Ecological Restoration Institute

Fact Sheet: *What Are the Consequences of Cutting Old Ponderosa Pine Trees?* A Systematic Review

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What Are the Consequences of Cutting Old Ponderosa Pine Trees?
A Systematic Review

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INTRODUCTION

In ponderosa pine forests, restoration treatments (including thinning and prescribed burning) are being implemented to reduce the threat of stand-replacing fire and to restore ecosystem structure, composition, and function to within the natural range of variability. In implementing treatments, old trees (>150 years) are typically retained due to their relative rarity and assumed ecological importance, and because old trees take centuries to replace. The oldest ponderosa pine have unique morphological and presumably functional characteristics and can exceed 700 years in age (Huckaby et al. 2003). The morphology of such trees often includes large trunks and branches, deeply furrowed bark, deformities in crown structure, epicormic branching, big mistletoe brooms, or external fire scars (Harrington and Sackett 1992; Huckaby et al. 2003; Morgan et al. 2002; Swetnam and Brown 1992), and thus they may have different functions than younger trees related to these different structures. As treatments are implemented at increasingly larger scales, a wide variety of thinning treatments, including cutting old trees, have been proposed. We used systematic review methodology to specifically address the question: What are the consequences to ecosystem function of cutting old ponderosa pine trees; particularly, do old trees serve a different function than younger trees?

Photo courtesy the Ecological Restoration Institute

METHODS

We searched Web of Science and Google Scholar in April 2013 and selected studies that met three criteria: (1) Subject: old ponderosa pine trees or stands, in any region; defined as trees >150 years of age; (2) Comparator: young ponderosa pine trees or stands; and (3) Outcome: any ecosystem function or service, including but not limited to biological diversity, fire/drought/insect resistance, carbon sequestration, social values, etc. We scored each study based on the study design (randomized, replicated, and controlled=5, replicated and controlled=4, controlled=3, observational=2, or inadequate due to problems with methodology=1), the quality of the journal (Journal Impact Factor™), and the number of times it has been cited in the scientific literature (according to Google Scholar). The final quality of evidence scores were calculated as: (quality of design) + (impact factor) + (citations/year), and binned in categories of High (score>20), Medium (10<score<20), or Low (score<10).

RESULTS

- Our weight-of-evidence summary showed that studies with greater strength demonstrated positive effects of old trees on ecosystem properties, compared to younger trees, in terms of cone production, basal area increment, and soil respiration (Table 1). Young trees show higher growth efficiency and photosynthetic rates, but there is no difference between old and young trees in terms of nutrient cycling (Table 1). Finally, old-growth stands of trees store more total ecosystem carbon than young trees (Table 1).
- Lower scoring studies (score of 3) showed that old trees have higher scenic beauty than younger trees (Table 1). All the wildlife studies had a quality of evidence score of 3; they produced a variety of positive, negative, and neutral impacts, implying that old-growth stands and younger stands often have different species compositions, and maintaining both types of stands on the landscape leads to higher overall wildlife diversity and abundance. Similarly, the only genetic study we found (score of 3) showed that old trees are no more genetically diverse than young trees, but have a different genetic composition and thus add diversity to the landscape (Table 1).

