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Risk assessment for biodiversity conservation planning in Pacific Northwest forests

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Abstract

Risk assessment can provide a robust strategy for landscape-scale planning challenges associated with species conservation and habitat protection in Pacific Northwest forests. We provide an overview of quantitative and probabilistic ecological risk assessment with focus on the application of approaches and influences from the actuarial, financial, and technical engineering fields. Within this context, risk refers to exposure to the chance of loss and typically involves likelihood estimates associated with outcomes. Risk assessment can be used to evaluate threats and uncertainty by providing: (1) an estimation of the likelihood and severity of species, population, or habitat loss or gain, (2) a better understanding of the potential tradeoffs associated with management activities, and (3) tangible socioeconomic integration. Our discussion is focused on threats identified as important influences on forest biodiversity in the region: natural, altered, and new disturbance regimes, and alien and invasive species. We identify and discuss three key challenges and opportunities specific to these threats and quantitative and probabilistic approaches to risk assessment: (1) endpoint selection and calculation of net value change, (2) probability calculations and stochastic spatial processes, and (3) evaluation of multiple interacting threats. Quantitative and probabilistic risk assessment can help bridge the current gap between information provided by general assessment and planning procedures and the more detailed information needs of decision and policy makers. However, management decisions may still fail to win public approval because important risks and issues can be missed or perceived differently by stakeholders. Stakeholder involvement at the inception of a risk assessment can help attenuate these problems. Stakeholder involvement also provides opportunities to communicate information that can influence public risk perceptions and attitudes.
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"Risk is a construct. Before risk there was fate." Bernstein (1996)

1. Introduction

Managing habitat for species of concern and conservation planning implicitly involve the capability to assess and predict the effects of dynamic, stochastic, and interacting natural and human-influenced processes across landscapes. Issues such as timber harvest, fuel build-up, and wildfire hazard now receive the most attention in western U.S. forests, but other disturbances, such as insect and disease outbreaks, changing climate, and alien and/or invasive species (including plants, insects, and diseases) and their interactions also influence forest biodiversity (Wilcove et al., 1998; Logan et al., 2003; Breshears et al., 2005; Dymond et al., 2006). Conserving biodiversity within the context of interacting natural, altered, or new disturbance regimes presents significant management challenges. For example, federal managers in Pacific Northwest forests are charged with protecting old-growth ecosystems in the zone of high wildfire occurence within the eastern range of the Northern Spotted Owl (*Strix occidentalis caurina*), a federally listed species that the Northwest Forest Plan (USDA and USDI, 1994) was designed to protect. Even though the Northwest Forest Plan reduced the overall rate of loss of old-growth forests, the amount of old growth continues to decline in the dry forests regions due to wildfire (Moeur et al., 2005). Ecological restoration and fuel reduction management activities designed to produce open, fire resilient old-growth forests, such as stand thinning and prescribed burning, are often in conflict with habitat conservation goals for Northern Spotted Owls (Spies et al., 2006). Many argue that comprehensive landscape strategies are needed to resolve these types of conflicts and prevent further habitat loss (Wilson and Baker,

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1998; Hessburg et al., 2005; Hummel and Calkin, 2005; Lee and Irwin, 2005; Spies et al., 2006).

Landscape-level strategies to conserve species of concern and their habitats could be advanced by a systematic identification of hazards and assessment of risks, and a clear understanding of potential mitigation outcomes and options. Specifically, risk assessment provides: (1) a process to evaluate threats and uncertainty, including estimations of likelihood and severity of species or habitat loss or gain, (2) a better understanding of potential tradeoffs associated with management activities, including ''no action'' alternatives, and (3) tangible socio-economic integration. In this paper, we provide an overview of ecological risk assessment relevant to Pacific Northwest forest land managers and others charged with protecting and maintaining species of concern. We focus on threats that have been identified as important to biodiversity conservation in the region: natural, altered, and new disturbance regimes, and alien and invasive species (DeLach, 2006; White and Molina, 2006). Examples of how these threats can potentially affect species of concern and their associated habitats have been extensively covered elsewhere (Wilcove et al., 1998; Stein et al., 2000; Harrod, 2001; Peterson and Robins, 2003; Breshears et al., 2005; Lee and Irwin, 2005; Parks et al., 2005; Dymond et al., 2006; Spies et al., 2006; Odion and Sarr, 2007; Vavra et al., 2007). We propose that quantitative and probabilistic risk assessment can provide a robust and flexible landscape-level strategy for project and planning challenges associated with the conservation of species and habitat protection. This focus is largely relevant to public forest land managers engaged in project and forest planning, but private forest landowners, managers, and other stakeholders interested in forest management certification programs and habitat conservation plans may also find this information useful. Our goal is not to provide an exhaustive literature review, but rather to clarify terminology and highlight issues, opportunities, and challenges within this context. A companion paper in this issue, Ager et al. (2007) provides a specific example of quantitative risk assessment of potential wildfire impacts on Northern Spotted Owl habitat.

