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A Time Comparison Study of Vegetation on The Island Research Natural Area in Central Oregon

Abstract

This study on The Island, a Research Natural Area (IRNA) in the central Oregon western juniper zone, measured vegetation cover during the early 1990s and compared it to an earlier study conducted in the early 1960s. Two plant associations were studied: western juniper/big sagebrush/bluebunch wheatgrass and western juniper/bitterbrush/bluebunch wheatgrass. The same study design and measurement techniques were used in both studies to document percent cover of vegetation on study-site macroplots, microplots, and aerial photographs. Major differences noted by 1993 included greater juniper and shrub cover, primarily big sagebrush, a more even mix of grass species rather than a dominance of bluebunch wheatgrass and cheatgrass as noted in the 1960 study, and higher litter cover. Weather data from 1952-1993 were analyzed, and no major events or trends were found in the 30 yr period between studies. This study also compared present-day IRNA sites in both plant associations with sites located in the nearby grasslands that had experienced greater impact from livestock and humans. The comparison sites had higher tree and shrub cover than IRNA and differed in Idaho fescue and bluebunch wheatgrass cover. Finally our study was compared to another recent study in the western juniper/big sagebrush/bluebunch wheatgrass plant association on IRNA. We established new representative macroplots whereas the other study used the exact plots of the 1960s study. Results were similar showing that either method may be satisfactory. A continuing bank of data sets of vegetation change and land use will assist us to understand the complexities of plant community dynamics over time.

Introduction

To study ecosystem dynamics and successional change it is absolutely necessary to develop long-term data sets on plant community populations (Franklin and Dyrness 1988). The Island Research Natural Area (IRNA) in the central Oregon western juniper (*Juniperus occidentalis*) zone provides an opportunity to study vegetation change in the relative absence of human impact or recent natural disturbance. It is a unique, semi-relict mesa located southwest of Madras (Figure 1). IRNA was first studied in the early 1960s by Driscoll (1962, 1964a, 1964b). Because of its isolated location it has avoided the fate of much of this area which Barbour et al. (1999) describes as having been converted to farmland or historically overgrazed and now invaded by weedy annuals and short-lived perennials.

Opportunities to build on past data sets are few, especially in plant communities that remain relatively undisturbed. Long-term studies reported in the literature on similar habitats include rangeland in southeastern Idaho (Anderson and Holte 1981), sagebrush grassland in eastern Oregon (Sneva et al. 1984), sagebrush semi-desert in west central Utah (West et al.1984), and the Horse Ridge Research Natural Area in central Oregon (Knapp and Soulé 1998). These studies were on sites with various intensities and frequencies of human and natural disturbance.

Once field studies are completed, causal factors of vegetation change are particularly difficult to evaluate. Mechanisms driving succession have been debated for nearly a century, and the debate is likely to continue into the future (Barbour et al. 1999). Disturbance regimes in the arid and semiarid western USA are complex and impacted by a mixture of anthropogenic and natural events (Hobbs and Huenneke 1992).

Without disturbance, especially without fire, a tree/shrub/grass plant community will develop slowly toward a dominance of woody vegetation (West et al 1984). Without periodic fire, big sagebrush (*Artemisia tridentata*) and juniper may outcompete perennial grasses through more efficient use of water, nutrients, and space (West et al.1979, Eddleman and Miller 1992). More shrub cover and less grass cover may also be caused by big

