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Sixty-seven Years of Landscape Change in the Last, Large Remnant of the Pacific Northwest Bunchgrass Prairie

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RESEARCH NOTE

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ABSTRACT: The Zumwalt Prairie in northeastern Oregon is the last large remnant of the Pacific Northwest Bunchgrass Prairie. Compared to other prairies in North America, relatively little is known about these arid temperate grasslands as the majority disappeared quickly after Euro-American settlement. In this paper we describe the landscape history of the Zumwalt Prairie through interpretation of historical aerial photos. Beginning with photos taken in 1938, we examined photos for area of cultivation and woody vegetation and number of buildings and stock ponds. Using data collected in 1976 and 2001, area of woody vegetation was further classified as aspen (*Populus tremuloides*, Michx.), conifers, and shrubs for analysis of trends. Area in cultivation and number of buildings decreased over the 67 years we examined. In contrast, the number of stock ponds increased. Overall, the area of woody species increased over the period of study; area of aspen declined while acreage of conifers and shrubs increased. The land cover and land-use changes observed on the Zumwalt Prairie reflect the complex social and economic changes that have occurred since Euro-American settlement began in the late nineteenth century.

Index terms: aspen, cattle grazing, cultivation, grassland, historic aerial photos, private lands, shrub encroachment, stock ponds, tree invasion

INTRODUCTION

The Zumwalt Prairie (hereafter "Zumwalt") is located in Wallowa County in northeast Oregon and is the last large (approximately 64,000 ha) relict of the Pacific Northwest Bunchgrass Prairie. The prairie is situated on a rolling basalt tableland (elevation 1060 – 1680 m) deeply incised by several tributaries of the Grande Ronde and Imnaha rivers. Annual precipitation for the area is approximately 49 cm/year, as measured by the nearest long-term weather station in Enterprise, Oregon (data from 1965 – 2005; Western Regional Climate Center 2009). Winters are cold and relatively moist; mean daily minimum temperatures were -7 ºC (December – March). Summers are very warm and relatively dry, though June's average precipitation of 4.9 cm exceeds that of any winter month. Daily maximum temperatures during June – September average 27 ºC.

Soils on the Zumwalt are predominantly Xerolls. Plant productivity and species composition vary strikingly as a function of slope, aspect, and soil characteristics (Loy et al. 2001; U.S. Department of Agriculture 2010; Schmalz 2011). Because of its dry climate and mostly shallow soils, the majority (> 90%) of the Zumwalt historically supported steppe vegetation dominated by bunchgrasses, forbs, and sub-shrubs. Shallow to moderately deep soils are dominated by Idaho fescue (*Festuca idahoensis,* Elmer), prairie junegrass (*Koeleria macrantha,* (Ledeb.) Schult), and bluebunch wheatgrass (*Pseudoroegneria spicata,*(Pursh) A. Löve), and a high diversity of forbs (The Nature Conservancy, unpubl. data). Shallow rooted species such as Sandberg's bluegrass (*Poa secunda,* J. Presl) and one-spike oatgrass (*Danthonia unispicata,*(Thurb.) Munro ex Macoun) share dominance with dwarf-shrubs and forbs such as Douglas' buckwheat (*Eriogonum douglasii,* Benth), hoary balsamroot (*Balsamorhiza incana,* Nutt.), and dwarf yellow fleabane (*Erigeron chrysopsidis,* A. Gray) in areas with more shallow, rocky soils (The Nature Conservancy, unpubl. data).

Historically, shrub and forest vegetation are localized and restricted to areas with deeper soils, cooler micro-climates, or higher soil moisture such as valleys, swales, slopes with northerly aspects, and riparian areas. The streams of the Zumwalt are mostly first- and second-order and ephemeral, running only during spring and early summer. Riparian vegetation includes black hawthorn (*Crataegus douglasii,* Lindl.), mockorange (*Philadelphus lewisii,* Pursh), and common snowberry (*Symphoricarpos albus,* (L.) S.F. Blake). In areas where soils are saturated throughout the growing season, willow-dominated (*Salix* spp.) communities occur.

