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TRANSITIONING FROM WILD COLLECTION TO FOREST CULTIVATION OF INDIGENOUS MEDICINAL FOREST PLANTS IN EASTERN NORTH AMERICA

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Abstract: The forest flora of eastern North America includes many herbaceous plant species traded in domestic and international medicinal markets. Conservation concerns surrounding wild-collection exist and transitioning to cultivation in agroforestry systems has potential economic and ecological benefits. Costs and revenues associated with adopting forest cultivation were modeled for eight North American medicinal forest plants. Sensitivity analysis examined profit potential in relation to (1) discount rates; (2) propagation methods; (3) prices; (4) growing period; (5) production costs; and (6) yields. Results indicate that intensive husbandry of six of eight species would be unprofitable at recent (1990-2005) price levels. Exceptions are American ginseng (*Panax quinquefolius* L.), and under certain circumstances (e.g., maximum historic prices, low production costs) goldenseal (*Hydrastis canadensis* L.). Direct marketing to consumers and retailers might improve grower profits, but is undermined by the availability of cheaper, wild-collected product. We suggest that the North American medicinal plant industry could play a key role in facilitating any transition from wild to cultivated product, perhaps through development of a certification and labeling program that brands "forest cultivated" products. This could generate price premiums, to be passed along to growers, but must be accompanied by aggressive consumer education. A "forest cultivated" certification and labeling program has potential to benefit industry and consumers if assurances regarding product identity and quality are a central feature. Plant species that are not viable candidates for commercial cultivation due to limited consumer demand (i.e., species with "shallow," erratic markets) are best addressed through proactive government and industry initiatives involving targeted harvester education programs.

Keywords: financial analysis, forest farming, medicinal plant conservation, non-timber forest products, plant husbandry, specialty forest products.

INTRODUCTION

As many as fifty plant species indigenous to eastern North American forestlands annually find their way into domestic and international medicinal trade networks (Robbins 1999; Strategic Sourcing 2008). Some of the most prominent North American trade species are gathered from forestlands (Bailey 1999; Emery *et al*. 2003; McClain and Jones 2005) and represent important non-timber forest products (NTFPs). Among these, collection pressure is widely acknowledged for American ginseng (*Panax quinquefolius* L.) and goldenseal (*Hydrastis canadensis* L.); however, there is also significant commerce in other species including black cohosh (*Actaea* *racemosa* L.), blue cohosh (*Caulophyllum thalictroides* L.), bloodroot (*Sanguinaria canadensis* L.), false unicorn root (*Chamaelirium luteum* L.) and wild yam (*Dioscorea villosa* L.)

Collection from wild populations is a concern since many species are slow-growing perennials with low fecundity and/or juvenile recruitment rates. Presently, two North American medicinal forest plants---American ginseng and goldenseal---are included in Appendix 2 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) due to concerns over sustainability of wild harvests, and additional species have been suggested as suitable candidates for listing.

Rather than collect from wild populations, cultivation of indigenous North American medicinal forest plants is an alternative (United Plant Savers (UPS) 2008). *In situ* cultivation using agroforestry practices such as forest cultivation are especially attractive (Rao, Palada, and Becker 2004), as there are potential advantages or benefits compared with field-based cultivation. Advantage include production cost savings, final product characteristics or qualities, and offers multiple economic and ecological benefits to landowner and society, since the practice has the potential to increase income while maintaining forest integrity (Hill and Buck 2000). Income derived from forest cultivation is received at shorter intervals than timber, giving private forest landowners more revenue options, enabling them to pay annual taxes and other carrying costs. Facilitating private landowner interest in adopting forest cultivation can therefore drive interest in forest stewardship, raise awareness about indigenous forest plants, and positively influence silvicultural decisions.

