Integrating risks into management and policy: challenges and economic insights

by Bo Jellesmark THORSEN

Introduction

The prospects of climate change and the inherent uncertainty surrounding it, calls for us to reconsider the way we evaluate and undertake many types of decisions and decision alternatives. While this could be said to be true for so many things in the everyday life to be affected by climate change, it is likely to be particular true and important for decisions with a long time-horizon. Such decisions are in plenty in many aspects of forest management. Forest management embed truly long-term decision on selection of species and genetic traits to favour in the reforestation phases of forestry, the choice of harvest regimes, both thinning of stands and final harvest ages or diameters for mature trees. Forests also cover larger land areas and apart from the roundwood and other marketed goods supply a number of forest environmental services. Many of the decisions actively made — or actively not made — by forest managers have an impact not only on the production of marketed goods, but also on the forests sensitivity climate change induced patterns of risks and hazards that will affect the forests, their productivity and stability, and on the many environmental services that forest provide, from stand level to landscape level.

Uncertainties related to climate change may affect the decision problems faced by forest managers – private and public. It should be stressed that risks and uncertainties come in different forms, raise different issues and may not be perceived in the same way by private forest owners as by society. Already for this reason, the forest owners' handling – through decision making - of climate change induced uncertainties and risk may not coincide with what society would ideally prefer the forest owner to do. This discrepancy may be further enhanced, by the fact that the objective of private forest owners cannot in general be expected to coincide with the objectives of society. For the forest owner, several forest services and values, positive or negative, are external to his ownership and the values it embeds for him, but not necessarily to his decisions. Climate change may affects also the forests' ability to provide crucial environmental services for the benefit of society, positive externalities, and also the risk of forests inflicting negative externalities on its surrounding, e.g. through fire hazard and related environmental costs.

The forest owner, society and the handling of known risks

From the forest owner's point of view several values are subject to risk and uncertainty. Prominently is of course the value of the wood production, including the loss of capital and assets (other than the roundwood) due to forest fires, windthrows, landslides etc, e. g. buildings or roads. But if forests are threatened by large spatial scale changes in ecosystem performance, also the value of marketed recreational goods and services, like hunting, trekking, mushroom picking etc, may come into focus of the forest owner. Finally, the potential costs of damages to externals can eb a concern, if the forest owner can be held liable.

The analyses of forest management under risk have investigated at length the effects of risks on standard forest management measures, e.g. the choice of rotation age, since the seminal paper by REED (1984) and his coworkers, e.g. REED and ERRICO (1985, 1986). The classical result of Reed (1984) is briefly illustrated in Figure 1. Later, these models have been further developed to take into account endogenous risk, e.g. THORSEN and HELLES (1998), MEILBY *et al* (2001, 2003) and GONZALEZ *et al* (2005a, b, 2008).

Less work has been made on possible discrepancies between the views of the forest owner and society in handling risk. Society of course shares the concerns of the forest owner regarding damages from risk, including the potentially increased risk under climate change. However, society may be more concerned than the forest owner, because windthrow and fire storms are seldom local events and may imply a risk to values outside the forest owner's control. Also large scale damages may cause a loss of positive externalities and enhance negative externalities, of little concern to the owner. The appropriate policies to counteract such a discrepancy exist and include, e.g. policy measures to induce owners to minimize risk of fires, to take out insurance against the material losses and liabilities from such events and e.g. in Denmark special transfers exist for contracts ensuring reforestation with species less susceptible to windthrow.

Diversification as a means to balance unknown climate change uncertainties

Climate change will affect the productivity of current forests, forest tree species and forest management systems in unkown, though perhaps not entirely unpredictable ways. To counteract the increased dynamic risk and uncertainties from this effect, the instrument of risk diversification may have much importance for the individual forest owner. The forest owner may diversify any kind of risk by combining his forest management activities with other assets (e.g. WASHBURN and BINKLEY 1993; LUNDGREN 2005), or he may apply various forest management measures to diversify risk in forest management it self. For example, he may reforest with a greater diversity of species to counteract possible uncertainty about which species will perform the better under future climate changes. Society may not care as much about risk as such, as the forest owner, but nevertheless, they may have a strong interest in how forest owners choose to implement diversification measures. Suppose for

