AN ABSTRACT OF THE THESIS OF

M. Anne Fox for the degree of Master of Science in Rangeland Resources presented on November 13, 1995. Title: "The Island" Research Natural Area: A Vegetation Study with Time and Location Comparisons.

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Lee E. Eddleman

The purpose of this study was to document vegetation on "The Island", a Research Natural Area at the confluence of the Crooked River and the Deschutes River in central Oregon's *Juniperus occidentalis* Zone and to compare the results with an earlier study reported in 1964 from 1960-'61 data. Present-day comparisons were also made between "The Island" vegetation and three nearby sites. Percent cover and constancy of major tree, shrub, grass, and forb species were considered along with percent cover of litter, moss/lichen, rock and bare ground. Climatic data from the Metolius, OR Station were examined, and the literature of succession especially succession in the juniper and sagebrush steppe of the Great Basin was reviewed.

Data from 1992-'93 show more woody vegetation on "The Island", both tree and shrub, than was measured thirty years ago. The only tree species present is *Juniperus occidentalis*, while major shrub species are *Artemisia tridentata* and *Purshia tridentata*. Grass cover appeared to be less, with a more even mix of the native perennial bunchgrass species *Agropyron spicatum, Festuca idahoensis, Poa sandbergii, and Stipa thurberiana,* than in the past when *Agropyron spicatum* and the alien annual grass, *Bromus tectorum* dominated. The two plant associations identified in the 1964 report by Driscoll, *Juniperus occidentalis / Artemisia tridentata / Agropyron spicatum* and *Juniperus*

occidentalis / Purshia tridentata / Agropyron spicatum were still identifiable, but the shrub, *Artemisia tridentata* appeared to be entering areas where *Purshia tridentata* had dominated in the past study. The present-day comparison sites showed many similarities with sites on "The Island." The comparison sites in the *Juniperus occidentalis / Artemisia tridentata / Agropyron spicatum* association measured slightly more tree and shrub cover but similar grass cover when compared to "The Island." The comparison site in the *Juniperus occidentalis / Purshia tridentata / Agropyron spicatum* association had more tree cover and more *Purshia tridentata* cover, but less shrub cover generally and more grass cover than the same association on "The Island." Forbs represented less than one percent cover on all study sites. The differences recorded in 1992-'93 from that of the study thirty years ago may reflect successional processes at work and a lack of any major natural fires in the system.

"The Island" Research Natural Area: A Vegetation Study with Time and Location Comparisons.

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INTRODUCTION

In order for ecosystem dynamics and succession to be studied, plant communities must be measured repeatedly and the results evaluated. For sampling to be done rationally and efficiently, the continuum of vegetation covering an area must be divided into discrete, describable vegetation types. A complete census of a community is usually not taken, possibly only one percent of total land is measured, thus samples must be taken carefully for accurate and useful results (Barbour et al 1980).

Franklin and Dyrness (1973) state a need for research to address synthesis and collation of plant community data and analysis of successional patterns. Further they say it is absolutely necessary to develop long-term data sets on populations and successional change.

The purpose of this study was to document vegetation in areas which are as close to pristine as can be found today. The main area of focus was "The Island," a Research Natural Area located on a unique, relatively flat, 101 ha mesa-top just south of the confluence of the Deschutes and Crooked Rivers in central Oregon's *Juniperus occidentalis* Zone. It is a relict area whose vegetational composition was documented by R.S. Driscoll (1962, 1964a, 1964b). Driscoll reported the dominant plant association was *Juoc/Artr/Agsp* (*Juniperus occidentalis* Hook. / *Artemisia tridentata* Nutt. / *Agropyron spicatum* (Pursh) Scribn. & Smith*) with a minor but identifiable 14 ha which was in the *Juoc/Putr/Agsp* (*Juniperus occidentalis/ Purshia tridentata*(Pursh) DC. /*Agropyron*

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* Taxonomy follows: Hitchcock, C.L. & Cronquist A. (1973) Flora of the Pacific Northwest. Seattle:Univ. Wash.. Pr. 730p.

spicatum) plant association. He found *J. occidentalis* in clusters throughout "The Island" unrelated to specific plant association types.

Data from this present study and from the past study by Driscoll may be used to predict future successional changes, to better understand plant competition, and to evaluate the impact of various land uses. Future data collection at these sites will be useful in continuing to clarify successional trends. Past, present, and future studies will assist with land use planning, rangeland management, and restoration planning for degraded sites.

A number of vegetation comparisons were made involving "The Island's" vegetation. First, a comparison was made of the present day vegetation density and cover with Driscoll's (1964a) report of 30 years ago. Secondly, aerial photos of "The Island" were available dating back to the mid 1940's so *J. occidentalis* cover was compared from that time to the present.

Three other near-by sites were a second area of focus of this study. They were selected for present-time comparisons with "The Island." All comparison sites had a vegetation cover of native plants in reasonably good condition but had had more livestock and human impact over the years than "The Island." Two sites were selected in the *Juoc/Artr/Agsp* plant association. One was on a butte top 13 km southeast of "The Island", the other was just across the canyon, on the same geologic flow and at the same elevation as "The Island." The third site was selected in the *Juoc/Putr/Agsp* plant association in an open flat area 10 km southwest of "The Island."

SUCCESSION AND THE CLIMAX COMMUNITY

Successional Models

Recent range literature suggests successional models with multiple pathways, thresholds, and numerous steady states leaving progressive succession, as described in the past, as only one of many options (West 1988, Westoby et al 1989, Laycock 1991). The present hypothesis is that neither secondary succession nor retrogression is a continuous, linear process. It has irregular movement, thresholds, plateaus or suspended stages (Freidel 1991). Clements (1916) brought succession into the forefront, and Sampson (1923) incorporated these views into rangeland analysis. Now these views are being examined, broadened, and challenged by many ecologists and rangeland specialists (Lauenroth & Laycock 1989).

Smith (1989) felt range condition models historically based on Clement's concept of "monoclimax," should be re-examined, because Clement's concepts are now basically rejected by most ecologists. He said climax-based models also promote the image that humankind and livestock are intruders in natural systems. Moir (1989 p71) stated "Don't cling to the past except as they might still represent islands of genetic diversity and opportunities for restoration of rangelands." A need for new models has become especially clear as studies conducted on degraded rangelands many years after livestock removal show no visible change is taking place to restore the abundance of native species and the progressive successional cycle (Laycock 1989). New models may be needed to manage much of the rangeland present today, but they may be less relevant for relict sites with minimal livestock/human impact. No area is without some level of human impact (West 1993), but progressive, directional succession may well be taking place on isolated relict sites.

Further complications with the successional model arise when the desired state is not the climax state. Dyksterhuis (1949) equated climax vegetation with "excellent" condition, and the state for which management should strive, as successional models typically do. Friedel(1991) stated that climax may not be the desired state at all, and Risser (1989) said the climax state, even when known and properly described, may not be the most desirable vegetation type to meet management needs. Successional theory may actually define climax in the arid rangelands of central Oregon as being dominated by the tree, *J. occidentalis* or by the shrub, *A. tridentata*, not the idealic native bunchgrass codominance with scattered shrubs and trees (Young et al 1979). Thus disturbances, such as fire, insect and rodent population fluctuations, or moderate grazing, which impact sporadically and randomly, may be desired by managers to maintain a strong presence of grasses.

Laycock (1989) and Risser (1989) pointed out that another problem with the management models of the past was the lack of knowledge about the dynamics of secondary succession on all range types. Franklin and Blinn (1988) agreed that some major research needs include the analysis of successional patterns and the development of long-term data sets on successional changes.

Definition of Succession

Primary succession begins on an uninhabited site and secondary succession takes place after some type of disturbance to the original community. Successional or seral communities leading to a climax community exhibit some directional, cumulative, non random change over time. The climax community is also not static, but is in a state of dynamic equilibrium (Barbour et al 1980).

Daubenmire (1968) defined a climax community as one in which there is no evidence of replacement of one species by another, one that is stable or permanent. He also stated that stability is a condition of equilibrium, but should not be considered literally true as all ecosystems are dynamic. At climax, successional change slows down and dominants increase in longevity and have greater resistance to disturbance.

Daubenmire (1968) combined some of the views on succession of Clements (1916) (a community as organism and mono-climax) and of Gleason (1926) (individualistic species and gradient communities) together into an ecosystem concept accepting plant communities or habitat types but allowing for overlap of individual species into more than one community. Other ecologists throughout the century have suggested adjustments on Clement's theory or rejected it all together. Range management professionals, by comparison may still be using management principles based on Sampson's (1923) guidelines which were in turn based on Clement's theory (Smith 1989).

The simplest concept of succession, suggested by Barbour et al (1980), is a population phenomenon of gradual replacement of opportunistic species with equilibrium species. The rate and pathway vary depending on rate of arrival of propagules and the nature of the macro-environment, however equilibrium species eventually become dominant because of longevity, large biomass, and moderated micro-environments. The frequency of disturbance, both temporal and spacial, usually allows opportunistic species to be present or nearby. Often periodic disturbance interrupts the systematic progression of a complete sere thus climax is never reached.

Barbour et al (1980) described primary succession as beginning with plant colonization on new land and secondary succession as occurring only on land with residual soil and plant propagules. Pendleton (1989) defined secondary succession as any succession after a disturbance which altered the site, but did not profoundly alter the character of the site, and if allowed to operate would restore equilibrium to the plant community and to the soil. Both definitions imply some lack of severity to the disturbance after which secondary succession can take place. It may be that land which has become extremely degraded will undergo a process closer to primary succession.

Time and Succession

Succession is generally considered vegetational change which occurs over a period of up to 500 years, not seasonally, nor over thousands or millions of years (Barbour et al 1980). Primary succession is considered a slower process (200 to 1000+ years) versus secondary successional processes which may reach a climax state in 50 to 300 years (Barbour et al 1980). Even 50 years is a long time for scientific study. Daubenmire (1968) and Pendleton (1989) both pointed out this problem in that succession often happens too slowly for an individual to experience in one lifetime, and so slowly that it is difficult to know when the stability of climax is actually reached.

On arid lands such as the *Juoc/Artr/Agsp* or the *Juoc/Putr/Agsp* plant associations succession may be moving too slowly to detect through comparison studies carried out even over a century or at least too slowly to reveal the full picture. Moir (1989) noted that succession is a particularly difficult concept in arid and semiarid environments where precipitation is the driving force but is low, variable, and unpredictable. The process of succession is really never observed, just inferred, and the incontestable visible signs of succession are slow to show or become measurable.

Succession was once considered a linear process, but now is understood to be more complex both in time and direction. Pendleton (1989 p31) summed it up by stating "Many current scientists and authors today are what I call ecologically impatient. Progress is slow, painfully slow, in arid areas. Succession does not respect one person's lifetime." He also said that a knowledge of the climax community and secondary succession were still important to range management to assist in understanding the possible stages of succession other than the present plant community.

Succession in the *Juniperus occidentalis* Zone

Very little has been documented concerning successional relationships in the *Juniperus occidentalis* Zone. Young et al (1979) suggested the sagebrush steppe of the Great Basin was originally a fairly open stand of brush with a good understory of perennial grasses and forbs. The cool season, C_3 , grasses have a short spring growing season and are sensitive to grazing. Over the years grazing has probably decreased native grass and forb cover, allowed the invasion of alien species, and accelerated the slower but natural increase in shrub cover. Humphrey (1945) described some areas that may have been open grasslands to now be a shrub/grass mix, but others that may have been a mix long before settlement by European-Caucasians. *Artemisia tridentata* is the dominant shrub found in central Oregon and much of the northern Great Basin, but Humphrey (1945) mentioned *Purshia tridentata* as a shrub found occasionally as the dominant on sandier soils. He stated that both shrubs can easily be killed by fire, but *A. tridentata* does reestablish more quickly. Grazing and reduced fire frequency are often mentioned as changes which have altered the path of succession, but the slow invasion of shrubs into a grassland may actually be natural succession at work (Smith 1989). Hull & Hull (1974) found that even undisturbed areas which show little change over time do show some increases in *A. tridentata*.

The same successional questions may be asked regarding the tree, *J. occidentalis*. Although it is moving into new areas it has been present in other, albeit fewer, areas for hundreds or even thousands of years (Miller & Wigand 1994). Harvesting/aging studies and age/height class density studies show the expansion of this species throughout the

20th Century, especially downslope and into wetland areas (Eddleman 1987, Miller & Rose 1995). As shrubs increase they provide more safe-sites for both shrub and *J. occidentalis* seedling establishment. In turn as young *J. occidentalis* become established they also provide safe-sites for seedlings (Eddleman 1987). Fire may interrupt this progression by killing most immature *J. occidentalis* and shrubs in all age classes thus temporarily producing a grass-forb community. After some time shrubs will reestablish again and *J. occidentalis* (Franklin & Dyrness 1973).

Stands fluctuate as affected by insects, disease, fire, or climatic factors even on areas undisturbed by man (Young et al 1979). Sneva et al (1984) said *A. tridentata* has a life span of 60-100 years but can be affected by insect infestations, as they were from 1962 to 1966 by *Aroga websterii*, a webworm or defoliator moth. They also mentioned that climatic change can affect succession. For example, precipitation increases can produce increased vegetation including shrub and tree cover. Wetter and milder than normal years in the late 1800's are sometime mentioned as a factor in conjunction with increased livestock grazing which possibly began the *J. occidentalis* expansion (Miller & Wigand 1994).

Autogenic forces combine with all of the above mentioned allogenic forces to determine plant establishment and survival and thus succession. Caldwell (1978) found *A. tridentata* to be a strong competitor because of its ability to photosynthesize at low temperatures and its maintenance of a large leaf area year around. It has a large and costly root system, but these roots can extract water from the driest of soils. *J. occidentalis* is an excellent survivor once established because of its unusual photosynthesizing and transpiring capacities (Eddleman & Miller 1992) and its invasive root system (Kramer 1990). Seed production capability is another important autogenic factor. *J. occidentalis* generally produces cones at 50 to 70 years of age, thus seed crops have increased in the last 20to 30 years due to the maturity of trees established in large numbers from 1880 to 1910 (Eddleman 1984) (Miller & Rose 1995). Eddleman also noted that trees first established in open areas were more likely to be female with male trees dominating in closed stands, another advantageous autogenic survival factor.

A clear picture of successional processes and the composition of the climax community in the *Juniperus occidentalis* Zone is elusive. Succession in arid areas is a slow process. Disturbance is always a possibility, whether natural or human-induced. Alien species are found near even the most pristine sites. In the final analysis the plant community currently occupying an area is largely dependent on available propagules and site conditions (soils, space, and microclimate) for establishment and survival.