Transitioning from wild-collection to forest cultivation of indigenous North American medicinal forest plants is an economic opportunity with concomitant conservation and ecological merits. However, there has been limited financial evaluation of agroforestry crop candidates in relation to recent market price trends. This paper presents financial analyses (i.e., cost and revenue models) for agroforestry cultivation of eight North American medicinal forest plants, using sensitivity analysis to examine profit potential relative to costs, revenues, discount rates, production length, propagation methods, and yields. Market price data were compiled for the period 1990-2005 and were adjusted for inflation. Results identify market and production factors requiring careful consideration by those interested in agroforestry cultivation of indigenous North American medicinal forest plants, and highlight constraints to transitioning from wild collection to forest cultivation.

METHODS

All analyses were conducted utilizing a spreadsheet template (= basic model) which was modified (= adjusted model) for sensitivity analyses (e.g., discount rate, time to harvest, no stock costs, no annual costs). The term "basic model" as used in this paper refers to the original template whereas "adjusted model" indicates modified templates where key variables were altered. Basic model parameters use the woods-cultivated approach to forest cultivation premised upon the idea that more intensive methods would tend to increase yields by increasing survival, growth, and root weight. However, adjusted models in which annual costs are removed are included and could be considered similar to the less intensive wild-simulated cultivation approach. Price data for developing this analysis came from contacts with "local buyers/country dealers" and "regional consolidators" and covers the period 1990-2005. Before conducting any analyses, all prices were adjusted for inflation. The basic model includes two propagation methods: seed and juvenile rootstock transplants sourced from a commercial nursery[1].

The basic model incorporated a four percent discount rate. Two slightly higher rates, six and eight percent, were used in adjusted models to examine net present value (NPV) sensitivity. Because both basic and adjusted models utilized real prices, future revenues were treated the same by removing inflation from discount rates (Klemperer 1996). Break even prices were calculated by dividing production costs by the projected yields. Break even yields were calculated by dividing production costs by minimum, maximum, and mean prices. In both calculations, only variable costs were used, in keeping with the variable versus fixed cost assumptions presented under "labor and material costs."

RESULTS

Net Present Value (NPV) results for both basic and adjusted models are given in Table 1. Only the most favorable production method (most profitable/least unprofitable) results are given for each selected discount rate. As expected, as discount rate increased, profitability decreased for all species. However, there were no changes from profitable to unprofitable with any species in response to increasing discount rates. In general, the NPV results for all models suggest adoption of forest cultivation for all species except American ginseng would be unprofitable at even the lowest discount rate. This is true regardless of propagation method, although for most species propagation from seed is apparently less costly despite the generally longer cropping period. The results did not differ with price level.

[1] See Burkhart and Jacobson 2008 for details about the 8 species, stocking requirements and estimated costs, crop production parameters and yield estimates, plant spacing and numbers, years to harvest, yield estimates, labor and material costs.

Table 1. Net present value (NPV, US$, 1/10 Ha) of North American medicinal forest crop candidates at three discount rates and three price levels (mean, minimum, maximum prices, 1990-2005). NPV given is for the most profitable propagation method. [@]

	NPV (4% discount rate, US$)			**NPV (6% discount rate, US$)**			**NPV (8% discount rate, US$)**		
	Mean price	Min price	Max price	Mean price	Min price	Max price	Mean price	Min price	Max price
ACRA [#]	-12,731^{T}	-12,888^{T}	-12,485^{T}	-12,312^{S}	-12,441^{S}	-12,092^{T}	-11,654^{S}	-11,770^{S}	-11,472^{S}
CATH	-15,609^{T}	-15,662^{T}	-15,495^{T}	-14,851^{T}	-14,899^{T}	-14,750^{T}	-14,171^{T}	-14,214^{T}	-14,081^{T}
CHLU	-14,137^{S}	-15,454^{S}	-12,720^{S}	-13,272^{S}	-14,403^{S}	-12,056^{S}	-12,505^{S}	-13,479^{S}	-11,458^{S}
DIVI	-12,971^{T}	-13,044^{T}	-12,810^{T}	-12,543^{T}	-12,610^{T}	-12,394^{T}	-12,148^{T}	-12,210^{T}	-12,010^{T}
HYCA	-10,518^{S}	-12,084^{S}	-8,423^{S}	-10,257^{S}	-12,084^{S}	-8,388^{S}	-10,011^{S}	-11,259^{S}	-8,340^{S}
PAQU	15,261^{T}	4,610^{S}	32,030^{T}	12,414^{T}	2,879^{S}	27,372^{T}	9,937^{T}	1,455^{S}	23,307^{T}
PHAM	-7,782^{S}	-7,816^{S}	-7,707^{S}	-7,611^{S}	-7,643^{S}	-7,538^{S}	-7,448^{S}	-7,480^{S}	-7,379^{S}
SACA	-13,441^{S}	-14,234^{S}	-12,632^{S}	-12,783^{S}	-13,490^{S}	-12,061^{S}	-12,190^{S}	-12,822^{S}	-11,545^{S}