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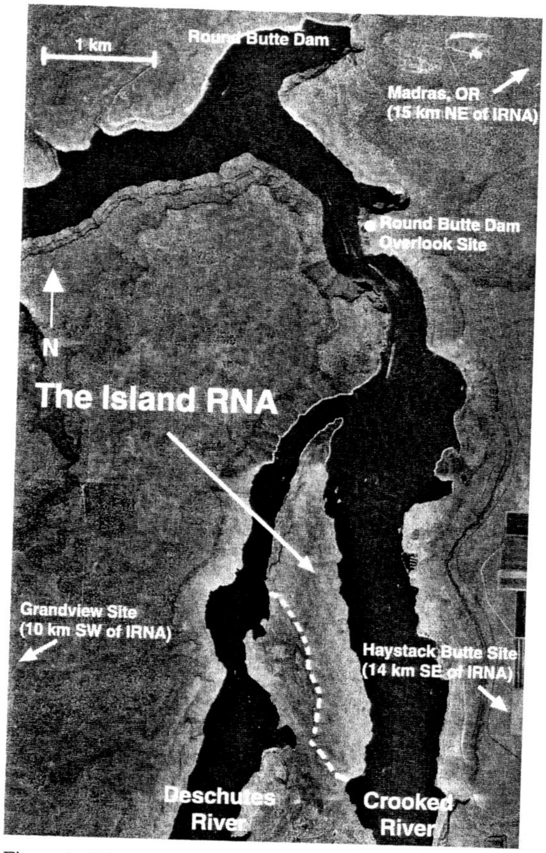

Figure 1. Digital orthophoto map of the study area (from Round Butte Dam, OR quadrangle)

sagebrush with its longer growing period outcompeting grasses for soil moisture, nitrogen, and other nutrients (Hyder and Sneva 1956, Doescher et al. 1984, Miller et al. 1986). Rooting structure plays a role in competition. Two dominant shrubs found in the juniper zone are bitterbrush (*Purshia tridentata)* and sagebrush. Bitterbrush requires stony soils with discontinuous hardpan and cracked bedrock, confining it to certain areas. Big sagebrush with a 1-4 m stout taproot and wide spreading lateral roots is more competitive and widespread (Frischknecht 1963).

Differences in life history traits and their interacting with environmental change are a crucial mechanisms driving succession (Barbour et al. 1999). Livestock grazing and human impact on a site results in higher tree and shrub cover and lower grass cover (Madany and West 1983). Invasive alien species may be brought to a site by livestock and humans. Grasses such as cheatgrass (*Bromus tectorum*), medusahead (*Elymus caput-medusae*), and red brome (*Bromus rubens*) are of concern in the western juniper zone. Medusahead is extremely competitive crowding out native grasses and the alien, cheatgrass (Whitson 1991).

The purpose of this study was twofold. First we measured the present vegetation on IRNA to compare our data with other studies. Driscoll (1962, 1964a, 1964b) documented two plant communities on IRNA: juniper/sagebrush/wheatgrass and juniper/bitterbrush/wheatgrass. A later study of the juniper/sagebrush/wheatgrass plant association located the plots of this earlier study and re-measured vegetation cover (Knapp and Soulé 1996). We established new plots in 1992 and 1993 in both plant associations and collected percent cover data for shrubs, grasses, forbs, and ground cover. We also examined change in western juniper cover over a 50-yr time period using aerial photos available for each decade back to the mid 1940s.

The second part of our study compared present-day vegetation cover on IRNA with sites in the two established plant associations, but located off the IRNA mesa in accessible areas with land use histories more impacted by humans and livestock than IRNA. These comparison sites were chosen because native species still dominated and few invasive or introduced species were present. They also had similar edaphic and climatic conditions.

Study Area

IRNA is located immediately south of the confluence of the Deschutes and Crooked Rivers east of the central Oregon Cascades (Figure 1). While known as The Island, it is technically an isolated plateau on the tip of a peninsula. This plateau is 730 m in elevation, and when first studied in 1960 and 1961 was surrounded by steep cliffs up to 200 m (Driscoll 1962, 1964a & b). In 1964 Round Butte Dam was completed, and the Crooked River and Deschutes River canyons were partially filled to form Lake Billy Chinook. Today the cliffs surrounding IRNA average 137 m in height above the surface of the water (Orr and Orr 1999). Access to the site is limited to a primitive trail winding up the cliffs near the south end of the peninsula. IRNA is a part of the Deschutes-Columbia Plateau formed by a lava flow approximately one million years ago (Orr and Orr 1999). The area around IRNA beyond the river canyons is generally a flat mosaic of farmland, pasture, and open rangeland, 730-884 m elevation, with occasional buttes rising to 1220 m. Our three comparison sites are in this open rangeland within 15 km of IRNA.

