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Option valuation of timberland under price uncertainty

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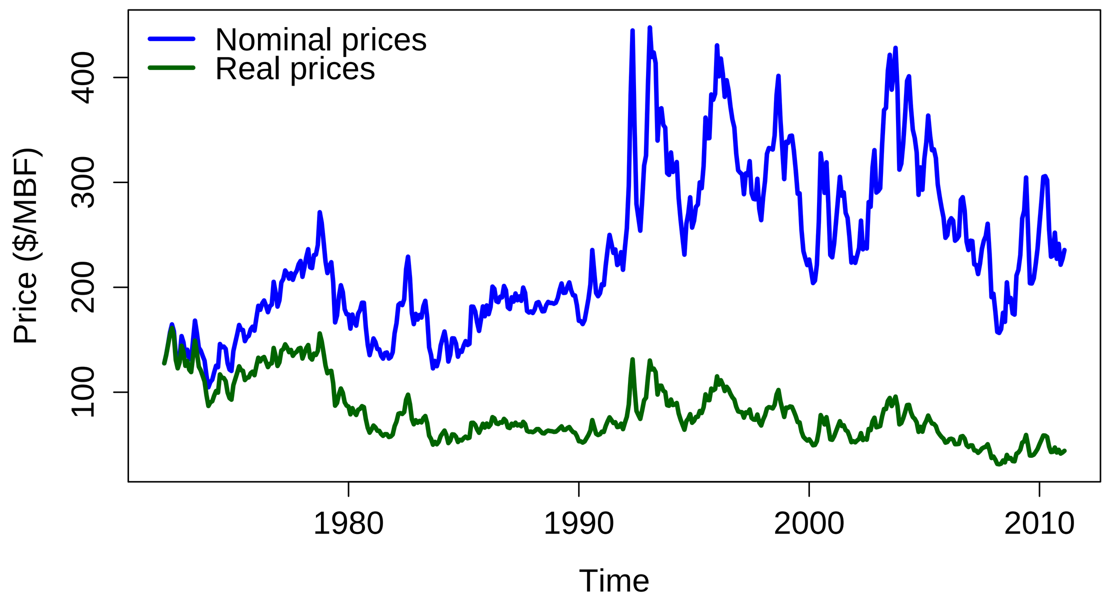
Research objective

Accurate valuation of timberland under price uncertainty

Traditional methods of forest valuation assume that management behavior is fixed over time: each timber harvest occurs at a fixed future date regardless of the evolution of timber prices. This study incorporates option value - the ability to delay an irreversible decision - into forest land valuation. When option value is ignored, long term investments are undervalued (Dixit and Pindyck, 1994).