DESCRIPTION OF THE AREA

General Location

"The Island" is a unique mesa top at the confluence of the Crooked and Deschutes Rivers approximately 6.5 km northwest of the small town of Culver, near Madras, Oregon. Driscoll (1964a) described it as a semi-isolated plateau, 101 ha in size and 730 m in elevation surrounded by steep cliffs 60-200 m high on all sides. In 1964, shortly after Driscoll's study, the Round Butte Dam was built, the Crooked and Deschutes River canyons in the area of "The Island" were filled to form Lake Billy Chinook, thus today the cliffs surrounding "The Island" are only 137 m in height (Orr et al, 1992). "The Island" is a Resource Natural Area jointly managed by the U.S. Bureau of Land Management and the U.S. Forest Service (Crooked River National Grasslands) and is located within the Cove Palisades State Park.

The area around "The Island" is generally a flat mosaic of farmland, pasture and open rangeland, from 730 m to 884 m in elevation. Occasional buttes, rising to 1220 m, are scattered throughout, including Juniper Butte and Haystack Butte to the southeast and Round Butte to the northeast of "The Island." Rivers and creeks have cut canyons 120 m to 200 m below the open flatland throughout the area. Franklin and Dyrness (1973) described the general area, centered around the Deschutes, Crooked, and John Day Rivers in central Oregon as a *Juniperus occidentalis* Zone, a savanna whose annual moisture places it between the *Pinus ponderosa* Dougl. forest and the shrub steppe. The study sites were located in this general area, primarily on "The Island," but also on sites near Round Butte Dam, on Haystack Butte and near the Grandview Cemetery. (Figure 1)

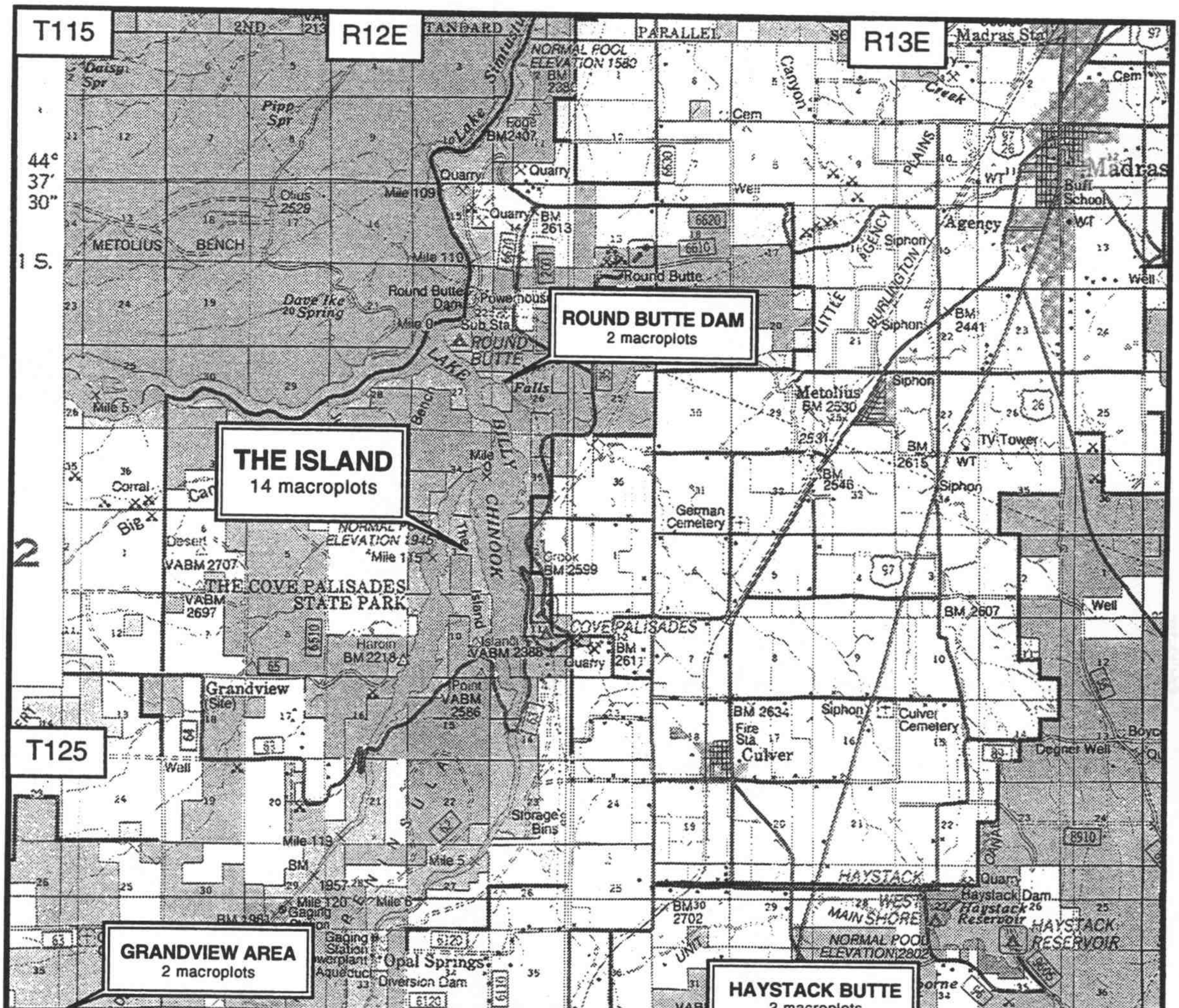

Figure 1. Location of Study Plots near Madras, Oregon

Geology

"The Island" and its immediately surrounding area are located in the southwestern part of the Deschutes-Columbia Plateau according to the fourth edition of Geology of Oregon (Orr et al 1992) rather than the northwestern part of the High Lava Plain as described in earlier editions of this standard work on the geology of Oregon.

The era of volcanic activity in the Pacific Northwest generally known for its mountain building began in the mid-Miocene period. Massive lava flows from northeastern Oregon and southeastern Washington entered the Central Oregon area. Basalts from the flows were interspersed with sediments from river flows and lakes as water was redirected by lava flows. Canyons were cut for seven million years, then two to three million years ago (Pliocene and Pleistocene) lava flowed again from local vents. Again rivers cut canyons in the path we see today. The latest flows in this area came about 1.6 millions years ago from the Newberry Crater area down the Crooked River Canyon in fifteen separate flows. "The Island" is a remnant of the last of these intracanyon flows. It is isolated now atop 135 m cliffs cut in the last million plus years of Deschutes and Crooked Rivers action (Orr et al 1992).

The macroplots for this study were located in four areas. The study sites near Round Butte Dam are on the same intracanyon lava flow and at the same elevation as the sites on "The Island". Other sites are on an open plain near the Grandview Cemetery, southwest of "The Island", and on the top of Haystack Butte, southeast of "The Island". They are on parent material formed from flows of two to three million years ago, earlier flows than that of "The Island".

Topography

All four study areas were located on level to slightly rolling, open areas. Elevation varies from "The Island" sites and the site near Round Butte Dam just below the canyon rim at 730 m, to the Grandview area at 880 m, to the top of Haystack Butte at 1220 m. All three comparison areas are within a 14.5 km radius of "The Island" in various directions.

Climate

The Great Basin was once a warm, wet area sloping west toward the Pacific Ocean. About twelve million years of mountain building left the Great Basin drier and colder, isolated from the coast by these mountains. The Great Ice Age occcurred about one million years ago with four major glacial periods, moving south into Washington, Idaho and Montana. Intermittent warming periods left large lakes throughout the Great Basin between the glacial periods. The last large lake period was about 12 thousand years ago, with cooler temperatures than today's by 3° to 4° C. Conifer forests were common (Trimble 1989).

Six to seven thousand years ago a warming trend began, vegetation moved north with the final retreat of the glaciers, and the Great Basin became warmer and drier. The large lakes disappeared, the flora and fauna changed, and temperatures rose 2° to 5° C above those of the present. The forests and grasslands became more of a desert scrub, junipers, appeared and have been present ever since (Trimble 1989). Juniper populations have ebbed and flowed from five thousand years ago to the present (Mehringer & Wigant 1985). By two thousand years ago the climate had cooled generally to present cooler conditions (Trimble 1989).

Driscoll (1964a) described the climate of the study area as continental and semi-arid, characterized by low annual precipitation, dry summers with warm days and cool nights, and cool to cold winters. The precipitation that is available comes as snow and rain fairly evenly distributed from October through June. No month is frost free but killing frosts are rare in June, July and August.

Climatic data for the general study area, based on 40 year averages from the Madras Station (U.S. Weather Bureau 1961), were reported by Driscoll(1964a). Annual precipitation averaged 236 mm and monthly temperatures ranged from -1.3° C in January to 19° C in July with extreme temperatures recorded from -42.7° C to 44° C. Driscoll (1964a) also reported the summers were droughty, temperatures exceeding 37.8° C were not uncommon, and that the years just preceding and during his study received below average precipitation.

Climatic data from the Metolius Station, southwest of Madras, have been recorded since 1949 with complete records available for 46 years between 1951 and 1993. Because this station is only nine km northeast of "The Island" and 763 m in elevation, similar to the 730 m on "The Island," these data will be used in this study. The average annual precipitation was reported to be 260 mm with an extreme high of 433 mm in 1985 and a low of 156 mm in 1983. Average annual temperatures ranged from a mean minimum of -0.6° C to a mean maximum of 16.4° C. Recorded temperature extremes ranged from -33.8° C in January, 1957 to 40.5° C in August, 1972.

Vegetation and Soils

Daubenmire (1988) described four major plant associations in eastern Washington dominated by the shrubs *Artemisia tridentata* and *Purshia tridentata*, and the grasses *Agropyron spicatum* and *Festuca idahoensis* Elmer in various combinations. His description of the first association, *Artemisia tridentata / Agropyron spicatum,* includes very few occurrences of other shrubs, but consistently includes *Poa sandbergii* Vasey and small amounts of *Bromus tectorum* L. A second association described is *Artemisia tridentata / Festuca idahoensis* which includes minor shrub representation of *Chrysothamnus vicidiflorus* (Hook.) Nutt. and *Tetradymia canescens* DC. as well as the grasses *A. spicatum*, *P. sandbergii*, and *B. tectorum* along with *F. idahoensis*. A third association described is *Purshia tridentata / Festuca idahoensis* which includes *Eriogonum heracleoides* Nutt., a semi-woody forb, and *F. idahoensis*, *A. spicatum*, and *P. sandbergii* as major grasses with some *B. tectorum*. The fourth association described is *Purshia tridentata / Agropyron spicatum*, found on slightly drier sites than *Purshia tridentata / Festuca idahoensis* and includes very few other shrubs. *A. spicatum* is the major grass with *P. sandbergii* and *B. tectorum* as minor components. Forbs in the genus *Lomatuim*, especially *L. macrocarpum* (Nutt.) Coult. & Rose are consistently mentioned. These associations also find their way into northern central Oregon (Daubenmire 1988). The associations described by Daubenmire (1988) do not contain the tree species *Juniperus occidentalis*, which is common in central Oregon.

Hironaka (1978) suggested that climax communities of one association may have the same species composition of dominants, but may vary in production, amount, and importance of the various species represented. He described an *Artemisia tridentata / Agropyron spicatum* association which may also have a *Festuca idahoensis* phase and a *Stipa thurberiana* Piper phase depending on the grass composition. He also described a separate *Artemisia tridentata / Festuca idahoensis* association and two minor *Artemisia tridentata* associations, *Artemisia tridentata / Poa sandbergii* and *Artemisia tridentata / Elymus cinereus* Scribn. & Merr.

Dealy (1971) described *Artemisia tridentata* and *Purshia tridentata* sites in central and southern central Oregon suggesting that *P. tridentata* is found on well drained sandy loam and *A. tridentata* on finer textured soils. He found these two shrubs to coexist and even to be codominant. *J. occidentalis* is found in or near most *Artemisia tridentata* and *Purshia tridentata* sites. It was often found on escarpments, rock outcrops, northern mesic slopes, and in intermittent drainages but is spreading into other open areas. It usually establishes in a pocket of slightly deeper soil when adjacent to *A. tridentata* on xeric sites (Dealy 1971).

Franklin and Dyrness (1973) described five plant associations in the *Juniperus occidentalis* Zone in Oregon. All were selected from eleven associations described by Driscoll (1962, 1964a,b). The predominant climatic climax association described was *Juoc/Artr/Agsp*. Four other variants were described and include *P. tridentata* as another dominant shrub and *F. idahoensis* as another dominant grass. Hopkins & Kovalchik (1983) described two associations found on flat to rolling terrain in the Crooked River National Grasslands of which "The Island" is a part. One was *Juoc/Artr/Agsp-Feid* (flat), the other was *Juoc/Artr/Agsp-Feid* (mound) & *Juoc/Artr/Posa* (swale). In these associations *J. occidentalis*, *A. tridentata*, and *Chrysothamnus* sp. were mentioned as "increasers," while *P. tridentata* and most native bunchgrasses are considered "decreasers."

Soils have developed in the central Oregon *Juniperus occidentalis* Zone over the last one to two million years depending on the age of the last lava flow. Alluvium, loess, and volcanic ash were deposited over the basaltic flows (Hopkins & Kovalchik 1983).

Soils were typically in the Haplargids (Brown soils and associated Regosols) soil groups. Surface soils are typically light colored, coarse textured (sandy loams) low in organic matter (1-4%) and slightly acidic (pH 6.0) to neutral (Franklin & Dyrness 1973).

This study will focus on the vegetation on "The Island" and three other nearby locations in the *Juniperus occidentalis* Zone and specifically on the *Juoc/Artr/Agsp* and *Juoc/Putr/Agsp* plant associations as described in varying forms above. *Chrysothamnus* sp. is often present but have a short-lived or minor presence in these associations. Characteristic grasses within these juniper/shrub communities are *A. spicatum*, *F. idahoensis*, *Stipa thurberiana* and *P. sandbergii*. A number of other grasses, annual and perennial, are present as well as several species of forbs, especially annuals, although forbs play a minor role in these plant associations. (Driscoll 1962).

Juniperus occidentalis was the only tree species present in the overstory of the study sites on "The Island" and at the three nearby comparison sites. These trees were found as scattered individuals and in open to closed stands throughout central Oregon between the pine forest zone and the open shrub steppe. Franklin and Dyrness (1973) described the *Juniperus occidentalis* Zone as a savanna setting and classed it as the most xeric of the tree dominated zones in the Pacific Northwest. Soils were generally shallow and rocky overlying relatively recent basaltic lava flows. Dominant shrubs with which *J. occidentalis* occurred were *A. tridentata*, *P. tridentata*, and *Chrysothamnus* spp.

