Agroforestry applications in forestry

by P.A. Williams and A.M. Gordon

In Canada, practices such as farm woodlot management, maple syrup production, windbreaks, Christmas tree production and the use of conifer plantations to rehabilitate degraded agricultural lands have traditionally been considered agroforestry. However, many other practices such as forest range management, intercropping fruit trees with vegetables, intercropping forest trees with grain crops and grazing forest plantations, have gained profile. While these "more innovative" techniques seem to be new, they are usually derived from traditional land uses. For example, the practice of using sheep to control weeds in forests is conceptually new to foresters, but is an organized adaptation of forest range management in the west and the use of rough pasture in the east. Noting that the theme of this conference is "Changes at the Stand Level", it should be realized that from a management point of view, agroforestry practices are prescribed and implemented at the stand level.

This paper will mainly discuss the application of agroforestry systems that are or can be used to achieve "traditional" forest management rather than agricultural or environmental goals. Agroforestry practices that require intensive long-term management on the agricultural side (e.g., wide-space intercropping, long-term silvipasture), Christmas tree plantations, and woodlot management will not be addressed. While farm woodlot management and plantation establishment using "normal" methods are important agroforestry practices, they are also considered to be traditional forestry practices.

As proposed in Williams (1993), agroforestry can be employed to satisfy two major goals: to maximize economic return, and resource enhancement or conservation. Examples of the use of agroforestry to enhance resources would be the planting of riparian buffer strips in farmland to improve water quality and the establishment of forest plantations on eroded farmland for site rehabilitation. Because the latter might also be the highest economic use of a degraded site, it could also be used as an example of a practice being used to maximize economic return.

When comparing landscapes dominated by agriculture with those dominated by forests, the level of management, economic productivity, availability of capital resources and the resident population are in stark contrast to one another. Realizing these differences, it is not surprising that agroforestry practices vary in usefulness and application in different environments. The utility of agroforestry in mainstream forestry, either in an agricultural or forest situation, is primarily associated with forest establishment. In an agricultural situation intercropping and silvopastoral systems have a great potential for widespread use in plantations for forestry purposes. Silvopastoral and agro-silvopastoral (where forages are seeded in) are being used operationally in western North America, particularly British Columbia, and on a trial basis across Canada and in the south-eastern United States. The use of livestock as a site preparation tool is also being evaluated in many areas.

Agricultural Areas

In agricultural areas, the use of agroforestry practices will result in vegetation cover shifts from cropped and open areas to fully or partially forested. These changes can have significant effects on wildlife populations, the environment and wood supplies. When managing for high income, wildlife benefits may be limited and dominant tree species will be those with a high unit value (e.g. black walnut) or high growth rates (e.g. hybrid poplar). Where conversion from marginal agricultural land is important, agroforestry practices can be more cost effective in establishing hardwood plantations than conventional establishment methods thus making hardwood plantings more feasible. The conversion of marginal or fragile lands to forest plantations and riparian or forest buffers has an obvious impact on the vegetation, wildlife populations and environmental quality. Farm woodlots are highly variable and in many cases higher levels of management could increase the "quality" of the forest for timber or natural values, but reduce them in others.

Hardwood plantations are notoriously difficult to establish because seedlings are extremely sensitive to competition and exposed conditions, and highly susceptible to damage from wildlife. von Althen (1990, 1991) described intensive methods that are often required to establish hardwood plantations. Cover crops have been also been used, with varying success, to displace weeds in hardwood plantations and are being actively researched by the Ontario Ministry of Natural Resources in Chatham. Research by the University of Guelph has shown that intercropping can be successfully employed to establish hardwood plantations. Surfactants, intercropping is the same as cover cropping, except that a crop is harvested and utilized with the intercropping scenario and with the use of cover crops, the cover is mowed or ploughed down.

The practice of intercropping involves planting trees in configurations that accommodate agricultural crops grown among them, a practice used worldwide. The taungya system is used in many parts of the tropics and makes use of impoverished subsistence farmers to grow crops during the early years of forest plantations (Lowe 1987). Acknowledging dissimilar socioeconomic situations between Ontario and the tropics, the potential of intercropping to establish hardwood plantations in North America is described by Williams and Gordon (1992). The overriding advantage of intercropping over clean-cultivation or cover cropping is that with intercropping an economic return is derived early in the rotation of the plantation. Even if this return only covers part of the weed control costs for the plantation, the return at the end of the rotation will be much greater. If the crops can be produced and sold at a profit, the entire establishment cost for the plantation can be recovered.

The critical factors to consider when designing an intercropping system include landowner objectives, soil and site conditions, tree species/crop combinations and planting configurations. Landowner objectives and configuration are linked. For example, a farmer may want to plant wider rows and grow crops for a longer period of time. On the other hand, a non-farmer may only want to intercrop for one or two years and may plant their

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Table 1. Means for third year height and survival and dieback for eight tree species intercropped with corn, soybeans and barley at the Guelph Research Station in Guelph, Ontario

Tree species	Height (cm) ¹			Survival (%)		
	Soybeans	Barley	Corn	Soybeans	Barley	Corn
Red oak ²	41.7	27.8	35.8	90.3x	93.0x	97.3y
Norway spruce	53.9	43.4	48.1	93.2	95.7	100.0
Black walnut	83.6	48.9	88.1	98.6	93.0	95.9
White ash	116.9a	65.0b	134.3a	100.0	100.0	100.0
White cedar	52.3	49.8	57.8	87.5	81.3	93.7
Red maple	18.8	21.4	40.7	75.0	38.9	75.0
Silver maple	142.5	97.7	143.3	93.8	93.8	100.0
Carolina poplar	359.6a	191.3b	380.3a	93.8	76.5	100.0

¹Height and survival are given for three growing seasons after planting (1990).

