INTEGRATION OF MINE RECLAMATION IN SEMIARID RANGELAND ENVIRONMENTS[1]

by

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Abstract. Mining reclamation has to be incorporated into the broader aspects of grazing and wildfire fuel management for successful application in the rangeland environments of northern Nevada. Predation of reclamation seedings during establishment periods is a major example of the need for integrated planning in the reclamation process. The eventual incorporation of large-scale mining reclamation projects into the general landscape requires prior planning and design features both within the reclamation project and the larger grazing allotments in which they are located.

ADDITIONAL KEY WORDS: Nevada, annual weeds, grazing, aversion planting.

Introduction

During the last three decades there has been a tremendous increase in the open pit mining for precious metals in northern Nevada. Waste rock is removed and large quantities of ore crushed, piled in heaps and leached with cyanide solution for recovery of gold and silver. These large-scale mining operations have created the need for reclamation operations. The environment where these operations are located impacts the reclamation process.

A few of the precious-metal mines in northern Nevada are located at high elevations in the mountain ranges of the Great Basin. Most of the mines, and certainly most of the mills, are located in the lower big sagebrush (*Artemisia tridentata*)-shadscale (*Atriplex confertifolia*) environmental zone. This places the reclamation operations in semi-arid to arid climates where most of the precipitation falls during the winter when temperatures are too low for plant growth.

The lands disturbed by mining operations were previously rangelands for domestic livestock production, habitat for wildlife, and watersheds. Most of the rangelands in northern Nevada are not in good ecological condition. Late 19th and early 20th century excessive, improperly timed, continuous livestock grazing depleted the perennial grass portion of many plant communities (Young and Sparks 1986). Because the dominant woody species on the sagebrush/bunchgrass rangelands were not preferred by livestock, the density of shrubs increased when the herbaceous vegetation was depleted (e.g. Stewart 1941). This produced shrub-dominated plant communities, with a near ecological vacuum in the understories. The accidental introduction of a series of alien annual species near

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the turn of the century filled this biological vacuum.

The dominant annual species is cheatgrass (Bromus tectorum). This annual is one of the most important forage species in the Great Basin. It competes with the seedling of native and artificially planted perennial species for moisture for growth. It competes so well that many communities are closed to the establishment of perennial species by cheatgrass competition. The early maturity and dense mass of fine textured herbage produced by cheatgrass changes the season, chance of ignition, and rate of spread of wildfires (Young and others 1987).

The scale of northern Nevada range landscapes is vast with unfenced pastures exceeding 2 million acres in extreme cases. In comparison to the average fenced pasture, the surface area disturbed by most mining operations is very small. Essentially mining reclamation in northern Nevada consists of a series of relatively small islands in an ocean of semiarid to arid vegetation that is not in good ecologic condition.

Purpose

Our purpose is to illustrate the ecological and management problems. This island physiography for mine reclamation in northern Nevada and to suggest means reclaimed areas can be integrated in the general landscape once mining is completed.

Exploration Versus Mining Plan Reclamation

In Nevada an estimated two thirds of the mining disturbance is the result of exploration work rather than actual recovery of ores (Based on review of mining reclamation in Nevada conducted by Agricultural Research Service, USDA, for the Bureau of Land Management, USDI). (Hereafter cited as Nevada Report 1993). Exploration disturbance consists of roads and pads for exploration drilling. We estimate that 0.6 hectares are disturbed per kilometer of drill road. Under current regulations, if less than 2.5 ha are disturbed it is not necessary to post bond to assure the reclamation of the disturbed area.

Exploration Reclamation

Mining exploration disturbance in Nevada tends to be linear and quite transitive in duration. Exploration disturbances seldom initially last for more than a year. Currently roads are often re-contoured by pulling the berm back with a tracklaying backhoe. Drill pads are scarified and cuts reshaped or backfilled. Attempting to revegetate such sites is the ultimate in "island biology".

