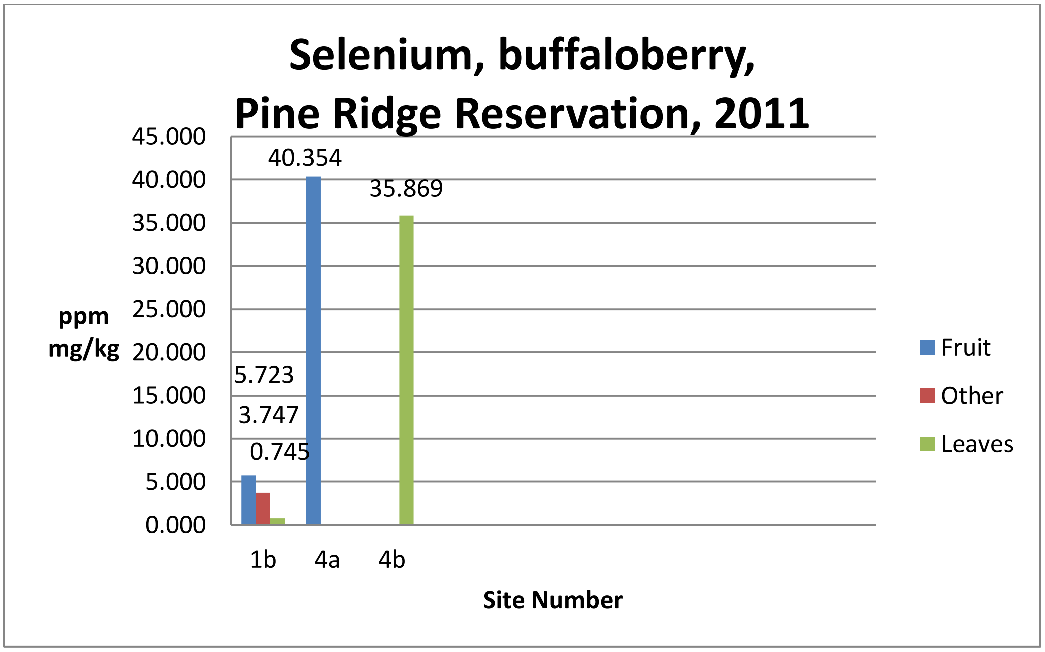


Figure G-1.

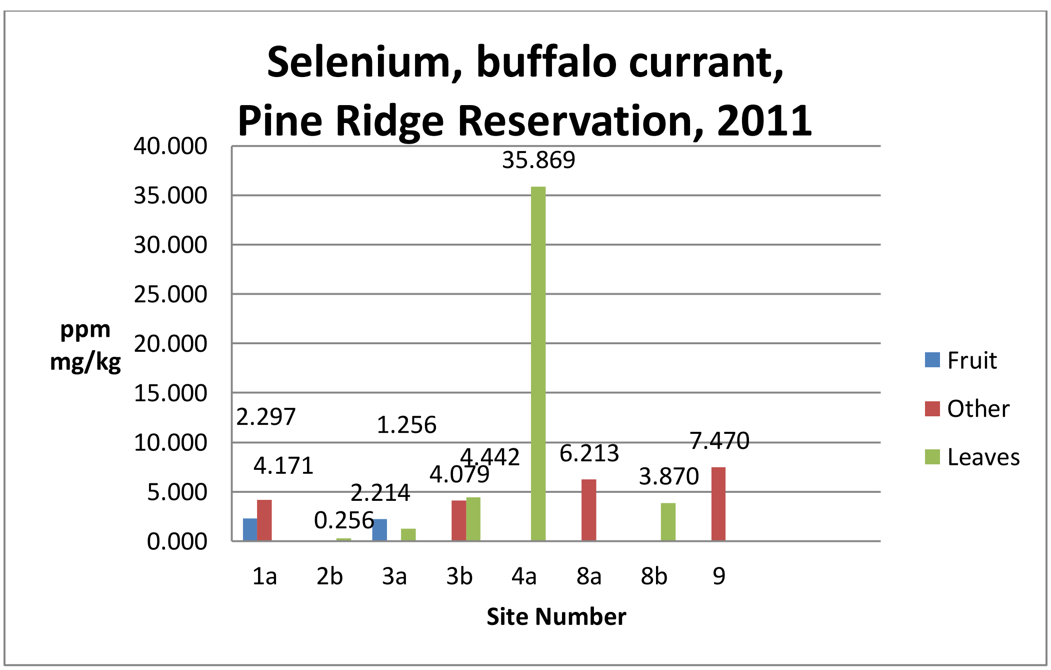


Figure G-2.

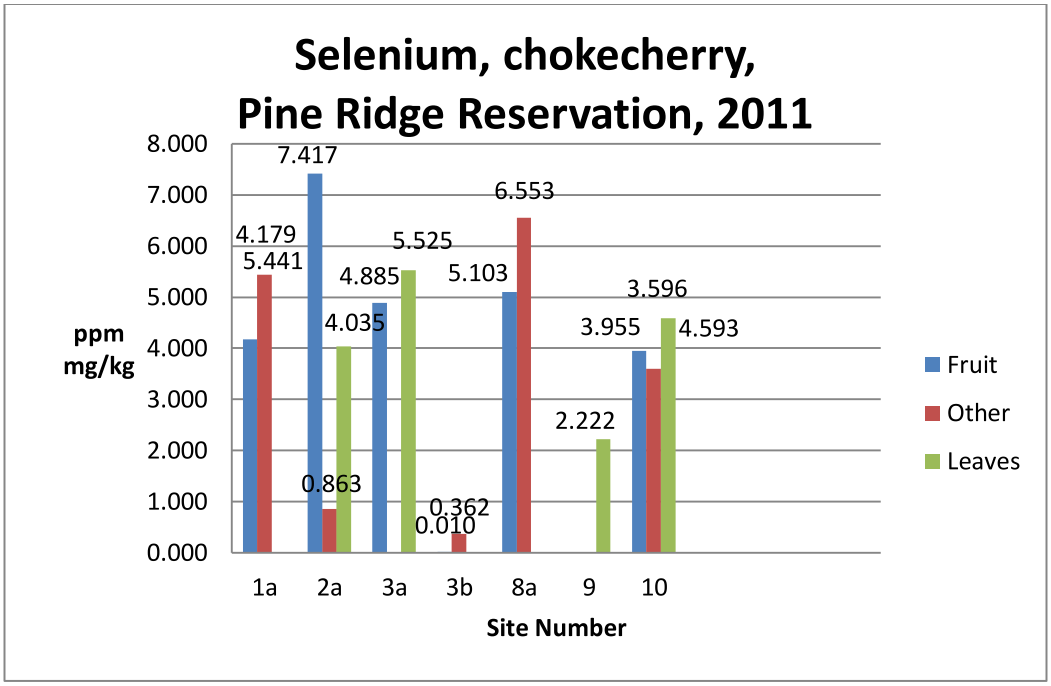


Figure G-3.

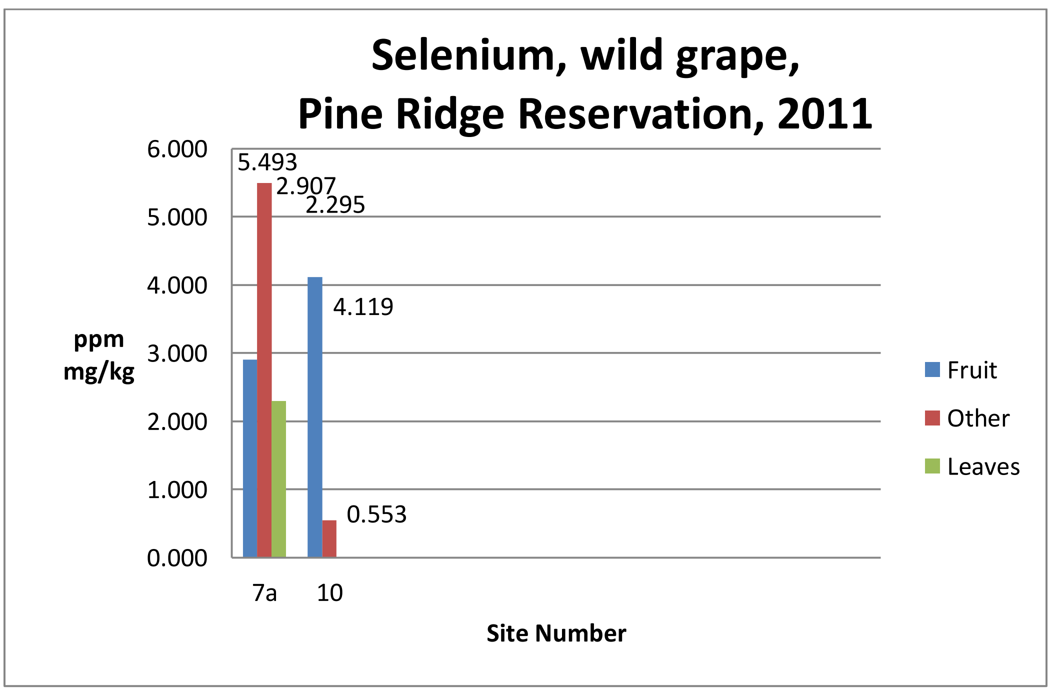


Figure G-4.

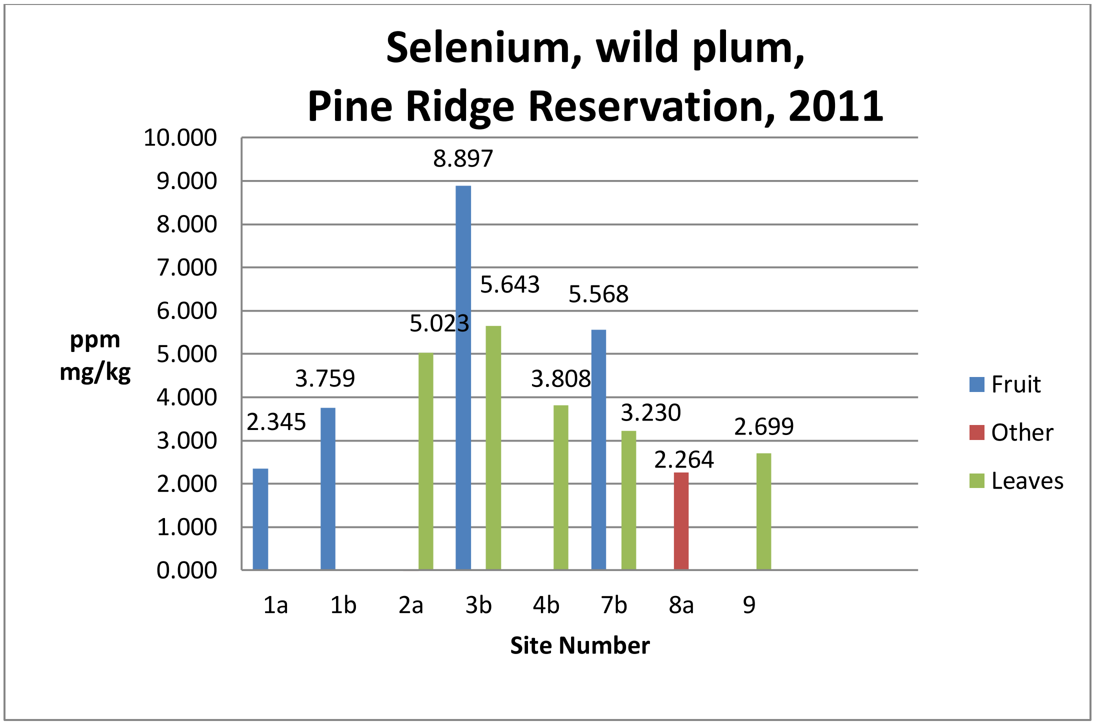

Selenium, wild plum,
Pine Ridge Reservation, 2011
ppm
mg/kg
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
2.345
3.759
5.023
8.897
5.643
3.808
5.568
3.230
2.264
2.699
1a
1b
2a
3b
4b
7b
8a
9
Site Number
Fruit
Other
Leaves

Figure G-5.