On "The Island" specifically, Driscoll (1964a) described two plant associations within three soil types. Two soil types were found in the *Juoc/Artr/Agsp* association and another soil type within the *Juoc/Putr/Agsp* association. The two plant associations are described below in detail.

1. *Juoc/Artr/Agsp* (*Juniperus occidentalis / Artemisia tridentata / Agropyron spicatum*)

Driscoll (1964a) described the dominant plant association, covering 87 ha of the 101 ha of "The Island" mesa top, to be *Juoc/Artr/Agsp*. *J. occidentalis*, the only tree species, had 10% cover and was scattered unevenly throughout the association. The dominant shrub *A. tridentata*, had 8.5% cover, and *Chrysothamnus nauseosus* (Pall) Britt. had a minor presence of 1.1% cover. Driscoll (1964a) described the most striking component of this association to be the native perennial bunchgrass *A. spicatum* with 9.2% cover. Other grasses and their respective percent cover included the native perennials *Stipa thurberiana*: 0.1%, *P. sandbergii*: 1.3%, *F. idahoensis*: 0.4%, *Sitanion hystrix* (Nutt.) Smith: 0.1%, and the alien annual, *B. tectorum*: 1.7%. Driscoll (1964a) mentioned a paucity of forbs, the most prevalent being *Lomatium triternatum* (Hook) Coult. & Rose at 0.6% cover.

Driscoll (1964a) reported two soil series were associated with the *Juoc/Artr/Agsp* plant association. Both were described as nonstony, Brown loams, but one developed from hardpacked, river and lake-laid sediments, 66 cm in depth, and the other developed from loose loess and fine sands, 33 cm in depth. Both series contained small basalt fragments. Both series also contained a nonstony clay layer, varying from 38 cm below the soil surface and 20 cm thick in the hardpacked sediments of the first series to 20 cm below the surface and 5 cm thick in the second series which developed from loess and sands. This clay layer restricted root penetration and water storage capacity in both series, the first more than the second. Similar compositions to what were reported in both series for organic matter: 1.5%, total nitrogen content: 0.08%, pH in the A horizon: 6.5 to 7, and pH in the B horizon: 7.5 to 8. The soil surface was 41.3% bare ground, and 30% litter cover, with the remaining surface having some type of vegetation cover.

2. *Juoc/Putr/Agsp* - (*Juniperus occidentalis / Purshia tridentata / Agropyron spicatum)*

The second plant association on "The Island", as described by Driscoll (1964a), was the *Juoc/Putr/Agsp* association, which covered 14 ha. Vegetation cover included *J occidentalis*: 4%, (somewhat less than the 10% reported for the *Juoc/Artr/Agsp* association) *P. tridentata*: 8.7%, *C. nauseosus*: 0.6%, and *A. tridentata* was absent. *A. spicatum* was again the dominant native perennial bunchgrass with 6.2% cover. Other grasses and their percent cover included *S. thurberiana*: 1.1%, *F. idahoensis*: 0.5%, *P. sandbergii*: 0.4%. A strong presence of the alien annual grass *B. tectorum* was reported at 12.4% cover, (somewhat more than the 1.7% reported for the *Juoc/Artr/Agsp* association). The most abundant forb was *Achillea millefolium* L. at 0.6% cover.

The single soil series in this plant association was described by Driscoll (1964a) as a shallow, sandy loam Regosol overlying a stony clay loam with a sandy parent material of aeolian origin which contained 30% pumice. The buried soil was stonier than the soil of the *Juoc/Artr/Agsp* association, containing 35% stone in the A horizon and 80-90% in the B horizon. A discontinuous hardpan was found at 46 to 50 cm below the surface overlying cracked bedrock, thus allowing for some root penetration. Other measurements reported included organic matter: 1.43%, total nitrogen content: 0.07%, pH in the A horizon: 6-6.5, pH in the B horizon: 7-8. The soil surface was composed of 18.7% bare ground, 62.3% litter, with the remaining area covered with various forms of vegetation.

Water regimes in the two plant associations differed in that available soil moisture storage capacity was 5.9 cm in the *Juoc/Artr/Agsp* sites and 4.2 cm in the *Juoc/Putr/Agsp* sites, but Driscoll (1964a) reported the latter sites would have improved moisture effectiveness due to stoniness and lighter textured soils.

METHODS

Climate

Climatic data have been recorded since 1949 at the Metolius Station, approximately six km southwest of Madras and approximately nine km northeast of "The Island." It is the station located nearest "The Island" and at a similar elevation, 763 m as compared to "The Island" at 730 m. Precipitation and temperature data from the Metolius Station from 1951 through 1993 were analyzed using data obtained from the U.S. Weather Bureau (1994) through the EarthInfo database and Microsoft Excel software to obtain an understanding of the climatic patterns and fluctuations during the last forty years in the area of this study.

Vegetation - Field Measurements

As noted earlier, Driscoll (1964a) reported two plant associations on "The Island" as a result of his field study in the summers of 1960 and 1961, *Juoc/Artr/Agsp* (*Juniperus occidentalis /Artemisia tridentata /Agropyron spicatum*) on 87 ha and *Juoc/Putr/Agsp* (*Juniperus occidentalis /Purshia tridentata /Agropyron spicatum*) on 14 ha along the northeast portion of the mesa top. Personal communication with Richard Driscoll and with his field assistant, Ed Dealy, in 1992 revealed that neither of them knew if their original documentation and the raw data from their study were still in existence. Nor could they recall the exact locations of their five macroplots in each of the two associations identified, but they did relate that the macroplots had been marked in one corner with a metal stake. While it was not considered feasible to locate their macroplots scattered over 101 ha, this study has tried to mirror the Driscoll (1964a) study as closely as possible.

Fourteen macroplots were located on "The Island," seven in each of the two identified plant associations. Six others were located at three comparison sites within a 15 km radius of "The Island." The location of all macroplots was recorded using a Global Positioning System. (See Appendix B.) Within each of these macroplots (15 m x 30 m) all types of vegetation and ground cover were recorded.

Seven representative macroplots were located in each of the two described plant associations, *Juoc/Artr/Agsp* and *Juoc/Artr/Agsp* with care to avoid ecotones. The *Juoc/Artr/Agsp* macroplots were located throughout the central longitudinal area of "The Island" and in the southern two/thirds latitudinal area again avoiding ecotones into the *Juoc/Putr/Agsp* areas or the *Artemisia rigida* areas in the scablands near the western rim. Macroplots placement was adjusted slightly so as to avoid having large *J. occidentalis* trees within them, thus vegetation directly under large trees was not sampled. Personal communication with Driscoll in 1995 revealed he also had avoided having large trees within his macroplots.

Driscoll (1964a) stated the *Juoc/Putr/Agsp* association was found on 14 ha in the northeast corner of "The Island" so this general area was relocated and four macroplots were set up within it. I was also interested in other small areas where *P. tridentata* was found. Three other macroplots were established in the southeast, the southwest, and west central areas of "The Island" where *P. tridentata* also existed. To compare my data with Driscoll's (1964a), I clustered the *Juoc/Putr/Agsp* macroplots from this study into two different organizational subdivisions:

1a. One set of the four macroplots taken in the northeast portion of "The Island" where Driscoll sampled his *Juoc/Putr/Agsp* association. They will be entitled the *Juoc/Putr/Agsp*-NE sites.

1b. Another set of the three macroplots sampling *P. tridentata* elsewhere on "The Island," primarily in the southern section. They will be entitled the *Juoc/Putr/Agsp*-S sites.

2. A combination set will group together all seven macroplots in which *P. tridentata* was found and be entitled simply the *Juoc/Putr/Agsp* sites.

The location comparison plots were located in three areas within a 15 km radius of "The Island." Two macroplots were located in each of the three areas. One *Juoc/Artr/Agsp* site was the top of Haystack Butte, at 1220 m in elevation and approximately 13 km southeast of "The Island." A second *Juoc/Artr/Agsp* site was chosen because it is located on the same intracanyon lava flow as "The Island." It was on a bench just south of the Round Butte Dam and just northeast of "The Island." The third location was a *Juoc/Putr/Agsp* site just northwest of and across the road from the Grandview Cemetery at 880 m in elevation and approximately eight km southwest of "The Island."

The sampling layout as described by Poulton & Tisdale (1961) was used by Driscoll (1964a) and thus used in this study as well although some modifications were made. Measurements were converted to the metric scale, and while macroplots were located randomly within representative areas of the two identified plant association, adjustments were made to avoid having large juniper trees located within the macroplots. Soil data and plant production data as reported in Driscoll's (1964a) study were not recollected

Each macroplot was 15 m x 30 m. Within each macroplot there were four, 1 m wide belt transects, 15 m in length and placed in accordance with the Poulton & Tisdale (1961) layout. Four line transects, 15m in length, ran parallel through the center of the belt transects with 10 microplots evenly spaced along each of the line transects. Each microplot was 30 cm x 60 cm. (Figure 2.)

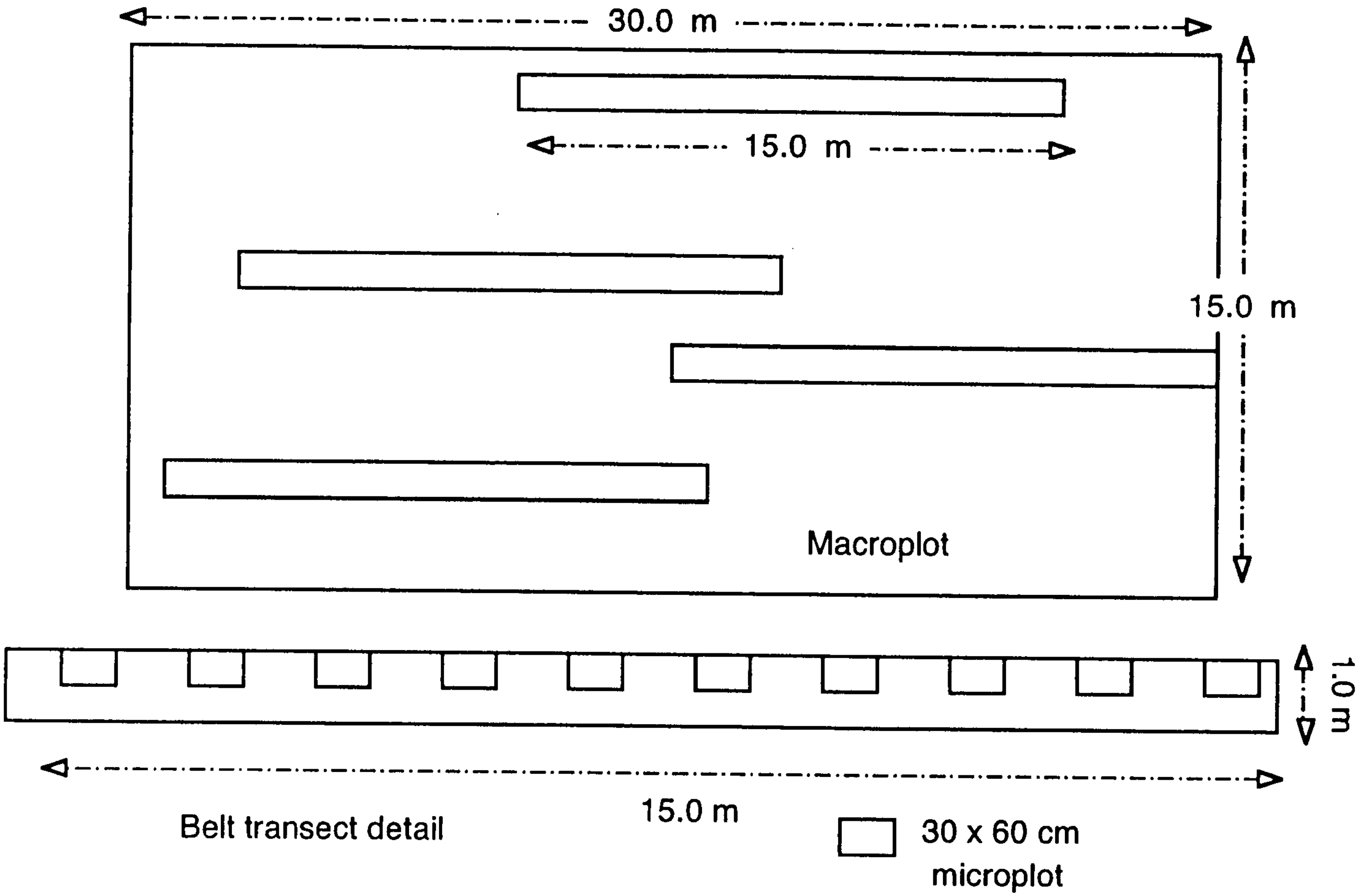

Figure 2. Macroplot Design

Within each microplot percent foliage cover was estimated and a density count was made of all herbaceous species, forbs and grasses, annual and perennial. Percent cover was also estimated for rock, mosses/lichens, bare ground, and litter. Daubenmire (1968) considered foliage cover to be a highly significant measurement to reflect relative dominance, potential production, precipitation intercept, and influence on soil temperature. Barbour (1980) defined cover, or coverage, as the percent of quadrat area beneath the canopy of a given species. Relative cover, or what Driscoll (1964a) referred to as percent composition, is the cover of a particular species as a percent of total vegetation cover. Relative cover totals 100% even when total absolute, or area cover was quite low. However Driscoll (1964a) calculated relative cover for perennial species only.

Shrub cover by species was measured by recording distance bisected by each shrub along the line transect using the line intercept method described by Canfield (1941) and used by Driscoll (1964a). Shrub height and diameter was measured for all shrubs rooted within the belt transect. Barbour et al (1980) suggested combining the line and belt transect methods to obtain density or frequency data along with cover. Bowns (1978) considered the line intercept method accurate and fairly precise along with being easy to use and having a low coefficient of variation.

Constancy was measured on the basis of presence or absence within each macroplot and reported by percent of total macroplots in which a species was found. Constancy is an artifact of plot size (Barbour et al 1980) but was somewhat useful here as comparison data with Driscoll's data (1964a). Percent composition of all perennial species was calculated from the cover data.

Vegetation - Aerial photograph Measurements

Driscoll (1964a) reported using aerial photographs and the Moessner (1960) method for measuring tree cover of *J. occidentalis*, the only tree species present. I repeated the same process on available aerial photographs of "The Island" dated 1944, 1951, 1975, 1985, and 1995, and of the other three sites dated 1951, 1975, and 1995. The 1985 and 1995 aerial photographs were purchased from the WAC Corporation in Eugene, Oregon, and the earlier ones were borrowed from the University of Oregon Map Library. Enlarged photocopies were made of aerial photos of all four sites and a plastic line/dot grid placed over the sites to estimate percent cover of the larger and thus visible *J. occidentalis* trees.

