Composition, Structure, and Distribution of Utah Juniper Plant Associations - Snake River Resource Area, Idaho

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Introduction

Pinyon-juniper woodland occurs at the northern extent of its range on the Snake River Plain (*sensu* Cronquist et al. 1972) in Idaho. Principle descriptive work on plant communities dominated by Utah juniper (*Juniperus osteosperma*), Rocky Mountain juniper (*Juniperus scopulorum*), and singleleaf pinyon pine (*Pinus monophylla*) has occurred in the Southern Rocky Mountains and Great Basin (e.g., Blackburn et al. 1969, Baker 1984, and others). Assessment of conservation status, development of effective habitat conservation and management strategies, and basic inventory of Utah juniper-dominated communities in the Snake River Plain region has been difficult due to a lack of basic ecological descriptive work.

Initial descriptive work on juniper woodland stands within and adjacent to natural areas and at selected representative sites on Snake River Resource Area was completed during the 1996 field season and is summarized in my report entitled, *Pinyon-juniper Woodland Classification and Description in Research Natural Areas of Southeastern Idaho* (Rust 1997).

The purpose of this study is to assist with the description of composition, structure, and ecological processing of juniper woodland communities on Snake River Resource Area lands and to assist in the development of strategies for their conservation and management. The objectives are to (1) develop landscape models of the natural/historic distribution and structure of juniper woodlands, (2) develop an understanding of the ecological processes which affect the distribution and structure of juniper woodlands, and (2) enhance the applicability of classification and description work completed in 1996 by sampling a broader range of juniper woodlands on the Snake River Resource Area.

Methods

The study area encompasses all of the public lands within the Snake River Resource Area (Map 1). I sampled juniper woodlands within representative watersheds selected on the basis of an environmental stratification of the study area. The study area was stratified on the basis of five 1000 foot elevation classes and 14 lithology classes. Each occupied cell of this stratification[1] was ranked according to its relative abundance. This initial prioritization of potential study sites was subsequently filtered on the basis of the potential for the actual occurrence of juniper woodland. (For example, based on prior knowledge of the study area, juniper woodlands do not occur in the 8001 - 9000 foot elevation class). I did not sample juniper woodland stands on mafic lava flows due to their lower priority relative to the study objectives. To the extent possible, stands present within each sampling site were delineated based on environmental features (topography and elevation) and apparent structure and composition (as viewed from the distance). Field sampling occurred within these reference stands. Ecological data was taken to capture the range of conditions in stand structure and composition.

To increase sampling efficiency, I used both stand-level point observation and standard ecology plot methods (Bourgeron et al. 1991; USDA Forest Service 1992). I used standard ecology plot methods to acquire detailed information on stand structure and composition. Basic environmental parameters (slope aspect, gradient and horizon; elevation; micro and macro topography; etc), plant cover, and the density and size distribution of live and standing dead trees were determined on a standard (fixed) one-tenth acre circular ecology plots. Plant cover data were taken by ocular estimate for all vascular plant species. Ocular estimates of the cover of tree species were differentiated by strata (height/diameter class). Live and standing dead tree stems present within the fixed area plot were tallied by species and size class (using the diameter at root crown). On relatively few ecology plots stem age data were collected from stem cross-sections or wedges. Soils and geology were documented from maps and, where necessary, verified and qualitatively described in the field.

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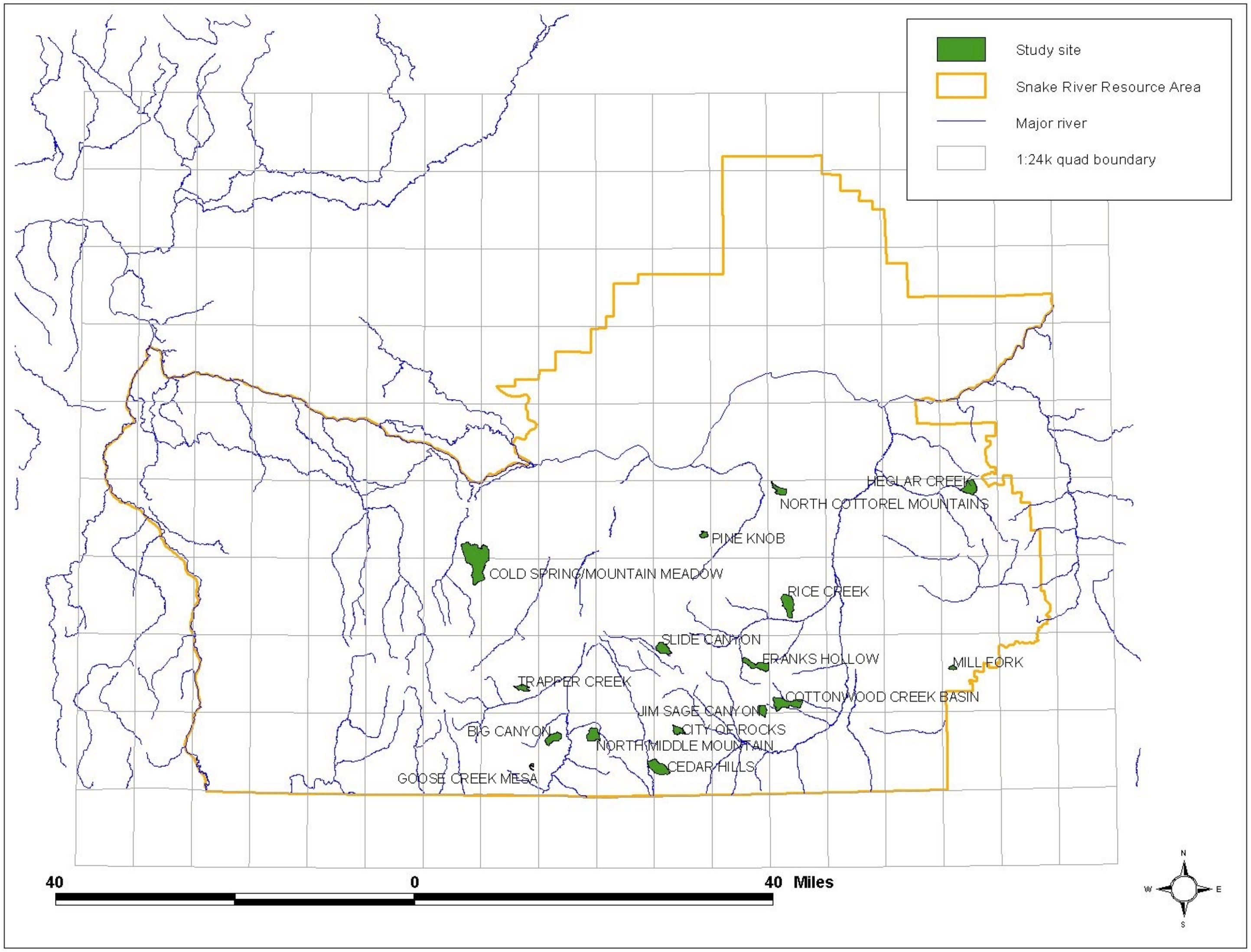
[1] The actual number of combinations of lithology and elevation (32) is less than the total number of potential cells (5 x 14 = 70) due to the correlation between geological stratification and elevation (i.e., some lithology classes only occur within one elevation class).



Map 1. Snake River Resource Area pinyon-juniper woodland study sites. USGS 1:24K topographical quadrangle perimeters and major rivers are shown to provide a geographical reference system.

In stand-level sampling, data on basic environmental data were collected (as described above) for the entire stand. The plant association was identified and stands were classified according to structure and ecological condition (see Rust and Moseley 1999 for a detailed description). Sample data cards and associated data dictionaries for plot and stand-level sampling methods are available upon request. All sample locations were geo-referenced using a navigation grade global positioning system unit and 1:24,000 USGS topographical maps.

I used multivariate classification and ordination analytical techniques in the description of plant communities and assessment of environmental factors. TWINSPAN (Hill 1979b) and DECORANA (Hill 1979a) were used interactively to derive an initial classification of the plot data through progressive decomposition of the plot data to smaller, more similar groups. This classification was refined and environmental correlations were developed through the use of CANOCO (ter Braak 1991), again using an approach of progressive decomposition. Data analysis was aided through the use of ECOAID (Smith 1993), a data manipulation and summary package.

Synecological Perspective and Nomenclature

Plant communities may be characterized as recurrent assemblages of species coexisting in similar landscape features (Bourgeron and Engelking 1994). A plant community classification may be likened to a language developed to meet the need of a set of commonly held objectives (Sawyer and Keeler-Wolf 1995). Plant community classifications pertinent to the study area are predominantly based on potential natural vegetation. Classification work in the Rocky Mountains (Cooper et al. 1991; Daubenmire and Daubenmire 1968; Mauk and Henderson 1984; Pfister et al. 1977; Steele et al. 1981, 1983) and the Intermountain Region (Daubenmire 1970; Hironaka et al. 1983; Tisdale 1986) is strongly influenced by the work of Daubenmire (1952, 1968), Wellner (1989), and Alexander (1985, 1988). In this work the "habitat type" is recognized as the basic classification unit and is defined as all the land areas that support, or have the potential to support, the same climax vegetation. The habitat type is named for the climax vegetation, or "plant association".

The concept of the habitat type as a land classification can be misleading because the classification unit, all areas of land which support a specific plant association, is actually derived through the analysis of floristic similarity (Hall 1988). In forested regions of Oregon and Washington the "plant association" is thought to be the most appropriate classification unit because it pertains to the classification of plant communities, rather than areas of land (for example, Johnson and Simon 1987; Williams and Smith 1991). The term "plant association" (or "association") refers to potential natural vegetation. With reference to much of the community classification work of Idaho, "plant association" refers to the vegetative expression of the habitat type.

In both of these approaches the potential natural vegetation classification unit - habitat type or plant association - encompasses all potential seral stages and structural conditions of a given site. In this report I use the term "plant association" to refer to plant communities that are classified on the basis of their potential natural vegetation and the associated environmental relations. I will use the term "plant community type" to refer to vegetation for which the seral status is unknown.

Results

A combined total of 240 point observations and ecology plots were generated from work during the 1997 and 1998 field seasons within seven representative watersheds. These data are combined with data from the 1996 field season to yield a data set of 363 observations for 16 sites within, or immediately adjacent, Snake River Resource Area[2] (Map 1).

Excluding the large areas of mafic lava flow, 24 plant associations and one community type were observed on the Resource Area (Table 1). The majority of these associations were observed during the 1996 field season and are described in my report, *Pinyon-juniper Woodland Classification and Description in Research Natural Areas of Southeastern Idaho* (and see Rust 1999). I will not repeat here the lengthy tables and descriptive information provided in that earlier report. Four new plant associations observed on the Resource Area are:

- *Pinus monophylla-Juniperus osteosperma/Artemisia tridentata vaseyana/Festuca idahoensis*
- *Juniperus scopulorum/Symphoricarpos oreophilus/Festuca idahoensis*
- *Juniperus osteosperma/Artemisia tridentata wyomingensis/Agropyron spicatum*
- *Juniperus osteosperma/Artemisia tridentata wyomingensis/Festuca idahoensis*.

