Harvesting Considerations for Ecosystem Restoration Projects

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Abstract

There is a need to identify and develop cost effective harvesting systems for ecosystem restoration projects. In the Western United States, pinyon-juniper woodlands are expanding into sagebrush and rangeland ecosystems. In many areas, this growth negatively impacts water, wildlife habitat, biodiversity, and other resources. In other areas, such as Texas and Oklahoma, expansion of eastern redcedar causes similar concerns for landowners. Treatment of these stems through harvesting has been constrained. It is expensive, and markets are limited. The number of stems per acre, transportation infrastructure, and physical stem characteristics are just a few of the variables that may contribute to the high cost of removal. This paper explores current stand conditions and prescribed treatments, then identifies harvesting technologies to meet ecosystem restoration objectives.

Keywords: Biomass Harvesting, Logging, Feedstock Quality

Introduction

Pinyon pine (*Pinus* spp.) and juniper (*Juniperous* spp.) are often referred to as pinyon-juniper woodlands or pinyon-juniper communities. Various species of pinyon and juniper can be found across the western United States (Table 1). States with these species include Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming. The USDA Natural Resources Conservation Service (1987) estimated that pinyon and juniper encompassed 81.9 million acres in the western United States. An estimated 24% of that amount was on non-federal land. By 2009, Romme (et al) estimated the western acreage of pinyon and juniper to be 100 million acres. Regardless of the ecosystem classification of these species as existing in woodlands or in rangelands, the acreage growth (approximately 18% in 22 years) is substantial.

Eastern Redcedar (*Juniperus virginiana*) is another type of juniper that is widely distributed across much of the eastern United States. It ranges from Texas to Maine and as far west as North Dakota and Colorado. The USDA plants database (www.plants.usda.gov, accessed 6/4/2014) indicates that eastern redcedar even exists in two counties in Oregon.

Growth and spread of these species is often attributed to historical management practices. Brockway (2002) references and summarizes many of these activities. Heavy livestock grazing of grasses and forbs may have led to high-density pinyon-juniper woodlands. Fire suppression is also often attributed to the growth and spread of pinyon and junipers. In addition, climatic

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changes may help explain the increase in the range and density of the pinyon and juniper woodlands. Both birds and mammals contribute to the spread of eastern redcedar through ingestion of the fruit-like cones (Horncastle et al, 2004). Management through removals may reduce the rate of spread of eastern redcedar.

Table 1. Primary Pinyon and Juniper Species in the Western United States

Juniper Species
Alligator juniper (*Juniperus deppeana* Steud.)
One-seed juniper (*Juniperus monosperma* (Engelm.) Sarg.)
Western juniper (*Juniperus occidentalis* Hook.)
Utah juniper (*Juniperus osteosperma* (Torr.) Little)
Rocky Mountain juniper (*Juniperus scopulorum* Sarg.)
Pinyon Species
Mexican pinyon (*Pinus cembroides* Zucc.)
Pinyon (*Pinus edulis* Engelm.)
Singleleaf pinyon (*Pinus monophylla* Torr. And Frem.)

Source: USDA, NRCS. 1987

Pinyon pine and junipers can create negative impacts on ecosystems. These trees can displace native plants, reduce habitat quality, and alter groundwater hydrology. In many cases, the numbers of forbs and grasses are reduced by the presence of junipers. Junipers are more effective in competing for water as compared to the grasses and forbs. When pinyon-junipers are removed, vegetative species richness may improve (Brockway, 2002).

There are several different treatments used to control the spread of pinyon and juniper. Chemical treatment has been used to kill the unwanted trees. Mechanical clearing can be accomplished by use of an anchor chain or bulldozer. Mechanical clearing is often followed by piling and burning. Chain saw harvesting has also been used to clear trees, and can be coupled with slash removal or a combination of fuelwood with slash removal. Chadwick et al (1999) found that chainsaw thinning coupled with 'lop and scatter' of felled stems cost 44% more than chaining. Mastication is becoming another popular treatment tool (Tausch and Hood, 2007). Young et al (1982) reported that treatments that remove trees (harvesting or mechanical clearing) leave the site in a state where mechanical treatments can be used for site preparation and seeding.

