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CLIMATE CHANGE AND FORESTS OF THE FUTURE: MANAGING IN THE FACE OF UNCERTAINTY

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Abstract. We offer a conceptual framework for managing forested ecosystems under an assumption that future environments will be different from present but that we cannot be certain about the specifics of change. We encourage flexible approaches that promote reversible and incremental steps, and that favor ongoing learning and capacity to modify direction as situations change. We suggest that no single solution fits all future challenges, especially in the context of changing climates, and that the best strategy is to mix different approaches for different situations. Resources managers will be challenged to integrate adaptation strategies (actions that help ecosystems accommodate changes adaptively) and mitigation strategies (actions that enable ecosystems to reduce anthropogenic influences on global climate) into overall plans. Adaptive strategies include *resistance* options (forestall impacts and protect highly valued resources), *resilience* options (improve the capacity of ecosystems to return to desired conditions after disturbance), and *response* options (facilitate transition of ecosystems from current to new conditions). Mitigation strategies include options to sequester carbon and reduce overall greenhouse gas emissions. Priority-setting approaches (e.g., triage), appropriate for rapidly changing conditions and for situations where needs are greater than available capacity to respond, will become increasingly important in the future.

Key words: carbon sequestration; climate change; desired conditions; ecosystem management; facilitated conservation; forest management; historical variability; resilience; resistance; wildfire.

COMMUNICATIONS

INTRODUCTION

During the last several decades, forest managers have relied on paradigms of ecological sustainability, historical variability, and ecological integrity to set goals and inform management decisions (Lackey 1995, Landres et al. 1999). These concepts commonly use historical forest conditions, usually defined as those that occurred before Euro-Americans dominated North American landscapes, as a means of gaining information about how healthy forests should be structured. There is no doubt that historical data have immense value in improving our understanding of ecosystem responses to environmental changes and setting management goals (e.g., Swetnam et al. 1999). However, many forest managers also use the range of historical ecosystem conditions as a management target, assuming that by restoring and maintaining historical conditions they are maximizing chances of maintaining ecosystems (their goods, services, amenity values, and biodiversity) sustainably into the future. This approach is often taken even as ongoing climate changes push global and regional climates beyond the bounds of the last several centuries to millenia (Intergovernmental Panel on Climate Change 2007). As importantly, novel anthropogenic stressors such as pollution, habitat fragmentation, land-use changes, invasive plants, animals, and pathogens, and altered fire regimes interact with climate change at local to global scales. The earth has entered an era of rapid environmental changes that has resulted in conditions without precedent in the past no matter how distantly we look. Attempts to maintain or restore past conditions require increasingly greater inputs of energy from managers and could create forests that are ill adapted to current conditions and more susceptible to undesirable changes. Accepting that the future will be different from both the past and the present forces us to manage forests in new ways. Further, although quantitative models can estimate a range of potential directions and magnitudes of environmental changes and forest responses in the future, models rarely can predict the future with the level of accuracy and precision needed by resource managers (Pilkey and Pilkey-Jarvis 2007). We might feel confident of broad-scale future environmental changes (such as global mean temperature increases), but we cannot routinely predict even the direction of change at local and regional scales (such as increasing or decreasing precipitation). A healthy skepticism leads us to use models to help organize our thinking, game different scenarios, and gain qualitative insight on the

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