

# CINTRAFOR NEWS

The Center for International Trade in Forest Products

## ECOSEL: An Auction Mechanism for Forest Ecosystem Services

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ECOSEL is a new auction mechanism that attempts to match willing sellers of forest ecosystem services with willing buyers. The tool was designed to set the stage for an open market trading scheme of ecosystems services, bypassing the often complicated valuation processes that would otherwise be needed. The goal is to maximize the revenues of the landowner as well as to potentially increase the provision of forest ecosystem services to the public.

ECOSEL has two modules. The first module is an optimization program<sup>1</sup> that generates a set of spatially-explicit forest management plans for the landowner (i.e., the seller) based on the demand of potential buyers. Each plan leads to a specific bundle of ecosystem services and has an associated reserve price which equals the timber revenues and real estate values that the landowner must forgo to implement the plan. In the second module, potential buyers can

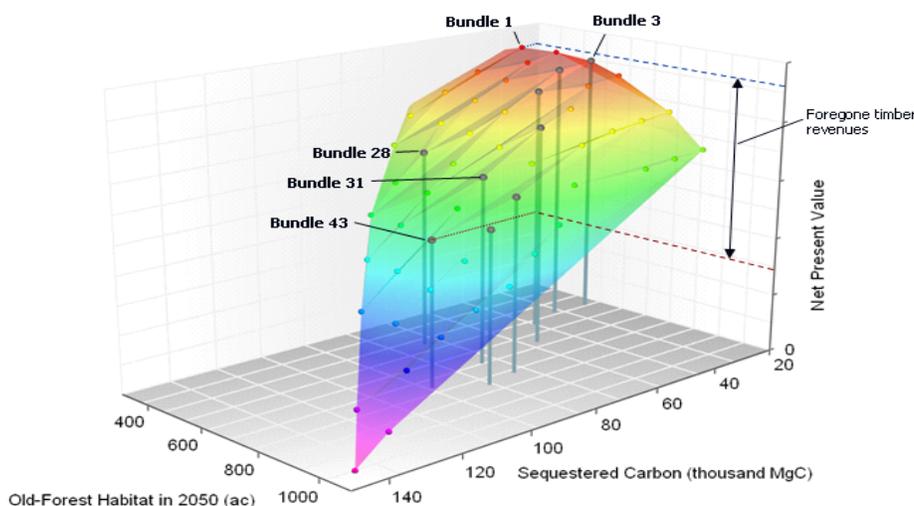
margin will be implemented. Clearly, only one plan can be implemented on a piece of forest land over a specific period of time. There is only one winner.

This auction mechanism has several unique features. First, management plans generated by ECOSEL are optimal in the sense that they represent the lowest-cost ways of achieving the desired environmental outputs. This guarantees minimal thresholds in reserve prices that the bidders must overcome in order to achieve a change in on-the-ground management. Minimal reserve prices might attract more bidders, which in turn benefits the auctioneer (i.e., the landowner) as well.

Second, the spatially-explicit management plan that corresponds to the winning bundle serves as

a contract between the buyers and the seller (landowner). The seller knows exactly what needs to be done on the ground over time to produce the contracted services. On the other hand, the buyers can use the plan as a monitoring device to detect departures from the plan. This monitoring capability should raise the bidders' trust in the system, as they can hold the landowner accountable if unjustifiable deviations to the management plan occur.