Statistical Analysis

Standard error was calculated and reported for all percent cover means of the 1992-'93 data sets. (See Appendices C, D, E.) Two-sample t-tests assuming unequal variances were performed to evaluate the statistical significance of the differences measured between the 1992-'93 sites on "The Island" with their near-by comparison sites of the same plant association. Few t-test comparisons could be made with Driscoll's (1964a) study because of lack of raw data from the earlier study. Driscoll (1962) did report standard errors for the means of percent cover for three species, *J. occidentalis, Artemisia tridentata, and Agropyron spicatum* in the *Juoc/Artr/Agsp* plant association so these were compared. Other comparisons were made using only the data sets from this study. Species within the two plant associations on "The Island," *Juoc/Artr/Agsp* and *Juoc/Putr/Agsp*, were compared as were the two subdivisions of the *Juoc/Putr/Agsp* association, the South sites and the NE sites.

RESULTS

Climate

Climatic variation during the 42 years from 1951 through 1993 was examined using data recorded at the Metolius Station. These years encompass the time before and during both studies, Driscoll (1964a) and this study. Average annual precipitation was recorded at 260 mm, and average minimum temperature was -0.6° C and the average maximum temperature was 16.4° C. Temperature patterns were fairly consistent, but precipitation patterns were much more erratic and unpredictable. (See Appendix J for monthly precipitation records.)

While the average annual maximum and minimum temperatures varied approximately 17° C (from -0.6 to 16.4), the variation over the 42 years within the average maximums recorded and the average minimums recorded was small, 2.7° C. The annual minimums ranged from -0.5° C to 2.2° C, and the annual maximums ranged from 15° C to 17.7° C. The monthly rise and fall of temperatures within each year was also very consistent. Average monthly temperatures ranged from 4.4° C (maximum) and -5.5° C (minimum) in January to 28.8° C (maximum) and 7.3° C (minimum) in July. Recorded temperature extremes varied from -33.8° C in January, 1957 to 40.5° C in August, 1972, but rarely occurred below -25° C, or above 37.7° C.

Precipitation patterns, both monthly and annual, were more difficult to determine. Driscoll (1964a), using climatic data from a 40 year period recorded at the Madras Station, reported that 88% of the precipitation occurred between October and June. By comparison, measurement from the Metolius Station for three years just before and during Driscoll's study recorded that 94% occurred between October and June, and for the three years before and during this study only 83% occurred between October and June. (See Appendix J for Metolius Station monthly precipitation records.)

To better understand the impact of precipitation on vegetation it may be advantageous to consider precipitation data on an annual basis from October through September rather than by the standard calendar year. October through March is the moisture recharge period, April through June the spring germination and growth period, and July through September the seed dispersal and senescent period. (Table 1)

Table 1. Metolius Station Precipitation in mm

	1959	1960	1961	1991	1992	1993
Annual ppt.	170	261	317	262	263	273
	1958-'59	1959-'60	1960-'61	1990-'91	1991-'92	1992-'93
Oct/Mar recharge	142	141	228	77	121	212
Apr/June spring	32	29	61	95	74	112
July/Sep summer	19	13	10	75	35	35
Total ppt.	193	183	299	246	231	358

*data from U.S. Weather Bureau (1994)

The month of highest precipitation also varied. During the 42 years examined between 1951 and 1993, the month of highest precipitation occurred within the following groups of months: October through December - 16 years, January through March - 9 years, April through June - 10 years, and July through September - 7 years.. While there were small clusters of years recording below average precipitation (1970-1974 and 1988-1990) and others recording above average precipitation (1961-1964 and 1980-1984) the majority of the below average years were intermittent with normal and above average years showing no particular pattern. Annual precipitation extremes have varied from a high of 458 mm in 1983 to a low of 163 mm in 1985, with 17 years falling outside the normal range of 210 mm to 310 mm, 7 years above and 10 years below.

Vegetation

Vegetation on "The Island", apparently subjected to minimal disturbance over the last thirty years, might be expected to show only minor changes. One ongoing disturbance would be the impact of native herbivores which are a part of the ecosystem and presumed to be a constant within bounds. Other disturbances would include small spot fires usually caused by lightning, climatic extremes, unusual weather events and increased recreational hiking. Considering the slowness of successional forces on arid lands, thirty years is a relatively short period of time over which to measure vegetation change. In this study change in the percent cover of various plant species were considered, comparing macroplots recorded on "The Island" in the summers of 1992 and 1993 with those recorded by Driscoll (1964a) in 1960 and 1961, and with comparison macroplots located in areas near "The Island" also recorded in 1992 and 1993. All macroplots were located on sites appearing to represent the *Juoc/Artr/Agsp* and *Juoc/Putr/Agsp* plant associations found on "The Island" and described by Driscoll (1964a).

"The Island Macroplots

Recorded differences between this study and that of Driscoll(1962, 1964a) in 1960 and 1961 do indicate vegetation change has occurred. Only the percent cover for *J. occidentalis, Artemisia tridentata, Agropyron spicatum,* and *P. sandbergii* in the *Juoc/Artr/Agsp* association could be statistically compared between the two studies. Of those four species only *A spicatum* and *P. sandbergii* were significantly different at the $p < 0.05$ level, *A. spicatum* having lower percent cover and *P. sandbergii* higher percent cover in this study. Driscoll (1962) reported standard errors of the mean for these species only and in the *Juoc/Artr/Agsp* plant association only, thus it was not possible to test the significance of other differences measured. These other differences will be summarized and discussed generally even though they cannot be tested. (Table 2)

Shrub cover was higher on all sites in the 1992-1993 study. *Juoc/Artr/Agsp* sites showed a change in total shrub cover from 9.6% to 15.4%. The only shrub species on the *Juoc/Artr/Agsp* sites with percent cover greater than 0.1 was *Artemisia tridentata* at 15.4%, but constancy data (see Appendix F) do show at least a presence of *Chrysothamnus nauseosus*, *Chrysothamnus visidiflorus* and *Tetradymia canescens*. *Juoc/Putr/Agsp* sites showed a change from 9.3 to 13.1% in total shrub cover. Cover by species changed from 8.7% *Purshia tridentata* and 0.6% *C. nauseosus* in 1960 and 1961 to 7.8% *P. tridentata*, 4.7% *A. tridentata*, 0.3% *C. visidiflorus*, 0.2% *T. canescens*, and 0.1% *C. nauseosus* in 1992 and 1993.

Dividing the *Juoc/Putr/Agsp* macroplots into NE and S showed an interesting but different picture. NE macroplots still showed a presence of *A. tridentata*, but percent cover was low, 2.1% as compared to 9.8% for *P. tridentata*. The S macroplots appeared to be sites in transition between the *Juoc/Artr/Agsp* sites and the *Juoc/Putr/Agsp* sites with percent cover for *A. tridentata* and *P. tridentata* 8.2 and 5.3 respectively. Examining each of the S and the NE macroplots individually did show variation in *A. tridentata* cover from 10.3% to 0% and in *P. tridentata* from 13.2% to 3.9%. One S macroplot (ISPt92-8) and one NE macroplot (ISPt93-3) showed similarities in percent cover for both species. (See Appendix D)

Table 2. "The Island" Percent cover by plant association 1992-'93 & 1960-'61

	Juoc/Artr/Agsp		*Juoc/Putr/Agsp*			
	92-'93	60-'61**	NE'92-'93	S '92-'93	All'92-'93	60-'61**
Juoc	10.0% a*	10.0% a	8.7%	10.0%	9.4%	4.0%
Total Tree	10.0%	10.0%	8.7%	10.0%	9.4%	4.0%
Artr	15.4% a	8.5% a	2.1%	8.2%	4.7%	
Putr			9.8%	5.3%	7.8%	8.7%
Chna	tr.	1.1%	0.3%	tr.	0.1%	0.6%
Chvi	tr.		0.5%	tr.	0.3%	
Teca			0.4%	tr.	0.2%	
Total Shrub	15.4%	9.6%	13.0%	13.5%	13.2%	9.3%
Stth	2.9%	2.0%	4.6%	0.4%	2.8%	1.1%
Agsp	3.4% a	9.2% b	2.5%	5.3%	3.7%	6.2%
Feid	2.6%	0.4%	4.8%	0.6%	3.0%	0.5%
Kocr			0.1%		0.0%	
Posa	2.8% a	1.3% b	3.9%	2.9%	3.4%	0.4%
Sihy	tr.	0.1%	0.2%		0.1%	tr.
Brte	0.1%	1.7%	2.6%	0.3%	1.6%	12.4%
Feoc	0.4%	0.6%	0.6%	1.1%	0.8%	0.3%
Total Grass	12.3%	15.3%	19.2%	10.5%	15.5%	20.9%
Acmi	tr.	0.1%	0.1%		tr.	0.6%
Agoseris sp.		0.1%				
Astragalus sp.	0.1%	0.3%	tr.	0.1%	tr.	0.1%
Baca				tr.	tr.	
Lotr	tr.	0.6%	tr.	tr.	tr.	0.1%
Phdo		0.1%	tr.		tr.	0.1%
Zypa			tr.	tr.	tr.	0.1%
Total Forb	0.1%	1.2%	0.1%	0.1%	0.0%	1.0%
Bareground	28.0%	41.3%	18.1%	24.5%	20.8%	18.7%
Rock	7.2%		4.1%	9.0%	6.2%	
Total Ground	35.3%	41.3%	22.2%	33.5%	27.0%	18.7%
Litter	41.0%	30.7%	36.1%	44.1%	39.5%	62.3%
Moss/lichen	14.9%		21.4%	11.1%	17.0%	
Total Litter	55.9%	30.7%	57.5%	55.2%	56.5%	62.3%

* Averages followed by different letters are significantly different ($p<0.05$). Four species tested.

** 1960's data from Driscoll (1964a) tr.=presence in macroplot but <0.1% cover

All sites showed generally less grass cover than reported by Driscoll (1964a). *Juoc/Artr/Agsp* sites changed from 14.3% to 12.2% in total grass cover, with the greatest change being in *Agropyron spicatum* which dropped from 9.2% to 3.4% ($p < 0.05$.) *Festuca idahoensis*, *Stipa thurberiana*, and *Poa sandbergii* appeared to have more percent cover, resulting in a more even representation of all four species. *P. sandbergii* changed from 1.3% to 2.8% ($p < 0.05$.) *Bromus tectorum* appeared to have less cover, from 1.7% to 0.1%. The other annual grass present, *Festuca octoflora*, showed less cover in the *Juoc/Artr/Agsp* sites, and was recorded at less than 1% total cover.

Juoc/Putr/Agsp sites showed less grass cover generally from the 20.9% found by Driscoll (1964a) to 15.4%. Again, there was a change in *A. spicatum* cover from 6.2% to 3.7%, and a dramatic change in *B. tectorum* from 12.4% to 1.6%. *S. thurberiana*, *F. idahoensis*, and *P. sandbergii* appeared to have more cover resulting in a fairly even mix of the four major perennial grasses, as similarly noted on the *Juoc/Artr/Agsp* sites. Dividing the *Juoc/Putr/Agsp* macroplots into NE and S produced a somewhat different picture. The NE macroplots showed *A. spicatum* to cover 2.5% with *F. idahoensis*, *S. thurberiana*, and *P. sandbergii* all more dominant at 4.8%, 4.6%, and 3.9% respectively. The S macroplots still showed a dominance of *A. spicatum* at 5.3% with *P. sandbergii* higher cover at 2.9% than *F. idahoensis* or *S. thurberiana* with 0.6%, 0.4% respectively. These macroplots were closer to Driscoll's data measured in the NE area with the exception of the reduction in *B. tectorum* cover from 12.4% to 0.3%. *F. octoflora* appeared to have more cover on *Juoc/Putr/Agsp* sites, but again was less than 1% of total cover.

Perennial forbs measured less cover in both the *Juoc/Artr/Agsp* and *Juoc/Putr/Agsp* sites from approximately 1.0% to 0.1%. Driscoll(1964a) mentioned a paucity of forbs, and that state seemed even more pronounced in my data. Percentages in both studies were low, however it is difficult to know what influence macroplot location had on the results. Annual forb species were numerous but their cover appeared to be low and their constancy varied from year to year. As their growing season may last only days or at the most weeks, they were identified for the plant list but cover was not evaluated in this study. (See Appendix A for a complete plant list.)

Driscoll (1964a) recorded bare ground and litter cover which showed striking differences between the two associations. He recorded *Juoc/Artr/Agsp* sites had 41.3% cover for bare ground and 30.7% litter cover, and *Juoc/Putr/Agsp* sites had 18.7% cover for bare ground and 62.3% cover for litter. On the assumption that he included rock cover with bare ground and moss/lichen cover with litter, my comparisons would be as follows: bare ground and litter cover on *Juoc/Artr/Agsp* sites 35.2% and 55.9% respectively, and on *Juoc/Putr/Agsp* sites 27.0% and 56.5% respectively. In general I found a less dramatic variation between the two associations than was recorded in the 1960-'61 study.

I tested the significance of differences observed within my own data sets. When considering these 1992-'93 data sets only and comparing the *Juoc/Artr/Agsp* sites with the *Juoc/Putr/Agsp* sites on "The Island" the only species which were significantly different ($p < 0.05$) from association to association were the *A. tridentata* and the *P. tridentata*. Bare ground cover was also significantly different, being higher on the *Juoc/Artr/Agsp* sites. When comparing the S and NE subdivisions within the *Juoc/Putr/Agsp* association the only significant differences ($p < 0.05$) were *A. tridentata* being higher in the S macroplots and the grasses *F. idahoensis* and *S. thurberiana* being higher in the NE macroplots. The moss/lichen cover was also significantly higher in the NE macroplots. (Table 2) Annual differences recorded on "The Island" in general between 1992 and 1993 for moss/lichen cover were 10.9% for 1992 and 22.7% for 1993.

