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Plant invasions in western North America : implications for temperate grasslands worldwide

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Key points : To varying degrees , temperate grasslands world-wide have become invaded by non-native plants and animals , products of both accidental and deliberate introductions . The susceptibility of these grasslands has been strikingly different and not strictly a function of the intensity of human occupation . Grasslands dominated by rhizomatous-spreading grasses have generally been more resilient to disturbance and plant invaders , while those in which caespitose grasses dominate have displayed decidedly lower resilience to agriculture , particularly the combined forces of farming and livestock . As outlined here , the fate of the steppe in the Intermountain West of North America in the last 100 years is emblematic of the severity of damage that results from a radical change in the disturbance regime in a temperate caespitose-dominated grassland , coupled with an onslaught of alien species pre-adapted to these new factors (Mack , 1986 , 1989) .

Temperate grasslands in the Intermountain West of the United States occur in a region with diverse geomorphology bounded east and west by the Rocky Mountains and the Sierra Nevada , respectively , and north and south by the forested northern Rocky Mountains and the Sonoran Desert , respectively . Several smaller mountain ranges and other highlands occur within this region , such as the Blue Mountains and the Owyhee Plateau , which support both forests and grassland . Grasslands within what is commonly referred to as the Great Basin and its extensions are steppe , i .e . , grasslands dominated by perennial grasses on zonal soils too dry to support trees (Mack , 1986) .

Vulnerability of this steppe to plant invasion is largely attributable to the dominant grasses consistent life form as caespitose (bunchgrass) grasses . These grasses (e .g . *Pseudoroegneria spicata [Agropyron spicatum]* , *Festuca idahoensis* , *Poa secunda*) are characterized by spreading exclusively by seeds ; none are rhizomatous , and all are readily damaged by recurring grazing , trampling and other physical damage by large , congregating mammals . Their persistence in the Great Basin steppe owed much to the general lack of herds of large , congregating mammals (e .g . elk , antelope and particularly bison) throughout most of the Holocene (Mack and Thompson , 1982) . As a result of bison s paucity in the Great Basin-in sharp contrast to the massive herds that migrated across the temperate grasslands east of the Rockies-these communities were characterized by a canopy of caespitose grasses along with shrubs (e .g . *Artemisia* spp . , *Chrysothamnus nauseosus* and *Purshia tridentata*) , overlying a low stature assembly of herbs (e .g . *Astragulus* spp . , *Balsamorhiza sagittata* , *Lomatium* spp . , *Lupinus* spp .) . Conspicuous in the undisturbed communities was a carpet of cryptogams (mosses , lichens , liverworts and cyanobacteria) (Daubenmire , 1970) .

These steppe communities , whether shrub/grass dominated or grass dominated and regardless of floristic composition , were swiftly and catastrophically altered beginning in the mid to late 19th century by the almost simultaneous entry of alien species : livestock (principally cattle , but also sheep and horses) along with a growing assembly of non-native grasses , herbs and some shrubs (Mack , 1981 , 1986 ; Mack and Thompson , 1982) . Livestock largely destroyed these communities through grazing , manuring , wallowing , congregating and especially trampling . So fragile is the cryptogamic crust that usually a single episode of intense community occupation by livestock is sufficient to destroy these exceptionally slow growing organisms . The caespitose grasses and shrubs are only marginally more tolerant of routine damage by livestock than the cryptogams . Recurring removal of flowering culms by grazers restricts the grasses sole mode of persistence on a site through sexual reproduction . Trampling dismembers the adult grasses into fragments from which regeneration is unlikely . Native shrubs , such as *Artemisia* spp . , while varying in their palatability to livestock , are probably more damaged through severe trampling ; for example sagebrushes do not re-sprout after breakage . None of these community dominants displays consistently high seedling recruitment each year , which exacerbates the loss of seeds to livestock (Mack and Thompson , 1982 ; and references therein) .