Response Variable	Result	Quality	Reference
Tree Nutrients/Growth			
Radial growth	+	High	(Knapp and Soulé 2011)
Growth efficiency	-	High	(Yoder et al. 1994)
Photosynthesis rate	-	High	(Yoder et al. 1994)
Litter decomposition rates	0	Medium	(Hart et al. 1992)
Net N mineralization rates	0	Medium	(Kelliher et al. 2004)
CO_2-C mineralization rate	0	Medium	(Kelliher et al. 2004)
Radial growth	-	Medium	(Skov et al. 2005)
Cone production	+	Medium	(Linhart and Mitton 1985)
Soil respiration and assimilation	+	Medium	(Irvine et al. 2002)
Basal area increment	+	Medium	(Fajardo et al. 2007)
Growth efficiency	-	Medium	(Fajardo et al. 2007)
Genetic diversity	+	Low	(Kolanoski 2002)
Wildlife			
Bird species diversity	0	Low	(George et al. 2005)
Flycatcher abundance	+	Low	(George et al. 2005)
Foliage gleaner abundance	-	Low	(George et al. 2005)
Bark gleaner abundance	+	Low	(George et al. 2005)
Woodpecker abundance	-	Low	(George et al. 2005)
Golden-crowned kinglet abundance	+	Low	(Mannan and Meslow 1984)
Red-breasted nuthatch abundance	+	Low	(Mannan and Meslow 1984)
Townsend’s warbler abundance	+	Low	(Mannan and Meslow 1984)
Dusky flycatcher abundance	-	Low	(Mannan and Meslow 1984)
Ruby-crowned kinglet abundance	-	Low	(Mannan and Meslow 1984)
Arthropod species richness/diversity	+	Low	(Gillette et al. 2008)
Arthropod species evenness	0	Low	(Gillette et al. 2008)
Mite abundance	-	Low	(Gillette et al. 2008)
Spider abundance	+	Low	(Gillette et al. 2008)
Beetle abundance	+	Low	(Gillette et al. 2008)
Springtail abundance	0	Low	(Gillette et al. 2008)
Bald eagle roost trees	+	Low	(Stohlgren and Farmer 1994)
Flammulated owl territory/foraging/nesting	+	Low	(Reynolds and Linkhart 1992)
Carbon			
Total ecosystem carbon storage	+	High	(Law et al. 2003)
Total ecosystem carbon content	+	High	(Law et al. 2001)
Net carbon uptake	+	Medium	(Anthoni et al. 2002)
Social			
Scenic beauty	+	Low	(Brown and Daniel 1984)

Table 1. Response variables; results in terms of whether old trees had a positive (+), negative (-), or neutral (0) effect on the response variable compared to young trees; quality of evidence scores; and citations for studies that met search criteria.

MANAGEMENT IMPLICATIONS

The weight-of-evidence (Table 1) indicated that both old and young ponderosa pine trees provide ecological functions; however, young trees are quick to grow and prevalent on the landscape. Further, since some important ecosystem functions are related to tree age (e.g., carbon storage, quality of wildlife habitat, social values, etc.), it is important to differentiate over the range of “old trees” from 150 to 700+ years old when making management decisions. In the Southwest, trees older than 400 years are very uncommon, and over 500 years old are incredibly rare (Swetnam and Brown, 1992). Further, while a 500-year-old tree is replaceable, a living tree that was alive in 1510 is not; nor is its dendrochronological record. There is a dearth of empirical studies on old ponderosa pine trees in terms of their value over young trees, which was a major result of this review. Given that old trees take centuries to “replace,” the precautionary approach suggests old ponderosa pine trees should be protected during management activities. More studies that specifically examine tree age and control for size are needed; if some ecosystem functions could be obtained with simply fast-growing, large trees, that information would be beneficial from a management perspective.

References

Anthoni, P.M., M.H. Unsworth, B.E. Law, J. Irvine, D.D. Baldocchi, S. Van Tuyl, and D. Moore. 2002. Seasonal differences in carbon and water vapor exchange in young and old-growth ponderosa pine ecosystems. *Agricultural and Forest Meteorology* 111:203-222.

Brown, T.C., and T.C. Daniel. 1984. Modeling forest scenic beauty: concepts and application to ponderosa pine. Research Paper RM-256. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Fajardo, A., J.M. Graham, J.M. Goodburn, and C.E. Fiedler 2007. Ten-year responses of ponderosa pine growth, vigor, and recruitment to restoration treatments in the Bitterroot Mountains, Montana, USA. *Forest Ecology and Management* 243:50-60.

George, T.L., S. Zack, and W.F.J. Laudenslayer. 2005. A comparison of bird species composition and abundance between late- and mid-seral ponderosa pine forests. GTR-PSW-198. USDA Forest Service, Pacific Southwest Research Station, Albany, California, USA.

Gillette, N.E., R.S. Vetter, S.R. Mori, C.R. Rudolph, and D.R. Welty. 2008. Response of ground-dwelling spider assemblages to prescribed fire following stand structure manipulation in the southern Cascade Range. *Canadian Journal of Forest Research* 38:969-980.