One community type was identified within the study area:

- *Juniperus osteosperma/Artemisia nova/Stipa thurberiana*.

The composition, structure, and environmental relations of these new communities are reported in Appendix C.

Four plant associations are most abundant and well distributed within the Resource Area. These are: JUOS/ARAR/AGSP, JUOS/ARAR/FEID, JUOS/ARNO/AGSP, and JUOS/ARTRV/AGSP (plant association codes are listed in Table 1). These associations account for over 50 percent of juniper woodland observations within the study area (Table 1).

Basic environmental data for the juniper woodland plant associations observed in the study area are summarized in Table 2.

Age data were collected on six tenth acre ecology plots. These data are summarized in Figures 1 and 2.

Discussion

A primary focus of this study is to develop landscape models concerning the natural/historic distribution of juniper woodlands on the Snake River Resource Area. A number of authors describe the distribution and ecology of juniper woodlands within the Great Basin region. The natural, pre-settlement distribution of juniper woodlands is generally described as being mid-slope positions associated with rocky substrates at (approximately) 5250 to 8525 feet elevation (Wight and Fisser 1968; Cronquist et al. 1972; Tueller et al. 1979; Peet 1988; West 1988; West et al. 1998; Harper and Davis 1999; Rust 1999; West 1999). Basic environmental parameters (slope, aspect, and elevation) of juniper woodland plant associations observed on Snake River Resource Area are summarized in Table 2.

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[2] As noted in the methods section, data from Big Juniper Kipuka and Sand Kipuka, which occur on the mafic volcanics of the Wapi Flow are not considered here. Trapper Creek, Slide Canyon, and City of Rocks are sites included in the study but not managed by the Bureau.

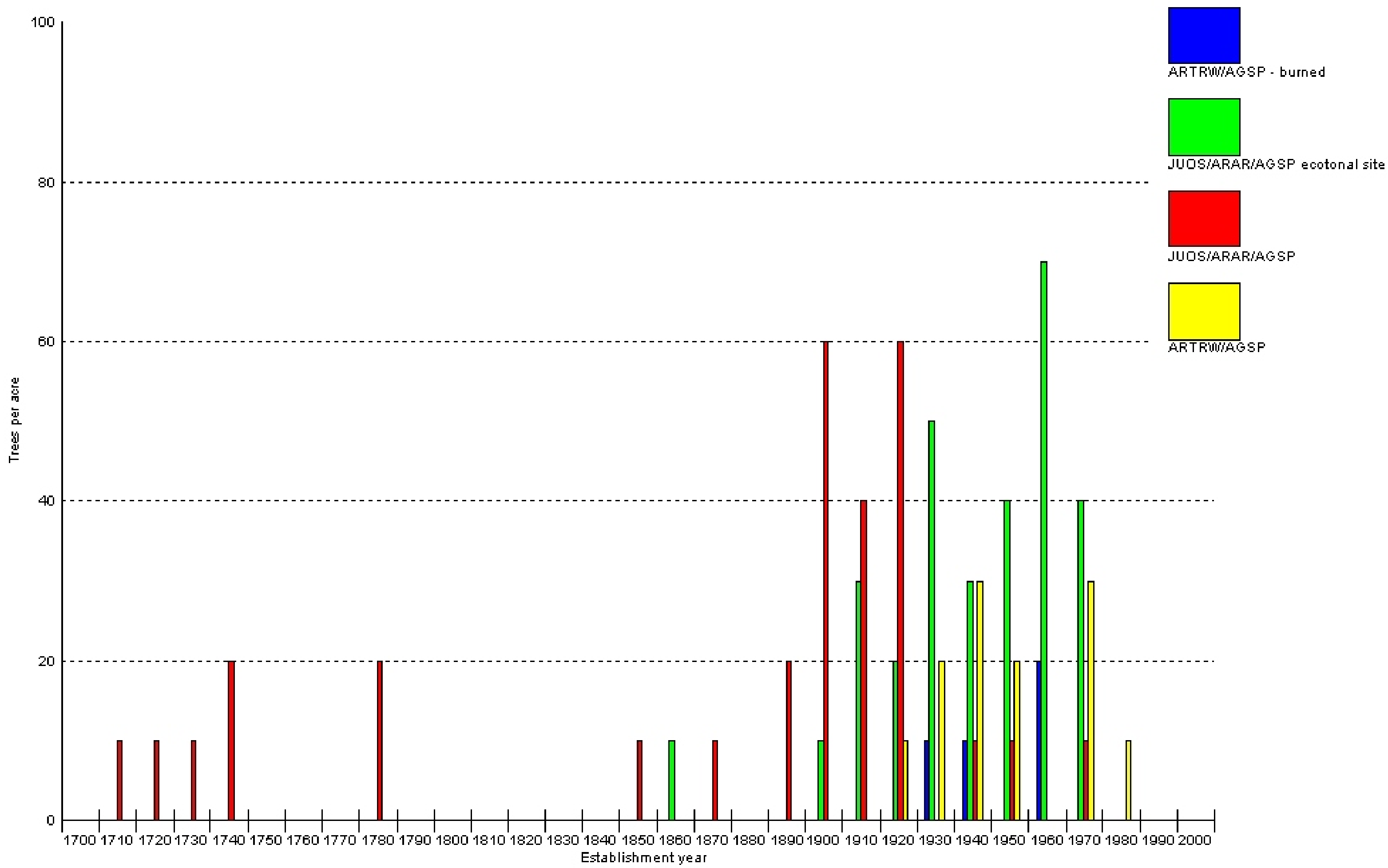


Figure 1. Establishment of *Juniperus osteosperma* within contrasting stands at the North Cotterel Mountains study site. The number of trees per acre becoming established within ten year intervals is shown for two JUOS/ARAR/AGSP stands (one mid-seral, medium-tree dominated [ecotonal site, the other late-seral, large-tree dominated) and two adjacent ARTRW/AGSP (one burned recently, the other un-burned).

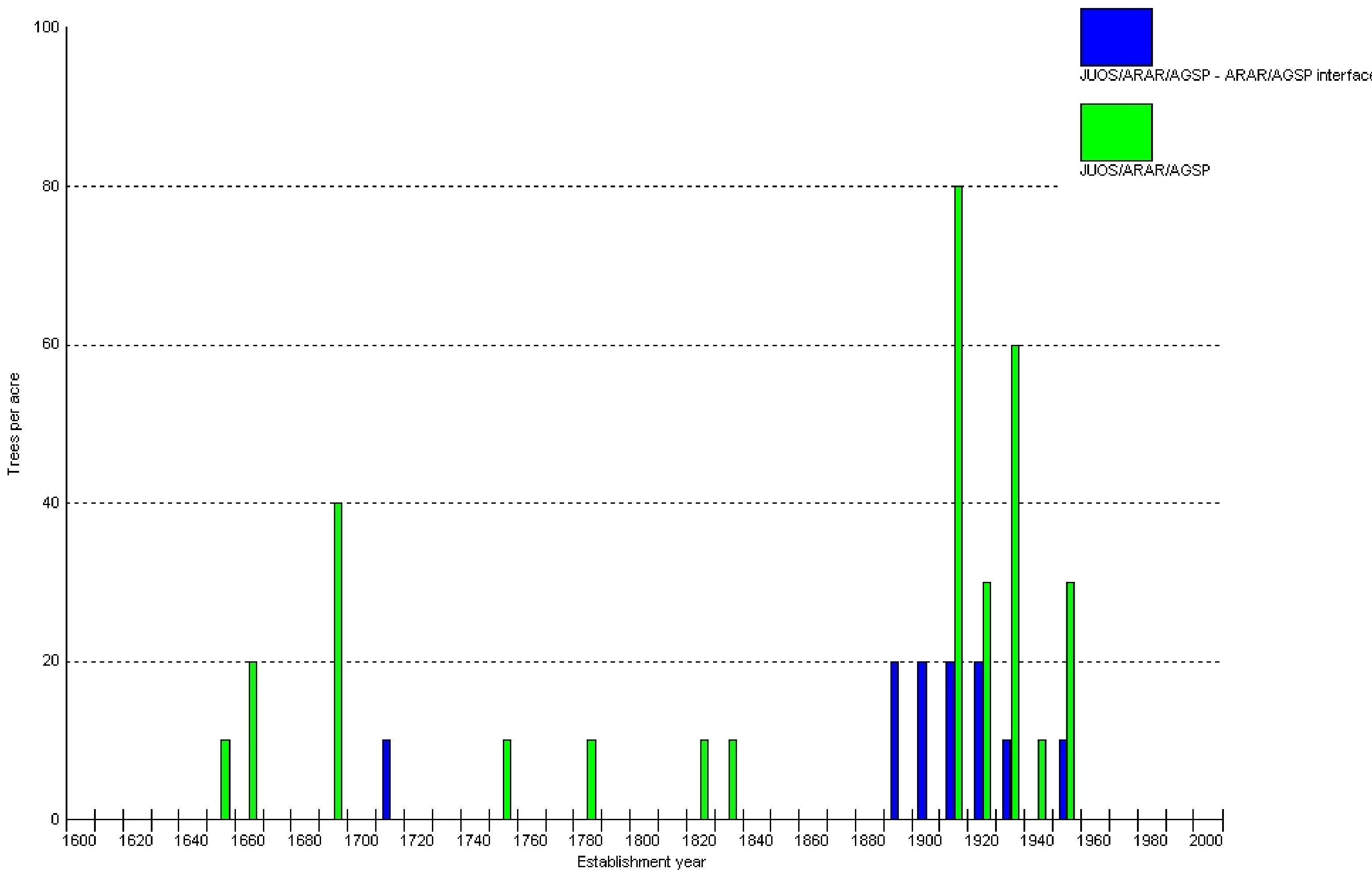


Figure 2. Establishment of *Juniperus osteosperma* within contrasting stands at Rice Creek. The number of trees per acre becoming established within ten year intervals is shown for a mid-seral, medium-tree dominated JUOS/ARAR/AGSP - ARAR/AGSP ecotonal stand versus a late-seral, large-tree dominated JUOS/ARAR/AGSP stand.

