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Original Research

Climatic Influences on Establishment Pulses of Four *Artemisia* Species in Nevada☆

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ABSTRACT

Shrub recruitment in arid and semiarid regions often occurs in pulses controlled by specific weather events. Previous research suggested that Wyoming sagebrush in Wyoming is no exception. We examined four species/subspecies of sagebrush in Nevada, in 2009 and 2010, to discover if evidence of recruitment pulses was contained in the annual growth-ring records. Sagebrush species and subspecies occur on a wide variety of ecological sites that require different management strategies. Species included black sagebrush (*Artemisia nova* A. Nelson), Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis* Beetle & Young), Lahontan sagebrush (*Artemisia arbuscula* subsp. *longicaulis* Winward & McArthur), and low sagebrush (*Artemisia arbuscula* Nutt. ssp. *arbuscula*). Eighty stem sections were collected from each of 24 stands (6 stands per species or subspecies) at different geographic locations along east-west or north-south gradients where each species or subspecies naturally occurred. Annual growth-ring analysis was used to determine the year of establishment and the relationship between recruitment and weather events. Results indicated stand ages and locations were different ($P > 0.001$) among species and subspecies, and years of recruitment were strongly correlated with local and hemispheric weather patterns. Linear and multiple regressions modeled recruitment pulses for all four species. Weather-based predictor variables indicated complex interactions between recruitment and climatic controls. Pacific Decadal Oscillation (PDO) index variables were prominent predictors for all four species at their associated sites. Other important local weather variables included total annual precipitation the year before recruitment, the year of recruitment, and the year following recruitment. In Nevada and the Great Basin, it is imperative that successful sagebrush seeding technologies are discovered and implemented. Ecological restoration and postfire rehabilitation methods should be timed correctly with respect to precipitation patterns (positive phase PDO) and/or designed to mimic conditions responsible for natural sagebrush recruitment.

Introduction

Woody sagebrush species (*Artemisia* L. spp.) occurrence is circumpolar and often vitally important to the ecological stability and function of the ecosystems they populate. Species from the section *Tridentatae* of the genus *Artemisia* are probably the most spatially widespread shrub (geographic and elevation) in western North America (Meyer, 2008). In the Intermountain West, most members of the section are found on well-drained soils, typically *Aridisols* or *Mollisols,* in areas with relatively cold winters. Annual precipitation is generally low (200 − 700 mm) and occurs largely during the winter months (Beetle and Johnson, 1982). *Artemisia* (L.) is the dominant genus throughout much of the Columbia and Colorado Plateaus, the Great Basin, and western Wyoming. The North American fossil record and later historical accounts indicate that sagebrush has existed in its approximate present-day distribution for at least 1.2 million yr (Tidwell et al., 1972; Barnosky et al., 1987).

Information about sagebrush germination requirements is limited to a few species. Evidence suggests that sagebrush seed requires both cold and light stratification to eliminate dormancy (Meyer, 2008). The amount of precipitation occurring from March to November is a good predictor of sagebrush seed weight (Busso and Perryman, 2005), and greater seed weight is positively correlated with better germination percentages (Busso et al., 2005). Germination timing mechanisms and successful establishment are keyed to a pattern of winter or early spring germination and early spring emergence, for all of the species previously examined (Meyer, 2008). The timing of germination is strongly related to weather variables at the seed collection site (Meyer, 2008). For example, seeds from high-montane environments with long, cold, snowy winters tend to germinate later (i.e., resist early germination),