Third, since many forest ecosystem services are public goods, meaning that more than one individual can enjoy them simultaneously, ECOSEL aggregates the bids that are placed on the same bundle. Not only does this encourage the participation of buyers whose potential bids might be very small individually, it also allows groups who demand different but compatible



**Figure 1.** Pareto-optimal forest management plans for Pack Forest, Washington. Each point on the 3-dimensional surface represents a management plan, or equivalently, an ecosystem services bundle. Only five of the bundles are labeled and the net timber revenues on the vertical axis are hidden in compliance with Pack Forest policies.

bid for the management plans that they prefer, through a structured auction process. The management plan with bids whose combined value exceeds the associated reserve price by the highest

### Footnote

<sup>1</sup>The details of the optimization algorithms can be found in Tóth et al. 2006 and Tóth and McDill In Press

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# Director's Notes

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Forests provide a wide variety of both market and non-market benefits, many of which are extremely difficult to quantify. Too often during the planning process, land use decisions do not take into account the value of the non-timber goods and services that forests provide. This failure means that land use decisions underestimate or ignore non-market values and often result in the degradation of natural ecosystems or conversion of forests to non-forest end-uses. A recent study of the market and non-market values of Canada's boreal forest estimates the value of sequestered carbon at \$3.7 trillion. More importantly, the value of ecosystem services provided by boreal forests in Canada are estimated to be \$93 billion annually, more than 2.5 times greater than the revenue generated by extractive industries in the boreal region. The report highlights the difficulty in estimating the value of ecosystem services provided by forests. The value of forests extends well beyond timber values to include a wide variety of services including providing species habitat, flood control, erosion control, non-timber forest products, visual amenities, sequestered carbon and mediation of global warming, just to name a few.

However, people and governments are often reluctant to pay for the ecosystem services provided by forests. It is this unwillingness to pay for ecosystem services that results in the undervaluation of forestland, thus skewing land-use decisions towards higher value land conversion options. In essence, by neglecting to include ecosystem services in the forest values, we unwittingly skew land-use decisions away from forest retention and towards forest conversion.

The undervaluation of forest ecosystem services also undermines forest management decisions. Ignoring the value of ecosystem services in forest management decisions often result in forests that are not proactively managed to improve forest health, and the resultant decline in timber harvests undermines the ability of local sawmills to operate which further reduces the management options

available for forest managers. The loss of timber processing capacity in rural areas reduces the value of timberlands and further skews land management decision towards conversion rather than retention. A



recent article in the Oregonian quotes the president of a Northwest environmental organization as saying "We have to realize private-land timber companies are our friend. Once land gets broken up into smaller pieces, our ability to protect it is eliminated."

Environmental groups are increasingly realizing that if forests are not actively managed by man, then they will be de facto managed by nature. We can see the results of this trade-off in forest management planning in the western US where the health of the National Forests is precarious due to a lack of active forest management. The high incidence of beetle-killed timber and large volumes of dead and dying small diameter timber provides the fuel for catastrophic forest fires during the dry summer months.

One strategy that could help to support active forest management and improve forest health is to encourage the public to pay for the ecosystem services that they value. The ECOSEL auction mechanism described in this edition of the CINTRAFOR News represents an important step in this direction. The development of a successful auction system requires an understanding of the forest amenities and ecosystem services that people value the most and for which they would be willing to pay. In return for these ecosystem payments, the forest owner would agree to the specified reduction in the volume of timber harvested.

Since the optimum mix of amenities and services varies between people and forests, the ECOSEL auction system provides a range of options comprised of different mixes of attributes which can be adjusted based on the preferences of the groups involved in the auction. Auctions provide a mechanism that allows the public to pay for the ecosystem services they value. In the absence of these payments, forest owners are asked to manage their forests for unpaid public amenities, as well as for the timber that has a real market value. Auction mechanisms increase the value of forest land by providing the forest owner with additional flow of revenues to support the maintenance of critical ecosystem services while still allowing the forest owners to sell variable volumes of timber. This is a market-based solution that can effectively reconcile the interests of the environmental community, forest landowners and the forest products industry in their efforts to maintain healthy working forests that provide the ecosystem services that are so important to the environmental health of the region. ▲

forest ecosystem services to bid collectively on the same management plan. Collaborative bidding, justified by the public nature of the services to be sold, increases the chance that a particular management plan might be adopted even if its associated reserve price is high. ECOSEL encourages collaborative bidding through an open auction platform, where each participant can observe the the real-time results of other players' anonymous bids and build, or even dynamically revise their own bidding strategies.