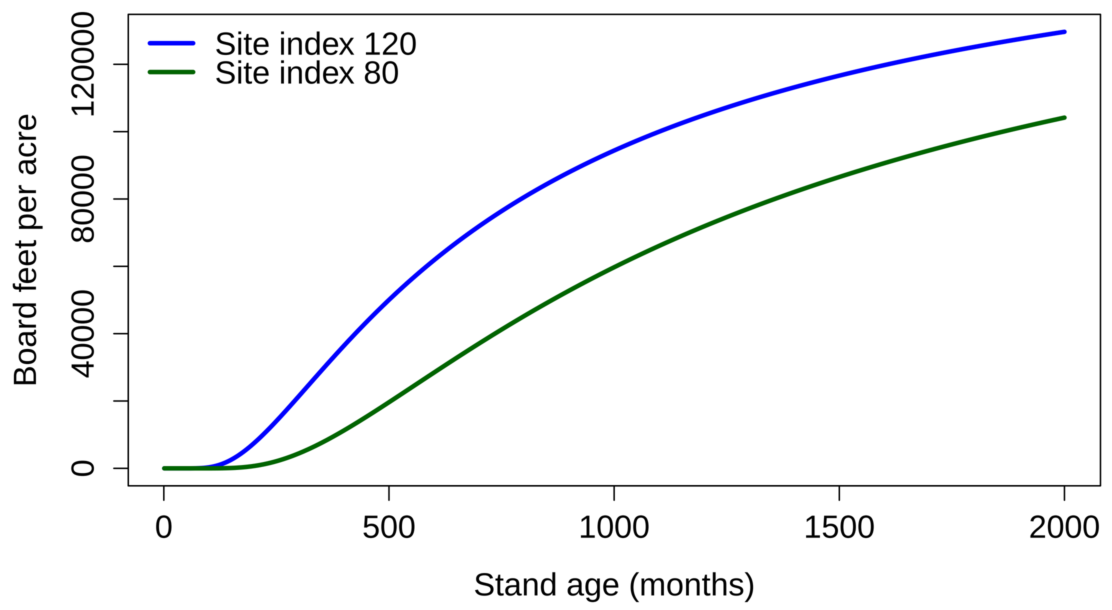
Prices fluctuate

Monthly series of lumber futures prices.



Timber grows

Volume functions for Loblolly pine on two different site qualities.



The estimated monthly per acre volume functions are

$$V_t = e^{\left[12.09 - \frac{52.9}{t/12}\right]} \text{ and } V_t = e^{\left[12.11 - \frac{92.71}{t/12}\right]} \qquad (1)$$

for a site index of 120 and 80, respectively.

Stochastic model of stumpage prices

Properties of the price process:

- Price variability is not constant.
- Percentage price changes are not normally distributed: large price changes are more common than the normal distribution implies.
- Prices exhibit clustering volatility.
- Prices are mean reverting.

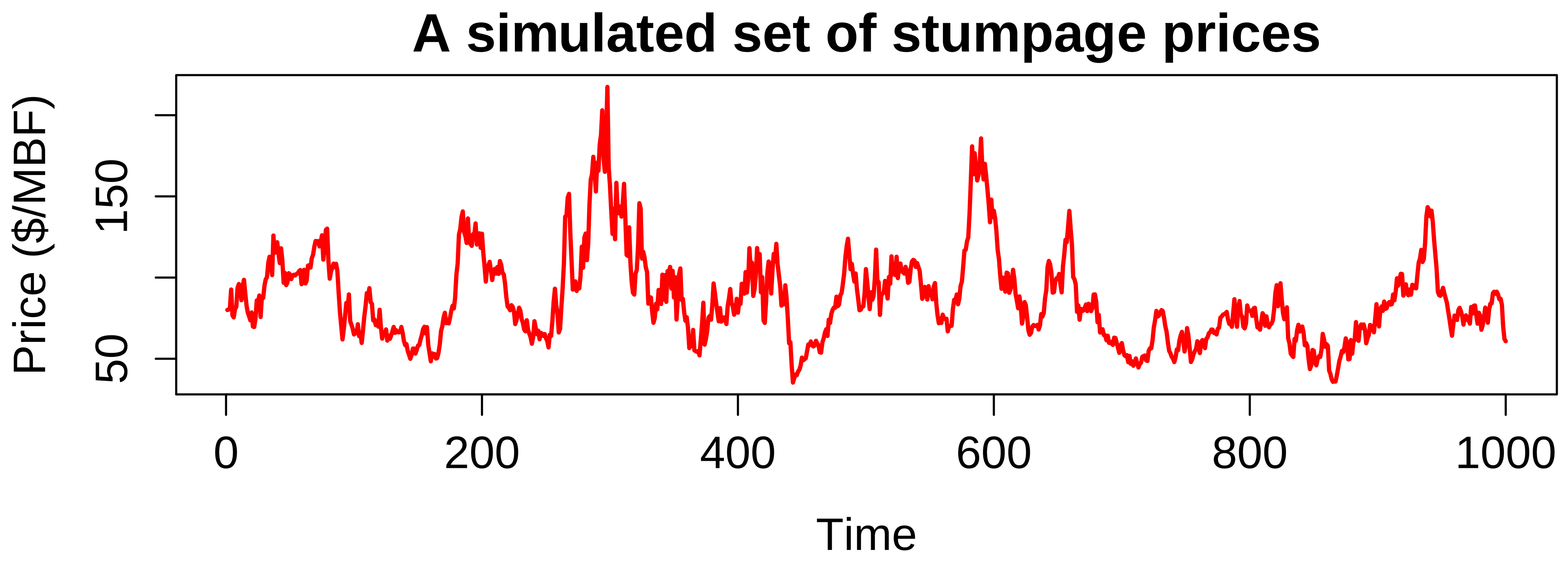
Based upon these characteristics, an **Onrstein-Uhlenbeck process with stochastic volatility** was chosen as the best representation of stumpage prices. **The process is simulated as**

