Learning from Project Implementation: Removing Pinyon and Juniper Trees from Sage-Steppe and Grassland Sites on the Fishlake National Forest in Central Utah, USA

Authors: Orlemann, Andrew, and Robison, Douglas L.

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Learning from project implementation: removing pinyon and juniper trees from sage-steppe and grassland sites on the Fishlake National Forest in central Utah, USA

Andrew Orlemann[1,*] and Douglas L. Robison[2]

[1]*Lassen National Forest, U.S. Department of Agriculture, 2550 Riverside Drive, Susanville, CA 96130*
[2]*Fillmore Ranger District, Fishlake National Forest, U.S. Department of Agriculture, 390 South Main Street, Fillmore, UT 84631*

Abstract.—In this paper, we share data collected during implementation of a vegetation management project on the Fishlake National Forest in central Utah. This project—designed to remove encroaching pinyon and juniper trees from sage-steppe and grassland communities—has been ongoing since 2017. While cutting and lopping the targeted woodland species, Fishlake employees counted and measured both cut and leave trees. The resulting data indicate that on sites like this one, the primary postsettlement encroacher is pinyon pine (*Pinus edulis*), and that due to slow growth rates, trees of just 25 cm in diameter at root collar may have been established prior to Euro-American settlement. For managers, it is important to recognize that some proposed pinyon-juniper removal projects will remove primarily pinyon, not juniper. Whether such pinyon eradication is either necessary or desirable should be carefully considered by land managers.

Resumen.—En el presente artículo compartimos los datos obtenidos durante la implementación de un proyecto de control de especies vegetales que se llevó a cabo en el Bosque Nacional Fishlake, al centro de Utah. Este proyecto, que se encuentra curso desde el año 2017, fue diseñado con el objetivo de eliminar pinos piñeros y enebros, de las estepas de artemisas y comunidades de pastizales. Mientras cortaban y podaban las especies arboladas seleccionadas, los empleados del Bosque Nacional Fishlake contaron y midieron tanto los árboles cortados como los vivos. Los resultados indican que, en sitios como este, el invasor primario post-asentamiento es el pino dulce (*Pinus edulis*) y que, debido a su tasa de crecimiento lenta, los árboles con un cuello de raíz de sólo 25 cm de diámetro podrían existir desde antes del asentamiento euroamericano. Es importante que los administradores del Bosque Nacional puedan reconocer que algunos proyectos propuestos para eliminar piñones y enebros, eliminarán principalmente a los piñones y no a los enebros. Por tal motivo, es fundamental que analicen cuidadosamente si el erradicar al piñón es necesario o conveniente.

In recent years, land managers throughout much of the Intermountain West and Great Basin have been concerned about the incursion of woodland species—pinyon and juniper—into other vegetation communities, such as sage-steppe and grassland. Numerous studies have shown that the ranges of these native tree species have expanded and contracted over the past millennia, primarily in response to fluctuations in climate (Wells 1970, Adams 1983, Tausch 1999, Romme et al. 2009); there is also evidence that recent changes have been accelerated by the direct and indirect effects of Euro-American settlement and land use (Miller and Wigand 1994). Under the theory that the latter has had greater influence, land managers have increasingly taken actions to remove pinyon and juniper trees from areas where they appear to have expanded since settlement.

In 2017, the managers of the Fishlake National Forest in south-central Utah authorized one such project, the primary purpose of which was to improve wildlife habitat, particularly for bird species that are dependent on sage-steppe and grassland ecosystems. Approved treatments, both hand and mechanized cutting, were designed to minimize site disturbance and were aimed at the removal of small-diameter pinyon and juniper trees, including *Pinus edulis* Engelm., *Pinus monophylla* Torr. & Frem., *Juniperus osteosperma* (Torr.) Little, and *Juniperus scopulorum* Sarg. The prescription limited removals to stems <38 cm (15 inches) in diameter at root collar so as to preserve

