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# An integrated spatial assessment of the investment potential of three species in southern Ontario, Canada inclusive of carbon benefits

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## Abstract

This study explores the economic feasibility of several long-rotation afforestation scenarios for southern Ontario, Canada. Three species, red pine (*Pinus resinosa* Ait.), Norway spruce (*Picea abies* L.) and black walnut (*Juglans nigra* L.) are examined. We integrate growth and yield models, site suitability maps, and several management scenarios to investigate the investment attractiveness of these species inclusive and exclusive of carbon sequestration values. We report net present values (NPV), internal rates of return (IRR) and two break-even price metrics. For wood value only scenarios the IRRs range from 4.3 to 4.6% for red pine and 3.4–3.6% for Norway spruce (for the most attractive 10,000 ha, in a single rotation scenario). Black walnut had rates of return 3.5–3.7% for the most attractive 10,000 ha area. Adding carbon valued at Cdn \$3.4 per metric ton $CO_{2-e}$ (roughly 2005 prices in the Chicago Climate Exchange) increases rates of return by about 0.6% for red pine and Norway spruce and 0.4% for black walnut scenarios. Perhaps surprisingly these returns are comparable and better than 20-year rotation hybrid poplar plantations. To achieve a 6% real rate of return break-even carbon prices were \$10.7/t $CO_{2-e}$ for red pine, \$12.6/t $CO_{2-e}$ for Norway spruce and \$17.2/t $CO_{2-e}$ for black walnut (again for the "best" 10,000 ha). Although somewhat unremarkable, the results suggest that these longer-rotation species may be a better investment than perhaps previously expected if landowners have the appropriate site conditions.


*Keywords:* Cost–benefit analysis; Afforestation; Carbon sequestration; Red pine; Norway spruce; Black walnut

## 1. Introduction

It is a common view that plantation investments in Canada either fail the standard cost/benefit test (Anderson, 1979) or are expected to do so. Recently a major Canadian federal government initiative examined the idea that faster growing, short (~20-year) rotation hybrid poplar could be an elixir for plantation investments in Canada (NRCan, 2005). Faster growing species like hybrid poplars have been tested in a variety of regions in Canada (Hall et al., 2004) and can generate growth rates ranging from 8 to more than 20 $m^3$/ha/year depending on specific climate and soil combinations. The initiative examined the idea of afforestation investments inclusive of carbon sequestration benefits. However, even with faster growth rates and carbon sequestration revenues the returns currently appear insufficient to induce large-scale private investments (McKenney et al., 2004; Binkley and Brand, 2006). While not true for all parts of Canada, high establishment and maintenance costs, poor social acceptance in some regions and, disease concerns all contribute to trump the (generally) fast growth rates that hybrid poplar offers.

Other more traditional but slower-growing species may in fact be viable alternatives for plantation investors. Emerging domestic and offshore carbon markets could provide additional revenues that enhance the benefit side of afforestation and plantation investments. The investigation noted above (NRCan, 2005) provided us with the opportunity and motivation to examine the economics of several other species more thoroughly. Although characterized with lower growth rates, these species usually require less upfront establishment costs and can potentially produce higher quality and valued timber. Other advantages

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include better-studied silviculture and management techniques and perhaps better acceptance among private landowners. While carbon sequestering fast-growing plantations have been explored in detail (van Kooten et al., 1999; McKenney et al., 2004), there are fewer published assessments for slower-growing plantations (Moulton and Richards, 1990; van Kooten et al., 1993). For Canadian conditions, recent studies show marginal returns from slow-growing plantations for western Canada (Prairies) and better economic potential for Eastern Provinces but with high dependence on the value of carbon incentives (Stephens et al., 2002; Yemshanov et al., 2005).

