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Conceptual model for comparative ecological risk assessment of wildfire effects on fish, with and without hazardous fuel treatment☆

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Abstract

Wildfire poses risks to fish and wildlife habitat, among other things. Management projects to reduce the severity of wildfire effects by implementing hazardous fuel reduction treatments also pose risks. How can land managers determine which risk is greater? Comparison of risks and benefits from fuel treatment projects to risks from severe wildfire effects is consistent with policies requiring public land managers to analyze short- and long-term environmental effects. However, formulating the problem as a comparison of temporal considerations often results in decisions to reject fuels treatment projects near imperiled species habitat, even though the adverse effects of short-term project actions may result in substantial long-term net benefits from reducing the severity of wildfire effects. Consistent with widely accepted ecological risk assessment methods, the problem is formulated in a conceptual model. Salmonid fish populations are the risk assessment endpoint, and one stressor adversely affecting them is sediment from wildfire or logging. The model compares short-term effects of implementing fuels reduction treatments to longer-term wildfire effects with and without fuel treatments, including risk reduction benefits. Used quantitatively or qualitatively, the model may contribute to sustainable resource management decisions by improving communication among stakeholders, risk managers in land and resource management agencies, and risk assessors in agencies responsible for enforcing the Endangered Species Act.

Keywords: Endangered Species Act; Fire regime condition class; Habitat quality; Hazardous fuels reduction; Healthy forests; Integrated management; Multiple-objective decision analysis; National Environmental Policy Act; Population viability; Risk analysis; Risk management; Salmonid fishes; Sediment; Silviculture; Sustainable resource management

1. Introduction

Forestry decision-making is increasingly difficult (Hollenstein, 2001). Land and resource management decisions always involve risk, including the decision not to take action (Thomas and Dombeck, 1996).

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Resource assessments of western USA federal lands reveal two related management challenges: (1) restoring salmonid fish populations, some of them imperiled and protected by the Endangered Species Act (ESA, 1973); and (2) reducing the potential for lethal fires that can damage fish habitat, water quality, and other resources (Quigley et al., 1996; Quigley and Bigler Cole, 1997). Any approach to integrating fire, fuels, and aquatic ecosystem management has inherent risks and uncertainties (Bisson et al., 2003). Federal managers also are challenged by the decision "process predicament" that tends to inhibit management action (USDA, 2002).

Managers need an integrated problem-oriented approach to reduce wildfire risks by treating fuels without causing irreparable harm to fish populations. I call this the "fire/fish risk problem" and use the US Environmental Protection Agency's *Guidelines for Ecological Risk Assessment* (US-EPA, 1998) to develop a simple conceptual model to support risk-based decisions. The main idea is that sustainable resource decisions are more likely to result from long-term comparisons of the magnitude of adverse and beneficial effects of management action than from the current approach of trying to determine an acceptable level for short-term adverse environmental effects without considering long-term effects. In fire-adapted forests typical of the western USA, adverse environmental effects from the inevitable wildfire burning under uncharacteristic conditions cannot be ignored, nor should the benefits of management designed to reduce the magnitude of wildfire's adverse effects.

Decision analysis and other structured problem-solving methods emphasize the need for clearly articulated objectives, along with criteria to evaluate how well various alternatives might meet those objectives (NRC, 1995). Sustainable resource management depends on clear objectives describing desired future conditions. Objectives provide managers with targets and others with benchmarks for holding managers accountable for their actions. For risk analysis objectives, called assessment endpoints, the EPA *Guidelines* recommend specific ecological entities and their attributes. The *Guidelines* caution against the use of vague concepts, such as "sustainability" and "integrity" (US-EPA, 1998).

The ultimate utility of decision analysis, including risk analysis, is not necessarily articulating the best policy option, but avoiding extreme events (Haimes, 1998). Decision analysis can improve endangered species conservation by making the connection between values, objectives, and decisions more transparent, helping to disarm criticisms that the government is capricious or partisan in implementing the ESA (NRC, 1995). Risk analysis traditionally has been used for other purposes, but it can address forest management issues in a transparent way and disclose risk trade-offs that are often not accounted for in other analysis techniques (Hollenstein, 2001). The problem formulation phase of the EPA *Guidelines* relies on a conceptual model consisting of a risk hypothesis with supporting rationale, and a diagram of predicted relationships. I begin by defining terms, formulating the problem, and identifying model parameters. Three diagrams related to the problem demonstrate the utility of conceptual models. This introductory material rationalizes the choice of selected parameters for the comparative risk assessment model and underpins concluding discussion of several issues associated with potential application of risk models.

2. Definitions

Risk terms are defined (Table 1) because they can pose a barrier to effective communications. At least nine federal agencies, including the US Department of Agriculture, Forest Service, have used the EPA *Guidelines* and agreed that they provide a common basis for analyzing risks (CENR, 1999). The *Guidelines* provide some definitions but are flawed. For example risk analysis is defined too narrowly as determining stressor–response relationships. Elsewhere, risk analysis is the all-encompassing process of risk assessment, characterization, and management (e.g. NRC, 1996; Haimes, 1998; Schierow, 2002; SRA, 2002; von Gadow, 2001). The *Guidelines* also rely on jargon developed in the 1980s for human health and toxicological risk assessment, such as "stressor"—a term that seems synonymous with hazard (Table 1). Furthermore, the *Guidelines* do not define risk or hazard, which are two closely related fundamental concepts.

A hazard is something that can cause an adverse effect. Judgments of adversity are value-based (Lackey, 1997). Risk gives meaning to things, forces,