The Nez Perce and other indigenous peoples hunted game and gathered plant foods on the Zumwalt for thousands of years. After acquiring livestock in the 1700s, the area was also used for grazing of their horses (*Equus ferus*) and cattle (*Bos taurus*) during spring and summer. Indigenous people were removed from the area in 1877, shortly after the arrival of Euro-American settlers. These settlers brought large herds of cattle and horses and acquired lands through the Homestead Acts of 1862 and 1909. Title to land was granted to applicants who "proved up," which generally required evidence of farming. Zumwalt homesteaders were, thus, compelled to plow land even though lands were often unsuitable or marginal for this activity. The extreme weather and unproductive soils of the prairie forced many homesteaders to sell off their lands. Lands were thus consolidated into larger holdings, and cultivated lands were re-seeded using exotic pasture grasses. When severe winters resulted in catastrophic die-offs of cattle in the 1880s, many ranchers switched to raising sheep (*Ovis aries*)). By the 1940s, low prices for sheep resulted in a return to cattle as the favored choice of stock (Rowley 1985; Williams and Melville 2005, unpubl. data). These ranches utilized a pastoral system of grazing where animals were wintered in low-elevation canyons and moved to the prairie only during summer and fall. Currently, over 95% of the Zumwalt is privately owned and is utilized primarily for the production of beef cattle, which are grazed from summer to fall. Because of this history, the Zumwalt still supports a mostly native flora with low cover of invasive exotic species (Johnson and O'Neil 2001; Anonymous 2005; Kagan et al. 2008; Kennedy et al. 2009).

Although certain portions of the Zumwalt (i.e., "Leap") have and continue to support significant agricultural activity, the northern portion of this area has experienced minimal conversion and includes a high diversity of native vegetation types. The northern Zumwalt Prairie, an area of approximately 57,000 ha in the upper Chesnimnus and Camp Creek watersheds, provides important habitat for populations of species of conservation concern including the ferruginous hawk (*Buteo regalis*) and Spalding's catchfly (*Silene spaldingii,* S. Watson), which depend on native steppe and shrub-steppe vegetation. It is this northern portion that was the focal area of this investigation. The purpose of this paper is to describe vegetation and land-use changes in the last large remnant of Pacific Northwest Bunchgrass Prairie by examining historical aerial photos.

METHODS AND MATERIAL

The study area was stratified based on habitat suitability as part of another investigation designed to examine the influence of landscape factors on territory occupancy of prairie nesting raptors (Bartuszevige et al., unpubl. data). We used this stratified random sampling approach for the landscape examination we report here. Based on historic data (1979 – 80: Cottrell 1981) and published habitat literature, the majority (~75%) of the study area was deemed suitable habitat. Areas deemed unsuitable were flat, high elevation ridge tops with little woody vegetation. We assume the land-use changes we document in our random samples of suitable habitat are applicable to these regions but we cannot evaluate this assumption. Historical landscape data were collected on 102, 800-m x 800-m plots. Because we sampled plots randomly, we extrapolate our observations to the entire prairie remnant.

Historical aerial photographs were obtained for the following years: 1938, 1947, 1956, 1971, 1976, 1984, and 1994. To represent the current landscape, we obtained 2001 Digital Ortho Quarter Quad photographs (DOQQs) – the most recent aerial dataset available during the study period. A complete set of aerial photos for 1947 was unavailable (approximately 25% of the study area was missing, 18 plots); therefore, landscape descriptions for this year are incomplete. The photos were georeferenced to the 2001 DOQQs using ArcMap (version 9.x, ESRI 2007). Important landscape features were digitized from these photos. These were features we established a priori as potential indicators of grassland fragmentation and degradation that could be obtained from historical photos. They include: area of cultivation and woody vegetation and number of buildings and stock ponds. We were able to digitize area of aspen (*Populus tremuloides,* Michx.) cover for 1976 and 2001 because an earlier investigator (Cottrell 1981) marked area of aspen on the 1976 photographs she obtained from the U.S. Soil Conservation Service, and we identified locations of all current aspen stands in the field. These data were not collected for the other decades because we could not easily and reliably distinguish aspen canopy from other types of tree canopy.

