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Developing and Comparing Silvicultural Alternatives: Goals, Objectives, and Evaluation Criteria

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FIELD NOTE

Developing and Comparing Silvicultural Alternatives: Goals, Objectives, and Evaluation Criteria

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ABSTRACT

We outline an approach for developing and comparing silvicultural alternatives. The approach has multiple advantages, including explicit links between goals, management approaches, and outcomes; efficient development of alternative means of accomplishing the goals; and effective communication of potential tradeoffs between both objectives and alternatives.

Keywords: silviculture, alternatives, Forest Vegetation Simulator, fire metrics

Silviculture is long past the time when it was applied exclusively to meet timber management goals (Guldin and Graham 2007). Silviculturists often find themselves developing plans for projects with multiple and sometimes ambiguous goals involving a broad range of resources and values. Development of silvicultural alternatives should begin with careful characterization of the goals–objectives–evaluation criteria hierarchy. Goals relate to general management direction, objectives represent more precise characterizations of general goals, and evaluation criteria are even more focused and specific with respect to desired outcomes. We suggest an approach that has multiple advantages, including explicit links between goals, management approaches, and outcomes; efficient development of alternative means of accomplishing the goals; and effective communication of potential tradeoffs between both objectives and alternatives.

From Goals to Objectives to Evaluation Criteria

Goals for a given project might come from a variety of sources. For example, they might come from established law or policy; from general management direction, such as standards or guidelines in a forest planning document; from the purpose and need statement for a proposed project, as required by the National Environmental Protection Act of 1969; or from private landowners' broad expectations for their forests. Regardless of their origin, goals are typically general and qualitative (e.g., "enhancing big game winter range" or "reducing risk of bark beetle infestation").

For each stated goal, one or more objectives must be derived. In this context, an objective is a concrete statement that is, in effect, an interpretation of a goal. Objectives should be specific, measurable, achievable, and time bound.

The next step is specifying evaluation criteria for each objective. These are indicators of whether an objective can reasonably be expected to be met by a given management approach (i.e., an alternative). An evaluation criterion, sometimes referred to as an evaluative or effectiveness indicator (Rempel et al. 2004), can be binomial or a continuous variable with a threshold identified as indicative of meeting the objective. Often it is the specification of evaluation criteria that makes objectives quantitative with respect to time and condition and allows effective comparison of alternatives. For each objective, there should be a few (e.g., one to three) well-chosen evaluation criteria that will highlight how alternatives differ with respect to the objective. In our experience, difficulty in specifying evaluation criteria is often a flag indicating that the objective may have been inappropriately characterized and needs to be reconsidered.

Developing and Comparing Silvicultural Alternatives

Development of alternatives should begin with consideration of clearly different approaches for accomplishing the management objectives. For example, an objective relating to future fire behavior might potentially be accomplished with prescribed burning, mechanical treatment, or some combination of the two. For a given basic alternative, there can be variations in the approach to management, e.g., variations in the timing and intensity of a treatment such as thinning. The effects of these variations are evaluated and a preferred system developed within the general framework of that basic alternative. This system will be compared with the best of the systems for other alternative approaches to management. The alternatives, and variations thereof, are individually assessed and compared with each other with respect to the evaluation criteria. Typically, it is necessary to project stand structure and composition into the future for each of the alternatives. Although these projections do not have to be perfect, they do have to be reasonable with respect to the basic elements of the analysis represented by the evaluation criteria.

Graphics are a valuable aid in comparing alternatives, and they should be integral to both the analysis of alternatives and the presentation of results to others. Well-designed graphics focus attention

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on the evaluation criteria and make differences between alternatives explicit with respect to various objectives.

We illustrate this process with an abbreviated example based on a mature second-growth, mixed-conifer stand in the Sierra Nevada Mountains of northern California. Simulations of stand dynamics are based on current stand exam data, including surface fuels. We use the Western Sierra Nevada variant of the Forest Vegetation Simulator (FVS) to simulate each alternative over a reasonable planning horizon (i.e., 50 years). In addition to conventional yield metrics (e.g., volumes, stand and stock tables), FVS is associated with a number of extensions and postprocessors that facilitate comparison of alternatives with respect to, for example, wildlife habitat suitability, hazard ratings for insects or wildfire, and predicting losses from fire and insects (Dixon 2002). The Stand Visualization System extension of FVS can also be effective in communicating important differences between alternatives. Once FVS is initialized for a stand, preliminary screening of an array of alternatives can be done rapidly. The most promising alternatives can then be examined in greater detail with respect to the various evaluation criteria and modified as necessary.

