RESPONSE OF UNDERSTORY SPECIES TO TREE HARVESTING AND FIRE
IN PINYON-JUNIPER WOODLANDS

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ABSTRACT: Fire and tree harvesting have been used successfully to increase understory production of pinyon-juniper woodlands when applied at the proper seral stage. Natural response is variable among sites and exhibits multiple entrance points into the successional model. Burning and tree harvesting stimulate reestablishment of early-to-midsuccessional species within the pinyon-juniper successional process.

INTRODUCTION

Understory cover in pinyon-juniper woodlands has declined dramatically over the last few decades because of increasing tree dominance (Blackburn and Tueller 1970; Tausch and others 1981). Unfortunately for both livestock and wildlife, the forage base has declined even faster. On some sites one-third of understory production has been lost when trees are still less than 6.6 feet (2 m) in height (West and others 1979) and herbage yields may decline by 82 percent when tree canopy cover exceeds 50 percent (Arnold and others 1964).

Removal of trees is imperative for forage improvement, but indiscriminate destruction of trees to release the understory wastes the tree resource. Tree products, such as cordwood, charcoal, Christmas trees, and nuts have economic value and a good case has been made for their management (Johnson 1975). Jensen's (1972) work in the House Canyon pinyon-juniper management unit of central Nevada demonstrated both tree and forage resources could be improved through appropriate silvicultural practices. Modern silvicultural (Meeuwig and Bassett) and range management (Evans and others 1975) practices recognize site quality differences for tree and forage production and recommend small (<5 acres [2 ha]) treatment areas following an intensive site selection process.

Where woodlands are managed for both forage and wood products, forage may be enhanced in a patchwork of small treated areas. Economic and topographic constraints make small treatment sites unamenable to mechanized seeding, thus natural plant response must improve the forage base. Understory establishment and growth can be expected following release from tree competition as indicated by pinyon-juniper successional models (fig. 1). These models suggest basic trends in plant succession, however, plant response on a particular site is not totally predictable. A site is a composite of subsites (microsites), each with its own sere and rate of successional advancement.

![Diagram of Pinyon-Juniper Succession](image)

Figure 1.--Pinyon-juniper succession following fire (Arnold and others 1964).

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DISCUSSION

Competition Between Tree and Understory Species

Plant response following tree release is influenced by the tree-induced effects that caused understory decline. Tree effects on understory vary with tree species, associated understory species, and site characteristics, thus no one scenario fits all conditions. To avoid confusion and the misinterpretation of findings, both authorship and the predominant tree species in cited studies are given.

Dominant tree species discussed are: Pinus monophylla (PIMO) singleleaf pinyon, Pinus edulis (PIED) piñon, Juniperus osteosperma (JUOS) Utah juniper, Juniperus monosperma (JUMO) one-seed juniper, Juniperus deppeana (JUDE) alligator juniper, and Juniperus occidentalis (JUOC) western juniper. If more than three tree species were covered in a given study, the key (MULT) will be used.

Adjacent trees outcompete most understory species for soil moisture (Jeppesen 1977 [JUOC]), light (Jameson 1966 [JUMO]), and nutrients (Barth 1980 [PIED]), thus understory declines as succession proceeds. In dense stands ubiquitous tree roots (Woodbury 1947 [MULT]; Plummer 1958 [PIED - JUOS]) cause rapid surface soil moisture withdrawal from all soil microsites—the duff (thick needle mat) under the crown, transition zone adjacent to the tree crown, and the interspace between trees. The tree species competitive advantage is partly due to the utilization of soil moisture prior to the breaking of dormancy of many understory species (Jeppesen 1977 [JUOC]) and the presence of a tap root that withdraws moisture at a depth unavailable to grass species (Emmerson 1932 [PIED - JUOM]).

As trees increase in size and the stand thickens, the duff under the tree crown occupies much of the ground surface (>50 percent; Everett and Koniak 1981 [PIMO]). A dense needle mat >10 m² in area under a single large singleleaf pinyon is not uncommon. Duff visibly delineates an area of nutrient enrichment (Barth 1980) at the expense of interspace soils and associated understory.