Weather records from the Metolius Station, northeast of IRNA, depict a semi-arid climate. Summers have warm days and cool nights, and winters are cool to cold. Average annual precipitation is 259 mm and annual mean temperature is 8.7°C (Oregon Climate Service 2002).

Vegetation in the study areas is classified in the western juniper zone, which lies in a savanna between ponderosa pine (*Pinus ponderosa*) forests and the shrub-steppe (Franklin and Dyrness 1988). Woody vegetation consists primarily of scattered western juniper, widely distributed big sagebrush, and narrowly distributed bitterbrush. Characteristic native perennial grasses are bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), Thurber's needlegrass (*Stipa thurberiana*), and Sandberg's bluegrass (*Poa sandbergii*). Annual grasses include slender fescue (*Festuca octoflora*) and the alien cheatgrass. Botanical nomenclature follows Hitchcock and Cronquist (1973).

Soils on the IRNA are classified as an Agency-Madras complex (USDA Natural Resources Conservation Service 2002). Two soil series were described for the juniper/sagebrush/wheatgrass association, covering ~87 ha. Both were nonstony, brown loams, one was 66 cm deep, the other 33 cm deep. Both series contained a clay layer from 20-38 cm deep (Driscoll 1964a). A single soil series was described for the juniper/bitterbrush/wheatgrass plant association, occupying ~14 ha. It was a shallow, sandy loam Regosol overlying a stony clay loam with high stone content. A discontinuous hardpan and cracked bedrock allowed some deep root penetration (Driscoll 1964a).

The first of three comparison sites was the Round Butte Dam Overlook site located 2 km south of the dam overlook building on the east side of Lake Billy Chinook and 5 km northeast of IRNA. The second site was on top of Haystack Butte, 14 km southeast of IRNA on the east side of US Highway 97. Both sites are in the juniper/sagebrush/wheatgrass plant association. The third site, Grandview, was located 10 km southwest of IRNA just north of the Grandview Cemetery. This site represents the juniper/bitterbrush/wheatgrass association. Soils on two of the comparison sites, Round Butte Dam Overlook and Grandview, are similar to those of IRNA and in the Agency-Madras complex. Soils on the Haystack Butte site are in the Tub series which is 100 cm deep with loam overlying clay loam and cobbly clay at 60 cm (USDA Natural Resources Conservation Service 2002).

Methods

During the summers of 1992 and 1993 we measured shrub, grass, forb, and ground cover using the same macroplot layout and measurement methods as used by Driscoll (1964a) and earlier described by Poulton and Tisdale (1961). We were unable to relocate Driscoll's exact macroplots, although the two plant associations were easily relocated, and new macroplots were randomly located in representative stands in each.

Fourteen 15x30 m macroplots were established, seven in each of the two associations with locations recorded using GPS equipment (Fox 1995). We avoided ecotones and scabland areas near the western rim and also omitted mature juniper trees within macroplots, as in the earlier study (Richard S. Driscoll, USDA Forest Service retired, Boulder, Colorado, personal communication). Four 1x15 m belt transects were placed within each macroplot. Line transects ran parallel along the belt transects with ten 30x60 cm microplots evenly spaced along each line transect (Figure 2).

Within each microplot percent foliage cover was estimated to the nearest 10% for all herbaceous species, bare ground (including rock), and litter (including moss and lichen). Shrub cover was measured by recording the distance to the nearest 1 cm bisected by each shrub species along the line transect. Shrub height and canopy diameter were measured for all shrubs rooted within the meter wide belt transect.

Macroplots in the juniper/sagebrush/wheatgrass association were located in the central and southern area of IRNA. Macroplots in the juniper/bitterbrush/wheatgrass association were located near the eastern edge of IRNA and labeled juniper/bitterbrush/wheatgrass East. We were also interested in scattered small areas where the juniper/bitterbrush/wheatgrass association occurred, which Driscoll (1964a) did not mention. Macroplots were established in three such areas and are labeled juniper/bitterbrush/wheatgrass South and West.

