TRUE(R) COST ACCOUNTING IN AGROFORESTRY SYSTEMS: AN INTRODUCTION TO THE BC SUSTAINABLE AGROFORESTRY CALCULATOR

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ABSTRACT

This paper documents the need for and the development of the *BC Sustainable Agroforestry Calculator*, an assessment tool that calculates the potential or realized value of agroforestry systems in northwestern North America. True cost accounting for agroforestry operations must accommodate the range of costs and benefits that cannot fully be assessed with the prescription of a monetary value and therefore must occur via creative, flexible and robust tools designed to more fully incorporate ecological and social considerations. The *BC Sustainable Agroforestry Calculator* compares costs and benefits "with or without" agroforestry systems, thereby integrating an analysis of economic, ecological and social impacts of agroforestry as compared with conventional agriculture or forestry systems. In order to provide BC landowners, growers, farmers, foresters and interested citizens access to this tool, a simple user-friendly spreadsheet is being developed, with a range of flexible indicators. After outlining the inherent complexity of agroforestry accounting, I set the context for the development of more integrative analyses of such systems, discuss and compare resource accounting and evaluation methodologies, and introduce the developing *BC Sustainable Agroforestry Calculator*.

Keywords: British Columbia, ecological economics, natural resource accounting, sustainability

INTRODUCTION

This study documents the need for and the development of the *BC Sustainable Agroforestry Calculator*, an assessment tool that calculates the potential or realized value of agroforestry systems in northwestern North America. For the purposes of this report, agroforestry is defined as:

> *A land management approach that deliberately combines the production of trees with other crops and/or livestock. By blending agriculture and forestry with conservation practices, agroforestry strives to optimize economic, environmental and social benefits* (Small Woodlands Program of BC [SWPBC] 2001).

The *BC Sustainable Agroforestry Calculator* may be used to determine the economic, ecological, and social worth (i.e., costs and benefits) of identified systems. Agroforestry may be compared with agriculture or forestry systems using this assessment tool.

While agroforestry systems have been in place for at least 1,300 years worldwide (Sanchez 1995) and have a rich history along North America's west coast, it is only within the past three decades that the considerable potential of such systems to meet economic, ecological, and social needs has been articulated (Young 1997). By integrating trees into the agricultural landscape, and recognizing and managing for nontimber forest values, agroforestry complements and reinforces traditional forestry and agricultural efforts (Current et al. 1995). The unique features of agroforestry stem from incorporation of a larger number of species in various arrangements and management techniques than conventional forestry or agricultural systems, over longer time horizons than most agricultural crops (Current et al. 1995; Oelbermann et al. 2004). As agroforestry systems are often designed to optimize both financial profits and ecosystem functions, interest in sustainable agroforestry is increasing as more value is being placed on goods and services that attain both these goals (SWPBC 2001).

This report addresses the following themes in three distinct sections:

1. The first section outlines the context of the paper by defining sustainability and by introducing an agroforestry systems approach;
2. The second section summarizes and compares different accounting systems which can be used to evaluate agroforestry systems, and introduces an integrative systems/ sustainability approach as a means of assessing agroforestry systems;
3. The third section introduces and describes the newly developing *BC Sustainable Agroforestry Calculator*. The end product will be an assessment framework which is intended to enable BC landowners, growers, farmers, foresters, and interested citizens to engage in true(r) cost accounting, including both fiscal and nonfiscal costs and benefits of adopting agroforestry systems. The *BC Sustainable Agroforestry Calculator* compares costs and benefits with or without agroforestry systems, thereby integrating an analysis of economic, ecological, and social impacts of agroforestry as compared with conventional agriculture or forestry systems.