"The Island" *Juniperus occidentalis* Cover

Juniperus occidentalis percent cover on "The Island" was measured using aerial photographs taken in 1944, 1951, 1975, 1985, and 1995. Because of the method used only larger trees were visible, thus it was likely that percent cover was underestimated. Cover data was not taken for *J. occidentalis* in the macroplots, but only by use of aerial photographs. (Table 3)

Table 3. "The Island" Percent Cover - *Juniperus occidentalis*

	Juoc/Artr/Agsp	*Juoc/Putr/Agsp*		
	All Artr Sites	S Sites	NE Sites	All Putr Sites
1944	5.5%	4.7%	4.4%	4.5%
1951	8.0%	5.7%	4.4%	5.1%
*1960	10.0%			4.0%
1975	8.2%	6.1%	5.2%	5.7%
1985	10.1%	8.9%	7.5%	8.2%
1995	10.5%	10.0%	8.7%	9.4%

*1960 data from Driscoll (1964a)

Tree cover for the *Juoc/Artr/Agsp* sites were not statistically different ($p < 0.05$) from that of the *Juoc/Putr/Agsp* sites in any of the years measured. Nor was the percent cover on "The Island" in general statistically different ($p < 0.05$) from one measured year to the next. The only comparison which was significantly different ($p < 0.05$) was between the years 1944 and 1995. Significant differences were difficult to determine partly because trees were unevenly clustered on "The Island" resulting in a high sample variance from the method employed.

In general tree cover appeared to increase gradually but steadily from 1944 to 1995 in both associations. Measurements from 1951 photographs, not long before Driscoll's study, varied from data reported by Driscoll (1964a) but both showed more *J. occidentalis* cover on the *Juoc/Artr/Agsp* sites than on the *Juoc/Putr/Agsp* sites. The

1951 photo showed *J. occidentalis* cover to be 8.0% on the *Juoc/Artr/Agsp* sites, and 5.0% on the *Juoc/Putr/Agsp* sites, whereas Driscoll reported 10% on the *Juoc/Artr/Agsp* sites and 4.0% on the *Juoc/Putr/Agsp* sites. The NE sites at 4.4% cover measured very close to Driscoll's sites at 4% cover. As mentioned above, the *Juoc/Artr/Agsp* site differences may have resulted from site selection variation because this plant association covered 86 ha. Trees were unevenly scattered with noticeable clusters in the central-eastern area and northwestern area of "The Island".

While cover data were not recorded for *J. occidentalis* in the macroplots, constancy (presence or absence) data were. Driscoll (1964a) reported 100% constancy of *J. occidentalis* in all of his macroplots. I recorded only 43% constancy (present in three of seven macroplots) in *Juoc/Artr/Agsp* and 57% constancy (present in four of seven macroplots) in *Juoc/Putr/Agsp* in my data, but my field notes reported *J. occidentalis* in the immediate area of all of the macroplots. (See Appendix F for constancy data.)

Combined Macroplots on "The Island"

When combining all of the macroplots on "The Island" into one unit and comparing the vegetation generally with Driscoll's (1964a) combined macroplot data, there appeared to be an increase over the 32 years in tree cover from 7% to 9.7%. (Table 4.) (*Juniperus occidentalis* is the only tree present.) Total shrub cover appeared to be higher, 14.3% compared to 9.5%. Grass cover appeared to be lower, 13.9% compared to 18.1%, and forbs, a very minor component, appeared to have decreased from 1.2% to 0.1%. Bare ground/rock cover stayed approximately the same, changing only from 30% to 31.2% and litter cover (including moss/lichen) changed from 46.5% to 56.2%. As previously mentioned, these differences were not tested for statistical significance because of the unavailability of raw data from Driscoll's (1962, 1964a) study.

Table 4. "The Island" Percent cover of combined macroplots

	1992-'93	1960-'61*
Total Tree	**9.7%**	**7.0%**
Total Shrub	**14.3%**	**9.5%**
Total Grass	13.9%	18.1%
Total Forb	0.1%	1.2%
Total Herbaceous	**14.0%**	**19.3%**
TOTAL VEGETATION	**38.0%**	**35.8%**
Bareground	24.4%	30.0%
Rock	6.7%	
Total Bareground	**31.2%**	**30.0%**
Litter	40.3%	46.5%
Moss/lichen	15.9%	
Total Litter	**56.2%**	**46.5%**

*1960's data from Driscoll (1964a)

Comparison Macroplots

Comparison macroplots were established on three sites, two on *Juoc/Artr/Agsp* sites and one on a *Juoc/Putr/Agsp* site, within 16 km of "The Island". These sites had presumably had some domestic livestock grazing impact but were selected because they still showed an abundance of native perennial grasses. Driscoll (1964a) also compared "The Island" with selected sites in the surrounding area, but because site selection would impact the results dramatically, I made no comparison with his results. Location comparisons were tested for statistical significance for the 1992-'93 data set. While few of the comparisons did prove to be significant ($p < 0.05$) the fact that there are fairly consistent similarities may be of greater interest than the differences. (Table 5)

Table 5. "The Island" and Comparison Sites

	Juoc/Putr/Agsp		*Juoc/Artr/Agsp*		*Juoc/Artr/Agsp*	
	IS Aver'92-'93	GRV Aver'93	IS Aver'92-'93	RBD Aver'93	IS Aver '92-'93	HB Aver'92
Juoc	9.4% a	16.9% b*	10.0% a	12.4% a	10.0% a	19.0% a
Artr	4.7% a	0.0% b	15.4% a	15.5% a	15.4% a	16.5% a
Putr	7.8% a	11.8% b				
Stth	2.8% a	6.4% a	2.9% a	2.8% a	2.9% a	0.0% b
Agsp	3.7% a	3.1% a	3.4% a	4.6% a	3.4% a	0.9% b
Feid	3.0% a	0.0% b	2.6% a	0.4% b	2.6% a	5.5% b
Posa	3.4% a	2.3% a	2.8% a	4.3% a	2.8% a	5.5% a
Brte	1.6% a	2.1% a	0.1% a	0.3% a	0.1% a	0.0% a
Feoc	0.8% a	0.8% a	0.4% a	0.5% a	0.4% a	0.1% a
Bareground	20.8% a	19.2% a	28.0% a	24.0% a	28.0% a	20.7% a
Rock	6.2% a	8.8% a	7.2% a	2.3% a	7.2% a	17.0% a
Litter	39.5% a	33.7% a	41.0% a	31.0% b	41.0% a	36.8% a
Moss/lichen	17.0% a	19.6% a	14.9% a	27.7% b	14.9% a	12.7% a

*Averages followed by different letters are significantly different ($p<0.05$)

GRV=Grandview Site RBD=Round Butte Dam Site HB=Haystack Butte Site

J. occidentalis cover was somewhat higher on two comparison sites than the 10% cover measured on "The Island," 19% on Haystack Butte, and 16.9% on the Grandview site. Only the Grandview site proved to be significantly different. Some areas on Haystack Butte had recently burned and thus had greatly reduced *J. occidentalis* cover, but the macroplots for this study were located in the non-burned areas. (Table 6)

Table 6. "The Island" and Comparison Sites Percent Cover - *Juniperus occidentalis*

	Juoc/Putr/Agsp		*Juoc/Artr/Agsp*		*Juoc/Artr/Agsp*	
	Island	GRV	Island	RBD	Island	HB
1951	5.1% a	19.0% a	8.0% a	11.0% a	8.0% a	17.5% b
1975	5.7% a	21.0% a	8.2% a	11.0% a	8.2% a	23.4% b
1995	9.4% a	16.9% b*	10.5% a	12.4% a	10.5% a	19.5% a

*Averages followed by different letters are significantly different ($p < 0.05$)

GRV=Grandview Site RBD=Round Butte Dam Site HB=Haystack Butte

Shrub cover in the *Juoc/Artr/Agsp* comparison macroplots, Round Butte Dam and Haystack Butte, was also slightly higher, 16.4 and 16.7% respectively, as compared to 15.4% in the *Juoc/Artr/Agsp* macroplots on "The Island". The *Juoc/Putr/Agsp* macroplots at the Grandview site were higher in *P. tridentata* cover, 11.8%, as compared to "The Island", 7.8%, but total shrub cover was lower because *A. tridentata* and other shrubs were not present at the Grandview site. Again, Grandview was the only site where shrubs showed a significant differences from "The Island." (Table 5) The *P. tridentata* plants were mature to old and widely spaced as they were on "The Island." Lack of propagules of the other species may be a contributing factor for the lack of *A. tridentata* at the Grandview site.

Grass cover on all comparison sites was generally within the range of that measured on "The Island", but the species mix varied. The *Juoc/Putr/Agsp* macroplots at Grandview most closely resembled "The Island" *Juoc/Putr/Agsp*-NE macroplots, except that Grandview had even more *S. thurberiana*, 6.4% as compared to "The Island's" 4.6%. *Sitanion hystrix,* though present at both locations, was higher at Grandview, 2.3% versus 0.2% on "The Island." *F. idahoensis,* 4.8% cover on "The Island" was absent at Grandview and was the only statistically significant difference. (Table 5)

The Round Butte Dam macroplots most closely resembled the *Juoc/Artr/Agsp* macroplots on "The Island" with *A. spicatum* having the highest cover (4.6% at Round Butte Dam and 3.4% on "The Island"). *S. thurberiana* cover was similar, 2.8% and 2.9% respectively for Round Butte and "The Island". *P. sandbergii* and *F. idahoensis* were present at both locations but cover varied as follows, *P. sandbergii* 4.3% at Round Butte and 2.8% on "The Island" and *F. idahoensis* 0.4% at Round Butte and 2.6% on "The Island". Higher amounts of *P. sandbergii* and lower *F. idahoensis* cover at Round Butte Dam site may reflect grazing impact. Again, only *F. idahoensis* proved to be statistically less. (Table 5)

The Haystack Butte macroplots were located in the area midway across the top of the butte where tree and shrub cover has not recently been impacted by fire. The burned areas just east of the macroplots on Haystack Butte appeared to contain a strong, robust presence of *A. spicatum*. These sites were unique with *F. idahoensis* and *P. sandbergii* being the major grass components along with a measurable presence of *Koeleria cristata*. *F. idahoensis* cover was significantly higher and *A. spicatum* cover was significantly lower than on "The Island." *S thurberiana* was not present in the Haystack Butte macroplots. (Table 5)

Ground cover on the Grandview *Juoc/Putr/Agsp* macroplots was similar to "The Island" *Juoc/Putr/Agsp* macroplots. Round Butte Dam and Haystack Butte macroplots compared closely with "The Island" *Juoc/Artr/Agsp* macroplots. Although the only significant differences were for litter and moss/lichen cover at the Round Butte Dam site, Haystack Butte macroplots with 17% rock cover appeared to have more than any other site. Haystack Butte macroplots showed low moss/lichen cover, 12.7%, but were sampled in 1992, and all sites sampled in that year showed less moss/lichen cover generally, 11.3% in 1992 as compared to 23.0% in 1993.

Comparing grass cover measured on all sites in 1992 versus that in 1993 produced small but interesting differences (see Appendix I.) *S. thurberiana* was the only perennial grass showing a noticeable difference in cover from 1992 to 1993, 1.4% to 4.5% respectively. Other perennial grasses showed remarkably similar cover from year to year. Annual species might be expected to show more variation, and *B. tectorum* did, 0.1% in 1992 and 1.6% in 1993, but the only other annual grass measured, *F. octoflora*, was consistent from year to year, 0.6% in 1992 and 0.5% in 1993.

DISCUSSION AND CONCLUSIONS

Successional change, recognizing it, defining it, predicting it, and using it as a vegetation management tool, is a highly debated topic in ecology and range management today, but it is a phenomenon worth considering especially when studying relatively pristine sites. With careful documentation of vegetation, climatic patterns, and disturbances within a given area, it may be possible to better understand the dynamics and patterns of succession, and near-pristine sites can serve as benchmarks by which to compare sites which have experienced more human-related impact. As succession drives a plant community toward a climax state, its vegetation composition may change, with early seral species phasing out and late seral species emerging or migrating in (Daubenmire 1968). Even if species composition remains relatively static, species dominance or the percent cover attributed to each of the species present may change (Hironaka 1978). Disturbances will produce a variety of effects on succession. When looking for these various cyclic and directional changes it is important to remember how very slowly successional changes become visible and thus measurable. This is especially true in relatively undisturbed, nearly pristine communities in an arid ecosystem (Pendleton 1989).

Vegetation change is complex and past studies which have measured certain plant associations in the Great Basin over time have reported varying results and conclusions. West et al (1984) found a decrease in grass cover in 13 years without livestock grazing on sites in west central Utah which had previously been grazed. Shrub measurements were not taken at the beginning of the study, but stands appeared vigorous and young sagebrush plants were present. The drawback of this study was its relatively short time period. West et al (1979) state that without periodic fire or a substitute, *Artemisia* sp. and *Juniperus occidentalis* may out-compete perennial grasses through more efficient use of water, nutrients, and space. The longevity of trees may also give *J. occidentalis* an advantage. Sneva et al (1984), reporting on grass and shrub frequency over 37 years in central Oregon, found an increase in grass cover and a decrease in shrub cover. But they also reported wetter decades during the study than just prior to it and a severe insect infestation in sagebrush approximately 10 years before the final measurements were taken. These two factors may have produced the opposite results to what might have been expected without them.

This vegetation study on "The Island" was undertaken primarily to compare the data gathered with those reported thirty years earlier by Driscoll (1964a). While few measured differences could be statistically tested because of lack of raw data from the Driscoll (1964a) study, the major differences noted include an increase in woody vegetation cover (tree and shrub) and a more even mix of grass species rather than the dominance of *Agropyron spicatum* and *Bromus tectorum* as noted by Driscoll (1964a).

No major climatic change nor major disturbance has taken place during the intervening years between the two studies. According to climatic data, the years just before and during Driscoll's study reported 193 mm, 183 mm, and 299 mm of precipitation when using an October to September year, whereas the years just before and during this study reported 209 mm, 230 mm, and 358 mm. I considered the annual patterns similar, with years lower than the long-term average of 260 mm up to and during the first summers of data collection (1959-'60 and 1991-'92) and years of higher than average up to and during the second summers (1960-'61 and 1992-'93). Seasonal patterns differed with more spring and summer precipitation during this study than during Driscoll's (1964a) study.

The intervening 30 years showed small clusters of drier than normal years from 1970 to 1974 and from 1988 to 1990 and wetter than normal years from 1961 to 1964 and from 1980 to 1984, but it was most common to find precipitation fluctuations in no particular pattern. (See Appendix J for climatic data.) Although precipitation records showed some differences, I did not find vegetation changes from one study to the next which I felt could be attributed directly to these climatic variations. I did find annual differences in my data sets between the summer of 1992 and the summer of 1993 which might be attributed to the increase in precipitation from 230 mm in 1991-'92 to 358 mm in 1992-'93. These differences will be discussed later in this chapter.

Small spot fires which have occurred on "The Island" during the thirty years between the two studies were not considered a major influence on the overall vegetation pattern because they were few in number, small in size and widely scattered. Driscoll (1964a) reported that charred stumps and other signs of fire were common, but it was my observation that while still present these signs are less widespread today. Aerial photographs from 1944 to the present show no major fire disturbance during these last 50 years. The lack of fire is the more probable influence on vegetation change based on the fact that this study found more woody vegetation cover and less grass and forb cover than the Driscoll (1964a) study.