Environmental Relationships

Nowak et al. (1999) describe the physiological ecology of *Juniperus osteosperma* and *Pinus monophylla* and make comparisons between these species and *Artemisia tridentata*. The comparative physiological traits of these species provide a basis for understanding and predicting distribution, competitive interactions, successional relationships, and, ultimately, potential stand composition. Both *Juniperus osteosperma* and *Pinus monophylla* possess relatively conservative carbon assimilation and water relations. *Pinus monophylla* has a greater capacity for assimilation than *Juniperus osteosperma*. *Juniperus osteosperma*, in contrast, is more tolerant of water stress than *Pinus monophylla*. In periods of high water stress *Juniperus osteosperma* is able to continue assimilating carbon more readily than *Pinus monophylla*. Work by Barnes and Cunningham (1987, as cited by Nowak et al. 1999) suggests that *Juniperus monosperma* is more capable of favorable response to high moisture availability than *Pinus edulis*. Similar comparative relationships may occur in *Juniperus osteosperma* versus *Pinus monophylla*. *Juniperus osteosperma* also shows a higher level of seasonal variation in plant water status compared to *Pinus monophylla*, which shows relatively little.

Artemisia spp. has a greater capacity for carbon assimilation (on a per gram leaf weight basis) than both *Juniperus osteosperma* or *Pinus monophylla* (Nowak et al. 1999). In addition photosynthetic carbon assimilation in *Artemisia* spp. is much less sensitive to water stress. Work by Flanagan et al. (1992, as cited by Nowak et al. 1999) suggests that *Juniperus osteosperma* or *Pinus monophylla* have a relatively high dependence on surface (precipitation generated) soil moisture. *Artemisia* spp. by comparison appears more capable of utilizing moisture at greater depths in the soil profile and can, as well, adapt more rapidly to uptake of surficial soil moisture supplies (e.g., produced by summer rain showers) compared to the coniferous tree species (Flanagan et al. 1992 as cited by Nowak et al. 1999).

These comparative ecophysiological traits of *Artemisia* spp., *Juniperus osteosperma*, and *Pinus monophylla* help resolve distributional patterns observed within the study area. Natural stands of juniper woodland (i.e., potential natural vegetation *Juniperus osteosperma* plant associations) occur on the Resource Area within an elevational range of 5300 to 7200 feet; on shallow or coarse, rocky soils located on mid- to upper-slope positions within a zone of greater than 12 inches mean annual precipitation. Figure 3 provides a general model for the natural distribution of juniper and pinyon dominated plant associations on the Snake River Resource Area.

An explicit, decision rule model for the distribution of juniper potential natural vegetation within the study area is provided in Box 1. This model appears effective in predicting the distribution of juniper woodlands though it is coarse and should benefit from further refinement. For example, soils mapped by USDA NRCS (1999) do not show in detail the distribution of mapping unit inclusions. More detailed soils information, or an alternative approach to depicting substrate conditions would improve capability, for example, in predicting the juniper stands on the sharp ridge spurs located in the lower portion of the Cottonwood Creek Basin study site. Juniper woodland stands are predicted to be less abundant in the Cotterel Mountains than observed on the ground. Conversely, woodlands are predicted by the model to be more abundant on Middle Mountain than on the ground.

Stand Dynamics

Disturbance is "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (Pickett and White 1985). A *disturbance regime* is characterized by the type (or causal agent, e.g., fire, wind, or flooding), frequency or predictability (the number, or probability, of events per time period), extent and magnitude, timing, and the coupling of multiple disturbance and stress factors. Disturbance affects plant community composition and structure through the differential response of individual species. Considering the historic natural range of variation (*sensu* Morgan et al. 1994), fire is the principal disturbance process effecting stand structure in juniper woodlands - that is, the distribution, size and age of juniper trees.

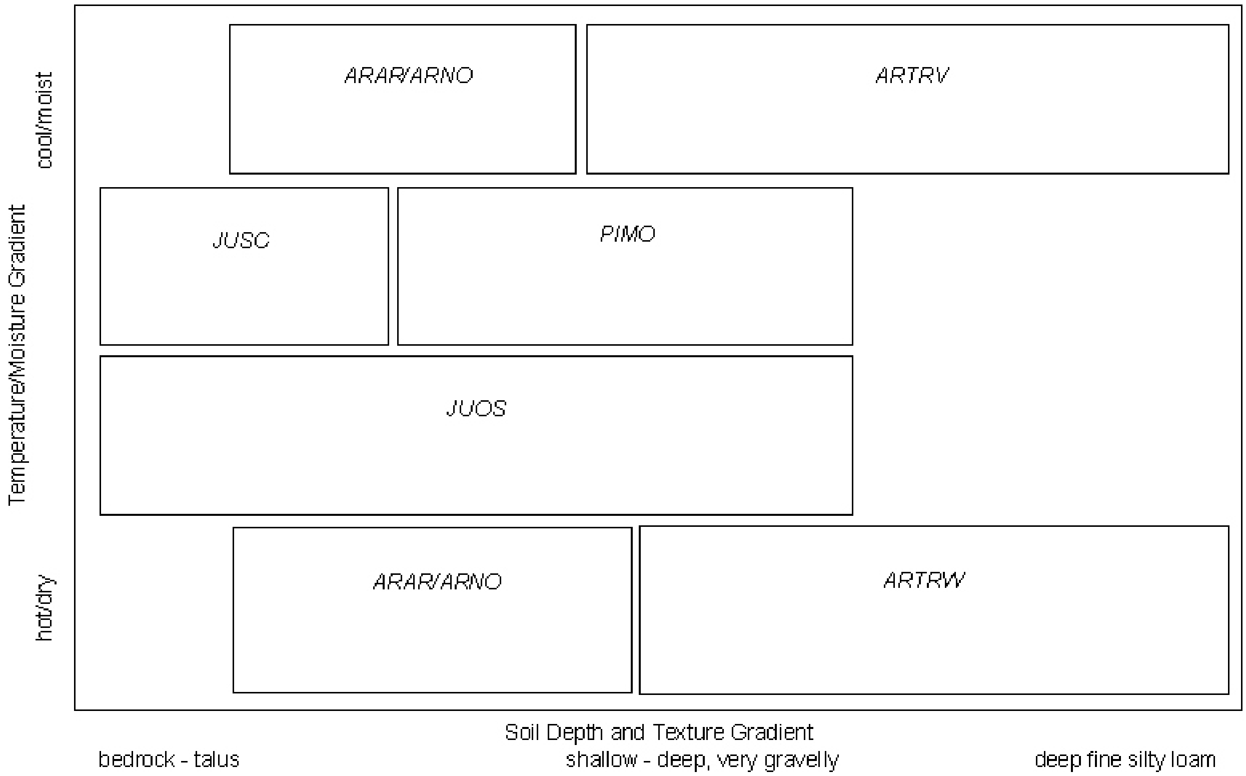


Figure 3. General model for the distribution of juniper-pinyon woodland plant association series on Snake River Resource Area. Rectangular boxes labeled by series name represent the relative distribution of juniper-pinyon woodland associations with respect to major environmental gradients of temperature, moisture, and soil depth and texture.

A fire disturbance regime is a generalized description of the role fire plays in an ecosystem (Agee 1993). Prominent methods for classifying fire disturbance regimes are based on the characteristics of disturbance, the dominant or potential vegetation, or the severity of effects. Heinselman (1973 as cited by Agee 1993) and Agee (1981) classify fire regimes on the basis of the nature of disturbance events, for example: no natural fire, infrequent light surface fire, frequent light surface fire, etc.... Fire groups (e.g., Bradley et al. 1992) are based on the characteristics of the potential natural vegetation. Agee (1990) provides a classification of fire regimes that is based on fire severity. In this approach the regime is defined in terms of the stem basal area removed by fire; ranging from 20 percent in low severity to 70 percent in high severity regimes. Fire severity may also be related in terms of tree mortality. In practice, since they are mutually supporting, these different approaches are often used in combination.

Some take exception to the apparent anthropomorphism of terms in discussion of fire disturbance, for example, “stand replacing wildfire event” or “increased risk of catastrophic wildfire” . The commonly used terms, *stand replacing* versus *stand maintaining* fire are based in a fire severity approach to the description of fire disturbance regimes. A *stand replacing* fire causes 100 percent (or near) mortality in trees (thus resulting in the initiation of a new stand of trees). A *stand maintaining* fire causes selective mortality, for example, only in small diameter, understory trees (thus maintaining the dominance of the overstory trees).

The term *catastrophic* or *catastrophe* is derived from the classic literature in disturbance ecology (Pickett and White 1985). Harper (1977) differentiates between disturbance events that occur frequently within the

Coarse Geographical Rule-based Distribution Model
Juniper-pinyon Woodland Potential Natural Vegetation
Snake River Resource Area

Annual precipitation is greater than or equal to 12 and less than or equal to 24 inches per year (Daly and Taylor 1998) **and** either 1. or 2. are true:

1. Elevation is greater than or equal to 5300 feet or less than or equal to 7200 feet **and** one of the following is true:

   A) Soil composition name (USDA NRCS 1999) is Rock Outcrop or Rubble Land.

   B) Soil surface texture is very cobbly loam, very gravelly loam, very gravelly silt-loam, very stony loam, very stony silt-loam, or extremely stony loam (USDA NRCS 1999).

   C) Soil surface texture is gravelly loam, gravelly silt loam, stony loam, or stony silt loam (USDA NRCS 1999) **and** slope gradient is greater than or equal to 12 percent.

   D) Rock outcrop, very cobbly loam, very gravelly loam, very gravelly silt-loam, very stony loam, very stony silt-loam, or extremely stony loam inclusions within the Coalbank (USDA NRCS 1999) mapping unit.

2. Elevation is less than or equal to 7200 feet **and** soil surface texture is very cobbly loam, very gravelly loam, very gravelly silt-loam, very stony loam, very stony silt-loam, or extremely stony loam (USDA NRCS 1999) **and** slope gradient is greater than or equal to 15 percent.

Box 1. Geographical model for the distribution of juniper woodlands on Snake River Resource Area. The discrete decision rule model is based on spatial data for elevation, precipitation, and soils. This is a preliminary, coarse model that has not been extensively verified for use at, for example, the 1:24,000 scale or in landscape-scale resource management planning processes.

life cycle of the affected organism versus those that occur infrequently within successive generations of the affected organism. He called the frequent disturbance events, *disasters*, and the infrequent events, *catastrophes*. I find it interesting that Harper (1977) hypothesizes disasters, in an evolutionary sense, increase fitness through selection, while catastrophes decrease fitness.

The fire disturbance regime describes multiple events over long periods of time. A single fire event may be characterized by the elements of fire behavior (known as the fire behavior triangle): weather, topography, and fuels. While the fire behavior triangle is most often used to predict the behavior of an event, it is also useful to understand or reconstruct past events.

Elevation, slope, aspect, slope position and physiography are topographical features that contribute to fire behavior. Elevation affects temperature and the length of the fire season. Slope gradient influences the rate of spread and fire intensity. Due to radiant and convective heat transfer, the rate of fire spread is faster on steep slopes, compared to gentle slopes. The point of ignition in relation to slope position also influences the rate of spread and intensity. An ignition in an upper slope position will result in a backing or flanking fire. Ignition in a lower slope position will result in a heading fire. Slope aspect influences air temperature and fuel moisture. The physiography of the landscape contributes to the local distribution of wind and the relative positioning of fuels.