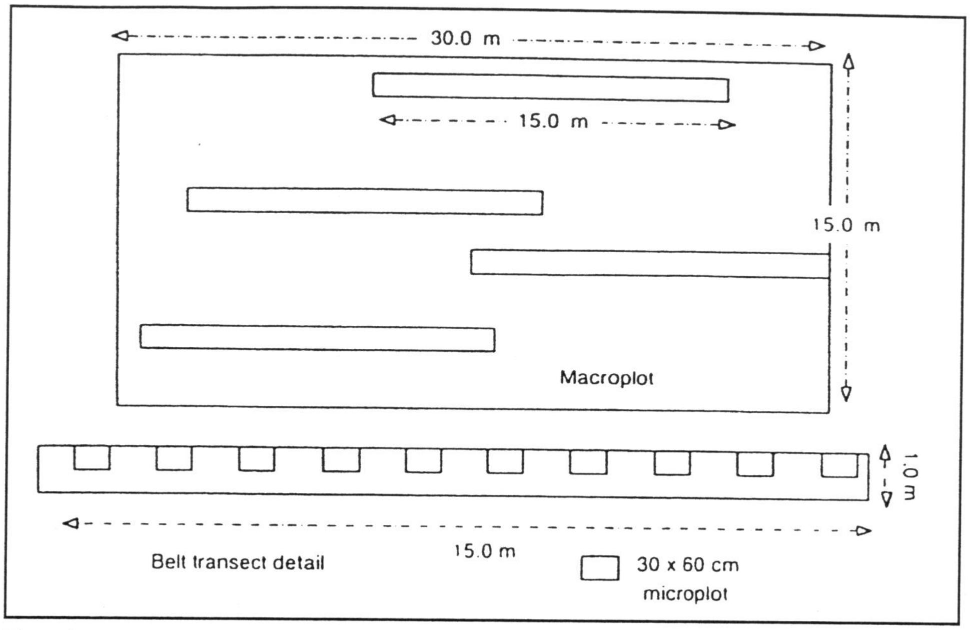

Figure 2. Macroplot, microplot, and belt transect layout

Two macroplots were established at each of the three comparison study sites off the IRNA plateau.

Aerial photographs were used to determine tree cover of western juniper on IRNA and the comparison sites at six time intervals over a 51 yr period: 1944, 1951, 1961, 1975, 1985, and 1995. Enlarged grayscale photocopies were made of aerial photos, and a plastic line/dot grid was placed over the sites to estimate percent cover of the visible juniper trees within each association, a method described by Moessner (1960) and used by Driscoll (1964a).

Weather data from 1952-1993 collected at the Metolius Station, 9 km northeast of IRNA, were examined for climatic trends using regression analysis. Available temperature data used for this study included mean annual, mean monthly maximums and minimums, and monthly extremes. Annual precipitation was examined as was monthly data for the two decades surrounding the 1960s and 1990s studies (Figures 3, 4).

Percent cover results for our plots on IRNA were compared with other studies (Driscoll 1964a,

