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Abstract. In 1936, vegetation analyses were conducted on repurchased federal lands in the Powder River Basin of eastern Wyoming. During the summer of 1987 the 74 remaining plots of 97 originally established on a 2.6 km² (1 mi²) area in Converse County were re-examined. Both surveys were conducted with the "square foot density procedure." During the past 51 years, vegetation abundance increased significantly on the saline upland site as a result of the interactive effects of favorable long-term weather patterns, annual grazing by livestock and wildlife, and reduced fire. Total vegetation cover increased significantly ($P < 0.05$) from 3% in 1936 to 11% in 1987, including a threefold increase for all grasses and a fourfold increase for all woody species. A negligible change occurred for all forbs. A shift in the cover composition occurred with grasses decreasing from 52% to 44% and non-grass species showing a corresponding increase. All growth forms, except shrubs, gained wider distribution over the study period, especially succulents and annual grasses. Continuation of current management practices probably means that this range will not return to a shortgrass-dominated prairie.

Key Words. long-term vegetation changes, grazing, drought, sampling procedures, vegetation analyses, Wyoming

INTRODUCTION

Lands in the Powder River Basin of eastern Wyoming were taken by homesteaders and other settlers in the early years of the present century. The settlers tried to establish a farming economy in the area, but many were forced off their small land holdings by drought and economic depression during the 1930's. By 1936 most farmers had abandoned their operations; only a few remained on the land and became livestock ranchers.

As a depression relief measure, many of the abandoned lands were purchased by the federal government under authority of the Land Utilization Act of 1935. Originally called L-U lands under the Resettlement Administration, they are now known as the Thunder Basin National Grassland administered by the USDA Forest Service. The area is now a patchwork of federal, state, and private ownership. Many of the repurchased federal lands have been seeded to re-establish perennial vegetative cover, usually with crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.]. Others have simply been left as "go-back" lands.

As a first step toward development of appropriate management plans, the Resettlement Administration conducted a rangeland survey in 1936. The survey included species frequency of occurrence and also estimates of vegetative ground cover as information toward determination of proper grazing capacity. These data formed the basis of grazing permits issued to private land holders for use of federal lands. Records indicate that most ranchers have practiced moderation in their utilization of federal permits for sheep and cattle. Current grazing is conducted with three and four-year rotation systems under supervision by the Forest Service.

During the 1936 survey, data were obtained from permanently marked plots on six 2.6 km² (1 mi²) sections of rangeland. One of the sections was not sampled again until the summer of 1987. This paper presents 51-year general trends based on a comparison of the 1936 and 1987 data collected from that section.

METHODS

Environment

The climate of the Powder River Basin is similar to that of Great Plains areas to the north and south. Precipitation amounts usually range from 300 to 400 mm annually, with the majority received during summer. Extreme droughts occur, as in the mid-1930's. Wet years, when precipitation exceeds 750 mm, also occur, as in the early 1980's. Temperatures are dramatically variable with extreme cold of -42 C in winter and extreme heat of 41 C during summer (Hambidge 1941). At Casper, Wyoming, with similar weather conditions to those at the study location, long-term records show monthly humidity during the two warmest months of the year, July and August, is at least 25%. The almost constant winds, with a mean monthly value of 5 m/sec, cause a desiccating effect to the native vegetation and to planted grain crops (Martner 1986). Eastern Wyoming in 1936 had already experienced several years of drought, and that year also was extremely dry. On some of the 1936 field data sheets of the area, comments were written emphasizing the extreme dryness. For example, some locations were described as having no living vegetation visible from horizon-to-horizon. In other instances it was noted that the shrubs and cactus were being killed by livestock grazing, even though shrubs are normally only a small portion of the animal's diet, especially during summer when they usually depend on native grasses and forbs for forage.

Vegetation

The Powder River Basin is a transitional zone between the shrub dominated ranges of the Great Basin and Intermountain areas to the west, and the grass-dominated ranges of the Great Plains to the east. Floristic elements common to both regions are found on the study site.

Most common plants were Wyoming big sagebrush [*Artemisia tridentata* var. *wyomingensis* (Beetle & Young) Welsh], western wheatgrass (*Agropyron smithii* Rydb.), blue grama [*Bouteloua gracilis* (H.B.K.) Lag. *ex* Griffiths], and birdsfoot sagewort (*Artemisia pedatifida* Nutt.) among a variety species listed on Table 1. Plains pricklypear (*Opuntia polyacantha* Haw.) was widely distributed but not a major component. Many annual and perennial forbs occur over the study site but were usually very sparse both during 1936 and 1987.

For study and analytical purposes, the species found on the study site were grouped under broad growth forms. Eight categories were adopted: shrub, half-shrub, mat-form, succulent, and the grasses and grasslikes which were categorized as shortgrass and grasslike, bunchgrass, rhizomatous grass and grasslike, and annual grass (Table 1).

Table 1. Plant species[1] on study site (single stem forbs excluded) grouped alphabetically by growth form.