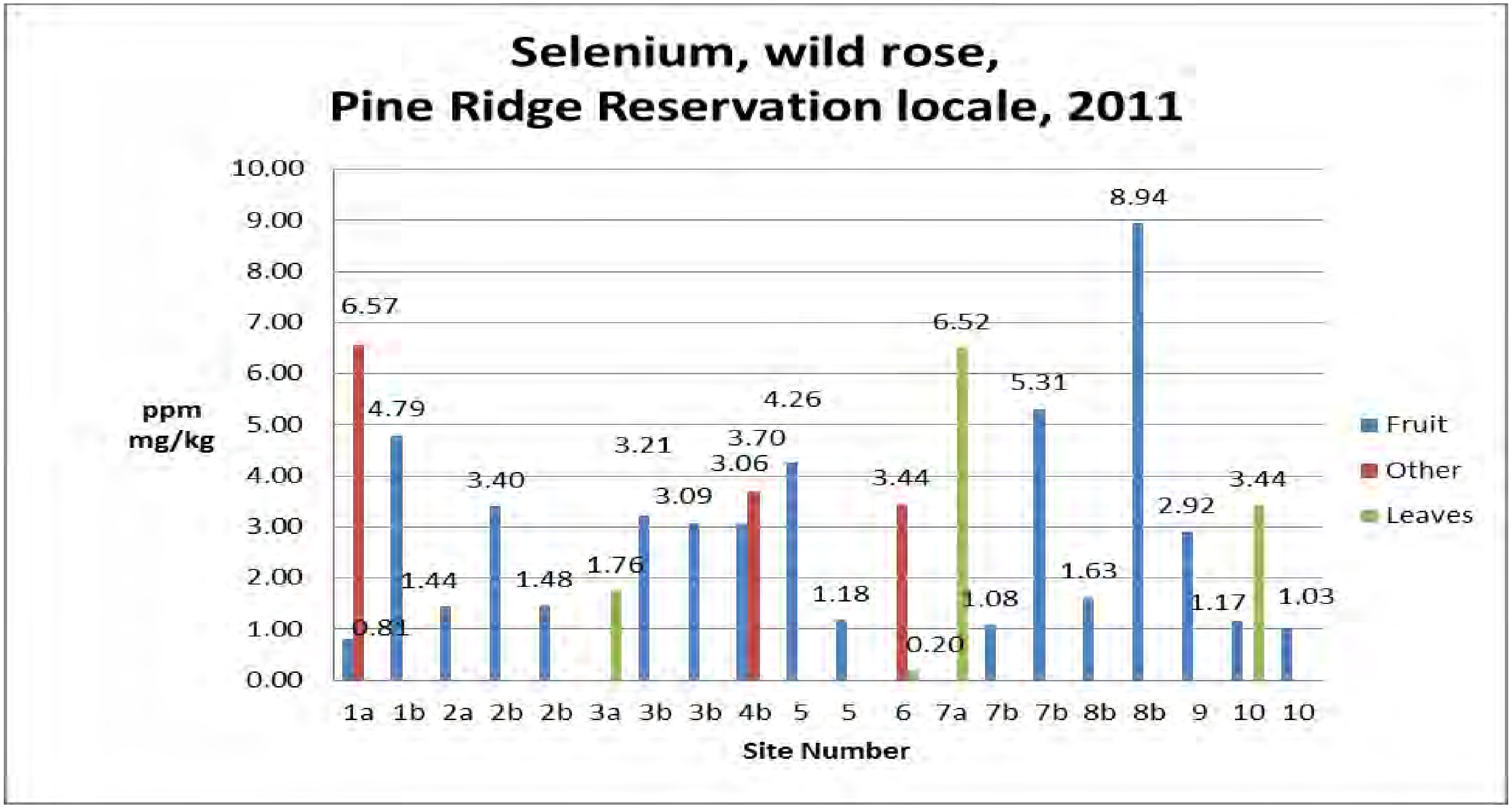

Selenium, wild rose,
Pine Ridge Reservation locale, 2011
ppm
mg/kg
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
6.57
0.81
4.79
1.44
3.40
1.48
1.76
3.21
3.09
3.06
3.70
4.26
1.18
3.44
0.20
6.52
1.08
5.31
1.63
8.94
2.92
1.17
3.44
1.03
1a 1b 2a 2b 2b 3a 3b 3b 4b 5 5 6 7a 7b 7b 8b 8b 9 10 10
Site Number
Fruit
Other
Leaves

Figure G-6.

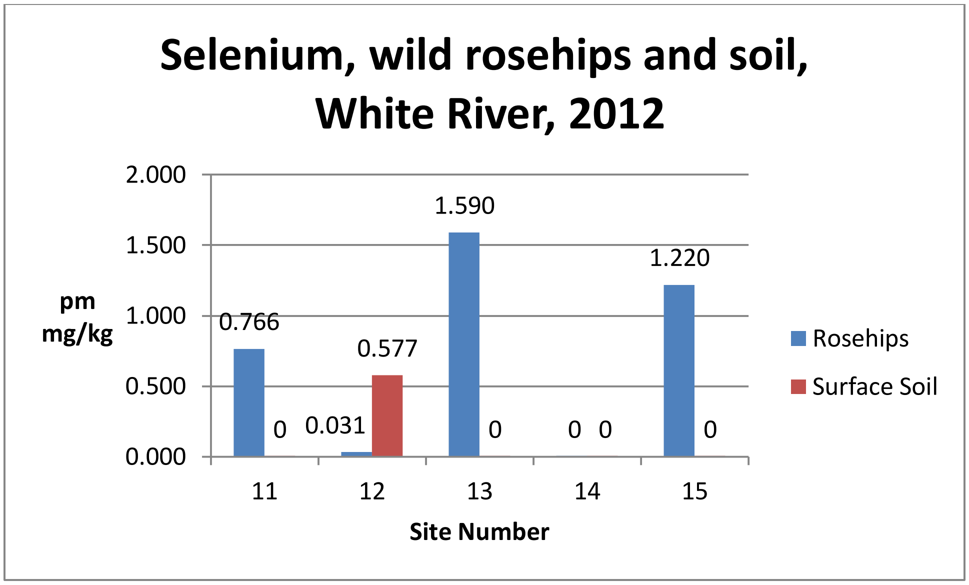

Selenium, wild rosehips and soil, White River, 2012
2.000
1.500
1.000
0.500
0.000
pm mg/kg
0.766
0
0.031
0.577
1.590
0
0 0
1.220
0
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure G-7.

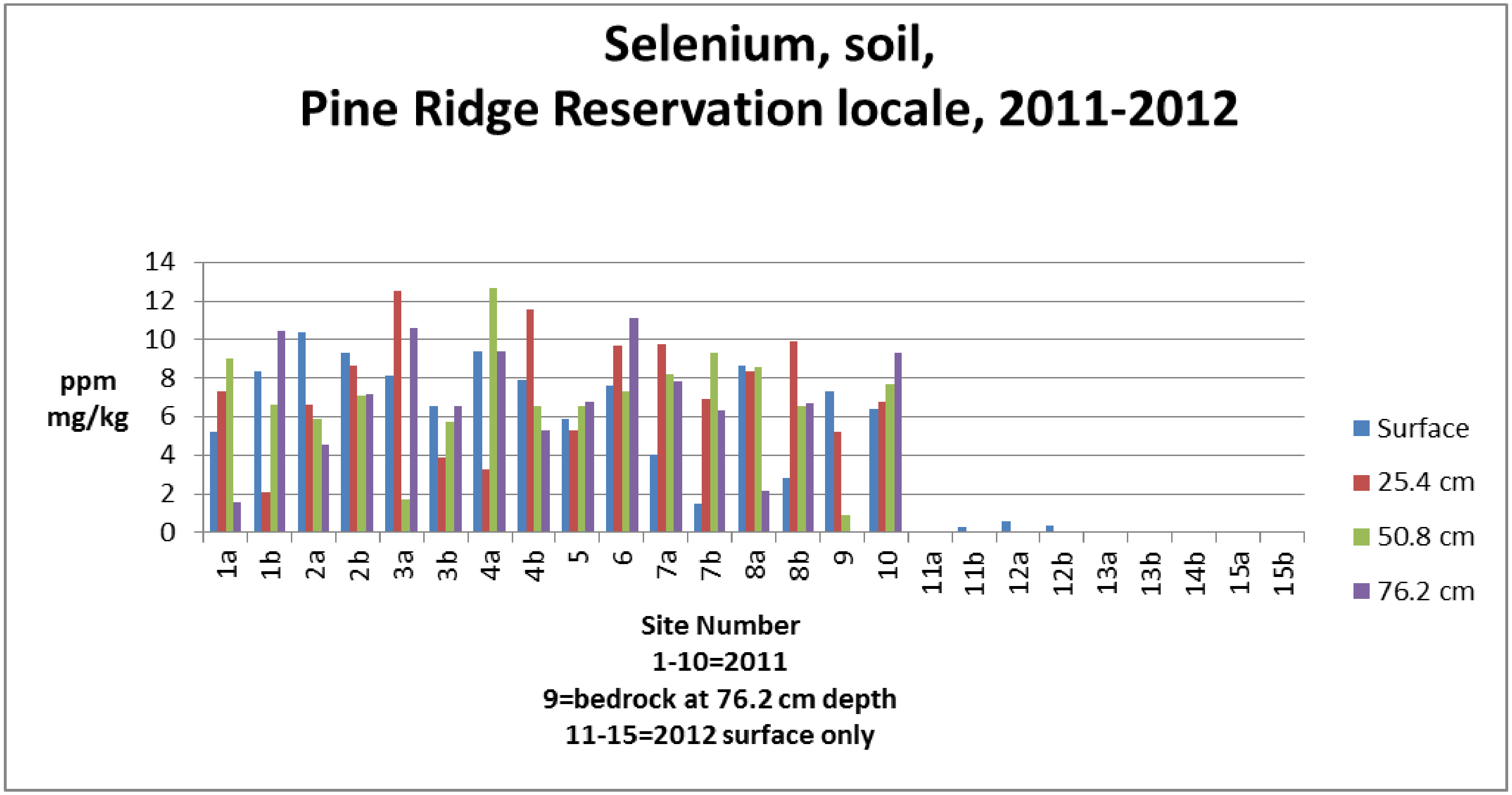

Selenium, soil,
Pine Ridge Reservation locale, 2011-2012
ppm
mg/kg
14
12
10
8
6
4
2
0
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15=2012 surface only
Surface
25.4 cm
50.8 cm
76.2 cm

Figure G-8.

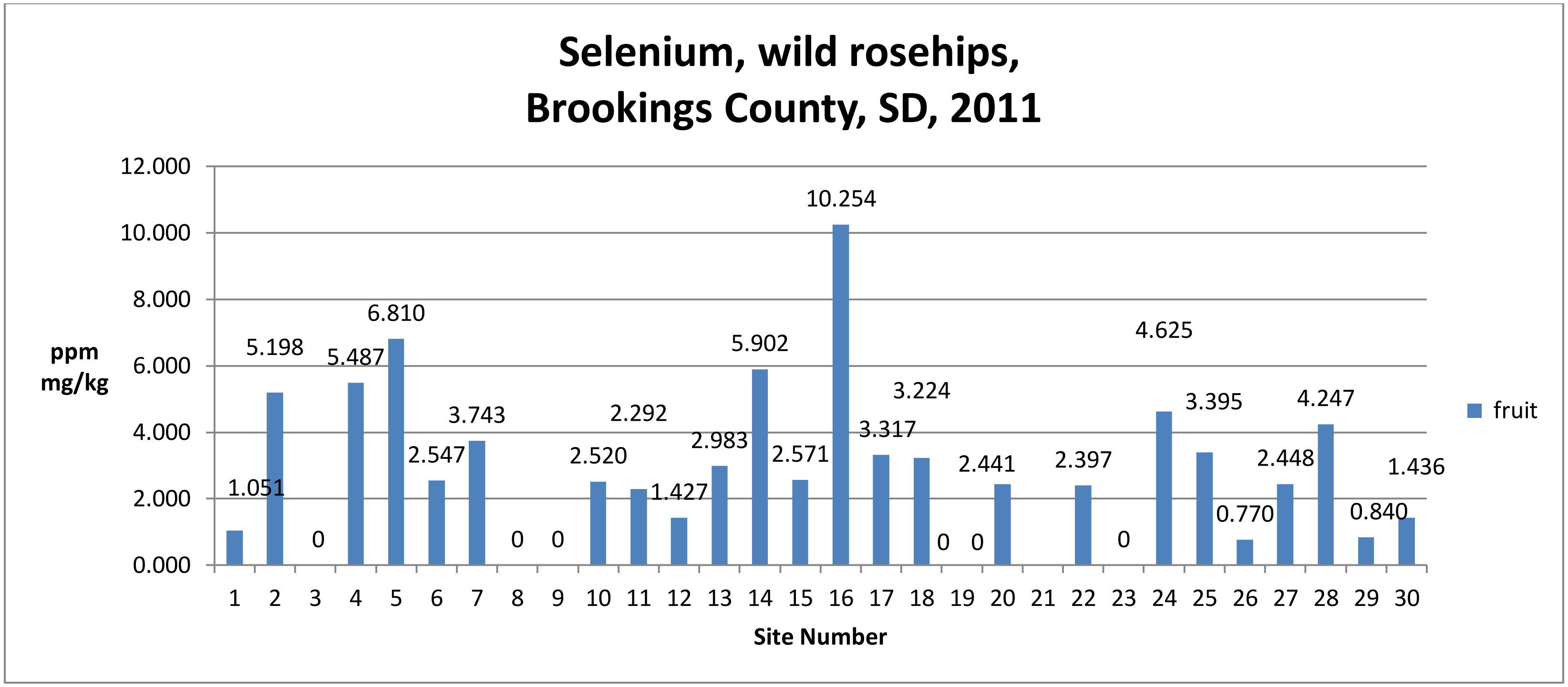

Selenium, wild rosehips,
Brookings County, SD, 2011
ppm
mg/kg
12.000
10.000
8.000
6.000
4.000
2.000
0.000
1.051
5.198
0
5.487
6.810
2.547
3.743
0
0
2.520
2.292
1.427
2.983
5.902
2.571
10.254
3.317
3.224
0
0
2.441
2.397
0
4.625
3.395
0.770
2.448
4.247
0.840
1.436
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Site Number
fruit

Figure G-9.

APPENDIX H: URANIUM ICP-OES RESULTS

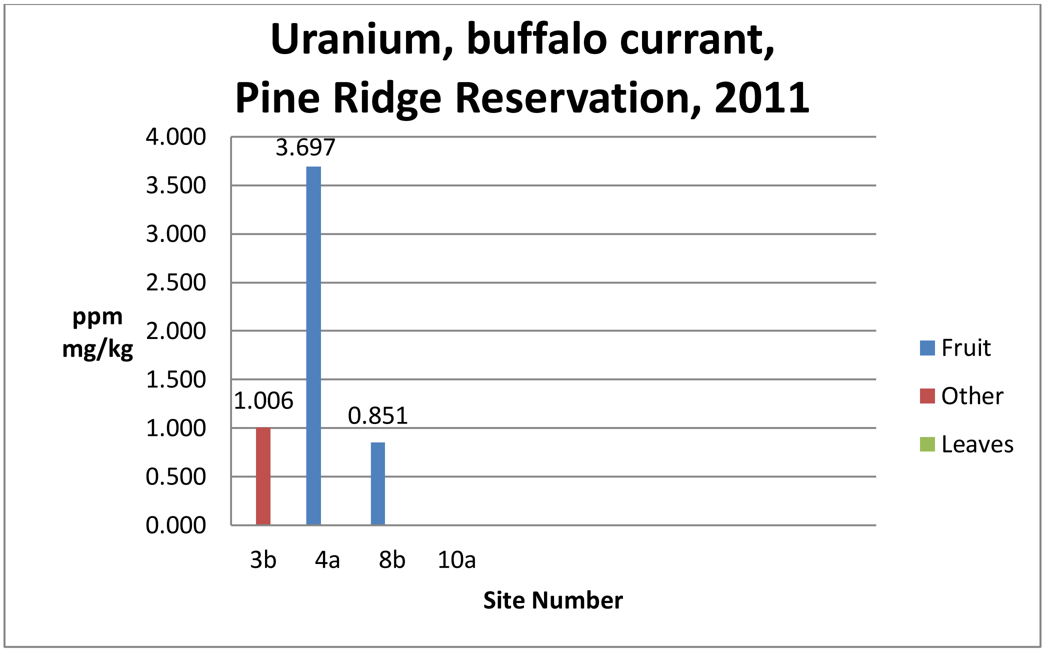


Figure H-1.