Between May and July 2005, we groundtruthed the data in the 2001 DOQQ. These field observations were used to validate feature identifications on photos from previous years. In 2006, we made notes regarding the type of woody vegetation found in the plots. We used three categories: conifer [mostly ponderosa pine (*Pinus ponderosa,* C. Lawson) and Douglas fir (*Pseudotsuga menziesii,* (Mirb.)Franco)], aspen, and shrubs [mostly black hawthorn and a few willows and cottonwoods (*Populus* sp.)].

RESULTS AND DISCUSSION

Based on our examination of the aerial photos, several profound changes have occurred on the Zumwalt between 1938 and 2001 (Table 1). The number of buildings on the Zumwalt declined over time from 83 in 1938 to 30 in 2001 in the examined plots (Table 1). This likely represents a decrease in both dwellings and farm-related buildings and may reflect demographic changes that were taking place in the region. The population of Wallowa County declined consistently during this period – from a maximum of nearly 10,000 to just over 6000 in 1970 (U.S. Census Bureau 1995). Population declines were likely even more pronounced on the Zumwalt as homesteaders left to re-settle in other parts of the county, which provided greater economic opportunity.

Between 1938 and 2001, there was a 90% reduction in the area cultivated on the Zumwalt (Figure 1, Table 1). Cultivation steadily decreased from 1938 until 1976. In 1984, there was a small increase in the area in cultivation, but the decline then resumes, until 2001 when only 57 ha of the prairie were cultivated in the examined plots. The most common crops planted in the study area were cereal grains (barley, oats, rye, and wheat) and hay (J. Williams, OSU Extension Service, pers. comm.). The low amount of cultivation that occurred on this prairie and the decrease over time is because the land was marginal for farming and those marginal lands that were cultivated were abandoned over time.

Table 1: Totals per decade (1938-2001) for a variety of landscape features found on the Zumwalt Prairie, Wallowa County, Oregon. Totals are summed over plots and not extrapolated to the entire prairie.

Year		1938	1946[c]	1956	1964	1976	1984	1990	2001
Trees	# plots[a]	51	35	52	61	50	49	55	57
	mean (ha)	0.4	0.4	0.4	0.6	0.7	0.6	0.6	1.0
	range, ha	0.003-7.2	0.003-8.2	0.01-7.2	0.002-11.8	0.008-13.7	0.01-11.1	0.002-10.9	0.002-22.1
	Total (ha)[b]	37.6	33.1	40.2	61.3	66.7	56.4	63.5	103.5
Cultivation	# plots	53	24	30	27	13	18	7	5
	mean (ha)	5.4	2.3	4.1	3.6	1.4	2.6	1	0.6
	range, ha	0.08-36.9	0.2-25.4	0.6-37.1	0.06-37.7	1.0-36.7	0.6-45.6	0.1-41.9	0.3-27.7
	Total (ha)[b]	549.9	195.3	421.8	363.2	146.4	267.9	104.9	57
Buildings	# plots	27	16	18	18	12	15	9	11
	mean (#)	0.8	0.6	0.5	0.6	0.3	0.4	0.3	0.3
	range, #	1-8	1-7	1-7	1-8	1-6	1-7	1-6	1-6
	Total buildings[b]	83	50	56	63	34	45	26	30
Stock ponds	# plots	7	21	53	67	66	76	73	79
	mean (#)	0.1	0.3	0.8	1.1	1	1.1	1.1	1.2
	range, #	1-4	1-4	1-5	1-6	1-4	1-4	1-4	1-4
	Total stock ponds[b]	12	29	79	112	97	116	109	118

[a] This represents the number of plots that contain the feature (e.g., trees, cultivations, buildings, or stock ponds).

[b] This represents the total summed across all plots within a year.

[c] The number of plots sampled in every year was 102. The 1946 set of photographs is missing approximately 25% of the study area; 84 plots were sampled. Therefore, results are not reflective of the same area as the remaining years.