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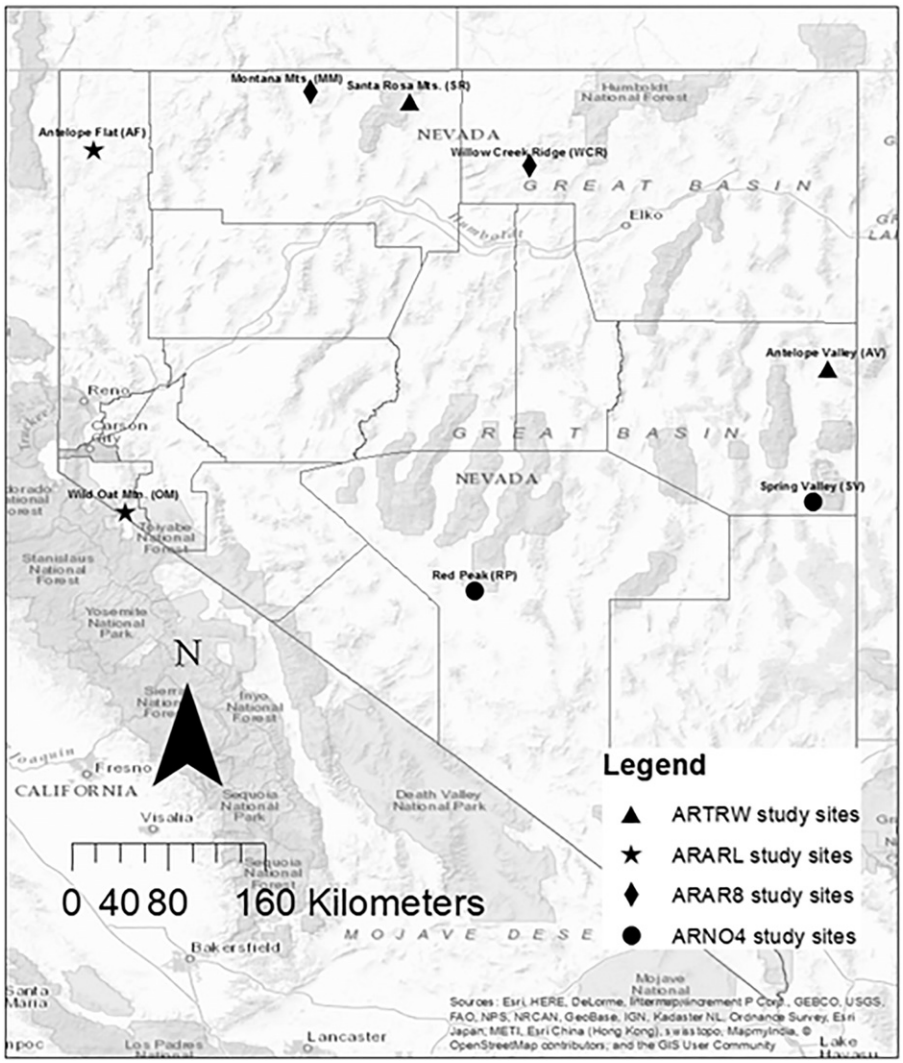

Figure 1. Study site locations.

which protects seeds and their embryos from emerging before temperature conditions are optimum for seedling survival.

Irregular, climatically controlled demographic pulses have been demonstrated for sagebrush species in Wyoming and British Columbia (Cawker, 1980; Perryman et al., 2001) but have not been studied in Nevada. Maier et al. (2001) hypothesized that in northeastern Wyoming, persistent winter snow cover served to protect seedlings from winter desiccation while providing additional soil moisture during snowmelt, ultimately controlling the magnitude of the demographic pulse. Snow cover in Nevada, especially at lower elevations (< 1 829 m) is often less seasonally persistent than in Wyoming.

Several researchers have delineated the presence of climatically controlled demographic pulses in sagebrush and other shrub species across the western United States (West et al., 1979; Cawker, 1980; Maier et al., 2001; Perryman et al., 2001). Understanding the climatic controls responsible for major demographic pulses of various sagebrush species can provide information about cultural practices that may increase the efficiency and success of ecological restoration or fire rehabilitation projects. Knowledge about demographic pulses will also improve our understanding of plant community dynamics, resulting in better state-and-transition models and land management plans. For example, the frequency and size of recruitment pulse events (Maier et al., 2001; Perryman et al., 2001) determines the time needed for an intact sagebrush site that has lost its sagebrush canopy but retains its perennial bunchgrasses to return to its previous level of sagebrush site occupancy. Furthermore, the time required for a return to a previous level of site occupancy is likely to vary by sagebrush species or subspecies and perhaps geographic location in the Great Basin. Since different sagebrush species/subspecies occur on different ecological sites that may require different rehabilitation techniques, several widespread species of sagebrush require investigation. The objectives of this study were to 1) investigate the demographic characteristics of four widespread sagebrush species important to Nevada ecosystems including black sagebrush (*Artemisia nova* A. Nelson), Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis* Beetle & Young), Lahontan sagebrush (*Artemisia arbuscula* subsp. *longicaulis* Winward & McArthur), and low sagebrush (*Artemisia arbuscula* Nutt.); and 2) determine how demographic characteristics are affected by weather variables or trends in annual precipitation.

Methods

In early 2009, study sites (Fig. 1) that represented different locations along geographic gradients where the species or subspecies of interest occurred in unseeded stands were identified. Individual stands were chosen for analysis if they appeared to have multiple cohorts; were similar in ecological site and landscape position; and were relatively free

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