*Corresponding author: andrew.orlemann@usda.gov

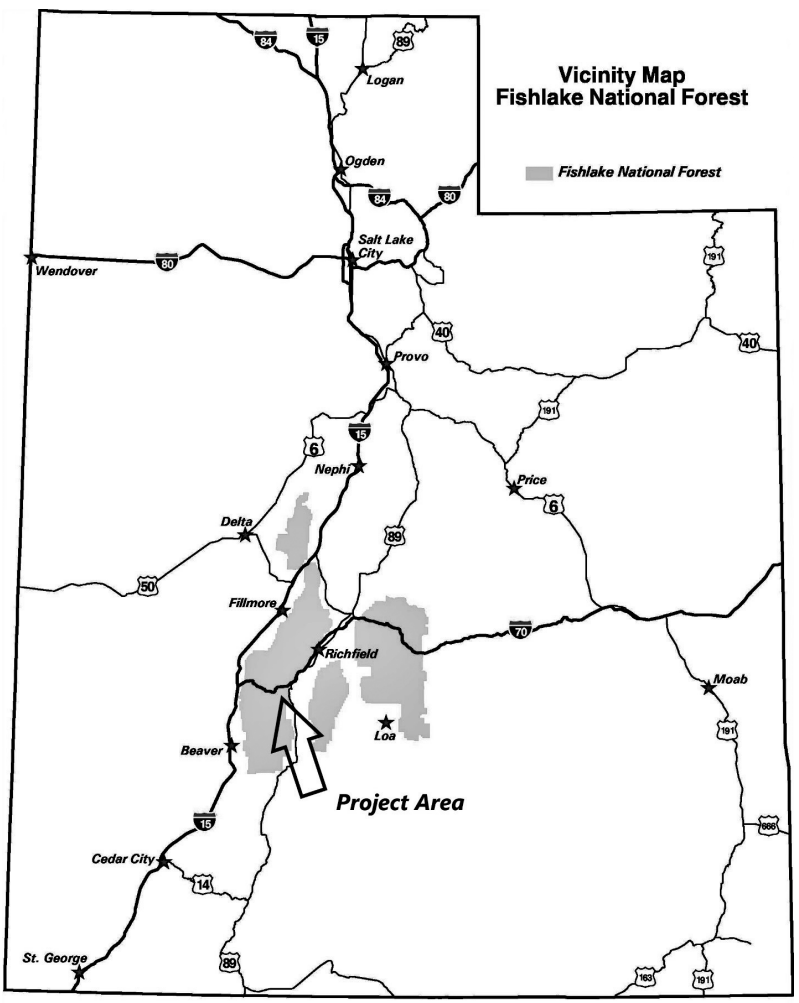

Fig. 1. General location of the project area on the Fishlake National Forest, Utah.

what National Forest staff estimated to be presettlement material. The protocol was for crews to cut the stem of any pinyon or juniper below that diameter threshold at 15 cm (6 inches) or less above ground level, lop the tops to 61 cm (24 inches), and leave the material scattered on the site.

The National Forest System—of which the Fishlake is a part—is the division of the USDA Forest Service that manages public lands, and its employees do not have a research mandate. (The USDA Forest Service Research Stations conduct most research.) Thus, our main purpose for this project initially was to remove these woodland species. As we began implementing the project, however, we soon recognized that we would be primarily cutting pinyon pines, which differed from our expectation and made us curious about species composition and tree establishment patterns on the site. We saw an opportunity to learn by doing. Thus, as we implemented the project, we measured tree density (all trees) and diameters (on a random subset of trees), and we dated a further subset of the cut stems with diameter measurements. This brief article describes the results.

METHODS

Site

We began implementing the project on a 7-ha (17-acre) unit just south of Interstate 70

TABLE 1. Composition of woodland species (*Pinus edulis* and *Juniperus osteosperma*) on our treatment site on the Fishlake National Forest in Sevier County, Utah.