One major event did take place, and that was the building of Round Butte Dam in 1964 and the filling of the reservoir, Lake Billy Chinook. The effect of this major change in the amount of water surface at the base of "The Island's" cliffs on its vegetation is unknown and probably subtle. It is possible that there has been a slight moderation in temperature maximums and minimums and a rise in humidity. Climatic data from the Metolius Station, nine km northeast of "The Island" show no such changes, although the station may be too far from the site to record subtle differences that might have occurred.

Driscoll (1964a) described two plant associations on "The Island," whereas my results appear to show three groupings. Possible descriptions might be a *Juoc/Artr/Agsp, Purshia tridentata* phase, or a transition of the *Juoc/Putr/Agsp* association to a *Juoc/Artr-Putr/Agsp* codominant association. Driscoll (1964a) explained the specificity of the presence of *Artemisia tridentata* and *P. tridentata* partially to different soil structure, texture and rooting depth. It is probable that the needs of *P. tridentata* for stony soils with discontinuous hardpan and cracked bedrock would confine it to certain areas. *A. tridentata*, on the other hand, has a stout taproot which can grow anywhere from one to four meters into the ground, plus it has wide spreading lateral roots and is generally very competitive (Mozingo 1987). Thus it appears to be able to adapt to a variety of soil profiles including those found on the *Juoc/Putr/Agsp* sites. I would suggest that the *Juoc/Putr/Agsp* association might, in the future, become one with *P. tridentata* and *A. tridentata* as codominants. My data tended to agree with the theory that without disturbance, especially without fire, a tree/shrub/grass plant community will move slowly toward a dominance of woody vegetation (Barbour et al 1980, West et al 1987). In analyzing the vegetation by canopy layer, generally I found more tree and shrub cover and less grass and forb cover than reported by Driscoll (1964a) for the years 1960-'61.

Lower total grass cover was recorded on "The Island," 13.9% in 1992-'93 as compared to 18.1% in 1960-'61 (Driscoll 1964a). There has also been a shift in grass species from a dominance of *A. spicatum* and *B. tectorum* to a codominant mix of the native perennials *A. spicatum*, *S. thurberiana*, *F. idahoensis*, and *P. sandbergii*. The codominants of the 1960-'61 study, *A. spicatum* and *B. tectorum*, both show considerably less percent cover. More shrub cover and less grass cover may be caused in part because *Artemisia tridentata* competes favorably with *Agropyron spicatum* and other grasses for soil moisture and nitrogen (Hyder & Sneva 1956) and for other nutrients (Doescher et al 1984). As the shrub cover increases, the nutrient pool increases around shrubs, probably reducing the nutrient pool in open spaces and thus decreasing grass cover (Miller et al 1986).

Why the mix of grass species has changed is not clear. Sampling variation may have impacted these results because my field notes at two macroplots show a greater presence of *A. spicatum* than the average reported. *B. tectorum* cover data may vary based on site selection also, as it can be found as a dominant in small and widely spaced patches. Native perennial bunchgrasses collectively show greater total cover from 10.5%

in 1960-'61 to 12.4% in 1992-'93, with annual grasses, primarily *B tectorum*, showing less coverage.

Agropyron spicatum showed the greatest reduction in coverbetween the two studies. Miller et al (1986) mention the sensitivity of *A. spicatum* with its erratic seed production, need for moisture in the late spring for primary shoot growth, low seedling vigor and continuing use of reserves for root growth when defoliated and the need of those reserves for shoot growth. Its ability to maintain vigor with the presence of large amounts of previous years' senescent or wolfy growth should be questioned also. It may need fire to maintain its vigor. It was my observation of side by side sites on Haystack Butte, the one recently burned appeared to have a much greater presence of *A spicatum.* than the one not recently impacted by fire.

Stipa thurberiana, which showed a higher percent cover in this study than in Driscoll's (1964a) study has low seed production, and also, along with *Sitanion hystrix* and *Poa sandbergii* is able to act as a vanguard in re-establishment on degraded sites before *A. spicatum,* thus implying greater adaptability (Miller et al 1986). *P.sandbergii* is often mentioned as being the last native perennial bunchgrass on degrading sites. Hopkins and Kovalchik (1983) classify it as an "increaser" along with the annuals, *B. tectorum* and *F. octoflora*, and classify all other native bunchgrasses as "decreases". Robertson (1972) reporting on a site ungrazed for 30 years, showed percent cover increase in the shrub, *A. tridentata*, but also an increase in *Stipa thurberiana*, *P. sandbergii,* and *Sitanion hystrix.* He mentioned that *A. spicatum* was reestablishing, but only in swales where conditions were just right and not on the study sites universally. *Sitanion hystrix* is considered a short-lived (10 years) perennial bunchgrass but a prolific seed producer with good seed dispersal mechanisms (Miller et al 1986), but generally it was a very minor component in the herbaceous cover in this study.

Bromus tectorum was of particular interest to Driscoll (1964a). He stated that its invasion was of general concern in the west as it was a strong competitor with native vegetation. He reported its cover as 1.7% in *Juoc/Artr/Agsp* macroplots and 12.4% in *Juoc/Putr/Agsp* macroplots and suggested that stands of this annual grass may persist 30-40 years. My data showed less percent cover, 0.1 and 1.6 respectively for the *Juoc/Artr/Agsp* and the *Juoc/Putr/Agsp* macroplots, greatly reduced especially in the *Juoc/Putr/Agsp* macroplots since Driscoll's (1964a) study. It's presence was most noticeable under some juniper trees and older shrubs, less so in open places. One might expect that as precipitation increased and decreased annually percent cover of this annual grass would increase and decrease accordingly. The years just before and during the 1960's study were drier than the years before and during the 1990's study so less precipitation does not appear to be the cause of its decrease in percent cover. Although *B. tectorum* was higher in cover during the summer of 1993, a wetter year than 1992, (Metolius Station reported 230 mm. in 1991-'92, 358 mm. in 1992-'93) it appeared generally to be a minor and diminishing component of the total vegetation composition. Stewart & Hull (1949) suggest that bunchgrasses can out compete *B. tectorum* in the long term if precipitation exceeds 230 mm per year.

Annual moisture differences on "The Island" may be reflected in the difference of the moss/lichen cover measured in 1992 as compared to 1993, 10.9% and 22.6% respectively. When all of the macroplots in this study, both on "The Island" and at the comparison sites, were averaged together percent cover for moss/lichen was 11.3 in the summer of 1992 and 23.0 in the summer of 1993. Annual differences may be somewhat confused with differences between *Juoc/Artr/Agsp* and *Juoc/Putr/Agsp* sites because the four NE *Juoc/Putr/Agsp* sites on "The Island" and the two Grandview *Juoc/Putr/Agsp* sites were all measured in 1993. *S. thurberiana* also showed a noticeable difference in percent cover from 1992 to 1993, 1.7 to 4.4 respectively on "The Island" and 1.4 to 4.5 respectively when all macroplots were averaged together. Other species appear to show remarkably similar measurements from year to year. (See Appendix I.)

"The Island" vegetation contains few alien, invasive species thus making it an ideal place to study native vegetation. Of great concern today is the fact that Medusahead grass (*Elymus caput-medusae*) is increasing in presence. It has been traveling up the trail with hikers and animals and has reached the staging area at the top of the trail. I also observed it just at "The Island's" edge in the NE *Juoc/Putr/Agsp* area and at the very northern tip, places where either wind or animals would more likely bring seeds than humans. According to personal correspondence in 1995 with Ron Halverson, B.L.M., Prineville, hikers have reported its presence all along the western portion of "The Island's" mesa top. According to Whitson et al (1991) it is extremely competitive, crowding out even such undesirable species as *B. tectorum* and prompt control of small isolated infestations is critical if the spread of the species is to be controlled. Young et al (1977) also mention the extremely competitive ability of *E. caput-medusae.* Another alien grass species, Red Brome (*Bromus rubens*) has also begun to appear.

The impact of native herbivores on vegetation is often unknown as was mentioned in West's (1984) report of a livestock grazing study and as was the case on "The Island." Driscoll (1964a) reports observing mule deer and cottontail rabbits and other small mammals. I observed deer, cottontail rabbits and one coyote. Some young *P. tridentata* and one form of *Chrysothamnus vicidiflorus* appeared to have been browsed. Personal correspondence with Driscoll in the fall of 1995 revealed he had visited "The Island" during the past summer for the first time in many years, and he noted considerably more browsing impact on *P. tridentata* than during his study in 1960-'61. Perennial bunchgrasses actually appeared senescent or wolfy rather than grazed, with new shoots emerging on the edge of or among large amounts of dried litter from the growth of past years. Driscoll (1964a) did report talking with a longtime resident of the area who said sheep had been taken up onto "The Island" for two summers in the 1920's, but that is the only known presence of domestic livestock.

Increased *J. occidentalis* cover appears to be the trend according to measurements taken from aerial photographs from 1944 to 1995. While percent cover increased with each measurement, only the 50 year difference comparing 1944 to 1995 proved statistically significant ($p < 0.05$), a reminder of the slowness of change in this ecosystem. Measuring exact cover is problematic due to the unevenness of the tree's distribution, site selection bias, and the lack of precision in the method of measurement used. The area could be more accurately measured using presently available technology rather than the manual method described by Moessner (1960), and used by Driscoll (1964a) and by myself. Driscoll (1964a) noted that trees were sparse and unevenly clustered throughout "The Island" in both of the plant associations he identified. He attributed the spottiness of *J. occidentalis* to past fires and stated that the species was not rapidly reestablishing in the burned areas. It is my observation that fires have been minimal in the thirty years since Driscoll's study, evidence of past burns is becoming less noticeable, and young *J. occidentalis* trees are rising above the shrub layer throughout "The Island."

Driscoll (1964a) noted several other vegetational features on "The Island." I found most of these features as he had described them. *Elymus cinereus*, occurred in several spots in the east-central area presumably where soils were especially sandy and deep. *Tetradymia canescens* was often nearby. The shrubs *Holodiscus dumosus*, *Ribes cereum* and most commonly, *Artemisia rigida*, are found along the rocky edges and in the scablands of the mesa top. Macroplots were not taken in these areas, but it was my observation that grass species were similar to other areas of "The Island" although the species dominance may have been different and percent cover appeared to be lower than in the measured plant associations. Several species of forbs were more commonly found along these rocky edges than in the *Juoc/Artr/Agsp* and *Juoc/Putr/Agsp* areas, such as *Allium douglasii*, *Balsamorhiza careyana*, and *Zigadenus paniculatus*. The small community of *Cercocarpus ledifolius* reported by Driscoll (1964a) to be along the western edge of "The Island" was still present.

Comparison sites did show more woody vegetation than "The Island," primarily *J. occidentalis*, but the only site which had significantly more tree cover ($p < 0.05$) was the Grandview site. It also showed significantly more *P. tridentata* cover, but no *A. tridentata* cover. The Round Butte Dam and Haystack Butte sites showed very similar percent cover of *A. tridentata* to that found on "The Island." While the comparison sites showed some significant differences in various species of grasses and one site showed differences in litter and moss/lichen cover, when comparing these sites with "The Island" generally, the more interesting results appeared to be the similarities.

On "The Island" and on all comparison sites shrub cover varied only from 12% to 17% and the grass cover also varied only from 12% to 17%. The higher shrub cover tended to be linked with the lower grass cover and visa versa, but there were no clear differences between "The Island" and other sites. The ground cover also appeared similar from site to site. Generally bare ground and rock cover was approximately 30% with litter and moss/lichen cover approximately 55% both on and off "The Island." It appears that whatever additional human and livestock impact these comparison sites have had, the vegetation differences between them and "The Island" are small.

Without major disturbance or dramatic climatic changes, I would expect the shrub and tree cover to slowly increase and the grass and forb cover to slowly decrease. If fires were allowed to burn or even purposefully introduced into the ecosystem this cycle would likely be set back to give grasses and forbs more of a presence. The present fire policy on "The Island" is a "let-burn" policy recently agreed upon by the joint managers of "The Island," the U.S. Forest Service, the Bureau of Land Management, and the Oregon State Parks within the last few years, according to personal correspondence in 1995 with Ron Halverson of the B.L.M. This policy may serve to reintroduce fire to "The Island" and provide interesting new vegetational dynamics to study. A natural state for this ecosystem would be the drive of succession interrupted by occasional natural fires along with insect and native herbivore influences, and the more subtle impacts of wet and dry periods. The major threats to the native vegetation on "The Island" at present and in the future may likely be increased human recreational use and exotic weed invasions.

The time comparisons in this study appeared to show a general movement toward more woody vegetation both on and off "The Island" and a different species mix of grasses on "The Island." No recent major fire impact on any of the areas studied may be the cause of these successional trends. The present-day location comparisons of "The Island" and near-by sites showed more similarities than differences. The lack of major fires appeared again to have a greater influence on the vegetation than any differences in human or livestock use. The most important aspect of this study may be to provide documentation with which to compare future studies. Thirty years is not a long period of time over which to study vegetation change in this arid ecosystem, but continuing periodic measurements of vegetation may eventually provide a clearer picture of the progress of succession and the impact of natural disturbances and various land uses.