[@] Method of propagation: ^{S} = seed, ^{T} = transplant.
[#] Abbreviations: ACRA= *Actaea racemosa*; CATH= *Caulophyllum thalictroides*; CHLU= *Chamaelirium luteum*; DIVI= *Dioscorea villosa*; HYCA= *Hydrastis canadensis*; PAQU= *Panax quinquefolius*; PHAM= *Phytolacca americana*; SACA= *Sanguinaria canadensis*.

To examine whether recent industry pricing will support forest cultivation, break even prices (i.e., the cost of production divided by the yield) were calculated for each species and compared with 1990-2005 prices[2]. With only one exception, American ginseng, both basic and adjusted model break-even price results were much higher than historic prices. This suggests that, barring significant future price increases, forest cultivation would not be profitable for seven of eight species included in this analysis. The exception, American ginseng, had break-even prices well below historic price levels in all model scenarios.

These findings did not change even when parsimonious adjusted models were created (i.e., early harvest + no stock costs + no annual costs), and did not differ with propagation method. Only goldenseal showed profit earning potential in adjusted models, if cropping period (early harvest) and production costs were reduced (no stock + no annual costs) and mean or maximum prices were obtained. When break-even prices were examined by propagation method, the calculated break-even price from seed was lower than transplants for more than half of the plant species (i.e., CHLU, HYCA, PAQU, PHAM, SACA), despite the fact that a shorter cropping period is

[2] See Burkhart and Jacobson 2008 for details of this model

generally required using transplants (in turn reducing labor and material costs). This resulted from the fact that seed is usually less expensive than rootstock in the nursery trade. Scenarios in which cultivation using transplants had a lower break-even price (i.e., ACRA, CATH, DIVI) resulted from relatively higher seed costs, coupled with added labor and material costs necessitated by the longer cropping period when grown from seed.

Even when all stock costs were removed from models (no stock costs), calculated break-even prices for all species except American ginseng remained well above recent historic prices. Moreover, removing stock costs from models affected break-even prices to a lesser extent than shortening the cropping period (early harvest) or eliminating annual production costs (no annual costs). These results suggest that while planting stock costs are an important determinant of profit potential, they are less important than other production costs such as cropping period, annual labor, and materials.

The influence of crop period on profitability was examined using an adjusted model to consider the shortest possible rotation (early harvest)[3]. The break-even prices calculated from these results indicate that hastening harvests can improve the economics of forest cultivation, but this alone is not enough to change the general findings that recent historic prices are well below break-even. Shortening the cropping period did have more influence on determining break-even prices than did eliminating planting stock costs.
Adjusted models in which annual production costs such as labor and materials were excluded (no annual costs) had the most significant impact on break-even prices. In all cases, the exclusion of annual costs produced break-even prices that were at most half those calculated in basic models.

Calculated break-even yield values indicate that yields for all species except American ginseng would need to greatly increase to recover investment costs. Half of the species (ACRA, CATH, DIVI, PHAM) would require unrealistic yield increases for cost recovery and profit potential. Of the remaining, three (CHLU, HYCA, SACA) would require modest yield increases and favorable market prices (e.g., mean, maximum prices). Only American ginseng would require no yield increases to recover production costs and provide profit; according to model results, yields for this species could be reduced and cost recovery and profit potential would likely remain.

