Silvicultural Treatments

Carl E. Fiedler

Abstract—Sustainable, ecologically-based management of pine/fir forests requires silviculturists to integrate several treatments that emulate historic disturbance processes. Restoration prescriptions typically include cleaning or heavy understory thinning, improvement cutting to reduce the proportion of firs, and modified selection cutting to reduce overall stand density, leading to stands that are moderately open, primarily ponderosa pine, uneven-aged, and large-tree dominated.

Several sources of information provide the basis for designing appropriate prescriptions for ecosystem-based management (EM) in pine/fir (*Pinus/Pseudotsuga-Abies*) forests. Detailed dendrochronological work in both the Northern Rockies (Arno and others 1995) and the Southwest (White 1985; Covington and Moore 1994), coupled with early photographs and written accounts, provide strong visual, descriptive, and interpretive documentation of common (if not prevalent) pre-European settlement conditions in ponderosa pine (*Pinus ponderosa*) forests. Anderson (1933) and Gruell and others (1982) report that virgin stands in this type were primarily ponderosa pine and uneven-aged or, quoting Meyer (1934), "the typical ponderosa pine forest of the Pacific Northwest is fairly pure, fairly open, and many-aged." Anderson (1933) noted, "Few timber trees west of the Great Plains are better adapted to selective logging than ponderosa pine. Fires, insect depredations, and mortality from old age throughout the past two or three centuries have resulted in uneven-aged stands with a rather irregular distribution of age classes ranging from young seedlings to 600-year-old veterans." Collectively, these sources profile a forest type that was moderately open, uneven-aged, large-tree dominated, and shaped by frequent, low-intensity fires.

The challenge to national forest silviculturists is to integrate a series of silvicultural treatments that will emulate the characteristic disturbance processes in pine forests to produce a semblance of historic structures and conditions—not because they are historic, but because they are sustainable (i.e., vigorous, self-perpetuating, pine-dominated, and at low risk to fire and insects). If silvicultural methods are selected to be compatible with the silvical attributes of ponderosa pine, approximate the nature and intensity of historic disturbances, and develop and sustain the structures that resulted from such disturbances, the path will generally lead to some variant of uneven-aged methods. Historic structures were generally uneven-aged, but not balanced; hence, traditional uneven-aged methods can best serve as points of departure, rather than as specific models for management.

The exact nature of historic conditions in these forests cannot be known, and likely varied substantially from place to place, and at a given place over time. Effects of EM treatments will also vary considerably within a given area on the landscape due to variation in existing stand conditions, application of treatments (particularly fire), and site and terrain features. Because there is no single, discrete "historic condition" does not negate the value of recognizing important features of sustainable conditions—moderate density, large-tree dominance, and primarily ponderosa pine composition—as targets for management. These attributes can be achieved while still allowing considerable latitude in the prescriptive design process to address social, economic, and ecological objectives and concerns. The moderate to low density of historic stands, which was likely both a cause and an effect of the characteristic, low-intensity fires, served several important functions. Moderate density and scattered openings favored regeneration of shade-intolerant ponderosa pine; the associated low fuel levels and frequent burning kept fires generally on the ground and nonlethal; and low density allowed development of large trees with thick bark, which were fire resistant and provided a perpetual seed source to regenerate scattered individuals or groups of trees. Some of this pine regeneration (though few firs) survived the frequent fire gauntlet to develop into large trees, thereby perpetuating the cycle and ensuring sustainability. Target stand conditions that embody these features are moderately open (40 to 90 ft^2/ac), uneven-aged, large-tree dominated [≥20" DBH (Diameter at Breast Height)], and primarily ponderosa pine composition (≥90 percent).

The kinds of silvicultural treatments most appropriate for EM in ponderosa pine/Douglas-fir (*Pseudotsuga menziesii*) forests have seldom been applied, at least in concert, on national forest system lands. For existing stands with irregular or uneven-aged structure, a comprehensive restoration prescription will commonly consist of several treatments: cleaning or heavy understory thinning to break up the continuity of seedling/sapling-sized ladder fuels, a modified selection cutting to reduce overstory density and induce regeneration of ponderosa pine, and an improvement cutting to remove most pole-sized or larger Douglas-fir/true firs and low quality trees of all species not otherwise reserved for snags or other wildlife purposes (Fiedler and others 1999). Alternative treatment regimes for implementing EM in second-growth, even-aged stands are presented by Fiedler (1999).

