ENVIRONMENTAL AND ECONOMIC BENEFITS OF TREE-BASED INTERCROPPING SYSTEMS

AGROFORESTRY DOSSIER AGROFORESTERIE

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While the Canadian furniture and wood-cabinet industry is a significant economic player, employing over 100,000 workers and shipping goods valued at $14 billion per year, it is currently facing a cycle of decline. And this, write Robert Bradley and his colleagues, is unlikely to change, "unless we improve our ability to compete without compromising the quality of our products." In this article, they articulate a vision in which Canada would increase its domestic production of high-value hardwood trees required to produce high-end furniture. They look at the benefits of this option and the factors militating against it.

Avec plus de 100 000 emplois et une production annuelle de 14 milliards de dollars, l'industrie canadienne du meuble est un acteur économique de premier plan. Mais elle traverse une période de déclin qui risque de se prolonger, estiment Robert Bradley et ses collègues, « à moins que nous ne renforcions notre compétitivité sans sacrifier la qualité de nos produits ». Ils proposent ici une vision qui verrait le Canada accroître sa production de bois de grande valeur, indispensable à la fabrication de meubles haut de gamme. Les auteurs examinent les avantages de cette approche ainsi que les facteurs qui font obstacle à sa mise en œuvre.

The Canadian furniture and wood cabinet industry comprises 3,600 companies employing over 100,000 workers and shipping goods valued at $14 billion per year. Many of these companies are small to mid-sized businesses located outside major urban centres, and they thus contribute significantly to the vitality of regional economies. Canada exports about half of the furniture it produces to the United States, which increases our net foreign exchange earnings with our neighbour, but exports have declined in the past five years as a result of competition from emerging world economies, notably China. This decline has been aggravated by an increase in the value of our Canadian dollar.

The loss of market shares to Asian producers is unlikely to recede over coming decades unless we improve our ability to compete without compromising the quality of our products. One long-term option might be to increase the domestic production of high-value hardwood, timber that is required to produce high-end furniture. Between 1995 and 2002, imports of hardwood timber destined for furniture manufacturers in Quebec increased by 50 percent and exceeded Quebec's domestic production by more than 20 percent. Paradoxically, Canada is the world's first exporter of forest products, but most of it is softwood destined for construction or pulping. A greater domestic supply of quality hardwood timber would allow the Canadian furniture industry to compete better on the world stage by reducing transportation costs, price fluctuations related to shifts in currency values, duties and legal wrangling over fair trade issues.

Hardwood manufacturing represents 25 percent of revenues in Quebec's forest products industry, yet 200 times more conifer seedlings than hardwood seedlings are planted each year in the province. The reason we lack high-value hardwood trees in Quebec and other parts of Canada is a demographic one. The natural distribution of most hardwood species in Quebec is restricted to the southern part of the province, where forests constitute less than 10 percent of the land base in some regions. Forested area has declined because of urbanization and to widespread agricultural activities. Sadly, the intensive use of the land base in southern Quebec for agricultural activities has led to the abandonment of marginal lands not suitable for annual cropping. The land base being farmed in Quebec declined from 3.2 million hectares in 1961 to 1.7 million hectares in 2001. Quebec's 20th-century farming legacy is a landscape bearing few quality trees and a conspicuous number of abandoned fields.

Planting high-value hardwood trees in rural southern Quebec appears, at first glance, to be a logical and economically viable means of revitalizing the furniture manufacturing industry as well as adding value to marginal land. Several factors militate against landowners planting trees.

First, given the age trees must reach before they can be harvested, landowners may never get a cash return on their investments during their own lifetime. Second, the technologies and skills needed to manage and market a tree plantation are not readily available to inexperienced landowners who may be tempted to do so. Third, there are few grants and subsidies to support the conversion of agricultural land into tree plantation. Fourth, there are incentives to maintain vacant land in southern Quebec to dispose of liquid manure generated by the hog industry. And last, abandoned land that is currently under restricted use ("green land") is subject to development speculation, because once it is declared unproductive it can be rezoned to unrestricted use ("white land), with much greater real estate value. The lack of interest in producing high-quality hardwood trees in Quebec and across Canada's rural land is exacerbated by the segregation of agriculture and forestry into different legislative ministries, university faculties, cultures and mentalities. Hence, there is a need for creative dialogue on this issue among stakeholders and appropriate decision-makers.