During the same time period, the number of stock ponds increased (Figure 1, Table 1). The largest increase in the number of stock ponds occurred between 1938 and 1956, during which time there was a 6-fold increase in the number of stock ponds (Table 1). This reflects changing priorities for producers on the prairie, from homesteading to spring/summer cattle range. The increase in stock ponds subsequent to 1945 was likely a consequence of a sudden increase in the availability of earth-moving equipment sold by the U.S. government at low prices after World War II due to surpluses. Historically, the water available to homesteaders came from snow run-off and early spring rains that flowed through the many ephemeral streams found throughout the prairie. These ephemeral streams could be harnessed and made available throughout the grazing season by stock ponds created on the downstream end of the stream. The impact of increased numbers of stock ponds on the vegetation composition

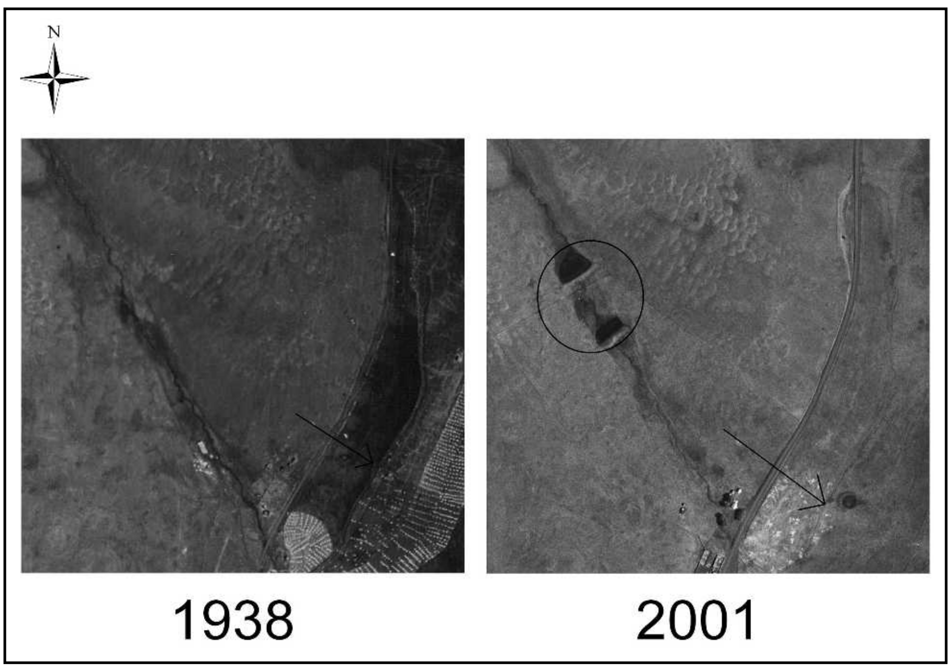

Figure 1: 1938 and 2001 aerial photos from an example plot on the Zumwalt demonstrating land use change. Note the cultivation in the lower right hand corner (arrow) in the 1938 photo and the lack thereof in the 2001 photo. In addition, there are no stock ponds in the 1938 photo, but there are two in the 2001 photo (circle).

is unknown. However, increased densities of stock ponds can have a homogenizing effect on prairie vegetation (Fuhlendorf and Engle 2001; Fontaine et al. 2004). Stock ponds have had adverse consequences for the many small headwater streams that drain this high plateau (National Riparian Service Team 2002, unpubl. data). When stock ponds are built along watercourses, they concentrate sediments, alter baseflows, and can cause excessive erosion and stream channelization (National Riparian Service Team 2002, unpubl. data).

The area of tree cover on the prairie has tripled in the last 67 years (Table 1). Our analysis of the 1976 and 2001 photos suggest coniferous trees are mostly responsible for this increase. In 1976, there were 7.2 ha of aspen and 36.9 ha of conifers. In 2001, aspen declined to 5.9 ha, and conifers increased to 60.0 ha (Figure 2). Aspen continues to decline on the Zumwalt Prairie in areas where cattle, elk (*Cervus elaphus*), and deer (*Odocoileus* spp) have not been excluded (The Nature Conservancy, unpubl. data). This declining trend in aspen is common throughout the western United States. There are multiple land-use (e.g., fire suppression, livestock herbivory) and ecological factors (e.g., native ungulate herbivory, climate change) influencing these trends (Brookshire et al. 2002; Frey et al. 2004; Rehfeldt et al. 2009).

