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P.O. Box 466
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**RE: Scoping Comments on the Ecological Effects of Uranium Mining
Mesa, Montrose, and San Miguel Counties, Colorado, USA**

Mr. Weisheit:

This letter presents my expert opinions regarding the ecological impacts associated with the proposed uranium mining in the vicinity of Mesa, Montrose, and San Miguel Counties, Colorado, USA. This report and my expert opinions are provided in support of Living Rivers – Colorado Riverkeeper ("Riverkeeper") scoping comments to the Draft *Programmatic Environmental Impact Statement* (*PEIS*) being developed by the United States Department of Energy (DOE) Office of Legacy Management (LM) for the proposed uranium mine lease renewals (http://ulpeis.anl.gov/index.cfm).

In addition to applying my experience and expertise, in forming the opinions expressed herein I drew upon the following documents:

1. US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

2. Colorado Division of Wildlife. *Comprehensive Wildlife Conservation Strategy and Wildlife Action Plans*. November 2, 2006.

3. Various technical reports, peer-reviewed scientific literature, and other documents cited herein that represent best available science on the subject.

A. *Introduction*

The proposed renewal of existing mineral leases and/or expansion to new mining areas for uranium mining will significantly and adversely affect the ecosystem. The context of the uranium mining is on the landscape scale, and because effects of the action will have global significance. The intensity of the mining and subsequent pollution from uranium and its radioactive decay products will very likely have an effect on organisms throughout the food chain, including humans.

B. Uranium Mining Process

The 2007 Uranium Leasing Program Final Programmatic Environmental Assessment describes some of the uranium mining process (page numbers in parentheses):

> “Uranium and vanadium ores would be recovered by either underground or open-pit mining methods. Activities common to both mining methods would include accessing the ore deposits, controlling possible pollutants, conducting mine maintenance, hauling ore and waste rock, and transporting ore to mills for processing.
>
> At underground mines, rubber-tired (trackless) equipment would typically be used to transport ore and mine-waste-rock from the mine workings (stopes and drifts) to the aboveground ore storage and mine-waste-rock pile areas through adits (almost horizontal mine entrances) or inclines/declines. In some instances, ore and mine-waste-rock would be transported by similar means to the ore skip and hoisted to the surface through the main production shafts. At open-pit mines, overburden consisting of mudstone, shale, and sandstone would be removed first to expose the ore deposit. This mine-waste-rock would be removed with conventional heavy equipment (e.g., backhoes, front-end loaders, scrapers, bulldozers, and haul trucks). Similar equipment would be used to remove the ore.
>
> Contaminants from mining operations that could be discharged inadvertently to an underground or surface water source would be controlled to minimize the potential for their release. Only three lease tracts (13, 13A, and 14) are located near perennial water sources (the Dolores River), and only one of those lease tracts (13) has existing mining activities close to the river. Diversion dams, berms, water bars, silt dams, dikes, and mine-waste-rock pile covers would be constructed to divert surface runoff from active areas of mine operations. Historically, water seepage into mine workings has been minor and would be expected to remain minor; however, a few mines (both underground and open pit) might require the leaseholder to pump water into treatment ponds. Methods of controlling water from these mines were discussed previously in the Mine-Water Discharge/Treatment Ponds discussion of this subsection. Limited rainfall throughout this region would have minimal potential to transport contaminants into water sources.
>
> Materials used to support mining activities could include bulk explosives, dynamite, and ammonium nitrate. These materials would be stored in approved areas within the underground mine or in an approved shed or building on the surface.” (3-16-17).[1]
>
> “[Underground] mining typically would be accomplished by a random room-and-pillar method, which involves leaving random pillars of ore and waste-rock in place to support the backs and removing ore material. Two different techniques could be used to mine the ore: the conventional drill/blast/muck technique (“muck” refers to the loading and removal of ore or mine-waste-rock from a mine) and the continuous-miner technique.

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[1] US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

The conventional technique might include the use of jackleg drills or similar devices to drill 2-inch diameter, 6- to 10-ft-deep holes in the rock face. The holes would then be filled with explosives, and the explosives would be detonated. The broken material would be removed with shuttle equipment such as load/haul/dumps (commonly referred to as LHDs) and multi-ton haul-trucks or buggies. Split-shooting also might be used in areas with narrow ore seams. In this technique, waste rock would be drilled, blasted, and mucked. The same process would then be used to remove the ore seam. After the ore seam was removed, shotcreting, rockbolting, timbering, or other methods would be used to support the mined-out areas.

The continuous-miner technique would use a machine referred to as a ‘miner,’ which removes ore and waste-rock without disturbing the surrounding host rock. The miner would deliver the ore and waste-rock directly to haul trucks for removal. As in the conventional technique, shotcreting, rockbolting, netting, timbering, or other methods would then be used to support the mined-out areas.

Ore removed from the mine would be stockpiled outside the mine for transport to the milling facilities by traditional over-the-road haul trucks.

During the course of underground mining, water would be needed to perform mining activities. Water would be required for underground drilling to prevent dust from becoming airborne and to remove cuttings from drill bits. Leaseholders could obtain water from a variety of sources, depending on the particular mine and its geographic location. Most underground mines are relatively dry; however, some mines receive seepage from nearby shallow aquifers. This water could be considered as a possible source for several of the mine operations. Other sources might include nearby municipal water supplies, springs, rivers, small ponds, and reservoirs. If water were not available on site, it would be obtained from the closest available source and hauled to the mine by water trucks. The amount of water needed would depend on the level of mining operation and the number of people working at the site. Permits and/or water right augmentations, if required, would be obtained from the appropriate local, state, or federal agencies.

The following operating conditions are considered appropriate for full production of ore on each of the 38 lease tracts; quantities of water for domestic use and surface drilling are not included.

- 120 drilling machines in operation
- 35 gallons of water per drilling machine per day
- 26 days of operation per month
- Multiple shift operations

Assuming historical amounts of ore would be produced under the Expanded Program alternative, about 10,000 gallons of water would be used monthly by each mining operation, which would be equivalent to the average amount consumed by 1.5 households. More than 90 percent of the water needed would be obtained from commercial sources. Continued use of this quantity of water would not have a noticeable

> impact on available water resources and would not affect adjudicated water rights. Under the Existing Program alternative, the quantities of water needed would remain at 10,000 gallons per month for each mining operation." (3-17-18).[2]
>
> "Small surface mining operations generally would use a trenching method, which involves the removal of only a small amount of waste rock to expose the ore. The ore would then be removed by conventional techniques. Once the ore was removed, reclamation would consist of backfilling the trench with waste rock materials and regarding and recontouring the immediate areas of disturbance.
>
> Larger operations generally would opt for a traditional, benched open pit in which the depth and size of the ore deposit would dictate the surface dimensions of the pit and benches. Underground mines, which would be used to access ore deposits around the periphery of the main deposit, might be associated with larger open-pit operations. The maintenance required for open-pit mine operations basically would be limited to maintaining the side walls of the pit, which would be subject to slope failure and to erosion from storm-water runoff. DOE's estimate of future disturbance assumes no new open-pit mines would be proposed. However, acreage of current disturbance includes the existing 200-acre open-pit mine at lease tract 7." (3-18, 3-19).[3]

C. Waste Materials from the Mining Process

"Both underground and open-pit mining operations would require removal of barren and low grade rock materials to allow access to the economical ore deposits. The removal process would result in large piles of mine-waste-rock. These mine-waste-rock materials typically contain limited quantities of miscellaneous mining-related debris (small remnants of mine timbers or wood lagging, drill steels, vent bags, etc.) that would be so intermingled with the mine-waste rock materials removed from the mine that it would be impractical to separate them. Accordingly, the leaseholder would be allowed to co-dispose of these materials in a mine-waste-rock pile. The mine-waste-rock piles would contain large fractions of coarse rock, much of which would be excavated from areas of little or no ore-grade mineralization. Consequently, the concentrations of radium and uranium in mine-waste-rock would be much lower than their concentrations in ore… Mining operations generate various types of non-hazardous waste including empty 55-gallon petroleum barrels, timbers, domestic trash, old mining equipment, and other mining debris." (3-16)[4]

One scientist writes about how different radioactive elements are produced from the mine tailings. "Uranium mining and ore-processing is an integral segment of the nuclear power program. The industry generates large quantity of waste called tailings. The tailings are mainly

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[2] US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

[3] US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

[4] US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

fine sand in slurry form, which is discharged into a large depository (tailings pond). Over the years there has been a growing emphasis on safe disposal of treated tailings effluent into freshwater ecosystems. The entire uranium series radionuclides are present in the tailings including ^{226}Ra, which has long radiological half-life (1,620Y), a similar behavior to Ca and a relatively high degree of radio toxicity compared with other uranium daughters (ICRP,1975). The distribution of ^{226}Ra into the biosphere depends on several factors such as physiochemical characteristics of the environmental media (e.g. soil, sediment, and water), physiological features of the concerned species and the role of competing ions."[5] (Cites ICRP, 1975: Report on the Task Group on Reference Man. Pergamon, Oxford. Public No. 23 [Chapter 2]).

Radioactivity can be described using a variety of units of measurement. Radioactive elements shed atomic particles, and become other elements. This shedding of atomic particles is disintegration. One disintegration per second (dps) is called a Becquerels (Bq), which is the SI (Systeme International) or metric unit, and may be expressed in microbecquerels, µBq, per kilogram or liter, kg or L. Another common unit of radioactivity is the curie (Ci), which is the amount of radioactive material giving off 3.7×10^{10} dps, or 37 billion disintegrations per second. The picocurie (1 pCi = 0.037 dps or 1×10^{-12} of a curie) is the unit used for many measurements of radioactive contamination. Seiverts, and miliSeiverts (mSv), are a measurement of energy per unit mass are also used to describe radiation.

Uranium takes different forms in water, each called a chemical species ("speciation"). "The speciation of uranium is relatively complex in natural surface waters (Markich and Camilleri, 1997). Uranium may occur in natural waters in three oxidation states: U^{4+}, UO_2^{+}, and UO_2^{2+}. The free uranyl ion (UO_2^{2+}) constitutes a minor proportion of the total U concentration (i.e., 8% at 0.1 µg/L declining to 2% at 4,000 µg/L) at pH 6. It is well recognized that the speciation of the uranyl ion in natural waters is influenced by factors such as pH and the concentration of inorganic and organic ligands (Markich et al., 1996). Markich et al. (1996) provided evidence that UO_2^{2+} and to a lesser extent UO_2OH^+ are the dissolved U species primarily responsible for causing adverse behavioral responses in the freshwater bivalve *Velesunio angasi*, between pH 5 and 6."[6] (Cites Markich and Camilleri, 1997: Investigation of metal toxicity to tropical biota. Recommendations for revision of the Australian water quality guidelines. Supervising Scientist Report 127. Supervising Scientist. Canberra: Australia.; and Markich et al., 1996: *Radiochim Acta* 74: 321-326).