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In April 2007, the national Workshop on Intensive Silvicultural Systems in Canada's Rural Landscape was held in St-Paulin, Quebec. It brought together a select focus group of people to discuss economic and environmental benefits of afforestation and agroforestry that will come to bear on future research and policy needs. Invited were a diverse mix of students and faculty members from seven Canadian universities from the fields of agriculture, biology, forestry and natural resource sciences. Also invited were officials from eight governmental and paragovernmental bodies involved in agriculture, forestry, the environment and the economy. Interested landowners and representatives from private companies also attended.

The conference culminated in a round table discussion, where participants agreed on the pressing need for expanding the knowledge base of biomass and bioenergy production systems that can provide multiple ecological and socio-economic services. The research needs are enormous, and current funding opportunities are limited. In conclusion, workshop participants recommended developing a blueprint for a national afforestation and agroforestry research network, which would address the most pressing research needs, train personnel to support agroforestry and related activities in Canada, emphasize the opportunities for innovation and investigate the socio-economic feasibility and acceptance of various silvoarable systems.

Over the past century agricultural practices in Canada have been modernized, which has led to remarkable gains in crop yields and a concomitant exclusion of trees from rural lands. In many parts of Canada, however, modern agricultural practices have created environmental impacts related to declining soil fertility, soil erosion, non-point-source pollution and loss of faunal habitat and biodiversity. By increasing the number of hardwood trees in rural lands, it may be possible to mitigate these impacts.

Tree-based intercropping (TBI) is a production system consisting of widely spaced tree rows with annual alley crops. Tree rows are typically 12 to 20 metres apart, which allows farm machinery to circulate in between the rows. Study plots established 22 years ago at the University of Guelph, Ontario, and similar studies established more recently in Quebec and in seven European countries have shown multiple environmental benefits of TBI systems and very few drawbacks.

Integration of trees into agricultural fields makes the cycling of plant nutrients more efficient than monocropping systems. Tree roots are able to explore deeper soil horizons than alley crops, and they do not have the same nutritional requirements. Thus, soil resources are partitioned more efficiently. Tree roots also intercept mobile soil nutrients, such as nitrate, that would otherwise leach and pollute the aquifer. The nitrogen absorbed as nitrate is later returned to the soil surface as leaf litter, which can decompose and be recycled in alley crops. This, in turn, will reduce the recommended rate of chemical fertilizer inputs and result in lower emissions of nitrous oxide, a powerful greenhouse gas. The root systems of some trees, such as hybrid poplars, have been shown to absorb and break down chemical herbicides in soil, such as atrazine. One recent study of TBI systems also revealed that tree roots intercept and absorb potentially harmful coliform bacteria that would otherwise contaminate the groundwater. Tree canopies reduce the impact of raindrops, and tree roots protect and stabilize soils from erosive forces. Thus TBI systems reduce surface runoff, which is the main vector by which particulate phosphorus washes off agricultural fields to cause the eutrophication of rivers and lakes.

Tree rows can be excellent windbreaks that protect crops and prevent soil erosion. In exposed areas, windbreaks help maintain thick winter snowpacks on the ground that protect the root systems of overwintering crops, such as perennial alfalfa or winter wheat, from freezing. Tree-induced microclimatic modifications can also increase the potential for alley crops to adapt to climate extremes and thus reduce climate-related stress. Trees planted near farm buildings can reduce the costs of heating in winter and cooling in summer. Trees may also act as biofilters for odorous compounds emanating from livestock operations, thereby reducing the need for mechanical filtration traps.

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The implementation of TBI systems is a means for improving biological diversity and associated ecological benefits. For example, TBI systems have been shown to increase earthworm populations. The feeding and burrowing activities of earthworms are extremely important to aerate and drain the soil, to accelerate litter decomposition and to maintain the stability of soil aggregates. A recent study in Sherbrooke, Quebec, showed an increase in the diversity of soil microorganisms that may result in a greater stability of soil microbial processes. Another study in Guelph showed more detritivorous insects (those feeding off dead organic matter) but fewer herbivorous insects (those feeding off living plants) in TBI systems. Such a change in the arthropod community results in more efficient nutrient cycling and a lower dependency on insecticides. Finally, TBI systems will increase landscape-level heterogeneity and connectivity for wildlife species, such as birds, that depend on trees.

Although we confidently expect substantial environmental benefits from planting trees in rural areas, the economic benefits that would entice private landowners to do so are not as obvious. Establishing and maintaining a tree plantation requires a high initial investment that will yield profits to future generations, not necessarily to those actually planting the trees. While this can be true for aging landowners, the value of their land can be expected, nevertheless, to increase once it has been restocked with high-value hardwood species, and the land can be sold at a bigger profit.