Here we assess the investment potential of 3 species in the southern part of Ontario, Canada, an agricultural land base of some 5.9 million hectares. We examine Red pine (*Pinus resinosa* Ait.), Norway spruce (*Picea abies* L.) and, Black walnut (*Juglans nigra* L.) from wood and carbon sequestration value perspectives. Red pine is considered an important native plantation species in much of eastern North America (Bassett, 1984) including Ontario (OMNR, 1986). It offers a wide range of products from pulpwood to saw and veneer logs and high quality utility poles depending on the rotation age and management regime. Norway spruce, although a non-native species has been planted in North America, including Ontario and Quebec for about a century. It exhibits uniform and consistent growth and is an increasingly popular conifer species due to a high growth rate and its aesthetic appeal. Norway spruce lumber also has superior mechanical properties (higher bending strength and stiffness) compared to native spruce species (Mottet et al., 2006). However, information on its growth and economics in Canadian conditions remains surprisingly scarce (McArthur, 1964). Both of these conifer species have longer-rotation ages than hybrid poplar and somewhat slower growth rates but are able to produce high quality timber. Our third choice is Black walnut, a slower-growing hardwood species. The high value of black walnut veneer and lumber warrants some ongoing interest in the species. In fact, prices paid for walnut logs are among the highest listed in Ontario and throughout the central US States (OFA, 2005). We note there are several other possible hardwood species that could be target of our investigations, including mixed species plantings. These will be the focus of future research.

The attractiveness of afforestation investments for these three species is examined using net present value (NPV), internal rate of return (IRR) and break-even price metrics. This is accomplished by linking biophysical plantation productivity models in a cost–benefit framework. The analysis is also spatial because we are interested in the total land areas that may be attractive to investors. Such analysis may also be of interest to agricultural and forest policymakers because of land-use change implications. Each scenario has associated costs for plantation establishment, management and agricultural land opportunity costs. Because of uncertainty over future values we also present break-even prices. We feel this metric is insightful to potential investors because future prices are highly speculative. Break-even prices plotted against land area could also be considered as a surrogate marginal cost curve. Our intent is not to develop economically optimal management strategies for any of these species. The information requirements for this are strict and indeed the biological data and price conditions too difficult for us to assess for all possible land owner types. Of note in this paper is the considerable effort explaining the plantation growth and yield estimates. This component is critical for defensible economic analyses and there is a gap in this literature for Ontario.

## 2. Methods and data

### 2.1. Economic model

The analyses proceeded along two lines. A set of biophysical models were generated for each species to calculate growth rates and timber yields from forest plantations. This process is described below. The cost–benefit analysis then uses these outputs and financial drivers such as silvicultural costs and other prices to calculate net revenues. We used a new cost–benefit model, CFS-FBM (Canadian Forest Service–Forest Bioeconomic Model). The model links biomass growth and carbon tracking in a cost–benefit framework and shares the same basic assumptions with the Afforestation Feasibility Model, CFS-AFM described in Yemshanov et al. (2005) and McKenney et al. (2006), however CFS-FBM has more advanced features. Here we provide a brief summary of the new model.

CFS-FBM uses a real-time (annual) accounting scheme. Importantly financial calculations are performed in year-to-year simulations and a finite planning horizon is used as opposed to the long-run, infinite series of rotations approach used in CFS-AFM (McKenney et al., 2006) and other Faustmann–Hartmann type models (Bowes and Krutilla, 1989; van Kooten, 1995; Alavalapati et al., 2002). The model is implemented by performing these calculations in a spatial, raster-based (regular grid) setting. The spatial resolution of the model is of course limited by the resolution of the input data. CFS-FBM uses per-hectare growth and yield tables that allows for simultaneous tracking of fibre supply and carbon sequestered on a grid cell by grid cell basis.

The model uses a new flow-based carbon tracking algorithm similar to that implemented in Canadian Forest Service Carbon Budget Model CFS-CBM2 (Kurz et al., 1992; Kurz and Apps, 1999). It is possible now to calculate physical flows of undiscounted carbon in addition to the economic outputs. Here we use ten ecosystem pools to track carbon dynamics in afforestation scenarios: five in biomass (merchantable and non-merchantable wood, other biomass, saplings and roots) and five in dead organic matter (tree snags, ultrafast, fast, medium and slow dead organic matter (DOM) pools, see Kurz and Apps (1999) for DOM descriptions and decay rates). Carbon transfers between ecosystem pools and $CO_2$ emissions from biomass decay are recalculated annually based on the algorithms described in Kurz et al. (1992) and Kurz and Apps (1999).

In summary, Net Present Value (NPV) for any given grid cell is calculated by combining the biophysical outputs with the appropriate prices over the plantation's life:

$$\mathrm{NPV} = \mathrm{PV_F} + \mathrm{PV_C} - \mathrm{PV_{AG}} - \mathrm{PV_{EST}} \quad (1)$$

$\mathrm{PV_F}$ are revenues from fibre as would be calculated by a land owner net of any harvesting costs. This value also