Species	Status	Count	Percent of total
Pinyon	Cut	931	77%
	Leave	44	4%
	Recent mortality	10	1%
	Subtotal	985	82%
Juniper	Cut	171	14%
	Leave	50	4%
	Recent mortality	2	0%
	Subtotal	223	18%
TOTAL		1208	100%

on the Beaver Ranger District in Sevier County, Utah (Fig. 1). The dominant shrub cover on the site is sagebrush (*Artemisia* spp.). Soils are well drained and rocky. The area is generally north-facing, though 3 small hills jut into the unit, creating both east- and west-facing slopes. Elevations range from 1760 m (5775 feet) to 1860 m (6100 feet). Past (and current) uses and disturbances include grazing, scattered post- and pole-cutting, and ATV use. The site is bisected by a major power transmission line, and the tower pads, though rehabilitated, contain significant cheatgrass (*Bromus tectorum* L.) infestations.

Density

For each species, we counted cut trees, leave trees, and recent mortality for a total of more than 1200 stems (Table 1). Although the project also allowed for the removal of single-leaf pinyon and Rocky Mountain juniper, we did not find either in this unit.

Tree Diameters

We measured the diameter at root collar (DRC) of each leave tree and of all the standing dead trees ($n = 106$). We also measured 50% of all cut trees ($n = 482$). Tree diameter was measured using a caliper; each stem at ground level was measured to the nearest tenth inch. For trees with multiple stems at the ground surface, we measured each stem, summed the squares, and took the square root.

Dating

From a further randomly selected subset of cut stems, we removed a cross section at ground level. We returned these samples to the lab, sanded them, and counted rings under a dissecting microscope. Using this method, we approximately dated the year of origin of 42 pinyon and 20 juniper cross sections. We did not, however, obtain cross sections from any of the trees retained on-site, and, as a result, have no age data from the trees >38 cm in diameter.

Modeling

While age-diameter relationships have generally been used in the forest, they can also function in woodlands. Gascho and Bailey (2006) demonstrated that DRC and age were significantly correlated for *P. edulis*. On limestone-derived soils, for example, a simple linear regression using pinyon pine age and DRC variables yielded an r^2 value of 0.90. In addition, while juniper age may, in some situations, be better correlated with tree height than with DRC, Gascho and Bailey (2006) obtained an r^2 value of 0.49 from a linear regression of age and DRC for Utah juniper growing in sandstone-derived soils. Similar to their approach, we used simple linear regressions—plotting our cross-section results against the DRC data—to develop equations that we could use to predict establishment date from DRC.

RESULTS

Species Composition

Prior to treatment, the major woodland species on the site was pinyon (Table 1). Eighty-four percent of what was cut was pinyon, and most of the tree mortality observed was also pinyon (10 of 12). Following treatment, the species composition shifted slightly toward juniper.

Size Classes

Because the project was designed to remove recent woody encroachment, the majority of the cut material was of small diameter. For pinyon, approximately 85% of the cut trees were <13 cm DRC (approximately 5 inches) (Fig. 2, top). Similarly, the junipers we removed were almost all <15 cm DRC (6 inches) (Fig. 2, bottom). Moreover, for pinyon, small trees dominated the site: 90% of all the pinyon trees were <25 cm DRC (approximately 10 inches). In contrast, just 61% of the juniper stems that we measured on the site had diameters of <25 cm.