The following section illustrates the ECOSEL concept using the University of Washington's Pack Forest as an example.

**A case study at Pack Forest**

The 4,300 acre Pack Forest is a self-sustaining forest with revenues coming from timber production. Since the real estate value of the forest is much higher than the revenues that can be made by selling timber, the administration is keen to explore non-timber revenue alternatives that could help to reduce the risk of forest conversion. Based on a preliminary assessment of stakeholder demand, ECOSEL was programmed to identify a set of management plans that would lead to Pareto-optimal allocations of timber revenues, old-forest habitat and carbon sequestration. For simplicity, old-forest habitat production was defined based on the total area of forest stands that would be older than 115 years at the end of the planning horizon (in 2050) assuming the corresponding management plan was implemented. Carbon sequestration was defined as the net change in carbon content of the standing timber over the same planning horizon. We note that in real auctions, where ultimately it is the buyers' demand that determines which ecosystem services should be produced and how, more sophisticated definitions could be used.

Figure 1 maps out the management plans for Pack Forest found by ECOSEL as a function of the net timber revenues, old-forest habitat and carbon sequestration services for the 5 management plans selected. The management plans form a 3-dimensional production possibilities frontier, whose shape characterizes the tradeoffs that are associated with the production of the three outputs. Of the hundreds of management plans found, the Director of Pack Forest selected five bundles (Bundle 1, 3, 28, 31, 43) to put up for hypothetical bidding. Bundle 1 represents the management plan that maximizes the discounted net timber revenues for the landowner, while the other bundles provide more of one or both of the two non-

timber services at gradually increasing opportunity costs. The reserve prices of the bundles were calculated based on the amount of the forgone timber revenues (see Figure 1) plus the value of forgone development rights that must be incurred by the landowner if the selected management plan were to be implemented. While the forgone timber revenues were computed by ECOSEL's optimization module, the value of development rights was arbitrarily set to a symbolic value. It should be noted that ECOSEL allows the seller to put up tracts of his land for sale for real estate development in the same auction where the ecosystem bundles are being offered. This way the real estate components of the reserve prices can be dynamically driven by the bids of the developers. In some auctions, there might not be any bids for development, in which case the reserve prices would be based on the forgone timber revenues only. Since the purchasing power of the developers reflects the preferences of the