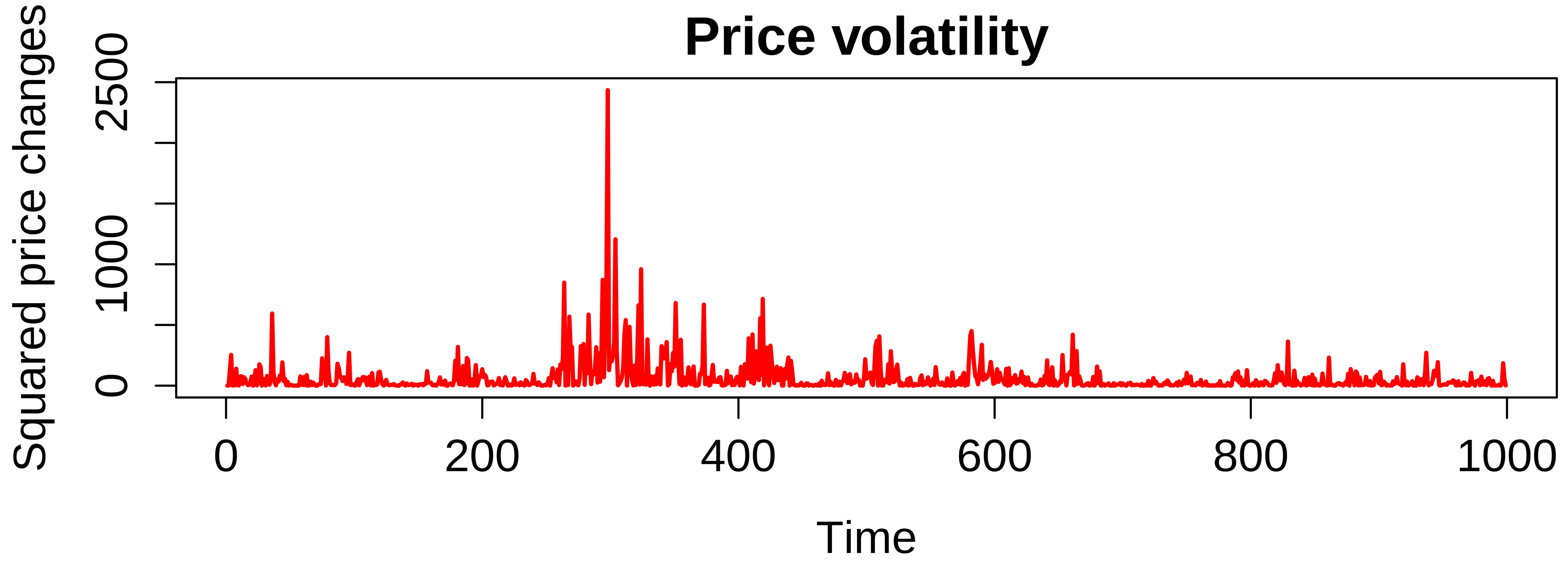
$$P_t = P_{t-1} + \eta\left(\mu - P_{t-1}\right) + \sigma_t^2 P_{t-1}, \qquad (2)$$

where P_t is the stumpage price at the beginning of period t,

$$\sigma_t^2 = \omega + \alpha\sigma_{t-1}^2 + \beta\epsilon_{t-1}^2, \qquad (3)$$

and $\epsilon_t \sim N(0,1)$ (Bollerslev, 1986). The parameters of the process were estimated using the lumber futures data.





Harvesting strategies

Two harvesting strategies are considered:

- Set a **fixed rotation length**: harvest timber every $t^\star$ years regardless of the price at the harvest date.
- Follow a **reservation price strategy**: harvest timber only if the current stumpage price is above the reservation (threshold) price.