Species	*Common Name*
Shrub Growth Form:	
Artemisia tridentata var. *wyomingensis* (Beetle & Young) Welsh	Wyoming big sagebrush
Atriplex canescens (Pursh) Nutt.	four-wing saltbush
Chrysothamnus nauseosus (Pall.) Britt.	rubber rabbitbrush
Half-shrub Growth Form:	
Artemisia frigida Willd.	fringed sagewort
Artemisia pedatifida Nutt.	birdfoot sagewort
Atriplex gardneri (Moq.) D. Dietr.	Gardner saltbush
Eriogonum microthecum Nutt.	slenderbush wildbuckwheat
Haplopappus nuttallii Torr. & Gray	toothleaf woodyaster
Hymenopappus filifolius Hook.	fineleaf hymenopappus
Xylorhiza glabriuscula Nutt.	alkali woodyaster
Mat-forming Growth Form:	
Arenaria hookeri Nutt. *ex* Torr. & Gray	Hooker sandwort
Astragalus spatulatus Sheldon	spoonleaf milkvetch
Haplopappus acaulis (Nutt.) Gray	stemless goldenweed
Phlox hoodii Richards.	Hood phlox
Succulent Growth Form:	
Coryphantha vivipara (Nutt.) Britt. & Rose	purple ballcactus
Opuntia polyacantha Haw.	plains pricklypear
Yucca glauca Nutt. *ex* Fraser	small soapweed
Shortgrass and Grasslike Growth Form:	
Bouteloua gracilis (H.B.K.) Lag. *ex* Griffiths	blue grama
Carex filifolia Nutt.	threadleaf sedge
Bunchgrass Growth Form:	
Andropogon gerardii var. *paucipilus* (Nash) Fern.	sand bluestem
Koeleria cristata (L.) Pers.	prairie junegrass
Oryzopsis hymenoides var. *contracta* (B.L. Johnson) Shechter	fine Indian ricegrass
Oryzopsis hymenoides (R. & S.) Ricker *ex* Piper	Indian ricegrass
Poa secunda Presl.	Sandberg bluegrass
Sitanion hystrix (Nutt.) J.G. Sm.	bottlebrush squirreltail
Stipa comata Trin & Rupr.	needleandthread
Stipa viridula Trin.	green needlegrass
Perennial Rhizomatous Grass and Grasslike Growth Form:	
Agropyron smithii Rydb.	western wheatgrass
Calamovilfa longifolia (Hook.) Scribn.	prairie sandreed
Carex douglasii Boott	Douglas sedge
Distichlis spicata (L.) Greene	inland saltgrass
Annual Grass Growth Form:	
Bromus japonicus Thunb. *ex* Murr.	Japanese brome
Bromus tectorum L.	cheatgrass brome
Vulpia octoflora (Walt.) Rydb.	common sixweeksgrass

[1]Nomenclature after Beetle (1970), Dorn (1988), Hitchcock and Cronquist (1973), and Kartesz and Kartesz (1980).

Initial (1936) Evaluation

The 1936 survey was based on five to ten systematically located sample plots in each 2.6 km² (1 mi²) section of 250 ha (640 a). Six different sections were surveyed more intensively with about 100 plots in nine rows at about 0.16 km (0.1 mi) intervals, each with 9 to 11 plots spaced about 0.16 km (0.1 mi) apart (Lang 1945 and 1973).

Each intensively sampled section characterized a different kind of rangeland: 1) abandoned farmland, 2) sagebrush, 3) cactus, 4) shortgrass-sagebrush, 5) mixed grass, and 6) poor rangeland. The latter term was utilized for a kind of land that would currently be identified as upland saline. This study focused on the "poor rangeland" section (S3 T40N R71W of the 6th principal meridian) in northern Converse County, Wyoming.

The estimate of vegetation ground cover was conducted with a method called the "square-foot-density procedure" (Stewart and Hutchings 1936, Pickford 1940). The technique became the standard survey procedure of the U.S. Cooperative Western Range Survey Project in the 1930's (Reid and Pickford 1944).

The sampling unit, described in English units of measure, was a circular plot of 100 ft² (9.3 m²) with a radius of 5.6 ft (1.7 m). The perimeter of a plot was scribed into the soil from a permanently marked center point prior to estimation of vegetation cover. Each plant species present in the plot was listed, thereby establishing frequency of occurrence. The ground cover (density) each contributed was estimated, using a 1 ft² (30 x 30 cm) plot as the basic unit. Data were recorded as T = trace, 0.25 ft² (0.9 dm²), 0.50 ft² (1.8 dm²), 0.75 ft² (2.7 dm²), 1.0 ft² (3.7 dm²), and larger numerical values. This rigid recording base obviously allowed for over-estimation of sparse species, especially because the trace values were often summed over multiple plots, with only seven to ten trace values being given the value of 0.25 ft². Many plants of the eastern Wyoming plains occur as single stems with diameters substantially less than 0.25 ft² or 6 x 6 inches (15 x 15 cm). This is one of the primary reasons the "square-foot-density procedure" was abandoned within a few years (Lang 1945). Also, the technique was open to personal bias or error in the estimation process, both between observers and between times, either with the same or different observers (Pickford 1940). The improper use of the term "density" for a value commonly identified in current literature as "vegetation cover" also contributed to the demise of the procedure (Reid and Pickford 1944).