example, that at a larger, newly harvested forest area two species may be relevant for reforestation, each believed to react differently to possible, but uncertain, forecasted climate changes. The forest owner may get the same degree of risk diversification from planting one large part with one species and the other large part with the second species. Then, if climate change causes losses on the one species, he may win some on the other. Society, however, may worry more about forests being unhealthy in larger, contiguous forest areas as this may increase the risk of negative externalities like fire risk, leaching of nutrients and loss of amenity values. Thus, they may prefer the forest owner to mix his two species in smaller lots, to reduce landscape level impacts. It may imply a cost for the forest owner to do so and hence an incentive mechanism is called for to align forest owner objectives with social objectives. To my knowledge, little research has been devoted to these issues so far.

Adaptive, dynamic risk handling

From a decision making point of view, uncertainty and risks not only raises the issue of risk diversification, but also further stresses the issue of decision timing. Decisions of the type considered in forest management often have a long time-horizon and tend to be irreversible. In forest economics the issue of decision making, notably timing, has been research at length with a significant focus on the final harvest decision under price uncertainty. Seminal papers include BRAZEE and MENDELSOHN (1988), but also the work of LOHMANDER (1987) and the approach have been extended to include also tax issues (THORSEN 1999a) as well as reforestation measures (ZHOU 1999). The literature on reservation prices is essentially a special strand of work within the larger field of real options (PLANTINGA 1998; THORSEN 1999a). Forest economists have also explored real option issues, e.g. related to the afforestation decision (THORSEN 1999b), the regeneration decision (JACOBSEN 2007), the adjacent harvesting problem (MALCHOW-MØLLER *et al* 2004) and forest investments in general (YIN and NEWMAN 1996).

Turning to the issue of adaptive forest management and uncertainty related to climate change, it is a clear that a great deal of the uncertainty concerns the lack of good information of how climate change will develop and with what impacts. As time unfolds, some of this uncertainty will be resolved and turn in to knowledge and experience. This provides an important additional value to waiting and points towards adaptive forest management strategies, when facing the uncertainty of climate change. Very few papers have yet addressed this, but JACOBSEN and THORSEN (2003) represent one important exception to this rule, the show that there is a significant option value to the mixing of species in the same stand if these may react differently to climate change. If it is a priori impossible to say which species will benefit or loose from climate changes, then mixing them will provide an option to favour, through selective thinning, the one that perform the best as climate change unfolds.

Note, however, that even if this is a more advanced way to handle climate change uncertainty, it makes important assumptions about the ability to span and model possible climate change outcomes a priori as well as dynamics. This is not necessarily a valid assumption when it comes to climate change development.

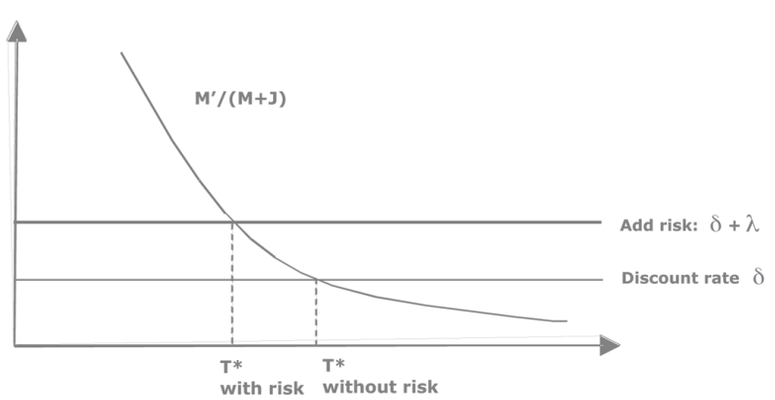

Figure 1:
The effect of a risk of fire on the optimal rotation age, T*, in the Faustmann solution, after Reed (1984). Here M(t) is value of the stand, t is age, and J (T), is the soil expectation value. The discount rate is δ and the risk of fire is λ.