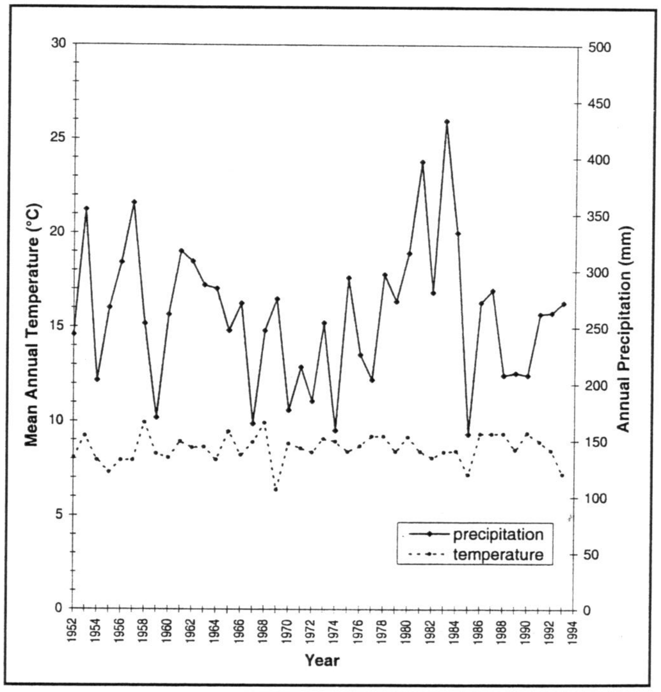

Figure 3. Mean annual temperature and precipitation (Metolius Station) 1952–1993

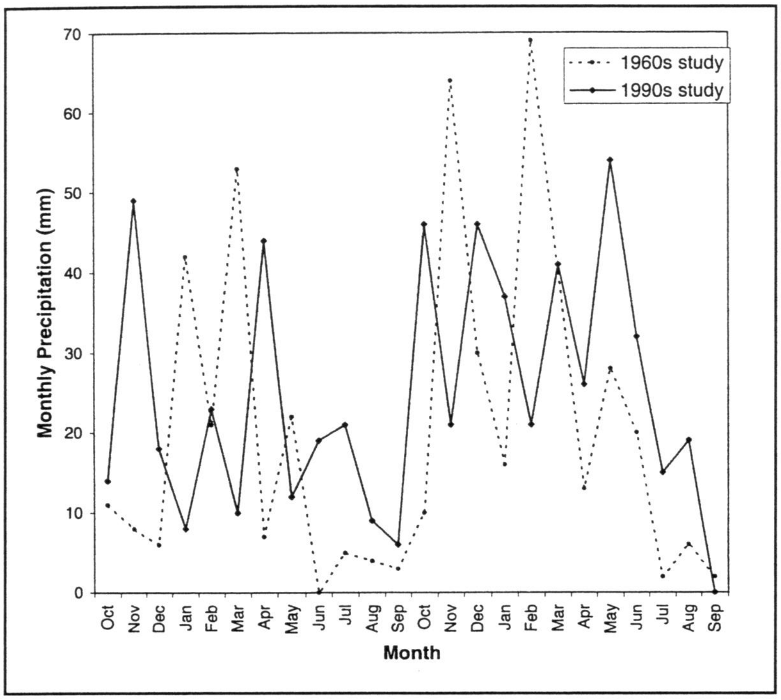

Figure 4. Monthly precipitation (Metolius Station) during the 1960s and 1990s studies

Knapp and Soulé 1996) and with our plots off IRNA for statistically significant differences using Student's t-test. Driscoll reported standard error for some species but not others. When he did not report a standard error, we used our standard error adjusted to his sample size as his reported standard errors were similar to ours.

Results

Temperature patterns recorded at the Metolius Station were fairly consistent from 1952 to 1993. While the annual mean temperature was 8.7° C and varied little from year to year there were variations between a July mean of 18.2° C and a January mean of 0.05° C. July mean maximum temperature was 29° C and January mean minimum was -4.9° C.

Annual precipitation was highly variable. Years above and below the long term mean of 259 mm were intermittent. Annual precipitation extremes ranged from a high of 397 mm in 1981 to a low of 156 mm in 1985. Three additional years were recorded above 320 mm and three below 200 mm, but no particular pattern emerged from the fluctuations scattered over the recorded 41 yr period (Figure 3). Monthly precipitation patterns varied markedly. The month in which the highest precipitation occurred included every month of the year. A comparison of monthly precipitation for two decades surrounding the study years, 1954-1963 and 1984-1993, found only May was significantly higher in the earlier decade (Figure 4).

Woody vegetation cover in the juniper/sagebrush/wheatgrass association consisted of one tree species, juniper, scattered unevenly throughout the association and one dominant shrub, sagebrush. Grass cover was divided evenly between four native perennial bunchgrasses. The two annual grass species played only a minor role. It is notable that shrub cover was slightly higher than grass cover (Table 1).

The juniper/bitterbrush/wheatgrass East plots consisted of juniper and a mix of two shrubs. Bitterbrush was the dominant shrub, but sagebrush was also present. The grass cover was a fairly even mix of four native perennial grasses plus the alien annual cheatgrass. In this association grass cover was higher than shrub cover. The juniper/bitterbrush/wheatgrass South and West plots varied from the East plots with more sagebrush and less bitterbrush present. The grass cover was lower than on the East plots. The four native perennials and two annuals were present, but bluebunch wheatgrass and Sandberg's bluegrass dominated (Table 2).