One study reports on the mine waste: "the principal risks from uranium tailings are gamma radiation, essentially from radium decay, windblown radioactive dust dispersal, and radon gas and its radioactive progeny, which are known to cause lung cancer. Uranium mining is also associated with high concentrations of highly toxic heavy metals, which are a major source of surface and groundwater contamination. The uranium tissue targets in mammals, and risks

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[5] Jha, V.N., R.M. Tripathi, et al. Bioaccumulation of 226-Ra by plants growing in fresh water ecosystem around the uranium industry at Jaduguda, India. *Journal of Environmental Radioactivity* 101 (2010) 717-722.

[6] Semaan, M., D. A. Holdway, et al. Comparative Sensitivity of Three Populations of the Cladoceran *Moinodaphnia macleayi* to Acute and Chronic Uranium Exposure. *Environ Toxicol* 16: 365-376, 2001.

linked to exposure are kidney (high chemical risk), bones and lungs (high and medium radiological risks, respectively) (1799)."[7]

The study also describes the fate of water near mine waste piles: "The run-off surface water and/or the pit lake water percolating through the permeable heap leach mine wastes is able to dissolve minerals, mobilize elements and promote their dispersion through water flow. Therefore the open pit area presents a risk to surface and groundwater by continuous contaminant leaching. The acidity, sulphate and metals that are present in high concentrations in the mine drainage water are the result not only of pyrite oxidation but also of the residual product of the acid mine waste leaching process (1803)."[8]

Open pit mine water can contain high amounts of uranium and other elements that can harm the ecosystem. One study measured the levels in a mine-waste-rock pond: "manganese (107.82 mg/L), uranium (8.72 mg/L), zinc (17.05 mg/L), total iron (19.98 mg/L) and ferric ion (12.56 mg/L). The highest average concentrations of sulfate (1,410 mg/L) and hardness (6,035.17 mg/L)..."[9]

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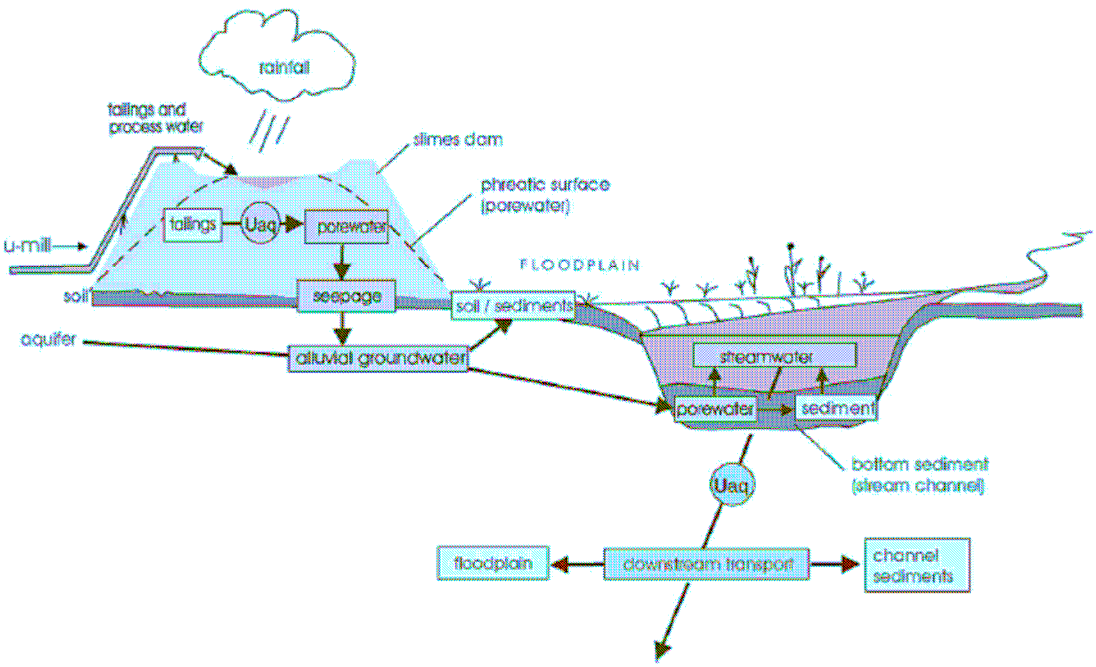

Fig. 1. Sediment-water systems of the aqueous pathway from slimes dams to streams (schematic).

Figure 1. Uranium (Uaq) moves from an unlined tailings pond to a stream.[10]

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[7] Neves, O., and M. J. Matias. Assessment of groundwater quality and contamination problems ascribed to an abandoned uranium mine (Cunha Baixa region, Central Portugal). *Environ Geol* (2008) 53:1799–1810.

[8] Neves, O., and M. J. Matias. Assessment of groundwater quality and contamination problems ascribed to an abandoned uranium mine (Cunha Baixa region, Central Portugal). *Environ Geol* (2008) 53:1799–1810.

[9] Campos, M.B., H.d. Azevedo, et al. Environmental assessment of water from a uranium mine (Caldas, Minas Gerais State, Brazil) in a decommissioning operation. *Environ Earth Sci* (2011) 62:857–863.

[10] Winde, Frank, Izak Jacobus van der Walt. The significance of groundwater–stream interactions and fluctuating stream chemistry on waterborne uranium contamination of streams—a case study from a gold mining site in South Africa. *Journal of Hydrology* 287 (2004) 178–196.

Gold mining can also produce uranium in tailings, which can migrate to streams under some conditions (Figure 1). The concentration of uranium, in parts per million (ppm) are shown below (Figure 2).

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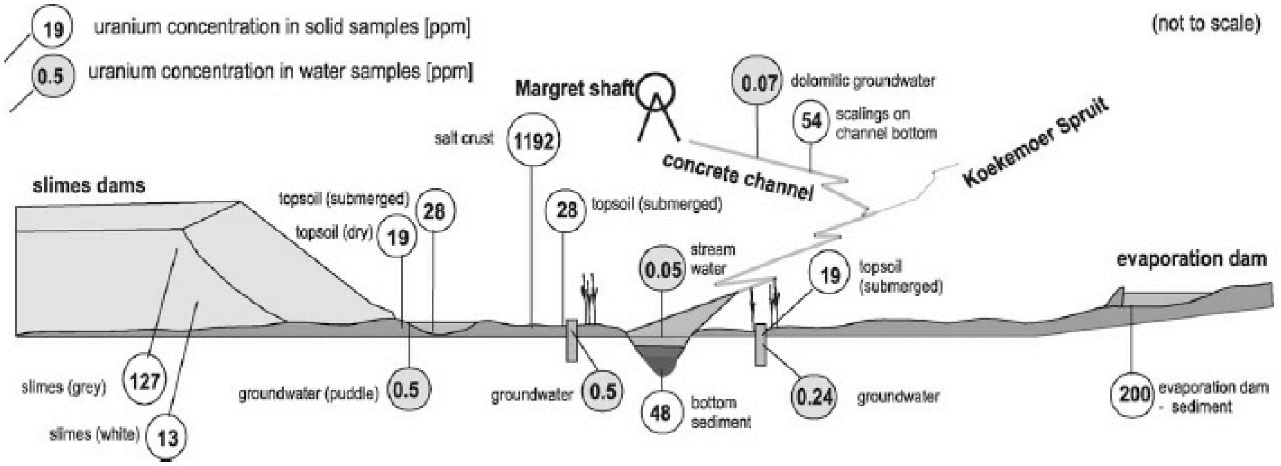

Fig. 4. Schematic cross-section through the floodplain of the Koekemoerspruit at gauging station C2H139 for illustrating the spatial distribution of uranium in water and sediments along the aqueous pathway.

Figure 2. Uranium levels (ppm) from unlined tailings pond to surface waters.[11]

Another study documents multiple instances of increased uranium levels in sediment near mines around the world, suggesting that despite mining regulations, contamination does occur. "Natural uranium concentrations in freshwater sediments range below 10 µg U/g dry wt (Kurnaz et al., 2007 and references therein), but higher levels have been measured in some specific sites. For example, maximum concentrations of 450 µg U/g dry wt (Lottermoser et al., 2005), 810 µg U/g dry wt (Lozano et al., 2002), 5,650 µg U/g dry wt (Neame et al., 1982) and 18,000 µg U/g dry wt (Hart et al., 1986) have been detected near mining sites in Australia, Spain and Canada." (527)[12] (Cites Kurnaz et al., 2007: *Appl. Radiat. Isot.* 65, 1281–1289; Lottermoser et al., 2005: *Environ. Geol.* 48, 748–761; Lozano et al., 2002: *J. Environ. Radioact.* 63, 153–171; Neame et al., 1982: *Hydrobiologia* 91–92, 355–361; Hart et al., 1986: *J. Great Lakes Res.* 12, 206–220).

"In the uranium district of northern Saskatchewan, Canada, most uranium deposits are situated relatively close to the surface and are mined using open-pit mining techniques. There are three primary 'contaminants of concern' associated with northern Saskatchewan uranium deposits, and they are nickel (Ni), molybdenum (Mo), and arsenic (As) (Golder Associates Ltd., 1996; Cameco Corp., 1997; Cameco Corp., 1998b). Potential sources of aquatic contamination arise from uranium ore processing (milling), open pit dewatering, and bulk water release from

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[11] Winde, Frank, Izak Jacobus van der Walt. The significance of groundwater–stream interactions and fluctuating stream chemistry on waterborne uranium contamination of streams—a case study from a gold mining site in South Africa. *Journal of Hydrology* 287 (2004) 178–196.

[12] Lagauze, Sandra, Raphael Terrail, et al. Ecotoxicity of uranium to *Tubifex tubifex* worms (Annelida, Clitellata, Tubificidae) exposed to contaminated sediment. *Ecotoxicology and Environmental Safety* 72 (2009) 527– 537.

old, mined-out, flooded open pits. Each source represents a different contamination scenario in different receiving environments."[13] (Cites: Golder Associates Ltd, 1996: RSP-0056. Atomic Energy Control Board, Ottawa, ON; Cameco Corp., 1997: Rabbit Lake Operation Decommissioning Annual Report. Atomic Energy Control Board (AECB), Saskatoon, SK; Cameco Corp., 1998b: Key Lake Operation: Annual Environmental Report 1997. Cameco Corporation, Saskatoon, SK).

D. Effects of Uranium Mines on the Ecosystem

Uranium mining has been shown to affect ecosystems around the world. Uranium can contaminate groundwater, enter drinking water sources, and pose a risk to human and ecosystem health via bioaccumulation through the food chain (or food web).[14] Studies discussed below have shown that uranium can move into organisms at every trophic level, which means that the context of the bioaccumulation effects goes beyond the mine site to wherever those organisms travel. The ability of uranium to move through groundwater also broadens the context of effects to include organisms in streams that may receive polluted groundwater inputs. Given the radioactive nature of uranium mine wastes, the intensity of the effects can be severe if pollution is concentrated enough to produce mortality, directly or indirectly. Because of the potentially severe intensity of the effects, uranium mining warrants careful review and consideration of ecological effects.

