COMRADES IN HARM

Livestock and Exotic Weeds in the Intermountain West

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Exotic weed invasion is one of the greatest ecological threats to grass and shrub ecosystems in the arid West, and livestock grazing is a leading cause of weed invasion. Livestock carry in weed seeds on their coats and in their digestive systems; they weaken native plants by grazing them; and they disturb the soil surface, thereby creating more favorable conditions for exotic invaders and less favorable conditions for native plants.

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In the midst of the vast expanses of sagebrush and bunchgrass that blanket the public lands of the Great Basin, a hiker passes through a livestock allotment in which native grasses have been grazed to the ground. Only nonnative plants, such as pink bull thistle, yellow leafy spurge, and brown curly dock, remain standing tall. The weeds seem poised to invade bare soils that were only recently vegetated by native bunchgrasses tall enough to reach a horse's underside. Dozens of fresh cattle patties dot the area, fouling every breath with the stench of fresh dung and revealing the cause of the damage. The hiker stands witness as livestock initiate the invasion and replacement of native grasslands by weeds.

Along the Salmon River, Idaho. It may look like one lovely green sward, but cheatgrass and other weed species have invaded the lower slope, while native bunchgrass still holds out on the upper slope.

Exotic weed invasions are possibly the greatest threat facing the grasslands and shrublands of the arid and semiarid West today. Species-rich ecosystems are being converted into monotonous "weedlands" as aggressive weeds replace native plants and degrade habitat for native wildlife. Some of the most notorious invaders - nonnative species such as cheatgrass, medusahead, knapweed, yellow starthistle, and leafy spurge - have already spread over more than 100 million acres of western lands **1** and are invading new areas at the rate of 5,000 acres per day. **2**

During the past century, a large number of scientific studies have documented that cattle and sheep are major causes of weed invasions into grasslands and shrublands of the arid West.

First, livestock carry weed seeds on their coats and in their guts. Where these seeds are brushed off the animals or excreted in dung, they can grow into mature plants capable of producing hundreds to thousands of seeds. One study in Alberta, for example, found that in a single growing season, one cow moved 270,000 viable weed seeds around a pasture. **3** It is clear that the millions of cattle and sheep now grazing our western public lands are annually moving tens of millions, if not hundreds of millions, of weed seeds from weed-infested communities into uninfested areas, even on our most remote public lands.

Second, livestock weaken many native plants by grazing them, thus removing their leaves and flowering stems - that is, their photosynthetic and reproductive organs. Grasses and other plants of the Intermountain West are especially vulnerable to grazing by large herbivores since they evolved in an environment that has not been home to many large grazers for the past ten thousand years. Bison are predominantly a Great Plains species, and only low densities of elk, deer, and pronghorn occupy the arid lands west of the Rocky Mountains. **4** As a result, Great Basin grasses and flowering plants evolved little tolerance of herbivory and are

severely damaged by close and repeated grazing. **5** In addition, livestock frequently prefer native plants to weeds, which are often covered with spines or contain toxic and distasteful compounds. **6** Where they preferentially consume native grasses and wildflowers, they leave weeds to grow unharmed and with little competition for water and nutrients. **7** Consequently, weedy species grow large and increase in number while native species decline. **8**

Finally, livestock contribute to weed invasions by disturbing the soil surface. Several factors are involved:

- Livestock trample the soil, creating patches of bare ground that serve as natural seed beds for the germination of weed seeds. **9** Trampling also compacts the soil, damaging the roots of native plants and preventing them from acquiring sufficient water and nutrients for vigorous growth. **10**

- By reducing plant cover through grazing and disturbing the soil surface with their hooves, livestock enhance wind and water erosion. **11** Dislodged soil particles then bury the weed seeds, increasing their ability to germinate. **12**

- Livestock hooves destroy fragile biological crusts that blanket exposed soils in deserts, arid grasslands, and shrublands. These crusts, which are composed of algae, bacteria, lichens, and mosses, enrich the soil with nutrients, especially nitrogen, and increase the vigor of native plants. **13** They also stabilize the soil and act as physical barriers to weed invasions. As the hooves of livestock pulverize the biological crusts, they remove an important defense against the invasion of weeds. **14**

- Livestock trampling also reduces the number of soil mycorrhizae, the microscopic fungi that benefit native plants by transporting nutrients and water from the soil into plant roots. Many exotic weeds, such as Russian thistle and halogeton, do not require or benefit from these fungi. As trampling reduces concentrations of mycorrhizae in the soil, the ability of native grasses to acquire nutrients and water is reduced, giving the exotic weeds a competitive advantage over the native plants. **15**