Stand density following treatment on moderate and drier sites should be less than 50 ft^2/ac to ensure regeneration of shade-intolerant pine, but will vary considerably across the treated area (Fiedler and others 1988). Subsequent harvest entries will occur at 20- to 35-year intervals in the future, when stand density reaches the 75 to 90 ft^2/ac

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Carl E. Fiedler is an Associate Research Professor, School of Forestry, University of Montana, Missoula, MT 59812.

range, depending on site quality, stand conditions, and management objectives. It will be necessary to harvest from about 2 to 5 MBF (thousand board feet per acre) at each entry to achieve the desired reserve density and structure.

In the initial entry, silvicultural treatments will typically need to kill many small trees without commercial value, while removing moderate numbers of medium-sized trees and relatively fewer large trees (usually firs) with commercial value. Fewer trees will need to be killed or removed in subsequent entries, and an increasing proportion of these will be medium- and larger-sized ponderosa pine with substantial commercial value. Leave tree marking is preferred for the initial entry and during the conversion to large-tree dominated conditions since it enables the marker to focus on tree quality, visualize the stand after treatment, and determine residual density more easily (Fiedler and others 1988). One regeneration-related modification of the individual tree selection approach is the creation of patchy openings up to about 1/2 acre by expanding natural openings through judicious marking. Under this approach, each tree is evaluated, with more stringent standards required for leave trees around existing openings. Conversely, occasional groups of larger trees are left intact (or nearly so) to accentuate horizontal and vertical diversity.

Abundant regeneration of ponderosa pine throughout the stand is not required. What is important is that cutting treatments create scattered openings every couple of acres within the stand to induce establishment and early growth of shade-intolerant ponderosa pine. Successional pressure from more shade-tolerant species will also need to be addressed at each entry in most stands, although this pressure should diminish over time if prescribed burning is an integral part of the comprehensive restoration treatment. Fire is especially effective and efficient at killing unwanted fir seedlings (<4.5 ft in height), fire and cutting are both reasonably efficient at killing excess sapling-sized trees, and cutting is generally more efficient for killing trees pole-sized and larger. A primary advantage of cutting, particularly of trees past the sapling stage, is that it allows for the controlled removal of specific trees in terms of number, size, and species to more precisely develop the desired stand condition, whereas fire is a much less selective killing agent. Prescribed burning of sufficient intensity to kill some of the larger trees may well kill the very leave trees desired as part of the future stand. Cutting trees also allows them to be used for timber products, generating income to offset treatment costs.

The initial entry into dense stands with thickets of small trees will likely entail the most severe treatments anticipated in the foreseeable future. Understories in these stands have been developing for decades in the absence of surface fires, and their treatment will generate heavy volumes of slash. Selection cutting in the mid- and upper-canopy and improvement cutting in the fir component will generate additional slash. The combined loading of natural and activity fuels will require well designed prescribed burning of sufficient intensity to reduce hazards and accomplish ecological goals, but not so intense as to damage significant numbers of reserve trees (Harrington, this issue).

Prescribed treatments in the future will entail selection cutting at sufficient levels to induce regeneration of shade-intolerant pine in parts of the stand, increasingly lighter improvement cuttings as the composition of fir decreases, and relatively light cleanings and low thinnings as small-tree density and regeneration are increasingly controlled by prescribed burning, either in concert with, or between harvest entries. Fuel loadings in future entries should be considerably lower than those associated with the initial entry, allowing broader burning windows for application of fire and lower risk of damage to reserve trees.

Air quality regulations, costs, and availability of personnel will likely limit the optimistic burning targets proposed for the future. Cutting treatments can be substituted for some fire effects while other desired effects of burning will not be realized. Even where prescribed burning is generally desirable and feasible, other treatments may be necessary. For example, fire will do little to prepare sites classified within the moister Douglas-fir habitat types for regeneration of ponderosa pine. On these sites, partial mechanical scarification will create conditions more favorable for pine regeneration.

A subtle but fundamental danger of EM is what sometimes appears to be the compromise of silvicultural and ecological principles when developing restoration prescriptions. The propensity to choose thinning-from-below, rather than comprehensive treatments that address all three critical stand characteristics—density, structure, and species composition—is one such example. Reserve density, species composition, and regeneration goals should not be compromised if the target range of conditions is to be achieved and sustained.

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