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Rick Miller

Jaime Ratchford

Dustin Johnson

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A History of Woodland Dynamics in the Owyhee's: Encroachment, Stand Closure, Understory Dynamics, and Tree Biomass

Rick Miller, Jaime Ratchford, and Dustin Johnson

INTRODUCTION

Piñon and juniper woodlands in the cold desert of the Intermountain West occupy over 44.6 million acres (Miller and Tausch 2001). These woodlands are commonly associated with sagebrush communities forming a mosaic of shrub-steppe and woodland across the region. Numerous studies have documented the recent expansion (since the late 1800's) of these woodlands that has resulted in the replacement of shrub-steppe communities. Recent debate has challenged the degree of expansion in terms of percent of new areas occupied by trees and the increase in total population of piñon and juniper since the late 1800's. Various interest groups have become concerned over the limited scientific evidence documenting the expansion of these conifers at a broad scale (in other words, landscapes or across entire woodlands) in the Intermountain Region. The fear of many groups is historic woodlands that occupied landscapes prior to Eurasian settlement in the late 1800's are being burned, cut, and chained in the name of restoration.

To evaluate the magnitude of expansion on a regional level we evaluated six woodlands from their lower to upper elevational boundaries in four different ecological provinces (Miller et al. 2008). In this report we summarize our findings of woodland expansion in the Owyhee Mountains and discuss our preliminary findings from an ongoing study documenting changes in plant composition, structure, biomass, and fuel loads with increasing tree dominance. Specific questions addressed in this report are:

1. What was the density and spatial extent of trees prior to 1850?
2. What was the chronological sequence of tree establishment and rates of expansion into shrub steppe communities during the past 150 years?
3. What is the current successional state of woodland development (Phase I – early, II – mid, III – late successional)?
4. How do plant cover, structure, and biomass change in relation to woodland succession (Phase I, II, and III)?

STUDY AREA

The study areas are located on Juniper and South Mountain in the Owyhee Mountain Range in Owyhee County, Idaho and are considered part of the Humboldt Ecological Province (Fig. 1). The geomorphology of this area is characterized as an uplifted region with doming and fault blocking common. The Owyhee Mountains are predominantly comprised of granite; however, most of the uplands are overlain by rhyolites and welded tuffs with silicic volcanic flows, ash deposits, and wind-blown loess. Topographic characteristics of this area include mountains dissected by deep canyons, rocky tablelands, and rolling plains ranging in elevation from 3,936 and 7,790 ft.

Climate across the Owyhee Mountains is characteristic of the northern Great Basin in that it is cool and semiarid. Mean annual precipitation within the juniper belts varies between 12 inches at lower elevations increasing to 16 inches at higher elevations. The majority of the annual precipitation is received as snow in November, December, and January and as rain March through June. Average temperatures vary from 20.2°F in January to 94.1°F in July. The growing season varies from 90 to 120 days. Soils range from shallow rock outcrops to moderately deep gravelly, sandy, or silt loams. Predominant soil taxa are Aridisols, Entisols, Alfisols, Inceptisols, and Mollisols that occur in combination with mesic and frigid soil temperature regimes and xeric and aridic soil moisture regimes. The National Resources Conservation Service has described the area's potential natural vegetation as sagebrush-