Anchor chaining is a type of mechanical clearing that has been around for decades. The process commonly consists of pulling a 'U' shaped heavy duty chain between two crawler tractors to fell trees or prepare a seedbed (Cox, 2004). While anchor chaining seems to be a technique that can create soil disturbance, research provides evidence that the disturbance can result in a positive impact on re-vegetation and seedbed preparation. Tausch and Hood (2007) recommend following chaining by prescribed burning to remove surviving trees. Farmer et al (1999) installed a study to quantitatively document the impact of anchor chaining on watershed health. In their 5 year study, they found that ground cover increased after anchor chaining and resulted in reduced runoff and soil erosion.

Costs for treating these juniper trees may be offset if markets develop. This paper reviews some of the uses, feedstock quality considerations, and harvesting options related to junipers.

Wood Uses

Uses for juniper can vary from traditional forest products to food uses to a potential biomass feedstock. Historically, juniper has been used for fuel wood and fence posts. It is also used for clothes hangers, animal bedding, mulch, pencils, and a number of everyday household items. The oils from redcedar are used in a variety of ways. Eastern redcedar oil has long been used to repel moths and fleas, and as a disinfectant (Hiziroglu, 2011). It is even used as a flavoring in food and for its olfactory value in the fragrance industry.

The oils from redcedar are primarily in the heartwood, with a lesser amount in the sapwood (Dunford et al, 2007). Age also has an impact on the amount of oil in the heartwood. Older trees (26 years or older) contain more oil than younger trees. Most oil is sourced from shavings related to furniture manufacture. Hiziroglu (2011) describes a widely used continuous steam distillation method for redcedar oil extraction. In this method, the feedstock would have to be reduced in size to fine particles ranging from 0.098-inch to 0.19 inch. High energy inputs are often required to create fine particles. Wood characteristics, such as fiber responses to chipping or grinding, would need to ensure that the material handling requirements for feeding a continuous process could be met. In addition, some comminution methods create fuzzy edges which can impact material handling (Mitchell and Rummer, 2007) and cause 'bridging' or other material flow problems.

Juniper may have potential as a biomass feedstock. Biomass conversion options for pinyon pine from pinyon-juniper woodlands were explored in Kim et al (2014). They processed finely ground pinyon pine (2 mm or less in size) using pyrolysis and investigated the conversion environment to determine the product yields. In another study, Yathavan and Agblevorwe (2013) report on their investigation of a red mud sludge from bauxite processing as a catalyst for conversion of pinyon−juniper into pyrolysis oils for higher-value applications. Another conversion process, torrefaction, was examined by Eseltine et al (2013) that characterized the friability of the torrefied material sourced from juniper and mesquite.

Harvesting Considerations

The brushy nature and existence of lower branches on junipers adds to the complexity of felling juniper trees. McNeel and Swan (2007) describe a pre-limbing function that precedes felling. In the Oregon study, this function prunes trees from the ground up six or eight feet in preparation for manual chain saw felling. For stems with an average DBH (diameter at breast height) of 13.6 inches, they recommend pruning up to a height of 8 feet. Pre-limbing by chainsaw at this height can be dangerous. Chainsaw manufacturers warn against use of chainsaws above shoulder level. Pole saws may help alleviate this safety risk.

Few alternatives to manual felling exist. Tracked loaders are often examined in situations where low capital investment, coupled with a range of attachments, can increase the number of hours that a machine is scheduled to do work. These attachments address worker safety in that the forest worker is inside the cab of a machine. However, these machines may not adequately address operator safety standards and windshields are often a purchase option. Examples of two felling attachments[3] are displayed in Figures 1 and 2.

Figure 1. Skid steer brush saw attachment for felling (Chappel et al, 2009)

Figure 2. Skid steer felling and accumulating attachment

[3] The use of trade or firm names in this publication is for reader information and does not imply endorsement of any product or service by the U.S. Department of Agriculture or other organizations represented here.