None of this widespread damage by livestock would probably have caused the wholesale alteration of these ecosystems physical features had the other group of alien species-grasses , herbs and some shrubs-not arrived . Most of these alien plant species (e . g . *Elymus caput-medusae* , *Halogeton glomeratus* , *Salsola iberica* , *Sisymbrium altissimum*) are native to Eurasia , a huge source region for species long associated with humans and their livestock and cereal agriculture (Mack , 1986 , 1989) . Most of these species were likely introduced accidentally as contaminants in cargo , livestock bedding and perhaps livestock fur and fleeces (although the role of this last dispersal mode may be largely apocryphal) (Mack , 1981 , 1986) . The most damaging of these invaders , the annual grass *Bromus tectorum* (cheatgrass) , most likely arrived repeatedly (Novak and Mack , 1991) as a seed contaminant in wheat seeds because the northern portion of the Great Basin was converted to cereal agriculture (wheat , barley , oats) in the last quarter of the 19th century , site of the first regional detection of cheatgrass (Mack , 1981) .

Cheatgrass and other plant invaders capitalized on the ongoing disturbance caused by livestock in steppe that had previously had a much lower level of animal disturbance (mainly trampling by small herds of deer , elk and antelope , local burrowing by ground

squirrels , mice , and other small mammals) (Mack and Thompson , 1982) . Unlike the native species , these alien plants thrive with recurring disturbance . They rapidly supplanted the destroyed or damaged native species locally and have transformed these steppe communities into almost entirely alien plant communities (Daubenmire , 1970 ; Mack , 1986) . The rate at which these invasions and the consequent transformations occurred ranks as one of the swiftness known through biological invasion : within less than 40 years , for example , the Columbia Basin of Washington became dominated by the annual Eurasian grass *B . tectorum* (Mack , 1981) . It has been joined by other alien species , that while not necessarily invasive , have directly benefited from the demise of the native steppe : e .g . *Avena fatua* , *Cirsium vulgare* , *Erodium cicutarium* , *Poa pratensis* (Mack , 1986 , 1989) . Although species , such as the annual cheatgrass , provide little competition for the large , long-lived native grasses and shrubs , they are superior competitors to the seedlings of these native species . Cheatgrass , for instance , resumes growth from its over-wintering stage weeks before many of the native species even germinate . Its head start in root growth allows it to usurp the limited soil water , thereby placing a consistent constraint in seedling survival (Harris , 1967) . Consequently , as adult native plants die , they are no longer replaced in the community by their offspring .

Almost insidiously , species such as cheatgrass not only thrive in the disturbance created by livestock and the annual plowing with cereal agriculture , they have also provided the *coup de grace* to the natives by so completely altering the region s fire regime . Fire was a component of pre-European settlement ecosystems in the Intermountain West . But the frequency (increased from once every 40-50 yrs to fires every decade or less) has consistently destroyed the native species . These fires have been particularly devastating to the seed banks of natives , assuming that any adult plants survive spring/summer fires to flower (Knick and Rotenberry , 1997 ; and references therein) . In contrast , invasive species , such as cheatgrass are not damaged as extensively and some of their seeds always survive these conflagrations . In effect , the emergence of cheatgrass within the region s steppe communities has served as a positive feedback mechanism in which more than a century of recurring fires has completed the demise of the native steppe that began with arrival of livestock and was furthered by introduction of cereal agriculture .

The regional destruction of temperate grassland is not yet complete-some small fragments of the original steppe that were never plowed or used by livestock remain . But in sum , these are pathetically small remnants of an array of communities that stretched across hundreds of thousands of square kilometers in North America . And new hazards , in the form of more recently introduced alien plants continue . In the last 40 years members of the genus *Centaurea* (Asteraceae) have become increasingly important in the northern half of the Great Basin . Unlike cheatgrass and some other alien grasses , these dicots are completely unpalatable by livestock because of their stiff , dense spines ; they consequently render a paddock totally unusable (Roche and Roche , 1988) . It is not clear yet whether one or more *Centaurea* spp . or some other invader will replace the current regional dominant , cheatgrass . There is no assurance of course that even more destructive alien species could arrive , either accidentally or through some deliberate plant introduction .