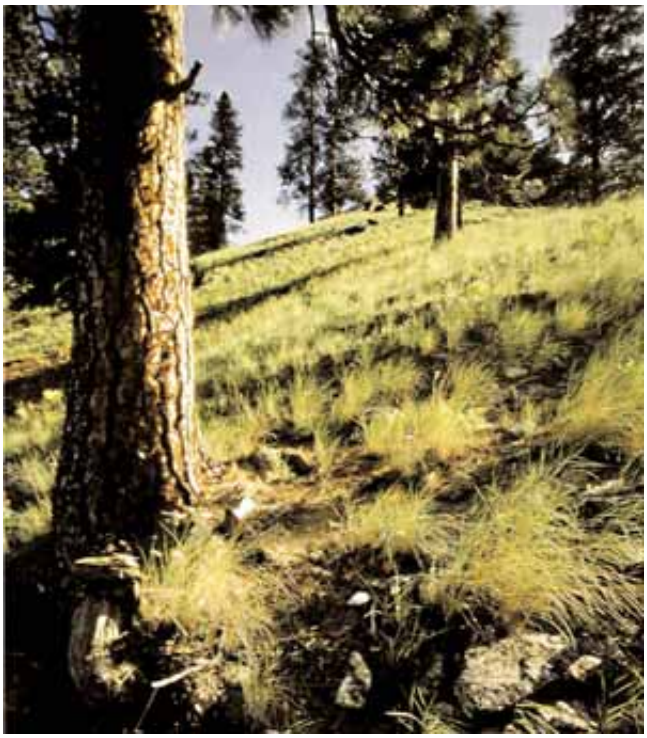
- Livestock deposit nitrogen on the ground in their urine and feces. These nitrogen "hot spots" are concentrated where livestock congregate, especially near streams, water tanks, and salt licks. They intensify invasions by nitrogen-loving weeds, such as cheatgrass and medusahead. **16** Repeatedly, scientists have found that sites that are disturbed and also receive high concentrations of livestock waste are the most severely invaded.

- By reducing plant and litter cover and compacting the soil, livestock create warmer and drier soils, an impact especially severe in parched deserts, where plants are already highly stressed by lack of water. **17** These drier soils reduce the vigor of native plants, whereas annual weeds simply go dormant.

Most, but not all, exotic weed species require the type of disturbance and open space created by livestock to germinate and grow vigorously. A few species, however, are able to flourish in plant communities ungrazed by livestock, as can be seen in national parks and other natural areas. This is because vehicles, miners, native wildlife, hikers, wind, and flooding streams can also carry weed seeds into grasslands and disturb the soils. Rarely, however, are these other influences as numerous or as widely distributed as livestock. Studies have shown that in most cases, plant species that invade undisturbed natural areas are less dense inside the natural areas than outside **18**-with localized exceptions, such as sites near roads and trails, or sites disturbed by recreationists and wildlife.

Many in the livestock industry and in federal agencies such as the Forest Service and the Bureau of Land Management ignore the connection between livestock grazing and weed invasions. Since these agencies deny the role of livestock grazing, they seldom reduce the number of livestock allowed to graze public lands, even in areas where weeds are a major problem. Agency personnel prefer using herbicides and biocontrol agents to eradicate the weeds rather than trying to prevent the invasion of weeds in the first place.

Because federal agencies ignore a major cause of weed invasions - that



Frank Church/River of No Return Wilderness, Idaho. This open slope of ponderosa pine and native bunchgrass has never been grazed by domestic livstock. There is little evidence of weed invasion.

is, livestock grazing, which is also the major land use in the western United States - their recent attempts to hold back the flood of exotic weeds onto public lands have been ineffective. By pouring toxic herbicides onto grasslands and shrublands, rather than working to prevent the invasions, they compound the problem, since herbicides kill beneficial species, poison soil ecosystems, and prepare soils for the next onslaught of weeds.

Preventing weed invasions by controlling livestock is the best tool we have, but unfortunately it is not being used.

The cause of the substitution is overgrazing. When the too-greatherds and flocks chewed and trampled the hide off the foothills, something ha to cover the raw eroding earth. Cheat did.

- Aldo Leopold, A Sand County Almanac, 1949

Endnotes

1. W. D. Billings, "Bromus tectorum, a Biotic Cause of Ecosystem Impoverishment in the Great Basin," *in* THE EARTH IN TRANSITION: PATTERNS AND PROCESSES OF BIOTIC IMPOVERISHMENT, edited by G. M. Woodwell (New York: Cambridge University Press, 1990); R. N. Mack, "Temperate Grasslands Vulnerable to Plant Invasions: Characteristics and Consequences," *in* BIOLOGICAL INVASIONS: A GLOBAL PERSPECTIVE, edited by J. A. Drake et al. (Chinchester, U.K.: Wiley and Sons, 1989), pp. 155-179; S. Whisenant, "Changing Fire Frequencies on Idaho's Snake River Plains: Ecological and Management Implications," *in* Proceedings from the Symposium on Cheatgrass Invasion, Shrub Dieoff and Other Aspects of Shrub Biology and Management, USDA Forest Service General Technical Report INT-276 (1990), pp. 4-10.