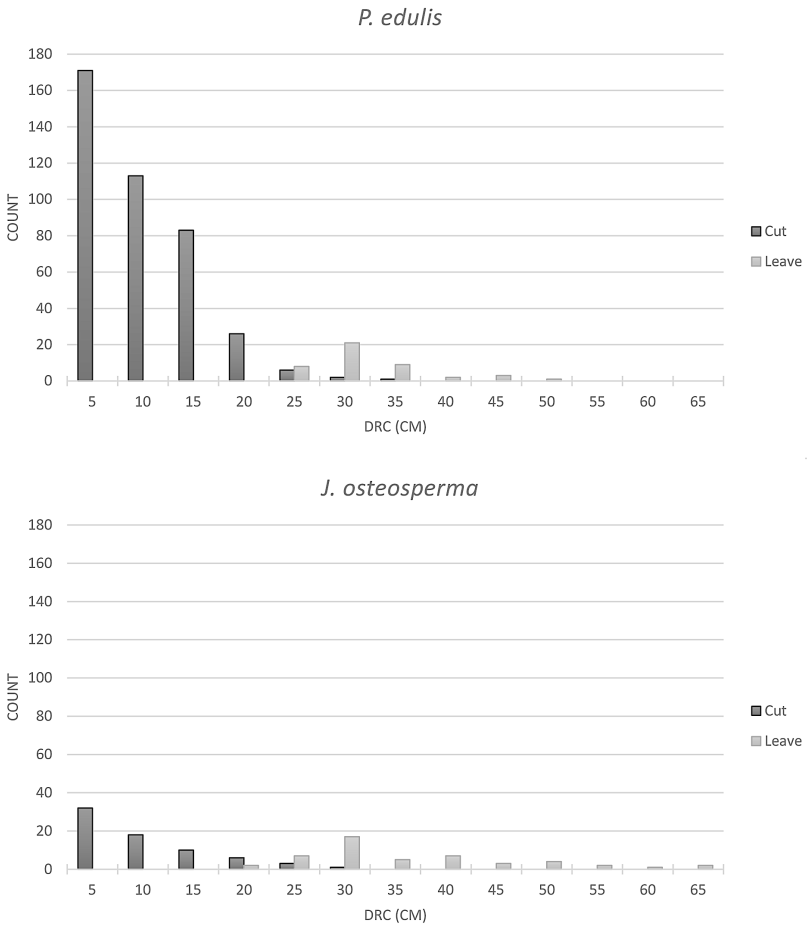

Fig. 2. Distribution of cut and leave stems by diameter at root collar (*Pinus edulis*, top; *Juniperus osteosperma*, bottom).

Growth Rates

The mean growth rates for both species were nearly identical: both species grew at approximately 0.13 cm (0.051 inches) per year on average. Our sample sizes were small, and at other locations we have observed divergent growth rates between the 2 species, but 2 things stand out: first, very small trees (tiny seedlings <2.5 cm DRC) may have become established 20–40 years ago; second, trees ≥25 cm (10 inches) are likely to have been present on the site at the time of Euro-American settlement.

Age-Diameter Relationships

Using simple linear regressions, we developed the following equations to predict tree age from DRC (Fig. 3):

Pinus edulis

age = (5.23 * DRC) + 22.86

$r^2 = 0.82$

Juniperus osteosperma

age = (6.05 * DRC) + 23.61

$r^2 = 0.42$

Establishment Dates

For pinyon pine, there was an episode of establishment in the middle of the nineteenth century followed by a strong upward trend during 1900–1980 (Fig. 4). For Utah juniper, the middle of the nineteenth century also saw a few decades of increased establishment. But, like pinyon, the strongest period for Utah juniper establishment occurred in the middle of the twentieth century, from about 1950 to 1980.

