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RESTORING PALOUSE AND CANYON GRASSLANDS: PUTTING BACK THE MISSING PIECES

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Restoring Palouse and Canyon Grasslands: Putting Back the Missing Pieces

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Overview

Prior to the middle of the nineteenth century, the natural vegetation of the Palouse region of southeastern Washington, northeastern Oregon, and adjacent parts of northern Idaho was dominated by steppe and meadow steppe plant associations. Beginning in the 1830s, Euroamerican settlement of the region led to dramatic changes. Deep soils were cultivated, and shallower soils were grazed by livestock. The extent and quality of native grasslands declined as a result of these changes in land use. For this reason, there is now considerable interest in restoring native vegetation in the Palouse region. This volume looks at the prospects for restoration of native steppe and meadow steppe communities, with an emphasis on methods that do not create areas of bare soil. Section 1 reviews work that has been done on the restoration of native steppe and meadow steppe. Section 2 reports on the results of pilot projects undertaken to (A) compare microbial soil communities in native and non-native vegetation at two meadow steppe and two steppe sites, (B) test the efficacy of bacterial control of a severe cheatgrass infestation, and (C) investigate the effectiveness of artificial ground covers on survival of transplanted native grass plugs.

1. Restoration of Palouse and Canyon Grasslands: A Review

B.J. Weddell and J. Lichthardt

1.1. Introduction

The Bureau of Land Management (BLM) manages extensive areas of bunchgrass steppe in all types of condition. Restoration of certain areas, if feasible, could be used to safeguard priority habitats and species and to improve conditions for wildlife. The purpose of this report is to summarize research and field trials relevant to steppe restoration in the Palouse region of southeastern Washington and adjacent Idaho.

Almost all Palouse steppe vegetation has been cultivated or grazed by domestic livestock. Remaining examples of uncultivated native steppe or meadow steppe vegetation are primarily found in the breaks of the Snake and Columbia Rivers. Most of these sites have been degraded by domestic livestock grazing and alien weed invasion. The conversion of vast areas of native steppe vegetation to alien-dominated communities has been the primary impetus for a growing interest in grassland restoration in the Palouse region.

The National Academy of Sciences attempted to standardize the terminology used in discussing land restoration following surface coal mining, and their definitions were reiterated by Allen (1988). “Restoration” is defined as a return to the natural processes that sustain a native ecosystem; “reclamation” as the return of similar organisms and ecological functioning; and “rehabilitation” as the return of the land to a useful condition, but probably to a use different than the original. These definitions have been widely adopted.

In practice, restoration of both the biota and processes of degraded grasslands is usually not possible due to the ubiquitous presence of opportunistic alien species which have altered natural succession. For this reason, grassland restoration projects may have to limit their scope to a specific goal, for example, the establishment of native vegetation with a composition and physiognomy needed to support native wildlife or particular species of conservation concern. Ideally, both reclamation and restoration should use material from locally adapted native populations collected in close proximity to the target site, because genetic material from non-local sources can genetically undermine locally adapted genotypes.[1]

This review focuses primarily on the semiarid bunchgrass steppe and meadow steppe of western North America (Daubenmire 1970; Franklin and Dyrness 1988). It considers re-establishment of native steppe vegetation on degraded sites, including sites converted to agricultural use (old fields), but it does not extend to the reclamation of non-native soils such as mine spoil.

The past was not static. Because natural disturbances, human activities, and arrivals of novel species cause changes on short-term time scales, and geological and climatic changes cause long-term changes, we cannot identify a single snapshot in time as “natural” (Botkin 1990; Sprugel 1991). The initial step in any ecological restoration project, therefore, is to answer the

[1] It has been suggested that this is what happened with reed canarygrass (*Phalaris arundinacea*). This species is native to the Pacific Northwest but has become highly invasive, perhaps because of hybridization between agronomic cultivars and native material (Merigliano and Lesica 1998).

question: what is the target condition to which we seek to return? Information about past conditions can be used to help make this decision. The vegetation of southeastern Washington and adjacent Idaho prior to 1917 was described by Weaver (1917). Areas that have received relatively light impacts can also serve as reference sites. Fortunately, extensive areas of steppe vegetation that remain in the region's major river canyons probably have a flora very similar to that of the former Palouse grasslands (Lichthardt and Moseley 1997; Weddell and Lichthardt 1998).