Fuels are a dynamic ecosystem component. The amount of fuel present is a function of site productivity, decomposition rates, and disturbance history. As the moisture content of fuel decreases the flammability of the fuel increases. If fuel moisture is above certain limits (termed the moisture of extinction), combustion will not occur. The rate of heat and moisture transfer depends on the fuel surface area/volume ratio. Small fuel particles have high surface area/volume ratios and great ability to gain and lose heat and moisture. Large logs have low surface area/volume ratios and gain and lose heat and moisture over comparatively longer time periods. Thus, with varying drying periods and the associated

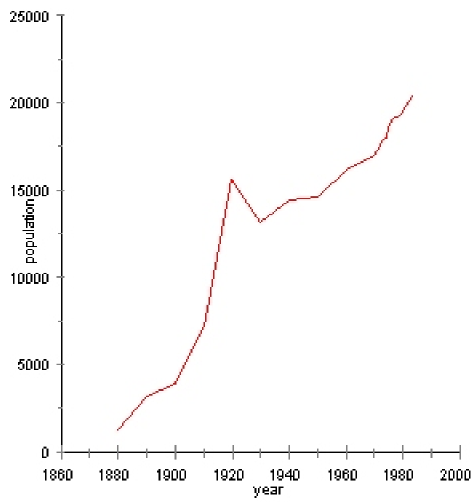


Figure 4. Patterns of population growth, Cassia County, Idaho.

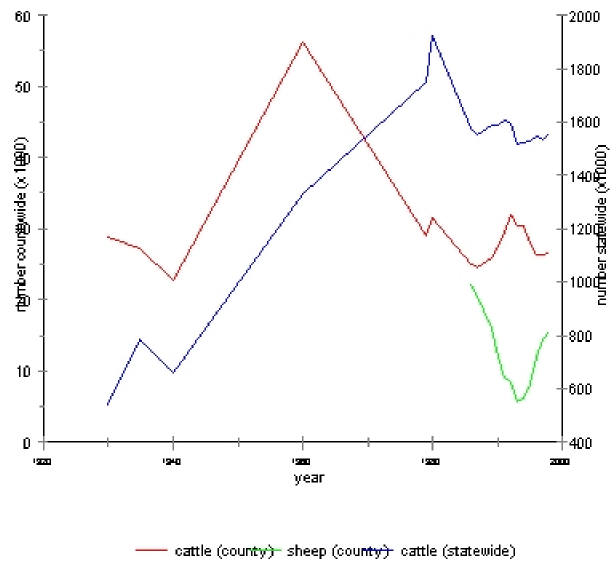


Figure 5. Estimated number of cattle and sheep within Cassia County and Idaho State (1930 - 1998).

effect on fuel moisture, varying proportions and components (e.g., leaf litter versus coarse woody debris) of the total live and dead biomass are available for combustion. The arrangement and density of fuel influences the supply oxygen to the fuel. Tightly packed fuel has a low level of aeration and is less flammable. Loosely packed fuel is well aerated and comparatively more flammable.

Juniperus osteosperma is often described as fire intolerant. This perception is coupled with the notion that juniper woodlands were historically restricted to fire-safe sites. Rather, observations from the study area - and the literature (Wright et al. 1979; Bradley et al. 1992; Gruell 1999) - support a contrasting view. Fire historically occurred within *Juniperus osteosperma* woodlands with regular frequency. Historic stand structure and distribution are the result of fire behavior (in relation to fuel characteristics and site productivity) and the differential survival of large versus small trees.

Evidence of fire abounds on old large trees within the study area. In stands of old growth *Juniperus osteosperma* evidence of fire is regularly distributed and infrequently absent. Stands of old growth *Juniperus osteosperma* were clearly maintained by low intensity understory fire. Clark (1995) reports historic fire return intervals of 31 to 47 years for stands located immediately south of the study area in the Bally Mountains of Utah. *Juniperus osteosperma* establishment patterns observed at the Rice Creek and North Cotterel Mountains study sites (Figures 1 and 2) suggest similar fire frequencies historically occurred on the Snake River Resource Area prior to European settlement ©. 1880).

In all of the watersheds visited, site productivity and its associated influence on the volume and characteristics of fuels is an important contributing factor to the distribution and structure of juniper woodlands. *Juniperus osteosperma* associations that occur on more productive sites - JUOS/ARTRV/AGSP, JUOS/ARTRV/FEID, and JUOS/SYOR/AGSP for example - are more frequently mid-seral, mature medium-tree dominated stands (Table 3). Juniper woodland stands on north-facing slopes are frequently mid-seral, mature medium-tree dominated while stands on the adjacent south-facing slopes are late-seral, old large-tree dominated. Due to the availability of continuous fuels, fire events occur on these more productive sites with sufficient frequency and intensity to prevent the development of late-seral, old large-tree dominated *Juniperus osteosperma* stands. These relationships are demonstrated at the Jim Sage Canyon, Rice Creek, Cottonwood Creek Basin, Franks Hallow, Big

Canyon, North Middle Mountain, and Cedar Hills study sites. One JUOS/ARTRV/AGSP stand in the Rice Creek site provides an excellent example of cyclic development to the mature pole structural condition and subsequent stand replacing fire. This stand appears to be the exception as fire typically appears to have resulted in only partial tree mortality and a more diverse structure.

The influence of slope position and length and physiography is also demonstrated at many sites. Stands which occur on straight slopes that are contiguous with the valley floor or alluvial fans are typically early- or mid-seral. Due to their connectedness to larger land areas these stands are exposed to relatively more frequent fire events (compared to sites on discontiguous, broken physiography) which appear to prevent the development of late-seral stands.

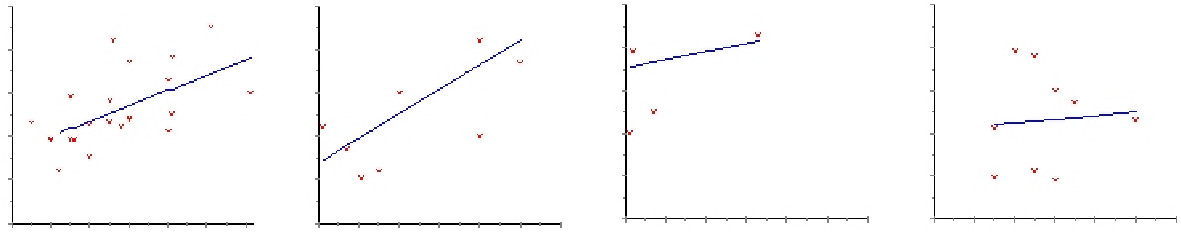
Late-seral old growth *Juniperus osteosperma* stands are most frequently associated with convex horizontal and vertical micro-topographical features (such as a ridge spur or slope break) and natural fire breaks (such as patches of talus, bedrock outcropping, or a rimrock face). Evidence of fire is consistently present in stands of late-seral old growth. Moderately frequent, low intensity fire is likely carried in the abundant bunchgrass (*Agropyron spicatum* or *Festuca idahoensis*) cover characteristic of these stands. The influence of topography is often enhanced or diminished by confounding factors such as the physiographic setting of the feature and the extent of exposure to prevailing fire-season wind.

Post-settlement Human Influences

Cassia County was settled by European immigrants in the late 1800's. In 1864 a stage station was established in Oakley. The first permanent settlement (in Oakley) was established in 1868. Cassia County was established in 1879. Schools had been constructed in Albion Valley and Basin by 1881. During the period from 1880 to 1920 the population of Cassia County grew by an order of magnitude, from approximately 1,300 to 15,000 (Figure 4; Androit 1980; United States Census Bureau 1982; 1992). By the year 1920 major irrigation projects on Snake River and Goose Creek supplied water for agriculture throughout the valley. Most of the communities within the valley were electrified by 1920. Axe hewn stumps and the pronounced lack of coarse woody debris (on easily accessed lower-slope positions) bear witness to these patterns of European settlement and the development of mining and agricultural industries within the study area. In the early years of settlement juniper and pinyon were heavily used for fuel, timbers, and posts. These uses influenced woodland stand structure by removing both large-diameter and pole-sized trees.

The great Northern Rocky Mountain fires of 1910 stimulated national concern over fire protection. Development of contemporary fire fighting efficiency began in the mid-1940's and continued to grow. A high level of interagency coordination (between the Forest Service, Bureau of Land Management, and National Weather Service), however, did not occur until the early 1970's (Pyne 1982; Agee 1993). Wildfire suppression has clearly had an influence on the distribution and structure of juniper woodlands on the Snake River Resource Area. Highly organized and well equipped fire suppression efforts have influenced how and when wildfire events occur, but not if wildfires occur within the study area. Numerous authors report that fire suppression in juniper woodlands throughout the Great Basin have contributed to increased densities of pole-sized trees, loss of understory grass and forb cover, and a trend toward catastrophic, stand-replacing fire behavior.

In this scenario, loss of fine fuels (which historically carried low intensity understory fire) is partly the result of increased density of trees and greater tree canopy cover. If this were the case, understory grass cover should be negatively correlated with tree canopy cover. Tausch (1980 as cited by Tausch et al. 1981) observed a negative correlation between tree and grass cover along a successional gradient (ranging from open sagebrush-steppe to dense woodland) at a site in Utah. Examining the relationship between tree canopy cover and the abundance of fine fuels (as reflected by the cover of perennial bunch grass species) on the range of study sites throughout the Snake River Resource Area different patterns are observed. In each of the four most common plant associations (including data from a range of seral, ecological, and structural conditions), grass cover is either not correlated with tree canopy cover or is



JUOS/ARAR/AGSP	JUOS/ARAR/FEID	JUOS/ARNO/AGSP	JUOS/ARTRV/AGSP
n = 24 r_s = 0.359 0.1 < $\alpha(2)$ > 0.05 Reject H_0: p_s = 0	n = 10 r_s = 0.606 0.1 < $\alpha(2)$ > 0.05 Reject H_0: p_s = 0	n = 5 r_s = 0.300 $\alpha(2)$ > 0.5 Cannot reject H_0: p_s = 0	n = 9 r_s = 0.083 $\alpha(2)$ > 0.5 Cannot reject H_0: p_s = 0

Box 2. Relationships between tree canopy cover and perennial grass cover observed in four most common *Juniperus osteosperma* plant associations on Snake River Resource Area (from left to right): JUOS/ARAR/AGSP, JUOS/ARAR/FEID, JUOS/ARNO/AGSP, and JUOS/ARTRV/AGSP. The horizontal axes represent tree canopy cover (0 - 60 percent; 5 percent intervals). The vertical axes represent perennial grass cover (0 - 50 percent; 5 percent intervals). Markers (X) represent values for individual fixed area tenth acre plots. Solid lines represent the linear trend of values. Results of two-tailed Spearman rank correlation tests (r_s = Spearman rank correlation coefficient) of the null hypothesis of no correlation (H_0: p_s = 0) between tree canopy cover and perennial grass cover are displayed directly below each graphic (Zar 1984).