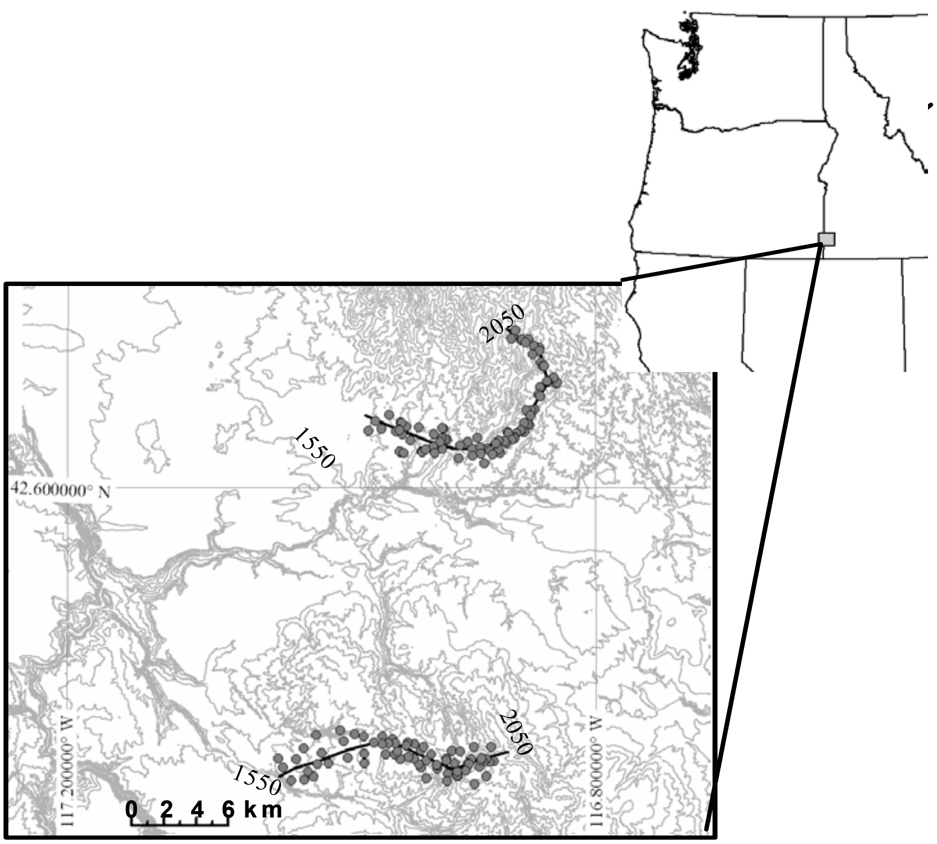

Figure 1. Map of the study locations on South Mountain (north transect) and Juniper Mountain (south transect) in southwest Idaho. Three circular plots were placed approximately every 0.3 miles along 3 parallel transects spaced 0.3 miles apart; plot locations were adjusted to fit within a uniform stand at least 1.25 acres in size with uniform characteristics (e.g. aspect, topography, soil, and vegetation).

grassland. Predominant vegetation in the area is western juniper, mountain big and low sagebrush, Idaho fescue, bluebunch wheatgrass, western needlegrass, Thurber's needlegrass, and Sandberg bluegrass.

METHODS

To gain a landscape scale perspective of both the spatial expansion and increasing density of juniper, we established two transects each approximately 10 miles long across two woodlands on Juniper and South Mountain. Each transect was located along an elevational gradient that extended from the lower to upper boundaries of each woodland. Across the two transects we sampled tree age structure and density. Expansion of post-settlement woodlands was determined by aging (coring and counting the rings) of the three largest trees with post-settlement morphological characteristics. This enabled us to estimate when the first post-settlement trees established on the plot. Tree density was measured by counting live and dead trees in 158, 0.2- to 0.7-acre plots (plot size varied with tree density). Stand density measurements included presence, absence, and density of trees establishing prior to and after 1850, standing dead, stumps, and logs. A complete age structure of trees was measured on Juniper Mountain by aging all trees within the plots. In an ongoing study, near Juniper Mountain we are measuring overstory and understory structure (cover and density) and biomass in 45, 0.25- acre plots.