TABLE 1. Mean percent cover for the IRNA juniper/sagebrush/wheatgrass plant association. Values followed by different letters indicate significant differences ($P \leq 0.05$). 1960s data from Driscoll (1964a)

Species	1960s study	1990s study
Juniper	10.0[a]	10.5[a]
Sagebrush	8.5[a]	15.4[a]
Bitterbrush	0.0	0.0
Other shrubs	1.1	tr.
Total Shrub	9.6[a]	15.4[a]
Thurber's needlegrass	2.0[a]	2.9[a]
Bluebunch wheatgrass	9.2[a]	3.4[b]
Idaho Fescue	0.4[a]	2.6[a]
Sandberg's bluegrass	1.3[a]	2.8[b]
Cheatgrass	1.7[a]	0.1[b]
Slender fescue	0.6[a]	0.4[a]
Total Grass	15.2[a]	12.2[b]
Bareground/rock	41.3[a]	35.3[a]
Litter/moss/lichen	30.7[a]	55.9[b]

TABLE 2. Mean percent cover for the IRNA juniper/bitterbrush/wheatgrass plant association. Values followed by different letters indicate significant differences ($P \leq 0.05$). 1960s data from Driscoll (1964a).

Species	1960s study	1990s study East plots	1990s study South & West plots
Juniper	4.0[a]	8.7[a]	10.0
Sagebrush	0.0[a]	2.1[a]	8.2
Bitterbrush	8.7[a]	9.8[a]	5.3
Other shrubs	0.6[a]	1.2[a]	tr
Total Shrub	9.3[a]	13.1[a]	13.5
Thurber's needlegrass	1.1[a]	4.6[b]	0.4
Bluebunch wheatgrass	6.2[a]	2.5[b]	5.3
Idaho fescue	0.5[a]	4.8[b]	0.6
Sandberg's bluegrass	0.4[a]	3.9[b]	2.9
Cheatgrass	12.4[a]	2.6[b]	0.3
Slender fescue	0.3[a]	0.6[a]	1.1
Total Grass	20.9[a]	19.0[a]	10.6
Bareground/rock	18.7[a]	22.2[b]	33.5
Litter/moss/lichen	62.3[a]	57.5[a]	52.2

Forbs were not abundant in IRNA in either plant association. Our study showed < 1% cover. We recorded 14 forb species present in the microplots and identified more than 40 species of forbs in the two associations (Fox 1995).

Open space between the shrubs, grasses, and forbs accounted for a high percent of total cover. The two plant associations showed similar results of > 30% bare ground and > 50% litter cover (Tables 1, 2).

Juniper cover increased gradually but steadily from 1944 to 1995 in both associations on IRNA. The percent cover differences were small when comparing one decade to the next, but significantly more cover was found in 1995 than in 1944. Tree cover on the juniper/sagebrush/wheatgrass sites was only slightly higher than on the juniper/bitterbrush/wheatgrass sites (Table 3).

TABLE 3. Mean percent cover for western juniper on IRNA by plant association. 1961–62 data from Driscoll (1964a); photo date not specified by author

Year	Juniper/ sagebrush/ wheatgrass	Juniper/ bitterbrush/ wheatgrass East	Juniper/ bitterbrush/ wheatgrass South & West
1944	5.5	4.4	4.7
1951	8.0	4.4	5.7
1961–62	10.0	4.0	
1961	8.6	5.8	5.8
1975	8.2	5.2	6.1
1985	10.1	7.5	8.9
1995	10.5	8.7	10.0

All of the less pristine, comparison sites off IRNA had somewhat higher juniper and shrub cover than found on IRNA. Juniper cover was significantly higher on the Grandview and Haystack Butte sites. Bitterbrush cover was significantly higher on the Grandview site compared to the juniper/bitterbrush/wheatgrass association on IRNA (Table 4).