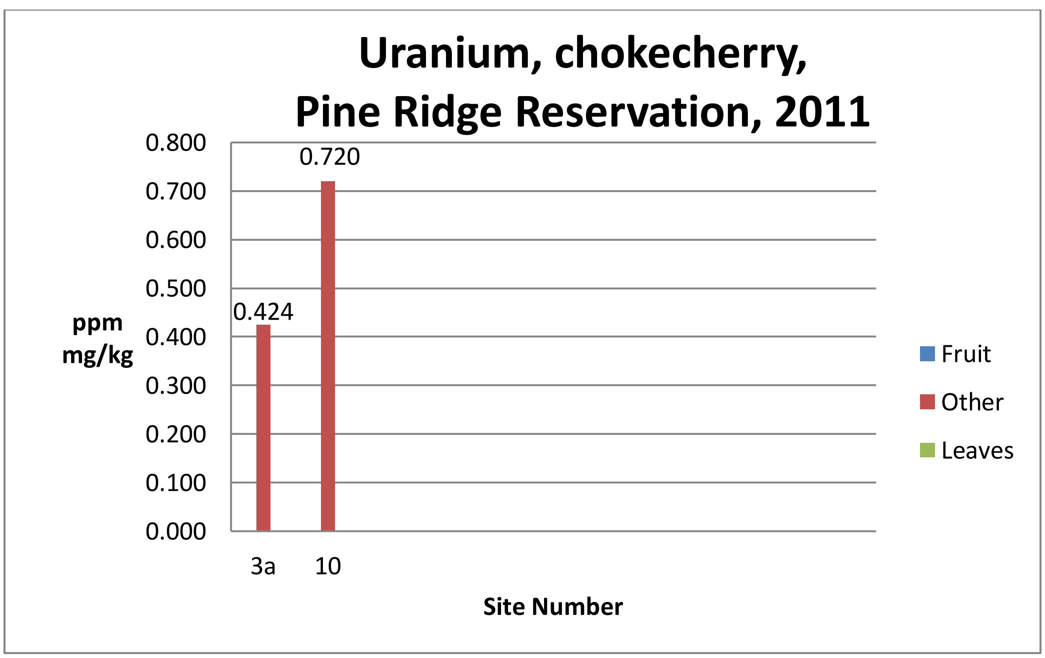


Figure H-2.

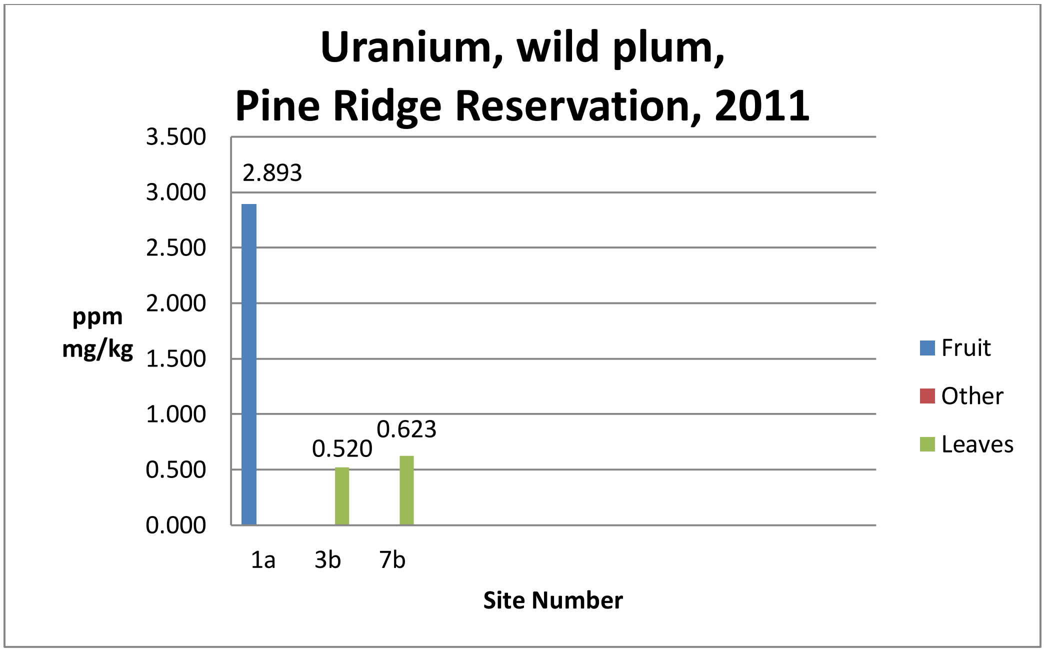


Figure H-3.

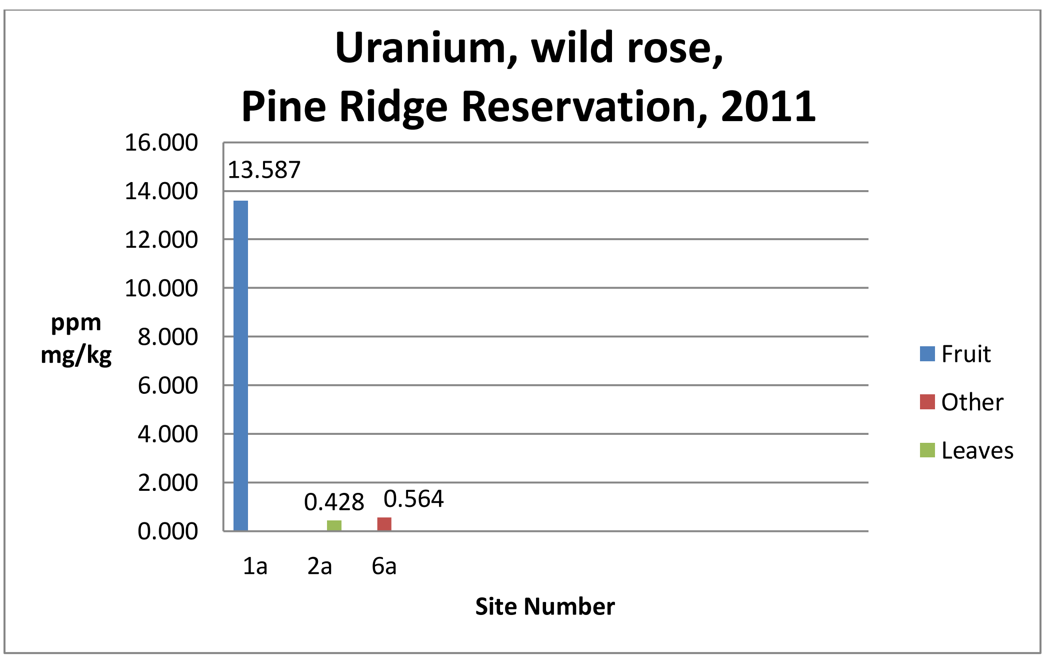
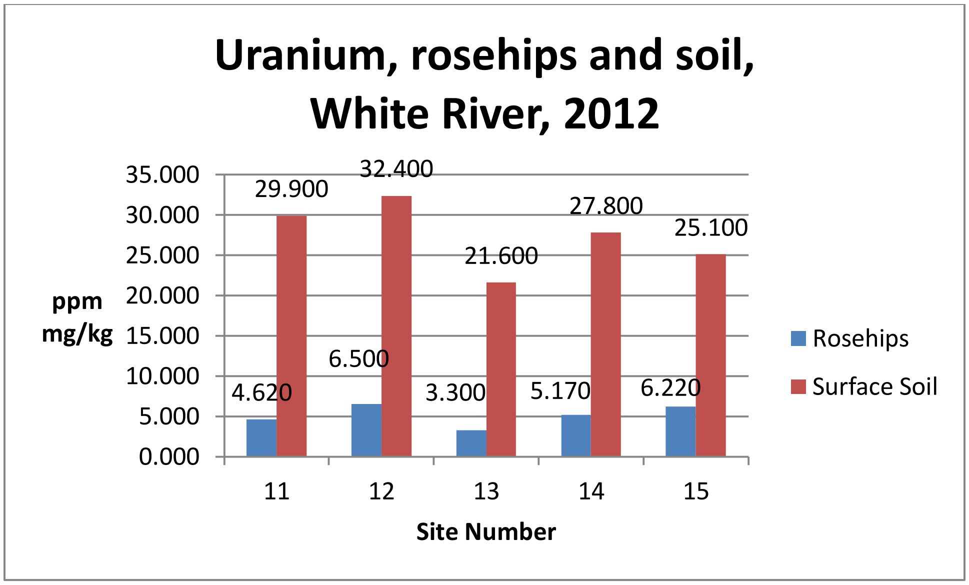


Figure H-4.



Uranium, rosehips and soil, White River, 2012
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
ppm mg/kg
29.900
32.400
21.600
27.800
25.100
4.620
6.500
3.300
5.170
6.220
11
12
13
14
15
Site Number
Rosehips
Surface Soil

Figure H-5.

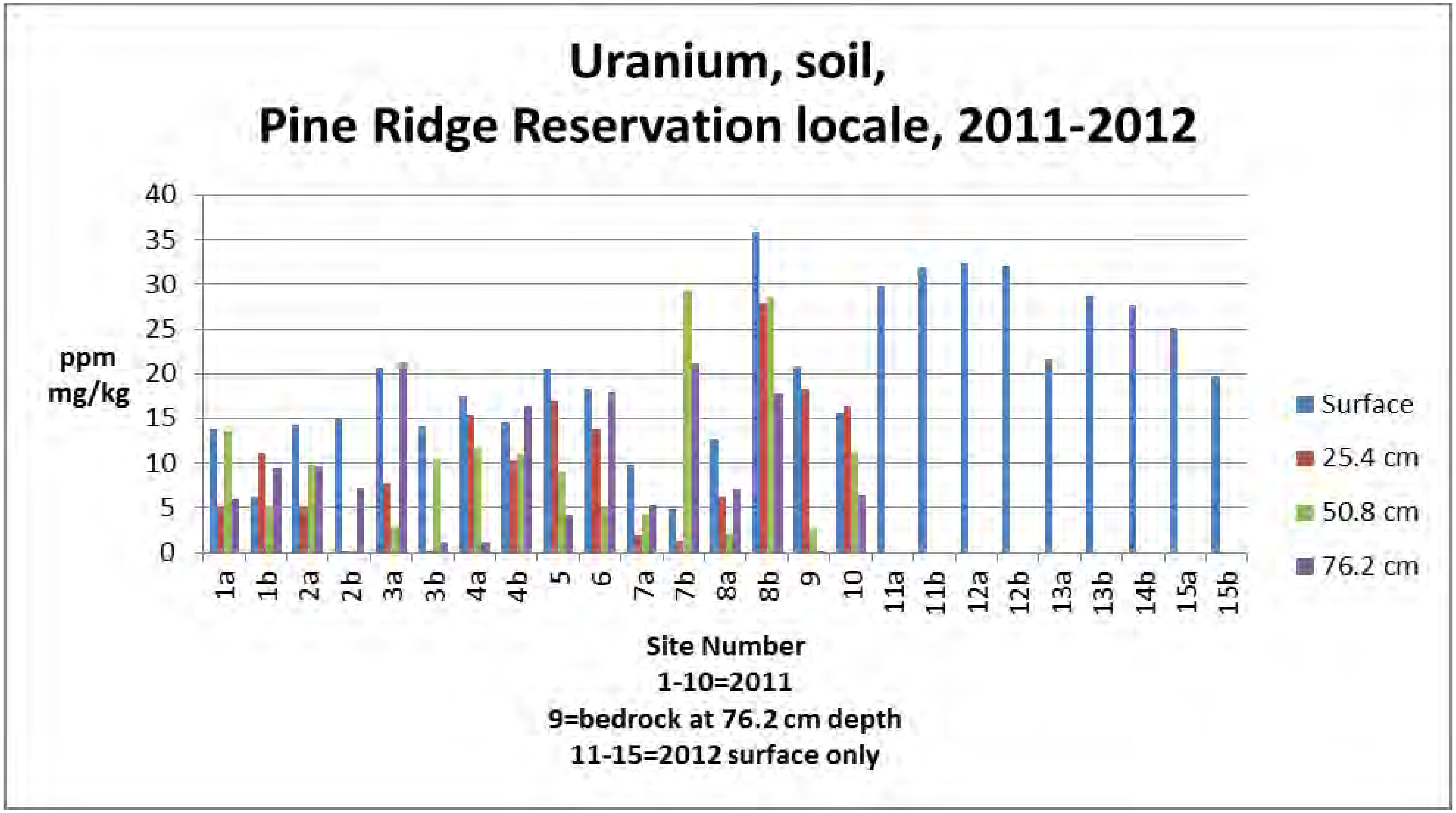

Uranium, soil,
Pine Ridge Reservation locale, 2011-2012
ppm
mg/kg
40
35
30
25
20
15
10
5
0
1a
1b
2a
2b
3a
3b
4a
4b
5
6
7a
7b
8a
8b
9
10
11a
11b
12a
12b
13a
13b
14b
15a
15b
Surface
25.4 cm
50.8 cm
76.2 cm
Site Number
1-10=2011
9=bedrock at 76.2 cm depth
11-15=2012 surface only

Figure H-6.