DISCUSSION

Individuals may choose to adopt forest cultivation for other than purely financial reasons such as personal interest, household consumption, and/or conservation intentions; however, any broad transition from wild collection to forest cultivation of the plants considered in this study is likely to require financial justification or rewards for adopters. This is especially true since many species require multiple years before harvesting, and the investment tied-up in each forest crop can be significant during intervening years. Net present value (NPV) results revealed that, with one exception (e.g., American ginseng), adopting forest cultivation for the plants considered in these models would be unprofitable, assuming wholesale product prices continue at recent historic levels.

[3] see Burkhart and Jacobson 2008 for details of this model

Adjusted models (i.e., sensitivity analyses) were used to examine the relative influence of key variables in determining break-even prices and yields. Of the variables examined, annual production costs (i.e., labor and supply costs) most affected break-even prices, because the majority of the species considered require multiple years until harvest, and annual production costs accrue during this period. From a practical standpoint, this suggests that husbandry approaches using minimal husbandry practices, i.e., "wild-simulated" approach, may best reduce production costs and thereby improve revenue potential. However, there are likely trade-offs to adopting a minimal husbandry approach, including reduced plant survival and yields. It must be emphasized that even when annual production costs (i.e., all costs except planting and harvesting costs) were removed from adjusted models, calculated break-even prices were still much greater than recent prices. Thus, reducing production costs is likely to be only part of any solution to improving the economics of forest cultivation.

Shortening the time between planting and harvest (i.e., cropping period) was the second most influential factor in determining break-even prices. Accordingly, propagation methods and production practices that reduce the cropping period are likely to benefit producers. Such practices might include using transplants rather than seed as planting stock. While transplant costs are generally greater than seed costs, annual production costs represented the greatest single investment expense in these models; thus, careful deliberation must be given to potential cost savings accrued by using transplants. The time to harvest is perhaps best shortened by selecting cropping sites most favorable to optimal growth for each species. Manipulation of soil conditions, via tillage or amendments, may encourage rapid growth and higher yields, but these will also increase production costs.

The economics associated with forest cultivation might also be improved by responsible gathering of local planting stock, since stock from nursery suppliers is presently very expensive for most species. One potentially less expensive alternative to buying nursery stock (although there will still be time and labor costs) is to use local germplasm through seed, seedling, or rootstock collection and replanting, which can concomitantly help to retain genetic diversity in the species.

Manipulating production practices through fertilization, irrigation, and/or increasing sunlight levels to improve yields may favorably alter forest cultivation economics. However, modeled break-even yield estimates indicate that significant yield increases would need to occur for nearly all species to recover costs, much less earn profits. Even where field cultivation appears to hold promise, artificial shade is a significant production cost to include in economic projections.

One solution for increasing grower profits, and thus forest cultivation, might be the development of industry certification and labeling programs for forest cultivated product. Such programs could be used to generate economic "premiums" and raise wholesale market prices to levels that support cultivation. Without price "premiums" generated through certification and labeling programs, transitioning from wild to forest cultivated sources for many plants is not likely to be profitable unless there are significant, demand driven increases in wholesale prices (in which case collection pressure would also increase) or unless alternative market opportunities develop. Educational efforts and promotional campaigns must therefore be a component of any efforts to develop product certification and labeling programs, and encourage consumer attention to product origins. Such efforts must articulate the benefits to consumer and society from purchasing certified forest cultivated materials, and should include assurances regarding identity, source, sanitation, and quality (i.e., appearance, chemical or otherwise).