Pinyon litter physically reduced understory plant establishment; shading or allelopathic effects reduced understory persistence under the tree crown. In time, the understory is displaced from the tree stem of singleleaf pinyon and one-seed juniper (Johnsen 1962). We found understory cover declined in the interspace between adjacent singleleaf pinyon trees, increased at the crown edge, and became negligible under the dense crown (Everett and others² [PIMO]). Understory cover as a whole declined with increased tree cover, but the transition zone adjacent the tree crown became somewhat more "favorable" for understory growth under these conditions. Plummer (1958) reported opposite understory distribution patterns associated with pygmy conifers in Utah, thus no one scenario will fit all understory-overstory species combinations.

Understory species are not equally suppressed by tree competition and this results in discernible species zones around the tree stem (Arnold 1964 [JUMO]; Johnsen 1962 [JUMO]). Several cool season grasses (i.e., prairie june grass Koeleria cristata; western wheatgrass Agropyron smithii; bottlebrush Sitania hystricis; mutton bluegrass Poa fendleriana) are more abundant under or adjacent the tree crown of alligator juniper than in the interspace between trees (Clary and Morrison 1973). We found Sandberg bluegrass (Poa sandbergii) only grudgingly displaced from singleleaf pinyon duff while prostrate forbs were readily expelled. These preexisting species patterns at the time of either burning or harvesting treatments are reflected in post-treatment response as discussed later.

Tree Harvesting and Prescribed Burning Treatment

The literature is replete with reports of increased understory cover and production following tree removal by hand chopping, chaining, herbicides, and prescribed burning (Arnold and Schroeder 1955 [MULT]; Aro 1971 [MULT]; Clary and others 1974 [JUDE - JUOS]; Evans and others 1975 [PIMO]). Mechanical treatments are applicable when planted seed must be covered to establish desirable species and exclude invaders (i.e., cheatgrass Bromus tectorum).

Where seeding or seed covering is not required, prescribed burning can be less expensive than mechanical or chemical treatment (Blackburn and Bruner 1975 [PIMO - JUOS]). Hand-harvested wood can provide a cash crop in itself, and cleared areas provide transitory range. Thus burning and wood harvesting are two viable alternatives for forage improvement. The choice between the two treatments is decided by future use of the site, economic value of the wood, and stand physiognomy.

Controlled burns require an understory adequate to carry fire (Bruner and Klebenow 1979 [PIMO - JUOS]; Richard Young,³ this symposium [JUOC]), thus early-to-midsuccessional stands are usually burned. Prescribed burning has been used successfully to increase understory production and to eliminate tree species (Barney and Frischknecht 1974 [JUOS]; Dyer and Pieper 1967 [JUDE]) and was selected by Aro (1971 [MULT]) as the optimum conversion method where practical. Closed stands lack understory necessary for


³Young, R. P. The use of fire to control and improve wildland sites.
controlled burns, but are more easily harvested for cordwood. Mean-cutting has been used effectively to reduce tree competition in Arizona (Arnold and Schroeder 1955 [MULT]) and Oregon (Jeppesen 1977 [JUOC]).

Plant Response Following Tree Harvesting or Prescribed Burning

The character of plant response following burning or tree harvesting is dependent upon the predisturbance level of understory suppression, which varies with tree cover, the tree species, and the soil type (Clary and others 1974 [JUOS - JUDE]; Springfield 1976 [JUMO - JUDE]). The selected conversion technique and resultant site disturbance further alters plant response (Clary and others 1974) such that quantitative response values can rarely be extrapolated from one project to another. Nevertheless, general trends of plant response and their probable causes can provide insight for land managers in the estimation of potential response on future treatment sites.

Plant succession following burning or tree harvesting may tend toward the standard successional model, but post-treatment plant assemblages may depict any number of the early successional stages (fig. 2). Even though pretreatment stands may be similar, initial plant composition of post-treatment communities can vary considerably (Everett and Ward4). This is due to the irregular germination of soil seed reserves (Koniak and Everett5) and the random immigration of off-site species.

![Multiple Pathways of Early Succession](image)

**Figure 2.**—Natural response following fire or tree harvesting in pinyon-juniper woodlands.


Plant response often varies as much within an array of burn or tree harvest sites as between the two treatments. Precise response is unpredictable for either treatment because of potentially unknown species immigration, soil seed reserves, and post-treatment environmental variables. General plant response may be estimated from soil characteristics such as CaCO$_2$ levels (O'Rourke and Ogden 1969 [JUDE]), soil depth, or stoniness (Stevens and others 1974 [JUOS - PJED]). Elevation, aspect, precipitation, and indicator plant species may also provide an estimate of potential post-harvest response (Stevens and others 1974 [JUOS - PJED]; Winward6). The qualitative character of succession is predetermined at an early stage on many sites because of the presence of numerous plant forms, including many mid-successional species (Everett and Ward6).