CONTEXT
Sustainability Reconfigured

The infamous “three legged stool” of sustainability is a variation of a Venn diagram that presents sustainability as a balancing act, depicting the “environment,” economics, and society as separate but related entities, presuming that each segment of the stool can act independently of the others to a certain extent (Lowe 2004). But can there be any economic or social activity without a functioning ecosphere? A more realistic depiction may be to integrate rather than balance the three entities, and use more descriptive terms, such as: ecological and biophysical systems (ecobiophysical systems), sociocultural systems and socioeconomic systems (e.g., see Rees 2002). In a more integrative depiction, ecological and biophysical systems beget sociocultural systems, which in turn beget socioeconomic systems. Social and economic systems are important—but not fundamental—subsets of natural ecological systems upon which we depend. Humans are embedded within our ecosystems and thus rely on ecological integrity and ecosystem health to cope with stresses to our environment(s) (Kay and Schneider 1994). Further, these conditions result in the production of ecosystem goods and services that function as the life-support system for Earth, and for life on Earth (Lubchenco 1998). The Earth, as a finite system, processes goods and services at quantities and rates that cannot be substituted, either sustainably or economically. Ecological integrity is fundamental to economic and societal well being and growth (Miller and Rees 2000; Kay and Schneider 1994). As such, the spheres’ configuration must represent that relationship, such that sociocultural and economic considerations are embedded with ecological or biophysical constraints, and the sustainability Venn diagram is refigured into concentric circles. In order for agroforestry systems to be widely adopted, they must ultimately meet practitioners' financial needs, specifically as compared with the relative profitability of alternatives (Current et al. 1995). Thus, the *BC Sustainable Agroforestry Calculator* incorporates assessment of the economic, ecological, and social implications of agroforestry systems as compared to those of pre-existing agriculture and forestry systems.

An Agroforestry Systems Approach

Globally, deforestation for agricultural production and the burning of fossil fuels serve as a net source of atmospheric carbon dioxide, the principally researched greenhouse gas (Booth 1994; Chapin et al. 2000; Oelbermann et al. 2004). Those agroforestry practices, wherein trees are deliberately integrated with traditional farm cultivation, can thus be used to reestablish some of a forest's ecological goods and services such as carbon sequestration (Williams and Gordon 1992; Booth 1994), soil fertility (Young 1997; Oelbermann et al. 2004) and timber production (Liu et al. 1998). In addition, agroforestry practices can restore degraded land (Oelbermann et al. 2004), potentially improve agricultural productivity, conserve land, enhance biodiversity, and diversify and increase farm-derived income; due to its multiple benefit potential, agroforestry is therefore an ideal point of collaboration between research and development partners with various priorities (Australian Government 2004).

Two key principle features are suggested to distinguish agroforestry from conventional agricultural and forestry management, competition and complexity, which in turn determine profitability and sustainability of the systems (Sanchez 1995). An integrated evaluation of agroforestry systems must therefore account for the multivaried nature of the systems' impacts. Ecological economics, a transdisciplinary field that focuses on sustainability, fairness in distribution and efficiency in allocation, factors in fiscal, natural and social capital in its accounting principles (Costanza et al. 1998). This emerging field unites the strengths of economics and ecology within a vision for a sustainable future and with a focus on natural capital[1] (Leefers and Castillo 1998). Assigning market prices to ecosystem goods and services monetarily values the ecosphere at approximately $33 trillion/year, an estimate considered to be highly conservative. That figure compares to a gross global national product total of about $18 trillion/year (Costanza et al. 1998). In other words, natural capital comprises most of the capital upon which humans depend. Understandably, a valuation paradigm shift with respect to natural resources must occur in order for this form of assessment to be successful and widely accepted.

EVALUATION METHODS

Evaluation models are inherently simplified approximations that almost always rely on incomplete data (Kay and Schneider 1994; Reid 1998). Modeling agroforestry systems is complicated by the complex relationships that are cultivated through management regimes (e.g., see Masera et al. 2003) and therefore care should be taken in interpreting evaluation results (Liu et al. 1998). Agroforestry configurations balance competition and facilitation over different production cycles and time span. If structured properly, the facilitative effects balance or exceed the competitive effects, providing a net benefit over conventional agriculture or forest practices. Simple economic modeling of agroforestry production fails to account for this balance and potential to positively or negatively affect system returns (Liu et al. 1998; Szymanski and Colletti 1999).