2. Bureau of Land Management, Partners Against Weeds: An Action Plan for the Bureau of Land Management, BLM/MT/ST-96/003+1020 (Billings, Mont.: Bureau of Land Management, 1996).

3. W. G. Dore and L. C. Raymond, "Viable Seeds in Pasture Soil and Manure," *Scientia Agricola* 23 (1942): 69-76.

4. G. A. Harris, "Grazing Lands of Washington State," *Rangelands* 13 (1991): 222-227; R. N. Mack, "Temperate Grasslands" (see note 1 above); R. N. Mack and J. N. Thompson, "Evolution in Steppe with Few Large, Hooved Mammals," *American Naturalist* 119 (1982): 757-773; D. G. Milchunas, O. E. Sala, and W. K. Lauenroth, "A Generalized Model of the Effects of Grazing by Large Herbivores on Grassland Community Structure," *American Naturalist* 132, no. 1 (1988): 87-106.

5. Mack and Thompson, "Evolution" (see note 4 above).

6. M. J. Crawley, HERBIVORY: THE DYNAMICS OF ANIMAL-PLANT INTERACTIONS (Berkeley and Los Angeles: University of California Press, 1983); Lacey, "The Influence of Livestock Grazing on Weed Establishment and Spread," Proceedings Montana Academy of Science 47 (1987): 131-146; G. Stewart and A. C. Hull Jr., "Cheatgrass (Bromus tectorum L.): An Ecological Intruder in Southern Idaho," *Ecology* 30 (1949): 58-74; B. R. Watkin and R. J. Clements, "The Effects of Grazing Animals on Pastures," *in* PLANT RELATIONS IN PASTURES, edited by J. R. Wilson (East Melbourne, Australia: CSIRO, 1978), pp. 273-289.

7. D. J. Bedunah, "The Complex Ecology of Weeds, Grazing, and Wildlife," *Western Wildlands* (Summer 1992): 6-11; Lacey, "Influence of Livestock Grazing" (see note 6 above); S. M. Louda, K. H. Keeler, and R. D. Holt, "Herbivore Interactions on Plant Performance and Competitive Interactions," *in* PERSPECTIVES ON PLANT COMPETITION, edited by J. B. Grace and D. Tilman (San Diego: Academic Press, 1990); R. L. Sheley, B. E. Olson, and L. L. Larson, "Effect of Weed Seed Rate and Grass Defoliation Level on Diffuse Knapweed," *Journal of Range Management* 50, no. 1 (1997): 39-43.

8. L. Ellison, "Influence of Grazing on Plant Succession of Rangelands," *Botanical Review* 26 (1960): 1-78; G. A. Harris, "Some Competitive Relationships Between Agropyron spicatum and Bromus tectorum," *Ecological Monographs* 37, no. 2 (1967): 90-111; W. H. Rickard, "Experimental Cattle Grazing in a Relatively Undisturbed Shrubsteppe Community," *Northwest Science* 59, no. 1 (1985):

66-72.

9. Ellison, "Influence of Grazing" (see note 8 above); R. J. Hobbs, "The Nature and Effects of Disturbance Relative to Invasions," *in* BIOLOGICAL INVASIONS: A GLOBAL PERSPECTIVE, edited by J. A. Drake et al. (Chinchester, U.K.: Wiley, 1989), pp. 389-405; R. J. Hobbs and L. F. Huenneke, "Disturbance, Diversity, and Invasion: Implications for Conservation," *Conservation Biology* 6, no. 3 (1992): 324-337; Rickard, "Experimental Cattle Grazing" (see note 8 above).

10. R. A. Dahlgren, M. J. Singer, and X. Huang, "Oak Tree and Grazing Impacts on Soil Properties and Nutrients in a California Oak Woodland," *Biogeochemistry* 39 (1997): 45-64; J. F. Dormaar and W. D. Willms, "Effect of Forty-Four Years of Grazing on Fescue Grassland Soils," *Journal of Range Management* 51 (1998): 122-126; J. W. Menke, "Management Controls on Productivity,"*in* GRASSLAND STRUCTURE AND FUNCTION: CALIFORNIA ANNUAL GRASSLAND, edited by L. F. Huenneke and H. A. Mooney (Dordrecht, Netherlands: Kluwer, 1989), pp. 173-199; Watkin and Clements, "Effects of Grazing Animals" (see note 6 above).

11. Ellison, "Influence of Grazing" (see note 8 above); G. C. Lusby, "Hydrologic and Biotic Effects of Grazing vs. Non-Grazing Near Grand Junction, Colorado," *Journal of Range Management* 23 (1971): 256-260.