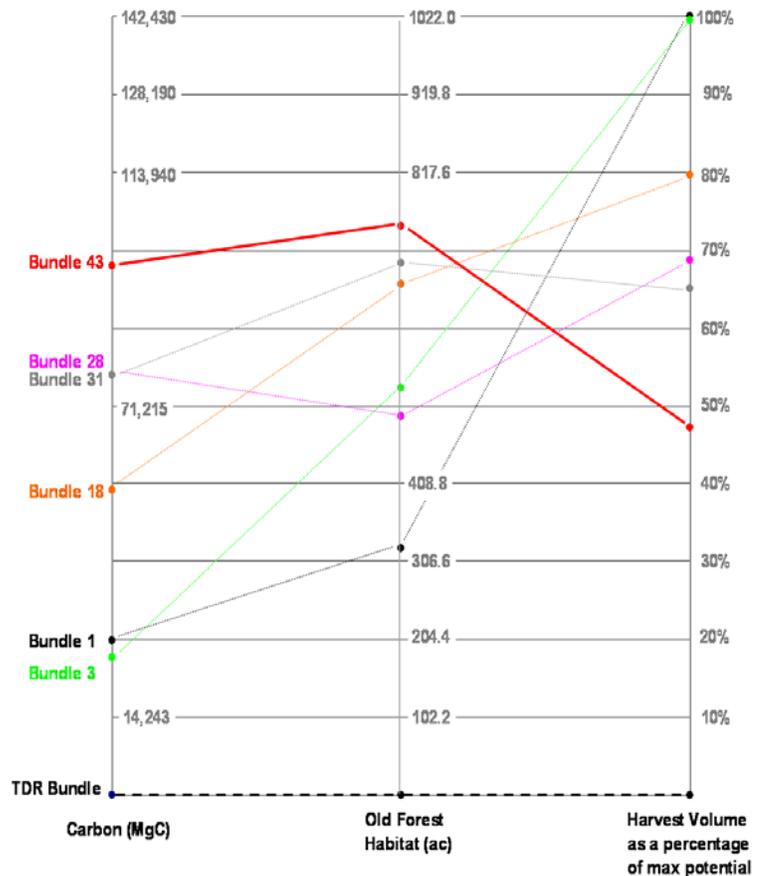


Figure 2. The value-path representation (Schilling 1976) of the 5 selected sets of bundles of management plans (and their combination of ecosystem services) at Pack Forest.

broader population, one can argue that an auction that allows bidding between conservationists, timber industry and developers is one way to gauge the true monetary values that people place on forest ecosystem services.