The goals for management of this stand are paraphrased from a project purpose and need statement:

1. Forest vegetation and fuels structure will result in fire behavior in which crown fire is unlikely.
2. The area will consist of healthy stands in which high rates of tree mortality are unlikely.
3. Opportunities will be captured to use activity receipts to offset project costs.

A key step in developing and comparing alternatives is the translation of each of these general goals into focused objective statements associated with specific evaluation criteria. The following objective is an explicit interpretation of the general goal to reduce fire hazard:

Objective 1

Create and maintain fuel profiles and loadings to minimize risk of crown fire under severe fire weather (e.g., 95th percentile).

Evaluation Criterion

Torching index greater than 27 mph.

The second goal concerns reducing the risk of catastrophic loss, which for this stand would most likely result from a mountain pine beetle (*Dendroctonus ponderosae* Hopkins) outbreak or stand replacing fire:

Objective 2A

Maintain relative stand density to reduce the likelihood of a mountain pine beetle outbreak.

Evaluation Criterion

Stand density index (SDI) <250.

Objective 2B

Create and maintain stand structure and fuels profile to reduce the likelihood of stand replacing fire under severe fire weather (95th percentile).

Evaluation Criterion

Mortality <50% of stand basal area.

The third goal has to do with economic efficiency:

Objective 3

Use silvicultural activities to provide commercial wood products.

Evaluation Criterion

Removals >1,000 ft^3/ac.

The goals, as is typical, are qualitative and broad. The objectives are more focused and, when coupled with the evaluation criteria, are quantitative with respect to conditions that can be assessed over time. Obviously, there is considerable flexibility in specifying the criteria by which objectives will be evaluated. We are not suggesting "shopping" for evaluation criteria so as to favor a priori one alternative over another. Rather, we acknowledge there may be more than one appropriate metric by which an objective can be assessed. For example, we used estimates of torching index to quantify the risk of crown fire. Instead, or in addition, we could have chosen an evaluation criterion directly reflecting the fuel profile (i.e., canopy base height). Similarly, with respect to the objective relating to bark beetle activity, we could have chosen to evaluate alternatives using a mountain pine beetle risk rating instead of the more generic stand density index.

Effective evaluation criteria serve to keep the analysis of alternatives focused, and their rationale should be briefly explained and supported with appropriate citations. For example, the evaluation criterion specifying torching index greater than the critical wind speed of 27 mph would be explained on the basis of the weather data and assumptions from which it was derived. It would be noted, for example, that values of torching index that "are multiple times the magnitude of any possible wind speed … [are] characteristic of a forest structure that is extremely resistant to passive crown fire" (Stephens et al. 2009). The threshold criterion of SDI < 250 associated with the objective relating to mountain pine beetle would be supported with a reference to Oliver (1995) or Long and Shaw (2005).

In our example, we include four evaluation criteria. Each alternative must be evaluated against each of these criteria over a reasonable length of time (e.g., 50 years). Ideally, at least one of the alternatives will meet all of the objectives, as indicated by the evaluation criteria. Of course, that does not always happen and, in fact, it is not unusual for some objectives to be mutually exclusive. Realistic projections of stand development in response to treatments allow assessment of how constraints, such as prohibiting removal of trees greater than an arbitrary diameter or restricting use of prescribed fire, might affect the accomplishment of objectives. The exposure of such inconsistencies early in project development is indeed an important value of systematically articulating objectives, specifying evaluation criteria, and developing alternatives that can be judged objectively with respect to the goals. Typically, it is not the role of the silviculturist to set goals or even to prioritize them; however, the silviculturist does have a key role in the evaluation and characterization of potential resource tradeoffs. When inconsistencies are exposed, the process can help focus attention on the goals, e.g., Are they realistic? Are they equally important? The silviculturist can and should evaluate and make explicit for the decisionmaker the important tradeoffs associated with incompatible goals and objectives.