Management of Livestock Predation

Nevada miners have been quite successful and innovative in reclaiming exploration roads. Innovative design drills (seeders) are under development that mount on the tool bar of tracklaying tractors so that roads can be furrowed and seeded in one operation after they have been recontoured. On extremely steep slopes, the recontoured roads are broadcast seeded by hand. There appears to be a need for a drill that could be used on such extremely steep slopes, perhaps as a readily removal attachment to the tracklaying backhoe bucket.

Such island reclamation efforts have often been totally destroyed by domestic livestock, free roaming horses, and/or mule deer predation. It is not even remotely feasible to fence such reclamation efforts to exclude herbivores. A common occurrence would be for the exploration disturbance to cover 10 ha widely distributed in a 1500 ha pasture.

Cattle are probably the largest herbivore that most frequently damage reclamation projects of exploration disturbance. Every grazing allotment in Nevada is subject to some type of grazing management plan. Most of these plans involve some type of complete rest that is applied in a (non-use) yearly rotation with deferment of grazing until after seeds are ripe, and early grazing. These systems are adaptations of the classic three pasture rest-rotation grazing systems of Hormay (Hormay 1956). In Nevada,

common practice has established that seedlings must not be grazed the first year and should not be grazed until after seed ripens the following year. A part of the predation problem encountered with reclamation of exploration disturbance could be solved through careful coordination of grazing management and the reclamation seedings. This would require the cooperation of the mining and grazing administration portions of regulatory agencies, ranchers, and the reclamation contractor. Obviously such cooperation is not easily coordinated, but the potential environmental benefits make it worth trying. Such coordination does not require any additional large capital input in comparison to the potential gains.

Management of Free Roaming Herbivore Predation

We previously suggested that cattle were the primary large herbivore to prey upon reclamation seedings. Coordination of reclamation with grazing management systems appears to offer a potential answer to this problem. Free roaming horses, burros, and mule deer are not subject to grazing management systems. The management of free roaming horses populations is an emotionally charged, politically volatile issue. The federal land management agency that has stewardship of the land being reclaimed control free roaming horses. Reducing densities that damage the environment is not easy because of the many political and budgetary restrains on management agencies. We do not know if a free roaming horse herd was ever reduced to ensure the establishment of reclamation seedings.

Mule deer pose many of the same problems. However, state wildlife management agencies are much more likely to have special harvesting hunts to control predation. We do not know if this has ever been done to assure the establishment of reclamation seedings on exploration disturbances because of the relatively small surface areas involved. Such control is much more likely to occur with large mining plan reclamation seedings.

If very few options are available for controlling free roaming animal predation on exploration reclamation seedings, what are the remaining possibilities? There are two that deserve attention from researchers. One is to avoid seeding and rely on natural revegetation of exploration disturbance. The second is what we have termed aversion seedings. This consist of planting species or eco-types of species that are not preferred by herbivores or are extremely resistant to grazing.

Natural Revegetation

Spontaneous Revegetation

If you mention relying on spontaneous revegetation of mining disturbance to environmentally concerned citizen groups outside of the mining industry, the instant reply is usually pointed references to 19th century mine or mill dumps that are still bare of vegetation. Such observations are valid, but remember that these dumps are usually unweathered rock from underground mining and mill spoils with specific texture classes that make poor seedbeds. Modern mining exploration disturbances have been re-contoured and should feature the conservation of topsoil. We have previously mentioned that such disturbances tend to be linear in distribution with maximum edge exposure for invasion.