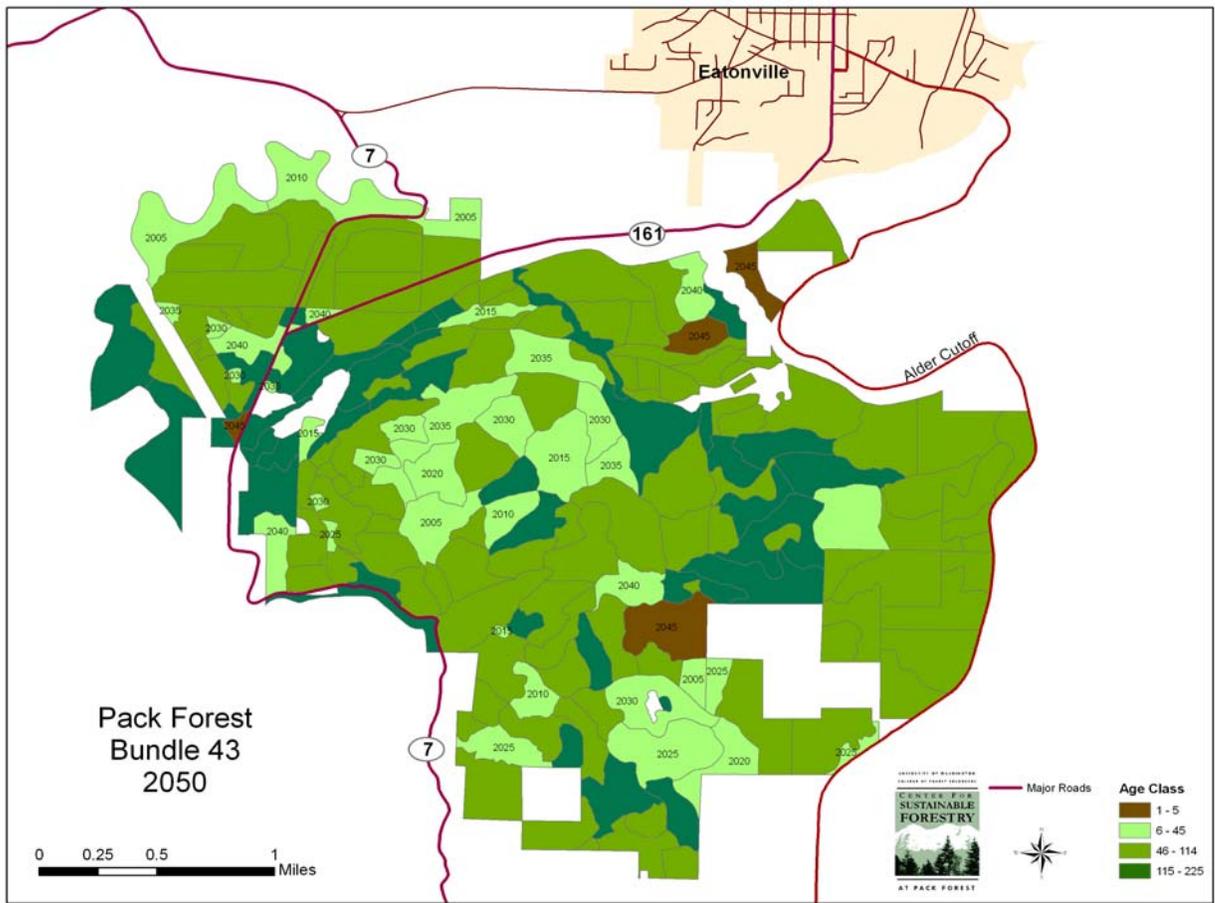


The characteristics of the bundles selected for the hypothetical auction are contrasted to each other in Figure 2. As a 2-dimensional representation of the response surface presented in Figure 1, Figure 2 shows the so called value-path graph (Schilling 1976) of the bundles. Some bidders might find this graphical representation easier to interpret and therefore more useful in guiding their decision making. Here, the total harvest volume is displayed instead of the net harvest revenues.

In addition to the production possibilities frontier and the value-path graph, ECOSEL also provides the landowners and potential buyers with detailed descriptions of the management plans that can help them understand what would be done on the ground, and when, to achieve the associated non-timber outputs. As an example, the map in Figure 3

were to be implemented as a result of the auction process.

In addition to providing information about the available forest management options and their associated attribute tradeoffs, a key feature of ECOSEL is that its auction module allows potential buyers to monitor the other participants' bidding behavior in real-time. Without disclosing the identity of the participants, ECOSEL provides a platform where bidders can build and dynamically revise their own bidding strategies based on the aggregated results of other participants' bids. As an example, suppose that a buyer, who is more interested in sequestering carbon than promoting old-forest habitat, placed a bid on Bundle 3 (Figure 4) thinking that a relatively cheap bundle is more likely to succeed in the auction. This individual

