The Value of Forests

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Aloha and mahalo for your invitation to speak and participate in this symposium on the future of *Acacia koa*, an indigenous species with a lot going for it. I hope my insights will complement the many perspectives brought together here by the Hawai'i Forest Industry Association.

One of my biggest problems with being on the luncheon speaking circuit is that typically there are two types of audiences to whom I am asked to make presentations. The first are those who have a general interest in current economic issues or phenomena. For these audiences my task is relatively easy because things economic change constantly, and I usually have the advantage of having kept closer track of them than those to whom I am speaking. In this case, the most difficult task is choosing a title to the presentation, because things change so fast.

The second kind of audience are those who have much more knowledge of the subject than I do, but for some reason have been convinced that I have something meaningful to contribute. For these audiences the task either involves a lot of homework or careful selection of things that the economic perspective renders in a different light from that to which the audience is accustomed. Imagine preparing presentations for the Consulting Engineers Council, the Hawai'i Crop Improvement Association, or the American Appraisal Institute-Hawai'i Chapter, and you'll see what I mean.

For this symposium, falling into the second category, I would like to choose a few ideas that economists familiar with natural resource issues think about, and a few ideas that economists not so familiar with natural resource issues think about. This is mostly because I will run out of good ideas if I stick with natural resource economics. It is also because the issues raised by longterm forestry investment are also prevalent outside the natural resource arena.

In speaking from a prepared text rather than extemporaneously, I am breaking my usual mold. This is being drafted on a long trip outside the country, so by the time I have heard what others are talking about at this symposium it may well become extemporaneous.

Simple issues: the Market

The simple way of thinking about the value of a koa forest is to distinguish between the market value of the forest and its nonmarket value. The market value of the forest is relatively straightforward: it is the yield in revenue obtained by selling harvestable forest products in the market(s) for those products. This may be lumber, but one can expand to include applications in various crafts involving woodworking, carpentry, and the like. Nowadays, we should probably expand the scope of our thinking to include a variety of manufactured wood products, those lighter but stronger fabrications of building materials now being developed in forest products laboratories. The point is that the market value of the forest is derived from the underlying value of wood products it can support, from the demand for its downstream forest products.

Some, maybe most, of these market values are unlikely to be relevant to the owner of a koa stand unless she is in fact the owner of a vertically-integrated firm in which production of the raw material, koa logs, is linked to downstream, within-firm alterations of the raw material, whether sawn timber, paneling, cabinets, or furniture. In this case, value-added along the chain of production is internalized, captured by the single owner.

Typically, vertical integration is not going to obtain. The owner of the koa stand may have very little interest, financially speaking, in what happens after the forest is logged and trucked away, other than getting the next rotation into the ground and enhancing the value of the underlying land. One of the reasons policy-makers in Hawai'i have been inclined to be attracted to large, offshore, corporate timber concerns is that they raise the prospect of scale and scope sufficient to solve a land-use problem which will otherwise pose enormous coordination problems, should policy-makers instead be required to weave together solutions based on small, specialized, entrepreneurially-oriented firms interested

in a specific piece of the action.

While large concerns will contribute substantially to the challenges Hawai'i faces in the transition of economically non-viable plantation or pasture uses of land, a policy framework capable of accommodating the small producer should also be crafted. Large concerns will internalize the costs—and benefits—of vertically-integrated production, but small concerns will give Hawai'i, and especially the small geographic and political jurisdictions that neighbor island communities represent, flexibility and variability of opportunity that was lacking during a century or more of plantation-oriented economic development through early statehood. An environment in which both big and small producers can thrive is less likely to suffer the distortions induced by monopoly or monopsony (monopolization of outputs or inputs).

(I might add that policy-makers might also want to consider minimizing their interventions in these emerging markets for koa wood production and products, as a rule of thumb, since interventions create their own unique distortions to market signals.)

(As an additional aside, I think it is worth noting that the rapid development of microprocessor-based applications will overcome many of the cost hurdles that large corporate organizations used to have an advantage dealing with. Because of the falling cost of information management and communication, small organizations have within their reach more powerful tools to overcome the scale economies once supportive of larger organizations' structures in which coordination problems were overcome by specialization. In addition, getting products to market will inevitably be managed electronically for any koa wood products we might now be thinking about planting to produce. Small producers will have greater electronic access to end-user markets for their products than ever in coming years.)