Plants and organisms with chlorophyll are the largest base of the food chain, because they photosynthesize solar energy, air, and water into sugar. They are considered primary producers, and represent the most direct living link to solar energy. Uranium is absorbed by plants, including food crops, which can receive uranium from polluted irrigation or groundwater; phytotoxicity may result at soil levels between 5 – 158 mg/kg U.[15]

"In most natural waters, uranium is present in concentrations between 0.1 and 10 µg/L. Uranium concentrations greater than 100 µg/L are quite rare and, generally, have been found only in aquifer systems containing uranium mineralization."[16] Groundwater wells near a reclaimed uranium mine in Portugal showed median uranium levels of 330 - 1,200 µg/L, and the mine water itself between 2,600 – 3,200 µg/L.[17]

Uranium decays into radium, a radioactive element discharged to rivers in Colorado and absorbed by organisms. "Tsivoglue (1964) used filamentous algae in monitoring the Animas River radioactivity in the vicinity of uranium mills at Colorado, USA. The ^{226}Ra concentration

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[13] Pyle, G.G, S.M. Swanson, et al. Toxicity of uranium mine receiving waters to early life stage fathead minnows (*Pimephales promelas*) in the laboratory. *Environmental Pollution* 116 (2002) 243–255.

[14] Neves, O., and M. J. Matias. Assessment of groundwater quality and contamination problems ascribed to an abandoned uranium mine (Cunha Baixa region, Central Portugal). *Environ Geol* (2008) 53:1799–1810.

[15] Neves, O., and M. J. Matias. Assessment of groundwater quality and contamination problems ascribed to an abandoned uranium mine (Cunha Baixa region, Central Portugal). *Environ Geol* (2008) 53:1799–1810.

[16] Neves, O., and M. J. Matias. Assessment of groundwater quality and contamination problems ascribed to an abandoned uranium mine (Cunha Baixa region, Central Portugal). *Environ Geol* (2008) 53:1799–1810.

[17] Neves, O., and M. J. Matias. Assessment of groundwater quality and contamination problems ascribed to an abandoned uranium mine (Cunha Baixa region, Central Portugal). *Environ Geol* (2008) 53:1799–1810.

of 1.5 x 10^2 Bq/kg of algal ash were recorded for uncontaminated streams, whereas, a concentration as high as 1.3 x 10^5 Bq/kg of algal ash was recorded for polluted locations in the Animas River, showing the high extent of potential contamination of algae for ^{226}Ra. This stimulated the development of carrying out environmental impact assessment following Uranium mill effluent discharge through the study of radioactivity associated with the algae growing in the habitat."[18] (Cites Tsivoglue 1964: Environmental monitoring in the vicinity of uranium mill. In: *Proc. of IAEA symposium on Radiological Health and Safety in mining and milling of nuclear materials*, Vienna, 1963, 2, 231-245).

Studies in India have shown that primary producers, including filamentous algae and rooted vascular plants, can absorb radioactive radium particles created from uranium mining, and thus enter the food web. The plant *Polygonum barbartum* (knotweed) contained 1.5 – 58 Bq/kg fresh weight of ^{226}Ra; *Cyperus rutundus* (purple nutsedge) contained 217 Bq/kg, *Vallesnaria sp.* (tapegrass, wild celery) contained 549 Bq/kg, *Marsilea sp.* (water clover) contained 310 – 610 Bq/kg, and *Nymphaea sp.* (water lily) contained 101 Bq/kg in parts.[19] Filamentous algae contained up to 9,850 Bq/kg fresh weight of ^{226}Ra, and the non-filamentous algae up to 987 Bq/kg.[20]

The second trophic level of the food web after the primary producers (plants) is the primary consumers. These include the zooplankton, tiny animals that eat plants, algae and detritus in the water column. Zooplankton in freshwater includes cladocerans, very small crustaceans that are consumed by larger animals. Research shows that uranium concentrations in water between 20 – 49 µg/L can impair cladoceran reproduction.[21] Uranium is also acutely toxic to cladocerans: "the 48 hour LOEC [lowest observed effect concentration] and EC50 (immobilization-lethality) [effective concentration on 50% of population] for uranium ranged between 180 – 370 µg/L and 160 – 390 µg/L, respectively." (374)[22]

Freshwater mussels (*Velesunio angasi*), are also primary consumers and feed on particles in the water column. Mussels that live near old uranium mines can absorb and store radium in calcium phosphate granules in the flesh, and have the potential to transmit it to humans, especially to native cultures that may consume mussels regularly (519).[23] Radium (^{226}Ra) decays into lead (^{210}Pb) and polonium (^{210}Po) after it is absorbed by the mussel, so all these decay products of uranium can move up the food chain and into humans and other consumers: "the maximum mining related dose due to the consumption of 2 kg of mussels from site 5 has been revised to 0.03 mSv [mili-Seivert] (0.01 mSv for an adult), originating from tailings ^{226}Ra. This

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[18] Jha, V.N., R.M. Tripathi, et al. Bioaccumulation of 226-Ra by plants growing in fresh water ecosystem around the uranium industry at Jaduguda, India. *Journal of Environmental Radioactivity* 101 (2010) 717-722.

[19] Jha, V.N., R.M. Tripathi, et al. Bioaccumulation of 226-Ra by plants growing in fresh water ecosystem around the uranium industry at Jaduguda, India. *Journal of Environmental Radioactivity* 101 (2010) 717-722.

[20] Jha, V.N., R.M. Tripathi, et al. Bioaccumulation of 226-Ra by plants growing in fresh water ecosystem around the uranium industry at Jaduguda, India. *Journal of Environmental Radioactivity* 101 (2010) 717-722.

[21] Semaan, M., D. A. Holdway, et al. Comparative Sensitivity of Three Populations of the Cladoceran *Moinodaphnia macleayi* to Acute and Chronic Uranium Exposure. *Environ Toxicol* 16: 365-376, 2001.

[22] Semaan, M., D. A. Holdway, et al. Comparative Sensitivity of Three Populations of the Cladoceran *Moinodaphnia macleayi* to Acute and Chronic Uranium Exposure. *Environ Toxicol* 16: 365-376, 2001.

[23] Ryan, Bruce, Andreas Bollhoefer, et al. Radionuclides and metals in freshwater mussels of the upper South Alligator River, Australia. *Journal of Environmental Radioactivity* 99 (2008) 509-526.

is approximately 15% of the total dose received by local Aboriginal people in the area from the ingestion of mussels. It is far less than the mining origin contribution from the consumption of terrestrial animals in the South Alligator River valley, which amounted to approximately 160 mSv for an adult in the region, with ^{210}Po being a main contributor. This emphasizes the need to determine concentration factors for terrestrial flora and fauna as well as aquatic food sources to be able to reliably estimate ingestion doses received due to remnants from past and rehabilitated mine sites (524).”[24] This research shows that not only the aquatic ecosystem can be affected by uranium and by-products, but also terrestrial plants and animals as well.

Worms also can absorb uranium contained in sediments through feeding and absorption.[25] Tubifex worms (*Tubifex tubifex*) are aquatic worms that dig burrows in the ground, and live exposed to both the water column and sediments. They are food for secondary consumers, predators, in the water column, and represent a link in the ecosystem between the primary consumers and secondary consumers.

An experiment with tubifex worms determined that survival fell significantly in aquatic sediment uranium levels of 599 µg U/g dry weight and above; “the LC [lethal concentration] values were LC_{20} = 1,778 ($CI_{95\%}$ = 1,222–2,575) and LC_{50} = 2,910 ($CI_{95\%}$ = 2,419–3,618) µg U/g dry wt.” (530).[26] Uranium in sediment can limit the length of the galleries the worms excavate for feeding, and the excavation can also increase the water column concentration by releasing uranium in contaminated sediment (533).[27] Observations indicate that “uranium may disrupt tissue mechanisms such as cell growth and differentiation… During the observations, it was obvious that the uranium-exposed worms had morphological differences (e.g., excrescences, deformities, formation of two heads) compared with control worms (534).”[28]

Tubifex worms are reportedly more hardy than other benthic invertebrates, and their ability to resist toxins like uranium in sediment is high. “The LC_{50} of our study was seven times higher than that for the amphipod, *Hyalella. azteca*, after 14 days (LC_{50} = 436 µg U/g dry wt; Environnement Canada, 2003) and 459 times higher than that for *Chironomus riparius* (Dias et al., 2008) after 10 days (LC_{50} = 5.30 µg U/g dry wt, respectively), all of which involved exposure to artificial sediments contaminated with uranium. Further, in a bioassay conducted on *C. riparius* under the same conditions as ours (same composition of water and sediments), the LC_{50} and LC_{20} were 856 µg U/g dry wt ($CI_{95\%}$ = 669–1,170) and 424 ($CI_{95\%}$ = 236–646) µg U/g dry wt, respectively (unpublished data). In this more comparable case, the LC_{50} and LC_{20} of *T. tubifex* were three times higher than those of *C. riparius*. On the basis of all these results, *T. tubifex* would thus seem to be less sensitive than these other three species of invertebrates (527-

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[24] Ryan, Bruce, Andreas Bollhoefer, et al. Radionuclides and metals in freshwater mussels of the upper South Alligator River, Australia. *Journal of Environmental Radioactivity* 99 (2008) 509-526.

[25] Lagauze, Sandra, Raphael Terrail, et al. Ecotoxicity of uranium to *Tubifex tubifex* worms (Annelida, Clitellata, Tubificidae) exposed to contaminated sediment. *Ecotoxicology and Environmental Safety* 72 (2009) 527– 537.

[26] Lagauze, Sandra, Raphael Terrail, et al. Ecotoxicity of uranium to *Tubifex tubifex* worms (Annelida, Clitellata, Tubificidae) exposed to contaminated sediment. *Ecotoxicology and Environmental Safety* 72 (2009) 527– 537.

[27] Lagauze, Sandra, Raphael Terrail, et al. Ecotoxicity of uranium to *Tubifex tubifex* worms (Annelida, Clitellata, Tubificidae) exposed to contaminated sediment. *Ecotoxicology and Environmental Safety* 72 (2009) 527– 537.

[28] Lagauze, Sandra, Raphael Terrail, et al. Ecotoxicity of uranium to *Tubifex tubifex* worms (Annelida, Clitellata, Tubificidae) exposed to contaminated sediment. *Ecotoxicology and Environmental Safety* 72 (2009) 527– 537.

528)."[29] (Cites: Environnement Canada, 2003: Liste des substances d'inte´ re^t prioritaire—Rapport d'e´valuation—Rejets de radionucle´ ides des installations nucle´ aires (effets sur les espe` ces autre que l'e^tre humain), Gouvernement du Canada; Dias et al., 2008: Chemosphere 71, 574–581).

