Available online at www.sciencedirect.com

Ecological Economics 48 (2004) 279–291

ECOLOGICAL ECONOMICS

www.elsevier.com/locate/ecolecon

Methods

Property evaluation and biodiversity conservation Decision support for making hard choices

William Trousdale*, Robin Gregory

EcoPlan International, Inc., 131 Water Street, #208, Vancouver, BC, Canada V6B 4M3

Received 31 January 2003; accepted 7 September 2003

Abstract

This paper presents an approach for aiding the identification and acquisition of priority properties for biodiversity conservation. Motivation for this paper comes from the widespread acknowledgement that property acquisition choices face the challenging context of competing land uses, multiple objectives and limited funding. The approach described in this paper, based on the principles of decision analysis, links the many scientific objectives of biodiversity conservation with practical management concerns and public decision-making needs, including transparency, accountability, communication and effective use of scarce funds. After a brief introduction, a case study is presented showing how the proposed approach was used by British Columbia Parks to design and implement a property evaluation and decision support tool for acquisition of private lands as part of the provincial Protected Area Strategy. Although the case study is specific to a public protected areas strategy (PAS), the approach is applicable to other land acquisition contexts. General recommendations are discussed in light of this experience.

Keywords: Biodiversity conservation; Property evaluation; Parks management; Decision-making

1. Introduction

One of the most important and challenging aspects of biodiversity conservation is identifying priority lands for protection from development or other incompatible uses. In many locations, much of the land with high biodiversity values is privately held and an interest in the property (e.g., fee simple, easement) must be acquired to achieve protected status. Tens of millions of dollars are spent annually by governments and non-governmental organizations (NGOs) to purchase private lands with the hope of enhancing long-term biodiversity goals. Typically, the groups engaged in the business of land acquisition must incorporate other complementary, and sometimes competing, objectives into their decision process, such as timber harvests, fishing rights, access to recreation or the retention of open space.

In response to evolving thought in biodiversity conservation, biologists, ecologists and economists have advanced a range of techniques to identify priority sites for biodiversity conservation. Unfortunately, published examples of successful implementation are scarce. As a result, there is an urgent need for defensible approaches that can help clarify and structure property acquisition choices in these multiple objective contexts, link scientifically supported approaches to practical case studies, and provide insight

* Corresponding author. Tel.: +1-604-228-1855; fax: +1-604-228-1892.

E-mail address: wtrousdale@ecoplanintl.com (W. Trousdale).

0921-8009/$ - see front matter © 2004 Published by Elsevier B.V.
doi:10.1016/j.ecolecon.2003.09.011

into issues that arise during implementation. The potential benefits—in addition to the conservation of significant properties—include greater transparency in decision-making, improved communication, and more effective use of both public and private funds.

Of course, purchasing lands as a means for enhancing biodiversity conservation objectives is only one of many possible habitat conservation policy options (Ferraro and Simpson, 2001). Other approaches include encouraging conservation on privately managed land through land lease arrangements (either short-term or long-term), creating easements (e.g., restrictions on owners) and acquiring concessions (e.g., for the right to use state-owned lands). Additional approaches include efforts to encourage ecologically friendly uses of the land base, either by paying for sustainable services (e.g., crops, biodiversity ranching) or by providing subsidies and revenue sharing arrangements that encourage specified activities (e.g., eco-tourism, searching for new pharmaceuticals).

In this paper, we focus on the development of methods for identifying and evaluating properties for biodiversity conversation, emphasizing the role to be played by protected areas. Section 2 outlines the context for developing property selection methods and describes how techniques from the decision sciences can aid in making sound decisions regarding property acquisition. We then present a case study of how the proposed evaluation framework was utilized to prioritize acquisitions by BC Parks as part of a protected areas strategy (PAS) introduced by the province. Implementation concerns and the generalizability of the approach are discussed in Section 5.

2. Evaluating candidate properties

2.1. Facing tough biodiversity choices

Often newspapers or environmental newsletters inform us that the government or a local conservation organization has spent hundreds of thousands, or even millions, of dollars to purchase a property in order to further biodiversity conservation objectives. These purchases are usually justified by the use of a superlative description: "the only", "the last", "the most severely threatened", "the best examples of...", etc. As these stories suggest, justifying the selection of a single property is simple, as all sites are unique and with a little imagination a powerful rationalizing description can be generated. The challenge comes with the need to justify priority choices across a range of alternative properties in a manner that makes sense to the public, a board, technical experts, an oversight committee or inter-agency constituents. This can only be done by showing that fundamental objectives of the biodiversity effort are satisfied as best as possible (i.e., within the key constraints).