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positively correlated with tree canopy cover (i.e., grass cover is observed to increase with tree canopy cover) (Box 2).

Westward-bound cross country immigrants traveled the area heavily on five different routes during the period (circa) 1840 -1860 (Hutchison and Jones 1993). Yensen (1980) estimates 250,000 head of livestock crossed the Snake River Plain annually during the peak years of westward migration. A large percentage of these animals trailed, bedded, and grazed on lower slopes and valley bottoms within the study area.

A principal attraction to settlement within the study area during the mid- to late-1800's was the great abundance of grass and plentiful supply of water (Campbell 1969). The number of cattle in the area grew rapidly between the period 1871 - 1885 (Roberts-Wright 1987; Estes 1977). It is difficult to derive precise values for the number of cattle within the study area during this period, due to (for example) the distances herds were driven (often between state and county jurisdictions - there were no range allotments), the use of steers (and later wethers), and (prior to the development of rail) the occurrence of overland cattle drives (Yensen 1980). Estes (1977) estimates 230,000 head of cattle and several thousand horses were present on rangelands within the study area and surrounding vicinity. For reference, numerous single operations managed more head of cattle than are currently reported for the entire county (Figure 5; Estes 1977; USDA National Agricultural Statistical Service 2000).

By the early 1890's, as cattle herds were severely diminished due to depletion of forage resources, drought, and a series of severe winters, sheep began to increase (Estes 1977; Clark 1995; Ogle and DuMond 1997). In 1895 85,000 sheep are reported to have occurred in the Goose Creek drainage of the study area (Clark 1995). Roberts-Wright (1987) estimates that approximately 72 families ran sheep in the area with bands of 2,500 - 3,500 head (approximately 216,000 head total; an order of magnitude more than are present in recent decades [Figure 5]). Overgrazing by sheep and cattle was prevalent in the early 1900's, a period of compounded loss of rangeland resources due to the conversion of valley bottom sites to agricultural cultivation.

During the period 1920 -1934, below normal precipitation followed by severe drought and overstocking (resulting from response to post World War I market opportunities and financial pressures of the Great Depression) caused severe overgrazing in southern Idaho (Yensen 1980; Pechanec et al. 1937). With the passage of the Taylor Grazing Act in 1934 the era of the open range came to close. The number of cattle on rangelands within Cassia County peaked most recently in 1959 (Figure 5; USDA National Agricultural Statistical Service 2000).

Patterns of *Juniperus osteosperma* establishment on plots within Rice Creek appear well correlated with the history of livestock use. Relatively abrupt increases in tree regeneration starting in the 1890's and 1910's, respectively, on the JUOS/ARAR/AGSP - ARAR/AGSP interface and JUOS/ARAR/AGSP woodland plots correspond to periods of peak cattle use in the study area. Similar patterns in establishment occur on the JUOS/ARAR/AGSP ecotonal and JUOS/ARAR/AGSP woodland plots at the North Cotterel Mountain study site. *Juniperus osteosperma* establishment on adjacent ARTRW/AGSP plots at this site may correspond to post World War I expansion of cattle stocking and the years of drought ending in 1934. Alternatively, environmental conditions suitable for *Juniperus osteosperma* establishment on these sites may have been in place in the 1890's and 1910's. The 20 - 30 year delay in the onset of establishment on ARTRW/AGSP (compared to adjacent JUOS/ARAR/AGSP) may reflect the rate of seed dispersal to these plot locations and the development of sufficient shrub canopy cover for suitable establishment micro-habitats (Chambers et al. 1999).

Burkhardt and Tisdale (1969; 1976), Blackburn and Tueller (1970), and Tausch et al. (1981) observed similar patterns in the historic establishment of *Juniperus occidentalis*, *Juniperus osteosperma*, and *Pinus monophylla* at sites located in Idaho, Nevada, and Utah. Authors working to address the causal factors contributing to the expanded distribution of juniper and pinyon in the Great Basin region identify three primary factors: (1) climate change, (2) historic intensive livestock grazing and associated influences on species competition and the abundance of fine fuel needed to carry fire, and (3) interruption of fire disturbance regimes due to fire suppression.

The influence of climate change is difficult to evaluate on the temporal scale of this study. Threshold transitions (Tausch et al. 1993) are probably operating in portions of the juniper pinyon ecosystem on Snake River Resource Area. The interruption of fire disturbance regimes due to fire suppression is probably influential in recent decades. During the period associated with abrupt woodland structural changes (1880 through 1920) fire suppression was only a minor factor. European settlement of the 1880's may have reduced the incidence of aboriginal ignitions.

Perhaps the most pervasive influence on juniper woodland distribution and structure on Snake River Resource Area is historic alteration of the characteristics and placement of fuel due to historic livestock grazing. Intensive consumption of grass by cattle and sheep during the period 1880 - 1934 removed the fine fuel necessary to carry moderately frequent, low intensity fire, may have reduced competition for seedling establishment, and likely increased the density of shrubs and associated micro-habitats suitable for *Juniperus osteosperma* establishment (West 1988; Chambers et al. 1999).

Conclusions

Natural stands of juniper woodland occur on the Resource Area within an elevational range of 5300 to 7200 feet; on shallow or coarse, rocky soils located on mid- to upper-slope positions that receive (on average) greater than 12 inches precipitation a year. Evidence of fire abounds on old large trees within the study area. Historic woodland stand structure and distribution reflect the interaction between fire behavior, topography, and site productivity and differential rates of survival of large versus small trees. Late-seral old growth woodlands - most frequently associated with convex horizontal and vertical micro-topographical features and natural fire breaks - were historically maintained by low intensity understory fire which occurred with moderate frequency (30 - 40 years). More productive sites - which typically occur on north-facing slopes or with convex topographical features - are frequently mid-seral and dominated by mature medium-sized trees. Due to the abundance and continuity of fuels, fire events appear to have occurred on these sites with sufficient frequency and intensity to prevent the development of late-seral stands.

Juniperus osteosperma is an opportunistic species. Discussion of management alternatives for ecosystems within the species' range often focus on the species itself. That is, juniper - its density, establishment, and growth - is viewed as the issue. Juniper is often viewed as the culprit - as the causal agent of decline in the quality and quantity of other resource values. Rather, *Juniperus osteosperma* is an indicator of a specific range of environmental conditions (which occur largely independent of the species itself) that are suitable for the species establishment and growth. An understanding of the ecological processes that give rise to these environmental conditions is the foundation for restoring the quality and quantity of resource values within the juniper woodland ecosystems on Snake River Resource Area.

Many stands within the study area appear to be within the range of natural variation in structure and composition. These are low to moderate density mature medium-tree dominated stands which occur on relatively productive sites. Management focused at the maintenance of ecological processes in these stands might be addressed through the use of prescribed fire (with appropriate precaution regarding the establishment of exotic plant species). In many mid- and lower-slope stands on Snake River Resource Area, the fuels required to carry the low intensity understory fire that historically maintained old growth juniper woodlands is no longer present. It is not likely that prescribed fire alone will serve to restore the ecological integrity of these stands. High quality, representative old growth *Juniperus osteosperma* woodland stands are present in upper-slope positions at numerous locations throughout the Resource Area.

Literature Cited

Agee, J. K. 1981. Fire effects on Pacific Northwest forests: flora, fuels, and fauna. Conference Proceedings, Northwest Forest Fire Council 1981, Portland, Oregon, November 23 - 24, 1981.

Agee, J. K. 1983. Fire ecology of Pacific Northwest forests. Island Press, Washington D. C.

Agee, J. K. 1990. The historic role of fire in Pacific Northwest forests. In: J. D. Walstad, S. R. Radosevich, and D. V. Sandberg, eds. Natural and prescribed fire in Pacific Northwest forests. Oregon State University Press, Corvallis.

Alexander, R. R. 1985. Major habitat types, community types, and plant communities in the Rocky Mountains. USDA Forest Service General Technical Report RM-123. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Co. 105 p.

Alexander, R. R. 1988. Forest vegetation on National Forests in the Rocky Mountain and Intermountain Regions: habitat types and community types. USDA Forest Service General Technical Report RM-162. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 47 p.

Andriot, J. L. 1980. Population abstract of the United States. Andriot Associations, McLean. 925 p.

Baker, W. L. 1984. A preliminary classification of the natural vegetation of Colorado. The Great Basin Naturalist 44(4):647-676.

Barns, F. J. and G. L. Cunningham. 1987. Water relations and productivity in pinyon-juniper habitat types. In: Everett, R. L., compiler. 1986. Proceedings--pinyon-juniper conference; 1986, January 13-16; Reno, NV. General Techinical Report INT-215. Ogcen, UT: U. S. Department of Agriculture, Forest Service, Intermountain Research Station; 1987. 581 p.

Blackburn, W. H.; Eckert, R. E. Jr.; Tueller, P. T.1969. Vegetation and soils of the Churchill Canyon Watershed. Nevada Agricultural Experiment Station Bulletin R-45. Reno. 157 pp.

Blackburn, W. H., and P. T. Tueller. 1970. Pinyon and juniper invasion in Black sagebrush communities in East-Central Nevada. Ecology 51(5): 841-848.

Bourgeron, P. S.; DeValice, R. L.; Engelking, L. D.; Jones, G.; Muldavin, E. 1991. WHTF site and community survey manual. Version 92B. Western Heritage Task Force, Boulder. 24 p.

Bourgeron, P. S., and Engelking, L. D. 1994. A preliminary vegetation classification of the Western United States. The Nature Conservancy, Western Heritage Task Force, Boulder.

Bradley, A. F., W. C. Fischer, and N. V. William. 1992. Fire ecology of forest woodlands in Utah. General Technical Report INT-287. Ogden, UT: USDA Forest Service, Intermountain Research Station. 128 pp.

Burkhardt, J. W., and E. W. Tisdale. 1969. Nature and successional status of western juniper vegetation in Idaho. Journal of Range Management 22: 264-270.

Burkhardt, J. W., and E. W. Tisdale. 1976. Causes of juniper invasion in southwestern Idaho. Ecology 57: 472-484.

Campbell, A. H. 1969. Report upon the Pacific wagon roads. Ye Galleon Press, Fairfield. 125 p.

Chambers, J. C., E. W. Schupp, and S. B Vander Wall. 1999. Seed dispersal and seedling establishment of pinon and juniper species with the pinon-juniper woodland. In: Monson, S. B.; Stevens, Richard, (compilers). 1999. Proceedings: ecology and management of pinyon-juniper communities within the interior west. 1997 September 15-18, Provo, UT. Proc. RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 411 pp.

Clark, T. J. 1995. A fire history study in Pinyon-Juniper. Unpublished report prepared for Sawtooth National Forest. 22 pp. plus appendices.