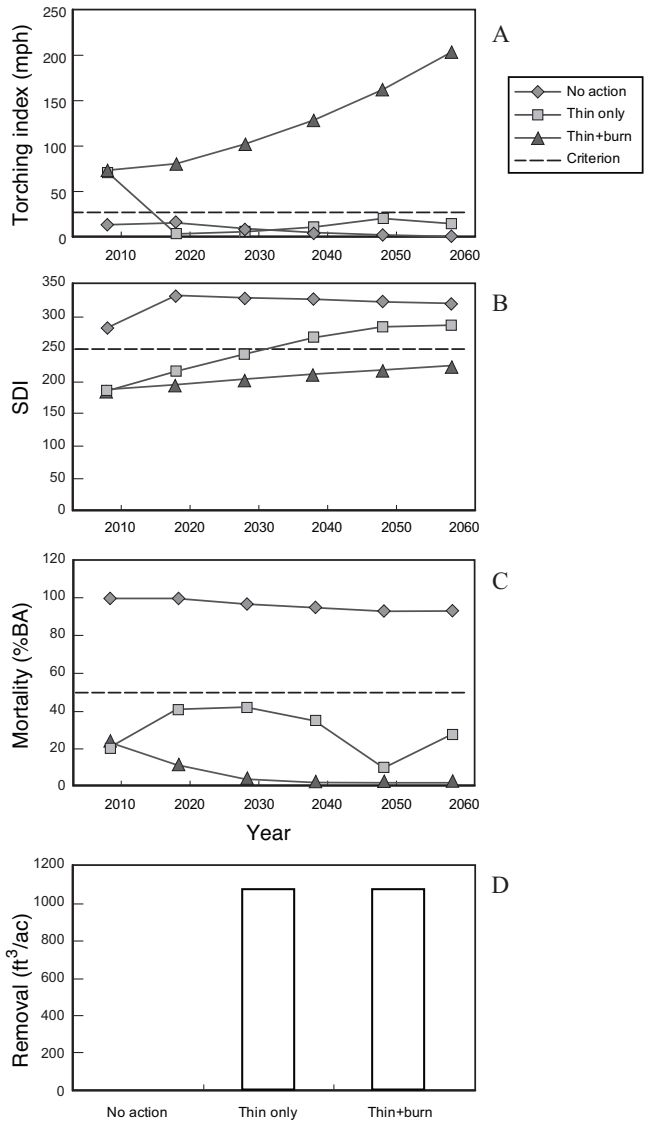

Figure 1. Comparison of three alternatives with respect to evaluation criteria: (A) torching index >27 mph; (B) stand density index (SDI) < 250; (C) mortality <50% of stand basal area (%BA); (D) removals >1,000 ft^3/ac.

To illustrate the process, we have developed and simulated three alternatives with FVS and its Fire and Fuels Extension. The first is the requisite no-action alternative. The second (thinning only) incorporates a thinning-from-below to remove fuel ladders and reduce overstory density. The third (thinning plus prescribed fire) superimposes prescribed fire every 10 years on the thinning-only alternative.

Figure 1 displays how each of the alternatives is expected to perform over time with respect to the evaluation criteria. It is obvious that the no-action alternative meets none of the objectives. It is also clear, for example, that the thinning-only alternative meets all of the evaluation criteria in the short term; however, periodic retreatment is needed to meet the objectives over time. Thinning followed by periodic prescribed fire is the only alternative that meets all objectives over the entire 50-year time frame.

For some projects, it is necessary to develop and compare alternatives for a complete silvicultural system (e.g., an entire even-aged rotation or many cutting cycles of an uneven-aged system). In these cases, the appropriate planning horizon would necessarily be much longer than the 50-year time frame used in our example involving intermediate treatment(s) of an existing stand.

Summary

Silviculturists face complex challenges in developing prescriptions to achieve multiple goals and objectives. At times, conflicting management direction may make it impossible to simultaneously or continuously meet all of the goals and objectives. Silviculturists should attempt to identify these conflicts, as well as trade-offs between feasible alternatives, as early in the planning process as possible.

The systematic development of a silvicultural system, beginning with careful and explicit characterization of the goals–objectives–evaluation criteria hierarchy, is an effective way to identify challenges and ambiguities in management objectives. Simulation of alternatives (e.g., with FVS) allows comparison of alternatives over time with respect to the evaluation criteria. Graphics can make differences between alternatives apparent. This approach greatly facilitates development and comparison of alternatives. We are not proposing this process as a decisionmaking system; however, its outcomes can be used in support of many of the decisionmaking frameworks used in natural resource management.

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