Rate of Natural Succession

There is a perceived ecological danger in leaving disturbed sites open to invasion by weed species versus rapid closure of such sites by artificial seeding. It has long been known that some form of weed control is required for establishment of perennial seedlings once cheatgrass dominates a disturbed site in the sagebrush zone of northern Nevada (see Robertson and Pierce 1945 for classic paper on seeding in closed communities). Cheatgrass is not an instant invader of disturbed soils. The initial succession consists of Russian thistle (Salsola australis), barbwire Russian thistle (S. paulsenii) and halogeton (Halogeton glomeratus). This is followed by tumble mustard (Sisybrium altissumum)

and/or tansy mustard (Descurainia pinnata) and finally followed by cheatgrass invasion and dominance (Piemeisel 1951). The time required for cheatgrass dominance is governed by the accumulation of litter on the surface of the seedbed (Evans and Young 1972). Perhaps three to five years are required for cheatgrass to largely close the site to establishment of seedlings of native or introduced perennial species.

Within that time period what are the opportunities for invasion by seeds of native plant species? The chances vary greatly depending on life-forms and species within life-forms. The species that are sufficiently competitive to suppress cheatgrass in the shortest time period are perennial grasses. We have previously mentioned that many perennial grass stands in northern Nevada have been severely depleted by past improper grazing. Even if the current gazing management system is designed to favor perennial grasses, in most situations it is doubtful that reserves of viable seeds of perennial grasses exist adjacent to the disturbed sites. For invasion by native perennials to occur, viable seeds have to be produced and dispersed to safe sites for germination and establishment on the disturbed area.

The grass that is most ecologically preadapted to invade areas disturbed by mining exploration is squirreltail (Elymus elymoides). This native, short-lived perennial grass was the natural secondary successional dominant before the annual weeds were accidentally introduced to the sagebrush/ bunchgrass communities. The seed heads of squirreltail disarticulate at maturity and are readily distributed across the soil surface. The production of seed by squirreltail is dependent on protection from early spring grazing. Squirreltail is an extreme ephemeral species that completes its life cycle very early in the season. The chances that squirreltail seeds find a safe site for germination are dependent on the surface microtopography and texture of the seedbed. This is the concept of seedbed potential for germination that was first proposed by Harper (1977).

The practical application of Harper's safe site for germination concept is the surface microtopography of the recontoured exploration road is going to determine the seedling success of squirreltail. Since seeds are wind dispersed they are most likely be captured in depressed topography. If vehicle traffic continues on the road after it is recontoured or livestock concentrate on the area, the chance of seedling establishment is greatly reduced.

The pappus of big sagebrush seeds is deciduous so even though the seeds are very small they are not dispersed long distances. Big sagebrush seeds germinate on the surface of seedbeds and again germination and seedling establishment are enhanced by optimum surface microtopography (Young and others 1990). Besides the microtopography of the seedbed surface, the physical structure of the seedbed soil is important (see Eckert and others 1989 for a comprehensive review of the influence of seedbed surface soils on germination and seedling establishment). If the exploration road is recontoured while the soil is wet and heavy equipment is repeatedly operated on the wet soils compaction may occur. This can result is severe crusting problems that influence seedling establishment.

The seeds of gray rabbitbrush (Chrysothamnus nauseosus) and green (C. viscidiflorus) rabbitbrush have a persistent pappus and are wind dispersed for great distances. These species are natural secondary succession species for disturbed areas. The texture and softness of the seedbed is important in the seedling establishment of these species (Stevens and others 1984).

Sometimes native annual broadleaf species, such as buckwheats (Eriogonum sp.) will become abundant on recontoured exploration roads, but their dominance is only transitory. The establishment of long-lived perennial broadleaf herbaceous species is often a long slow process. Silver lupine (Lupinus caudatus) will

sometimes colonize roads where its presence will not be welcome by ranchers because of its poisonous nature. The tap rooted perennial species of Wyethia and Balsamorhiza are very slow to invade exploration sites.

In the shadscale zone, shadscale (Atriplex confertifolia) may rapidly colonize disturbed areas. We know so little about the germination and seedbed ecology of this species it is difficult to determine which factors control its establishment.

In this section we have talked a lot about seedbed quality and safe sites for germination. We have suggested that seedbed microtopography is the key to increasing the potential for natural seedling establishment. There is not enough experimental evidence available to make definitive statements about exactly how the surface of re-contoured exploration roads should be left to bring about the most rapid colonization by native plant species. This research has to be done in a combination of manipulating seedbeds and understanding the inherent potential of seeds to germinate in order to fully utilize the potential technology transfer to practical application.