Conventional economics focus only on finances and thus cannot be used to demonstrate the true value of an ecological system that encompasses, or is designed around, a food producing, ecology enhancing agroecological core. The value of biodiversity, for example, will not be measured, and if it is, it will be greatly underestimated as its functional importance cannot be effectively communicated in monetary terms (Miller and Rees 2000). Rather, methodologies for evaluating agroforestry systems must account for the separate and synergistic costs and benefits that emerge from intimately mixed systems (Liu et al. 1998).

More integrative, predictive and adaptive approaches to ecosystem management require three basic types of information:

1. Reliable site-specific baseline information on ecosystems;
2. Knowledge of how the production of goods and services in specific ecosystems will respond to biophysical changes; and
3. Integrated regional models that incorporate biophysical, economic, and technological change (Ayensu et al. 1999).

Specific Evaluation Methods

1. Cost-Benefit Analysis (CBA) is a set of techniques developed by economists to determine whether a proposed project has "benefits" that outweigh the "costs." CBA refers to the monetary valuation of items normally not exchanged on the market, often priced according to individuals' willingness to pay (Sagoff 1998). Debate over the effectiveness of these and similar methods has focused on the advantages and disadvantages in the "monetization" of products (Glass 1997), particularly those such as increasing wildlife habitat or social perception of management (O'Neill and Richardson 1999).

The convention of CBA, which is based upon a common national accounting framework, has several fundamental problems with respect to its role in assessing natural capital, including:

a. CBA does not adequately reflect the depletion and degradation of natural resources and the environment. Essential waste-assimilating and life-support roles of the ecosphere are easily ignored and generally excluded from balance sheets. Many of these goods and services are not traded in the market and as such, it is extremely difficult to estimate the true value of natural capital simply in monetary values (Leefers and Castillo 1998).
b. The CBA model necessarily uses monetary opportunity costs and discount rates which tend to disfavour long-term investments such as tree planting (Kapp 1998). Thus, with respect to natural resources derived from ecological goods and services, monetary-based valuation methodologies such as CBA must be complemented with environmental impact assessments and valuation of nature in non-monetary terms (Jepsen 2003).
c. CBA necessarily relies on arbitrary choices of rates (both for opportunity costs and discount rates) thereby leading to debatable results and incomparable models.

2. Natural resource valuation and accounting emerged from the need to better understand the complex relationships between human societies and economies, and natural systems. Maintaining the value of natural systems as part of the total capital of a society is necessary in enabling a population to prosper economically in the future as in the present (Leefers and Castillo 1998). Management and valuation of natural resources requires consideration from many perspectives to effectively account for economic, ecological and social costs and benefits derived from such goods and services. This form of assessment ideally complements neoclassical economic models with more integrative environmental analyses. The evaluation of natural resource accounting must be related to the contribution of an item to meet a specific goal(s) (Costanza and Folke 1997), thus alternative outcomes must be articulated and weighted accordingly.

3. Qualitative multicriteria analysis (MCA) is intended to be a combination of “the straightforwardness of CBA with the flexibility of MCA” (Gomez-Sal et al. 2003). Aspects that can be monetarized are incorporated into the CBA, while those that fall outside of fiscal evaluation are integrated and analyzed in their own dimension. This evaluation can be optimized by weighting a land use pattern against alternatives that are ordered hierarchically. Such analyses may also be considered as multi-objective and multilevels evaluation approaches. Such classifications are intended to be practical, transparent, and robust in their evaluations within short and long time horizons, and with market and nonmarket goods and services. Optimization methods try to account for multiple goals and restrictions for the farmer in choosing the most profitable resource allocation over a chosen period (Liu et al. 1998).

4. Physical accounting is based on a cyclical equation:

> Opening stock **+** net changes (e.g., growth, plantation development) **–** reductions (e.g., harvest, wastes, mortality, land conversion) = closing stock = new opening stock …

Accounting for physical stocks allows insight into natural system conditions, whereas monetary accounts only inform policy makers about the relevance of natural resources in the economic system (Leefers and Castillo 1998).