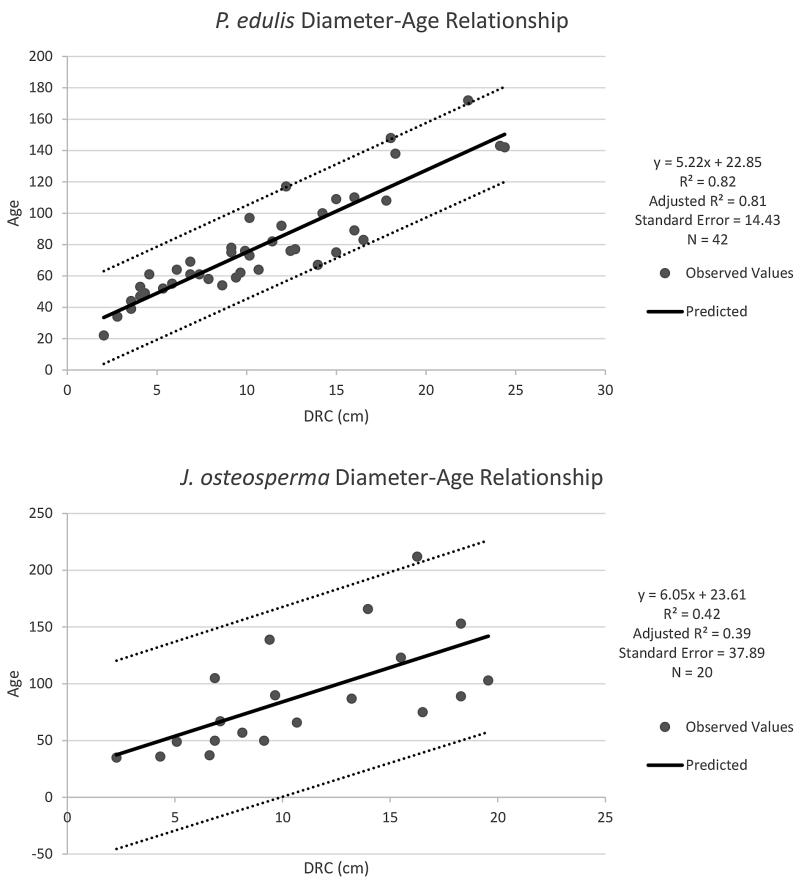

Fig. 3. Linear regression diameter-age relationship and 95% confidence interval for the prediction curve (*Pinus edulis*, top; *Juniperus osteosperma*, bottom).

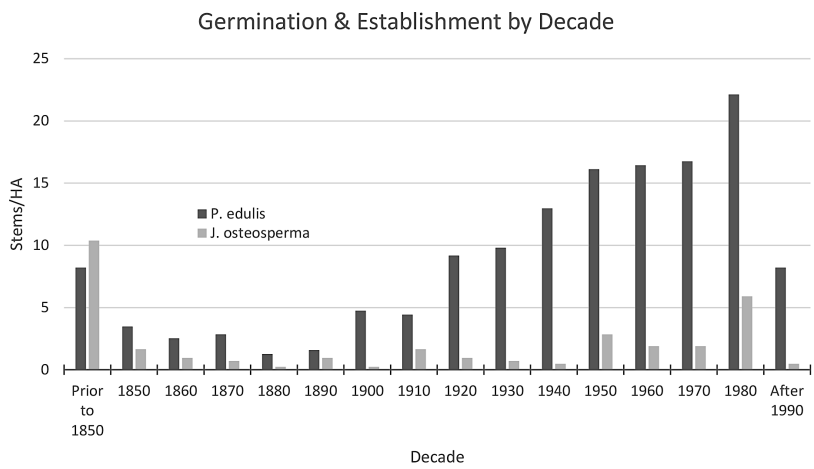

Fig. 4. Frequency distribution of establishment dates by decade for both *Pinus edulis* and *Juniperus osteosperma*. Years of establishment for the oldest and youngest trees were pooled to reflect less certainty in modeled estimates due to the range of diameter data collected. Figure includes both measured and predicted dates; unmeasured stems were included as a proportion of the overall density.

Discussion

Management of the Dominant Species

Pinyon pine is the primary encroacher: our data demonstrate that on our sites, pinyon is the dominant woodland species, and that it has recently enjoyed a period of rapid and successful establishment. Though Utah juniper is certainly present across the Fishlake National Forest in substantial numbers and has also had episodes of successful establishment, its rate of expansion on our site during the middle of the twentieth century was just one-fifth that of pinyon pine. This result is important because land managers and natural resource specialists have often told us that juniper is the concern—that juniper expansion threatens other ecosystems (e.g., see review by Belsky 1996). At the same time, wildlife biologists have often expressed to us a preference for pinyon retention (e.g., Mueller et al. 2005). Thus, if juniper removal and pinyon retention are management goals, there may be no reason to treat many of these sites.