Cooper, S. V., K. E. Neiman, and D. W. Roberts. 1991. Forest habitat types of northern Idaho: a second approximation. USDA Forest Service General Technical Report INT-236. Intermountain Research Station, Ogden, UT. 143 p.

Cronquist, A.; Holmgren, A. H.; Holmgren N. H.; Reveal, J. L. 1972. Intermountain flora: vascular plants of the Intermountain West, USA. Vol. 1. Hafner Publishing Company, Inc., New York. 270 p.

Daly, C. and G. Taylor. 1998. Idaho average monthly or annual precipitation, 1961 - 1990. U.S. Department of Agriculture, Natural Resources Conservation Service, Water and Climate Center, Portland.

Daubenmire, R. 1952. Forest vegetation of northern Idaho and adjacent Washington and its bearing on concepts of vegetation classification. Ecol. Monogr. 22: 301 - 330.

Daubenmire, R. 1968. Plant communities: A textbook of plant synecology. Harper and Row, New York.

Daubenmire, R. F. 1970. Steppe vegetation of Washington. Washington State University Agricultural Experiment Station Technical Bulletin No. 62. 131 p.

Daubenmire, R. F. and J. B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington State University Agricultural Experiment Station Technical Bulletin No. 60. 104 p.

Estes, V. 1977. A pause for reflection. J. Grant Stevenson, Provo. 808 p.

Flanagan, L. B., J. R. Ehleringer, and J. D. Marshall. 1992. Differential uptake of summer precipitation among co-occurring trees and shrubs in a pinyon-juniper woodland. Plant Cell Environ. 15: 831 - 836.

Gruell, G. E. 1999. Historical and modern roles of fire in pinyon-juniper. In: Monson, S. B.; Stevens, Richard, (compilers). 1999. Proceedings: ecology and management of pinyon-juniper communities within the interior west. 1997 September 15-18, Provo, UT. Proc. RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 411 pp.

Hall, F. C. 1988. Pacific Northwest ecoclass codes for plant associations. USDA Forest Service, Pacific Northwest Region, R6 Ecol. Tech. Paper 289-87, Portland, OR. 164 p.

Harper, J. L. 1977. Population biology of plants. Academic Press, London.

Harper, K. T. and J. N. Davis. 1999. Biotic, edaphic and other factors influencing pinyon-juniper distribution in the Great Basin. In: Monson, S. B.; Stevens, Richard, (compilers). 1999. Proceedings: ecology and management of pinyon-juniper communities within the interior west. 1997 September 15-18, Provo, UT. Proc. RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 411 pp.

Heinselman, M. A. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Quat. Res. 3: 329 - 382.

Hill, M. O. 1979a. DECORANA - a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Ecology and Systematics, Cornell University, Ithaca.

Hill, M. O. 1979b. TWINSPAN - a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of individuals and attributes. Ecology and Systematics, Cornell University, Ithaca.

Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Forestry, Wildlife, and Range Experiment Station Bulletin No. 15, University of Idaho, Moscow. 44 p.

Hutchison, D. J. and L. R. Jones. 1993. Emigrant trails of southern Idaho. Adventures in the Past - Idaho Cultural Resource Series, Number 1. Joint publication of USDI Bureau of Land Management and Idaho State Historical Society. Boise. 230 p.

Johnson, Charles G. and Steven A. Simon. 1987. Plant associations of the Wallowa-Snake province. R6-ECOL-TP-255A-86. Baker City, OR: U.S. Department of Agriculture, Forest Service, Wallowa-Whitman National Forest. 400 p. plus appendices.

Mauk, R. L. and J. A. Henderson. 1984. Coniferous forest habitat types of northern Utah. USDA Forest Service General Technical Report INT-170. Intermountain Forest and Range Experimental Station, Ogden, UT. 89 p.

Morgan P., G.H. Aplet, J.B. Haufler, H.C. Humphries, M.M. Moore and W.D. Wilson. 1994. Historic range of variability: a useful tool for evaluating ecosystem change. In: R.H. Sampson and D.L. Adams (eds.). Assessing for ecosystem health in the Inland West. Journal of Sustainable Forestry 2(1/2): 87 - 111.

Nowak, R. S., D. J. Moore, and R. J. Tausch. 1999. Ecophysiological patterns of pinyon and juniper. In: Monson, S. B.; Stevens, Richard, (compilers). 1999. Proceedings: ecology and management of pinyon-juniper communities within the interior west. 1997 September 15-18, Provo, UT. Proc. RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 411 pp.

Ogle, K., and V. DuMond. 1997. Historical vegetation on National Forest lands in the Intermountain Region. United States Department of Agriculture, Forest Service, Intermountain Region, Ogden. 129 p.

Pechanec, J. F., G. D. Pickford, and G. Stewart. 1937. Effects of the 1934 drought on native vegetation of the upper Snake River Plains, Idaho. Ecology 18: 490-505.

Peet, R. K. 1988. Forests of the Rocky Mountains. Pages 63-101 in M. G. Barbour and W. D. Billings, editors, North American terrestrial vegetation. Cambridge University Press, New York.

Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby. 1977. Forest habitat types of Montana. USDA Forest Service General Technical Report, INT-34. Intermountain Forest and Range Experiment Station, Ogden, UT. 174 p.

Pickett, S. T. A. and P. S. White. 1985. The ecology of natural disturbance and patch dynamics. Academic Press, New York.

Pyne, S. J. Fire in America. A cultural history of wildland and rural fire. University of Washington Press, Seattle.

Roberts-Wright, B. M. S. 1987. Oakley, Idaho: pioneer town. A century of fabulous growth. Horizon Publishers, Bountiful. 211 p.

Rust, S. K. 1997. Pinyon-juniper woodland classification and description in research natural areas of Southeast Idaho. Unpublished report prepared for USDI Bureau of Land Management, Burley Field Office and USDA Forest Service Northern Region, Intermountain Region and Intermountain Research Station. Conservation Data Center, Idaho Department of Fish and Game, Boise. 84 pp.

Rust, S. K. 1999. Pinyon-juniper woodland classification and description in Research Natural Areas of southeastern Idaho. In: Monson, Stephen B.; Stevens, Richard; Tausch, Robin J.; Miller, Rick; Goodrich, Sherel. 1998. Proceedings: ecology and management of pinyon-juniper communities within the interior west. 1997 Sept. 15-18, Provo, UT. Gen. Tech. Rep. INT-GTR-000. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Rust, S. K. and R. K. Moseley. 1999. Monitoring the effects of enhanced Air Force training in Idaho: baseline vegetation map for wildlife habitat monitoring, first year results. Unpublished report prepared for United States Air Force, Mountain Home Air Force Base.

Smith, B. G. 1993. ECOAID, a users guide. Unpublished software and guide. USDA Forest Service, Pacific Northwest Region, Portland.

Sawyer, J. O. and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento.

Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kittams. 1981. Forest habitat types of central Idaho. USDA Forest Service General Technical Report INT-114. Intermountain Forest and Range Experiment Station, Ogden, UT. 138 p.

Steele, R., S. V. Cooper, D. M. Ondov, D. W. Roberts, and R. D. Pfister. 1983. Forest habitat types of eastern Idaho-western Wyoming. General Technical Report INT-144. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 122 p.

ter Braak, C. J. F. 1991. CANOCO - a FORTRAN program for canonical correspondence analysis, principal components analysis, and redundancy analysis (version 3.12). IWIS-TNA, Wageningen, The Netherlands.

Tausch, R. J., N. E. West, and A. A. Nabi. 1981. Tree age and dominance patterns in Great Basin pinyon-juniper woodlands. Journal of Range Management 34(4): 259-264.

Tisdale, E. W. 1986. Canyon grasslands and associated shrublands of west-central Idaho and adjacent areas. Bulletin Number 40; Forest, Wildlife and Range Experiment Station; Moscow. 42 p.

Tueller, P. T., C. D. Beeson, R. J. Tausch, N. E. West, and K. H. Rea. 1979. Pinyon-juniper woodlands of the Great Basin: distribution, flora, vegetal cover. USDA Forest Service Research Paper INT-229. Intermountain Forest and Range Experiment Station, Ogden, UT. 21 p.

United States Census Bureau. 1992. Intercensal Estimates of the Resident Population of States and Counties, 1980-1989. Population Estimates and Population Distribution Branches. U.S. Bureau of the Census, Washington.

United States Census Bureau. 1982. Intercensal Estimates of the Resident Population of States and Counties, 1970 -1979. Population Estimates and Population Distribution Branches. U.S. Bureau of the Census, Washington.

United States Department of Agriculture, Forest Service. 1992. Ecosystem Inventory and Analysis Guide (7/92). Northern Region, Missoula, MT.

United State Department of Agriculture, National Agricultural Statistical Service. 2000. Published Estimates Data Base. Online data base, www.usda.gov/nass. Washington.

USDA, NRCS. 1999. Soil Survey Geographic (SSURGO) database for Cassia County, Idaho, Eastern Part. U.S. Department of Agriculture, Natural Resources Conservation Service. Fort Worth.

Wellner, C. A. 1989. Classification of habitat types in the Western United States. In: Ferguson, D. E., P. Morgan, and F. Johnson, comps. Proceedings-land classifications based on vegetation: applications for resource management; 1987 November 17-19; Moscow, ID. USDA Forest Service General Technical Report INT-257. Intermountain Research Station, Ogden, UT. 315 p.

West, N. E. 1988. Intermountain deserts, shrub steppes, and woodlands. Pages 209-230 in M. G. Barbour and W. D. Billings, editors. North American Vegetation. Cambridge University Press, New York.

West, N. E., J. Robin, and P. T. Tueller. 1998. A management-oriented classification of pinyon-juniper woodlands of the Great Basin. General Technical Report RMRS-GTR-12. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT. 42 pp.

West, N. E. 1999. Distribution, composition, and classification of current juniper-pinyon woodlands and savannas across western North America. In: Monson, S. B.; Stevens, Richard, (compilers). 1999. Proceedings: ecology and management of pinyon-juniper communities within the interior west. 1997 September 15-18, Provo, UT. Proc. RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 411 pp.

Wight, J. R. and H. G. Fisser. 1968. *Juniperus osteosperma* in northwestern Wyoming: their distribution and ecology. University of Wyoming Agricultural Experiment Station Science Monograph 7. Laramie. 28 pp.

Williams, C. K. and B. G. Smith. 1991. Forested plant associations of the Wenatchee National Forest - Draft. Wenatchee National Forest, Wenatchee, WA.

Wright, H. A., L. F. Neunschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: a state of the art review. USDA Forest Service General Technical Report INT-58. Intermountain Forest and Range Experiment Station, Ogden, UT. 48 pp.

Yensen, D. 1980. A grazing history of southwestern Idaho with emphasis on the Birds of Prey Study Area. USDI Bureau of Land Mangement, Boise District Office, Snake River Birds of Prey Research Project, Boise, ID. 82 pp.

Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall, New Jersey.