Canada has several national-level resource accounting programs (Leefers and Costillo 1998). Two examples include:

1. STRESS, a macro-information system, was initiated in the 1970s to collect and analyze different types of environmental data. From these data, natural resource stocks and flows have been documented and linked with the economy and state-of-the-environment and natural productivity databases have been initiated.
2. Statistics Canada began relating satellite accounts for natural resources with national balance sheets in the System of National Accounts.

Considerations

Discounting

The discount rate is used to estimate the "time value of money." Discount rates in the literature range from 0-20%, depending on the market and environmental climate, along with social perception (see Current et al. 1995; Kapp 1998). In agroforestry analyses, comparisons are made between agriculture costs and returns that occur annually, and forestry costs and returns that occur over a longer timeframe. Thus discounting may be an important aspect of analysis for multiple-objective farming (Agriculture Western Australia et al. 1999). Concern over discounting arises from the perception that discount rates are systematically biased in favor of projects that generate short-term profits even if high resulting costs arise in the future (e.g., loss of productivity through soil erosion) (Kapp 1998). Long-term investments such as tree planting are negatively biased as the farther into the future the costs and benefits actualize, the less they are valued today (Agriculture Western Australia et al. 1999). Therefore it has been suggested that if a discount rate is to be applied, it should be moderate to allow for agroforestry systems to be weighted competitively in market situations (Liu et al. 1998). Even when discounting is used agroforestry systems, however, the annual cash flow from the agricultural part of agroforestry offsets the long term discounting of the forest production.

Incorporating uncertainty

Agroforestry systems are based on multiple objectives, various timelines, and complex natural, social, economic, and cultural environments. Further, agroforestry products can be vulnerable to fluctuating market demands, subsidy withdrawal, and unforeseeable ecological fluctuations. Thus, evaluations of agroforestry systems must incorporate uncertainty factors into the calculations (Liu et al. 1998), recognizing these as "risk factors" to balance CBA and ecological considerations.

Characterization of indicator set

The multifaceted nature of natural resource accounting is best dealt with by monitoring a range of indicators that reflect the complexity of sustainability. Many sustainability indicators have been proposed in the literature, but the choice of effective evaluative criteria must be based on the specifics of the management focus and an underlying conceptual framework (Pannell and Glenn 2000). While integrative assessments are necessary to model quality, quantity, and spatial and temporal dynamics of ecosystems, indicators must be ordered hierarchically before they are used to evaluate whether the system has met the desired scenario (Gomez-Sal et al. 2003). Indicators must also be chosen such that the gross benefits from monitoring them outweigh the overall costs (Pannell and Glenn 2000). See Table 1 for a list of some economic, ecological, and social indicators.

THE BC SUSTAINABLE AGROFORESTRY CALCULATOR

The *BC Sustainable Agroforestry Calculator* compares costs and benefits with or without agroforestry systems, thereby integrating an analysis of economic, ecological, and social impacts of agroforestry as compared with conventional agriculture or forestry systems. An integrative systems/sustainability approach, based on a qualitative multicriteria analysis (Gomez-Sal et al.

Table 1: Potential indicators to use in agroforestry assessment (based on work by Gomez-Sal (2003), Pannell and Glenn (2000), Sanchez (1998)):