Besides the length of time required for spontaneous revegetation of exploration roads, the exposure to accelerated erosion plays a role. In seedbed quality we mentioned the importance of fine textured particles in the soil surface. Most accelerated soil erosion from disturbed sites in the Great Basin occurs in low frequency, high intensity precipitation events. The longer a disturbed site is exposed with limited vegetative cover the greater the opportunity that one of these events occur (e.g. Brown and others 1985). If you have a successful artificial seedling recruitment on an exploration mine road, the site is protected from a high intensity precipitation event in about two growing seasons. Reliance on natural regeneration may mean two to five times as long exposure to potential accelerated erosion.

The supposed advantage of using spontaneous revegetation was to lessen the impact of animal predation. Animal predation is probably less, because there is much less vegetation to attract animals.

The ecological condition of range sites surrounding the mining exploration activity should have a significant impact on the possibility for spontaneous regeneration. In a high condition site, the community consist of a diverse number of species that annually produce abundant seed. Theoretically it should be much easier to obtain rapid spontaneous regeneration. We discuss this theoretically because we have not observed such a site in northern Nevada that was impacted by mining exploration disturbance.

Sprouting Species

Several of the subdominant shrubs of the sagebrush zone sprout from crown or root buds when the aerial portion of the plant is removed. The rabbitbrush species are good examples of crown sprouting and horsebrush species (Tetradymia sp.) sprout from roots. Other species sprout from large underground, indurate, woody masses, sometimes referred to as woody tubers. Desert peach (Prunus andersonii) and the ephedra species (Ephedra sp.) are examples of this kind of reproduction. If exploration roads are promptly re-contoured, and care is taken in dragging soil back from the berm area, it may be possible to save these sprouting woody species on the margins of roads from damage.

Repeated Disturbance

A fairly common feature of exploration disturbance is that the same site will be repeatedly explored by the same or different mining companies. Biologically and physically this is extremely damaging to the site. It is a fact of life in the world of economic geology that such repeated explorations occur.

Aversion Plantings

Aversion plantings are an alternative to spontaneous stand renewal for avoidance of excessive herbivory of exploration disturbance

reclamation. When management agencies are asked to comment on reclamation plants they characteristically suggest the most highly preferred species be planted. In the case of the reclamation of exploration disturbance this is the best way to assure the plantings are going to suffer from excessive predation.

What is the primary purpose of the reclamation project? Should the primary goal be to protect the disturbed and adjacent site from accelerated erosion and colonization by weed species that would truncate subsequent succession? Returning the site to primary productivity in the environment is a goal of all mine reclamation projects. A temporary production that ends with denuding of the site and opening the area to accelerated erosion defeats the purpose of the reclamation.

Crested wheatgrass (Agropyron desertorum) is a perennial grass that is extremely resistant to grazing once established. This grass does an excellent job of biologically suppressing cheatgrass. This perennial has great persistence in northern Nevada, but is almost always non-invasive. By that we mean it stays where it was planted, but can not invade surrounding vegetation without the intervention of man for weed control, seed dispersal, and seedbed preparation.

There has been about 250,000 ha of crested wheatgrass seeded in northern Nevada, estimated to furnish 25% of the forage base for the livestock industry. Crested wheatgrass has the inherent potential to tolerate very heavy grazing and still survive. Modern cultivars of crested wheatgrass such as Hycrest (Agropyron desertorum X A. cristatum) have improved seedling vigor for better establishment. Crested wheatgrass has the inherent competitiveness to biologically suppress cheatgrass. Most crested wheatgrass seedings become invaded by big sagebrush seedlings. Once shrubs become established in the grass stands the combination supports a much more diverse bird community than cheatgrass or big sagebrush alone (McAdoo and others 1989).