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APPENDICES

Appendix A Plant List for "The Island"*

TREES and SHRUBS

ABBR.	SCIENTIFIC NAME	COMMON NAME	FAMILY
Juoc	*Juniperus occidentalis* Hook.	Western juniper	Cupressaceae
Artr	*Artemisia tridentata* Nutt.	Big sagebrush	Compositae
Arri	*Artemisia rigida* (Nutt.) Gray	Stiff sagebrush	Compositae
Cele	*Cercocarpus ledifolius* Nutt.	Curlleaf mt. mahogany	Rosaceae
Chna	*Chrysothamnus nauseosus*(Pall) Britt.	Gray rabbitbrush	Compositae
Chvi	*Chrysothamnus visidiflorus* (Hook.) Nutt.	Green rabbitbrush	Compositae
Hodu	*Holodiscus dumosus* (Hook.) Heller	Littleleaf oceanspray	Rosaceae
Putr	*Purshia tridentata* (Pursh) DC.	Bitterbrush	Rosaceae
Rice	*Ribes cerium* Dougl.	Wax current	Grossulariaceae
Teca	*Tetradymia canescens* DC.	Gray horsebrush	Compositae

GRASSES

Agsp	*Agropyron spicatum* (Pursh) Scribn. & Smith	Bluebunch wheatgrass	Gramineae
Brte	*Bromus tectorum* L.	Cheatgrass	Gramineae
Elca	*Elymus caput-medusae* L.	Medusahead wildrye	Gramineae
Elci	*Elymus cinereus* Scribn. & Merr.	Basin wildrye	Gramineae
Feid	*Festuca idahoensis* Elmer	Idaho fescue	Gramineae
Feoc	*Festuca octoflora* Walt. (*Vulpia*)	Slender fescue	Gramineae
Kocr	*Koeleria cristata* Pers.	Junegrass	Gramineae
Posa	*Poa sanbergii* Vasey	Sanberg's bluegrass	Gramineae
Poam	*Poa ampla* Merr.	Big bluegrass	Gramineae
Sihy	*Sitanion hystrix* (Nutt.) Smith	Bottlebrush squirreltail	Gramineae
Stth	*Stipa thurberiana* Piper	Thurber's needlegrass	Gramineae

FORBS

Acmi	*Achillea millefolium* L.	Western yarrow	Compositae
	Agoseris sp.	False dandelion	Compositae
Aldo	*Allium douglasii* Hook.	Douglas onion	Liliaceae
Amre	*Amsinckia retrorsa* Suksd.	Amsinckia	Boraginaceae
Arsp	*Arabis sparsiflora* Nutt.	Elegant rockcress	Cruciferae
Asfi	*Astragalus filipes* Torr.	Basalt astragalus	Leguminosae
	Astragalus sp.	Locoweed	Leguminosae

* Taxonomy follows: Hitchcock, C.L. & Cronquist, A. (1973) Flora of the Pacific Northwest. Seattle:Univ. of Washington Pr. 730 p.

ABBR.	SCIENTIFIC NAME	COMMON NAME	FAMILY
Basa	*Balsamorhiza careyana* Gray	Carey's balsam root	Compositae
Blsc	*Blepharipappus scaber* Hook.	Blepharippapus	Compositae
Cama	*Calochortus macrocarpus* Dougl.	Mariposa lily	Liliaceae
	Castilleja sp.	Indian paintbrush	Scrophulariaceae
Copa	*Collinsia parviflora* Lindl.	Blue-eyed Mary	Scrophulariaceae
Cogr	*Collomia grandiflora* Dougl.	Large-flowered collomia	Polemoniaceae
Croc	*Crepis occidentalis* Nutt.	Western hawksbeard	Compositae
Cram	*Cryptantha ambigua* (Gray) Greene	Obscure cryptantha	Boraginaceae
	Delphinium sp.	Larkspur	Ranunculaceae
Depi	*Descurainia pinnata* (Walt.) Britt.	Tansymustard	Cruciferae
Drve	*Draba verna* L.	Spring draba	Cruciferae
Epmi	*Epilobium minutum* Lindl.	Sm-flower willow-herb	Onagraceae
Erfi	*Erigeron filifolius* Nutt.	Threadleaf purple daisy	Compositae
Erli	*Erigeron linearis* (Hook.) Piper	Linear yellow daisy	Compositae
Ersp	*Eriogonum spharocelphalum* Dougl.	Rock eriogonum	Polygonaceae
Erst	*Eriogonum strictum* Benth.	Strict buckwheat	Polygonaceae
Erum	*Eriogonum umbellatum* Torr.	Surfurflower buckwheat	Polygonaceae
Ervi	*Eriogonum vimineum* Dougl.	Broom buckwheat	Polygonaceae
Erla	*Eriophyllum lanatum* (Pursh) Forbes	Oregon sunshine	Compositae
Erco	*Erodium cicutarium* (L.) L'Her.	Stork's-bill	Geraniaceae
Frpu	*Fritillaria pudica* (Pursh) Spreng.	Yellow fritillary	Liliaceae
Gisi	*Gilia sinuata* Dougl.	Shy gilia	Polemoniaceae
Houm	*Holosteum umbellatum* L.	Jagged chickweed	Caryophyllaceae
Lagl	*Layia glandulosa* (Hook.) H. & A.	Layia	Compositae
Libu	*Lithophragma bulbifera* Rydb.	Prairie star	Saxifragaceae
Loca	*Lomatium canbyi* Coult. & Rose	Canby's lomatium	Umbelliferae
Loco	*Lomatium cous* (Wats.) Coult. & Rose	Cous lomatium	Umbelliferae
Loma	*Lomatium macrocarpum* (Nutt.) Coult. & Rose	Bigseed lomatium	Umbelliferae
Lotr	*Lomatium triternatum* (Hook.) Coult. & Rose	Nineleaf lomatium	Umbelliferae
Mitr	*Microseris troximoides* Gray	False agoseris	Compositae
Migr	*Microsteris gracilis* (Hook.) Greene	Microsteris	Polemoniaceae
Mope	*Montia perfoliata* (Donn.) Howell	Miner's lettuce	Portulacaceae
Nade	*Nama densum* Lemmon	Matted nama	Hydrophyllaceae
	Penstemon sp.	Penstemon	Scrophulariaceae
Phli	*Phacelia linearis* (Pursh) Holz.	Threadleaf phacelia	Hydrophyllaceae
Phca	*Phlox caespitosa* Nutt. *(P.douglasii)*	Tufted phlox	Polemoniaceae
Phho	*Phlox hoodii* Rich.	Hood's phlox	Polemoniaceae
Plte	*Plagiobothrys tenellus* (Nutt.) Gray	Slender plagiobothrys	Boraginaceae
Plma	*Plectritis macrocera* T. & G.	Longhorn plectritis	Valerianaceae
Pomi	*Polemonium micranthum* Benth.	Annual polemonium	Polemoniaceae
Seca	*Senecio canus* Hook.	Wooly groundsel	Compositae
Trdu	*Tragopogon dubius* Scop.	Yellow salsify	Compositae
Zipa	*Zigadenus paniculatus* (Nutt.) Wats.	Death camus	Liliaceae

Appendix B Macroplot Locations

"The Island" *Juoc/Artr/Agsp*	Township/Range/Section	Latitude/Longitude
ISAt 92-2	T12S R12E S10	N44°32'52.6" W121°16'20.2"
ISAt 92-3	T12S R12E S10	N44°33'02.7" W121°16'22.3"
ISAt 92-4	T12S R12E S3	N44°33'10.8" W121°16'26.3"
ISAt 92-5	T12S R12E S10	N44°32'58" W121°16'22.8"
ISAt 93-5	T12S R12E S3	N44°33'13.7" W121°16'32"
ISAt 93-6	T12S R12E S3	N44°33'21" W121°16'29.2"
ISAt 92-7	T12S R12E S10	N44°32'53.7" W121°16'25.6"

"The Island" *Juoc/Putr/Agsp*	Township/Range/Section	Latitude/Longitude
ISPt 92-1 (S)	T12S R12E S10	N44°32'47" W121°16'25.3"
ISPt 92-6 (S)	T12S R12E S10	N44°32'51.5" W121°16'17.8"
ISPt 92-7 (S)	T12S R12E S3	N44°33'25.5" W121°16'35.7"
ISPt 93-1 (NE)	T12S R12E S3	N44°33'09.9" W121°16'18.3'
ISPt 93-2 (NE)	T12S R12E S3	N44°33'22.6" W121°16'23.6"
ISPt 93-3 (NE)	T12S R12E S3	N44°33'17.3" W121°16'13.6"
ISPt 93-4 (NE)	T12S R12E S3	N44°33'27.5" W121°16'25.5"

Comparison Sites	Township/Range/Section	Latitude/Longitude
GRPt 93-1 (Grandview)	T12S R11E S26	N44°29'45.7" W121°22'48.5"
GRPt 93-2 (Grandview)	T12S R11E S26	N44°29'43.2" W121°22'39.3"
RBAt 93-1 (Round Butte Dam)	T11S R12E S26	N44°35'20" W121°16'12"
RBAt 93-2 (Round Butte Dam)	T11S R12E S26	N44°35'32.8" W121°16'14.2"
HBAt 92-1 (Haystack Butte)	T13S R13E S3	N44°28'06.5" W121°09'23.3"
HBAt 92-2 (Haystack Butte)	T13S R13E S3	N44°28'07.5" W121°09'19.9"

Appendix C "The Island" *Juoc/Artr/Agsp* Macroplot Data

	ISAt92-2	ISAt92-3	ISAt92-4	ISAt92-5	ISAt93-5	ISAt93-6	ISAt92-7	**1992-'93**	**SE**	**1960-'61**	**SE**
Juoc								**10.5%**	**1.7**	**10.0%**	**2.0**
Artr	19.0%	14.7%	15.0%	20.7%	15.5%	23.1%	0.0%	**15.4%**	**2.8**	**8.5%**	**2.4**
Putr	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**			
Chna	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**		**1.1%**	
Chvi	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**			
Stth	3.7%	0.9%	3.4%	0.0%	4.5%	3.6%	4.4%	**2.9%**	**.7**	**2.0%**	
Agsp	3.1%	4.6%	1.9%	7.1%	2.0%	4.2%	1.1%	**3.4%**	**.8** *	**9.2%**	**.4**
Feid	2.9%	2.1%	2.4%	0.0%	6.2%	1.7%	3.2%	**2.6%**	**.7**	**0.4%**	
Kocr	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**		**0.0%**	
Posa	2.2%	4.1%	3.8%	3.1%	1.5%	2.9%	2.3%	**2.8%**	**.3** *	**1.3%**	**.3**
Sihy	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**.3**	**0.1%**	
Brte	0.1%	0.0%	0.0%	0.1%	0.1%	0.4%	0.1%	**0.1%**	**.1**	**1.7%**	
Feoc	0.7%	0.3%	0.4%	0.6%	0.0%	0.3%	0.4%	**0.4%**	**.1**	**0.6%**	
Acmi	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**.0**	**0.1%**	
Agoseris sp.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**		**0.1%**	
Astragalus sp	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.0%	**0.1%**	**.1**	**0.3%**	
Lotr	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**		**0.6%**	
Phdo	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**		**0.1%**	
Bareground	30.5%	26.8%	34.5%	32.4%	21.3%	22.0%	28.9%	**28.0%**	**1.9**	**41.3%**	
Rock	3.1%	4.4%	3.1%	6.1%	0.9%	28.9%	4.3%	**7.2%**	**3.7**		
Litter	45.7%	46.7%	37.5%	41.4%	39.6%	33.3%	43.1%	**41.0%**	**1.8**	**30.7%**	
Moss/lichen	7.9%	11.1%	13.2%	9.5%	23.4%	26.9%	12.2%	**14.9%**	**2.8**		

* difference between studies is significant at $p < 0.05$

Appendix D "The Island" *Juoc/Putr/Agsp* Macroplot Data

	ISPt92-1S	ISPt92-6S	ISPt92-8S	ISPt93-1NE	ISPt93-2NE	ISPt93-3NE	ISPt93-4NE	92-S	93-NE	1992-'93	SE	60-'61
Juoc								10.0%	8.7%	**9.4%**	**1.60**	**4.0%**
Artr	10.3%	6.6%	7.6%	0.0%	1.0%	7.3%	0.0%	8.2%	2.1%	**4.7%**	**1.60**	**0.0%**
Putr	3.9%	6.2%	5.8%	9.8%	13.2%	5.2%	10.9%	5.3%	9.8%	**7.8%**	**1.30**	**8.7%**
Chna	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	**0.1%**	**.10**	**0.6%**
Chvi	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.0%	0.5%	**0.3%**	**.30**	
Teca	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	0.0%	0.4%	**0.2%**	**.20**	
Stth	0.1%	0.0%	1.1%	4.6%	5.3%	2.8%	5.7%	0.4%	4.6%	**2.8%**	**.90**	**1.1%**
Agsp	3.4%	4.2%	8.2%	4.1%	1.2%	3.4%	1.5%	5.3%	2.5%	**3.7%**	**.90**	**6.2%**
Feid	0.0%	0.6%	1.1%	5.9%	1.3%	5.7%	6.4%	0.6%	4.8%	**3.0%**	**1.10**	**0.5%**
Kocr	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	**0.0%**	**.00**	**0.0%**
Posa	1.4%	4.8%	2.5%	2.3%	3.6%	4.5%	5.1%	2.9%	3.9%	**3.4%**	**.50**	**0.4%**
Sihy	0.0%	0.0%	0.0%	0.1%	0.4%	0.0%	0.1%	0.0%	0.2%	**0.1%**	**.10**	**0.0%**
Brte	0.3%	0.1%	0.4%	4.8%	2.8%	1.9%	1.0%	0.3%	2.6%	**1.6%**	**.60**	**12.4%**
Feoc	2.3%	0.7%	0.4%	0.2%	1.3%	0.6%	0.3%	1.1%	0.6%	**0.8%**	**.30**	**0.3%**
Acmi	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.1%	**0.0%**	**0**	**0.6%**
Astragalus sp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	**0.0%**	**0**	**0.1%**
Baca	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	**0.0%**	**0**	
Lotr	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**0**	**0.1%**
Phdo	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**0**	**0.1%**
Zypa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**0**	**0.1%**
Bareground	31.3%	23.5%	18.9%	21.1%	15.4%	17.2%	18.6%	24.5%	18.1%	**20.8%**	**2.00**	**18.7%**
Rock	12.8%	5.4%	8.8%	1.0%	7.0%	6.7%	1.9%	9.0%	4.1%	**6.2%**	**1.50**	
Litter	38.1%	46.7%	47.5%	37.0%	39.1%	32.1%	36.1%	44.1%	36.1%	**39.5%**	**2.10**	**62.3%**
Moss/lichen	8.1%	14.2%	11.0%	16.2%	22.0%	24.7%	22.7%	11.1%	21.4%	**17.0%**	**2.40**	