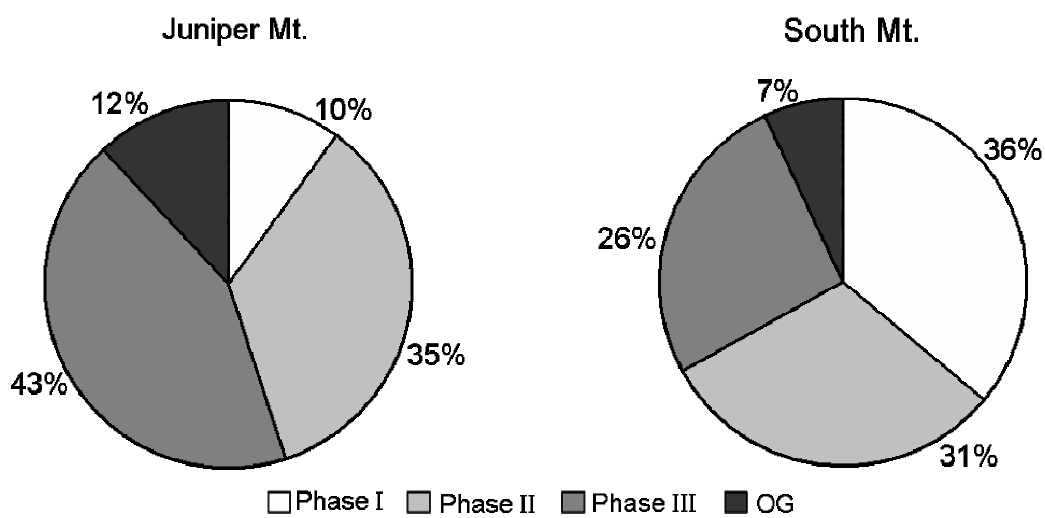

Figure 2. Proportion of woodlands in four successional states; Phase I = trees present but shrubs and grasses dominate the site, Phase II = trees co-dominate the site with shrub and grasses, Phase III = trees dominate the site and shrubs and grasses have declined, and OG = stands with ≥ 75% of the trees older than 150 years.

RESULTS AND DISCUSSION

Presettlement Western Juniper Stands

Prior to 1850, 12% and 7 % of the landscape in Juniper Mountain and South Mountain, respectively, were occupied by juniper woodland (Fig. 2). The remaining 88 to 93% were dominated by shrub-steppe and grasslands with an intermingling of scattered western juniper. Within these shrub-steppe and grassland communities 48 and 67% on Juniper and South Mountain, respectively were occupied by a low density of scattered juniper trees prior to 1850 (Fig. 3a). Of the current population of trees greater than 3 ft tall, 5 and 10% established prior to 1850 (Fig. 3b). Both density and frequency of occurrence of western juniper prior to 1850 were greater across the two Idaho woodlands compared to woodlands measured in southeastern Oregon where pre-1850 trees occurred in less than 30% of the stands measure and 2% or less of the current population of trees (Johnson and Miller 2007).

