Medusahead and Clay: The Rarity of Perennial Seedling Establishment

JAMES A. YOUNG, CHARLIE D. CLEMENTS, AND GLENN NADER

At one time it was quite common for range managers to rationalize the poor condition of a particular range site with the statement, "Give it a couple good wet years and you would not know this place". **In the Great Basin, the standard rancher prayer is for a few good warm spring rains as opposed to a downpour thunderstorm when the hay is mowed and in the field or 6 inches of snow during calving time.** Hay gets wet in the fields, cold storms happen during the early spring, but warm well distributed spring rains are very rare events.

Any serious student of the biology of temperate deserts of western North America, cannot help but be struck by the episodic nature of perennial seedling recruitment. Many species do not recruit seedlings to the stand every year. You can walk through many Great Basin plant communities and find the seedling age class of native perennials is completely absent on most years. Grant Harris pointed out many years ago that recruitment of bluebunch wheatgrass seedlings, especially in the face of competition from cheatgrass, is a highly episodic event conditioned by unusually favorable amounts and periodicity of moisture. Our experience has been, the drier the site the more episodic seedling recruitment becomes.

Our purpose is to describe the nature of the range site in the western Great Basin most frequently infested with medusahead and contrast perennial grass seedling recruitment during drought, modal, and exceptionally favorable seasons for seedling recruitment.

Medusahead

Medusahead is an annual grass native to Asia that first invaded the Mediterranean region and then was introduced to the western United States. Once established on rangeland sites, medusahead reduces harvestable forage for domestic and wild herbivores, greatly limits the establishment of seedlings of perennial species, and increases the chance of ignition and the rate of spread of wildfires.

Nature of Sites Infested With Medusahead

In the western Great Basin, medusahead usually invades sites already infested with the accidentally introduced annual cheatgrass. Cheatgrass is a highly successful competitor for soil moisture and it inhibits the establishment of seedlings of other annuals or perennials. Because medusahead matures about a month later than cheatgrass, it initially only replaces cheatgrass on soils with sufficient moisture holding capacity that some soil moisture remains after the maturity of cheatgrass. For years managers and scientists have noticed a strong correlation between medusahead dominance and clay textured surface soils. Medusahead plants have the root system to completely exploit all soil moisture in the soil profile and the plants have the inherent capacity to extract moisture from extremely dry soils.

Smectite Clay Soils

It is very fitting that Robert Blank worked out the sequence in soil environment change that resulted from medusahead invasion in the western Great Basin. Blank's graduate studies mentor was M. A. Fosberg at the University of Idaho, who first reported the association between clay soils and medusahead invasion. Blank determined that for the vast Columbia Basalt formation, that extends from northern California, northwestern Nevada, and southwestern Idaho to British Columbia, Canada, the soils where medusahead is found are often associated with the development of the Cascade volcanos to the west. On the Modoc Plateau in northeastern California, during the Tertiary period, extrusive volcanic flows periodically dammed water flows, which resulted in the formation of large lakes. Contemporaneous with the lake formation, volcanic ejecta from the rising Cascades contributed large volumes of tephra (ash and cinders) that rained into the lakes. Diagenesis or alternation of this lake-laid tephra formed 2 to 1 expanding lattice aluminosilicate clay minerals (group name of smectite). The type of smectite clays found on the Modoc Plateau possess high levels of shrink-swell and unusual water retentive properties.

Soils dominantly smectitic in composition, are referred to as self-churning Vertisols. These are soils that swallow themselves annually. When they dry the soils shrink until an extensive system of cracks is formed. Surface soil layers partially sluff into the deep cracks. Upon re-wetting the soils swell, burying the material entombed in the cracks or sometime ejecting it back on the soil surface. In contrast to normal soil development where horizonation is used as an interpretative tool, these soils continually erase their own history. Over thousands of years, the shrink-swell action of the clays has rafted underlying rock, from cobble to boulders in size, to the soil surface. **The resulting landscape is one of the most miserable to walk, drive or ride horseback across on the western range. At turn-out date in the spring, cows have the choice of standing on four rocks or sinking 10 inches deep in sticky clay.** By late summer, yawning cracks 4 to 10 inches wide stretch among the rocks. Some open to the bedrock 3 to 6 feet below. Sometimes the soils are sorted into huge, irregular polygons of rock almost entirely composed of rock with only clay films.

Rock sorting to the surface and rock polygon formation, precludes the tillage of medusahead sites for weed control and seedbed preparation. The infested sites usually cannot be seeded with a drill, even a heavy duty rangeland drill. Artificial seeding is limited to broadcasting on the soil surface with no possibility of obtaining seed coverage.