2. Risk assessment overview

What is risk and what is a risk assessment? These terms are in common usage, but with a number of different meanings to people. Confusingly, the term *risk assessment* has been loosely used for any document or process that assembles and synthesizes data and information to determine whether or where a range of potential hazards might exist to an ecological system or organism (e.g. environmental impact assessments, bioregional assessments, etc.). The term *hazard* generally refers to anything that has the potential to injure or damage and is synonymous with a term often used in ecological risk assessment: *stressor*. The terms *hazard*, *stressor*, and *threat* are often used synonymously with the term *risk*. However, hazard alone is not risk. For example, does every person who plays a game of football become injured? Risk refers to the ''exposure to the chance of loss'' (Haynes and Cleaves, 1999), and typically involves likelihood estimates and probable outcomes. The Society for Risk Analysis (2006) defines risk as ''the potential for realization of unwanted, adverse consequences to human life, health, property, or the environment.'' Although outcomes are traditionally defined as adverse consequences such as property loss, harm, or injury, risk analysis can also include positive effects and net outcomes across both time and space, a point that will be discussed later in more detail.

As human risk assessment became widespread in the 1980s, considerable attention was focused on applying similar formal processes to assess the effects of stressors or threats on ecosystems, creating the discipline of ecological risk assessment (ERA). Over the past 25 years, key definitions, concepts, and systematic processes for ERA have evolved out of statutory frameworks for the regulation of health and environmental risks (U.S. EPA, 1992, 1998; National Research Council, 1983, 1996; Suter, 1993). The EPA defines ERA as ''a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors'' (U.S. EPA, 1992). Reports that describe the EPA's process in greater detail are widely available (U.S. EPA, 1992, 1998). Ecological risk assessment is based on the human risk assessment paradigm, but differs in several critical aspects. For example, unlike human risk assessment, in an ERA no single set of ecological values can be generally applied. Ecological risk assessments also frequently assess a range of effects on more than a single species and may include populations, communities, or entire ecosystems. Effects can be extrapolated from one or a few species to entire communities (U.S. EPA, 1992).

The EPA's ERA framework is the prevailing paradigm in ecological risk assessment (Sikder et al., 2006). However, it is a process, and not a technique. Specific procedures, protocols, and models used within the ERA framework can be qualitative, quantitative, or contain elements of both. Qualitative risk assessments and assessments that contain a combination of quantitative and qualitative components often use expert judgment and ranking systems because data (available data, situation-specific data, relevant empirical information) are lacking or adequate models may not even exist (e.g. Andersen et al., 2004a,b; Landis, 2005; Allen et al., 2006). Yet the complexity of ecological systems can sometimes render verbal models and biological intuition insufficient (Andersen et al., 2004a). Moreover, some risk models have been criticized for using expert judgment about risk and mixing qualitative expert judgment, value-laden terms, and personal preferences (Maguire, 2004). Although lack of data or information may dictate that expert judgment is necessary for risk analysis, there are systematic ways to use expert opinion to avoid mingling opinions about the way the world works with personal values. Systematic use of expert opinion bridges the gap between purely qualitative rating schemes and more quantitative analyses, and can reduce unintentional mingling of facts and values in decision procedures (Shaw, 1999; Maguire, 2004).

Purely quantitative probabilistic tools have been under-utilized in ERA, especially with respect to disturbances. However, probabilistic approaches and influences from the actuarial, financial, and technical engineering fields are