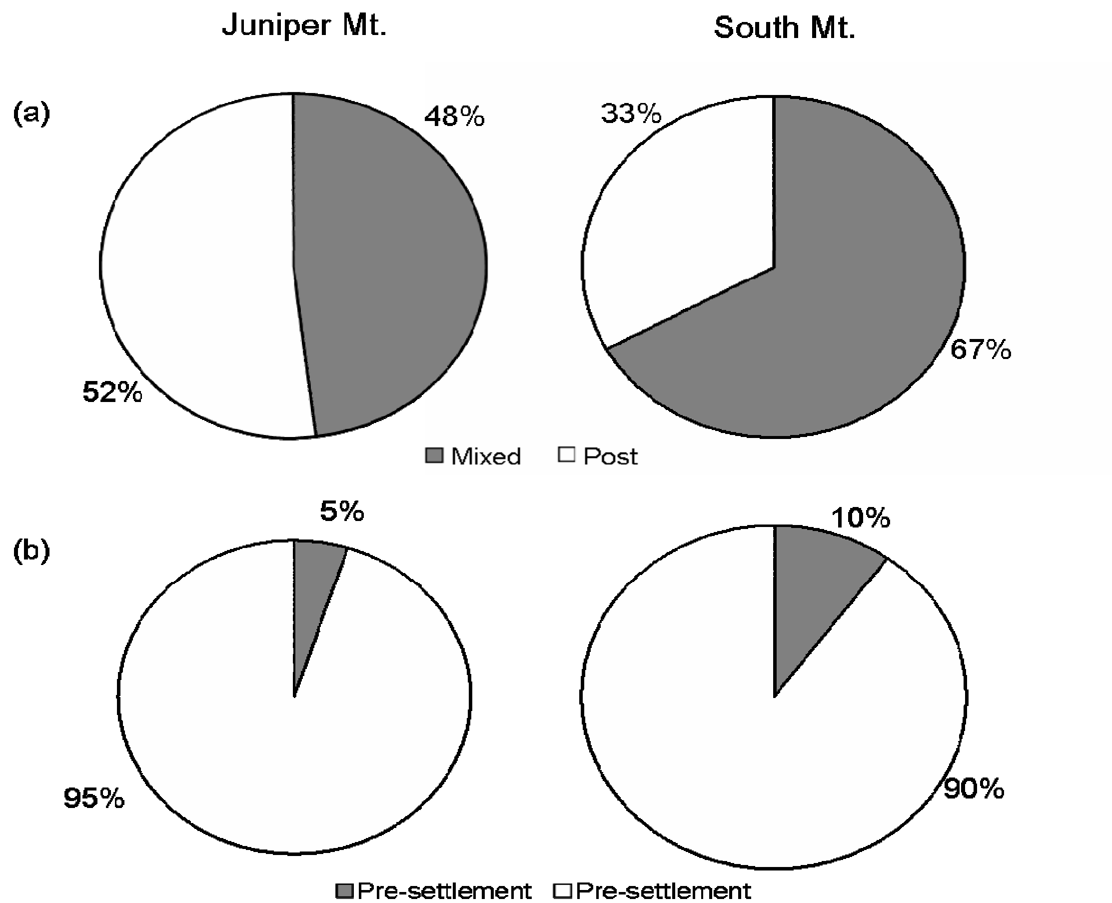

Figure 3. The proportion of (a) mixed age (contained at least on tree $\geq$ 150 years old in a 0.7 acre plot) and post settlement age stands (trees < 150 years); (b) percent of the total tree population $\geq$ 3 ft tall that were presettlement ($\geq$ 150 years old) and post-settlement (<50 years old).

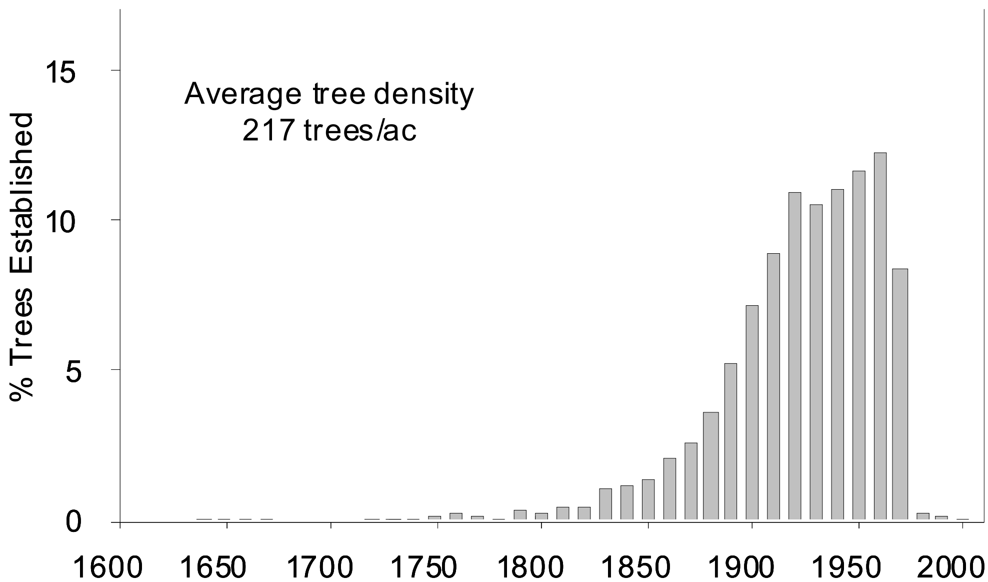

Figure 4. Current mean juniper density and decadal establishment on Juniper Mountain, Idaho.

Pattern of Expansion and Establishment

On Juniper Mountain where we did the intensive age structure sampling, current density of trees is 217/acre. Since 1850, tree densities have increased more than 10 fold. There was a slight increase in the rate of establishment in the mid 1800s, which then increased rapidly during the late 1800s and early 1900s (Fig. 4). The sudden decrease in tree establishment in the past three decades is largely a result of the large proportion of stands that are closed or approaching closure (late Phase II and Phase III). Competition among overstory trees reduces seed crops and tree seedling establishment. The rate of tree expansion into treeless shrub-steppe communities peaked between 1880 and 1930 (Fig. 5). The decline is a result of a shrinking proportion of the landscape without trees. Tree establishment (number of trees establishing/year) rates increased with elevation and a shift from southerly to northerly aspects (Fig. 6). Currently over half of the stands measured on both Juniper and South Mountains are in Phase II and III with a third or less in Phase I (Fig. 2).

Overstory-Understory Relationships

Many of the closed stands today shifted from Phase II to Phase III in the mid 1950s. This is based on a sharp decrease in the relative annual growth rates in the 1950s, which continue to remain low compared tree growth rates in Phase I stands (Fig. 7). The decline is probably caused by intra-specific competition among trees, a result of limited soil resources. As soil nutrients and water become increasingly limited, the abundance of understory vegetation declines. The relationship between understory (shrubs and herbaceous plants) and overstory cover (trees) shown in Figure 8 is for a mountain big sagebrush/Idaho fescue plant association near Juniper Mountain. The maximum juniper cover measured across 31, 0.25 ac