The clay textured soil surface among the rocks is a hostile environment for the establishment of perennial grass seedlings. The structure of these clays when dry is granular. As the seedbed surface dries in the spring the aggregated particles of clay are readily wind erodible. As the drying clays shrink, they pull away from the crown of perennial grass seedlings leaving the adventitious roots exposed and the seedling attached by the true or seminal root only. This process is aggravated by frost heaving during the winter. In the spring it is common to observe semi-circular patterns on the seedbed surface where the wind has whipped such precariously attached seedlings back and forth until they die. These seedlings are easily pulled from the ground by grazing animals.

Natural Communities

Robert Blank and James Trent searched for range sites similar to those invaded by medusahead to study how native plants became established on the clays. When considering medusahead invasion on volcanic landforms in the Great Basin, it is important to be aware that the seemingly flat basaltic tablelands appear very uniform, but actually support a multitude of micro-topoedaphic features and plant assemblages. One of the plant communities most frequently encountered and most extensive in area is characterized by Lahontan sagebrush/Sandberg bluegrass (Figure 1).

Figure 1. *Lahonton sagebrush/Sandburg bluegrass plant community. This site will become dominated by medusahead following repeated wildfires fueled by cheatgrass and medusahead herbage. Even though this is a fairly high condition site, it already contains scattered medusahead plants. The meter range pole is divided into decimeters.*

Blank and Trent found the soils of the Lahontan sagebrush communities were fascinating micro-environments of dust, developed physical, and microphytic crust. These sites were selected as parallel environmental potentials to adjacent degraded sites infested with medusahead. The shrubs grow on mounds rising above the clay soil. The mounds are composed largely of eolian dust, from the vast playa system left in the Great Basin by drying Pleistocene (pluvial) lakes. The shrubs trap the falling dust and coarse particles bouncing across the surface of the clays (a process known as saltation). The shrubs add leaf fall to the soil accumulations beneath their canopies. This supports an extensive microphytic community. The eolian veneer extends to the interspace and varies in depth from 0 to 10 inches. Shrub interspaces, which make up 50% of the area, are largely bare of vegetation except for Sandberg bluegrass plants growing on pedestals.

Common and scientific names of plant material.

Appar flax	*Linum lewisii*
Big sagebrush	*Artemisia tridentata*
Bluebunch wheatgrass	*Pseudoroegneria spicata*
Cheatgrass	*Bromus tectorum*
Crested wheatgrass	*Agropyron desertorum*
Idaho fescue	*Festuca idahoensis*
Lahontan sagebrush	*Artemisia arbuscula* ssp.*longicaulis*
Medusahead	*Taeniatherum caput-medusae* spp. *asperum*
Palmer penstemon	*Penstemon palmeri*
Sandberg bluegrass	*Poa secunda* ssp. *secunda*
Sherman big bluegrass	*Poa ampla*
Squirreltail	*Elymus elymoides*
Tall wheatgrass	*Elytrigia elongata*

Obviously, the mounds with their relatively thick layers of eolian deposited soil, nutrient cycling from leaf and litter fall, and potential nitrogen fixation from the cryptogamic crust are a much more desirable location for plant growth than the bare Vertisol beds of clay. The interspaces between the shrubs were largely bare, but Robert Blank suggested they play an important part in making the Lahontan sagebrush community function. They developed vesicular crust that are so impermeable that they reduced water penetration to the clay beds and tended to channel deep moisture penetration to the mound areas. If the deep clays do not get wet they have reduced expansion and shrinkage. The mounds composed of coarser-textured material serve to dampen the surface effects of the expanding lattice clays.

Apparently, what has occurred in the process of degradation of these sites is that first cheatgrass invaded the former Lahontan sagebrush sites. Then the cheatgrass was replaced by medusahead. Recurring wildfires, carried by the dense accumulation of annual grass herbage, killed the non-sprouting shrubs. Once the shrubs were gone the eolian derived mounds eroded away and the entire system reverted to a clay-rock surface. This resulted in a drastic change in seedbed diversity and quality. Diversity of safesites for germination is greatly reduced because all of the multitude of varied litter and microphytic crust sites that formed in irregular halos on the shrub mounds were lost. The shrinking-swelling, frost heaving clays provided a very unstable and hostile environment for germination and seedling establishment.

Medusahead Germination On The Clay Seedbeds

If the smectite clay beds offer such a hostile seedbed how is medusahead so successful in colonizing the sites? The answer lies in the inherent potential of medusahead seeds to germinate and the rapid accumulation and slow decay of the litter of this grass. Medusahead seeds (technically more complex than a simple seed, a type of fruit known as a caryopsis) can germinate suspended in litter without the callus end of the seed in contact with a moisture supplying substrate. Not only can they do this once, but repeated germination from adventitious buds can occur if the initial root dries before seedling establishment is obtained.