APPENDIX I: COMPREHENSIVE ICP-OES RESULTS BY SITE

Table I-1. All plant samples, PRR locale, Sites 1-10, 2011.
Key: Blue highlights indicate high score in the range, BC=buffalo currant, CC=chokecherry, PL=plum, RE=rose, BB=buffaloberry, and GR=grape.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
1a	40	0.000	4.968	0.000	2.297	0.000	BC fruit	PRR	2011
1a	41	0.000	31.314	0.000	4.171	0.000	BC other	PRR	2011
1a	42	0.000	28.803	0.074	4.179	0.000	CC fruit	PRR	2011
1a	43	1.091	1.320	0.000	5.441	0.000	CC other	PRR	2011
1a	44	0.000	29.852	0.000	2.345	2.893	PL fruit	PRR	2011
1a	45	0.744	4.878	0.166	0.000	0.000	PL other	PRR	2011
1a	270	0.000	211.506	0.000	0.000	13.587	RE fruit	PRR	2011
1a	51	0.000	13.029	0.000	0.805	0.000	RE fruit	PRR	2011
1a	46	0.000	40.400	0.275	6.572	0.000	RE other	PRR	2011
1b	49	0.683	27.390	0.000	5.723	0.000	BB fruit	PRR	2011
1b	170	0.000	227.351	0.000	3.747	0.000	BB other	PRR	2011
1b	50	0.000	5.501	0.000	0.445	0.453	BB leaf	PRR	2011
1b	54	1.033	23.450	0.013	3.759	0.000	PL fruit	PRR	2011
1b	53	1.935	15.499	0.000	4.794	0.000	RE fruit	PRR	2011
2a	55	0.000	2.873	0.000	7.417	0.000	CC fruit	PRR	2011
2a	56	0.000	6.841	0.000	0.863	0.863	CC other	PRR	2011
2a	57	0.000	30.225	0.000	4.035	0.000	CC leaf	PRR	2011
2a	58	0.124	61.308	0.000	5.023	0.000	PL leaf	PRR	2011
2a	63	0.720	42.900	0.000	1.438	0.000	RE fruit	PRR	2011
2a	59	3.051	40.766	0.000	0.000	0.428	RE leaf	PRR	2011
2b	60	0.000	23.461	0.000	0.256	0.000	BC leaf	PRR	2011
2b	61	0.000	15.368	0.000	3.403	0.000	RE fruit	PRR	2011
2b	64	0.133	13.013	0.000	1.477	0.000	RE fruit	PRR	2011
2b	62	1.267	31.909	0.000	0.000	0.000	RE leaf	PRR	2011

Table I-1, continued.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
3a	65	2.577	15.341	0.000	2.214	0.000	BC fruit	PRR	2011
3a	66	0.000	27.863	0.000	0.000	0.000	BC other	PRR	2011
3a	67	1.694	59.116	0.000	1.256	0.000	BC leaf	PRR	2011
3a	68	0.275	58.710	0.000	0.000	0.000	CC fruit	PRR	2011
3a	90	1.933	33.503	0.000	4.885	0.000	CC fruit	PRR	2011
3a	70	0.363	7.860	0.000	0.000	0.424	CC other	PRR	2011
3a	71	0.000	49.979	0.000	5.525	0.000	CC leaf	PRR	2011
3a	86	0.000	68.823	0.000	0.000	0.000	RE fruit	PRR	2011
3a	72	0.000	56.600	0.000	1.755	0.000	RE leaf	PRR	2011
3b	73	0.000	21.435	0.000	0.000	0.000	BB leaf	PRR	2011
3b	88	0.000	68.823	0.000	0.000	0.000	BB leaf	PRR	2011
3b	75	0.000	27.710	0.143	0.143	1.006	BC other	PRR	2011
3b	77	0.000	63.330	0.000	4.442	0.000	BC leaf	PRR	2011
3b	78	0.000	41.312	0.000	0.010	0.000	CC fruit	PRR	2011
3b	79	0.009	17.234	0.000	0.362	0.000	CC other	PRR	2011
3b	80	1.457	56.045	0.000	0.000	0.000	CC leaf	PRR	2011
3b	81	0.000	178.236	0.000	8.897	0.000	PL fruit	PRR	2011
3b	83	0.858	1.397	0.000	5.643	0.520	PL leaf	PRR	2011
3b	84	1.495	67.283	0.000	3.214	0.000	RE fruit	PRR	2011
3b	89	0.000	19.913	0.000	3.093	0.000	RE fruit	PRR	2011
3b	85	0.521	48.745	0.000	0.000	0.000	RE leaf	PRR	2011
4a	91	0.000	10.455	0.000	40.354	0.000	BB leaf	PRR	2011
4a	93	0.000	5.542	0.000	0.000	0.000	BB leaf	PRR	2011
4a	96	0.000	0.000	0.000	0.000	0.000	BB leaf	PRR	2011
4b	92	1.601	5.566	0.000	35.869	3.697	BC leaf	PRR	2011
4b	97	0.000	24.572	0.244	6.412	0.000	BB leaf	PRR	2011
4b	95	0.000	16.820	0.000	3.808	0.000	PL leaf	PRR	2011
4b	98	0.000	12.109	0.000	3.059	0.000	RE fruit	PRR	2011
4b	94	0.000	3.576	0.000	3.701	0.000	RE other	PRR	2011

Table I-1, continued.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
5	99	0.000	0.000	0.000	4.257	0.000	RE fruit	PRR	2011
5	101	0.377	40.304	0.000	1.179	0.000	RE fruit	PRR	2011
5	100	0.000	35.386	0.000	0.000	0.000	RE leaf	PRR	2011
6	102	0.000	31.400	0.000	0.000	0.000	RE fruit	PRR	2011
6	106	0.000	39.675	0.000	0.000	0.000	RE fruit	PRR	2011
6	104	0.000	14.644	1.024	3.445	0.564	RE other	PRR	2011
6	105	1.105	27.378	0.000	0.197	0.000	RE leaf	PRR	2011
7a	107	0.000	13.596	0.000	0.000	0.000	CC fruit	PRR	2011
7a	108	0.000	12.217	0.000	0.000	0.000	CC other	PRR	2011
7a	110	0.000	77.226	0.000	0.000	0.000	GR fruit	PRR	2011
7a	118	1.108	43.370	0.286	2.907	0.000	GR fruit	PRR	2011
7a	111	0.000	27.468	0.000	5.493	0.000	GR other	PRR	2011
7a	120	0.275	18.565	0.000	2.295	0.000	GR leaf	PRR	2011
7a	121	0.000	69.385	0.000	6.517	0.000	RE leaf	PRR	2011
7b	112	0.000	27.431	0.000	0.000	0.000	CC fruit	PRR	2011
7b	113	0.000	15.275	0.000	0.000	0.000	CC other	PRR	2011
7b	114	0.000	45.211	0.000	5.568	0.000	PL fruit	PRR	2011
7b	115	0.000	11.463	0.000	3.230	0.623	PL leaf	PRR	2011
7b	116	0.000	12.352	0.000	1.084	0.000	RE fruit	PRR	2011
7b	122	0.135	54.446	0.000	5.314	0.000	RE fruit	PRR	2011
7b	117	2.205	17.612	0.000	0.000	0.000	RE other	PRR	2011

Table I-1, continued.

Site	Control Number	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
8a	124	0.821	10.548	0.000	6.213	0.000	BC other	PRR	2011
8a	125	0.660	40.239	0.000	5.103	0.000	CC fruit	PRR	2011
8a	126	0.000	2.263	0.000	6.553	0.000	CC other	PRR	2011
8a	128	0.000	69.539	0.000	2.264	0.000	PL other	PRR	2011
8b	129	0.000	20.937	0.550	3.870	0.851	BC leaf	PRR	2011
8b	130	0.000	87.289	0.000	1.625	0.000	RE fruit	PRR	2011
8b	132	0.000	66.436	0.033	8.943	0.000	RE fruit	PRR	2011
8b	131	2.359	39.255	0.000	0.000	0.000	RE leaf	PRR	2011
9	133	0.000	23.360	0.000	7.470	0.000	BC other	PRR	2011
9	135	1.710	0.000	0.000	0.000	0.000	BC leaf	PRR	2011
9	136	0.785	0.000	0.000	2.222	0.000	CC leaf	PRR	2011
9	137	0.000	0.107	0.000	2.699	0.000	PL leaf	PRR	2011
9	138	0.000	0.000	0.000	0.000	0.000	RE fruit	PRR	2011
9	140	1.865	0.000	0.000	2.916	0.000	RE fruit	PRR	2011
9	139	1.216	0.000	0.000	0.000	0.000	RE leaf	PRR	2011
10	141	0.000	0.000	0.049	3.955	0.000	CC fruit	PRR	2011
10	142	0.000	9.779	0.000	3.596	0.720	CC other	PRR	2011
10	143	0.000	44.211	0.000	4.593	0.000	CC leaf	PRR	2011
10	145	0.000	67.446	0.000	0.000	0.000	GR fruit	PRR	2011
10	150	0.571	31.051	0.000	4.119	0.000	GR fruit	PRR	2011
10	146	0.145	44.041	0.000	0.553	0.000	GR other	PRR	2011
10	148	3.203	31.251	0.000	1.172	0.000	RE fruit	PRR	2011
10	151	0.000	27.181	0.148	1.026	0.000	RE fruit	PRR	2011
10	149	1.118	14.826	0.000	3.435	0.000	RE leaf	PRR	2011
mean		0.44	33.33	0.03	3.23	0.27			
range		0-3.20	0-227.35	0-1.02	0-40.35	0-13.59			
standard dev.		0.75	37.60	0.13	5.59	1.44			
# ND		61/98	8/98	86/98	28/98	87/98			
% ND		62.2%	8.2%	87/8%	28/6%	88/8%			

Table I-2. Wild rosehips along White River, Sites 11-15, 2012. Yellow highlights indicate highest score in the range.

Site	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
11a	0.000	5.860	0.364	0.766	4.620	RE fruit	Dawes Co, NE	2012
12a	0.902	36.100	0.687	0.031	6.500	RE fruit	PRR	2012
13a	0.000	7.560	0.000	1.590	3.300	RE fruit	PRR	2012
14a	0.284	9.470	0.281	0.000	5.170	RE fruit	PRR	2012
15a	0.000	14.700	0.010	1.220	6.220	RE fruit	Jackson Co., SD	2012
mean	0.24	14.74	0.27	0.72	5.16			
range	0-0.90	5.86-36.10	0-0.69	0.03-1.60	3.30-6.50			
std. dev.	0.35	11.09	0.25	0.63	1.16			
range	0-0.90	5.9-36.10	0-0.69	0-1.60	3.30-6.50			
# ND	3/5	0/5	1/5	1/5	0/5			
% ND	60%	0%	20%	20%	0%			

Table I-3. Soils along White River, Sites 11-15, 2012.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
11a	5.290	258.000	8.440	0.000	29.9	Soil surface	Dawes Co., NE	2012
11b	4.180	263.000	9.140	0.265	31.9	Soil surface	Dawes Co., NE	2012
12a	4.760	340.000	18.300	0.577	32.4	Soil surface	PRR	2012
12b	7.170	413.000	9.940	0.366	32.1	Soil surface	PRR	2012
13a	6.100	654.000	7.930	0.000	21.6	Soil surface	PRR	2012
13b	5.920	345.000	7.460	0.000	28.7	Soil surface	PRR	2012
14b	4.470	337.500	7.040	0.000	27.8	Soil surface	Jackson Co., SD	2012
15a	4.870	288.000	8.400	0.000	25.1	Soil surface	PRR	2012
15b	3.460	401.000	6.550	0.000	19.8	Soil Surface	PRR	2012
mean	5.136	366.611	9.244	0.134	27.700			
range	3.46-7.17	258-654	6.55-18.30	0-0.58	19.80-32.40			
std. dev.	1.06	113.85	3.35	0.20	4.36			
# ND	0/9	0/9	0/9	6/9	0/9			
% ND	0%	0%	0%	67%	0%			

Table I-4. Soils, PRR locale, Sites 1-10, 2011. Yellow highlights indicate highest score in the range.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
1a	3.713	13.219	16.219	5.187	13.827	soil surface	PRR	2011
1a	3.545	257.114	7.674	7.330	5.083	soil 25.4 cm	PRR	2011
1a	2.768	205.914	6.417	8.987	13.616	soil 50.8 cm	PRR	2011
1a	0.000	207.197	6.146	1.518	5.949	soil 76.2 cm	PRR	2011
1b	0.000	186.207	10.319	8.325	6.338	soil surface	PRR	2011
1b	2.795	224.016	9.005	2.046	11.156	soil 25.4 cm	PRR	2011
1b	0.000	235.546	7.148	6.644	5.106	soil 50.8 cm	PRR	2011
1b	3.638	194.620	6.973	10.404	9.472	soil 76.2 cm	PRR	2011
2a	1.867	229.427	12.552	10.324	14.286	soil surface	PRR	2011
2a	1.309	220.404	8.739	6.650	4.970	soil 25.4 cm	PRR	2011
2a	3.755	203.967	9.125	5.896	9.842	soil 50.8 cm	PRR	2011
2a	4.195	213.082	7.602	4.558	9.563	soil 76.2 cm	PRR	2011
2b	1.073	658.835	12.698	9.331	14.893	soil surface	PRR	2011
2b	2.666	216.054	7.343	8.632	0.000	soil 25.4 cm	PRR	2011
2b	4.617	201.159	7.848	7.104	0.000	soil 50.8 cm	PRR	2011
2b	2.639	180.979	7.507	7.140	7.167	soil 76.2 cm	PRR	2011
3a	3.180	244.636	7.121	8.152	20.695	soil surface	PRR	2011
3a	0.274	182.354	6.796	12.518	7.709	soil 25.4 cm	PRR	2011
3a	0.000	188.872	6.305	1.674	2.868	soil 50.8 cm	PRR	2011
3a	0.000	180.979	6.479	10.581	21.330	soil 76.2 cm	PRR	2011
3b	0.000	209.645	6.761	6.529	14.119	soil surface	PRR	2011
3b	0.521	210.715	5.836	3.857	0.000	soil 25.4 cm	PRR	2011
3b	0.000	247.883	6.284	5.725	10.494	soil 50.8 cm	PRR	2011
3b	1.310	1311.865	7.382	6.543	1.124	soil 76.2 cm	PRR	2011
4a	5.560	313.423	7.820	9.387	17.468	soil surface	PRR	2011
4a	6.295	312.735	8.664	3.304	15.351	soil 25.4 cm	PRR	2011
4a	12.302	314.950	28.445	12.690	11.769	soil 50.8 cm	PRR	2011
4a	6.933	142.108	7.794	9.784	1.163	soil 76.2 cm	PRR	2011
4b	7.248	303.430	10.088	7.874	14.533	soil surface	PRR	2011
4b	2.735	320.246	8.604	11.575	10.218	soil 25.4 cm	PRR	2011
4b	5.504	242.317	6.848	6.560	10.981	soil 50.8 cm	PRR	2011
4b	4.554	677.153	6.901	5.276	16.332	soil 76.2 cm	PRR	2011