Restoration of these grasslands has been an object of concern for more than 100 years . By 1904 , some observers deemed the destruction of the native range species as already irreversible (Cotton , 1904) and attempts have followed to find non-native species that could tolerate the region s physical environment and the new biotic/physical environment imposed by ranching and farming . The purported solutions have ironically also drawn on Eurasian species , such as *Agropyron desortorum* , which have been deemed satisfactory for livestock forage (Asay et al . , 2003 ; Huber-Sannwald and Pyke , 2005) . Widespread sowing of these species has been problematic at best . Quite aside from their value as forage , some of these species have not been persistent where sown , thereby requiring costly and recurring re-sowing . Alternatively , they have elsewhere spread beyond the area for which they were intended . More fundamentally , these are non-native species introduced and fostered to take up roles on sites than long supported native steppe . Still missing is an informed public discussion of the fate of these regional grasslands . Should they be restored to some resemblance of their native composition and structure ? Or will they ultimately become simply artificial ecosystems in which any species community membership is decided by strictly anthropocentric values (sustained , low cost livestock production , minimal fire risk , fragmentation of land parcels for diverse human use , and no attention to the conservation of native plants and animals) ?

These are not questions unique to the Intermountain West . Each temperate grassland , whether in the Great Plains of North America , the steppe in Patagonia , or even the now changing steppe in Mongolia , will be viewed in the context of highly varied human values and aspirations for land use . These grasslands are universally viewed as essential to humans because of their roles in food production . The question will be whether society in the broadest sense will have the wisdom and will to view native steppe as more than simply the one-time place-holders for highly restricted communities that serve only humans immediate interests .

References

Asay , K .H . , Chatterton , N J . , Jensen , K .B . , Jones , T .A . , Waldron , B .L . , Horton , W .H . 2003 . Breeding improved grasses for semiarid rangelands . *Arid Land Research and Management* 17(4) : 469-478 .
Cotton , J .S . 1904 . A report on the range conditions of central Washington . Wash . State Agric . Coll . Exp . Sta . Bull 60 .
Daubenmire , D . 1970 . Steppe vegetation of Washington . Wash Agric . Expt . Sta Tech . Bull 62 .
Harris , G . A . 1967 . Some competitive relationships between Agropyron spicatum and Bromus tectorum . *Ecological*

Monographs 37 :89-111 .
Huber-Sannwald , E . , Pyke , D .A . 2005 . Establishing native grasses in a big sagebrush-dominated site : An intermediate restoration step . *Restoration Ecology* 13(2) : 292-301 .
Knick , S .T . , Rotenberry , J .T . 1997 . Landscape characteristics of disturbed shrub steppe habitats in southwestern Idaho (U . S .A .) . *Landscape Ecology* 12 : 287-297 .
Mack , R . N . 1981 . Invasion of *Bromus tectorum* L . into western North America : An ecological chronicle . *Agro-Ecosystems* 7 : 145-165 .
Mack , R . N . 1986 . Alien plant invasion into the Intermountain West : A case history . In : Mooney , H .A . and J . Drake , J . Ecology of Biological Invasions of North America and Hawaii . (New York : Springer-Verlag , 192-213 .
Mack , R . N . 1989 . Temperate grasslands vulnerable to plant invasion : Characteristics and consequences . In : Drake , J . et al . , Biological Invasions : A Global Perspective . New York : Wiley & Sons , 155-179 .
Mack , R . N . , Thompson , J .N . 1982 . Evolution in steppe with few large hooved mammals . *American Naturalist* 119 : 757-773 .
Novak , S . J . , Mack , R .N . , Soltis , D .E . 1991 . Genetic variation in *Bromus tectorum* L . : Population differentiation in its North American range . *American Journal of Botany* 78 : 1150-1161 .
Roche , C .T . , Roche , B .F . 1988 . Distribution and amount of four knapweed (*Centaurea* L .) species in eastern Washington USA . *Northwest-Science* 62(5) : 242-253 .