Rod Bovey determined that medusahead herbage has a higher silica content than that of any other grass. Between not being preferred by herbivores and decaying slowly because of its silica content, medusahead communities develop a thick layer of litter. Litter is excellent for damping the extremes of bare seedbeds and bringing the potential of the seedbed within the germination requirements of plant seeds. In this case the effects of the litter goes even farther. Moisture events, or perhaps even diurnal fluctuations in relative humidity, cause clay particles to cling to the lower surface of the fine medusahead litter. This is close to the time honored recipe for manufacturing adobe bricks. In this case a flexible mat containing the seed reserves of the medusahead community is formed. Not only are the extremes of the seedbed environment mollified, the medusahead seedbank is kept free of the self-churning action of the clay soils. Miniature bridges span cracks and flex with the swelling and shrinking of the clay. Seeds that fall into the cracks are buried far deeper than they can emerge. Medusahead seeds germinate in the litter and drop incredibly strong juvenile roots to the clays. These juvenile roots are capable of transporting moisture back to the seedling.

This is such a favorable modification of a harsh seedbed it would seem reasonable that seeds of other plant species would find favorable sites for germination. They do, but the fierce competition from dense stands of medusahead effectively eliminate the seedlings of other species from establishing. **If you are going to establish seedlings of desirable species you must first reduce competition from the dense stands of medusahead.**

We have established several different species of native shrubs, including Lahontan sagebrush, on the clay beds by transplanting seedlings and providing first season weed control. Many of these transplants successfully established and even persisted through years of extreme drought. These plantings have been established for as long as 15 years and produce abundant crops of viable seeds as determined by field collection and laboratory testing. We have never observed natural successful establishment of shrub seedlings around these nursery plants.

Herbicidal Control Of Medusahead

There are several herbicides that give excellent control of medusahead. There has been little commercial activity in registering herbicides for this use because of lack of interest by ranchers and land management agencies conditioned by the

Figure 2. *Wheatgrass seedlings growing from furrows where sand was applied to clay seedbed. Broadcast spreading a thin layer of sand consistently produces perennial grass seedling establishment. Placing the sand in furrows is not as consistent because the sand sometimes disappears down cracks in the clay beds.*

cost of such treatments and environmental concerns. Control has not been the problem. **Getting perennial replacement species established to *biologically suppress* medusahead has been the problem.** If you are going to biologically suppress an annual grass you must establish a perennial grass. The lack of perennial grass seedling establishment is directly related to the harshness of the churning clay soils that form the seedbed.

There are two basic systems for applying herbicides to control an annual grass. One is to create a herbicidal fallow by applying a soil active herbicide in the fall and waiting a year for the herbicide activity to dissipate before seeding. Fallow systems have the advantage of storing moisture and nitrates, but it results in the loss of the litter layer. This is not a problem on sandy to clay-loam textured soils found on most big sagebrush potential sites where cheatgrass is the annual being controlled, but in the case of these medusahead sites the churning clay is exposed. The second herbicidal control involves using a contact herbicide that is inactivated when it reaches the soil surface. The only applicable material for medusahead is glyphosate (Trade name Roundup). Another potential herbicide in this class is paraquat, but it does not kill medusahead under Intermountain environmental conditions. In Utah, the best control of medusahead that has led to perennial grass establishment, occurred when the periodicity and amount of fall rains induced excellent germination of medusahead before winter. After applications of glyphosate, wheatgrasses were seeded into the litter with a no-till drill

Seeding Attempts

The standard perennial grass that has been historically used for seeding in the precipitation zone where our research plots are located in northeastern California is crested wheatgrass. We started seeding crested wheatgrass at several locations on the clay soils in 1970. Establishment and subsequent growth have both been very disappointing. We tried many different

Figure 3. *Moderately successful perennial grass establishment on clay soils infested with medusahead. Medusahead competition was reduced with application of the herbicide glyphosate and the site broadcast seeded in the spring over the medusahead litter. Seedling establish - ment such as this only occurred once in the last 25 years.*

native and introduced species with continued out-right failure to sporadic, inconsistent sub-marginal success. The large seeded tall wheatgrass has given the most consistent, but always sub-marginal, results.

Physically Modifying The Seedbed

We worked our way, with no success, through a host of applied organic mulches in an attempt to improve the quality of seedbeds. We hit upon a highly effective inorganic mulch, sand. You normally do not think of a coarse sand as a desirable seedbed, but a 1 to 2 inch layer of sand applied across the clay results in excellent and consistent establishment of several different species of native perennial grasses (bluebunch wheatgrass, Idaho fescue, squirreltail) and forbs (Palmer penstemon and Appar flax) (Figure 2). Was the problem solved? Unfortunately, it has not been solved on a practical basis. Calculate the amount of sand that is required to cover an acre a couple inches deep. Except for limited applications in high value situation, the sand mulch is not economically feasible.