12. R. A. Evans and J. A. Young, "Microsite Requirements for Establishment of Annual Rangeland Weeds," *Weed Science* 23, no. 5 (1972): 354-357.

13. J. Belnap and O. L. Lange, BIOLOGICAL SOIL CRUSTS: STRUCTURE, FUNCTION AND MANAGEMENT (Berlin: Springer-Verlag, 2001).

14. J. Belnap, "Surface Disturbances: Their Role in Accelerating Desertification," *Environmental Monitoring and Assessment* 37 (1995): 39-57; Belnap and Lange, "Biological Soil Crusts" (see note 13 above); R. E. Eckert Jr. et al., "Effects of Soil-Surface Morphology on Emergence and Survival of Seedlings in Big Sagebrush Communities," *Journal of Range Management* 39, no. 5 (1986): 414-420; R. D. Evans and J. R. Ehleringer, "A Break in the Nitrogen Cycle in Aridlands? Evidence From N15 Isotope of Soils," *Oecologia* 94 (1993): 314-317; R. N. Mack, "Temperate Grasslands" (see note 1 above); T. J. Stohlgren et al., "Patterns of Plant Invasions: A Case Example in Native Species Hotspots and Rare Habitats," *Biological Invasions* 3 (2001): 37-50

15. E. B. Allen, "Mycorrhizal Limits to Rangeland Restoration: Soil Phosphorous and Fungal Species Composition," *in* Proceedings of the Fifth International Rangeland Congress, vol. 2, Rangelands in a Sustainable Biosphere, pp. 57-61 (Salt Lake City, 1995); E. B. Allen and M. F. Allen, "Facilitation of Succession by the Nonmycotrophic Colonizer Salsola kali on a Harsh Site: Effects on Mycorrhizal Fungi," *American Journal of Botany* 75 (1988): 257-266; G. J. Bethlenfalvay and S. Dakessian, "Grazing Effects on Mycorrhizal Colonization and Floristic Composition of the Vegetation on a Semiarid Range in Northern Nevada," *Journal of Range Management* 37, no. 4 (1984): 312-316; G. J. Bethlenfalvay, R. A. Evans, and A .L. Lesperance, "Mycorrhizal Colonization of Crested Wheatgrass as Influenced by Grazing," *Agronomy Journal* 77 (1985): 233-236; T. B. Doerr, E. F. Redente, and F. B. Reeves, "Effects of Soil Disturbance on Plant Succession and Levels of Mycorrhizal Fungi in a Sagebrush-Grassland Community," *Journal of Range Management* 37 (1984): 135-139.

16. Evans and Ehleringer, "Break in the Nitrogen Cycle" (see note 14 above); Hobbs, "Nature and Effects of Disturbance" (see note 9 above); L. F. Huenneke et al., "Effects of Soil Resources on Plant Invasion and Community Structure in Californian Serpentine Grassland," *Ecology* 71 (1990): 478-491.

17. S. Archer and D. E. Smeins, "Ecosystem Level Processes," *in* GRAZING MANAGEMENT: AN ECOLOGICAL PERSPECTIVE, edited by R. K. Heitschmidt and J. W. Stuth (Portland, Ore.: Timber Press, 1991); W. L. Loope and G. F. Gifford, "Influence of a Soil Micro-Floral Crust on Select Property of Soils Under Pinyon Juniper in Southeastern Utah," *Journal of Soil and Water Conservation* 27 (1972): 164-167; R. L. Piemeisel, "Causes Affecting Change and Rate of Change in a Vegetation of Annuals in Idaho," *Ecology* 32, no. 1 (1951): 53-72.

18. Belnap, "Surface Disturbances" (see note 14 above); R. F. Daubenmire, "Plant Succession on Abandoned Fields, and Fire Influences, in a Steppe Area in Southeastern Washington," *Northwest Science* 49 (1975): 36-48; R. F. Daubenmire, Steppe Vegetation of Washington, Washington Agricultural Experimental Station Technical Bulletin No. 62 (1970); J. R. Goodwin et al., "Persistence of Idaho Fescue on Degraded Sagebrush Steppe," *Journal of Range Management* 52 (1999): 187-198; J. R. Lacey, P. Husby, and G. Handl, "Observations on Spotted and Diffuse Knapweed Invasion into Ungrazed Bunchgrass Communities in Western Montana," *Rangelands* 12 (1990): 30-32; G. D. Pickford, "The Influence of Continued Heavy Grazing and of Promiscuous Burning on Spring-Fall Ranges in Utah," *Ecology* 13 (1932): 159-171; R. L. Piemeisel, "Causes Affecting Change and Rate of Change in a Vegetation of Annuals in Idaho," *Ecology* 32, no. 1 (1951): 53-72; J. A. Young and F. L. Allen, "Cheatgrass and Range Science: 1930-1950," *Journal of Range Management* 50, no. 5 (1997): 530-535.