Table I-4, continued

Site	As ppm	B ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
5	0.000	245.898	15.061	5.904	20.539	soil surface	PRR	2011
5	2.184	189.822	13.168	5.314	16.959	soil 25.4 cm	PRR	2011
5	6.817	160.849	11.777	6.541	9.054	soil 50.8 cm	PRR	2011
5	2.395	252.882	11.420	6.811	4.127	soil 76.2 cm	PRR	2011
6	1.701	251.764	13.601	7.591	18.296	soil surface	PRR	2011
6	5.725	253.549	10.447	9.662	13.828	soil 25.4 cm	PRR	2011
6	2.338	268.372	7.517	7.271	4.929	soil 50.8 cm	PRR	2011
6	3.057	239.048	7.612	11.136	17.907	soil 76.2 cm	PRR	2011
7a	3.321	386.184	6.289	3.981	9.844	soil surface	PRR	2011
7a	4.302	139.529	6.347	9.732	1.901	soil 25.4 cm	PRR	2011
7a	5.660	145.334	5.477	8.168	4.236	soil 50.8 cm	PRR	2011
7a	6.920	204.083	5.329	7.823	5.329	soil 76.2 cm	PRR	2011
7b	1.914	407.821	7.026	1.508	4.793	soil surface	PRR	2011
7b	1.891	176.200	3.913	6.934	1.281	soil 25.4 cm	PRR	2011
7b	5.126	265.397	5.913	9.830	29.352	soil 50.8 cm	PRR	2011
7b	3.750	450.090	6.724	6.349	21.095	soil 76.2 cm	PRR	2011
8a	3.176	552.741	7.625	8.651	12.659	soil surface	PRR	2011
8a	6.062	247.686	6.039	8.309	6.200	soil 25.4 cm	PRR	2011
8a	2.426	271.568	6.991	8.547	2.126	soil 50.8 cm	PRR	2011
8a	1.334	255.913	6.562	2.137	7.114	soil 76.2 cm	PRR	2011
8b	2.281	270.487	8.567	2.803	35.942	soil surface	PRR	2011
8b	5.012	254.479	7.128	9.937	27.945	soil 25.4 cm	PRR	2011
8b	4.751	283.934	6.196	6.517	28.554	soil 50.8 cm	PRR	2011
8b	0.000	251.566	7.265	6.709	17.756	soil 76.2 cm	PRR	2011
9	1.461	262.686	18.100	7.297	20.821	soil surface	PRR	2011
9	5.135	458.750	12.511	5.190	18.248	soil 25.4 cm	PRR	2011
9	4.247	731.951	12.881	0.860	2.584	soil 50.8 cm	PRR	2011
10	3.520	475.944	10.502	6.432	15.563	soil surface	PRR	2011
10	0.635	619.230	11.093	6.776	16.395	soil 25.4 cm	PRR	2011
10	2.668	642.228	11.691	7.645	11.258	soil 50.8 cm	PRR	2011
10	1.092	543.415	11.007	9.343	6.420	soil 76.2 cm	PRR	2011
mean	3.11	304.93	8.94	7.05	11.44			
range	0-12.30	13.22-1311.87	3.1-28.45	.086-12.69	0-35.94			
std. dev.	2.36	192.71	3.77	2.71	7.85			
# ND	9/63	0/63	0/63	1/63	0/63			
% ND	14.3%	0%	0%	0%	1.6%			

Table I-5. Rosehips, Brookings County, SD, comparison Sites B-1 through B-30, 2011. Yellow highlights indicate highest score in the range.

Site	As ppm	Ba ppm	Pb ppm	Se ppm	U ppm	Sample Type	Location	Year
B1	0.000	25.306	0.000	1.051	0.000	RE, fruit	Brookings	2011
B2	0.000	5.225	0.000	5.198	0.000	RE, fruit	Brookings	2011
B3	0.000	1.653	0.000	0.000	0.000	RE, fruit	Brookings	2011
B4	0.000	2.342	0.000	5.487	0.000	RE, fruit	Brookings	2011
B5	0.000	2.989	0.000	6.810	0.000	RE, fruit	Brookings	2011
B6	0.000	11.452	0.000	2.547	0.000	RE, fruit	Brookings	2011
B7	0.000	15.068	0.000	3.743	0.000	RE, fruit	Brookings	2011
B8	1.321	6.304	0.000	0.000	0.000	RE, fruit	Brookings	2011
B9	0.000	5.468	0.000	0.000	0.000	RE, fruit	Brookings	2011
B10	0.000	7.835	0.000	2.520	0.000	RE, fruit	Brookings	2011
B11	0.000	3.751	0.000	2.292	0.000	RE, fruit	Brookings	2011
B12	2.073	15.510	0.000	1.427	0.000	RE, fruit	Brookings	2011
B13	2.550	2.302	0.146	2.983	0.000	RE, fruit	Brookings	2011
B14	1.110	5.306	1.665	5.902	0.000	RE, fruit	Brookings	2011
B15	0.000	4.786	0.000	2.571	0.000	RE, fruit	Brookings	2011
B16	0.039	4.226	0.247	10.254	0.000	RE, fruit	Brookings	2011
B17	0.000	16.052	0.000	3.317	0.000	RE, fruit	Brookings	2011
B18	0.000	2.605	0.000	3.224	0.000	RE, fruit	Brookings	2011
B19	0.000	6.534	0.237	0.000	0.000	RE, fruit	Brookings	2011
B20	0.000	4.982	0.000	2.441	0.000	RE, fruit	Brookings	2011
B21	0.000	9.019	0.000	0.000	0.000	RE, fruit	Brookings	2011
B22	0.000	4.862	0.000	2.397	0.000	RE, fruit	Brookings	2011
B23	0.000	5.435	0.000	0.000	0.000	RE, fruit	Brookings	2011
B24	0.000	2.142	0.091	4.625	0.000	RE, fruit	Brookings	2011
B25	0.000	0.454	0.000	3.395	0.000	RE, fruit	Brookings	2011
B26	0.693	3.108	0.000	0.770	0.000	RE, fruit	Brookings	2011
B27	0.000	12.169	0.125	2.448	0.000	RE, fruit	Brookings	2011
B28	0.000	7.720	0.000	4.247	0.000	RE, fruit	Brookings	2011
B29	0.000	5.757	0.000	0.840	0.000	RE, fruit	Brookings	2011
B30	0.000	7.785	0.000	1.436	0.000	RE, fruit	Brookings	2011
mean	0.260	6.938	0.084	2.731	ND			
range	0-2.56	0.45-25.31	0-1.67	0-10.25	ND			
standard dev.	0.64	5.29	0.30	2.34	0.00			
# ND	24/30	0/30	24/30	6/30	30/30			
% ND	80%	0%	80%	20%	100%			

APPENDIX J: LOCATION OF SITES

Table J-1. GPS all sites, 2011-2012.

Site	x= Pine Ridge Reservation, SD or *=bordering	Latitude N degrees	Longitude W degrees		Site	x=Brookings County, SD	Longitude N degrees	Latitude W degrees
1	x	43.3683	102.2509		B1	x	44.4514	96.9475
2	x	43.2381	102.4701		B2	x	44.4702	97.0001
3	x	43.1375	102.3724		B3	x	44.4846	96.9724
4	x	43.0898	102.7977		B4	x	44.3229	96.7080
5	x	43.4853	102.8807		B5	x	44.3335	96.6880
6	x	43.5114	102.4981		B6	x	44.3661	96.7477
7	x	43.6580	102.8947		B7	x	44.3596	96.7880
8	x	43.5351	101.9881		B8	x	44.3382	96.8202
9	x	43.6099	101.5027		B9	x	44.3471	96.8288
10	x	43.5627	101.3129		B10	x	44.3554	96.8533
11	*	42.8861	103.0667		B11	x	44.3553	96.8294
12	x	43.3136	102.7887		B12	x	44.3556	96.8928
13	x	43.5081	102.5055		B13	x	44.3560	96.8876
14	*	43.6942	101.9348		B14	x	44.3842	96.8928
15	x	43.7520	101.5260		B15	x	44.4062	96.9069
					B16	x	44.3937	96.8488
					B17	x	44.2684	96.7684
					B18	x	44.2534	96.7689
					B19	x	44.2400	96.7671
					B20	x	44.2369	96.7677
					B21	x	44.2534	96.7751
					B22	x	44.2534	96.7711
					B23	x	44.2356	96.7470
					B24	x	44.2132	96.7469
					B25	x	44.2501	96.7071
					B26	x	44.2538	96.6823
					B27	x	44.2550	96.6674
					B28	x	44.2849	96.6673
					B29	x	44.2462	96.7682
					B30	x	44.2535	96.7641

APPENDIX K: CALCULATIONS

Table K-1. Calculations for US CDC MRL comparisons of chronic yearly doses of heavy metals in fruits, Sites 1-15, near and on PRR, 2011 and 2012. Yellow highlights indicate potential maximum number of cups meeting MRL standards, as well as number of persons and percentage of persons above allowed MRL dosage per fruit, not including total dose for all fruits consumed.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Fruit	Heavy metal species in US CDC standard	Maximum reported fruit, estimated as freshly picked, and used by individual per year, cups [1 c. volume=0.24 L]	Dry weight per cup kg	Arithmetic mean of samples mg/kg	Highest score in range of samples mg/kg	Yearly "dose" arithmetic mean mg	highest score in range mg	Minimal Risk Levels MRLs heavy metal baseline mg	Body weight standard kg	Days of chronic oral use	Exposure in mgs of heavy metal/ kg of body weight/ 365 days (except uranium/364 days)	# persons/ % above lowest MRL dosage *	Effective date US CDC standard
Buffalo currant	arsenic	100	0.02117	1.288	2.577	2.7273	5.455509	0.0003	55	365	6.0225		Aug. 2007
	barium soluble salts	100	0.02117	10.154	15.341	21.4960	32.476897	0.2000	55	365	4015.0000		Aug. 2007
	lead	100	0.02117	NA & ND	NA & ND	NA & ND	NA & ND	not established	55	365	NA & ND		NA
	selenium	100	0.02117	2.256	2.297	4.775952	4.862749	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	100	0.02117	ND	ND	ND	ND	0.0002	55	364	4.0040		Feb. 2013
Chokecherry	arsenic	150	0.05161	0.319	1.933	2.4669	14.9643	0.0003	55	365	6.0225		Aug. 2007
	arsenic	80	0.05161	0.319	1.933	1.3157	7.9810	0.0003	55	365	6.0225		Aug. 2007
	arsenic *	16	0.05161	0.319	1.933	0.2631	1.5962	0.0003	55	365	6.0225	4 persons/ 12.5%	Aug. 2007
	barium soluble salts	150	0.05161	27.385	58.71	212.0022	454.5035	0.2000	55	365	4015.0000		Aug. 2007
	lead	150	0.05161	0.014	0.074	0.1055	0.5729	not established	55	365	NA		NA
	selenium	150	0.05161	2.839	7.417	21.9767	57.4187	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	150	0.05161	ND	ND	ND	ND	0.0002	55	364	4.0040		Feb. 2013
Wild grape	arsenic	80	0.03696	0.420	1.108	1.241	3.2761	0.0003	55	365	6.0225		Aug. 2007
	barium soluble salts	80	0.03696	54.773	77.226	161.954	228.3418	0.2000	55	365	4015.0000		Aug. 2007
	lead	80	0.03696	1.757	0.286	5.194	0.8456	not established	55	365	NA		NA
	selenium	80	0.03696	1.757	4.119	5.194	12.1791	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	80	0.03696	ND	ND	ND	ND	0.0002	55	364	4.0040		Feb. 2013
Wild plum	arsenic	150	0.0247	0.258	1.033	0.9567	3.8273	0.0003	55	365	6.0225		Aug. 2007
	barium soluble salts	150	0.0247	69.187	178.236	256.3394	660.3644	0.2000	55	365	4015.0000		Aug. 2007
	lead	150	0.0247	0.003	0.013	0.01191	0.0482	not established	55	365	NA		NA
	selenium and compounds	150	0.0247	5.142	8.897	19.0515	32.9634	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	150	0.0247	0.723	2.893	2.6794	10.7186	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	80	0.0247	0.723	2.893	1.4290	5.7166	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts *	32	0.0247	0.723	2.893	0.5716	2.2866	0.0002	55	364	4.0040	2 persons/ 6%	Feb. 2013
Wild rose	arsenic	64	0.05364	0.409	3.203	1.4049	10.9958	0.0003	55	365	6.0225		Aug. 2007
	arsenic *	16	0.05364	0.409	3.203	0.3510	2.7489	0.0003	55	365	6.0225	1 person/ 3%	Aug. 2007
	barium soluble salts	64	0.05364	34.943	211.506	119.9585	726.0916	0.2000	55	365	4015.0000		Aug. 2007
	lead	64	0.05364	0.056	0.687	0.1936	2.3584	not established	55	365	NA		NA
	selenium	64	0.05364	1.941	8.943	46.6436	30.7010	0.0050	55	365	100.3750		Sept. 2003
	uranium soluble salts	64	0.05364	1.459	13.587	5.0091	46.6436	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	16	0.05364	1.459	13.587	1.2522	11.6609	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	10	0.05364	1.459	13.587	0.7825	7.2881	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts	6	0.05364	1.459	13.587	0.4695	4.3728	0.0002	55	364	4.0040		Feb. 2013
	uranium soluble salts *	2	0.05364	1.459	13.587	0.1565	1.4576	0.0002	55	364	4.0040	4 persons/ 12.5%	Feb. 2013

Table K-2. Calculations for US CDC MRL comparisons of chronic yearly doses of heavy metals in fruits, Sites B1 through B30, Brookings County, SD, 2011.