Uranium appears throughout the food chain and in secondary consumers, in this case predatory insects. Ground beetles (12 families identified, including predatory beetles) at former mine sites accumulated uranium at 2-41 times the levels found in uncontaminated areas, and exhibited reduced community diversity.[30] Soil macrofauna, consisting of various beetle larvae and other invertebrates, was significantly less abundant at contaminated sites.[31]

Amphibians such as frogs and toads can also be affected by uranium mining. This is important in the food web because "amphibians are, in many cases top predators, playing an important role in the aquatic community and bioaccumulating contaminants (Loumbourdis et al., 1999). In addition they are some of the most sensitive vertebrates to environmental changes, due, in most cases, to an early aquatic-dependent development stage and a highly permeable skin (Duellman and Trueb, 1994). Several studies have shown the toxic effects of metals in this kind of animals. Among the most common deleterious effects of metals on amphibians, reduction of immune functions (Linzey et al., 2003), limb, mouth and tail malformations and other kind of abnormalities (Calevro et al., 1998; Rowe and Freda, 2000; Linzey et al., 2003), behaviour alterations, growth reduction and survival decrease (Lefcort et al., 1998) were recorded. (29)"[32] (Cites: (Loumbourdis et al., 1999): *Environ Pollut* 1999;104:429–33; (Duellman and Trueb, 1994): Biology of amphibia. Baltimore, MD: John Hopkins University Press; 1994. 670 pp; (Linzey et al., 2003): *Int J Environ Health Res* 2003;13:125–48; (Calevro et al., 1998): *Chemosphere* 1998;37:3011–7; (Rowe and Freda, 2000): In: *Ecotoxicoloy of amphibians and reptiles.* SETAC technical publication series. Columbia, USA: SETAC Press; 2000. p. 545–70; (Lefcort et al., 1998): *Arch Environ Contam Toxicol* 1998;35:447–56).

Frog larvae (*Rana perezi* Seoane) grown in water from the effluent pond near an *in situ* uranium mine showed reduced body size, increased pigmentation, and tail abnormalities, and reduced movement after 96 hours (33).[33] The effluent also contained other heavy metals, which accumulated in the frog larvae. The dry weight of the metals found in frog larvae after 192 hours were: aluminum (Al) 603.01 mg/kg, manganese (Mn) 118.63 mg/kg, iron (Fe) 321.48 mg/kg, nickel (Ni) 5.36 mg/kg, zinc (Zn) 237.97 mg/kg, strontium (Sr) 2.83 mg/kg, lead (Pb) 2.27 mg/kg, and uranium (U) at 113.37 mg/kg (33). The pond water contained uranium and other metals: 7,450 μg/L Mn, 3,260 μg/L Fe, 154 μg/L Ni, 451 μg/L Zn, 65.3 μg/L Sr, 0.69 μg/L Pb,

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[29] Lagauze, Sandra, Raphael Terrail, et al. Ecotoxicity of uranium to *Tubifex tubifex* worms (Annelida, Clitellata, Tubificidae) exposed to contaminated sediment. *Ecotoxicology and Environmental Safety* 72 (2009) 527– 537.

[30] Gongalsky, Konstantin. Impact of Pollution Casued by Uranium Production on Soil Macrofauna. *Environmental Monitoring and Assessment* 89: 197–219, 2003.

[31] Gongalsky, Konstantin. Impact of Pollution Casued by Uranium Production on Soil Macrofauna. *Environmental Monitoring and Assessment* 89: 197–219, 2003.

[32] Marques, S.M., F. Goncalves, et al. Effects of a uranium mine effluent in the early-life stages of *Rana perezi* Seoane. *Science of the Total Environment* 40:2 (2008) 29 – 35.

[33] Marques, S.M., F. Goncalves, et al. Effects of a uranium mine effluent in the early-life stages of *Rana perezi* Seoane. *Science of the Total Environment* 40:2 (2008) 29 – 35.

and 1,750 µg/L U (33).[34] This water caused a significant 28 percent mortality to the tadpole test subjects.[35]

Fish are present in the food web as primary consumers (vegetarian fish), secondary consumers (small predatory fish), and sometimes tertiary consumers (large predatory fish). They are of particular concern near uranium mines. According to the best available science, mine waste contaminant mixtures may have different effects than the individual compounds in the mixture, and should be addressed for all discharges: "fish inhabiting water bodies that receive industrial effluents are exposed to a complex mixture of potential toxicants. The toxicity of a particular contaminant is dependent on the chemistry of the receiving water, the sensitivity of individual species, and site-specific characteristics of the local geology (Holdway, 1992). Environmental regulations are typically based on concentrations of individual contaminants released to the receiving environment, and may not adequately protect indigenous biota against toxicity arising from exposure to a complex mixture. The scientific basis for these regulations is derived from laboratory toxicity testing using standard methodologies and test species that may or may not reflect a realistic exposure scenario (Chapman, 1983; Cairns, 1986; Holdway, 1992)."[36] (Cites: Holdway, 1992: *Ecotoxicology* 1, 75–88; Chapman, 1983: In: *Aquatic Toxicology and Hazard Assessment: Sixth Symposium.* American Society for Testing and Materials, Philadelphia, PA, pp. 315–327; Cairns, 1986: *BioSci.* 36, 670–672).

Research shows that fish from ponds near uranium mines can absorb and/or concentrate uranium, thorium, lead, and polonium.[37] Concentration in an organism is described by a ratio between the organism and environment. "The concentration ratio (CR) is a transfer parameter calculated as the ratio between steady-state concentrations in connected compartments of a model under equilibrium conditions (ICRP, 1978). Compartments may include vegetation comprising the diet and the tissues of an animal (e.g. bone). The CR is used to model equilibrium conditions. (208)"[38]

The CR was measured for laketrout (*Salvelinus namaycush*) and whitefish (*Coregonus clupeaformis* and *Prosopium cylindraceum*), and the concentration ratios listed for each species:

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[34] Marques, S.M., F. Goncalves, et al. Effects of a uranium mine effluent in the early-life stages of *Rana perezi* Seoane. *Science of the Total Environment* 40:2 (2008) 29 – 35.

[35] Marques, S.M., F. Goncalves, et al. Effects of a uranium mine effluent in the early-life stages of *Rana perezi* Seoane. *Science of the Total Environment* 40:2 (2008) 29 – 35.

[36] Pyle, G.G, S.M. Swanson, et al. Toxicity of uranium mine receiving waters to early life stage fathead minnows (*Pimephales promelas*) in the laboratory. *Environmental Pollution* 116 (2002) 243–255.

[37] Clulow, F.V., N.K. Dave', et al. Radionuclides (lead-210, polonium-210, thorium-230, and-232) and thorium and uranium in water, sediments, and fish from lakes near the city of Elliot Lake, Ontario, Canada. *Environmental Pollution* 99 (1998) 199-213.

[38] Clulow, F.V., N.K. Dave', et al. Radionuclides (lead-210, polonium-210, thorium-230, and-232) and thorium and uranium in water, sediments, and fish from lakes near the city of Elliot Lake, Ontario, Canada. *Environmental Pollution* 99 (1998) 199-213.

Table 1. Corresponding CRs calculated in this study[39] are:

	[wet bone]/[total in water]	[wet muscle]/[total in water]
^{210}Pb		
Laketrout	747-1690	
Whitefish	1020-1280	
U		
Laketrout	27.3-167	
Whitefish	206-8320	1.55-24.3

The study shows that fish bioaccumulate and concentrate uranium and radioactive decay products. Uranium in laketrout bone was found as high as 4.40 µg/g dry weight (mean), and 14.60 µg/g dry weight (mean) in whitefish bone. Polonium-210 (^{210}Po) was measured by dry weight in bone of laketrout as high as 208 mBq/g and whitefish at 86 mBq/g. Lead-210 (^{210}Pb) was measured in bone by dry weight as high as 186 mBq/g in laketrout, and 76 mBq/g in whitefish.[40]

This Canadian study recommends: "Although activity levels of radioactive materials in fish tissues are low, in aggregate they may represent 2-16% of the public dose limit, using worst case scenarios. On this basis, we recommend that: Regular monitoring of muscle radionuclide levels, especially ^{210}Pb, in fish from watersheds containing U operations, be carried out, and that the contribution of consumption of such fish to the public dose be calculated. As possible effects of radionuclides on the health of fish (and other non-human organisms) are of concern (vide Waite et al., 1988, 1990), it is recommended that: Fish in the Serpent River watershed be studied to assess their pathology and genetics. A survey should be conducted on the health of fish in the watershed that includes recording the incidence of any malformations and neoplasms, any anomalous reproductive or anatomical parameters, and the genetic composition of fish stocks in waters affected by the mining and milling operations."[41] (Cites Waite et al., 1988, 1990: *Archives of Environmental Contamination and Toxicology* 17, 373-380).

Lake water near uranium strip mining operations caused fathead minnow (*Pimephales promelas*) eggs to hatch earlier than unaffected control lakes, and "egg hatchability was negatively correlated ($P<0.05$) with As, B, Ba, Cd, Mo, and Sr. The time required for fathead minnow eggs to hatch was positively correlated with Al, As, B, Ba, Cd, Mo, and Sr, but negatively correlated with U ($P<0.05$). Larval growth as measured by weight was positively correlated with Co and Ni ($P<0.05$). Larval mortality was significantly and negatively related to Ba, Ni, and U concentration ($P<0.05$). (249)"[42]

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[39] Clulow, F.V., N.K. Dave', et al. Radionuclides (lead-210, polonium-210, thorium-230, and-232) and thorium and uranium in water, sediments, and fish from lakes near the city of Elliot Lake, Ontario, Canada. *Environmental Pollution* 99 (1998) 199-213.

[40] Clulow, F.V., N.K. Dave', et al. Radionuclides (lead-210, polonium-210, thorium-230, and-232) and thorium and uranium in water, sediments, and fish from lakes near the city of Elliot Lake, Ontario, Canada. *Environmental Pollution* 99 (1998) 199-213.

[41] Clulow, F.V., N.K. Dave', et al. Radionuclides (lead-210, polonium-210, thorium-230, and-232) and thorium and uranium in water, sediments, and fish from lakes near the city of Elliot Lake, Ontario, Canada. *Environmental Pollution* 99 (1998) 199-213.

[42] Pyle, G.G, S.M. Swanson, et al. Toxicity of uranium mine receiving waters to early life stage fathead minnows (*Pimephales promelas*) in the laboratory. *Environmental Pollution* 116 (2002) 243–255.

E. Sensitive Wildlife Species Affected by Mining

The federally-listed threatened, endangered, and candidate (C) plant and animal species found in Mesa, Montrose, and San Miguel counties are listed below (Tables 2, 3).

Table 2. Federally-listed Animal Species

Common Name	**Scientific Name**	**Status**	**Mesa**	**Montrose**	**San Miguel**
Uncompahgre fritillary butterfly	*Boloria acrocnema*	E			X
Bonytail chub	*Gila elegans*	E	X		
Humpback chub	*Gila cypha*	E	X		
Whooping Crane	*Grus americana*	E	County-level Range Undefined		
Black-footed ferret	*Mustela nigripes*	E	County-level Range Undefined		
Southwestern willow flycatcher	*Empidonax traillii extimus*	E			X
Canada lynx	*Lynx canadensis*	T	X	X	X
Mexican spotted owl	*Strix occidentalis lucida*	T		X	X
Colorado pikeminnow	*Ptychocheilus lucius*	E	X		
Razorback sucker	*Xyrauchen texanus*	E	X		
Greenback cutthroat trout	*Oncorhynchus clarki ssp. stomias*	T	X	X	
Gray wolf	*Canis lupus*	E	County-level Range Undefined		
Grizzly bear	*Ursus arctos horribilis*	T	Not Known in Co. Since 1979		

Table 3. Federally-listed Plant Species

Common Name	**Scientific Name**	**Status**	**Mesa**	**Montrose**	**San Miguel**
Colorado hookless cactus	*Sclerocactus glaucus*	T	X	X	
Debeque phacelia	*Phacelia submutica*	T	X		
Clay-loving wild buckwheat	*Eriogonum pelinophilum*	E		X	

The state of Colorado has its own list of state sensitive species. The list includes state threatened, state endangered species, and species of “state special concern.” These additional wildlife species of concern (SC) are listed below (Table 4).