It is also worth noting that pinyon pine can be thinned in a dramatic way by a bark beetle, the pinyon ips (*Ips confusus* [LeConte, 1876] [Coleoptera: Scolytidae]), especially during periods of drought (Floyd et al. 2009, Clifford et al. 2011). In fact, in the period following the 2002 drought, the beetle killed nearly 40,000 trees on the Beaver Ranger District, an impact that has been well documented across the Southwest (Kleinman et al. 2012). Indeed, some researchers have recently expressed concern that pinyon is at risk of large-scale mortality events due to climate change, insect infestations, or both (Kyllo 2016, Johnson et al. 2017). This risk of potentially high rates of pinyon mortality points to the need for managers to be clear about the history, current condition, and potential for future changes of the target species before prescribing its removal.

Pinyon Establishment

According to a number of studies, climate is the primary driver of woodland expansion, and pinyon pine in particular responds to wet periods with increased germination and growth (Barger et al. 2009, Shinneman and Baker 2009, Clifford et al. 2011). Though there were a few dramatic drought years in Utah during the 20th century—1959, 1977, and 2002, for example—the overall trend has been one of increasing precipitation (Gillies et al. 2012), which may have played a role in pinyon establishment on this site. Pinyon pine also appears to benefit from the expansion of woodland types into open rangelands due to creation of favorable microsite conditions via the presence of "nurse" trees (Chambers et al. 1999). Thus, the steadily increasing canopy cover on our site may have been especially helpful to pinyon in recent years. In addition, post-Euro-American settlement land uses, particularly grazing (Shinneman and Baker 2009), may have played a role in pinyon establishment and expansion over the past century (Miller and Wigand 1994). While our data indicate a peak in pinyon establishment during the mid-to-late 1900s, our project was not designed to provide insight into its causes, indicating an area for further research.

Mortality Rates

An obvious problem with a study such as ours is that, with the exception of recently killed trees, we do not account for long-term mortality rates or historic disturbances. Other studies have done so both by using archived data and by taking measurements from tree skeletons (Macalady and Bugmann 2014). Scattered, older deadwood was present on our site, but it was beyond the scope of this project to quantify it or to identify the cause of mortality. Moreover, many small trees have likely germinated and failed to survive through past decades, but we have no record of these. Knowledge of these long-term natural mortality rates and past disturbances could explain at least a portion of the current establishment patterns for both species (e.g., Bristow et al. 2014).

Old Growth

Finally, our data suggest that, in areas where restoration to pre-Euro-American settlement condition is an objective, there is no reason to cut trees >25 cm (10 inches) DRC on these or similar sites within the Beaver Ranger District. Organized settlement of the surrounding communities began in the 1850s (Fillmore, 1851; Beaver, 1856; Richfield, 1864) (Arrington 1994). While possessing an establishment date prior to this time does not mean that a tree should never be cut, the intent with projects like this one has generally been to remove postsettlement material

that became established during a period of increased livestock grazing and fire suppression. That being so, the growth rates that we documented at this particular site suggest that most trees ≥25 cm DRC are approximately 155 and 175 years old or older for pinyon and juniper, respectively.

CONCLUSIONS

In researching the ecological literature regarding pinyon-juniper woodlands for a better understanding of proper management, we have learned that pinyon-juniper tree species are often considered to be "expanding," "encroaching," and "invading" other cover-types, particularly sagebrush. While the evidence—frequently buttressed by repeat photography—often appears strong, we are concerned that some of the assumptions about these invasions may not be entirely supported by the data. In this short article, we present our observations from a small study area in central Utah, and we highlight the possibility that Utah juniper may not be the primary encroacher on many similar sites in the region. Instead, it should be recognized that, if the intent is to remove encroachers, managers may need to focus their efforts on pinyon removal. Moreover, if there is a significant pinyon *ips* outbreak over the current decade, Mother Nature may do the thinning for free. In addition, due to slow growth rates, the targeting of postsettlement trees should be focused on those 25 cm (10 inches) DRC or less. We also recognize that, given the range and diversity of these plant communities, the findings from this small study area may not be representative of other pinyon-juniper landscapes, especially those with dissimilar soils, climate, land use, or disturbance histories. Finally, we suggest that where feasible, managers implementing other such projects throughout the state should count what they cut, thereby providing similar data from multiple locations.

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