1.2. Native steppe and meadow steppe ecosystems

Native steppe and meadow steppe ecosystems were historically dominated by caespitose perennial grasses, especially Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata* [=*Agropyron spicatum*]), Sandberg's bluegrass (*Poa secunda*), and junegrass (*Koeleria macrantha* [=*cristata*]). In the relatively mesic meadow steppe associations, these were accompanied by diverse native forbs and low shrubs. Though less obvious, organisms in and on the soil, including cyanobacteria, bacteria, algae, microfungi, lichens, bryophytes, protozoa, and nematodes, also performed important functions.

A well developed microbiotic (or cryptobiotic) crust is characteristic of many arid and semiarid ecosystems of the Inland Northwest and throughout the world. In North America, cryptobiotic crusts are prevalent in the Great Basin, the Columbia Basin, and the Colorado Plateau. Because these crusts affect surface stability, soil fertility and structure, water infiltration, seedling establishment, and plant growth (Fletcher and Martin 1948; Harper and Marble 1988; St. Clair et al. 1984; 1993; West 1990; Belnap and Gardner 1993; Harper and Pendleton 1993; Belnap 1994; Kaltenecker and Wicklow-Howard 1994; Williams 1994; Leonard et al. 1995; Quigley and Arbelbide 1997), they are potentially important in restoring steppe, shrub steppe, and desert vegetation. The soil crusts of grasslands in the Palouse region were characterized by Cooke (1955).

Crust composition varies with climate and successional stage. The cryptobiotic crust may be removed or damaged by burning, trampling, cultivation, or burial (for instance, by volcanic ash) (Harris et al. 1987). Disturbance of the crust can result in changes in rates of ecosystem processes such as nitrogen fixation (Evans and Belnap 1999). The nitrogen-fixing properties of surface cyanobacteria may be of limited importance for grassland restoration, however, because native grasses thrive under conditions of low nitrogen availability, and higher nitrogen levels may selectively benefit annuals (Morgan 1994). Algae and cyanobacteria are the primary microbial photosynthetic agents of the below-ground ecosystem. They also contribute to nitrogen fixation and soil particle aggregation.

Mycorrhizae (fungi associated with roots) play a pivotal role in structuring steppe and shrub steppe communities through their influences on nutrient uptake, growth, and reproduction in associated vascular plants (Dhillion and Friese 1992; Harnett and Wilson 1999). Endomycorrhizae, also known as arbuscular mycorrhizae, form important associations with the roots of many native grasses and shrubs in steppe and shrub steppe communities. Sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.), and native bunchgrasses are highly dependent upon arbuscular mycorrhizae. By contrast, many alien annual grasses such as cheatgrass and medusahead (*Taeniatherum caput-medusae*), are nonmycorrhizal or facultatively mycorrhizal (Goodwin 1992; Wicklow-Howard 1994; 1998).

Because arbuscular mycorrhizae enhance resource acquisition in some species and not others, they can affect competitive interactions between species. The colonization of rangeland by nonmycorrhizal species is associated with declines in arbuscular mycorrhizal fungi (Goodwin 1992). When arbuscular mycorrhizae are absent, nonmycorrhizal species capture soil resources more effectively than mycorrhizal species such as caespitose grasses (Goodwin 1992). In some contexts, however, mycorrhizal fungi indirectly enhance non-native species. In greenhouse experiments, arbuscular mycorrhizae increased the effect of spotted knapweed (*Centaurea biebersteinii* [=*maculosa*]) on Idaho fescue (Marler et al. 1999).

One of the most important influences of soil crusts may be their effects on seedling establishment, but these effects are not well understood. (See Harper and Marble 1988 for review.) In some studies, cryptobiotic crusts enhanced the establishment of seedlings (Belnap 1994; Belliveau 1998); but in other studies cryptogams were associated with negative effects on seedling establishment (St. Clair et al. 1984). Negative effects might result because of inhibitory substances produced by crusts (Pyatt 1967) or because crusts present a physical barrier to germinating seeds (Schlatterer and Tisdale 1969).

1.3. Techniques used in restoration

1.3.1. Manipulation of soil biota

Because organisms in the soil and in soil crusts are such an important part of steppe and meadow steppe ecosystems, restoration efforts should take them into consideration. First of all, care should be taken to insure that weed control measures undertaken for the sake of restoration do not do more harm than good by harming microbiotic crusts. This can be a problem with fire and herbicides. (See sections 3.2. and 3.4.)