Unfortunately, defining such objectives is far from straightforward. Scientifically, there is no consistent definition of biodiversity (Gaston, 1996) or common framework to guide biologists or ecologists seeking to implement actions that might affect population and evolutionary processes (e.g., endangered species) as well as material and energy processes (e.g., ecosystem functions) (Martinez, 1996). The task is further complicated by the multiple dimensions of value that lie behind most biodiversity initiatives, including material resources (e.g., timber, drugs, food), environmental services (e.g., clean water, habitat), ethical concerns and cultural or spiritual needs.

As a result, agencies and organizations involved in biodiversity property acquisition are typically ill equipped to make hard choices concerning how best to allocate funds for biodiversity concerns. For example, how does one best spend a $10 million biodiversity protection fund? Lets suppose the choice is limited to only three available options: Property A, Property B and Property C. If Property A costs $10 million dollars and is home to a globally rare species, does the organization spend all its money on this option? Or should it spend $6 million on Property B, which is home to four regionally rare species, and the remaining $4 million dollars on Property C, an important staging habitat for migrating waterfowl? What if only part of Property A will be logged if it is not purchased, whereas Property C in its entirety will definitely be subdivided for a residential development? What if the organization is sensitive to other objectives, and Property B has outstanding scenic qualities whereas Property A also includes an archeological site and has excellent rock climbing? Now imagine there are dozens or hundreds of such sites, how does an organization choose to spend its limited funds? How do you measure these different factors and decide how important they are? How do you organize the data in an efficient way to support decisions? Equally important, with the potential for litigation and increased scrutiny from government, NGOs and the public: How should choices about whether to acquire sites, or to not acquire sites, be communicated to those who care?

Biodiversity researchers recognize this challenge of making difficult conservation choices and are now seeking practical ways to compare biodiversity acquisition options. Leading conservation biologists (BCL, 2000) are calling for property evaluation processes that are explicit, accountable and repeatable. A critical component is that values, objectives and goals should be defined and made explicit from the beginning to minimize conflict and promote informed communication. An influential recent paper indicates that the single most important issue confounding biodiversity preservation today is poorly defined objectives—determining what it is that is being optimized (Metrick and Weitzman, 1998). Evaluation approaches also should be flexible, designed to explore consequences of different values, and inform decision-making—rather than rigidly replace it. Vane-Wright (1996) suggests that there should be simple procedures to extract meaning from the data and appeal to reason by placing biologically determined priorities within a broader framework. Furthermore, techniques that substitute mathematical elegance for powerful heuristics may not be practical; instead, there is a need for structured approaches that promote transparency and understanding. A similar conclusion is reached by a recent analysis of property selection techniques, finding that simpler heuristic algorithms may be the most appropriate method in some complex situations (Csuti et al., 1997).

We agree with these analyses and, in Section 2.2, we describe the application of an approach that builds on this body of work. We also recognize that no one approach will work for all cases: understanding of property distributions will vary, different measures will be more or less useful for different purposes, and no single scoring system will work in all acquisition contexts (Williams, 1996; Williams and Gaston, 1998). These evaluation realities are not unique to biodiversity conservation initiatives, however; taken as a whole, they argue for the adoption of uncomplicated approaches that clearly define key values and successfully link property acquisition activities to identified core concerns.

2.2. Property evaluation perspectives

Evaluations of potentially valuable biodiversity properties often face the challenge of reconciling two different points of view. The first perspective comes from the technical assessments of scientific experts, who have developed lengthy lists of ecological qualities that characterize a property as valuable. The second perspective is that of public stakeholders, interest groups and political decision-makers, who often value biodiversity properties because of aesthetic, recreational or symbolic characteristics that may be quite unrelated to experts' ecological criteria (both are addressed in the BC Parks case study in Section 3).

Both perspectives are problematic from the standpoint of distinguishing the relative attractiveness of properties. New approaches that combine ecological surrogates with statistical modeling have been developed to utilize more of the existing or potential data for property evaluation (e.g., Vane-Wright et al., 1991; Nicholls and Margules, 1993; Williams et al., 1994; Williams, 1996). Using number of species as an indicator, researchers conclude that methods exist for finding optimal biodiversity reserve networks solutions (Csuti et al., 1997). However, large data sets and numerous indicators tend to be difficult for non-specialists to interpret, communicate and ultimately use in decision-making. As a result, decisions may become data driven, rather than value driven, causing hard data to squeeze out soft data (e.g., large mammal occurrence vs. aesthetics).