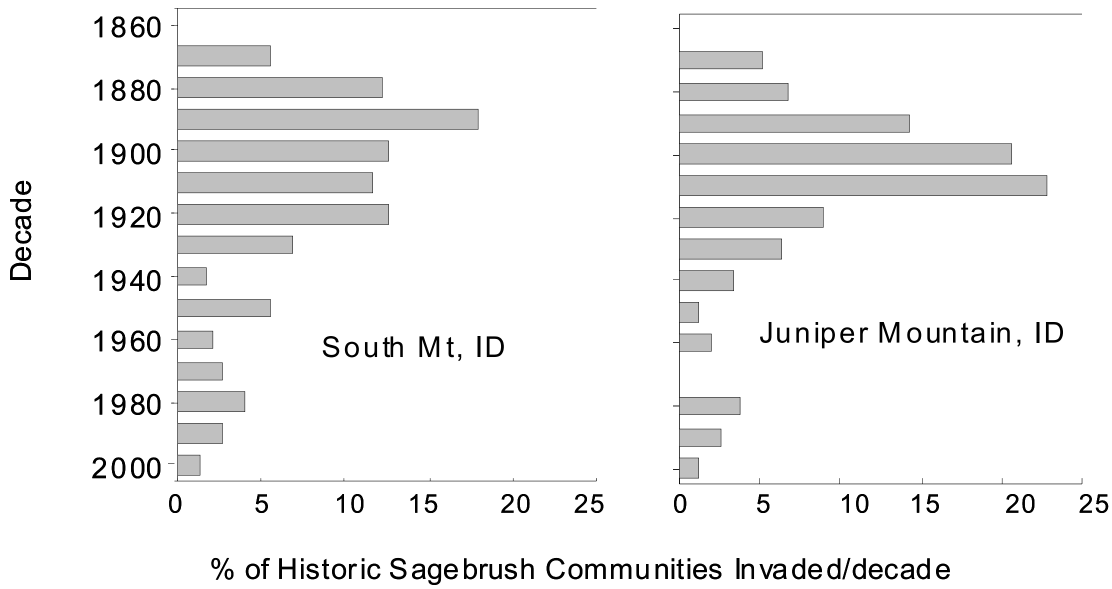

Figure 5. The proportion of decadal encroachment of juniper between 1860 and 2000 into treeless (no evidence of presettlement trees) sagebrush-steppe communities.

plots approached 70% on Juniper Mountain. Similar values have been reported by Miller et al. (2000) for this plant association in southeastern Oregon and northeastern California. Variation of understory cover within phases of woodland development is partially a result of different soil characteristics, especially depth to a restrictive layer. However, the graph illustrates that a shift from Phase I to II occurs at about ¼ of maximum potential juniper cover (approximately 15% tree cover). The shift from Phase II to III occurs at about one-half of maximum potential cover (approximately 30% tree cover). Tree biomass in Phase I was below 9,000 lbs/acre and increasing to over 30,000 lbs/acre in phase III (Fig. 8).

ACKNOWLEDGEMENTS

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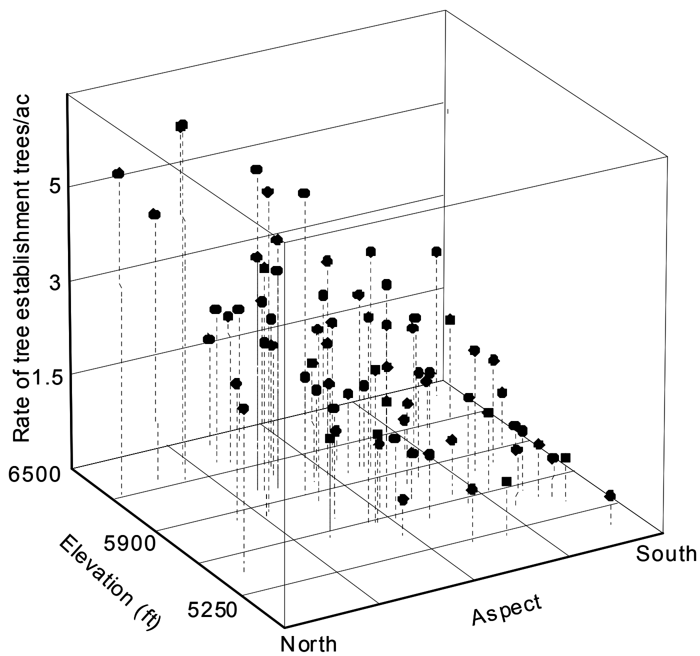

Figure 6. Relationship of tree establishment rates (trees/acre/year) with elevation and site exposure in stands associated with mountain big sagebrush. Site exposure shifts from a northerly to southerly aspect from left to right.