Table 4. Colorado State-Listed Wildlife Species. *Status Codes: FE = Federally Endangered; FT = Federally Threatened; SE = State Endangered; ST = State Threatened; SC = State Special Concern (not a statutory category).

Common Name	**Scientific Name**	**Status***
AMPHIBIANS		
Boreal Toad	*Bufo boreas boreas*	SE
Northern Cricket Frog	*Acris crepitans*	SC
Great Plains Narrowmouth Toad	*Gastrophryne olivacea*	SC
Northern Leopard Frog	*Rana pipiens*	SC
Wood Frog	*Rana sylvatica*	SC
Plains Leopard Frog	*Rana blairi*	SC
Couch's Spadefoot	*Scaphiopus couchii*	SC
BIRDS		
Whooping Crane	*Grus americana*	FE, SE
Least Tern	*Sterna antillarum*	FE, SE
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	FE, SE
Plains Sharp-Tailed Grouse	*Tympanuchus phasianellus jamesii*	SE
Piping Plover	*Charadrius melodus circumcinctus*	FT, ST
Bald Eagle	*Haliaeetus leucocephalus*	SC
Mexican Spotted Owl	*Strix occidentalis lucida*	FT, ST
Burrowing Owl	*Athene cunicularia*	ST
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	ST
Western Yellow-Billed Cuckoo	*Coccyzus americanus*	SC
Greater Sandhill Crane	*Grus canadensis tabida*	SC
Ferruginous Hawk	*Buteo regalis*	SC
Gunnison Sage-Grouse	*Centrocercus minimus*	SC
American Peregrine Falcon	*Falco peregrinus anatum*	SC
Greater Sage Grouse	*Centrocercus urophasianus*	SC
Western Snowy Plover	*Charadrius alexandrinus*	SC
Mountain Plover	*Charadrius montanus*	SC
Long-Billed Curlew	*Numenius americanus*	SC
Columbian Sharp-Tailed Grouse	*Tympanuchus phasianellus columbianus*	SC
FISH		
Bonytail	*Gila elegans*	FE, SE
Razorback Sucker	*Xyrauchen texanus*	FE, SE
Humpback Chub	*Gila cypha*	FE, ST
Colorado Pikeminnow	*Ptychocheilus lucius*	FE, ST
Greenback Cutthroat Trout	*Oncorhynchus clarki stomias*	FT, ST
Rio Grande Sucker	*Catostomus plebeius*	SE
Lake Chub	*Couesius plumbeus*	SE
Plains Minnow	*Hybognathus placitus*	SE
Suckermouth Minnow	*Phenacobius mirabilis*	SE
Northern Redbelly Dace	*Phoxinus eos*	SE
Southern Redbelly Dace	*Phoxinus erythrogaster*	SE
Brassy Minnow	*Hybognathus hankinsoni*	ST

Common Name	**Scientific Name**	**Status***
FISH, Continued		
Common Shiner	*Luxilus cornutus*	ST
Arkansas Darter	*Etheostoma cragini*	ST
Mountain Sucker	*Catostomus playtrhynchus*	SC
Plains Orangethroat Darter	*Etheostoma spectabile*	SC
Iowa Darter	*Etheostoma exile*	SC
Rio Grande Chub	*Gila pandora*	SC
Colorado Roundtail Chub	*Gila robusta*	SC
Stonecat	*Noturus flavus*	SC
Colorado River Cutthroat Trout	*Oncorhynchus clarki pleuriticus*	SC
Rio Grande Cutthroat Trout	*Oncorhynchus clarki virginalis*	SC
Flathead Chub	*Platygobio gracilus*	SC
MAMMALS		
Gray Wolf	*Canis lupus*	FE, SE
Black-Footed Ferret	*Mustela nigripes*	FE, SE
Grizzly Bear	*Ursus arctos*	FT, SE
Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*	FT, ST
Canada Lynx	*Lynx canadensis*	FT, SE
Wolverine	*Gulo gulo*	SE
River Otter	*Lontra canadensis*	ST
Kit Fox	*Vulpes macrotis*	SE
Townsend's Big-Eared Bat	*Corynorhinus townsendii pallescens*	SC
Black-Tailed Prairie Dog	*Cynomys ludovicianus*	SC
Botta's Pocket Gopher	*Thomomy bottae rubidus*	SC
Northern Pocket Gopher	*Thomomys talpoides macrotis*	SC
Swift fox	*Vulpes velox*	SC
REPTILES		
Triploid Checkered Whiptail	*Cnemidophorus neotesselatus*	SC
Midget Faded Rattlesnake	*Crotalus viridis concolor*	SC
Longnose Leopard Lizard	*Gambelia wislizenii*	SC
Yellow Mud Turtle	*Kinosternon flavescens*	SC
Common King Snake	*Lampropeltis getula*	SC
Texas Blind Snake	*Leptotyphlops dulcis*	SC
Texas Horned Lizard	*Phrynosoma cornutum*	SC
Roundtail Horned Lizard	*Phrynosoma modestum*	SC
Massasauga	*Sistrurus catenatus*	SC
Common Garter Snake	*Thamnophis sirtalis*	SC

Common Name	Scientific Name	Status*
MOLLUSKS		
Rocky Mountain Capshell	*Acroloxus coloradensis*	SC
Cylindrical Papershell	*Anodontoides ferussacianus*	SC

The uranium and other elements released from mining that enter the food chain show that the potential for harm exists even if pollutant levels are low. Once a pathway from the environment into the organism exists, higher concentrations of those pollutants have an opportunity to cause biological harm as they are absorbed in greater amounts. Since organisms throughout the food chain absorb mining pollution, the ecological effects could be catastrophic.

The uranium mining could affect the life history of several rare, threatened, or endangered species. A few are detailed below that may be of particular concern. Because of the low numbers of individuals in the populations, protection of habitat that may be colonized if numbers increase is very important. So even if a listed species does not occur on the site, it may be affected by the proposed mining's disruption of habitat, because it cannot grow into that area if conditions improve. Sensitive fish that live downstream will be affected by pollution as demonstrated by the studies presented elsewhere in this letter.

Sage Grouse. The greater sage grouse is a candidate species for listing under the ESA and is in rapid decline. The uranium mines are located in or near current and historic Gunnison sage grouse range, as shown in Figures 3 and 4.[43]

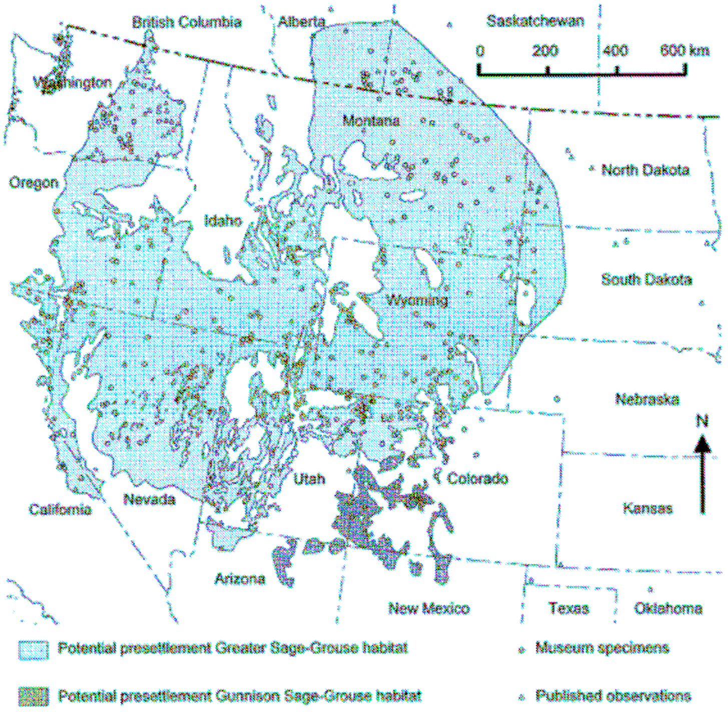

Figure 3. Historic Distribution of Greater and Gunnison Sage Grouse (Schroeder, M.A. *et al,* 2004).

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[43] Schroeder, Michael, A., Cameron L. Aldridge, et al. Distribution of Sage-Grouse in North America. *The Condor*, 106(2): 363-376. 2004.

Figure 4. Current Distribution of Greater and Gunnison Sage Grouse (Schroeder, M.A. *et al,* 2004).

Energy exploration activity and mining are known to disturb sage grouse in several ways. In addition to destroying the sagebrush habitat directly, greater sage grouse tend to avoid areas where drilling is occurring, as seen in the Powder River Basin of Wyoming.[44] Changes to the ecosystem can affect the survival of the birds, and human-caused "ecological traps" may be attractive nesting areas but show high risk of mortality.[45] For example, birds might get hit by vehicles on back roads, or exposed to raptors perching on structures. "Chick mortalities tended to occur in proximity to oil and gas developments."[46]

The proposed uranium mine operations should be evaluated for similarity to oil and gas developments, and if similar, should be assumed to have the same negative effects on the sage grouse. Much of the research on sage grouse pertains to the greater sage grouse, and may also apply to the Gunnison sage grouse and other species.

The 2007 DOE *Programmatic Environmental Assessment* states that Gunnison sage grouse are located in near lease tract 9, in Montrose County. "The occupied habitat of the Gunnison sage grouse, a state candidate species, overlaps the western portion of lease tract 9. Disturbance

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[44] Dougherty, K.E., *et al*. Greater Sage-Grouse Winter Habitat Selection and Energy Development. *Journal of Wildlife Management,* 72(1): 187-195. 2008.

[45] Aldridge, Cameron L. and Mark S. Boyce. Linking Occurrence and Fitness to Persistence: Habitat-Based Approach for Endangered Greater Sage-Grouse. *Ecological Applications*, Vol. 17, No. 2 (Mar., 2007), pp. 508-526.

[46] Aldridge, Cameron L. and Mark S. Boyce. Linking Occurrence and Fitness to Persistence: Habitat-Based Approach for Endangered Greater Sage-Grouse. *Ecological Applications*, Vol. 17, No. 2 (Mar., 2007), pp. 508-526.

in this area is unlikely because the occupied habitat exists on the valley floor, not on the mesa top where mining activities are located." (p. 5-31).[47]

These birds are could be experiencing higher chick mortality and increased survival pressure compared to birds in less disturbed areas. Because of the existing developments, the proposed continuation of uranium mining may add to the harmful effects the sage grouse may be experiencing, and could cause increased mortality and nest failure.