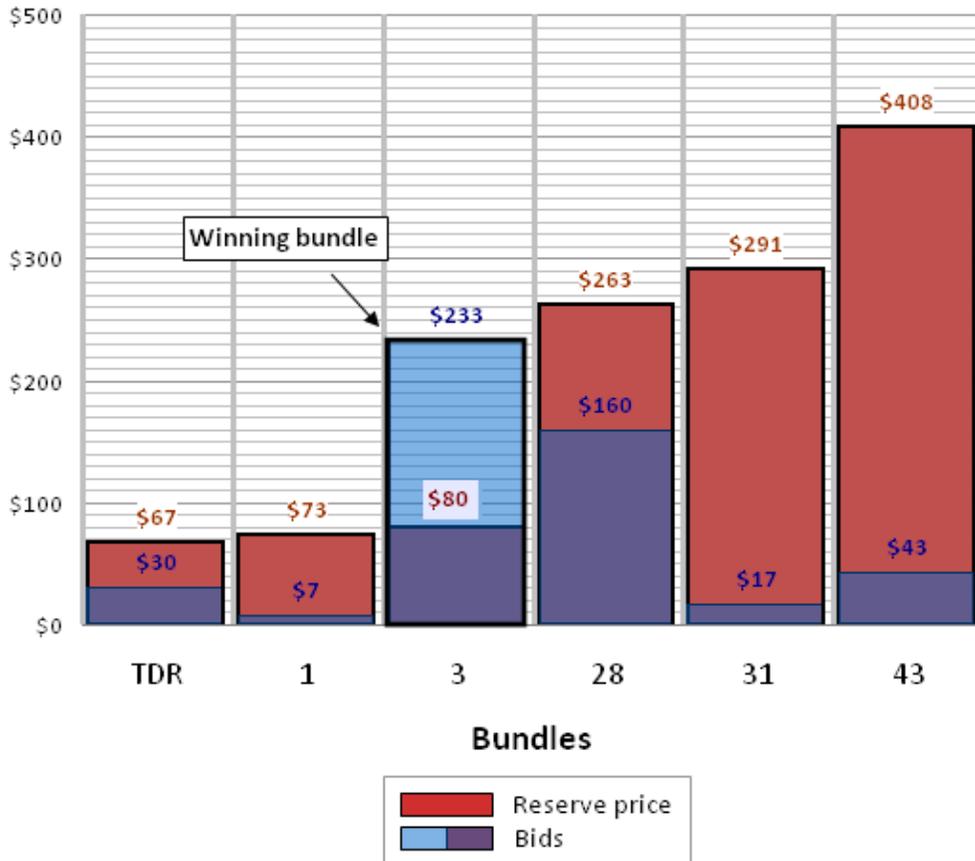


**Figure 3.** This figure is an example of the forest stand structure at Pack Forest resulting from a specific management plan (e.g. Bundle 43) in the year 2050. The darkest green stands would be older than 115 years in 2050, while the lighter greens correspond to younger stands. Stands that would be cut between 2045 and 2050 (i.e., stands that are in a clear-cut state or in a very early stage of development in 2050) are brown. The 4-digit figures indicate when a stand is scheduled to be cut.

displays the harvest schedules as well as the resulting age-class distribution of Pack Forest in the year 2050 if the management plan designed to produce the timber and nontimber outputs associated with Bundle 43



might reallocate his bid to Bundle 28, a more expensive management option that leads to almost three times more carbon than does Bundle 3 (Figure 2), if he sees that the total value of the bids placed by others on Bundle 28 are quickly



**Figure 4.** The final snapshot of the bidding chart used to symbolically sell old-forest habitat and carbon sequestration services from Pack Forest, Washington. The red bars are the reserve prices and the purple/blue bars represent the aggregate value of the bids that were placed on each bundle (purple=those below the reserve price; blue=those above the reserve price).

approaching the \$263 reserve price (reserve prices were scaled for purposes of a mock auction).

Technically, ECOSEL resembles the *Anglo-Dutch* auction mechanism (Klemperer 2004, p. 116) in that it has an initial open bids phase, followed by a final round of sealed bidding. The open phase encourages collaborative bidding while the sealed phase minimizes free riding. Free riding occurs in this context when a potential bidder does not enter the auction if it is clear that their preferred alternative is winning regardless of whether they bid or not. Free riding behavior is minimized by sealing the bids at the final stage of the auction. This mechanism is likely to maximize the landowners’ revenues because the sealed phase prompts players to place bids that represent their true values with respect to the bundles being sold. ECOSEL can also be thought of as a voluntary public goods contribution game with refundable contributions (also called a *subscription game*). Economic theory suggests that a mechanism like ECOSEL may be able to provide an efficient level of ecosystem services while earning a profit for the landowner (e.g., Bagnoli and Lipman 1989; Menezes et al. 2001; Barbieri and Malueg 2008).

To simulate how a real auction might play out at Pack Forest, a mock auction was set up to sell the five ecosystem bundles shown in Figures 1 and 2, as well as an alternative that represents a simple *transfer of development rights* (TDR). The TDR Bundle was priced at a symbolic dollar value lower than those of the other bundles. The reason behind the lower reserve price was that after selling the TDRs, the landowner still enjoys tremendous flexibility in making forest management decisions. The only restriction is that the land can not be developed or sold for development. On the other hand, if any of the other five bundles win the auction, not only does he forgo his development rights, but he also has to follow the specific management plan embedded in the adopted ecosystem bundle. A premium for this loss of management flexibility is incorporated in the reserve prices that were developed for the five ecosystem bundles.