Fruit	**Heavy metal species in US CDC standard**	**Number of cups per year, fresh, volume (1 c. = 0.24 L)**	**Yearly "dose" based on arithmetic mean mg**	**Yearly "dose" based on highest score in range mg**	**Body weight standard kg**	**Days of chronic oral use**	**MRL conversion mg of heavy metal/ kg of body weight/ 365 days (except uranium/364 days)**
Wild rose	arsenic	64	0.089	8.788	55	365	6.0225
	barium soluble salts	64	23.818	80.022	55	365	4015.0000
	lead	64	0.288	5.733	55	365	NA
	selenium	64	9.375	35.188	55	365	100.3750
	uranium soluble salts	64	ND	ND	55	364	4.0040

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VIEW IN BROWSER

Pegasus Resources and Cowboy Exploration Cancel the Chord Option Agreement in Fall County, South Dakota

December 03, 2022 – Pegasus Resources Inc. (TSX-V: PEGA; Frankfurt – OQS2, OTC/Pink Sheet symbol SLTFF) (the "Company" or "Pegasus") reports that Pegasus and Cowboy Exploration and Development LLC ("Cowboy Exploration") have mutually agreed to cancel the Chord Option Agreement in Fall County, South Dakota, previously announced April 12, 2022.

Opposition to uranium projects in South Dakota was considered low when Pegasus and Cowboy Exploration initially signed the agreement for the Chord Project. However, in late September 2022, Pegasus opened negotiations with Cowboy Exploration when the Company became concerned with an increased anti-mining sentiment in Fall County, specifically toward uranium exploration and development. Since then, Fall River County voters have declared uranium mining a nuisance.

Pegasus and Cowboy Exploration failed to negotiate an agreement that was satisfactory to all parties, and, therefore, mutually agreed to terminate the agreement.

About Pegasus Resources Inc.

Pegasus Resources Inc. is a diversified Junior Canadian Mineral Exploration Company with a focus on uranium, gold, and base metal properties in North America. The Company is also actively pursuing the right opportunity in other resources to enhance shareholder value. For additional information please visit the Company at www.pegasusresourcesinc.com or contact Charles Desjardins at charles@pegasusresourcesinc.com.

On Behalf of the Board of Directors:

Christian Timmins
President and Director
Pegasus Resources Inc.
700 – 838 West Hastings Street
Vancouver, BC V6C 0A6
PH: 1-604-369-8973
E: info@pegasusresourcesinc.com

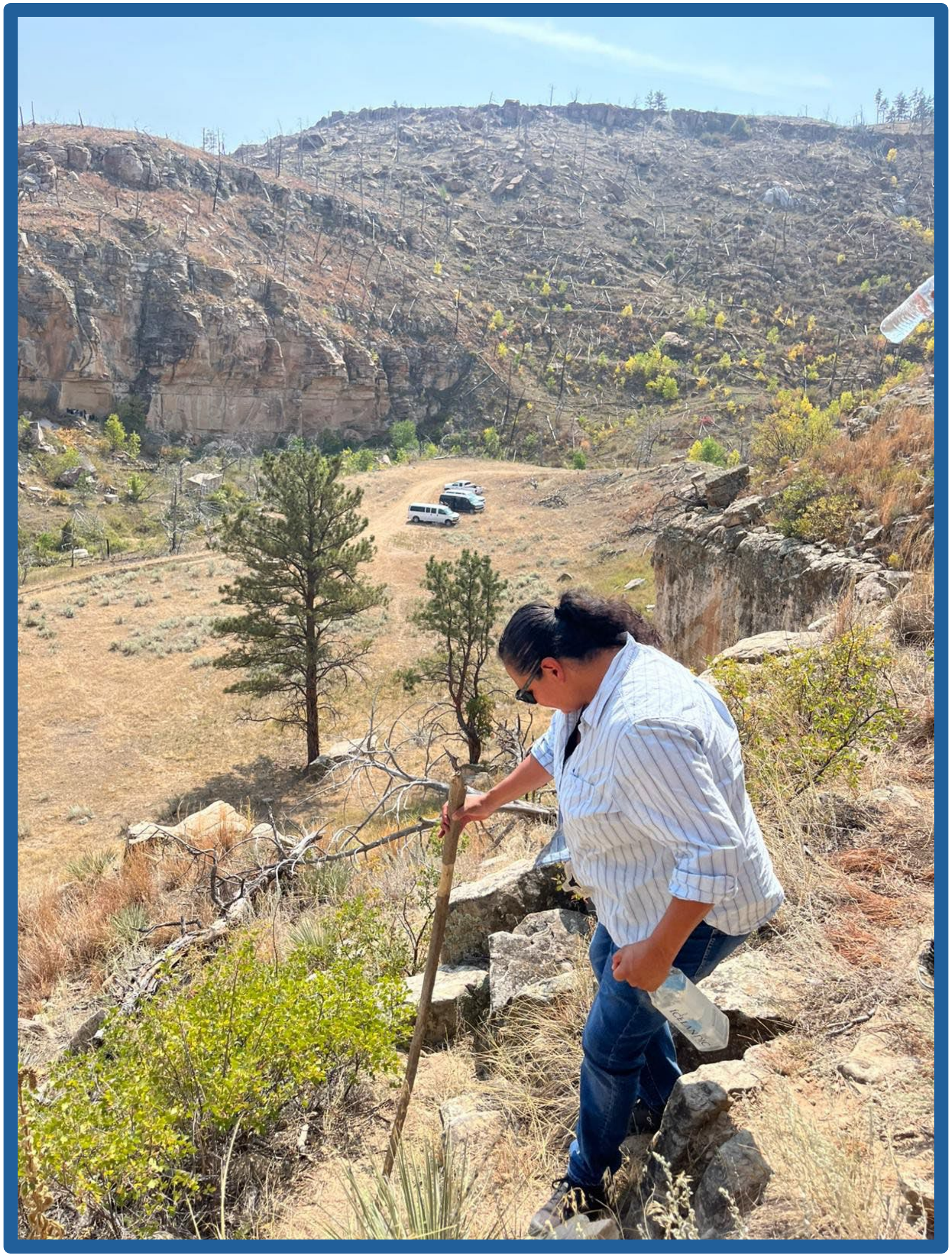
Neither the TSX Venture Exchange nor its Regulation Services Provider (as that term is defined in the policies of the TSX Venture Exchange) accepts responsibility for the adequacy or accuracy of this release.

Forward Looking Statements

Statements included in this announcement, including statements concerning the Company's plans, intentions, and expectations, which are not historical in nature are intended to be, and are hereby identified as, "forward-looking statements." Forward-looking statements may be identified by words including "anticipates," "believes," "intends," "estimates," "expects" and similar expressions. The Company cautions readers that forward-looking statements, including without limitation those relating to the Company's future operations and business prospects, are subject to certain risks and uncertainties that could cause actual results to differ materially from those indicated in the forward-looking statement

Tribal Water Alliance

Exhibit 20_____

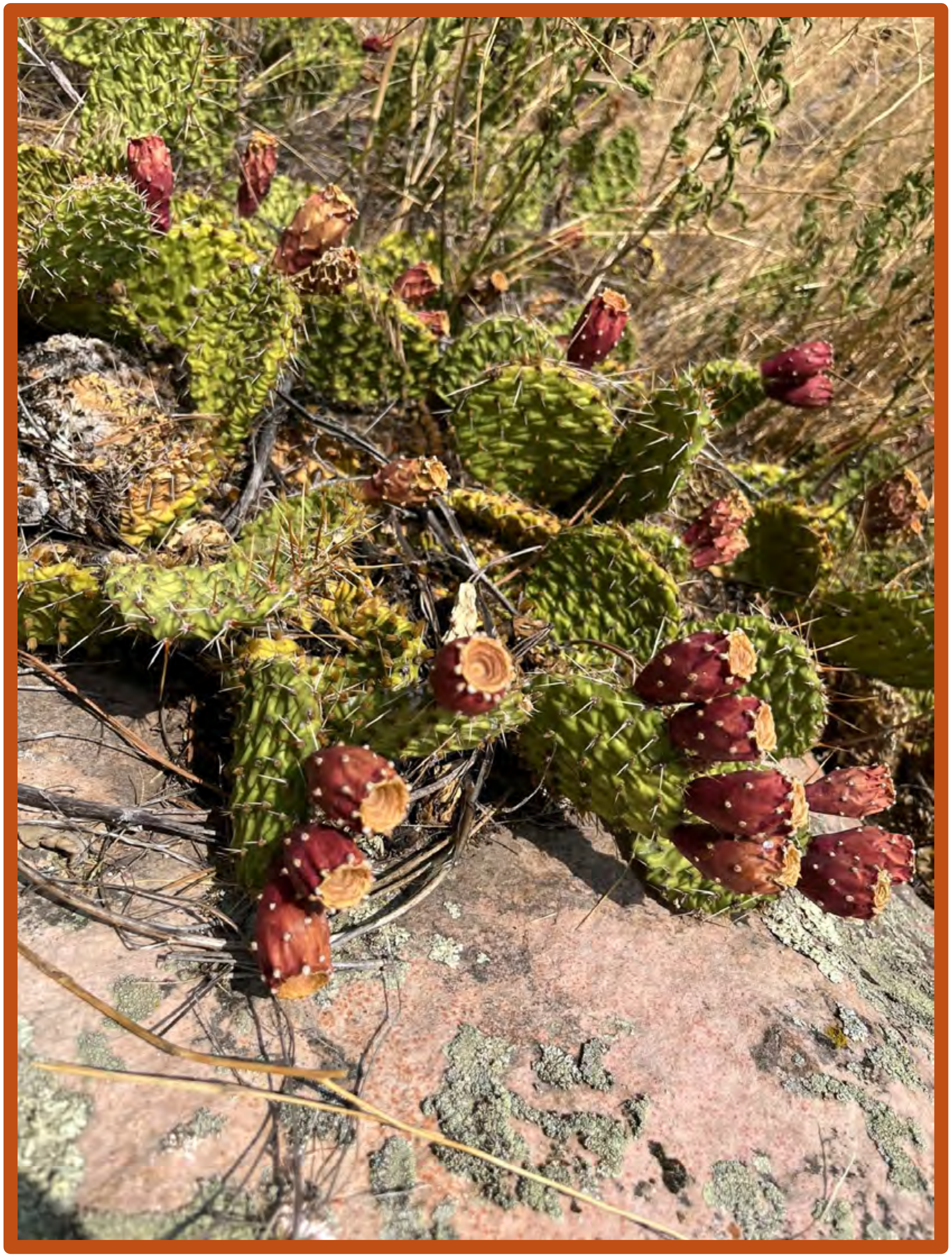


Examining Fragrant sumac, a traditional food.
Yucca in the foreground, a soap source.

Tribal Water Alliance
Exhibit 20_____

Holding Prairie coneflower, a medicinal plant.

Looking at Wild bergamot, a ceremonial and medicinal plant.



Prickly pear, a traditional food of the Lakota.

STATE OF SOUTH DAKOTA)
)
COUNTY OF: Fall River)

CERTIFICATE

We, Joe Allen, Les Cope, Joe Falkenburg, Heath Greenough, Deb Russell, the County Board of Canvassers in Fall River County for the General Election held on November 8, 2022, hereby certify that the foregoing is a true abstract of the votes cast in the jurisdiction of Fall River County, South Dakota, at the election as shown by the returns certified to the person in charge of the election.

Joe A Falkenburg

Deborah Russell

Heath Greenough

Les Cope

Joe Allen

Sworn to before me this 10 day of Nov, 2022.

County Auditor

Fall River County, South Dakota

SEAL County Auditor State of SEAL South Dakota Fall River & Oglala Lakota

Tribal Water Alliance
Exhibit 20_____

General Election - November 8, 2022
Fall River County

Precinct Name	Initiated Measure : Uranium Mining is a nuisance in Fall River County	
	Yes	No
BEA	52	80
CAS	109	60
EDA	194	329
HS 1	268	161
HS 2	237	174
HS 3	210	123
HS 4	224	134
JAC	622	379
Oelrichs Area	77	98
Total	**1,993**	**1,538**

ITIATED MEASURE : URANIUM MINING IS A NUISANCE IN FALL RIVER COUNTY - FALL RIVER

FOLLOW THIS CONTEST **PRECINCTS FULLY: 9 / 9 | PARTIALLY: 0 / 9** **EXPORT**

✔ YES	56%	1,993
NO	44%	1,537
	TOTAL VOTES	3,530

MAP COUNTY RESULTS

FALL RIVER COUNTY

PRECINCTS FULLY: 9 / 9 | PARTIALLY: 0 / 9

YES	56%	1,993
NO	43%	1,537
	TOTAL VOTES	3,530

PRECINCT RESULTS

FALL RIVER COUNTY

BEA		
YES	39%	52
NO	60%	80
CAS		
YES	64%	109
NO	35%	60
EDA		
YES	37%	194
NO	62%	329
HS 1		
YES	62%	268
NO	37%	161
HS 2		
YES	57%	237
NO	42%	174
HS 3		
YES	63%	210

NO	36%	123
HS 4		
YES	62%	224
NO	37%	134
JAC		
YES	62%	622
NO	37%	378
OELRICHS AREA		
YES	44%	77
NO	56%	98
	TOTAL VOTES	3,530

INITIATED MEASURE : AN ORDINANCE OF

STATE OF SOUTH DAKOTA)
)
COUNTY OF HUGHES)

CERTIFICATE

We, Steve Barnett, Shirley Jameson-Fergel, Charles McGuigan and Steven Kohler, the Board of Canvassers in the State of South Dakota for the General Election held in said state on November 15, hereby certify that the attached is a true and correct record of the votes for the candidates as shown by returns certified to the Secretary of State of South Dakota.