In this study area, the decline in aspen can likely be partially attributed to the high levels of native and domestic ungulate grazing and differences in the palatability of the woody species. The invading species, conifers and hawthorns, are less palatable to ungulates (Kauffmann and Krueger 1984; Darambazar 2003) and aspen are a particularly desired foraging substrate for elk (Wooley et al. 2008) and are also eaten by cattle. Therefore, due to high abundance of native and domestic ungulates, there are few unprotected aspen stands where new stems are able to grow tall enough to escape the increased pressure from browsing (Taylor and Arends 2012).

Another factor that has likely resulted in an increase in woody species cover is change in the fire regime since European settlement. Early explorers of eastern Oregon documented fires as a common occurrence. Fires were intentionally set by native peoples to promote growth of plants gathered for food or important as forage for hunted animal species (Reinheardt 2009, unpubl. data). Fires of low and moderate severity burned more frequently in this area (every 10 – 20 yr) than they do today (Black et al. 1998; Reinheardt 2009, unpubl. data). Aspen is known to increase following fire; the absence of fire can result in stands being replaced by competing species such as conifers (Bartos 2001; Di Orio et al. 2005; but see Rehfeldt et al. 2009 for a discussion of other influences on aspen distribution in the western U.S.). In the absence of fire and under conditions of high ungulate herbivory, conifers and fire intolerant shrubs, such as black hawthorn, would be expected to increase.

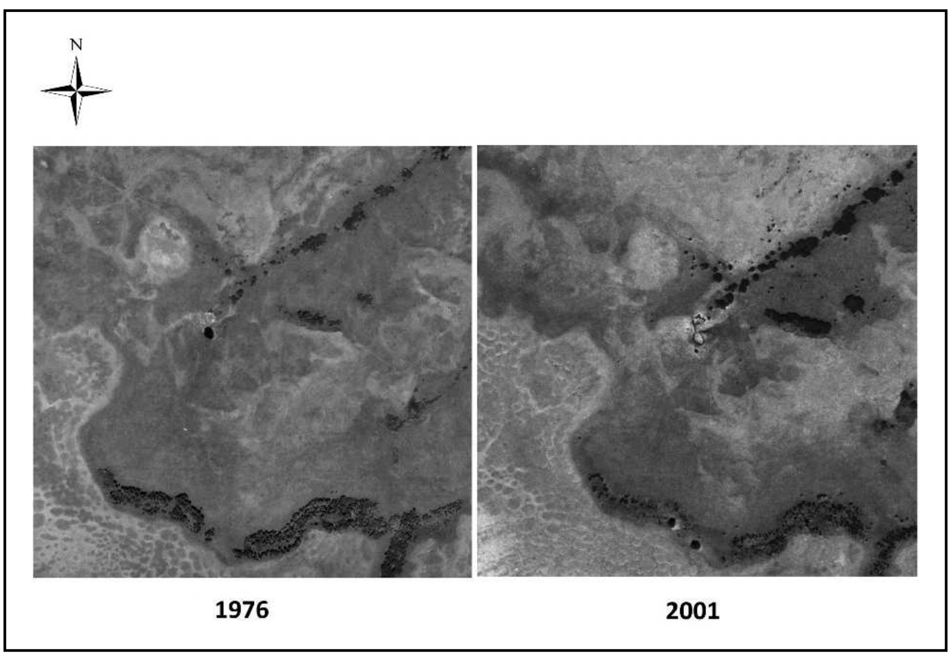

Figure 2: 1976 and 2001 aerial photos from an example plot on the Zumwalt demonstrating changes in woody species. Note the decrease in aspen in the lower portion of the photos between 1976 and 2001. In addition, note the increase in the amount of shrubs in the upper right hand corner of the 1976 and 2001 photos.

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