Chapter 15
Economic Concepts, Methods, and Tools for Risk Analysis in Forestry under Climate Change

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ABSTRACT

Climate change will affect the expected values and distributions of key variables that influence forest management decisions. Risk analysis will likely play a more prominent role in forestry decision making. There are, however, different types of risk problems and different types of models and approaches to choose from. Three possible models that could have application in a climate change risk context are: (1) the Markowitz Portfolio Frontier Model; (2) Expected Value-variance/Chance Constraint Hybrid Model; (3) Discrete Stochastic Programming. These models are applicable in different contexts and answer different questions. For example, the Markowitz model looks for the asset mix that minimizes portfolio variance subject to a minimum expected return. The expected value-variance/chance constraint model accounts for risk preferences and uncertainty in both objective function and constraints variables. The objective function is to maximize certainty equivalent. The discrete stochastic programming model allows for learning to occur and for the decision maker to modify his/her decisions as new information becomes available over a planning horizon.

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INTRODUCTION

Climate change will affect productivity, growth, mortality, species composition, disturbance frequency and intensity, plantation success and the age class structure of forests (Williamson et al., 2009). The expected future values of key variables used in timber supply and economic analysis (such as stand yield and timber prices) will change as will variances. Economic theory predicts that risk affects decisions (e.g., optimal harvest timing choices). Therefore, to the extent that climate change is a source of risk and uncertainty, we might expect that climate change will have impacts in terms of changed utility and changes in solutions that optimize objectives. Increased risk due to climate change, therefore, may result in increased demand for risk modeling approaches in forest management as climate change considerations begin to become incorporated into timber supply analysis and long-term forest management planning. This chapter outlines a number of concepts, methods and approaches for incorporating risk related to climate change into forestry decision models[1]. We review some core economic concepts associated with risk, including expected utility theory, risk preference and certainty equivalent. This is followed by discussion of statistical concepts related to random variables and an approximation method for estimating distribution functions and covariance matrices (i.e., Monte Carlo simulation). We then briefly describe three different types of risk models that may be used in forest management planning.

CLIMATE CHANGE AND FORESTS

There is a growing body of scientific evidence that the earth's climate is changing and that these changes are at least in part due to human activities such as burning of fossil fuels and land-use changes. The IPCC reports that there has been an estimated 0.74 ° C (± 0.18 ° C) increase in mean global temperature over the period 1906-2005 (Intergovernmental Panel on Climate Change 2007). On the basis of scenario projections of atmospheric greenhouse gas concentrations, general circulation models suggest that mean global temperature could increase by a further 1.8 ° C to 4.0 ° C by 2090. In northern countries such as Canada, temperature increases are expected to be even more pronounced (Intergovernmental Panel on Climate Change 2007).

Trees and forests are sensitive to climate. Relatively small changes in ambient climate can have significant impacts on forests in particular locales. The rate of climate change that is expected to occur over the next century will likely exceed naturally occurring rates of climate change. Climatic regimes in particular locales could shift at rates that may exceed the ability of some tree species to migrate in response to climate change or adapt or tolerate the changes in situ (Johnston et al., 2009). Climate change may, therefore, affect the distribution, health, composition and productivity of trees and forests (Williamson et al., 2009). However, there is uncertainty about the direction, timing and magnitude of future impacts on forests and ultimately on forest management at specific locations. One thing is certain. Deterministic predictions of future productivity, survival and species distributions based on historical observation may not provide a useful basis for predictions. These variables are, however, important for long term forest planning, yield estimation and timber supply analysis. Other types of approaches such as modeling, scenario development or solicitation of expert knowledge will be needed. However, the predicted values that result from these approaches will be random and subject to potentially high variances. Thus, the information that supports forest management planning and decision making will shift from being deterministic to being stochastic in nature. One adaptation option available to forest managers is to develop decision support tools that