Second, restoration efforts should include restoration of soil microbiota. Attention should be paid to enhancing the survival and colonization of residual propagules such as spores and mycorrhizal fungi and to creating environments that promote the establishment and growth of desirable microorganisms (Wicklow-Howard 1994; Johnston and Belnap 1997). Belnap (1993) reported some success in hastening the recovery of cyanobacterial-lichen crusts by inoculation with crusts from undisturbed sites, although recovery rates were low. Soil algae and cyanobacteria can be used to enhance the fertility of agricultural fields (Zimmerman 1993), and could be used in ecosystem restoration. Green algae that produce extracellular polysaccarides which stabilize soil aggregates and improve soil tilth are used commercially for agricultural purposed in the Pacific Northwest. (See Zimmerman 1993 for review.)

Mycorrhizal inoculation can promote the revegetation of severely disturbed soils where few native plants remain. Thorne et al. (1998) demonstrated that inoculation with native arbuscular mycorrhizal fungi enhanced establishment and growth of the cultivar Secar bluebunch wheatgrass on mine spoils. Mycorrhizal hyphae in root fragments are probably the most important source of inoculum (Dhillion and Friese 1992), which can be added to the soil of containerized planting stock.

3.1.2. Weed control

The degree of degradation of terrestrial ecosystems is often diagnosed by the presence and extent of alien plant species (e.g., Andreas and Lichvar 1995); frequently their presence is related to soil disturbance and overgrazing. Increasingly, however, aggressive aliens are becoming established even in ostensibly undisturbed bunchgrass vegetation, wherever their seed can reach. The most notorious alien species in the Palouse region are upland species that can dominate and exclude perennial grasses over a wide range of elevations and substrate types.

Alien annual plants are now the primary impediment to restoration of grassland sites. Weed control is therefore central to reclamation and restoration of grasslands in the Palouse region. Usually, this step must precede and/or accompany efforts to establish native vegetation. Even where communities of exotics can successfully be replaced with native species, an ongoing program of weed control is generally necessary to protect the site. Several aggressive alien perennials have also become widespread.

Much of the research on grassland restoration focuses on techniques for enhancing perennial grass growth by suppressing the growth of aggressive alien annuals (Youtie 1997; Youtie et al. 1998, 1999). Intensive methods for reducing weeds are often impractical, however, due to steep terrain, extent of the infestation, and low land values. Weed reduction involves site- and weed-specific methods of control. The selection of appropriate methods also depends on whether a treatment area contains native species and their phenology. Herbicides should be applied when they will do maximum damage to exotics and minimal damage to native species.

The Nature Conservancy has experimented with hand-pulling, mowing, chemical treatments, and fire in attempts to decrease weed infestations and reestablish native bunchgrasses in Palouse grassland (Youtie 1997, Youtie et al. 1998, 1999; Weddell 1996, 1997). In trials at Rose Creek Preserve in eastern Washington, weeding and fall application of herbicide resulted in reduced coverage of medusahead (Weddell 1996, 1997). At the Lawrence Memorial Grassland Preserve in north-central Oregon, Youtie and her coworkers tested the effectiveness of spring application of herbicides, prescribed summer burning, and repeated mowing to control cheatgrass and medusahead in a mounded prairie dominated by Idaho fescue and bluebunch wheatgrass. Although each treatment was initially effective, the effects were only temporary, and the alien annual grasses returned to pretreatment levels within two years after the treatments were applied (Youtie et al. 1998). Research on controlling weeds in canyon grasslands by hand-pulling or herbicide application and the effects of these treatments on rare plants is in progress at Craig Mountain in Idaho (Janice Hill, The Nature Conservancy, Idaho Chapter, personal communication).

Biological control with soil microorganisms is another approach to weed problems. Some success has been obtained in using *Pseudomonas* bacteria to suppress growth of cheatgrass (*Bromus tectorum*) in wheat fields in a steppe zone (Kennedy et al. 1991); however, preliminary attempts to control a heavy cheatgrass infestation in a meadow steppe restoration project were unsuccessful. (See Weddell et al., this volume.)

