

AGRICULTURAL

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Economics of Agroforestry

W.B. Kurtz, H.E. Garrett and J.P. Slusher, School of Natural Resources
D.B. Osburn, Department of Agricultural Economics

Agroforestry provides a landowner the opportunity to develop a portfolio of short- and long-term investments that allow for some spreading of financial risk through diversification. In general, diversification of investment provides financial advantages, although it also introduces the need for additional management expertise to deal with the added complexity of the farm operation. For farms with land particularly unsuitable for crops, agroforestry provides a way to remove the unsuitable land from crop production over an extended period as the trees mature. Agroforestry also provides social benefits by functioning as a protective system that ensures resource conservation, although some of these benefits are not directly measurable.

The following agroforestry practices are particularly applicable to the U.S. temperate zone:

1. Riparian buffer strip systems combine vegetative types in areas alongside streams and rivers. These systems may be used to regulate microenvironments and protect fish habitats or to regulate waterway pollution from nonpoint sources. This is accomplished by reducing summer water temperature, trapping sediment and filtering and storing nutrients.

2. Tree-agronomic crop systems involve planting rows of trees at wide spacings and cropping the tree rows or alleyways. By alley cropping, or intercropping, farm operators can increase or diversify farm incomes, abate soil erosion and nutrient loading and protect watersheds.

3. Tree-animal systems — silvopastoral or forest livestock grazing — include the intensive management of forages grown with trees. This practice, which shows significant potential in Missouri, can yield economic benefits as well as improve wildlife habitat, soil protection and forest management.

4. Windbreak systems — shelterbelts — in the plains and western states protect soils from wind erosion, enhance production of crops and animals and stabilize microenvironments.

5. Natural forest specialty crop systems — forest farming — provide suitable microenvironments in managed natural forest stands for growing specialty crops such as mushrooms, ginseng or pinestraw.

Financial aspects

Agroforestry, in general, provides a greater economic return than other cropping combinations where it is the most appropriate system (see Table 1). In most instances this is due to the timing of returns. For example, agroforestry provides the highest returns of the four land-use regimes considered in Table 1, followed by timber and nuts and then by soybean/wheat rotation. The early returns from the intercrops of soybeans and winter wheat in the agroforestry regime, coupled with nut production, which begins in year 20 (or sooner with select planting material), are responsible for the high financial yield. In the case of walnut agroforestry, nut revenues are responsible for the bulk of the financial returns. Under the conditions assumed here (tree rows only 40 feet apart), row crops can be grown only for about 10 years (for further information, see MU publication G 5020, *Walnut Agroforestry*). The rotation of soybeans and winter wheat ranks third because it yields an annual return. The straight timber production regime ranks last because it yields positive returns only twice during the rotation period — in years 45 and 60 in the model shown.

Table 1. Financial measures of alternative land-use regimes, medium-quality land, 60-year rotation for black walnut.

Land use	Present net worth* (\$/acre)	Internal rate of return (%)	Annual equivalent value* (\$/acre/year)
Agroforestry	2,096	11.7	92.64
Timber and nuts	2,022	10.8	89.38
Soybean/wheat rotation	695	—	30.84
Timber	146	4.3	6.47

*4% interest rate

Financial measures

Three financial measures — present net worth (PNW), internal rate of return (IRR), and annual equivalent value (AEV) — are typically used in presenting to the potential investor a complete picture of the various alternatives.

Present net worth (PNW) is defined as the net value of a future stream of costs and revenues discounted back to the present at a predetermined interest rate (in this case 4%). PNW is usually expressed in dollars per acre or dollars from a given investment on a given piece of land. When PNW is computed with land values omitted (as in Table 1), its value is the amount that can be paid for land and still yield the predetermined interest rate on the investment.

Internal rate of return (IRR) is expressed as an interest rate, much like the rate earned on a certificate of deposit or a savings account. It is the average interest rate earned on all costs accrued before the investment matures. The interest rate at which $PNW = 0$ is where the present value of revenues equals the present value of the costs.

PNW and IRR differ in their underlying assumptions regarding investment of intermediate costs and revenues. With PNW the reinvestment rate is controlled, while with IRR we solve for it.

Annual equivalent value (AEV) is the annualized value of the cash flow. It is the PNW converted to an average annual value (a somewhat difficult concept since it is not a true mean, but rather one that takes into account the timing of costs and revenues). AEV is usually expressed as dollars per acre per period (usually one year).

AEV is most useful when comparing a forestry investment with an alternative that typically yields annual returns, such as agricultural crops.

Production aspects

From the standpoint of production economics, agroforestry is representative of the multiple output model of joint production, where several fixed and variable inputs are combined to produce at least two products. Implicit in this model is that quantities of all outputs can be varied by deliberate management decisions. Thus, the main concern with agroforestry is in production efficiency, that is, to add trees to the land so long as the benefits from each additional tree are greater than the benefits forgone from the crop that the tree is replacing.

There are three general relationships between outputs, only one of which has any real relationship to the production decision (Filius, 1982). These relationships can be illustrated with a two-product system. A supplementary relationship between products exists where the level of production of one product can be increased with no decrease in the level of output of the other. A complementary relationship between products exists where the level of produc-

tion of one product can be increased and it results simultaneously in an increase in the level of production of another. These cases are similar in that no economic rationale exists for determining a level of production within their range. Consequently, the level of production should take place in the competitive relationship where an increase in the production of one product is achieved only with a corresponding decrease in level of production of the other.

Because of the long-term nature of agroforestry, any or all of the preceding three relationships may be found within a given system over its duration. As an agroforestry system matures, these relationships change. Therefore, it is important for one to be fully informed and familiar with the dynamic nature of the system because the adoption decision must be made with respect to maximizing the cumulative net benefits. Further, to make a valid decision regarding adoption of an agroforestry system, it is important that all costs and revenues be brought to a single point in time through either discounting or compounding.

General comments

Three general economic benefits are typically ascribed to agroforestry: (1) spreading (sharing) of fixed costs because of the joint-production relationship; (2) reducing the initial time period required to produce income from land devoted exclusively to tree production; and (3) diversifying income sources, in effect spreading the risk generally associated with a monoculture. Likewise, from an operational standpoint, agroforestry to some extent increases flexibility in agricultural operations since many silvicultural practices may be delayed with little or no detrimental effect until free time is available. In addition, agroforestry offers a means by which farm operators can phase out part or all of their row crop production at a rate approximating the rate of depreciation of their farm equipment.

On the other hand, agroforestry systems have been criticized from an economic standpoint in the following ways: (1) The initial cost of establishment, in terms of capital and labor, may be prohibitive if no early income is possible. (2) Growing more than one crop at a time in the same field can complicate management. (3) In some areas, there may be a shortage of knowledgeable contractors or markets for alternative products.

Literature cited

Filius, A. M. 1982. Economic aspects of agroforestry. *Agroforestry Systems* 1:347-360.



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