Harrington, M.G., and S.S. Sackett. 1992. Past and present fire influences on southwestern ponderosa pine old growth. In M. R. Kaufmann, W.H. Moir, and R.L. Bassett (Eds.), Old-growth forests in the Southwest and Rocky Mountain Regions: Proceedings of a workshop (pp. 44-50). Portal, Arizona, USA: Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins, Colorado, USA.

Hart, S.C., M.K. Firestone, and E.A. Paul 1992. Decomposition and nutrient dynamics of ponderosa pine needles in a Mediterranean-type climate. *Canadian Journal of Forest Research* 22:306-314.

Huckaby, L.S., M.R. Kaufmann, P.J. Fornwalt, J.M. Stoker, and C. Dennis. 2003. Field guide to old ponderosa pines in the Colorado Front Range. In (pp. 43). Fort Collins, Colorado: USDA Forest Service, Rocky Mountain Research Station.

Irvine, J., B.E. Law, P.M. Anthoni, and F.C. Meinzer 2002. Water limitations to carbon exchange in old-growth and young ponderosa pine stands. *Tree Physiology* 22:189-196.

Kelliher, F.M., D.J. Ross, B.E. Law, D.D. Baldocchi, and N.J. Rodda. 2004. Limitations to carbon mineralization in litter and mineral soil of young and old ponderosa pine forests. *Forest Ecology and Management* 191:201-213.

Knapp, P.A., and P.T. Soulé. 2011. Increasing water-use efficiency and age-specific growth responses of old-growth ponderosa pine trees in the Northern Rockies. *Global Change Biology* 17:631-641.

Kolanoski, K.M. 2002. Genetic variation of ponderosa pine in northern Arizona: implications for restoration. Northern Arizona University, Flagstaff, Arizona, USA.

Law, B.E., O.J. Sun, J. Campbell, S. Van Tuyl, and P.E. Thornton. 2003. Changes in carbon storage and fluxes in a chronosequence of ponderosa pine. *Global Change Biology* 9:510-524.

Law, B.E., P.E. Thornton, J. Irvine, P.M. Anthoni, and S. Van Tuyl. 2001. Carbon storage and fluxes in ponderosa pine forests at different developmental stages. *Global Change Biology* 7:755-777.

Linhart, Y.B., and J.B. Mitton. 1985. Relationships among reproduction, growth rates, and protein heterozygosity in ponderosa pine. *American Journal of Botany* 72:181-184.

Mannan, R.W., and E.C. Meslow. 1984. Bird populations and vegetation characteristics in managed and old-growth forests, northeastern Oregon. *The Journal of Wildlife Management* 48:1219-1238.

Morgan, T.A., C.E. Fiedler, and C. Woodall. 2002. Characteristics of dry site old-growth ponderosa pine in the Bull Mountains of Montana, USA. *Natural Areas Journal*, 22, 11-19.

Reynolds, R.T., and B.D. Linkhart. 1992. Flammulated owls in ponderosa pine: evidence for preference for old growth. Pages 166-169 in M. R. Kaufmann, W. H. Moir and R. L. Bassett, editors. Old-growth forests in the Southwest and Rocky Mountain Regions: Proceedings of a workshop. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins, Colorado, USA, Portal, Arizona, USA.

Skov, K.R., T.E. Kolb, and K.F. Wallin. 2005. Difference in radial growth response to restoration thinning and burning treatments between young and old ponderosa pine in Arizona. *Western Journal of Applied Forestry* 20:36-43.

Stohlgren, T.J., and C.A. Farmer. 1994. Reevaluating delineated bald eagle winter roost habitat in Lava Beds National Monument, California. *Journal of Raptor Research* 28:205-212.

Swetnam, T.W., and P.M. Brown. 1992. Oldest known conifers in the southwestern United States: temporal and spatial patterns of maximum age. Pages 24-38 in M. R. Kaufmann, W. H. Moir and R. L. Bassett, editors. Old-growth forests in the Southwest and Rocky Mountain Regions: Proceedings of a workshop. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins, Colorado, USA, Portal, Arizona, USA.

Yoder, B.J., M.G. Ryan, R.H. Waring, A.W. Schoettle, and M.R. Kaufmann. 1994. Evidence of reduced photosynthetic rates in old trees. *Forest Science* 40:513-527.

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