Appendix E Comparison Macroplot Data

	Grandview - *Juoc/Putr/Agsp*				Round Butte Dam - *Juoc/Artr/Agsp*				Haystack Butte - *Juoc/Artr/Agsp*			
	GRPt93-1	GRPt93-2	**Aver'93**	**SE**	RBFI93-1	RBFI93-2	**Aver'93**	**SE**	HBAt92-1	HBAt92-2	**Aver'92**	**SE**
Juoc	16.2%	17.6%	**16.9%**	.8	14.3%	10.5%	**12.4%**	1.8	17.9%	20.0%	**19.0%**	1.1
Artr	0.0%	0.0%	**0.0%**		13.5%	17.4%	**15.5%**	2.0	14.8%	18.2%	**16.5%**	1.7
Putr	11.9%	11.7%	**11.8%**	.1	0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**	
Chna	0.0%	0.0%	**0.0%**		1.0%	0.0%	**0.5%**	.5	0.0%	0.0%	**0.0%**	
Chvi	0.0%	0.0%	**0.0%**		0.0%	0.9%	**0.4%**	.4	0.4%	0.0%	**0.2%**	.2
Teca	0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**	
Stth	4.0%	8.7%	**6.4%**	2.3	1.7%	3.9%	**2.8%**	1.1	0.0%	0.0%	**0.0%**	
Agsp	3.4%	2.8%	**3.1%**	.3	5.0%	4.1%	**4.6%**	.4	0.9%	0.9%	**0.9%**	.0
Feid	0.0%	0.0%	**0.0%**		0.8%	0.0%	**0.4%**	.4	5.1%	5.9%	**5.5%**	.4
Kocr	0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**		0.0%	0.8%	**0.4%**	.4
Posa	3.0%	1.6%	**2.3%**	.7	3.6%	5.0%	**4.3%**	.7	7.0%	4.1%	**5.5%**	1.4
Sihy	2.0%	2.6%	**2.3%**	.3	0.4%	0.0%	**0.2%**	.2	0.0%	0.0%	**0.0%**	
Brte	0.6%	3.6%	**2.1%**	1.5	0.2%	0.5%	**0.3%**	.6	0.0%	0.0%	**0.0%**	.0
Feoc	0.4%	1.3%	**0.8%**	.4	0.5%	0.4%	**0.5%**	.0	0.0%	0.2%	**0.1%**	.1
Acmi	0.2%	0.0%	**0.1%**	.1	0.3%	0.1%	**0.2%**	.1	0.0%	0.0%	**0.0%**	
Astragalus sp	0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**		0.0%	0.1%	**0.1%**	.1
Erli	0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**		0.4%	0.0%	**0.2%**	.2
Ersi	0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**	
Phdo	0.0%	0.0%	**0.0%**		0.0%	0.0%	**0.0%**		0.4%	0.4%	**0.4%**	.0
Bareground	23.5%	14.9%	**19.2%**	4.3	20.9%	27.0%	**24.0%**	3.1	18.9%	22.4%	**20.7%**	1.8
Rock	8.0%	9.7%	**8.8%**	.8	2.9%	1.6%	**2.3%**	.6	20.3%	13.7%	**17.0%**	3.3
Litter	31.6%	35.8%	**33.7%**	2.1	32.0%	30.0%	**31.0%**	1.0	36.8%	36.7%	**36.8%**	.1
Moss/lichen	22.0%	17.3%	**19.6%**	2.4	29.8%	25.6%	**27.7%**	2.1	10.0%	15.3%	**12.7%**	2.7

Appendix F Constancy Data (presence/absence per macroplot)

	"The Island"				Comparison Sites		
	Juoc/Artr/Agsp		*Juoc/Putr/Agsp*		Grandview	Round Butte	Haystack
	'92-'93	'60-'61	'92-'93	'60-'61	'93	'93	'92
Trees/Shrubs							
Juoc	43%	100%	57%	100%	100%	100%	100%
Artr	100%	100%	100%	0	0	100%	100%
Putr	0	0	100%	100%	100%	0	0
Chna	14%	100%	71%	40%	0	50%	0
Chvi	28%	0	57%	0	100%	100%	100%
Teca	14%	0	28%	0	0	50%	100%
Grasses-Perennial							
Stth	85%	80%	100%	100%	100%	100%	0
Agsp	100%	100%	100%	100%	100%	100%	100%
Feid	85%	60%	85%	60%	0	50%	100%
Kocr	0	0	28%	0	0	0	50%
Posa	100%	100%	100%	80%	100%	100%	100%
Sihy	14%	40%	43%	20%	100%	50%	0
Grasses-Annual							
Brte	85%	100%	100%	100%	100%	100%	0
Feoc	100%	100%	100%	80%	100%	100%	100%
Forbs-Perennial							
Acmi	57%	100%	71%	100%	100%	100%	100%
Agoseris sp	0	60%	0	0	0	0	0
Allium sp	0	0%	14%	0	0	50%	0
Astragalus sp	57%	100%	14%	20%	50%	100%	100%
Baca	0	0	28%	0	0	0	50%
Cama	28%	0	57%	0	50%	50%	0
Croc	14%	0	14%	0	0	0	0
Erigfi	14%	0	14%	0	50%	100%	50%
Erigli	0	20%	14%	0	0	50%	100%
Eriogonum sp	14%	20%	0	0	0	100%	0
Eriopla	28%	0	0	0	0	50%	50%
Lomatium sp	100%	100%	85%	40%	50%	100%	100%
Phdo	0	20%	14%	20%	0	50%	100%
Seca	0	0	14%	0	0	0	0
Zypa	0	20%	28%	20%	50%	0	0

Appendix G Tree and Shrub Data by Site

	"The Island"			"The Island"			Comparison Sites		
	Juoc/Artr/Agsp		*Juoc/Putr/Agsp*				*Juoc/Putr/*	*Juoc/Artr/Agsp*	
	'92-'93	'60-'61	'92-'93 S	'92-'93NE	'92-'93	'60-'61	GrView'93	RBDam'93	Haystack'92
Juoc cover	10.0%	10.0%	10.0%	8.7%	9.4%	4.0%	16.9%	12.4%	19.0%
den/ha	0.4		0.38	0.36	0.37				
Artr cover	15.0%	8.5%	8.2%	2.1%	5.2%	0.0%	0.0%	15.0%	16.5%
den/ha	466	526	431	66	248.5		0	547	831
ht. in cm	77	59	61	97	79		0	72	46
Putr cover	0.0%	0.0%	5.3%	9.8%	7.6%	8.7%	11.8%	0.0%	0.0%
den/ha	0		109	202	155.5	142	317	0	0
ht. in cm	0		89	98	93.5	4.57	98	0	0
Chna cover	0.0%	1.1%	0.0%	0.3%	0.2%	0.6%	0.0%	0.5%	0.0%
den/ha	3.6	81	7.3	38	22.65	20	197	65.6	0
ht. in cm	32	62	60	50	55	76	21	40	0
Chvi cover	0.0%	0.0%	0.0%	0.5%	0.3%	0.0%	0.0%	0.4%	0.2%
den/ha	3.6		22	33	27.5		0	219	328
ht. in cm	22		21	60	40.5		0	22	21
Teca cover	0.0%	0.0%	0.0%	0.5%	0.3%	0.0%	0.0%	0.0%	0.0%
den/ha	0		0	22	11		0	0	33
ht. in cm	0		0	63	31.5		0	0	38

Appendix H *Juniperus occidentalis* Cover by Site (from aerial photographs)

"THE ISLAND" SITES

Juoc	ISAt-S1	ISAt-C2	ISAt-N3		Average *Juoc/Artr/Agsp*	SE
1944	6.0%	6.6%	4.0%		5.5%	.53
1951	6.1%	12.4%	5.6%		8.0%	1.55
1975	5.4%	12.8%	6.3%		8.2%	1.64
1985	9.4%	13.8%	7.2%		10.1%	1.37
1995	10.4%	14.6%	6.4%		10.5%	1.67

Juoc	ISPu-SW1	ISPur-SE2	All Putr-S	SE
1944	5.0%	4.3%	4.7%	.35
1951	7.1%	4.3%	5.7%	1.42
1975	5.7%	6.4%	6.1%	.35
1985	10.0%	7.8%	8.9%	1.10
1995	10.0%	10.0%	10.0%	.00

Juoc	ISPt-NE3	ISPt-NE4	All Putr-NE	SE	Average *Juoc/Putr/Agsp*	SE
1944	2.7%	6.0%	4.4%	.17	4.6%	.70
1951	5.0%	3.9%	4.4%	.58	5.1%	.70
1975	3.9%	6.5%	5.2%	.13	5.7%	.60
1985	4.4%	10.5%	7.5%	.31	8.2%	1.50
1995	5.0%	12.4%	8.7%	3.70	9.4%	1.60

COMPARISON SITES

	Grandview			
Juoc	Site 1	Site 2	Aver. Grv	SE
1951	20.8%	18.1%	19.5%	1.35
1975	19.0%	23.0%	21.0%	2.00
1995	16.2%	17.7%	17.0%	.75

	Round Butte Dam			
Juoc	Site 1	Site 2	Aver. RB	SE
1951	12.0%	10.0%	11.0%	1.00
1975	10.8%	11.3%	11.0%	.23
1995	14.3%	10.5%	12.4%	1.80

	Haystack Butte			
Juoc	Site 1	Site 2	Aver. HB	SE
1951	16.8%	18.1%	17.5%	.65
1975	25.0%	22.1%	23.6%	1.45
1995	17.9%	20.0%	19.0%	1.05

Appendix I "The Island" Combined Macroplots Data

	1992-'93	1960-'61		1992-'93	1960-'61
Juoc	9.7%	7.0%			
			Total Tree	9.7%	7.0%
Artr	10.0%	4.3%			
Putr	3.9%	4.4%			
Chna	0.1%	0.6%			
Chvi	0.2%	0.3%			
Teca	0.1%	0.0%			
			Total Shrub	14.3%	9.5%
Stth	2.9%	1.6%			
Agsp	3.6%	7.7%			
Feid	2.8%	0.5%			
Kocr	0.0%	0.0%			
Posa	3.1%	0.9%			
Sihy	0.0%	0.1%			
Brte	0.9%	7.1%			
Feoc	0.6%	0.5%			
			Total Grass	13.9%	18.1%
Acmi	0.0%	0.4%			
Agoseris sp.	0.0%	0.1%			
Astragalus sp.	0.1%	0.2%			
Baca	0.0%	0.1%			
Lotr	0.0%	0.4%			
Phdo	0.0%	0.1%			
Zypa	0.0%	0.1%			
			Total Forb	0.1%	1.2%
Bareground	24.4%	30.0%			
Rock	6.7%				
			Total Ground	31.2%	30.0%
Litter	40.3%	46.5%			
Moss/lichen	15.9%				
			Total Litter	56.2%	46.5%

Appendix J METOLIUS STATION Precipitation in Millimeters

Station	METOLIUS			Units in mm																
Year	1951	1952	51-52	1953	52-53	1954	53-54	1955	54-55	1956	55-56	1957	56-57	1958	57-58	1959	58-59	1960	59-60	1961
Jan	34	17		57		53		8		74		23		33		45		42		16
Feb	36	35		36		6		8		38		27		45		30		21		69
Mar	5	4		13		13		8		9		56		9		18		53		40
Recharge			161		169		173		48		282	0	159		180		142		141	
Apr	3	3		21		10		25		0		23		10		1		7		13
May	39	23		38		21		11		64		75		49		21		22		28
Jne	5	74		40		40		15		41		14		44		10		0		20
Spring			100		99		71		51		104	0	111		103		32		29	
Jly	8	0		0		0		7		15		17		7		0		5		2
Aug	1	10		46		19		0		10		5		1		0		4		6
Sep	3	16		1		18		23		4		27		7		19		3		2
Summer			26		46		36		29		29	0	50		15		19		13	
Oct	20	0		13		11		15		37		27		1		11		10		10
Nov	45	3		51		9		45		4		8		29		8		64		74
Dec	40	59		37		4		101		12		58		19		6		30		37
T-Annual	239	243		354		203		266		307		360		253		170		261		317
Oct/Sep			287		314		280		129		416		320		297		193		183	

60-61	1962	61-62	1963	62-63	1964	63-64	1965	64-65	1966	65-66	1967	66-67	1968	67-68	1969	68-69	1970	60-70	1971	70-71
	11		34		38		42		42		39		23		35		70		44	
	36		14		3		0		11		3		34		8		10		1	
	25		22		6		4		10		15		0		15		11		26	
228		193		200		146		242		131		185		92		150		164	0	135
	9		48		2		29		3		45		8		4		1		7	
	56		22		1		4		4		5		31		36		2		46	
	7		18		31		51		8		21		5		90		17		6	
61		72		88		34		84		16		71		45		130		20	0	60
	0		4		1		16		44		0		6		0*		0		1	
	24		5		3		30		0		1		38		0*		0		7	
	8		21		2		3		21		1		10		14		3		21	
10		31		30		7		49		66		2		54		14		3	0	28
	57		11		11		7		9		15		15*		21		13		14	
	31		54		39		62		74		14		32		6		43		28	
	42		34		147		0		45		6		45		45		6		12	
	306		287		284		247		271		165		247		275		177		215	
299		297		318		187		375		212		258		191		294		186		223

* missing values estimated from near-by station data

Appendix J METOLIUS STATION Precipitation in Millimeters (continued)

Station METOLIUS Units in mm																					
1972	71-72	1973	72-73	1974	73-74	1975	74-75	1976	75-76	1977	76-77	1978	77-78	1979	78-79	1980	79-80	1981	80-81	1982	81-82
25		19		27		35		17		7		64		50		61		35		18	
4		12		13		48		27		9		16		14		27		29		32	
31		7*		41		42		16		2		18		36		10		27		3	
	115		98		235		165		128		39		214		131		196		189		252
7		8		27		10		39		1		53		16		27		9		19	
21		12		3		6		10		31		15		4		34		33		6	
17		0		0		25		4		4		50		3		39		19		32	
	45		20		29		41		53		36		117		23		99		61		57
0		3		8		12		10		1		14		0		3		12		17	
15		3		0		48		74		14		28		45		0		0		19	
6		37		0		0		7		20		8		7		18		33		43	
	21		42		8		60		91		35		50		52		21		45		78
12		23		10		24		6		13		0		42		19		14		49	
13		91		8		13		14		48		23		45		32		71		9	
35		39		21		30		1		55		8*		10		46		114		34	
185		254		159		294		226		204		297		273		316		397		281	
	181		160		273		266		272		110		381		206		315		295		388
1983	82-83	1984	83-84	1985	84-85	1986	85-86	1987	86-87	1988	87-88	1989	88-89	1990	89-90	1991	90-91	1992	91-92	1993	92-93
38		8		3		50		33		37		30		58		9		8		37	
62		40		11		76		33		4		11		1		7		23		21	
57		41		9		15		23		15		55		18		34		10		41	
	248		240		194		220		150		145		183		95		77		121		212
26		24		5		3		8		25		36		11		8		44		26	
27		11		24		12		16		4		24		45		37		12		54	
17		30		7		3		8		30		6		8		49		19		32	
	70		66		35		17		32		59		66		64		95		74		112
23		1		3		15		67		0		7		13		7		21		15	
26		3		1		1		5		0		20		25		31		9		19	
7		4		14		36		2		5		3		1		0		6		0	
	56		8		19		52		74		5		30		40		37		35		35
24		32		14		16		0		0		6		13		14		46		5	
54		126		26		33		15		81		6		6		49		21		9	
74		13		39		13		74		7		7		9		18		46		13*	
433		334		156		272		283		208		210		208		262		263		272	
	374		313		248		290		256		209		279		199		209		231		358

* missing values estimated from near-by station data