The least restrictive policy environment for the development of koa woods products and markets will generate the greatest benefits for those producers interested in koa production and the communities they inhabit. These conditions do not exist in Hawai'i, the only state I know of that had to pass a law to ensure that one has the right to harvest a tree one plants for commercial purposes. It would be a shame if *Acacia koa* did not succeed commercially in Hawai'i, but rather did succeed in some Third World competitor. The importance of Hawai'i having the first shot at commercially viable koa silviculture or agroforesty is underscored by a long list of predecessor Hawai'i crops (pineapple, sugar, macadamia nuts, even orchids and anthuriums to name but a few) which have had to face international competitive challenges.

Not-so-simple issues: External benefits

Much discussion yesterday was to have focused on technical issues surrounding the commercial development, propagation and cultivation of koa. Today's discussion will have broadened the focus to include some nonmarket issues. For forests, the increasing recognition of these nonmarket, economic aspects is significant. There are two directions in which the forestry economics literature on this has evolved. The first is the increasing sophistication of dynamic analysis developed in the last half century. During this time, optimal control theory, in particular, has significantly advanced the sophistication of modeling of renewable natural resources including forests.

The second has to do with the recognition of the economic value of natural environments. The recognition of nonmarket economic values contributed by forests is symbolized by the first and second editions of Colin Clark's classic *Mathematical Bioeconomics*, in the second edition of which the section on the Faustmann model of optimal rotation (Faustmann 1849) has appended a discussion on externalities and notes on modeling the joint production of timber and environmental benefits (Clark 1990), in place of an optimal thinning model, I might add. We now pay attention to the production of wildlife habitat, watershed, and aesthetic amenities, not to mention global atmospheric change, in a way previously ignored in formal, forestry economic analysis.

For some of us the elegance of these elaborations of the models themselves is the primary attraction, but I think it can be fairly said that society has revealed its collective preference for formal inclusion of these items in the economic calculus of natural resource valuation through the political process, just judging by the rhetoric of modern political campaigns, if not the actions of elected officials.

However, we are a long way from a satisfactory, meaningful preference revelation mechanism involving society's willingness to pay for the production of these external benefits of forests. The problem, in the economic way of viewing things, is that there is a missing

market. There is no market for environmental amenities, and we observe people's willingness to pay for them at best indirectly, as in the valuation of homes or other real estate assets with desirable locational attributes.

When markets are missing, economists recommend creating markets in which willingness to pay (or accept compensation) can be manifested. As one tangential renewable resource management example illustrates, the allocation of primary water use rights (e.g., extraction and wholesale distribution) by impaneled commissioners listening to expert witnesses in contested-case proceedings is unduly costly and cumbersome, and ultimately allocatively inferior to, a system of revocable, tradable primary water-use permits allocated by electronic auction, to which a derivative system of water-use futures and options would add intertemporal preference revelation. We need to approach the public management of forest development with an open mind to market-oriented solutions.

Perversely, the ill-recognized nonmarket benefits of forests actually add a selling point for someone trying to pitch a forestry investment. The reality is that society is much more willing to enjoy environmental benefits at someone else's expense than it is to shoulder the cost of those investments itself. Private sources of capital, unable to capture these returns, tend to underinvest as a result. This leads me to commend efforts to adapt the regulatory and policy framework to recognize the contributions that investors in commercial koa forests make to the production of environmental externalities in the calculus of social net benefits that ultimately should guide regulatory and public policy decisions. Forest developers should not be penalized *ex post* for the production of habitat, watershed or aesthetics when harvest time arrives, and yet be unable to capture the present value of their future external contributions *ex ante*. Yet, I believe this is exactly what the treatment of prospective forest investors boils down to. One can write down a model that says that the optimal tax on a forest is negative.(1) (This is presumably the logic of the forest incentives programs discussed at breakfast this morning.) It is important to frame this in a meaningful public policy posture towards forest investment. Educating policy-makers is crucial, as administrators of natural resource policies in Hawai'i I'm sure agree; many are the strongest advocates of these policies. We all need to educate our legislators, who want to learn.