The reservation price strategy allows forest owners to **update** decisions based upon new price information. By following a reservation price strategy, forest owners can increase the net present value of land relative to a fixed rotation strategy.

Dynamic programming model

- In each period, a forest owner decides to harvest or delay the harvest.
- The payoff from harvesting at the beginning of period t is $P_t V_t + \lambda$, where λ is the value of bare land.
- The discounted expected value of a harvest in any future period is $\beta E\left[J\left(P_{t+1}, V_{t+1}\right)\right]$, where

$$J\left(P_{t+1}, V_{t+1}\right) = \max\left[P_{t+1}V_{t+1} + \lambda, \beta E\left[J\left(P_{t+2}, V_{t+2}\right)\right]\right] \qquad (4)$$

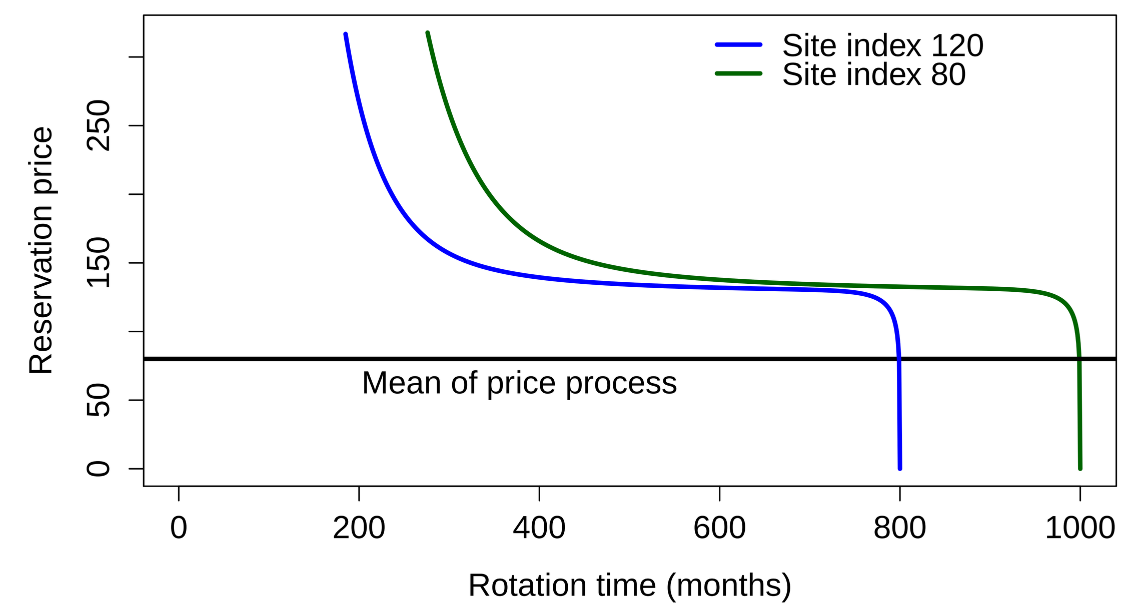
and β represents a constant discount factor.

- The **reservation price** is the value of P_t that makes a forest owner indifferent between the two options:

$$RP_t = \frac{\beta E\left[J\left(P_{t+1}, V_{t+1}\right) | P_t\right] - \lambda}{V_t}. \qquad (5)$$

- The sequence of reservation prices was calculated using a **backward recursion algorithm**.

Reservation prices



Results

For a baseline Ornstein-Unlenbeck process with stochastic volatility on a site index of 120, ***a fixed rotation model undervalues forest land by 30%***. For a site index of 80, ***a fixed rotation model undervalues forest land by 35%***.

References

[1] Bollerslev, T. Generalized autoregressive conditional heteroskedasticity *Journal of Econometrics*, (1988), 307-327.

[2] Dixit, A. K. and Pindyck, R. S. Investment Under Uncertainty Princeton, NJ: Princeton University Press, (1994).

The report and a full set of results and references are available at `http://people.clemson.edu/~campbwa/dissertation/`.