Grass components on the comparison sites differed significantly from IRNA. On the Round Butte Dam Overlook site Idaho fescue cover was lower. On the Haystack Butte site Thurber's needlegrass and bluebunch wheatgrass cover were lower but Idaho fescue higher. On the Grandview site the grass mix was similar to IRNA except that Idaho fescue was absent. Only the Grandview site had significantly higher levels of bare ground

TABLE 4. Mean percent cover for the 1990s study of the IRNA and nearby comparison plots. Values followed by different letters indicate significant differences ($P \leq 0.05$).

Species	Bitterbrush sites INRA NE	Bitterbrush sites Grandview	Sagebrush sites INRA	Sagebrush sites Round Butte	Sagebrush sites INRA	Sagebrush sites Haystack
Juniper	8.7[a]	16.9[b]	10.5[a]	12.4[a]	10.5[a]	19.0[b]
Sagebrush	2.1[a]	0.0[a]	15.4[a]	15.5[a]	15.4[a]	16.5[a]
Bitterbrush	9.8[a]	11.8[a]				
Thurbers needlegrass	4.6[a]	6.4[a]	2.9[a]	2.8[a]	2.9[a]	0.0[b]
Bluebunch wheatgrass	2.5[a]	3.1[a]	3.4[a]	4.6[a]	3.4[a]	0.9[b]
Idaho fescue	4.8[a]	0.0[b]	2.6[a]	0.4[b]	2.6[a]	5.5[b]
Sandberg's bluegrass	3.9[a]	2.3[a]	2.8[a]	4.3[a]	2.8[a]	5.5[a]
Cheatgrass	2.6[a]	2.1[a]	0.1[a]	0.3[a]	0.1[a]	0.0[a]
Slender fescue	0.6[a]	0.8[a]	0.4[a]	0.5[a]	0.4[a]	0.1[a]
Total Grass	19.3[a]	14.7[a]	12.2[a]	12.9[a]	12.2[a]	12.0[a]
Bareground/rock	22.2[a]	28.0[b]	35.2[a]	26.3[a]	35.2[a]	37.7[a]
Litter/moss/lichen	57.5[a]	53.3[a]	55.9[a]	58.7[a]	55.9[a]	49.5[a]

than IRNA, and there were no significant differences in litter cover (Table 4).

Discussion

Our study was first undertaken to determine vegetation change over a 30 yr period on a semi-relic site. The major differences noted include greater tree and shrub cover, and a more even mix of grass species rather than the dominance of bluebunch wheatgrass and cheatgrass noted by Driscoll (1964a). We also found sagebrush present in the juniper/bitterbrush/wheatgrass whereas Driscoll (1964a) reported none. Driscoll (1964a) described two plant associations on IRNA, whereas we identified the possibility of three. The juniper/bitterbrush/wheatgrass South and West plots (Tables 1, 2) are more closely aligned with the juniper/sagebrush/wheatgrass association described by Driscoll (1964b). Possible descriptions for this third association are juniper/sagebrush/wheatgrass - bitterbrush phase, or a transition of the juniper/bitterbrush/wheatgrass association to a juniper/sagebrush-bitterbrush/wheatgrass codominant association. The separation of big sagebrush and bitterbrush is partially attributed to different soil structure, texture, and rooting depth (Driscoll 1964a). Big sagebrush adapts to a variety of soil profiles, including those found on the juniper/bitterbrush/wheatgrass sites (Frischknecht 1963). In any case, big sagebrush is becoming a more prominent member of both associations.

Driscoll (1964a) noted substantial differences in bare ground and litter cover between the two associations, with more bare ground in the juniper/sagebrush/wheatgrass plots and more litter in the juniper/bitterbrush/wheatgrass plots (Tables 1, 2). We found a less dramatic variation between the two associations than was recorded in the 1960s.

Our results for tree, shrub and general grass cover for the juniper/sagebrush/wheatgrass association are similar to Knapp and Soulé (1996). An important benefit when comparing the results of the two recent studies is that the effectiveness of the two plot location methods can be evaluated. Using newly established plots within a defined area rather than re-measuring plots from an earlier study will provide the opportunity for more areas to be studied.