1.3.3. Propagation of native plants

Establishment of grass cover is indispensable for grassland reclamation. Not only do grasses dominate in native communities, but they are essential to controlling weeds, and are the easiest elements to establish. Seed should generally be collected from the local vicinity and then planted and increased off-site, a time-consuming process.

The steep terrain of canyon grasslands severely limits the options available for seeding and site preparation. Most sites must be chemically treated to control competing weeds. This is usually followed by broadcast seeding. Unfortunately, broadcast seeding is very undependable and requires twice the application rate of drill seeding. In a project in Asotin Canyon, in southeastern Washington, more than 90% of the seed broadcast on a plowed site was lost to rodents or birds (Nelson et al. 1970). Losses of only 23% occurred on unplowed, chemically prepared sites, however.

Reclamation of old fields on Palouse uplands is less problematic than on rugged canyon sites because machinery can be used to prepare a seedbed and drill seed. Drilling places seed in an optimum environment for germination and seedling development and requires less seed than broadcast seeding (Nelson et al. 1970). Native grass seed must be mixed with rice hulls if it is to feed evenly through the drill. Native forbs and shrubs should not be added to the grass seeding, so that chemical weed treatments will be an option during the initial years of grass establishment.

Although most grassland reclamation projects in the Inland Northwest are in only their early stages, grass seeding for erosion control and soil improvement under the Conservation Reserve Program has been a common practice for decades. Improved varieties of alien grasses are generally used in these plantings, but the same methods for seedbed preparation and planting are applicable to planting natives, at least on rolling uplands of the Palouse (USDA-NRCS 1998).

Even with drill seeding, it may take two or more years to develop grass cover that can out-compete annual weeds. In the interim, chemicals can be used to control broadleaf weeds and mowing to keep annuals from reseeding. Slender wheatgrass (*Elymus* [=*Agropyron*] *trachycaulum*) or mountain brome (*Bromus marginatus*) are sometimes used as nurse crops because they establish more quickly than bluebunch wheatgrass or Idaho fescue but are not long-lived. When a nurse crop is used, it must be mowed to keep it from reseeding, which can delay the development of cover by target species (Mark Stannard, U.S. Department of Agriculture, Plant Materials Center, Pullman, WA, personal communication).

Transplanting young plants is another approach. Weddell (1997) reported that transplanting plugs of bluebunch wheatgrass was moderately successful in the short term at Rose Creek Preserve, and Youtie et al. (1998) found that the survival of transplanted bunchgrasses (Idaho fescue, bluebunch wheatgrass, and squirreltail, *Elymus elymoides*) at the Lawrence Memorial Grassland ranged from 43-87% per mound after one year. Although this method can produce good survival, it requires large inputs of labor and time. Other disadvantages of this approach are that mortality may be substantial in hot, dry weather (Wright and Bunting 1986) and it selects for genotypes adapted to germinate and emerge under greenhouse conditions rather than under field conditions.

1.3.4. Fire management

Some publications (e.g. Adams 1989; Fedrizzi 1998; Johnson 1998) recommend using prescribed fire to restore or improve native steppe vegetation. Fire is considered beneficial in terms of its effects on site productivity, species composition, and litter removal. Although there is considerable interest in restoring "natural" fire regimes, however, the effects of fire on Palouse and canyon grasslands are not well understood. In the Midwest, fire is an important tool in maintaining prairie remnants. The historical role of fire in the steppe and meadow steppe vegetation of the Palouse region is less clear (Weddell 2001). Daubenmire (1970) dismissed it as relatively unimportant, whereas others conclude that fires were probably more prevalent in the recent past than at present (Morgan et al. 1996). The lack of information about the pre-settlement fire frequency of steppe and meadow steppe ecosystems makes it difficult to emulate the natural fire regime in restored communities.

Fire also has some disadvantages. It destroys or reduces diversity in the soil crust (Antos et al. 1983; Youtie et al. 1999). While the algal component may reestablish relatively rapidly, estimated recovery times for lichens and mosses are on the order of decades or even centuries (Johansen et al. 1984; Belnap 1993). In addition, burning and crust destruction favor the establishment of disturbance-adapted species that are present in the seed bank or nearby. These are usually non-natives. For this reason, the benefits of fire must be weighed against its effects on weed invasion in situations where exotics are ubiquitous (Weddell 2001).

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