Steve Barnett
Secretary of State

for the Supreme Court

for the Governor

for the Attorney General

Sworn to before me this 15th day of November, 2022.

Kea L Warne
Notary Public

KEA L. WARNE
NOTARY
SEAL SEAL
PUBLIC
STATE OF SOUTH DAKOTA

My commission expires 1-21-27.

Tribal Water Alliance
Exhibit 20_____

General Election - November 8, 2022
Fall River County

Precinct Name	Initiated Measure : Uranium Mining is a nuisance in Fall River County	
	Yes	No
BEA	52	80
CAS	109	60
EDA	194	329
HS 1	268	161
HS 2	237	174
HS 3	210	123
HS 4	224	134
JAC	622	379
Oelrichs Area	77	98
Total	**1,993**	**1,538**

STATE OF SOUTH DAKOTA)
)
COUNTY OF HUGHES)

CERTIFICATE

We, Steve Barnett, Shirley Jameson-Fergel, Charles McGuigan and Steven Kohler, the Board of Canvassers in the State of South Dakota for the General Election held in said state on November 15, hereby certify that the attached is a true and correct record of the votes for the candidates as shown by returns certified to the Secretary of State of South Dakota.

Steve Barnett
Secretary of State

for the Supreme Court

for the Governor

Charles McGuigan
for the Attorney General

Sworn to before me this 15th day of November, 2022.

Kea L Warne
Notary Public

KEA L. WARNE
NOTARY
SEAL
PUBLIC
STATE OF SOUTH DAKOTA

My commission expires 1-21-27.

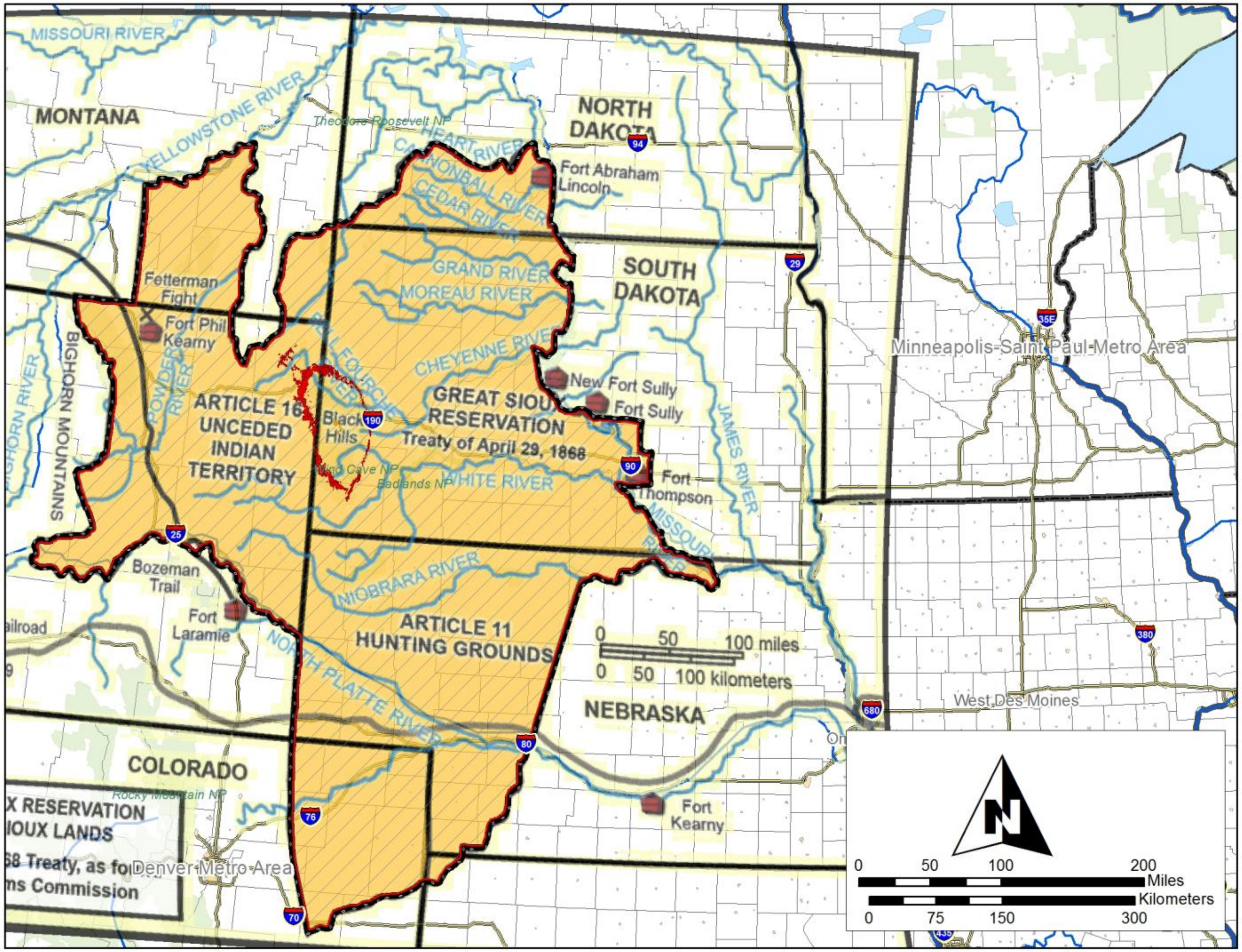
Litho in U.S.A.

© GOES 340

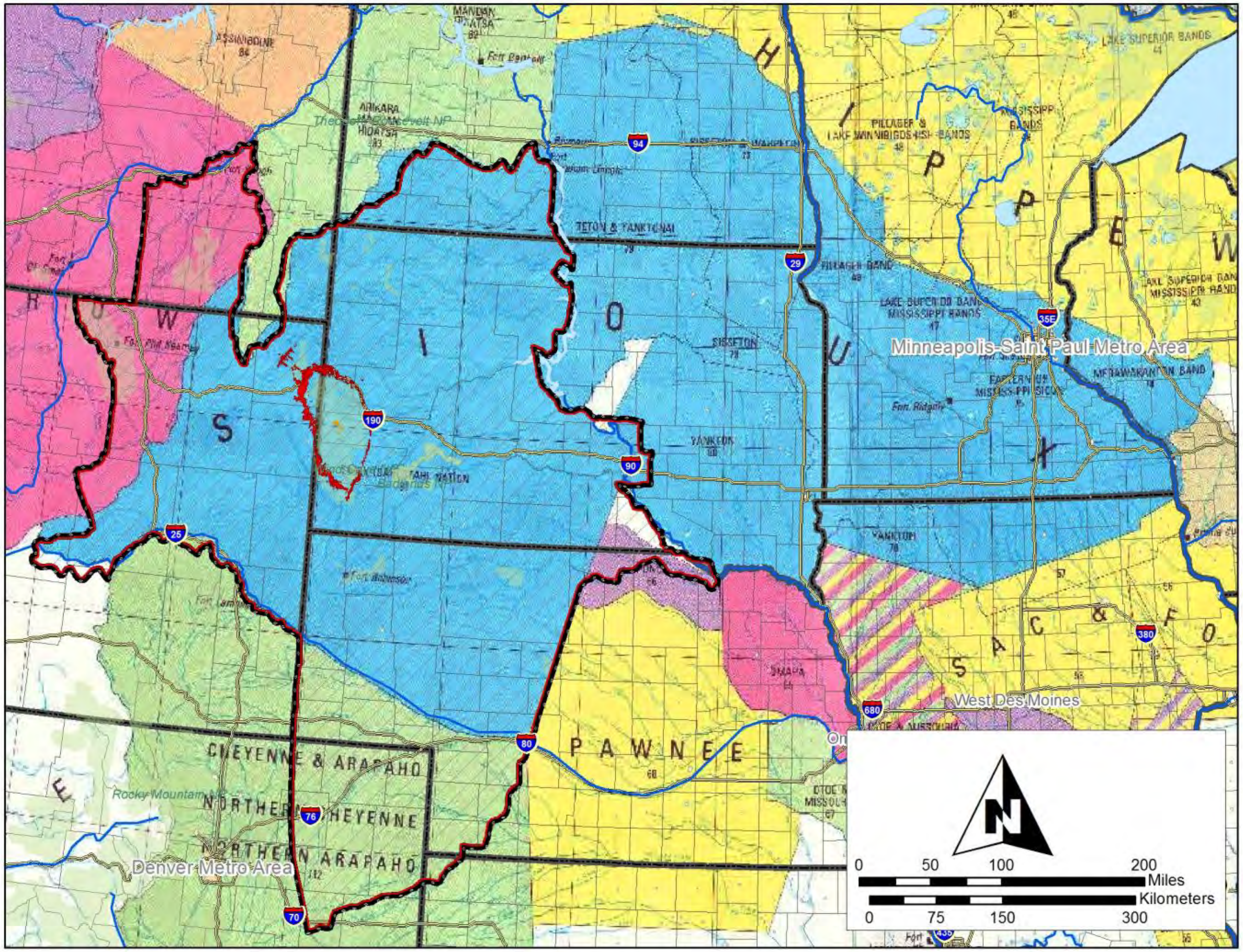
EXHIBIT B

General Election - November 8, 2022
Fall River County

Precinct Name	Initiated Measure : Uranium Mining is a nuisance in Fall River County	
	Yes	No
BEA	52	80
CAS	109	60
EDA	194	329
HS 1	268	161
HS 2	237	174
HS 3	210	123
HS 4	224	134
JAC	622	379
Oelrichs Area	77	98
Total	**1,993**	**1,538**



Tribal Water Alliance
Exhibit 20_____



RST Exhibit ________
1986-1, 2792-2, 2793-2

Tribal Water Alliance

Exhibit 20_____

Published by the United Nations

07-58681—March 2008—4,000

United Nations

United Nations DECLARATION on the RIGHTS of INDIGENOUS PEOPLES

United Nations

United Nations Declaration on the Rights of Indigenous Peoples

Resolution adopted by the General Assembly

[*without reference to a Main Committee (A/61/L.67 and Add.1)*]

61/295. United Nations Declaration on the Rights of Indigenous Peoples

The General Assembly,

Taking note of the recommendation of the Human Rights Council contained in its resolution 1/2 of 29 June 2006,[1] by which the Council adopted the text of the United Nations Declaration on the Rights of Indigenous Peoples,

Recalling its resolution 61/178 of 20 December 2006, by which it decided to defer consideration of and action on the Declaration to allow time for further consultations thereon, and also decided to conclude its consideration before the end of the sixty-first session of the General Assembly,

Adopts the United Nations Declaration on the Rights of Indigenous Peoples as contained in the annex to the present resolution.

107th plenary meeting
13 September 2007

Annex

United Nations Declaration on the Rights of Indigenous Peoples

The General Assembly,

Guided by the purposes and principles of the Charter of the United Nations, and good faith in the fulfilment of the obligations assumed by States in accordance with the Charter,

Affirming that indigenous peoples are equal to all other peoples, while recognizing the right of all peoples to be different, to consider themselves different, and to be respected as such,

[1] See *Official Records of the General Assembly, Sixty-first Session, Supplement No. 53* (A/61/53), part one, chap. II, sect. A.

Affirming also that all peoples contribute to the diversity and richness of civilizations and cultures, which constitute the common heritage of humankind,

Affirming further that all doctrines, policies and practices based on or advocating superiority of peoples or individuals on the basis of national origin or racial, religious, ethnic or cultural differences are racist, scientifically false, legally invalid, morally condemnable and socially unjust,

Reaffirming that indigenous peoples, in the exercise of their rights, should be free from discrimination of any kind,

Concerned that indigenous peoples have suffered from historic injustices as a result of, inter alia, their colonization and dispossession of their lands, territories and resources, thus preventing them from exercising, in particular, their right to development in accordance with their own needs and interests,

Recognizing the urgent need to respect and promote the inherent rights of indigenous peoples which derive from their political, economic and social structures and from their cultures, spiritual traditions, histories and philosophies, especially their rights to their lands, territories and resources,

Recognizing also the urgent need to respect and promote the rights of indigenous peoples affirmed in treaties, agreements and other constructive arrangements with States,

Welcoming the fact that indigenous peoples are organizing themselves for political, economic, social and cultural enhancement and in order to bring to an end all forms of discrimination and oppression wherever they occur,

Convinced that control by indigenous peoples over developments affecting them and their lands, territories and resources will enable them to maintain and strengthen their institutions, cultures and traditions, and to promote their development in accordance with their aspirations and needs,

Recognizing that respect for indigenous knowledge, cultures and traditional practices contributes to sustainable and equitable development and proper management of the environment,

Emphasizing the contribution of the demilitarization of the lands and territories of indigenous peoples to peace, economic and social progress and development, understanding and friendly relations among nations and peoples of the world,

Recognizing in particular the right of indigenous families and communities to retain shared responsibility for the upbringing, training, education and well-being of their children, consistent with the rights of the child,

Considering that the rights affirmed in treaties, agreements and other constructive arrangements between States and indigenous peoples are, in some situations, matters of international concern, interest, responsibility and character,

Considering also that treaties, agreements and other constructive arrangements, and the relationship they represent, are the basis for a strengthened partnership between indigenous peoples and States,

Acknowledging that the Charter of the United Nations, the International Covenant on Economic, Social and Cultural Rights[2] and the International Covenant on Civil and Political Rights,[2] as well as the Vienna Declaration and Programme of Action,[3] affirm the fundamental importance of the right to self-determination of all peoples, by virtue of which they freely determine their political status and freely pursue their economic, social and cultural development,

Bearing in mind that nothing in this Declaration may be used to deny any peoples their right to self-determination, exercised in conformity with international law,

Convinced that the recognition of the rights of indigenous peoples in this Declaration will enhance harmonious and cooperative relations between the State and indigenous peoples, based on principles of justice, democracy, respect for human rights, non-discrimination and good faith,

Encouraging States to comply with and effectively implement all their obligations as they apply to indigenous peoples under international instruments, in particular those related to human rights, in consultation and cooperation with the peoples concerned,

Emphasizing that the United Nations has an important and continuing role to play in promoting and protecting the rights of indigenous peoples,

---

[2] See resolution 2200 A (XXI), annex.

