# Determining the Impact of Hurricane Risk on Optimal Forest Management in Southern Pine Plantations

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## Background

Catastrophic natural events have a significant influence on forest management decisions, and climate change has the potential to increase risks related to hurricanes and other extreme weather events. In the southern U.S., hurricanes pose a major economic threat; from 1949-2006, total economic property losses due to hurricanes amounted to $127 billion, representing 85% of the nation's total losses due to hurricanes.

The traditional Reed model (1984) is a tool used to assess the effect of the risk of catastrophic event on optimal timber harvesting and profitability of a forest stand. One of the limitations of the traditional Reed model is that the probability of risk of catastrophic events and salvageable portion of the forest stand are assumed to be constant for all harvest time periods. Age, as well as biological and ecological conditions of the forest stand, may influence the probability of a natural hazard and the possibility of salvageable operations. These parameters are highly variable and uncertain, thereby increasing the risk of management decisions related to rotation age.

## Methods

We developed a generalized version of the Reed model that accounts for not only risk of natural hazards but also allows all other factors to vary between different timber crops (Figure 1). Consequently, the optimal harvest age may also vary from timber crop to timber crop. We applied the generalized Reed model to a representative even-aged slash pine plantation.

$$\frac{\partial V_k(T_k)}{\partial T_k} + e^{(r_k+\lambda_k)T_k}\emptyset_k = (r_k+\lambda_k)V_k(T_k) + (r_k+\lambda_k)LEV_{k+1}$$

**MRV**

Net marginal revenue of the stand (MRV) resulting from waiting an extra year to harvest

$V_k(T_k)$ = stumpage value of $T_k$ years old stand of timber crop $k$

$\emptyset_k$ = marginal return due to salvage operations for timber crop $k$

$r_k$ = discount rate for timber crop $k$

$\lambda_k$ = probability of risk of fire for timber crop $k$

**MCW**

Marginal cost of waiting (MCW) one extra year to harvest

$r_k$ = discount rate for timber crop $k$

$\lambda_k$ = probability of risk of fire for timber crop $k$

$V_k(T_k)$ = stumpage value of $T_k$ years old stand timber crop $k$

$LEV_{k+1}$ = the future land expectation value for timber crop $k+1$ year

If the MRV ≤ MCW, the landowner should harvest the forest stand.

If the MRV > MCW, the landowner should wait for another time period.

**Figure 1.** The generalized Reed model equation and key relationships. The left side of the equation represents the net marginal revenue of the stand (MRV) by waiting one extra year to harvest. It includes earnings due to the growth in stumpage value and the marginal return due to salvage. The right side of the equation represents the marginal cost of waiting (MCW) one extra year to harvest, including the cost of holding the stand value-interest earned on the stumpage value and the cost of holding the land-interest earned on the future land value.

This equation stipulates a rule regarding harvesting: the optimal harvest age is reached when both sides of the equation are equal. Thus, if the MRV ≤ MCW, the landowner should harvest the forest stand. If the MRV > MCW, the landowner should wait for another time period.

## Results

Increases in the current risk of hurricane-related losses would shorten the predicted optimal harvest age (Figure 2). However, a higher future risk while the current risk remains unaffected would have the opposite impact, therefore lengthening the optimal rotation age. A similar approach is applied to salvageable value, and we find that increases in current salvageable portions would lengthen the harvest age, while higher future salvageable portions would reduce the harvest age. The generalized Reed model indicates that, regardless of the timing of the natural hazard, profitability of forestlands would be negatively impacted. This suggests that increased weather variability, perhaps due to climate change or changes in local weather patterns, would have negative consequences for profitability in southern pine plantations.

## Implications

The risk of hurricanes is not under human control, which means that there is a need for mitigation practices to help lessen the impacts of hurricanes. For example, coordinated efforts on the part of government could encourage landowners to enroll in a catastrophic risk insurance system to enhance the financial stability of forest management. Other strategies to reduce vulnerability to hurricanes may include changes in stand structure by balancing tree age classes and managing stand density to create wind resistant stands.

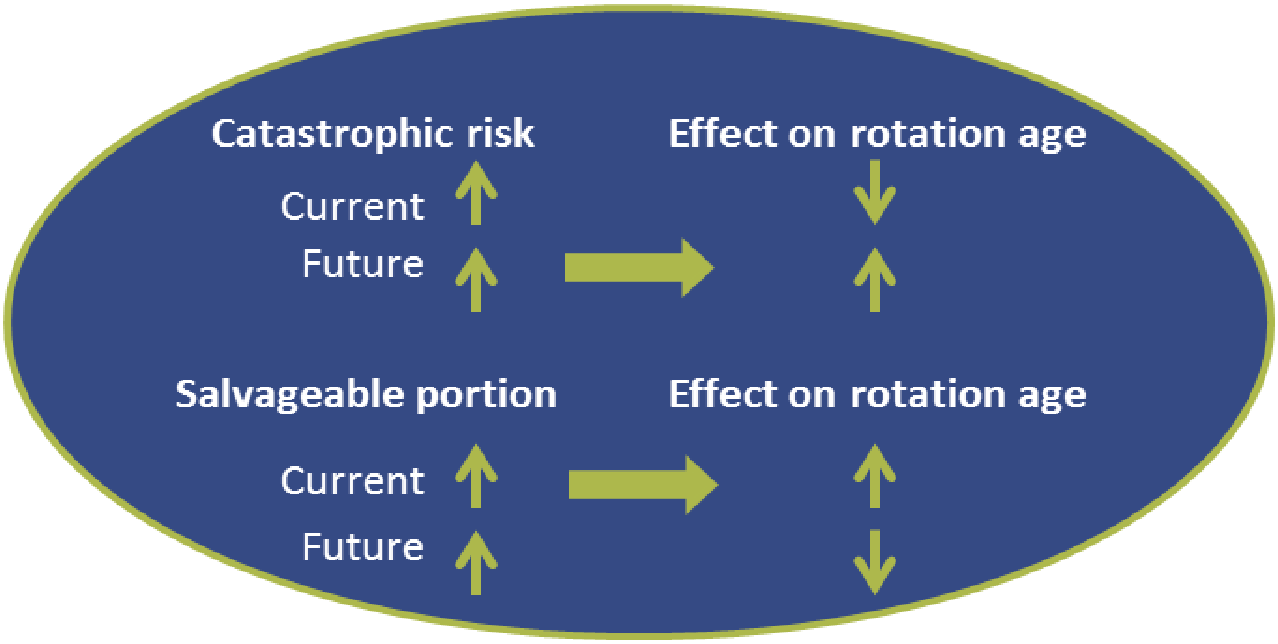


**Figure 2**. Effect of current and future increase in catastrophic event and salvageable portion on current rotation age.

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