Sage grouse management has traditionally centered on the leks as the focal point of efforts, and a similar nest-based approach is used in the previous environmental assessment. The 2007 *PEA* states, "Because federal law prohibits the destruction of birds and nests, roads or other structures would be constructed during a time of year when no migratory birds are nesting in the area, or nesting areas would be located and avoided." (5-31).[48]

Recent research shows that areas such as nesting grounds, in addition to lekking grounds, are critical to the species. "However, our approach of modeling and mapping high-quality nesting and brood-rearing habitats suggests that such a heavy focus on habitat protection around lek sites may not be suitable to ensure the viability of Sage-Grouse populations… a threshold occurs at ~10 km from leks, within which the majority (~90%) of all source habitats occur."[49]

"Thus, using a fixed buffer distance around leks of <10 km to protect Sage-Grouse habitat may not suitably protect important nesting and brood-rearing habitats. Wakkinen et al. (1992) suggested that the originally recommended 3.2-km buffer around leks (Braun et al. 1977) may not be large enough to protect nesting habitats, and Connelly et al. (2000) suggested that polygons of 5 km and 18 km may be required to protect breeding habitats for nonmigratory and migratory populations, respectively."[50] Since the uranium mine operations may be within ten kilometers of the habitat, it should be managed as active habitat for sage grouse and should not be disturbed.

The timing restrictions mentioned in the 2007 *PEA* may not protect the grouse from mining impacts. "Timing restrictions on construction and drilling during the breeding season do not prevent impacts of infrastructure (e.g., avoidance, collisions, raptor predation) at other times of the year, during the production phase (which may last a decade or more), or in other seasonal habitats that may be crucial for population persistence (e.g., winter). Previous research suggests that a more effective mitigation strategy would also include, at minimum, burying power lines (Connelly et al. 2000b); minimizing road and well pad construction, vehicle traffic, and industrial noise (Lyon and Anderson 2003, Holloran 2005); and managing water … to prevent

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[47] US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

[48] US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

[49] Aldridge, Cameron L. and Mark S. Boyce. Linking Occurrence and Fitness to Persistence: Habitat-Based Approach for Endangered Greater Sage-Grouse. *Ecological Applications*, Vol. 17, No. 2 (Mar., 2007), pp. 508-526.

[50] Aldridge, Cameron L. and Mark S. Boyce. Linking Occurrence and Fitness to Persistence: Habitat-Based Approach for Endangered Greater Sage-Grouse. *Ecological Applications*, Vol. 17, No. 2 (Mar., 2007), pp. 508-526.

the spread of mosquitoes that vector WNv [West Nile virus] in sage-grouse habitat (Zou et al. 2006, Walker et al. 2007)."[51]

Mine reclamation for sage grouse habitat is historically unsuccessful. In one long-term study, shrub cover was not established after more than ten years, and neither site was suitable sage grouse habitat.[52] "Less than optimal shrub canopy cover, density, plant community composition, and diversity on these study sites suggest that a long time period or improved cultural methods will be required for reclaimed shrub communities to achieve desired wildlife habitat characteristics similar to native sagebrush-grassland steppe ecosystems."[53]

Mexican Spotted Owl. The spotted owl's hunting ability may be jeopardized by the noise of the uranium mine operations. Noise from the operation of ventilation fans in surface intake and radon-exhaust vents, which may operate 24 hours a day, can travel over a mile, depending on the topography. Owls hunt primarily by sound, not by sight. Their slit-like ears are slightly asymmetrical to assist in locating prey such as rodents. Their large eyes are needed to fly safely in the moon and starlight, but not to catch prey. Recent research on acoustic predators (bats and owls) shows that even low levels of traffic noise will mask the rustling sounds of rodents, and reduce the ability of the owls to hear them.[54] The noise of the mine operations may have a similar effect, and prevent the owls from catching prey. Owls that consume significantly fewer calories each night will likely be at a survival disadvantage, so the mining may kill spotted owls by masking their prey and starving them.

Greenback Cutthroat Trout, Razorback Sucker, Colorado Pikeminnow, and other fish. These fish may be affected by mine pollution as described in the ***Effects of Uranium Mines on the Ecosystem*** section in this document, and by the pollutants described below.

Uranium mining can cause excess selenium (Se) to enter the ecosystem, and bio-accumulate in salmonids and other fish.[55, 56] "Once released into the aquatic environment selenium can be accumulated through the food chain reaching levels that can cause deleterious effects (e.g., impaired reproduction) in top predator fish species (Lemly, 1997)." (Cites Lemly, 1997: *Biomed. Environ. Sci.* 10, 415-435)[57]

According to one study, "similar to the pattern of accumulation observed for cutthroat trout [5], largemouth bass, and bluegill sunfish [18]. Selenium concentrations in the eggs of both

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[51] Walker, Brett L. et al. Greater Sage-Grouse Population Response to Energy Development and Habitat Loss. *Journal of Wildlife Management*, 71(8): 2644-2654. 2007.

[52] Olson, Richard A., J.K. Gores, et al. Suitability of shrub establishment on Wyoming mined lands reclaimed for wildlife habitat. Western North American Naturalist 60(1), pp. 77-92. 2000.

[53] Olson, Richard A., J.K. Gores, et al. Suitability of shrub establishment on Wyoming mined lands reclaimed for wildlife habitat. Western North American Naturalist 60(1), pp. 77-92. 2000.

[54] Björn M. Siemers and Andrea Schaub. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. *Procedings of the Royal Society B*. 278, 1646-1652. 2011.

[55] Holm, Jodi, Vince Palace, et al. Developmental Effects of Bioaccumulated Selenium in Eggs and Larvae of Two Salmonid Species. *Environmental Toxicology and Chemistry*, Vol. 24, No. 9, pp. 2373–2381, 2005.

[56] Muscatello, J.R., A.M. Belknap, and D.M. Janz. Accumulation of selenium in aquatic systems downstream of a uranium mining operation in northern Saskatchewan, Canada. *Environmental Pollution* 156 (2008) 387-393.

[57] Muscatello, J.R., A.M. Belknap, and D.M. Janz. Accumulation of selenium in aquatic systems downstream of a uranium mining operation in northern Saskatchewan, Canada. *Environmental Pollution* 156 (2008) 387-393.

species also showed a strong relationship with Se concentrations in muscle, suggesting that maternal transfer of Se is efficient in both brook trout and rainbow trout. A similar relationship between Se concentrations in muscle and eggs has been reported for razorback suckers [19] and cutthroat trout [5] (2380)."[58] (Cites 5: *Arch Environ Contam Toxicol* 39:46–52; 18: *Environ Toxicol Chem* 5:695–701; 19: *Arch Environ Contam Toxicol* 27:195–201)."

Because these species showed similar tendencies to absorb selenium, it is reasonable to conclude that other similar fish may be similarly affected, as mentioned in the study. Fish such as the Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*), greenback cutthroat trout (*Oncorhynchus clarki stomias*), razorback sucker (*Xyrauchen texanus*), and other fish such as the Colorado pikeminnow (*Ptychocheilus lucius*) may be at risk if they occur downstream of selenium-releasing mining activities.

Eggs from rainbow trout (*Oncorhynchus mykiss*) grown in high-selenium streams in mined watersheds were tested and contained 9.9 µg/g (micrograms per gram) wet weight of selenium, and the fish tissue 1.5 ± 0.3 µg/g.[59] Brook trout (*Salvelinus fontinalis*) are also affected and bioaccumulate selenium. The stream water was tested and contained between 6 – 32 µg/L of selenium. "Significantly higher average concentrations of Se were found in the eggs of rainbow trout (9.9 µg/g) and brook trout (7.8 µg/g) captured at Luscar Creek than at the reference sites (<4 µg/g; p , 0.001; Tables 2 and 3, respectively). Correspondingly, the mean axial muscle Se concentration of both species were higher in fish captured at Luscar Creek (1.5 and 3.8 µg/g) compared to reference fish (<1 µg/g; $p < 0.001$). Brook trout eggs from the intermediate exposure site, the Gregg River, were also significantly elevated in Se compared to reference values ($p < 0.001$). Selenium in eggs was positively correlated to Se in muscle tissue for both rainbow trout ($r = 0.864$; $p = 0.012$) and brook trout ($r = 0.954$; $p < 0.001$; Fig. 1) based on a subsample of fish where both tissues were analyzed. Of interest, the slope of the brook trout correlation was steeper than that for rainbow trout, indicating that rainbow trout accumulated higher concentrations of Se in eggs at lower muscle burdens than did brook trout. Regression analysis showed no significant relationship between the weight of females and the concentration of Se in their eggs." (2376)[60]

The elevated selenium levels caused deformities in the developing fish larvae, which harms the fish. The study reports, "craniofacial defects and edema were found to occur in larvae… In most cases, edema appeared as fluid surrounding the yolk sac or heart and was often associated with hemorrhaging and spinal curvatures. Edematous fry were often shorter and had used less of their yolk than fry that had not developed edema at the time of sampling. In addition, fluid accumulated in the head, often resulting in a spreading of the cranial features… Statistically significant relationships between egg Se and edema, craniofacial defects, and skeletal defects approximated exponential functions." (2377)[61]

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[58] Holm, Jodi, Vince Palace, et al. Developmental Effects of Bioaccumulated Selenium in Eggs and Larvae of Two Salmonid Species. *Environmental Toxicology and Chemistry*, Vol. 24, No. 9, pp. 2373–2381, 2005.

[59] Holm, Jodi, Vince Palace, et al. Developmental Effects of Bioaccumulated Selenium in Eggs and Larvae of Two Salmonid Species. *Environmental Toxicology and Chemistry*, Vol. 24, No. 9, pp. 2373–2381, 2005.

[60] Holm, Jodi, Vince Palace, et al. Developmental Effects of Bioaccumulated Selenium in Eggs and Larvae of Two Salmonid Species. *Environmental Toxicology and Chemistry*, Vol. 24, No. 9, pp. 2373–2381, 2005.

[61] Holm, Jodi, Vince Palace, et al. Developmental Effects of Bioaccumulated Selenium in Eggs and Larvae of Two Salmonid Species. *Environmental Toxicology and Chemistry*, Vol. 24, No. 9, pp. 2373–2381, 2005.

Selenium that is released by mining enters the aquatic food chain through primary producers, such as plankton, which are eaten by invertebrates, which are then eaten by forage fish[62] (general freshwater species include minnows, chubs, shiners and daces; suckers, killifish, shad, some sunfish, small carp, and other small fish that larger fish feed on).