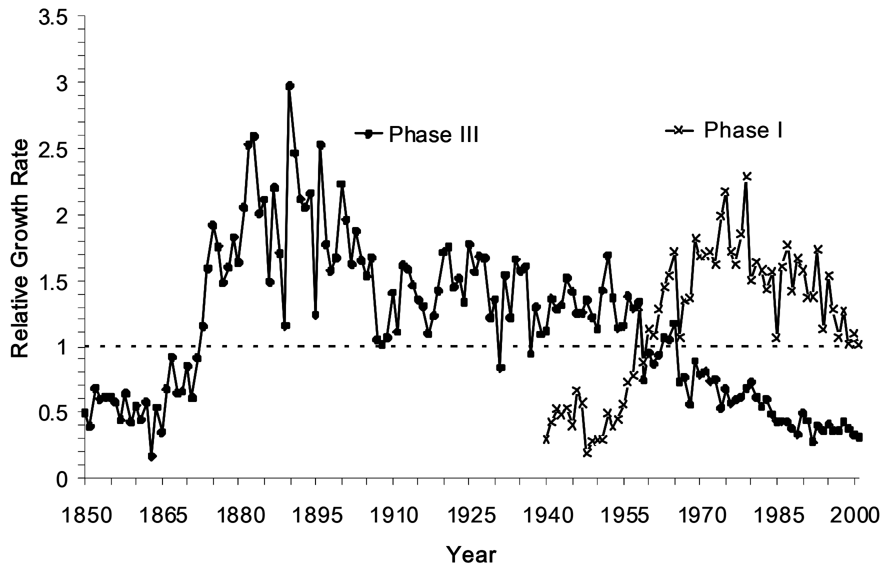

Figure 7. Relative growth rates based on tree ring widths for Phase I and III. Relative growth is typically slow during the first 15-20 years of tree growth. The number 1 is the relative mean ring width for a composite of trees in Phase III. The y-axis is the relative growth rate (or magnitude) of growth compared to the mean. To compare growth rates between Phase I and III, the relative growth rate for trees currently in Phase I was based on the mean growth rate for the Phase III trees.

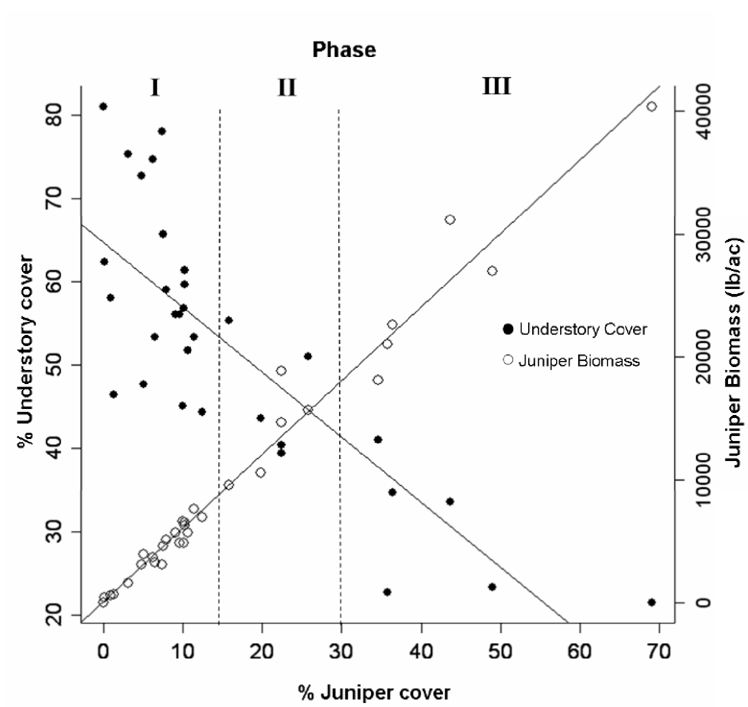

Figure 8. Relationship between overstory juniper cover, total tree biomass, and total understory (shrubs and herbaceous plants) cover. Phase I = trees present but shrubs and grasses dominate the site, Phase II = trees co-dominate the site with shrubs and grasses, Phase III = trees dominate the site and shrubs and grasses have declined.