The alternative to planting cultivars that are resistant to grazing is to select, within segregating populations, a plant material that is not preferred by herbivores. Fourwing saltbush (Atriplex canescens) is the only shrub species that is consistently established by direct seeding in mine reclamation in northern Nevada (Nevada Report 1993). The shrub is dioecious with obligate out-crossing so most populations are quite variable. In many mine reclamation plantings in northern Nevada, it is easy to observe segregation in populations for browsing preference by blacktailed jackrabbits (Lepus californicus). We have previously reported on the occurrence of preferred and non-preferred lines in fourwing saltbush populations (Young and others 1984). It is relatively common to observe individual plants or groups of individual plants in native populations as diverse as western juniper (Juniperus occidentalis) and spiny hopsage (Grayia spinosa) that exhibit lack of preference by jackrabbits and/or mule deer populations. Apparently a real potential exists to select, for reclamation, plants that are resistant to herbivory.

Management of Granivores

Granivorous (seed eating) animals have can be major influences on the recruitment of seedlings in big sagebrush plant communities in northern Nevada (e.g. LaTourrette and others 1971). Small mammals collect, often process, and then cache in scatter hoards the seeds of many native species (Longland 1987). The rodents may recover the seeds for recaching or consumption, or the seeds may germinate in the caches. Often the granivores place the seeds in ideal situations for germination and emergence and their manipulation of the seeds may eliminate physical restrictions to germination (McAdoo and others 1983).

Much of the spontaneous regeneration of native vegetation on recontoured mining exploration roads may be the result of granivores caching seeds in the disturbed area. The linear nature of such disturbance

reduces the distance rodents must travel from seed collection to caching sites. The cover of undisturbed areas alongside the exploration roads provides protection for the granivores from predation.

Do the activities of granivores respond to habitat manipulations? Certain granivores are very sensitive to the quality of seedbeds where they cache seeds (e.g. antelope bitterbrush (Purshia tridentata) seeds, West 1968; Christensen and others 1974). If we understood more about this natural process it might be possible to enhance natural seedling recruitment by manipulating the surface of seedbeds to enhance caching.

Relating Exploration to Mining Plan Reclamation

Is there any relation between our discussion of integrated management of exploration reclamation and the problems faced by miners in mining plan reclamation in northern Nevada? In many ways mining plan reclamation magnifies the problems related in exploration reclamation. The actual mining process is usually much longer in duration than exploration disturbance and tends to be concentrated in one area rather than linear in distribution. Someday the mining activity has to end and perhaps the enclosing fences come down, and the reclamation integrated into the surrounding landscape. To our knowledge this has not happened in northern Nevada. When it does, an island of quality, often highly preferred forage and browse species, will be open to grazing within an often much larger pasture in fair to poor ecological condition.

Perhaps the most logical answer to this problem is that the land management agencies should be planning and implementing active range and wildlife habitat improvement projects on all allotments that contain areas of significant mining disturbance that is in the reclamation process. Some of the mine reclamation projects will be of sufficient size so they should be considered separate management units with permanent fencing and water developments planned into the reclamation process.

Fuel Management

The most frequent stand renewal process in the sagebrush and upper shadscale zone in northern Nevada is burning in wildfires. Remember the dominant species of sagebrush do not sprout after being burned. Reclamation seedings stand a good chance of being burned if fuel management is not practiced.

Land management agencies have active programs of using plantings of perennial grasses and grazing management as fuel breaks to suppress wildfires in areas where cheatgrass is the landscape dominant. This program is commonly identified as green stripping.

Mining reclamation projects need to be integrated into these green stripping projects so that valuable revegetation efforts are not destroyed. Remember the woody portion of reclamation seedings are often the most expensive to establish.

Integrated Reclamation Planning

Obviously mining reclamation in northern Nevada and throughout the sagebrush rangelands of the intermountain area will benefit greatly from coordinated planning that includes specialists in grazing management and wildfire fuel management as well as reclamation.

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