Shrubby shapes and limby stems pose a problem in skidding as well as in felling. Grapple skidders would be a reasonable choice of skidder type. However, the springy limbs and limited bunching due to manual felling could reduce skidder efficiencies. As found by Klepac and Rummer (2000), skidder production can be improved with bunch size. On a related note, tons per turn also impact production. Increased grapple efficiencies are achieved as stems of the skidded material fill the area within the grapples. However, juniper limbs may prevent efficient grappling as the limbs prevent grapples from encompassing more than a few stems. In the McNeel and Swan study (2007), the skidder operator averaged only 2.27 stems per turn. Larger grapples mounted on a small to medium sized skidder may aid in increasing turn payloads. This configuration could match grapple opening size with horsepower, dimensions and tree weight to minimize the cost per ton of skidding (Rummer et al, 2010).

Forwarding can be an alternative to skidding. Rummer and McAvoy (2013) demonstrated the use of a forwarder in Utah. They found that forwarding was a valid option, and was especially suited to areas with larger material, long distance extraction, and steeper terrain. Forwarders with crushing arms to help break the limbs and densify the felled material can help achieve a higher payload and possibly make the cost of forwarding more economical. Forwarders with variable width bunk systems can also result in this type of efficiency through increased bunk capacity.

Delimbing can be by manual or mechanical methods. Manual delimbing can occur at the stump or on the landing. Delimbing at the stump should reduce the amount of slash at the landing and improve skidding production by increasing the number of stems per turn. Alternatively, delimbing can be accomplished at the landing with a pull-through delimber. The numerous limbs on junipers force single stem handling, even in delimbing. Efficiencies are often achieved with multi-stem handling.

Pre-limbing also aids in stem handling when using a pull-through delimber. The limb free bottom portion of each stem improves the loader operator's handling while also assisting with feeding the stem into the pull-through delimber. McNeal and Swan (2007) describe some issues with knife angle and length of delimbing knives. If forest products markets increase the need for delimbed stems, equipment adjustments could possibly be explored to improve delimbing cycle times.

Alternatives for harvesting pinyon-juniper include technologies that process stems at the stump. Mobile terrain chippers can chip felled stems at the stump. These stems could be manually delimbed before chipping or chipped whole tree, depending on the end use. Transportation of chipped material to a landing or road varies. Some machines have on-board hoppers which take the machine out of the processing function while it transports the hopper. While this impacts chipping production, it requires fewer forest workers and additional in-woods transport equipment is not needed. Other machines chip the felled material and blow it out of a spout. These types of machines require some type of capture and transport equipment. A fleet of towed trailers can be used and shuttled back and forth in a way so as to not impact the chipping function. If the terrain allows, vehicles can drive alongside the spout and capture much of the chipped material as it leaves the spout. Various implementation methods can be tested to improve the efficiencies of this type of in-woods transport.

Swathe harvesters, such as the willow harvester (Abrahamson et al, 2010) can cut and chip standing material. The willow harvester uses a vertical shaft mechanism to cut and pull severed stems into the chopper. Processed material is blown from a spout, and like some mobile chippers, requires some type of transportation to the landing or roadside. Technologies like this were developed for use in short rotation woody crops, and the machines may not be robust enough for pinyon-juniper.

Balers offer another alternative for harvesting scattered, shrubby trees. One currently available baler is robust enough to sever, process, and bale standing stems. While the processed material is not a uniform chip, the large round bales provide a compact, high density form, for transport. Application of this technology may be limited to smaller stems (Rummer and McAvoy, 2013). Processed bales also require transport to the landing or roadside. Special trailers or even tractors with bale forks have been successfully demonstrated for off-road transport.

Summary

There have been many meetings and conferences about a variety of topics surrounding pinyon juniper woodlands. Expansion of pinyon and juniper into adjacent areas continues. Many of the treatments focus on clearing the land rather than harvesting stems. Wood uses for pinyon-juniper are broad and vary from essential oils to clothes hangars. In recent years, research has begun to examine pinyon-juniper for a biomass feedstock. Brushy stem character and existence of lower branches pose challenges for harvesting. Existing harvesting technologies continue to be tested in an attempt to harvest these stems at a reasonable cost.

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