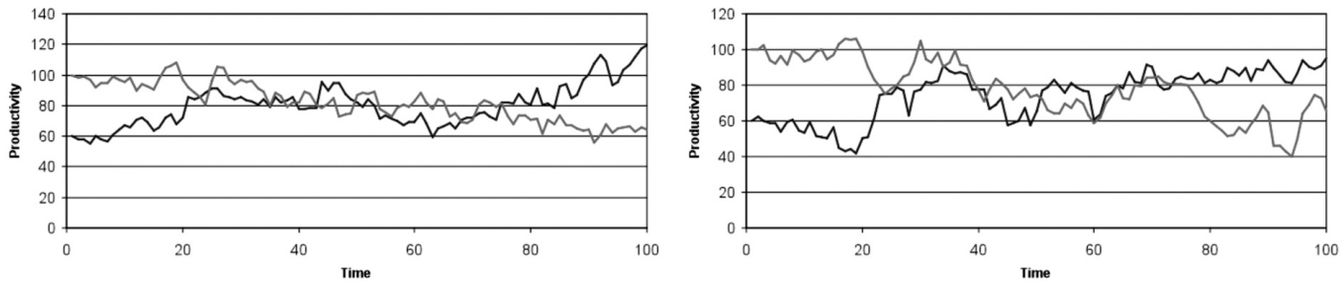

Figure 2:
Hypothetic simulated productivity measures for two different species under two hypothetical climate developments. Illustrating that it may be difficult to predict when productivity ranking will in fact have changed.

A concluding remark on decision making and the (in)predictability of climate change

Science predicts significant climate change over the next century as climate equilibrium adjusts it self in response to the increased content of greenhouse gasses in the atmosphere. However, the development is as yet highly uncertain and furthermore, future equilibrium climate levels as well as the speed of adjustment depends also on the actions of politicians and decision makers today and in the years to come.

From a decision making point of view, this could be said to leave the future climate change hard to predict and certainly that the probabilities assigned to any specific potential scenario will change as time passes and future events unfold and change these probabilities. Due to natural climate change variation it may be several years or decades before fairly firm predictions of the new climate equilibrium can be reliably predicted, see Figure 3 for an illustration. The implication is, that decision making models cannot easily rely on e.g. stochastic dynamic programming approaches, but may in stead turn to simulations and Bayesian methods for analyses.

Nevertheless, the issue of flexible management strategies is relevant for the private forest owner and society both; though of course the actual strategies and decision may again differ. For society and the forest owner both, timely adaptation measures are crucial. For that reason, one important research question is if forest owners form expectations about the future that are systematically different from those of society? If 'yes', forest owners may adapt too quickly or too slow from the view point of society, and society needs to take steps to align expectations. Relevant policy measures include dissemination of the best state-of-the-art research to forest owners. Furthermore, politicians and other key decision makers should signal clearly their policy goals and act accordingly — even if it is to aim for the 4° —scenario. This will reduce uncertainty, align expectations and ensure a better adaptation for society and the forest owners as well.

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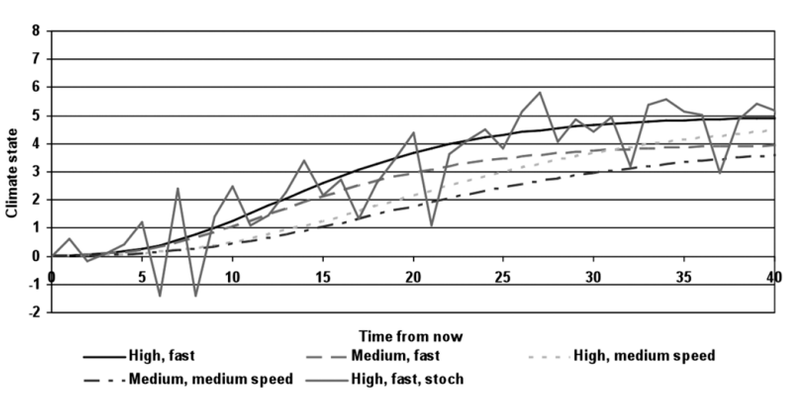

Figure 3:
Conceptual illustration of the difficulty in telling which future climate change path we are on.

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