Figure 4. *Excellent stand of Sherman big bluegrass growing on site where medusahead was controlled with herbicides. Range pole divided into decimeters.*

Yearly Variation

During the prolonged struggle to find adapted plant material for seeding on the medusahead sites, we became well acquainted with variation in the amount and periodicity of precipitation received on the experimental sites. This included 3 years when it was too dry for medusahead to grow and reproduce (less than 5 inches of total precipitation annually). Average precipitation for our experimental site is about 12 inches. Years of seeding on these clay soil sites with average precipitation from 8 to 14 inches have resulted in failure. In 1996-1997 the site was blessed with just under 9 inches of precipitation during early and mid-winter. Unfortunately, it never rained after February first and the seedings were complete failures.

Mythical Wet Spring Materialize

The winter of 1997–1998 finally turned out to be the mythical wet winter with abundant warm spring rains. We obtained good stands of tall wheatgrass on both atrazine (1 lb per acre) and sulfometuron methyl (0.3 oz per acre) fallowed plots from fall seeding, and marginal, but consistent over a large area, stands with applications of 0.5 lb per acre of glyphosate followed the same day with spring seeding (Figure 3). The most successful stands were obtained with `Sherman' big bluegrass, a cultivar which we had not previously tried (Figure 4).

Sherman Big Bluegrass

The cultivar Sherman was developed from plant material first collected in eastern Oregon. Sandberg bluegrass is the most abundant perennial herbaceous species in the un-degraded Lahontan sagebrush communities. When medusahead dominates, Sandberg bluegrass is completely absent from the community. We noted this association many years ago and have repeatedly tried to establish local collections on the medusahead infested clay soils. We were never successful with these trials.

Is Sherman big bluegrass a potential break through in plant material for revegetation of medusahead sites? Or was the success with this native species a fluke associated with the exceptionally wet spring? **Repeated trials over time will provide the answer, but if we have to wait for reoccurrence of the exceptional warm wet spring of Great Basin mythology, the answer may have to wait for the next generation of researchers.**

References

Blank, R. R., J. T. Trent, and J. A. Young. 1992. Sagebrush communities on clayey soils of northeastern California, a fragile equilibrium. pp 198–200. *in* Proc. Sam. Ecology and Management of Riparian Shrub Communities. Gen. Tech. Rpt. 289, USDA, Forest Service, Odgen, Utah.

Charley, J. L. and N. E. West. 1977. Micro-patterns of nitrogen mineralization activity in soils off some shrub-dominated semi-desert ecosystems of Utah. Soil Biol. Biochem. 9:357–365.

Eckert, R. E., Jr., F. F. Peterson, M. K. Wood, W. H. Blackburn, and J. L. Stephens. 1989. The role of soil surface morphology in the function of semi-arid rangelands. Bulletin 89–91. Nevada Agric. Experiment Sta., Univer. of Nevada, Reno.

Evans, R. A. and J. A. Young.1970. Plant litter and establishment of alien annual species in rangeland communities. Weed science 18:697–703.

Evans, R. A., R. E. Eckert, Jr., and B. L. Kay. 1967. Wheatgrass establishment with paraquat and tillage on downy brome ranges. Weeds 15:50–55.

Evans, R. A., R. E. Eckert, Jr., B. L. Kay, and J. A. Young. 1969. Downy brome control by soil-active herbicides for revegetation of rangelands. Weed Sci. 17:166–169.

Harris, G. A. and A. M. Wilson. 1970. Competition for moisture among seedlings of annual and perennial grasses as influenced by root elongation at low temperatures. Ecology 51:530–534.

Robertson, J. H. and C. K. Pearce. 1945. Artificial reseeding and closed communities. Northwest Sci. 19:58–66.

Soreng, R. J. 1993. Poa. pp. 1294–1291 *In:* J. C. Hickman (ed.) The Jepson Manual. Univer. Calif. Press, Berkeley, Calif.

West, N. E. 1990. Structure and function of microphytic crust in wildland ecosystems of arid and semi-arid regions. Advances in Ecological Research 20:179–223.

Young, J. A. 1992. Ecology and management of medusahead (*Taeniatherum caput-meduase* ssp. asperum [Simk.] Melderis). Great Basin Naturalist 52:245–252.

Young, J. A. and R. A. Evans. 1986. Erosion and deposition of fine sediments from playas. J. Arid Environments 10:103–115.

Young, J. A. and R. A. Evans. 1970. Invasion of medusahead into the Great Basin. Weed Sci. 18:89–97.

Young, J. A., R. A. Evans, and B. L. Kay. 1971. Germination of caryopses of annual grasses in simulated litter. Agronomy J. 63:551–555.

Authors are range scientist and research technician, USDA, Agric. Res. Ser., 920 Valley Road, Reno, NV 89512, and Univer. California Cooperative Extension farm advisor, Sutter/Yuba/Butte Counties, Yuba City, CA. 95991.