1987 Evaluation

During the summer of 1987, the members of the research team worked together in recording vegetation cover values. Prior to conducting work on the permanently marked plots the authors reviewed pertinent procedural aspects as noted by Stewart and Hutchings (1936), Pickford (1940), Reid and Pickford (1944), and Lang (1945). Test plots were established to include shrubs and other plant growth forms. Only when researchers felt similarly confident of each other in conducting the procedural estimates, and of being able to conduct the work as closely as possible to the thoughts and evaluations of the 1936 workers, did estimation activities begin on the relocated permanent plots. Seventy-four of the original 97 plots (76%) were relocated.

The estimation at each plot was conducted with two, and in some cases three, observers concurrently deriving independent estimates. Inconsistencies of estimate were adjusted by re-reviewing the numbers and sizes of individual plant elements to form an adjusted value acceptable to each worker. In all cases, care was utilized to be sure that each species within a plot was listed, as was done in 1936, and that the estimated values were taken in the same manner used by the 1936 researchers. The subjectivity of the "square-foot-density procedure" does not, however, preclude statistical analysis (National Research Council 1962).

Analyses

The relationships of the 1987 data to that of 1936 were determined by comparison of the vegetation cover with two quantitative procedures. The Paired Plot t-test (Freese 1967) was used to determine differences that may have occurred over the years on the basis of: 1) individual species, 2) groups of species with similar growth forms, and 3) total vegetation. The frequency data were inspected similarly by species, groups, and total vegetation. An additional data evaluation involved inspection of the frequency data to determine the number of plots which had lost or gained specific plant elements from 1936 to 1987.

RESULTS

Total vegetation cover increased three and one-half times over the 51 year period from 3% in 1936 to 11% in 1987 (Table 2). Cover increased three times (1.6% to 5.0%) for all grasses ($P < 0.01$), and four times (1.5% to 6.3%) for woody growth forms ($P < 0.01$). The total cover of all grass species in 1936 at less than 2% was not an unusually low value for the upland saline sites currently recognized in the region.

Table 2. Mean vegetation cover (%) and plot frequency number (n = 74) of major vegetation classes for 1936 and 1987.

Vegetation	*Cover*		*Frequency*	
Class	*1936*	*1987*	*1936*	*1987*
	----------%----------			
Shrub	0.34	0.98	43	38
Half-shrub	0.38	0.82	63	66
Mat-form	0.72	3.58	61	66
Succulent	0.08	0.89	16	40
Bunchgrass	0.14	0.41	55	70
Rhizomatous	0.26	0.59	64	72
Shortgrass	1.24	3.91	42	48
Annual grass	0.0+	0.07	2	46
All forbs	0.0+	0.0+	57	73
All species	3.16	11.25	73	73

A shift occurred in the cover relationship between herbaceous and woody species. In 1936 grasses comprised 52% of all vegetative cover but declined to 44% in 1987, with non-grass species showing corresponding increases.

Another measure of long-term vegetation response over the 51-year period is the change in distribution indicated by frequency values on the 74 relocated plots (Table 2). With the exception of shrubs, all growth forms gained wider distribution, especially succulents and annual grasses. Increases ranged from 3 plots for half-shrubs to 44 for annual grasses. Shrubs decreased in 5 plots.

It is likely that most of the 51-year period has had substantially better growing conditions than the drought years of the 1930's. The area has undergone annual foraging by livestock and wildlife. This has affected the vegetation directly to a moderate degree and also served to reduce fire occurrence through reduction of fine fuels. Fire has been further restricted by construction of roads, which act as fire barriers, and by active fire-fighting efforts.

Some of the non-grass cover increase can be attributed to greater plant size, since many species are able to live longer than 50 years. The influence of annual grazing by livestock certainly has limited grass re-establishment, especially since most of the sampled area occurs on saline soils, restrictive to many native grasses.

CONCLUSIONS

The comparison of 1936 and 1987 vegetation shows significant increases in overall plant cover in the Powder River Basin of eastern Wyoming. These increases may reflect the fact that the initial evaluation was conducted at a time when the region was in the midst of an extreme drought, whereas conditions since that time have been more favorable thus allowing for greater plant production. Long-term grazing management and fire control, against the background of climatic influences, have apparently combined to produce: 1) a significant increase both in total ground cover and in all growth forms except forbs, 2) a decrease in the herbaceous and an increase in the woody components of total vegetative cover, and 3) an increase in the distribution of all growth forms except shrubs. Continuation of these management practices effectively ensures that this range will not return to shortgrass-dominated prairie.

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