Following burning, number of understory species increases because of the rapid return of pretreatment species together with the establishment of numerous fire-induced species (Everett and Ward6). This result could be expected from Nabi's (1978) report that species numbers decline as pinyon-juniper succession proceeds. Tree harvest of fully stocked stands did not dramatically increase species numbers because soil seed reserves were low and few understory plants remained when succession had proceeded this far (Everett 1978; Koniak and Everett5).

Understory species provided approximately 30 percent ground cover 5 years following prescribed burning (Everett and Ward6 [PIMO]), but less than 9 percent cover following tree harvesting on fully stocked singleleaf pinyon stands. Greater understory response following burning was expected because predisturbance understory cover on burns (38 percent) was 10 times greater than predisturbed understory on tree-harvested (3 percent) plots.

Increases in forage production following fire of 400 to 1100 lbs/acre (448 - 1232 kg/ha) have been reported by Aro (1971 [MULT]). Similar increases in herbage production following tree harvesting have been reported by Arnold and Schroeder (1955 [MULT]), Clary (1974 [JUDE]), and Springfield (1976 [MULT]). Herbage production can continue to increase for 13 years following tree harvest (Arnold and others 1964 [MULT]), but response is site and year specific (Clary 1974 [JUDE]). No increase in herbage production following tree removal has been noted on some sites (O'Rourke and Ogden 1969 [JUDE]; Clary and others 1974 [MULT]). Unfavorable moisture regimes and the absence of understory species capable of utilizing released resources were suggested causes for the lack of response.

Plant response is not uniform within treated sites partly because of the various soil microsites present and the pretreatment plant distribution patterns. Burned duff zones have remained devoid of vegetation much like the burned slash piles following mechanical treatments (Arnold and others 1964 [MULT]). Thus plant response has been most rapid in the microsites between the trees on harvest plots.

On tree harvest sites with a contiguous grass understory, response has been greatest at the crown edge. Increased soil moisture storage and nutrient reserves under the duff promote the vigor of established plants in accord with the preharvest plant distribution patterns discussed earlier. Where understory is more sparse, response is less orderly because of the random location of remnant plants, soil seed reserves, and plant establishment from off-site immigration.

CONCLUSIONS

In pinyon-juniper woodlands, understory declines dramatically under intense tree competition for soil moisture, light, and nutrients. Thus, attempts to improve forage by grazing management alone are unsuccessful. Prescribed burning and tree harvesting at different seral stages have generally increased herbaceous growth but response varies considerably. Attempts to predict post-treatment response based on standard successional models have failed because of the multiple entrance points into the successional model and the absence of specific seral stages as succession proceeds. Response has been most fruitful when desirable species already present were capable of utilizing released resources and occurred in sufficient quantities to do so.

Cover and productivity of understory are not uniform across treatment sites following tree removal, but reflect pretreatment plant distribution patterns, and an array of soil surface microsites that vary in available soil nutrients. Response on grossly similar sites, that vary in the proportion of each soil microsite, may well be qualitatively but not quantitatively similar.

Understory response to burning in mid-successional stands can be more rapid than to tree harvesting of fully stocked stands due to the negligible understory of the latter sites. Where understory is more vigorous, post-harvest understory response provides substantial increases in forage.

PUBLICATIONS CITED


Blackburn, W. H.; Bruner, A. D. Use of fire in manipulation of the pinyon-juniper ecosystem. In: Proceedings, the pinyon-juniper ecosystem: a symposium; 1973 May; Logan, UT: Utah State University; College of Natural Resources, Utah Agricultural Experiment Station; 1975: 91-96.


Evans, R. A.; Eckert, R. E.; Young, J. A. The role of herbicides in management of pinyon-juniper woodlands. In: Proceedings, the pinyon-juniper ecosystem: a symposium; 1975 May; Logan, UT: Utah State University; College of Natural Resources; Utah Agricultural Experiment Station; 1975: 83-90.


Johnson, C. M. Pinyon-juniper forests: asset or liability. In: Proceedings, the pinyon-juniper ecosystem: a symposium; 1975 May; Logan, UT: Utah State University; College of Natural Resources; Utah Agricultural Experiment Station; 1975: 121-125.