Appendix A. Tables.

Table 1. Juniper woodland plant associations observed on the Snake River Resource Area. The plant associations are listed with the symbol used within the text and the percent of observations.

Table 2. Sumary of physical environmental factors. The mean slope, aspect, and elevation of plant associations observed on the Snake River Resource Area are list alphabetically by plant association.

Table 3. Distribution of structural conditions within juniper woodland plant associations. The percent of observations within nine structural condition classes is summarized by plant association.

Table 4. Stem size distribution within juniper woodland plant associations. The mean density (trees per acre) of trees are listed by stem size class, stand structural condition and plant association.

Table 1. Juniper woodland plant associations observed on the Snake River Resource Area. The plant associations are listed with the symbol used within the text and the percent of observations.

Series and Plant association	Symbol	Percent of observations
Juniperus osteosperma Series	JUOS	
Juniperus osteosperma-Cercocarpus ledifolius/Symphoricarpos oreophilus/Agropyron spicatum	JUOS-CELE/SYOR/AGSP	0.35
Juniperus osteosperma/Agropyron spicatum	JUOS/AGSP	0.35
Juniperus osteosperma/Artemisia arbuscula/Agropyron spicatum	JUOS/ARAR/AGSP	18.44
Juniperus osteosperma/Artemisia arbuscula/Festuca idahoensis	JUOS/ARAR/FEID	8.51
Juniperus osteosperma/Artemisia nova/Agropyron spicatum	JUOS/ARNO/AGSP	13.47
Juniperus osteosperma/Artemisia nova/Poa secunda	JUOS/ARNO/POSE	3.90
Juniperus osteosperma/Artemisia nova/Stipa thurberiana	JUOS/ARNO/STTH	2.12
Juniperus osteosperma/Artemisia tridentata vaseyana/Agropyron spicatum	JUOS/ARTRV/AGSP	12.41
Juniperus osteosperma/Artemisia tridentata vaseyana/Festuca idahoensis	JUOS/ARTRV/FEID	4.25
Juniperus osteosperma/Artemisia tridentata vaseyana/Oryzopsis hymenoides	JUOS/ARTRV/ORHY	3.90
Juniperus osteosperma/Artemisia tridentata wyomingensis/Agropyron spicatum	JUOS/ARTRW/AGSP	0.70
Juniperus osteosperma/Artemisia tridentata wyomingensis/Festuca idahoensis	JUOS/ARTRW/FEID	0.35
Juniperus osteosperma/Artemisia tridentata wyomingensis/Stipa comata	JUOS/ARTRW/STCO	2.48
Juniperus osteosperma/Symphoricarpos oreophilus/Agropyron spicatum	JUOS/SYOR/AGSP	4.60

Juniperus scopulorum Series	JUSC	
Juniperus scopulorum/Symphoricarpos oreophilus/Festuca idahoensis	JUSC/SYOR/FEID	1.41
Pinus monophylla Series	PIMO	
Pinus monophylla-Cercocarpus ledifolius/Holodiscus dumosus/Elymus cinereus	PIMO-CELE/HODU/ELCI	2.48
Pinus monophylla-Cercocarpus ledifolius/Poa secunda	PIMO-CELE/POSE	6.38
Pinus monophylla-Cercocarpus ledifolius/Symphoricarpos oreophilus-Berberis repens/Agropyron spicatum	PIMO-CELE/SYOR-BERE/AGSP	1.77
Pinus monophylla-Juniperus osteosperma/Agropyron spicatum	PIMO-JUOS/AGSP	2.83
Pinus monophylla-Juniperus osteosperma/Artemisia arbuscula/Agropyron spicatum	PIMO-JUOS/ARAR/AGSP	0.35
Pinus monophylla-Juniperus osteosperma/Artemisia arbuscula/Festuca idahoensis	PIMO-JUOS/ARAR/FEID	0.35
Pinus monophylla-Juniperus osteosperma/Artemisia nova/Poa secunda	PIMO-JUOS/ARNO/POSE	3.19
Pinus monophylla-Juniperus osteosperma/Artemisia tridentata vaseyana/Agropyron spicatum	PIMO-JUOS/ARTRV/AGSP	4.25
Pinus monophylla-Juniperus osteosperma/Artemisia tridentata vaseyana/Festuca idahoensis	PIMO-JUOS/ARTRV/FEID	0.70

Table 2. Sumary of physical environmental factors. The number of observations, mean slope, aspect, and elevation of plant associations observed on the Snake River Resource Area are list alphabetically by plant association.

Plant Association	N	Mean slope (range)	Mean Aspect	Mean elevation (range)
JUOS-CELE/SYOR/AGSP	1	29 (29 - 29)	155	6880
JUOS/AGSP	1	52 (52 - 52)	173	5580
JUOS/ARAR/AGSP	51	32 (8 - 58)	81	6017 (4520 - 7200)
JUOS/ARAR/FEID	24	24 (3 - 59)	70	5951 (5100 - 6810)
JUOS/ARNO/AGSP	37	26 (5 - 56)	91	5704 (4740 - 7325)
JUOS/ARNO/POSE	11	23 (3 - 60)	83	5521 (4565 - 6520)
JUOS/ARNO/STTH CT	6	13 (5 - 18)	128	5340 (5110 - 5520)
JUOS/ARTRV/AGSP	31	34 (5 - 64)	118	6173 (5330 - 6820)
JUOS/ARTRV/FEID	12	24 (6 - 49)	58	6132 (5410 - 6740)
JUOS/ARTRV/ORHY	10	51 (21 - 67)	120	6087 (5940 - 6230)
JUOS/ARTRW/AGSP	1	33 (33 - 33)	87	5090
JUOS/ARTRW/FEID	1	33 (33 - 33)	11	5220
JUOS/ARTRW/STCO	7	13 (4 - 35)	102	5299 (5030 - 5430)
JUOS/SYOR/AGSP	13	37 (15 - 80)	110	6592 (5610 - 7150)
JUSC/SYOR/FEID	4	36 (25 - 53)	67	5997 (5870 - 6070)
PIMO-CELE/HODU/ELCI	7	55 (35 - 75)	91	6873 (6592 - 7218)
PIMO-CELE/POSE	18	43 (15 - 70)	127	6738 (6431 - 7218)
PIMO-CELE/SYOR-BERE/AGSP	5	50 (45 - 55)	123	7090 (6693 - 7431)

PIMO-JUOS/AGSP	8	30 (13 - 40)	100	6844 (5740 - 7300)
PIMO-JUOS/ARAR/AGSP	1	33 (33 - 33)	167	6700
PIMO-JUOS/ARAR/FEID	1	35 (35 - 35)	169	6890
PIMO-JUOS/ARNO/POSE	9	37 (15 - 55)	126	5811 (5578 - 6320)
PIMO-JUOS/ARTRV/AGSP	12	47 (20 - 65)	86	6459 (5600 - 6956)
PIMO-JUOS/ARTRV/FEID	2	32 (28 - 35)	87	7030 (7000 - 7060)

Table 3. Distribution of structural conditions within juniper woodland plant associations. The percent of observations within nine structural condition classes is summarized by plant association.

Plant association	Structural condition class								
	mature large tree	mature medium tree	mature pole	mature sapling	old large tree	old medium tree	old pole	old giant tree	young pole
JUOS-CELE/SYOR/AGSP					100				
JUOS/AGSP					100				
JUOS/ARAR/AGSP	2	37	12	5	32	9			2
JUOS/ARAR/FEID		46			15	38			
JUOS/ARNO/AGSP		34	9		34	19	3		
JUOS/ARNO/POSE		28			43	28			
JUOS/ARNO/STTH		25	50			25			
JUOS/ARTRV/AGSP	7	50	3		17	7		10	3
JUOS/ARTRV/FEID		60	40						
JUOS/ARTRV/ORHY					67				33
JUOS/ARTRW/STCO		100							
JUOS/SYOR/AGSP		80			20				

Table 4. Stem size distribution within juniper woodland plant associations. The mean density (trees per acre) of trees are listed by stem size class, stand structural condition and plant association.

Plant Association	Structural condition	Density (trees per acre) by stem size class					
		giant	large	medium	pole	sapling	seedling
JUOS/ARAR/AGSP	mature medium tree			45	95	25	15
JUOS/ARAR/AGSP	old large tree		30	70	40	80	180
JUOS/ARAR/FEID	mature medium tree			30	10	10	
JUOS/ARAR/FEID	old giant tree	10	20	50	10		
JUOS/ARAR/FEID	old large tree		10	45	30	25	65
JUOS/ARNO/AGSP	mature large tree		10	20		20	60
JUOS/ARNO/AGSP	mature medium tree			130	170	80	70
JUOS/ARNO/AGSP	mature pole				50	30	40
JUOS/ARNO/AGSP	old large tree		10	140	210	30	
JUOS/ARNO/AGSP	old medium tree			10	90	45	10
JUOS/ARNO/STTH	old large tree		40	40	40	30	80
JUOS/ARTRV/AGSP	mature large tree		10	230	100	70	40
JUOS/ARTRV/AGSP	mature medium tree			120	180	40	10
JUOS/ARTRV/AGSP	old giant tree	25	60	115	5	5	10
JUOS/ARTRV/AGSP	old large tree		20	50	280	240	150
JUOS/ARTRV/FEID	mature medium tree			30	15	5	5
JUOS/ARTRV/FEID	old large tree		20	20			
JUOS/ARTRV/ORHY	mature medium tree			40	10		

Plant Association	Structural condition	Density (trees per acre) by stem size class					
JUOS/ARTRV/ORHY	old giant tree	10		40	10		
JUOS/ARTRV/ORHY	old large tree		80	40		5	
JUOS/ARTRV/ORHY	old medium tree			30	20		10
JUOS/ARTRW/AGSP	old large tree		10	60	20		30
JUOS/ARTRW/FEID	mature medium tree			40			50
JUOS/ARTRW/STCO	old large tree		17	70	83	33	13
JUOS/ARTRW/STCO	old medium tree		10	70	50	10	50
JUOS/STCO	old large tree		20	10	80	90	160
JUOS/SYOR/AGSP	mature large tree		10	20	20	10	10
JUOS/SYOR/AGSP	old giant tree	20	40	80	20		
JUOS/SYOR/AGSP	old large tree		10	50	90	30	20
JUOS/SYOR/AGSP	old medium tree			90	110	170	60
JUSC/SYOR/FEID	mature medium tree			35	20	5	
JUSC/SYOR/FEID	old giant tree	10			30		
JUSC/SYOR/FEID	old large tree		10	30	20	10	

Appendix B. Stand Composition Tables.

In the tables below the constancy (abbreviated CON) and characteristic cover (CHAR) of species occuring in four plant associations and one community type are listed by physiologic group. Constancy is the percent of plots in which the species was observed. Characteristic percent cover is calculated as the relative mean cover. Note the total number of plots for each association listed below the association code. Cover values less than 0.25 percent are indicated as trace (abbreviated as "tr").