Bats. Bat roosts in the area may be affected by the mining, especially the Townsend's Big-eared Bat (*Corynorhinus townsendii*), which is easily disturbed by uranium mining.[63] A new bat fungal disease, called white-nose syndrome, is causing colonies of bats to die out. Two species of bats, the eastern small-footed bat (*Myotis leibii*) and the northern long-eared bat (*Myotis septentrionalis*) were proposed for listing as endangered or threatened by the USFWS on June 29, 2011 because of white-nose syndrome.[64] Bat roosts in or near uranium mines should be evaluated and monitored for risk assessment and disease detection. They can be affected by noise as described for the Mexican spotted owl, and because they hunt using sonar (sound), their prey can be masked by noise, potentially the noise from uranium mine vent fans and operations.[65]

The Wyoming Game and Fish Department published a *Strategic Plan for White-Nose Syndrome in Wyoming* in 2011. It reports, "Cave and abandoned mine-hibernating bats across North America are at risk of contracting a fungus that is causing major declines in bat populations in the Eastern U.S., namely, white-nose syndrome (WNS). WNS is named after a conspicuous white fungus, *Geomyces destructans,* which invades and erodes the skin of hibernating bats. The fungus causes hibernating bats to arouse more frequently and deplete fat stores more rapidly. *G. destructans* growth causes a loss of dermal integrity and disrupts the skin's regulatory properties for fluid balance. Bats particularly susceptible to WNS are species that are sensitive to evaporative water loss during hibernation (e.g., *Myotis lucifugus*, *M. septentrionalis*, and *Perimyotis subflavus*) (Cryan et al. 2010). WNS-affected bats are known to leave hibernacula mid-day during winter presumably to forage or drink, and to roost in unusual areas of the hibernacula. While the ultimate cause of death in bats is *G. destructans* infection, proximal causes of death as a result of infection include starvation, dehydration, and exposure to cold temperatures. Updated information on signs of *G. destructans* infection and WNS symptoms is available at http://www.fws.gov/WhiteNoseSyndrome/."[66]

"Three species of bats have tested positive for *G. destructans* infection but have not exhibited the symptoms of WNS (Table 1). *G. destructans* was reported on a live *Myotis velifer* in northwestern Oklahoma in the spring of 2010. Not only does this mark the western-most occurrence of the fungus, it marks the first known occurrence of *G. destructans* in a western bat species (BCI 2010). *M. velifer* are known to share roosts with *Tadarida brasiliensis*, a

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[62] Muscatello, J.R., A.M. Belknap, and D.M. Janz. Accumulation of selenium in aquatic systems downstream of a uranium mining operation in northern Saskatchewan, Canada. *Environmental Pollution* 156 (2008) 387-393.

[63] Colorado Bat Working Group web site, accessed on 9/8/2011. http://www.cnhp.colostate.edu/teams/zoology/cbwg/issueDisplay.asp?id=0

[64] Federal Register / Vol. 76, No. 125 / Wednesday, June 29, 2011 / Proposed Rules, p. 38095.

[65] Björn M. Siemers and Andrea Schaub. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. *Procedings of the Royal Society B*. 278, 1646-1652. 2011.

[66] Abel, Becky, and M. Grenier. *Strategic Plan for White-Nose Syndrome in Wyoming*. Accessed online on 9/8/2011 at http://www.fws.gov/whitenosesyndrome/pdf/WyomingWNSStrategicPlan2011.pdf.

wideranging, migratory species (BCI 2010). The potential for *T. brasiliensis* to act as a vector for spreading *G. destructans* further west and south is unknown at this time."[67] (Cites: Cryan et al 2010: Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. *BMC Biology*, 8: 135; BCI 2010: White-nose syndrome jumps to a 'Gateway to the West' [Press release]. Retrieved from http://batcon.org/pdfs/whitenose/WNSCaveMyotisinOklahomaFINAL.pdf)."[68]

River otter. Uranium decay products produced from mining may move up the food chain into predators such as river otters. One of the decay products is radium-226 (^{226}Ra), which is absorbed in to the bones of animals in the same way as calcium, and sequestered there.[69]

In a Canadian study, "the similarity in mean ^{226}Ra values reported here for mink and otter bone, 32.7 and 32.8 mBq/g dry weight respectively, is not surprising as the feeding habits of the two animals overlap with common prey found in each diet. Mink are opportunistic predatory secondary consumers that are well adapted to hunting both aquatic and terrestrial prey; its dietary items include crayfish, fish, amphibians, and birds (Linscombe et al 1982). The otter, also a secondary consumer, takes a variety of items – but with fish predominating in the diet (to 95%) (Toweill and Tabor 1982). The diets of both mink and otter are seasonal and depend on population levels of prey species (Linscombe, et al 1982; Toweill and Tabor 1982)."[70]

"Bone ^{226}Ra levels reported here are less than those reported for the herbivorous (primary consumer) beaver (112.7 mBq/g dry-weight, Clulow et al 1991) and muskrat (468.0 mBq/g dry-weight, Mirka et al 1996) taken from contaminated waters in the same region. These herbivores consume aquatic roots and tubers, in the case of muskrat (Perry 1982), almost certainly with adherent mud and silt particles high in radionuclides, or vegetation harvested from the bank (and also at risk of being contaminated by radionuclide-rich particulates during spring runoff and flooding) and cached in lodges, in the case of beaver (Hill 1982). The lower levels in the carnivores can be explained by a limited intake of bone (the primary site of ^{226}Ra deposition) in relation to other tissues taken from prey animals."[71]

Boreal toad. If the boreal toad occurs in the area where mine waste is present, then it may be subject to effects on amphibians discussed in the ***Effects of Uranium Mines on the Ecosystem*** section in this document. Habitat for the state-listed boreal toad includes sagebrush,

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[67] Abel, Becky, and M. Grenier. *Strategic Plan for White-Nose Syndrome in Wyoming*. Accessed online on 9/8/2011 at http://www.fws.gov/whitenosesyndrome/pdf/WyomingWNSStrategicPlan2011.pdf.

[68] Abel, Becky, and M. Grenier. *Strategic Plan for White-Nose Syndrome in Wyoming*. Accessed online on 9/8/2011 at http://www.fws.gov/whitenosesyndrome/pdf/WyomingWNSStrategicPlan2011.pdf.

[69] Dewit, TJ, V. Clulow, et al. Ra-226 in Bone of Mink (*Mustela vison*) and Otter (*Lutra canadensis*) Taken Near U Workings at Elliot Lake, Canada, and from Reference Areas, with Calculation of Transfer Parameters. *Bull. Environ. Contam. Toxicol.* (2002) 68:878–884.

[70] Dewit, TJ, V. Clulow, et al. Ra-226 in Bone of Mink (*Mustela vison*) and Otter (*Lutra canadensis*) Taken Near U Workings at Elliot Lake, Canada, and from Reference Areas, with Calculation of Transfer Parameters. *Bull. Environ. Contam. Toxicol.* (2002) 68:878–884.

[71] Dewit, TJ, V. Clulow, et al. Ra-226 in Bone of Mink (*Mustela vison*) and Otter (*Lutra canadensis*) Taken Near U Workings at Elliot Lake, Canada, and from Reference Areas, with Calculation of Transfer Parameters. *Bull. Environ. Contam. Toxicol.* (2002) 68:878–884.

desert shrub, chapparal-mountain shrub, pinyon-juniper, and mountain meadows ecosystems.[72] The USDA Forest Service describes the boreal toad: "In Colorado, the largest populations are typically found in areas characterized by willows (*Salix spp.*), bog birch (*Betula glandulosa*), and shrubby cinquefoil (*Potentilla fruticosa*) [41]. ... Western toads are widespread througout the mountainous areas of northwestern North America, ranging from sea level to elevations near or above regional treeline, or 10,000 feet (305-3,050 m) in elevation [15, 20]. Elevational range in Colorado is from about 7,000 feet to 11,860 feet (2,131-3,615 m). In the mountains of Colorado, the largest western toad populations usually occur from about 9,500 feet to 11,000 feet (2,896-3,353 m) elevation [34]. Western toads occupy desert streams and springs, grasslands, and mountain meadows; they are less common in heavily wooded regions. They are usually found in or near ponds, lakes (including saline lakes), reservoirs, rivers, and streams within the above mentioned habitats [15, 16]. Under laboratory conditions western toads were able to survive in 40 percent seawater, but died within a week when exposed to 50 percent seawater [11]."[73] (Cites: 41: USDIFWS, 50 CFR Part 17. Tuesday, November 15, 1994. Federal Register. 59(219): 58982-59028. [24357]; 15: Stebbins, R. C. 1951. *Amphibians of western North America*. Berkeley, CA: University of California Press. 539 p. [24390]; 20: Verner, Jared; Boss, Allan S., tech. coords. 1980. California wildlife and their habitats: western Sierra Nevada. Gen. Tech. Rep. PSW-37. Berkeley, CA: USDA, Forest Service, Pacific Southwest Forest and Range Experiment Station. 439 p. [10237]; 34: Campbell, James B.; Degenhardt, William G. 1971. Bufo boreas boreas in New Mexico. *The Southwestern Naturalist*. 16(2): 219. [24382]; 16: Stebbins, Robert C. 1985. *Western reptiles and amphibians*. 2nd ed. Peterson Field Guides No. 16. Boston: Houghton Mifflin Company. 336 p. [22647]; 11: Porter, Kenneth R. 1972. *Herpetology*. Philadelphia, PA: W. B. Sanders Company. 524 p. [24388]).

F. Unique Soil Properties and Ecosystem Effects of Disturbance

Cryptobiotic soil crust is mapped as potentially occurring in the mining areas.[74] This cryptobiotic crust is a unique assemblage of cyanobacteria, algae, lichens, and/or mosses that live together in a thin crust on the soil surface. It is biologically unique, and supports the entire ecosystem in arid regions by providing nutrients to the soil, fixing nitrogen in soil, preventing wind erosion, retaining moisture, aiding seed germination, and absorbing solar energy.[75] This crust is easily disturbed by walking, driving, and trampling, and can take up to 250 years to fully recover all functions in some cases.[76] The lack of crust affects plants growing in the area. The crust supports native plants and excludes exotic invasive grasses, which grow in the disturbed

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[72] Sullivan, Janet. 1994. Bufo boreas. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2011, September 8].

[73] Sullivan, Janet. 1994. Bufo boreas. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2011, September 8].

[74] Belnap, Jayne, Kaltenecker, J.H., et al. *Biological Soil Crusts: Ecology and Management*. USDI Bureau of Land Management Technical Reference 1730-2. 2001.

[75] Belnap, Jayne, Kaltenecker, J.H., et al. *Biological Soil Crusts: Ecology and Management*. USDI Bureau of Land Management Technical Reference 1730-2. 2001.

[76] Belnap, Jayne. Surface Disturbances: Their Role in Accelerating Desertification. *Environmental Monitoring and Assessment*. 37: 39-57. 1995.

soil.[77] Plants growing in the encrusted undisturbed soil tested up to 31 percent higher in nitrogen content than those in disturbed soils.[78] This nutrient concentration has implications for wildlife browsing in the area that may experience a survival edge by consuming the higher-nutrient forage.

This nitrogen cycling is one of the most important aspects of the soil crust: the cyanobacteria are one of the few organisms on Earth that can take airborne N_2, atmospheric nitrogen, and convert it to a biologically usable form, like ammonia (NH_3) or nitrate (NO_3), that a plant can absorb.[79] The effect is the same as nitrogen-fixing bacteria in the roots of legumes like clover. The cryptobiotic crust literally feeds the ecosystem nitrogen from the air, which goes into plants, gets eaten by invertebrates and herbivores like deer, and then to predators like cougar, coyote, and humans.