However, if TBI systems are implemented rather than mono-specific tree plantations, landowners could receive an annual income from about 80 percent of the land area under alley crop cultivation, they could obtain a second source of income (about $3,000 per hectare) on a 12-to-15 year cycle from alternate rows of hybrid poplar (assuming 144 stems per hectare), and they or their descendants could receive a windfall gain of about $140,000 per hectare on a 35-to-40-year cycle from alternate rows of black walnut (assuming 144 stems per hectare) or other high-value hardwood species. This diversification of landowners' income could provide them with financial stability over the long term.

Trees will grow faster in a TBI system than in a regular tree plantation because of the scavenging of fertilizer nutrients below the rooting zone of the alley crops, and the reduced competition for other resources. On the other hand, one may expect the yield of alley crops to diminish with time as trees grow and create more shade. Pilot study plots established in the mid-1980s in Guelph Ontario revealed, however, that the growth of some alley crops, such as wheat, actually increases in the presence of trees while others, such as pulse crops, exhibit no change in growth rates.

One way to assess the economic benefits of the positive interactions between plant species growing within TBI systems is to measure the land equivalence ratio (LER). LER is an index used to compare the weighted productivity of all plant species growing together with their yields when grown separately. Near Montpellier, France, extensive research work on TBI systems revealed LER values above 1.3 for certain crops, indicating an increase in the system's productivity greater than 30 percent.

With the growing concern over climate change, the eventual creation of cap-and-trade carbon markets could generate returns to landowners implementing TBI systems. On a global scale, soils contain three to four times more carbon than the atmosphere, such that a modest increase in soil carbon can result in a significant decrease in atmospheric carbon. Over the past century, the plowing and tilling of agricultural land has resulted in the loss of 10 to 20 tonnes of soil carbon per hectare to the atmosphere. These historical losses equal the current carbon sequestration potential of agricultural lands, and studies have suggested that afforestation could restore these soil carbon pools in as little as 50 years. In other words, for a carbon credit value of $25 per tonne, a 250-hectare property that sequesters 20 tonnes of carbon per hectare would provide a supplementary economic return of $2,500 per year over 50 years.

Another economic constraint preventing the implementation of TBI systems is that government subsidies given to farming or forestry operations are not as bounteous when the two activities are combined. For example, agricultural subsidies are determined by the land area cultivated for agricultural crops only, and do not cover the proportion of land occupied by trees. Only a concerted action between the various legislative bodies governing agriculture, forestry and the environment can lead to meaningful reforms in the way subsidies are allocated to resource managers.

Despite these aforementioned economic benefits that are expected from TBI systems, several economic constraints must be resolved. In eastern Canada, where rainfall exceeds evapotranspiration rates, crop production depends on subsoil drainage tiles, and these could be damaged by tree roots. This situation raises, however, an interesting debate as to whether future crop production systems should adapt to current subsoil drainage structures, or current drainage structures should be replaced to match the evolution of future crop production systems.

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Finally, perhaps the most dissuading factor of all is the difficulty in predicting how markets will react over the long term. Will an increase in domestic supply of valuable hardwood trees lead to discounting of their value over time? It is difficult to imagine how accurate even the best economic projections will be when dealing with woody crops that may take 40 years to produce. Alternatively, if nothing is done, we will never reap the environmental benefits TBI systems have to offer, and Canadian industries that depend on hardwood timber will continue to wallow in their dependency for timber imports.

Here we have presented a vision to increase the production of hardwood trees in Canada, while improving soil quality, reducing non-point source pollution, increasing carbon sequestration, enhancing biodiversity, diversifying farmers' income and creating novel landscapes. By implementing TBI systems, we are thus inviting landowners and governments to think globally while acting locally. Marginal or degraded agricultural land in Canada that is technically suitable for the establishment of TBI systems is estimated at about 57 million hectares.

Studies in the US concluded that TBI systems were at least as profitable to landowners as conventional monocropping systems. The multiple benefits of TBI systems have motivated five states to adopt policies that encourage their implementation.

Unlike our southern neighbours, Canada has no instance of large-scale operational TBI systems within its borders, let alone a policy for implementing these systems. We strongly support the creation of a national research network that would fill crucial knowledge gaps on the biological functioning of different sylvoarable systems, reduce the uncertainties concerning the feasibility of these systems in Canada, provide economic and biophysical models and databases for assessing the benefits of afforestation and agroforestry in Canada's rural landscape and propose policy changes to meet these objectives. Suitable policy incentives should include those that support high returns on market goods, such as trees and alley crops, and those that internalize non-market goods, such as carbon sequestration and soil conservation, to the benefit of landowners.

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