More not-so-simple issues

I will mention only three more issues, as they are to be reckoned with in the future of koa forestry, at least from the economic perspective. Not to bore you with jargon, but the three are: (1) nonlinearities, (2) asymmetric information, and (3) uncertainty.

Nonlinearity. The minute you take an optimal forest rotation model and plug in a nonlinear growth function for the tree, your brain starts to hurt. We all use logistic growth models because they tend to abound in nature, thank goodness, but also because lurking in some textbook is an analytical solution to the continuous-time problem (by separation of variables, if I recall) that guides the construction of a numerical solution of a discrete-time equivalent. In short, the optimal stopping problem of choosing a date to chop down the tree that maximizes its value, the integral of all discounted future values, market and nonmarket, is not just complicated, it's nonlinear. What that basically means is that things can change in a hurry: what at one point in time may not look valuable may very shortly thereafter suddenly appear valuable. (Note that I'm still talking about the deterministic case in which we have perfect foresight of all future states of the world.)

We need to come to grips with nonlinearity in our analysis of koa forest investment prospects because nonlinearity enters intrinsically into the question of the forest's value. This straight-line stuff will simply not do. As a concrete example, we need a proper analysis of the parameters of koa's growth function under managed, agronomic conditions made possible by several current and past trials in koa production. Financial feasibility analysis must be grounded firmly in an understanding of the growth properties of koa under modern cultivation. The observation that old growth koa under competing conditions in native forests must be at least 40 years old before commercially viable harvest is warranted is uninformative as to the optimal stopping time for a koa grown in homogenous stands under fertilization and pest control. *Acacia koa* may be a fast-growing woody legume, and we don't even know about it! And of course, there are lots of koas; basic research must receive higher levels of public investment. One compelling nonlinearity is the prospective movements of market prices for tropical hardwoods in an era of global deforestation. The economic implications of deforestation probably cannot be unwound in our lifetimes. Those of you who remember Hotelling's Rules (Hotelling 1931)

recall that an exhaustible resource price should rise at more than the real rate of return on alternative assets to be worth holding rather than harvesting. Forests fall into that category of renewable resources with life-cycles long enough to be, for one human generation, quasi-exhaustible. How much will she who plants a koa forest today benefit, when harvested two decades from now, from the dramatic rise in tropical hardwood prices during the interim, if unmitigated by the development of substitutes?

Asymmetric information. Asymmetric information is a subject on which a background in banking might contribute to understanding where another might not. Asymmetric information is the name economists give to a common phenomenon in which one economic agent has more (or different) information than (from) another. Borrowers often know more about their creditworthiness than lenders. Old investors often know more about a company than new investors. Management often knows more about a company's financial health than labor. The result can be economic transactions entered into that do not yield the win-win outcomes ordinarily associated with market allocation through voluntary exchange.

Because of information asymmetries, banks do their homework on prospective borrowers to learn what borrowers already know but may have an incentive not to reveal to a prospective lender. This limits "adverse selection." Covenants and conditions in loan documents assure that borrowers face compatible incentives; collateral reduces "moral hazard" by creating additional incentives for the borrower to pay back the loan.

How does this affect forests? I believe one of the most significant stumbling blocks to the commercial development of koa forests in Hawai'i is the provision of long-term financing. One simple case in point: How are you going to talk an investor or lender into providing capital for an asset that generates no cash flows and whose return is generated in a lump sum after 20–30 years? There are several answers, one of which is a large firm that can internalize the lack of cash flow by enjoying other returns, such as tax advantages. Another is to produce joint products, like an "eco-tourism" service provider who sells educational benefits and, when you think about it, generates a prospective repeat visitor interested in seeing the forest as it matures.