[3] A/CONF.157/24 (Part I), chap. III.

Believing that this Declaration is a further important step forward for the recognition, promotion and protection of the rights and freedoms of indigenous peoples and in the development of relevant activities of the United Nations system in this field,

Recognizing and reaffirming that indigenous individuals are entitled without discrimination to all human rights recognized in international law, and that indigenous peoples possess collective rights which are indispensable for their existence, well-being and integral development as peoples,

Recognizing that the situation of indigenous peoples varies from region to region and from country to country and that the significance of national and regional particularities and various historical and cultural backgrounds should be taken into consideration,

Solemnly proclaims the following United Nations Declaration on the Rights of Indigenous Peoples as a standard of achievement to be pursued in a spirit of partnership and mutual respect:

Article 1

Indigenous peoples have the right to the full enjoyment, as a collective or as individuals, of all human rights and fundamental freedoms as recognized in the Charter of the United Nations, the Universal Declaration of Human Rights[4] and international human rights law.

Article 2

Indigenous peoples and individuals are free and equal to all other peoples and individuals and have the right to be free from any kind of discrimination, in the exercise of their rights, in particular that based on their indigenous origin or identity.

Article 3

Indigenous peoples have the right to self-determination. By virtue of that right they freely determine their political status and freely pursue their economic, social and cultural development.

Article 4

Indigenous peoples, in exercising their right to self-determination, have the right to autonomy or self-government in matters relating to

[4] Resolution 217 A (III).

their internal and local affairs, as well as ways and means for financing their autonomous functions.

Article 5

Indigenous peoples have the right to maintain and strengthen their distinct political, legal, economic, social and cultural institutions, while retaining their right to participate fully, if they so choose, in the political, economic, social and cultural life of the State.

Article 6

Every indigenous individual has the right to a nationality.

Article 7

1. Indigenous individuals have the rights to life, physical and mental integrity, liberty and security of person.

2. Indigenous peoples have the collective right to live in freedom, peace and security as distinct peoples and shall not be subjected to any act of genocide or any other act of violence, including forcibly removing children of the group to another group.

Article 8

1. Indigenous peoples and individuals have the right not to be subjected to forced assimilation or destruction of their culture.

2. States shall provide effective mechanisms for prevention of, and redress for:

(*a*) Any action which has the aim or effect of depriving them of their integrity as distinct peoples, or of their cultural values or ethnic identities;

(*b*) Any action which has the aim or effect of dispossessing them of their lands, territories or resources;

(*c*) Any form of forced population transfer which has the aim or effect of violating or undermining any of their rights;

(*d*) Any form of forced assimilation or integration;

(*e*) Any form of propaganda designed to promote or incite racial or ethnic discrimination directed against them.

Article 9

Indigenous peoples and individuals have the right to belong to an indigenous community or nation, in accordance with the traditions and customs of the community or nation concerned. No discrimination of any kind may arise from the exercise of such a right.

Article 10

Indigenous peoples shall not be forcibly removed from their lands or territories. No relocation shall take place without the free, prior and informed consent of the indigenous peoples concerned and after agreement on just and fair compensation and, where possible, with the option of return.

Article 11

1. Indigenous peoples have the right to practise and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures, such as archaeological and historical sites, artefacts, designs, ceremonies, technologies and visual and performing arts and literature.

2. States shall provide redress through effective mechanisms, which may include restitution, developed in conjunction with indigenous peoples, with respect to their cultural, intellectual, religious and spiritual property taken without their free, prior and informed consent or in violation of their laws, traditions and customs.

Article 12

1. Indigenous peoples have the right to manifest, practise, develop and teach their spiritual and religious traditions, customs and ceremonies; the right to maintain, protect, and have access in privacy to their religious and cultural sites; the right to the use and control of their ceremonial objects; and the right to the repatriation of their human remains.

2. States shall seek to enable the access and/or repatriation of ceremonial objects and human remains in their possession through fair, transparent and effective mechanisms developed in conjunction with indigenous peoples concerned.

Article 13

1. Indigenous peoples have the right to revitalize, use, develop and transmit to future generations their histories, languages, oral traditions, philosophies, writing systems and literatures, and to designate and retain their own names for communities, places and persons.

2. States shall take effective measures to ensure that this right is protected and also to ensure that indigenous peoples can understand and be understood in political, legal and administrative proceedings, where necessary through the provision of interpretation or by other appropriate means.

Article 14

1. Indigenous peoples have the right to establish and control their educational systems and institutions providing education in their own languages, in a manner appropriate to their cultural methods of teaching and learning.

2. Indigenous individuals, particularly children, have the right to all levels and forms of education of the State without discrimination.

3. States shall, in conjunction with indigenous peoples, take effective measures, in order for indigenous individuals, particularly children, including those living outside their communities, to have access, when possible, to an education in their own culture and provided in their own language.

Article 15

1. Indigenous peoples have the right to the dignity and diversity of their cultures, traditions, histories and aspirations which shall be appropriately reflected in education and public information.

2. States shall take effective measures, in consultation and cooperation with the indigenous peoples concerned, to combat prejudice and eliminate discrimination and to promote tolerance, understanding and good relations among indigenous peoples and all other segments of society.

Article 16

1. Indigenous peoples have the right to establish their own media in their own languages and to have access to all forms of non-indigenous media without discrimination.

2. States shall take effective measures to ensure that State-owned media duly reflect indigenous cultural diversity. States, without prejudice to ensuring full freedom of expression, should encourage privately owned media to adequately reflect indigenous cultural diversity.

Article 17

1. Indigenous individuals and peoples have the right to enjoy fully all rights established under applicable international and domestic labour law.

2. States shall in consultation and cooperation with indigenous peoples take specific measures to protect indigenous children from economic exploitation and from performing any work that is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development, taking into account their special vulnerability and the importance of education for their empowerment.

3. Indigenous individuals have the right not to be subjected to any discriminatory conditions of labour and, inter alia, employment or salary.

Article 18

Indigenous peoples have the right to participate in decision-making in matters which would affect their rights, through representatives chosen by themselves in accordance with their own procedures, as well as to maintain and develop their own indigenous decision-making institutions.

Article 19

States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free, prior and informed consent before adopting and implementing legislative or administrative measures that may affect them.

Article 20

1. Indigenous peoples have the right to maintain and develop their political, economic and social systems or institutions, to be secure in the enjoyment of their own means of subsistence and development, and to engage freely in all their traditional and other economic activities.

2. Indigenous peoples deprived of their means of subsistence and development are entitled to just and fair redress.

Article 21

1. Indigenous peoples have the right, without discrimination, to the improvement of their economic and social conditions, including, inter alia, in the areas of education, employment, vocational training and retraining, housing, sanitation, health and social security.

2. States shall take effective measures and, where appropriate, special measures to ensure continuing improvement of their economic and social conditions. Particular attention shall be paid to the rights and special needs of indigenous elders, women, youth, children and persons with disabilities.

Article 22

1. Particular attention shall be paid to the rights and special needs of indigenous elders, women, youth, children and persons with disabilities in the implementation of this Declaration.

2. States shall take measures, in conjunction with indigenous peoples, to ensure that indigenous women and children enjoy the full protection and guarantees against all forms of violence and discrimination.

Article 23

Indigenous peoples have the right to determine and develop priorities and strategies for exercising their right to development. In particular, indigenous peoples have the right to be actively involved in developing and determining health, housing and other economic and social programmes affecting them and, as far as possible, to administer such programmes through their own institutions.

Article 24

1. Indigenous peoples have the right to their traditional medicines and to maintain their health practices, including the conservation of their vital medicinal plants, animals and minerals. Indigenous individuals also have the right to access, without any discrimination, to all social and health services.

2. Indigenous individuals have an equal right to the enjoyment of the highest attainable standard of physical and mental health. States shall take the necessary steps with a view to achieving progressively the full realization of this right.

Article 25

Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.

Article 26

1. Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired.

2. Indigenous peoples have the right to own, use, develop and control the lands, territories and resources that they possess by reason of traditional ownership or other traditional occupation or use, as well as those which they have otherwise acquired.

3. States shall give legal recognition and protection to these lands, territories and resources. Such recognition shall be conducted with due respect to the customs, traditions and land tenure systems of the indigenous peoples concerned.

Article 27

States shall establish and implement, in conjunction with indigenous peoples concerned, a fair, independent, impartial, open and transparent process, giving due recognition to indigenous peoples' laws, traditions, customs and land tenure systems, to recognize and adjudicate the rights of indigenous peoples pertaining to their lands, territories and resources, including those which were traditionally owned or otherwise occupied or used. Indigenous peoples shall have the right to participate in this process.

Article 28

1. Indigenous peoples have the right to redress, by means that can include restitution or, when this is not possible, just, fair and equitable compensation, for the lands, territories and resources which they have traditionally owned or otherwise occupied or used, and which have been confiscated, taken, occupied, used or damaged without their free, prior and informed consent.

2. Unless otherwise freely agreed upon by the peoples concerned, compensation shall take the form of lands, territories and resources

equal in quality, size and legal status or of monetary compensation or other appropriate redress.

Article 29

1. Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. States shall establish and implement assistance programmes for indigenous peoples for such conservation and protection, without discrimination.

2. States shall take effective measures to ensure that no storage or disposal of hazardous materials shall take place in the lands or territories of indigenous peoples without their free, prior and informed consent.

3. States shall also take effective measures to ensure, as needed, that programmes for monitoring, maintaining and restoring the health of indigenous peoples, as developed and implemented by the peoples affected by such materials, are duly implemented.

Article 30

1. Military activities shall not take place in the lands or territories of indigenous peoples, unless justified by a relevant public interest or otherwise freely agreed with or requested by the indigenous peoples concerned.

2. States shall undertake effective consultations with the indigenous peoples concerned, through appropriate procedures and in particular through their representative institutions, prior to using their lands or territories for military activities.

Article 31

1. Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions.

2. In conjunction with indigenous peoples, States shall take effective measures to recognize and protect the exercise of these rights.

Article 32

1. Indigenous peoples have the right to determine and develop priorities and strategies for the development or use of their lands or territories and other resources.

2. States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources.

3. States shall provide effective mechanisms for just and fair redress for any such activities, and appropriate measures shall be taken to mitigate adverse environmental, economic, social, cultural or spiritual impact.

Article 33

1. Indigenous peoples have the right to determine their own identity or membership in accordance with their customs and traditions. This does not impair the right of indigenous individuals to obtain citizenship of the States in which they live.

2. Indigenous peoples have the right to determine the structures and to select the membership of their institutions in accordance with their own procedures.

Article 34

Indigenous peoples have the right to promote, develop and maintain their institutional structures and their distinctive customs, spirituality, traditions, procedures, practices and, in the cases where they exist, juridical systems or customs, in accordance with international human rights standards.

Article 35

Indigenous peoples have the right to determine the responsibilities of individuals to their communities.

Article 36

1. Indigenous peoples, in particular those divided by international borders, have the right to maintain and develop contacts, relations and cooperation, including activities for spiritual, cultural, political, economic and social purposes, with their own members as well as other peoples across borders.

2. States, in consultation and cooperation with indigenous peoples, shall take effective measures to facilitate the exercise and ensure the implementation of this right.

Article 37

1. Indigenous peoples have the right to the recognition, observance and enforcement of treaties, agreements and other constructive arrangements concluded with States or their successors and to have States honour and respect such treaties, agreements and other constructive arrangements.

2. Nothing in this Declaration may be interpreted as diminishing or eliminating the rights of indigenous peoples contained in treaties, agreements and other constructive arrangements.

Article 38

States, in consultation and cooperation with indigenous peoples, shall take the appropriate measures, including legislative measures, to achieve the ends of this Declaration.

Article 39

Indigenous peoples have the right to have access to financial and technical assistance from States and through international cooperation, for the enjoyment of the rights contained in this Declaration.

Article 40

Indigenous peoples have the right to access to and prompt decision through just and fair procedures for the resolution of conflicts and disputes with States or other parties, as well as to effective remedies for all infringements of their individual and collective rights. Such a decision shall give due consideration to the customs, traditions, rules and legal systems of the indigenous peoples concerned and international human rights.

Article 41

The organs and specialized agencies of the United Nations system and other intergovernmental organizations shall contribute to the full realization of the provisions of this Declaration through the mobilization, inter alia, of financial cooperation and technical assistance. Ways and means of ensuring participation of indigenous peoples on issues affecting them shall be established.

Article 42

The United Nations, its bodies, including the Permanent Forum on Indigenous Issues, and specialized agencies, including at the country level, and States shall promote respect for and full application of the provisions of this Declaration and follow up the effectiveness of this Declaration.

Article 43

The rights recognized herein constitute the minimum standards for the survival, dignity and well-being of the indigenous peoples of the world.

Article 44

All the rights and freedoms recognized herein are equally guaranteed to male and female indigenous individuals.

Article 45

Nothing in this Declaration may be construed as diminishing or extinguishing the rights indigenous peoples have now or may acquire in the future.

Article 46

1. Nothing in this Declaration may be interpreted as implying for any State, people, group or person any right to engage in any activity or to perform any act contrary to the Charter of the United Nations or construed as authorizing or encouraging any action which would dismember or impair, totally or in part, the territorial integrity or political unity of sovereign and independent States.

2. In the exercise of the rights enunciated in the present Declaration, human rights and fundamental freedoms of all shall be respected. The exercise of the rights set forth in this Declaration shall be subject only to such limitations as are determined by law

and in accordance with international human rights obligations. Any such limitations shall be non-discriminatory and strictly necessary solely for the purpose of securing due recognition and respect for the rights and freedoms of others and for meeting the just and most compelling requirements of a democratic society.

3. The provisions set forth in this Declaration shall be interpreted in accordance with the principles of justice, democracy, respect for human rights, equality, non-discrimination, good governance and good faith.