Ecological	· Farmer's natural resource base and endowment (% "natural," % riparian, % habitat for Species At Risk, % "seminatural," % slope >12 with forest covering, % forest, % agrarian, landscape fragmentation by natural or seminatural vegetation, % area stands of connecting woodlands, % area protected as natural area, % remnant forest)
	· Risk-buffering capacity
	· Resilience of ecosystem
	· Sustained productivity
	· Biodiversity (i.e., mean richness in birds, plants, animals, fungi)
	· More favorable soil physical properties than agricultural soils
	· Minimize soil erosion
	· Combination of trees and crops increase rainfall water use
	· Less competition between trees & crops that develop canopies at different times
	· Microbial biomass within soil
	· Organic matter in soils
	· Protein levels of crops
	· Diversity of production
	· Earthworm density in soil
	· Pesticide usage
	· Soil pH
	· Effective crop root depth
	· Depth to groundwater table
Social	· Perceived social benefits of increasing environmental stewardship
	· Cultural preferences
	· Increasing biodiversity
	· Improved aesthetic
	· Greater confidence in future
	· Contentment
	· Community gatherings
	· Information and technology transfers
	· Noise/smell reductions
	· Agroforestry tourism
Economic	· Degree of market integration
	· Gross profit margin (GPM) of agriculture
	· GPM/ total subsidy/ working person/ agricultural area/capita
	· Subsidy of crops/ha
	· On-farm profitability
	· Risk-buffering capacity
	· Sustained productivity
	· Available family income/capita
	· Number of jobs on farm, in industry, in admin.
	· Agroforestry tourism

2003), was selected as the means of most appropriately assessing agroforestry systems. In order to provide BC landowners, growers, farmers, foresters and interested citizens access to this tool, a simple user-friendly spreadsheet is being developed, with a range of flexible indicators. For each agroforestry system, as defined in British Columbia, a list of relevant indicators was compiled and most are assigned an economic value, positive or negative, thereby incorporating a range of disciplines, including hydrology, agronomy, ecology, and economics (Jepsen 2003). Those variables where it is not appropriate to assign market values are rated and ranked on a grading system. A ranking system of -2 to 2 is used in the *BC Sustainable Agroforestry Calculator*, whereby current management regimes are assigned a mark of 0 as a starting point. The scale does not reflect the positive or negative nature of *current* practices; rather, the goal of engaging with such a scale is to evaluate *changes* to the system, through a ranking process of those variables considered. On a -2 to 2 scale, 0 is the starting point, 1 is improved, 2 is greatly improved, -1 is degraded, -2 is greatly degraded further. The projected benefit is kept at the starting condition of 0 if there is no change or if one does not know how to rank the change.

In order to integrate economic, ecological and social impacts of agroforestry systems as compared with conventional agriculture or forestry systems, the *BC Sustainable Agroforestry Calculator* compares costs and benefits with or without agroforestry systems, and allow producers to input their own relevant data for comparison purposes. A simple user-friendly spreadsheet layout facilitates accessibility to the program, as well as flexibility in terms of indicators. Both the Calculator and the indicators measured have the potential to be developed further to incorporate more comprehensive ranges of (economic, ecological, social) outcomes that depend on systems' balances of trees, crops, and animals.

The current framework is a preliminary version of the Calculator, which will be augmented to take into account input from producers and other stakeholders. As part of the development process, the draft tool will be tested with current demonstration systems being implemented within British Columbia. It will be modified to address the gaps and concerns identified in the testing process. The overall objective is to provide a tool for producers (and others) considering agroforestry systems to rank the feasibility of their options based on the economic, ecological and social considerations. The framework will also serve as a tool to increase awareness among the producer, consumer and resource professional communities of what agroforestry systems are, their integrated nature and the 'triple bottom line' of their returns or products. Thus the intent of the framework is to be both a planning and an educational tool, raising awareness and understanding.

CONCLUSION

The interest in accounting for the true costs and benefits of agroforestry operations must be met with creative, flexible, and robust tools to enable the transition from a fiscal economy to one that includes ecological and social considerations that cannot be effectively assigned monetary value. Natural resource accounting for agroforestry systems must accommodate the range of costs and benefits that do not benefit from the prescription of a monetary value.

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ENDNOTES

[1] Natural capital refers to ecological goods and services (Costanza et al. 1998). Ecological services are defined as the processes and conditions of natural ecosystems that support human activity and sustain human life, e.g., soil fertility, natural pest control, climate regulation. Ecological goods are those derived from ecosystem services, e.g., food, timber, fresh water (Chapin III et al. 2000).