Species	JUOS/ARNO/STTH CT 1 Plots		JUOS/ARTRW/AGSP 1 Plots		JUOS/ARTRW/FEID 1 Plots	
	CON	CHAR	CON	CHAR	CON	CHAR
Trees						
Juniperus osteosperma	100.0	41.5	100.0	31.1	100.0	10.1
Juniperus scopulorum	.	.	.	.	.	.
Pinus monophylla	.	.	.	.	.	.
Grasses, sedges and rushes						
Stipa thurberiana	100.0	5.0	100.0	1.0	.	.
Bromus tectorum	100.0	tr	100.0	10.0	.	.
Sitanion hystrix	100.0	4.0	.	.	.	.
Agropyron spicatum	100.0	tr	100.0	15.0	.	.
Poa secunda	100.0	6.0	100.0	4.0	100.0	5.0
Stipa comata	.	.	.	.	100.0	1.0
Koeleria cristata	.	.	.	.	100.0	2.0
Elymus cinereus	.	.	.	.	.	.
Elymus glaucus	.	.	.	.	.	.
Festuca idahoensis	.	.	.	.	100.0	60.0
Agropyron spp.	.	.	.	.	.	.
Poa spp.	.	.	.	.	.	.
Carex spp.	.	.	.	.	.	.
Stipa occidentalis	.	.	.	.	.	.
Bromus carinatus	.	.	.	.	.	.
Herbs						
Lomatium spp.	100.0	tr	.	.	.	.
Penstemon deustus	100.0	8.0	.	.	.	.
Cryptantha spp.	100.0	tr	.	.	.	.
Gutierrezia sarothrae	.	.	100.0	2.0	.	.
Balsamorhiza hookeri	100.0	tr	.	.	.	.
Draba spp.	100.0	tr	.	.	.	.
Chaenactis douglasii	100.0	tr	.	.	.	.
Lupinus sericeus	.	.	100.0	0.5	.	.
Phlox hoodii	100.0	tr	.	.	.	.
Opuntia polycantha	100.0	tr	.	.	100.0	tr
Cirsium canovirens	.	.	100.0	tr	.	.
Tragopogon dubius	.	.	100.0	tr	.	.
Astragalus spp.	.	.	100.0	tr	.	.
Antennaria microphylla	100.0	tr	.	.	100.0	2.0
Taraxacum officinale	.	.	.	.	100.0	tr
Cordylanthus ramosus	.	.	.	.	100.0	tr
Cryptantha spp. (perennial)	.	.	.	.	100.0	tr
Arabis spp.	100.0	tr	.	.	100.0	tr
Eriogonum microthecum	.	.	.	.	100.0	1.0
Calochortus eurycarpus	.	.	.	.	100.0	tr
Aster scopulorum	.	.	.	.	100.0	tr
Erigeron spp.	.	.	.	.	100.0	tr
Collomia grandiflora	.	.	.	.	100.0	tr
Lupinus spp.	.	.	.	.	100.0	4.0
Agastache urticifolia	.	.	.	.	.	.
Aster spp.	.	.	.	.	.	.
Lithospermum ruderale	.	.	.	.	.	.
Phacelia spp.	.	.	.	.	.	.
Hieracium albertinum	.	.	.	.	.	.
Galium triflorum	.	.	.	.	.	.
Achillea millefolium	.	.	.	.	.	.
Senecio spp.	.	.	.	.	.	.
Fritillaria spp.	.	.	.	.	.	.
Senecio multilobatus	.	.	.	.	100.0	tr
Crepis acuminata	.	.	.	.	.	.

Penstemon spp.	.	.	.	.	.	.
Agoseris spp.	.	.	.	.	.	.
Orobanche fasciculata	.	.	.	.	.	.
Montia parvifolia	.	.	.	.	.	.
Castilleja miniata	.	.	.	.	.	.
Allium acuminatum	.	.	.	.	.	.
Balsamorhiza sagittata	.	.	.	.	.	.
Hackelia micrantha	.	.	.	.	.	.
Collinsia parviflora	.	.	.	.	.	.
Comandra umbellata	.	.	.	.	.	.
Penstemon humilis	.	.	.	.	.	.
Arabis holboellii	.	.	.	.	.	.
Cryptantha spp. (annual)	.	.	.	.	.	.
Polygonum douglasii	.	.	.	.	.	.
Heuchera spp.	.	.	.	.	.	.
Sedum lanceolatum	.	.	.	.	.	.
Leptodactylon pungens	.	.	.	.	.	.
Machaeranthera canescens	.	.	.	.	.	.
Senecio integerrimus	.	.	.	.	.	.
Castilleja spp.	.	.	.	.	.	.
Zigadenus venenosus	.	.	.	.	.	.
Shrubs						
Eriogonum caespitosum	100.0	tr	.	.	.	.
Artemisia nova	100.0	10.0	.	.	.	.
Eriogonum umbellatum	100.0	tr	.	.	100.0	tr
Artemisia tridentata wyomingensis	.	.	100.0	2.0	100.0	6.0
Artemisia arbuscula	100.0	1.0	.	.	.	.
Chrysothamnus nauseosus	.	.	.	.	100.0	1.0
Chrysothamnus viscidiflorus	.	.	.	.	.	.
Prunus virginiana	.	.	.	.	.	.
Holodiscus dumosus	.	.	.	.	.	.
Amelanchier alnifolia	.	.	.	.	.	.
Ribes cereum	.	.	.	.	.	.
Pachistima myrsinites	.	.	.	.	.	.
Purshia tridentata	.	.	.	.	.	.
Eriogonum microthecum	.	.	.	.	.	.
Artemisia tridentata vaseyana	.	.	.	.	.	.
Symphoricarpos oreophilus	.	.	.	.	.	.
Berberis repens	.	.	.	.	.	.

Species	JUSC/SYOR/FEID 4 Plots CON	CHAR	PIMO-JUOS/ARTRV/FEID 2 Plots CON	CHAR
Trees				
Juniperus osteosperma	.	.	100.0	25.0
Juniperus scopulorum	100.0	28.8	.	.
Pinus monophylla	.	.	100.0	23.6
Grasses, sedges and rushes				
Stipa thurberiana	.	.	.	.
Bromus tectorum	75.0	10.0	.	.
Sitanion hystrix	25.0	1.0	50.0	tr
Agropyron spicatum	75.0	1.2	50.0	1.0
Poa secunda	75.0	1.4	50.0	10.0
Stipa comata	.	.	.	.
Koeleria cristata	.	.	50.0	2.0
Elymus cinereus	25.0	2.0	.	.
Elymus glaucus	25.0	2.0	.	.
Festuca idahoensis	100.0	16.0	100.0	12.5
Agropyron spp.	.	.	50.0	tr
Poa spp.	.	.	100.0	tr
Carex spp.	.	.	50.0	tr
Stipa occidentalis	.	.	50.0	1.0
Bromus carinatus	.	.	50.0	tr
Herbs				
Lomatium spp.	.	.	.	.
Penstemon deustus	.	.	.	.
Cryptantha spp.	.	.	.	.
Gutierrezia sarothrae	.	.	.	.
Balsamorhiza hookeri	50.0	0.6	.	.
Draba spp.	.	.	50.0	tr
Chaenactis douglasii	.	.	50.0	tr
Lupinus sericeus	25.0	2.0	.	.
Phlox hoodii	25.0	tr	50.0	tr
Opuntia polycantha	.	.	50.0	tr
Cirsium canovirens	50.0	tr	.	.
Tragopogon dubius	50.0	tr	.	.
Astragalus spp.	75.0	tr	.	.
Antennaria microphylla	75.0	1.0	50.0	5.0
Taraxacum officinale	.	.	.	.
Cordylanthus ramosus	.	.	.	.
Cryptantha spp. (perennial)	.	.	.	.
Arabis spp.	.	.	100.0	tr
Eriogonum microthecum	.	.	.	.
Calochortus eurycarpus	25.0	tr	.	.
Aster scopulorum	.	.	50.0	tr
Erigeron spp.	.	.	50.0	tr
Collomia grandiflora	25.0	tr	50.0	tr
Lupinus spp.	50.0	5.0	50.0	2.0
Agastache urticifolia	25.0	tr	.	.
Aster spp.	25.0	1.0	.	.
Lithospermum ruderale	75.0	tr	.	.
Phacelia spp.	25.0	1.0	.	.
Hieracium albertinum	25.0	tr	.	.
Galium triflorum	50.0	tr	.	.
Achillea millefolium	100.0	1.0	.	.
Senecio spp.	25.0	1.0	.	.
Fritillaria spp.	25.0	tr	.	.
Senecio multilobatus	.	.	100.0	tr
Crepis acuminata	100.0	1.3	.	.
Penstemon spp.	25.0	0.3	.	.
Agoseris spp.	25.0	tr	.	.
Orobanche fasciculata	25.0	tr	.	.
Montia parvifolia	50.0	tr	.	.
Castilleja miniata	50.0	0.3	.	.
Allium acuminatum	50.0	1.0	50.0	tr
Balsamorhiza sagittata	75.0	0.5	100.0	1.5
Hackelia micrantha	75.0	0.4	100.0	tr

Collinsia parviflora	25.0	tr	50.0	tr
Comandra umbellata	25.0	tr	50.0	2.0
Penstemon humilis	.	.	50.0	tr
Arabis holboellii	.	.	50.0	tr
Cryptantha spp. (annual)	.	.	50.0	tr
Polygonum douglasii	.	.	50.0	tr
Heuchera spp.	.	.	50.0	tr
Sedum lanceolatum	.	.	100.0	1.0
Leptodactylon pungens	.	.	50.0	tr
Machaeranthera canescens	.	.	50.0	tr
Senecio integerrimus	.	.	100.0	tr
Castilleja spp.	.	.	50.0	tr
Zigadenus venenosus	.	.	50.0	tr
Shrubs				
Eriogonum caespitosum	.	.	.	.
Artemisia nova	.	.	.	.
Eriogonum umbellatum	.	.	50.0	tr
Artemisia tridentata wyomingensis	25.0	1.0	.	.
Artemisia arbuscula	50.0	1.0	100.0	0.6
Chrysothamnus nauseosus	.	.	50.0	1.0
Chrysothamnus viscidiflorus	100.0	1.8	.	.
Prunus virginiana	25.0	tr	.	.
Holodiscus dumosus	25.0	5.0	.	.
Amelanchier alnifolia	50.0	1.5	.	.
Ribes cereum	100.0	1.5	.	.
Pachistima myrsinites	25.0	2.0	.	.
Purshia tridentata	75.0	7.3	.	.
Eriogonum microthecum	50.0	tr	50.0	tr
Artemisia tridentata vaseyana	100.0	6.5	100.0	10.5
Symphoricarpos oreophilus	75.0	4.0	100.0	10.5
Berberis repens	25.0	1.0	50.0	2.0