This cash flow problem is surmountable, but the more generic asymmetric information problem must still be dealt with. Those assembled here know many times more about koa than does a prospective financier. The asymmetric information problem looms large. How are you going to convince an investment banker to package something like a zero-coupon security to finance the planting of a commercial koa forest whose returns do not arrive for a couple decades? Zero-coupon securities are not uncommon—they are a popular college investment vehicle, for example—packaging them for trees has not been done, to my knowledge. In my dream world I can see a state government-guaranteed, tax-free municipal bond-type mutual fund investing in privately-issued, zero-coupon securities to finance commercial koa plantings, sold to small investors, kama'ainas, and those whose hearts are in Hawai'i, who want to see further propagation of indigenous forests. Hey, I can even imagine selling the fund over Internet to the "green" investor community. "A koa mutual fund to go with that cup of Starbuck's coffee, ma'm?" But can anybody talk Salomon Brothers or Hawaiian Trust Company into it? We must figure out a way to do so, or come up with an alternative, like equity investments. Waiting for a Kiwi conglomerate or mainland insurance company to do it may not be the best answer to the forestry financing dilemma. Speaking as Chairman of the Council of Revenues, I would guess there is no near-term capital financing for koa available from the state's General Fund revenue stream.

Uncertainty. By now the principal uncertainty you are facing is: will I ever finish this presentation? I do want to mention uncertainty just to give you a flavor for what it means to take it into consideration formally in the analytics of forestry economics. If we live in a nonlinear universe, we surely live in a stochastic one. Another addition to Clark's second edition of *Mathematical Bioeconomics* is the introduction of a chapter on stochastic resources models, considering the effects of uncertainty on renewable resource harvests. Forests burn down randomly, and though this may have only second-order effects on harvest strategy, "the cumulative risk of [catastrophic destruction] does bias the [optimal] rotation towards earlier harvests."

Investment under uncertainty raises similar technical issues. Think of how asymmetric information complicates investment activity, giving rise to the existence of financial intermediation itself. Now imagine adding the complications of not having a lot of basic botanical or agronomic knowledge about koa and then consider the implications of global warming for hurricane fre-

quency and intensity, or the mysterious pattern of cohort senescence observed in a genus like *Metrosideros* or suggested by koa dieback. Future prices and costs are inherently unknown, as are the nature of future consumer preferences over wood products and future government regulations.

One interesting newer approach to the understanding of the interaction of uncertainty and investment poses an investment as a kind of real option, like the financial options traded in many futures exchanges today. Planting a tree gives you the right, but not the obligation, to harvest at some date T, to exercise a "call" on your option to harvest. Option valuation techniques can be applied to price this option, in effect, to determine the value of a forest. Whether increasing uncertainty improves or worsens prospects for koa forest investment depends on whether it increases or decreases the value of the real option: it is not necessarily bad for investment to have increasing uncertainty. Banks routinely test the sensitivity of their portfolios and, in essence, the value of bank stock by running Monte Carlo simulations involving thousands of interest rate shocks, to "fill out the distribution," so to speak, of possible future valuations. There is no computational barrier to approaching the valuation of forests in a similar manner.(2)

For example, increasing uncertainty about the future of tropical hardwoods prices because of deforestation might raise the value of the option to harvest an indigenous Hawaiian hardwood in 20 years. "Keeping the option open," so to speak, by planting koa forests today, allows the future to reveal itself to us and for us to learn in a way that could not be possible if we don't plant now. Research and development outlays today could go a long way to improving the value of those options, particularly if investments in planting and research are explicitly designed to further our knowledge of optimal koa forest management. "Learning by doing," after all, is what made sugar and pineapple Hawai'i's economic mainstays for two or three generations.

Conclusions

The value of a forest has lots of meanings. I've suggested a few economic aspects of that valuation. Koa seems to be to be a natural gamble for Hawai'i to take, though I have my biases on the issue. Perhaps the greatest legacy we can leave to our descendants in Hawai'i is the knowledge that we accumulated about koa forestry by giving it a try.

Literature cited

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Hotelling, H. 1931. The economics of exhaustible resources, Journal of Political Economy 39, 137-175.

Notes

1. Ken Judd of Stanford University has models that says the optimal tax on capital should be negative even without external benefits.

2. Though I haven't read the literature that closely, my guess is that a stochastic optimal control problem maximizing the value of a forest by choosing a harvest date subject to the biological growth dynamics of the forest inventory and price dynamcis subject to Brownian motion, i.e. a stocahstic diffferential equation, can be solved in a straightforward manner. An interesting elaoration would be to add a Poisson shock (like a hurricane or pathogen) to the equation of motion for the tree stock.