RES-FOR HIGHLIGHT #2

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Economic Evaluations of Tree Improvement for Planted Forests: A Systematic Review

Overview

Planted forests play an important role in sustainable forest management and can help to fulfil a wide variety of social, economic, and environmental objectives. As planted forests become more common, it makes economic sense to improve the quality of seed and subsequent seedling stock used, which includes planting improved (superior) trees rather than planting unimproved seed and seedling stock year after year. Using improved seedling stock also creates economic incentives for investors to pursue plant domestication and tree improvement activities to capture the benefits of these improvements and innovations.

Tree improvement is the application of genetic principles to increase the value of trees. Many traditional breeding programs around the world were initiated in the 1950s and involved selecting superior (plus) trees, breeding or simply collecting seed from these selected trees, and testing the progeny for the desired traits. Since the 1990s, biotechnologies, such as tissue culture, cloning, marker assisted selection, and genetic modification/transgenics programs, have been developed and introduced to forestry and more recently, the use of genomic selection. While the use of biotechnology has the potential to improve trees by enabling foresters to achieve gains in selected traits more quickly and effectively, such as greater volumes or better wood quality, the key question before any specific program can be implemented is "*What exactly will the benefits be*?" Private woodlot owners and investors may be more interested in the potential (financial) profitability of the program, while policy makers will also consider the societal benefits.

Research Goal

In order to consolidate the knowledge that exists about the financial and societal benefits generated from tree improvement programs, we conducted a systematic review of existing literature on the economic analysis of employing tree improvement as a management option for planted forests.

Research Questions

1. Are there economic/financial benefits of using improved reforestation stock from tree breeding and improvement programs over the use of unimproved reforestation stock?

2. What are the most common evaluation methods for assessing the economic returns of using improved planting stock for planted forests?

3. What are the knowledge gaps in the existing literature, and what are the challenges and issues that may affect the economic evaluation of employing tree improvement for planted forests?

Document Acquisition

In total, 15 studies were identified through systematic web-based searches. The studies were located in seven countries, including Canada (5 studies), the United States (1), Finland (3), Sweden (2), the United Kingdom (2), New Zealand (1), and Australia (1). Under the category of tree species, most studies (14 articles, >90%) focused on the examination of softwood species and only one study focused on a hardwood species. Among all of the studies investigated, the majority (11 articles, or 78%) focused on the economic analysis of the use of improved tree stock generated from conventional seed orchards versus unimproved material (wild seeds); four studies (22%) investigated the financial incentives in comparisons of alternative tree breeding strategies (e.g., seed orchard, rooted cuttings, or genetic marker approaches) for planted forests. For the economic evaluation methods, cost-benefit analysis is the primary empirical approach for estimating the economic effects of tree improvement for planted forests, which was employed in all of these studies and tended to focus on assessing the derived market (financial) benefits.

Main Findings

1. Tree improvement is an effective tool to improve forest productivity and to realize financial returns.
2. Economic gains from wood production with selection for breeding traits (e.g., high volume yield or height growth) are the main reasons forest managers adopt new biotechnologies in tree improvement.
3. Cost-benefit analysis is the primary empirical approach for estimating the economic effects of tree improvement for planted forests.
4. There is very little literature on estimating the non-market benefits (e.g., improved watershed protection, amenities, or conservation of genetic diversity) that tree improvement brings using non-market valuation techniques.

Conclusion and Future Prospects

We suggest that future research should:

1. Consider the additional benefit, extra research and development costs, and time saved by applying new biotechnologies in tree improvement (e.g., genomics-assisted tree breeding leading to genomic selection) in the cost-benefit analysis;
2. Investigate the trade-offs between timber volume and wood quality traits and assess the economic effects of new biotechnologies in tree improvement along different stages of the forestry supply chain; and
3. Explicitly account for the non-market trait values for the targeted breeding traits (e.g., drought/pest resistance) so that tree improvement programs can contribute to sustainable production systems.

Economic analyses along these lines could help policy makers, forest managers, and forest company owners better understand the trade-offs of alternative breeding objectives and make economically efficient investment decisions for planted forests.

Reference

Chang, W.-Y., Wang, S., Gaston, C., Cool, J., An, H. and Thomas, B. R. 2019. Economic evaluation of tree improvement for planted forests: A systematic review. *BioProducts Business* **4**(1): 1-14.

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