The willingness of some individuals to collect indigenous forest plants despite low prices facilitates low prices in the wholesale market. Collectors may engage in collection regardless of pricing because wild plant products serve as a secondary or tertiary income source, or a "safety net" during difficult financial times (Bailey 1999; Cozzo 1999; Emery *et al.* 2003). Accordingly, there may be little desire or ability to adopt intensive husbandry practices requiring significant investment and costs. Many collectors choose to collect wild plant products for enjoyment (Bailey 1999; Emery *et al.* 2003). Additionally, markets for many plants are easily satiated and annual consumer demand unpredictable. Although the outlook at the time of establishment can be favorable, one cannot predict future market conditions, and "bust" cycles can erode any projected profits. Buyers frequently require contractual agreements before purchasing larger quantities (e.g., 100 lbs or more), and growers may consequently have a difficult time selling product even if market conditions are "good" at the time of planting. In this context, wild-collection is considered by many in the North American industry as perhaps the only practical means for obtaining plant materials when consumer demand for a particular botanical suddenly increases.

Because of these constraints, wild collection is likely to continue for many indigenous forest plants. Concern for trade species that do not garner a high enough price to support cultivation must be addressed through alternative programs including wild management and collector education programming, rather than through initiatives encouraging cultivation. In such efforts, the development of certification programs for non-timber forest products or harvesters may provide a mechanism for addressing stewardship concerns for wild-collected species (Shanley, Pierce, and Laird 2005). While these could be state or federal government programs, programs would likely be more effective and self-sustaining if industry initiated, in consultation with botanists, horticulturalists, collectors and others who can provide guidance and grounded perspective. Basic guidelines and standards for North American species could be regionally tailored, using published international standards for wild collection (e.g., WHO 2003) as a foundation. Product certification and labeling accompanied by consumer education could provide assurances to consumers, and generate price "premiums" to support harvester outreach and other program components.

CONCLUSION

The model results obtained suggest that forest farming of many native medicinal plants in eastern North America would not be profitable at recent historic prices. Wholesale market prices are far below production costs for many species, and pricing is not equitable among species with similar production requirements. Significant price differences exist between species with approximately the same production requirements and yield potentials (e.g., American ginseng versus blue cohosh). While this difference can be attributed to market factors (e.g., differences in consumer demand, scarcity of supplies), there is nevertheless little incentive for adoption of intensive husbandry given such realities. Even the most parsimonious crop production models (e.g., early harvest + no stock costs + no annual costs) failed to generate break-even prices commensurate with recent historic wholesale prices; rather, with all species except American ginseng and goldenseal, calculated break-even prices far exceeded recent industry prices. Yield increases alone are not likely to resolve financial shortcomings since many species would need dramatic, and largely unrealistic, yield gains to even recover production costs, much less earn a profit.

Although this analysis only included eight plant species, these conclusions are equally applicable to other indigenous forest plants including bethroot (*Trillium erectum* L.), cranesbill (*Geranium maculatum* L.), mayapple (*Podophyllum peltatum* L.), stoneroot (*Collinsonia canadensis* L.), and Virginia snakeroot (*Aristolochia serpentaria* L.). For all of these species, the wholesale prices paid during 1990-2005 for raw materials was well below agroforestry production costs (data and model results not included in this paper). Wild collection is likely to continue for these species because investment in cultivation is simply not profitable, and because collection is amenable to the industry's need to respond to intermittent demand in an often highly volatile marketplace (i.e., "boom and bust" cycles). Accordingly, there is need for both technical support for agroforestry production of species with profit potential and significant demand (e.g., American ginseng and goldenseal) as well as for collector guidance for species that are likely to continue to be collected because prices do not support intensive husbandry and/or demand is sporadic. While there may be conservation benefits associated with forest cultivation of indigenous plant species, guidance provided to those interested in transitioning from lesser to more intensive forms of forest plant husbandry must include consideration of inflation, discount rates, and other time-related economic factors that will inevitably impact the profitability of crops requiring multiple years to attain harvestable maturity. Species that are not economically feasible for cultivation, particularly due to limited market demand, are best served through development of proactive government and industry initiatives involving targeted harvester education and possibly NTFP certification programs.

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