Cryptobiotic crust is a crucial element of the ecosystem and should be preserved. Some mine plans may discuss "topsoil" stockpiling and replacement, mine tailings piles, ponds, or other infrastructure. "Topsoil" replacement does not replace the cryptobiotic crust, only excavated mineral material. Open pit mining or pond construction will result in direct removal of the crust, and mine-waste-rock disposal areas may impact crust beneath and potentially around them. If the crust is sensitive to the types of chemical pollution that mining will produce (and is documented to have produced in the past), then the off-site, indirect effects to the ecosystem could be sustained and the nitrogen cycle disrupted.

G. Temporal Loss of Ecosystem Function During Mining

Temporal loss (also called restoration lag) is the effect created by the time lag between the event of ecological destruction and the maturation of the reclamation site. In other words, when the mining begins, habitat is destroyed, and ecological functions are lost. This is the mining temporal loss. During the ten-year long proposed mining lease extension,[80] those functions are not replaced. This effect is common knowledge among ecologists.

When the mining is over, the reclamation will be completed. From that time until the ecosystem matures, the ecological functions are still much lower than the pre-developed condition. The time between reclamation installation and maturity is the post-mining temporal loss. In this case, the minimum post-mining temporal loss can be estimated by the time it takes the cryptobiotic crust to re-grow and provide all ecological functions, which takes 250 years.[81]

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[77] Belnap, Jayne. Surface Disturbances: Their Role in Accelerating Desertification. *Environmental Monitoring and Assessment*. 37: 39-57. 1995.

[78] Belnap, Jayne. Surface Disturbances: Their Role in Accelerating Desertification. *Environmental Monitoring and Assessment*. 37: 39-57. 1995.

[79] Belnap, Jayne. Surface Disturbances: Their Role in Accelerating Desertification. *Environmental Monitoring and Assessment*. 37: 39-57. 1995.

[80] US Department of Energy Office of Legacy Management. *Uranium Leasing Program Final Programmatic Environmental Assessment*. DOE/EA 1535. July 2007.

[81] Belnap, Jayne. Surface Disturbances: Their Role in Accelerating Desertification. *Environmental Monitoring and Assessment*. 37: 39-57. 1995.

Therefore, the total temporal loss of ecological functions is the sum of the mining and post-mining temporal loss, which is 10 + 250 = 260 years until all ecological functions are restored.

Research shows that other reclaimed mine sites are still significantly ecological different from the original landcover. A study that investigated the mine-induced negative effects of nutrient cycling (carbon, nitrogen, and phosphorus) from land into a nearby stream found “major impacts on the adjoining stream ecosystem.”[82] These impacts show the interconnectedness of the ecosystem, and further add to the temporal loss time estimate:

“Currently the goal of mine reclamation is simply the establishment of permanent vegetative cover. This approach is shortsighted and does not take into account the importance of ecosystem processes like nutrient cycling nor the potentially harmful conditions created... As a result, recovery of comparable ecosystem function will take decades to centuries.”[83]

The final estimate for the temporal loss would then be 260 years or longer to build up soil crust, nutrients, and other ecological elements to the current levels. Even established reclamation sites are still too young. Reclamation produces an ecologically compromised landscape. No compensation for this temporal loss is included in the mining proposal. Therefore, the mining will result in overall damage to the ecosystem.

Temporal loss is frequently addressed by federal agencies such as the US Army Corps of Engineers, and is accepted as a known phenomenon.[84] When industry fills wetlands and applies for mitigation, they must address and compensate for temporal losses of ecosystem function as well as permanent losses. Although temporal loss is commonly addressed in state and federal wetland regulation, it is not addressed in mining regulation. This regulatory oversight harms the environment and results in a net loss of ecosystem function in every case.

The result is economic harm to society, because the community loses a functional part of the landscape. That loss of function has a dollar value, as one Ohio study quantifies over a 50-year period:

> Findings of this study make a strong case that time lag costs to society of wetland function restoration should no longer be ignored in the mitigation decision-making process. Restoration lag costs for the low elevation sites range from $2,939 to $11,179 per acres with an average of $6,136 per acre for floristic functional restoration. Restoration lag costs to achieve equivalency under logarithmic growth for both floristic and soil indicators range from $3,460 to $49,811 per acre with an average of $16,640 per acre. For high elevation constructed inland marshes, time lag costs range from

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[82] Simmons, Jeffrey A, William S. Currie, Keith N Eshleman, et al. Forest to Reclaimed Mine Land Use Change Leads to Altered Ecosystem Structure and Function. *Ecological Applications*, 18(1), 2008, pp. 104-118.

[83] Simmons, Jeffrey A, William S. Currie, Keith N Eshleman, et al. Forest to Reclaimed Mine Land Use Change Leads to Altered Ecosystem Structure and Function. *Ecological Applications*, 18(1), 2008, pp. 104-118.

[84] US Army Corps of Engineers Regulatory Guidance Letter 02-2. December 24, 2002.

> $22,368 to $31,511 per acre when achieving floristic equivalency with an average cost of $27,392 per acre.[85]

The economic costs of temporal loss in the proposed continuing mine sites may be much greater because of the slow growth rates and time required to achieve full function of the cryptobiotic crust. The mining and reclamation temporal losses must, at a minimum, be addressed by the agencies, and preferably should be avoided by denial of the mining permit.

H. Shortcomings of Reclamation Plans

The reclamation process has been found to degrade the environment by failing to return it to the pre-mining condition. Reclamation methodologies around the world are being questioned and evaluated.[86]

In the case of uranium mining, true reclamation is largely impossible because there is no way for the mining company to install cryptobiotic crust when land is disturbed. Natural colonization must occur, and during that time ecological functions will be lower. A 46-year study found that the soil fauna, animals like worms that live in the soil, undergo community changes and cannot be replaced to the original condition:

"The goal is a self-sustaining rehabilitation… finally reaching the "original ecosystem," i.e. a full restoration approaching the "perturbation point." This is seldom achieved and the more frequent alternative approach is the replacement by another system..." [87]

"Bond release criteria requiring the reclaimed shrub community to be similar to pre-mine conditions within the 10-yr bonding period for this region are unrealistic. Native shrub communities may require 30–60 yr to develop through natural successional processes."[88]

Another study points out the similarity of strip mine land to urban land in terms of the negative ecological effects compared to forest:

"There are some parallels between a forest to mineland conversion and a forest to urban land-use conversion. In both cases soil permeability decreases; in one case due to soil compaction and in the other due to addition of buildings and pavement… Some of the reported symptoms include a flashier hydrograph, elevated concentrations of nutrients, … , reduced biotic richness, increased dominance of tolerant species, … , and a decrease in leaf breakdown."[89]

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[85] Gutrich, John J, and Fred J. Hitzhusen. Assessing the substitutability of mitigation wetlands for natural sites: estimating restoration lag costs of wetland mitigation. *Ecological Economics* 48 (2004) 409– 424.

[86] Neves, O., and M. J. Matias. Assessment of groundwater quality and contamination problems ascribed to an abandoned uranium mine (Cunha Baixa region, Central Portugal). *Environ Geol* (2008) 53:1799–1810.

[87] Dunger, Wolfram, and Manfred Wanner, et al. "Development of soil fauna at mine sites during 46 years after afforestation" *Pedobiologia* 45, 243–271 (2001).

[88] Olson, Richard A., J.K. Gores, et al. Suitability of shrub establishment on Wyoming mined lands reclaimed for wildlife habitat. Western North American Naturalist 60(1), pp. 77-92. 2000.

[89] Simmons, Jeffrey A, William S. Currie, Keith N Eshleman, et al. Forest to Reclaimed Mine Land Use Change Leads to Altered Ecosystem Structure and Function. *Ecological Applications*, 18(1), 2008, pp. 104-118.

Strip mine areas are generally impervious, but to replicate the effects of the urban landscape, the land surface does not have to be 100% impervious. Urban landscapes include areas such as lawns, medians, and natural areas as well as pavement. It is common knowledge among civil planners that urban areas with greater than 12% impervious surface will produce negative effects from runoff. Some cities mandate that new developments limit impervious area to about this level in order to protect water quality.

If the ecological trajectory after mining progresses from completely barren toward the reclaimed attempt at the original condition, but does not reach the original condition, then the mine site has a net decrease of ecological and wetland function level. The degree of the decrease depends on the site condition at any given moment during the 260-year estimated temporal loss period identified elsewhere in this letter.

Waters of the US may be filled with waste-mine-rock or other mined material, and no mitigation is proposed other than reclamation. These impacted waterways drain the surroundings and often the upper parts of their micro-watersheds. In this landscape position, both the potential and opportunity to transmit pollution downstream. The materials from mining operations that are disposed of in waterways impair the natural state of the waterways and prevent ecological functions from occurring. These materials and their placement should be regulated under the Clean Water Act as pollution discharges to Waters of the US.

The fact that no water is observed in the drainages is immaterial. Many streams only flow for a part of the year. The presence of an observable "active channel" means that an ordinary high water mark is present, which qualifies this drainage as a Water of the US,[90] unless specifically determined non-jurisdictional by the Army Corps of Engineers, who reserves the right to determine it's own jurisdiction. Any discharges of fill material to these Waters of the US is prohibited under Section 404 of the Clean Water Act.

I. Conclusions and Recommendations

Pollutants released by the uranium mining process and radioactive decay products can be absorbed by organisms on every level of the food chain. Combinations of pollutants may have different effects than individual pollutants. The potential and opportunity for these pollutants to harm the ecosystem exist as a result of the uranium mining process. The pollutants can move through the food chain into humans, potentially exposing them to radiation. Since the pathways from the environment into organisms exist, greater concentrations of pollutants can produce more severe effects, including mortality.

The effects of the uranium mine pollution on the ecosystem are documented by research around the world and in Colorado. Uranium can move through the groundwater and into streams and rivers. Plankton, algae, plants, worms, arthropods, insects, fish, amphibians, otter, mink, beaver, muskrat, humans and other organisms may absorb, ingest, or concentrate uranium or other pollutants, which may kill the organism. The presence of pollutants from uranium mining

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[90] 33 CFR 328.4: Definition of Waters of the United States, Limits of Jurisdiction.

in every level of the food chain suggests that the potential exists to significantly harm the entire ecosystem.

Other mining operations may disturb sensitive wildlife, fill Waters of the US, or destroy the fragile cryptobiotic soil crust. The reclamation plans are likely to be inadequate, and no mitigation for temporal loss of ecosystem function is proposed. The mine operations will represent a long-term strain on the environment.

Based on the best available science, the uranium mining process is harmful to the ecosystem. The existing leases should be allowed to expire, and all mines shut down. The reclamation plans should be revised to actually restore the landscape, and compensation for temporal loss of ecosystem function should be proposed. Monitoring of the ecosystem should be conducted to track pollution and its effects.

Sincerely,

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Certified Ecologist

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