The major difference between our results and Knapp & Soulé (1996) was in specific grass species found. They reported substantially more bluebunch wheatgrass and somewhat less Idaho fescue than we found on the same association. Our plots supported a fairly even mix of bluebunch wheatgrass, Thurber's needlegrass, Idaho fescue, and Sandberg's bluegrass (Table 1). This difference could be due to differences in macroplot location, but we did find a similarly even mix of grasses in the juniper/bitterbrush/wheatgrass association and on our comparison sites.

Juniper cover increased slowly, a reminder of the slowness of change in this ecosystem (Table

3). Our 1995 measurements of 10.5% cover in the juniper/sagebrush/wheatgrass association agreed closely with those reported by Knapp and Soulé (1996) of 9.8% cover. Driscoll (1964a) reported a greater difference in juniper cover between the two associations than we found, but measuring exact tree cover is problematic due to the unevenness of distribution, site selection bias, inability to identify small trees in aerial photographs, and the lack of precision in the method of measurement used. We observed young juniper trees rising above the shrub layer throughout IRNA, and Soulé and Knapp (2000) reported that juvenile juniper populations on IRNA represented as much as 81% of the total population.

Our study of the more accessible, less pristine comparison sites showed slightly higher tree and shrub cover and lower grass cover than found on IRNA (Table 4), which may be due to more livestock grazing and human impact on the comparison sites (Madany and West 1983). Notable differences in grass cover included an absence of Idaho fescue on the Grandview site, low cover of this grass on the Round Butte Dam Overlook site, but greater cover on Haystack Butte site.

The general lack of fire is a probable influence on the trend toward a greater presence of woody species on IRNA and on the comparison sites. Aerial photographs from 1944 to 1995 show no major fire disturbance during this 51 yr period. Driscoll (1964a) reported that charred stumps and other signs of fire were common on IRNA. We observed evidence of small spot fires, however, they appeared to have minimal influence on the overall vegetation pattern being few in number and widely scattered. Our findings agree with West et al. (1979) and Eddleman and Miller (1992) that woody vegetation may out-compete perennial grasses unless periodic fires are present in the system.

In general our data agreed with the theory that without disturbance, especially without fire, woody vegetation will increase in cover (West et al. 1984, Barbour et al. 1999). In analyzing the vegetation by canopy layer, our study found more tree and shrub cover and less grass and forb cover in both plant associations than reported by Driscoll (1964a).

The building of Round Butte Dam in 1964 to create Lake Billy Chinook might be considered a disturbance, but the effect of the lake on IRNA vegetation is unknown and probably subtle. Climatic data from Metolius Station show no trend toward more moderate temperatures or higher humidity, but the station, located ~10 km east of IRNA may be outside the lake influence zone. Weather data, analyzed from decade to decade between the 1950s and the 1990s showed no measurable trends. Annual temperature was stable and precipitation, while varying widely from year to year, showed no significant pattern of change.

Although access to IRNA is limited, other major threats to its native vegetation may likely be increased human use and exotic weed invasions. Driscoll (1964a) expressed concern about the presence of the alien cheatgrass, but our study and Knapp and Soulé (1996) found less cheatgrass cover than in the 1960s. Medusahead, while not found in the microplots, is also present on IRNA as is another alien annual grass, red brome.

Previously recognized plant associations on IRNA are in the process of change. Without a major disturbance we expect the directional change toward more woody vegetation to continue. If fires were reintroduced into the ecosystem this would likely set back woody plants to give grasses and forbs greater presence. The present fire policy on IRNA recently agreed upon by the joint managers, the USDA Forest Service, Bureau of Land Management, and Oregon State Parks, is one of non-intervention (Ron Halvorson, BLM, Prineville, Oregon, personal communication). This policy may serve to reintroduce fire to IRNA and provide interesting new vegetation dynamics to study.

An important aspect of this study was to provide documentation with which to compare future studies on IRNA and in the nearby grasslands. Ongoing examination of vegetation cover, land use histories, climatic data, and fire events in this area will continue to broaden our understanding of vegetation dynamics and the complex process of plant succession over time.

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