²Within rows, means followed by different letters are significantly different (Duncan's multiple range test).

tree-rows at a narrower spacing. The choice of intercrop can greatly influence the growth and survival of planted seedlings (Table 1), since each crop creates a distinct microclimate that affects tree seedling growth. Examples of differences among three crops are shown for soil moisture and windspeed (Figures 1 and 2).

Intercropping systems are generally more appropriate on high-quality sites but may be impractical on impoverished or wetter sites. On marginal agricultural lands, silvopastoral systems can also be used successfully in plantation establishment. Grazing of plantations and woodlots is generally discouraged, but with proper controls and supervision, is an effective way to control competing vegetation and obtain a return from the property. In an agricultural area, a practitioner can have a great deal of control over the pasture and may seed or intensively manage for high-quality forage. In this situation a practitioner is likely to have greater access to different types and quantities of livestock and materials (e.g., fencing, barns). In agricultural areas, the size of the parcels grazed can be quite small compared with forest land because of the size of fields and their proximity to animals, facilities and labour.

The key to successful silvipasture lies in regulating the livestock access to an area and monitoring the availability of forage. A shortage of preferred forage may result in damage to the trees. Livestock may have to be kept out of a field for sev-

eral years after planting to allow seedlings to become established before grazing.

Forested Areas

Silvipastoral systems are being considered for use in forestry operations across the country. There has been ongoing research in North America on silvipasture for over 20 years, but activity has recently increased dramatically because of concerns over the use of herbicides to control weeds in plantations. Not dwelling on intensive pasture management in plantations as discussed previously, the use of livestock for vegetation management in reforestation is relatively new to most foresters. The practice is likely derivative of range management in forested areas in the west, and is quite different in nature from silvipasture in an agricultural situation.

The available forage is variable and can be relatively rough in a forested area. Weeds can provide excellent forage, but it is not consistent and is often composed of a mixture of grasses, forbs and woody plants. It is important to know the quality of the forage on a site, as well as whether it is preferred by livestock. It is also important to know where the desired tree species are on the forage preference list. The timing of grazing, number of treatments, number of livestock, and the length of the grazing periods all affect the success of the weed control.

Figure 1. Water potential in three crops at 40 cm depth, from May 20 to October 3, 1992.

Figure 2. Daily wind patterns in three crops, 30-min averages for June 23-27, 1992.

It is also important to be aware of potential risks to and from wildlife when using silvipasture in the bush. There are risks to the livestock from predators like coyotes, wolves and bears, and risks to wildlife from disease transmission. Risks from predators can be minimized by the use of guard and herding dogs, and by keeping animals penned at night. Hazards of disease transmission to wildlife can be minimized by having the animals examined by veterinarians before putting them in the field and monitoring their condition.

One must keep in mind that we are in the development phase of silvipastoral methods and that there is a great deal to learn. However, silvipasture can be an effective forest management tool for site preparation and competition control. Using livestock for site preparation usually involves large numbers of animals for a short period of time. The objective is to have the animals consume or trample the vegetation occupying a site prior to planting or otherwise regenerating a stand. Cattle, sheep, goats and pigs have been used for this purpose and are generally cheaper than normal site prep equipment to use. In weed control, sheep have most commonly been used because they are browsers, but much easier to control than goats. Cattle have been effective where there are more herbaceous weeds and on dryer sites (less compaction). Goats have been tried, but are not recommended as their dietary habits are not restrictive enough and they can be difficult to control. Not to limit the scope of possibilities, the Ontario Ministry of Natural Resources has recently conducted a trial using geese to weed nursery beds in a Provincial nursery.

The increasing use of silvipasture will result in shifts in forestry practices and stand composition. Since each type of livestock has its own considerations (e.g., forage preferences, herding characteristics and site impacts), their use will result in different effects on a stand. Livestock likes and dislikes will favour certain tree species in planting or natural regeneration, effect the quality of the competition control, and future understory composition.

Rural Communities

The health of rural communities has been of increasing concern in recent years as the industrial bases change and affect employment. This is of particular concern in forest areas that

rely on the forest as the mainstay of their economy. In many forest regions (e.g. northern Ontario) agriculture is a marginal industry. If silvipastoral practices are included in regular forest management activities, they may generate enough economic activity to make some farm operations more viable. This may be easier to visualize in a region like the Maritimes where communities with farm activity are relatively integrated with the forestland. However, in areas like British Columbia or northern Ontario where forestland and agriculture are more disjunct, silvipastoral activity should increase revenues to the agricultural sector. This increased activity will enhance community involvement with forestry, providing other benefits in addition to alternatives to herbicides.

Conclusions

Agroforestry systems have a place in mainstream forestry and their use will increase as the knowledge and experience base increases and forestry personnel become more familiar with the technologies. This is true for areas dominated by agriculture, mixed landscapes and areas dominated by forests.

It must be acknowledged that agroforestry systems require more intensive management than conventional forestry or agronomic systems. Agroforestry systems are composed of crop plants, animals and/or trees. Each component is important and for the system to work, the practitioner must manage or be knowledgeable about them.

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