**The mock auction**

The mock auction took place during the 2008 Northwest Environmental Forum in Blaine, Washington in October 2008. The 75 participants at the Forum included forest landowners, representatives of environmental,



conservation and land management organizations, timber companies, academia and state of Washington officials. Each participant was given \$10 in cash and told that they could either keep the money or use it in the auction. The true reserve prices that were generated by ECOSEL were adjusted to the purchasing power of the participants, which was equal to the total amount of cash that was distributed for the auction. To simulate the open phase of the auction, the participants were allowed to bid in three rounds and in each round they could reallocate their bids from the previous round. The evolving distribution of the total bid amount for each bundle was displayed in real-time on a large screen using a chart similar to Figure 4. The participants were allowed, but not obliged, to discuss their strategies with others. The third, final round of bids was sealed by disabling the dynamic display. Finally, rather than actually implementing the management plan corresponding to the winning bundle of ecosystem services, the auctioneer pledged to double the dollar amount received for the winning bundle and donate the final amount to a combination of forest conservation, academic and carbon credit issuing organizations. To emulate the outcome of a successful real auction, the donations to the three outlets were proportional to the old-forest habitat, TDRs and carbon sequestration outputs of the winning bundle.

The final result of the mock auction is shown in Figure 4. Bundle 3 was the winning bundle and was the only bundle where the total value of the bids (\$233) exceeded the reserve price (\$80). The difference between these two figures (\$153) is the profit that the landowner generated<sup>2</sup>. The fact that the majority of the Forum attendees participated in the mock auction indicates that there is an interest in financially promoting forest management alternatives that produce certain environmental outputs. In fact, 65% of the dollars that we gave to the participants to participate in the auction were used to bid for bundled ecosystem services.

### Remarks

The true monetary value of forest ecosystem services can only be estimated through transactions where people make monetary sacrifices to compensate forest landowners for providing these services. ECOSEL is designed to facilitate these transactions by providing information about the different management alternatives that are available to the landowner to produce various levels of the desired environmental services by providing a bidding platform where

potential buyers can reveal their true preferences using their own financial resources. This study represents a first step in evaluating what bundles of ecosystem services are likely to be desired by the bidding public. Bundle 3 was the winning bid of this auction; a relatively inexpensive bundle that includes substantially more mature forest habitat than Bundle 1, the option that maximizes timber revenues.

We are currently assessing the ecosystem attributes that are most likely to be desired by stakeholders through a series of small group meetings, mock auctions, and surveys. If you would like to participate in one of our meetings or fill out a survey, please contact Sándor Tóth at [toths@u.washington.edu](mailto:toths@u.washington.edu). ▲

### Acknowledgements:

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**The following references provide additional information for those interested in this subject.**

### References:

- Bagnoli, M. and B.L. Lipman. 1989. Provision of Public Goods: Implementing the Core through Private Contributions. *The Review of Economic Studies* 56(4): 583-601.
- Barbieri, S., and D.A. Malueg. 2008. Profit-Maximizing Sale of a Discrete Public Good: linear equilibria in the private information subscription game. Working paper, available at: <http://www.economics.ucr.edu/seminars/winter08/ets/Barbieri-Malueg.pdf>.
- Klemperer, Paul 2004. *Auctions: Theory and Practice*. Princeton University Press. Princeton, New Jersey. 256p.
- Menezes, F. M., P.K. Monteiro, and A. Temimi. 2001. Private provision of discrete public goods with incomplete information. *Journal of Mathematical Economics* 35: 493-514.
- Schilling, D. 1976. *Multiobjective and Temporal Considerations in Public Facility Location*. PhD. Thesis, Dep. of Geog. and Environ. Engrg., John Hopkins University, Baltimore, Maryland. 118p.
- Tóth, Sándor F. and Marc E. McDill. Finding Efficient Harvest Schedules under Three Conflicting Objectives. *Forest Science* (In Press)
- Tóth, S.F., M.E. McDill, and S. Rebaín. 2006. Finding the efficient frontier of a bi-criteria, spatially-explicit harvest scheduling problem. *Forest Science* 52(1): 93-107.



### Footnote

<sup>2</sup> A similar game played with University of Washington undergraduates resulted in Bundle 43 winning. We are currently in the process of further testing the performance of ECOSEL in experimental settings.

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