Economists, policy analysts and other social scientists reviewing this work over the past decade have suggested that broader approaches are required to assist decision-makers in property evaluations. One response is to introduce methods that take cost effectiveness into account by incorporating land values (Ando et al., 1998; Metrick and Weitzman, 1998). Other approaches attempt to account for expressed (in contrast to revealed) preferences through the adoption of methods that seek to extend the market paradigm to non-marketed ecological resources; examples include contingent valuation and other survey-based methods (Freeman, 1993). However, economic approaches remain limited by the necessity to translate multiple dimensions of value into a summary, dollar-based measure. As a result, many potential participants are uneasy with what appears to be a resulting neglect of many important elements of biodiversity decisions (e.g., the value of connectivity) and a lack of emphasis on procedural components of the associated management prescriptions (e.g., the value of an adaptive management approach).

Overall, the success of property evaluation techniques has been limited. Most approaches have framed the problem as a single objective optimization problem (preserve biodiversity) within identified constraints (e.g., cost, total number of sites, percentage of land base) and rely almost entirely on science and the values of scientists. Resource managers and practitioners, in contrast, typically face incomplete data sets and demands for transparency in decision-making. Furthermore, the *realpolitik* is one of many interested parties, with often competing and conflicting values as well as poorly defined objectives. These problems are heightened by uncertainties associated with land availability and the perceived need to link biodiversity priorities with conservation actions by including factors such as threat, proximity to other reserves and broader management issues (Nicholls and Margules, 1993; Gaston, 1996; Pressey et al., 1996).

As a result, many agencies and organizations spend millions of dollars annually on private land acquisition using only informal decision methods to promote poorly defined biodiversity conservation values. Many times these groups are also pursuing related, and sometimes conflicting, objectives (e.g., open space, recreation, flood protection). At best, these efforts may generally contribute to biodiversity conservation. However, problems arise when tougher standards are used to assess performance, when funding becomes more limited, or when disputes arise within organizations or between stakeholders with regard to acquisition priorities. When such questions arise, it becomes apparent that more informal methods do a poor job of achieving accountability, meeting (or even identifying) fundamental program objectives or addressing tradeoffs. In such cases, a more systematic approach to biodiversity protection choices is needed.

2.3. A decision analysis approach to property evaluations

We have found that a value-focused approach using decision analysis can help to provide insight into an operational property evaluation framework (Keeney, 1992). Central to this approach is the belief that property evaluation, like other policy development problems, should employ decision-relevant criteria and explicit performance measures. The first task is identifying what is important (values or objectives) by defining a complete range of criteria and practical constraints. This requires taking a participatory approach, working with all those interested and involved in the evaluation. By eliciting what is important to them in the context of land acquisition problems, an unambiguous list, or hierarchy, of structured criteria can be generated. This helps to refine stakeholders' thinking about what it is that is being promoted and provides a framework for systematically appraising property choices.

Next attributes, or performance measures, are established to gauge how well alternative land acquisition choices (properties) satisfy the criteria (program objectives), within defined constraints. Establishing clear performance measures helps clarify the meaning of the objectives, greatly improving communication. For the purpose of developing a formal decision support tool, performance measures also allow for the incorporation of technical data into the decision in a consistent, quantifiable way. Two aspects of developing decision relevant performance measures are particularly helpful in the context of laying a sound foundation for biodiversity acquisition choices.

One is the development of context-specific performance measures for key concerns, typically referred to as "constructed" attributes (Keeney, 1992). These are important in situations where universally recognized "natural" attributes or measures, such as dollars (e.g., for project costs) do not exist. An example is ecological health, which often is defined in terms of an index composed of several different considerations (A, B, C, D) which can be separately weighted (so that A counts for 40% of the total, B 30%, and C and D both 15%) and used to describe the health of a selected ecosystem (for example, 1=little damage to the ecosystem as the result of an initiative, whereas 4=severe damage). The development of such constructed measures provide a means for helping participants to make tradeoffs between different levels of both easy- and hard-to-define values relevant to the decision at hand.

The other key component for developing decision relevant performance measures is applying a set of procedures for incorporating the judgments of knowledgeable persons into discussions of anticipated consequences in order to deal with key uncertainties and data gaps. Such "expert judgment" processes (Keeney and vonWinterfeldt, 1991) typically provide a small group of knowledgeable individuals with some training in decision-making and help them to understand similarities and differences in how a problem is viewed. Codifying these judgments and incorporating them into the performance measures helps to make them explicit, encourages careful thought, and facilitates dialogue across experts (which, in turn, helps to understand the reasons for similarities and differences in the expressed views).

Once the objectives and measures are established, both technical information (e.g., number of rare species, cost of the land) and values-based information (e.g., relative importance of criteria) are needed for the decision support model. Quantitative information is used to develop simple algorithms to rank and sort properties, supported by qualitative information to improve communication. Once the decision structure (the criteria and performance measures) is established, specific property information collected, and the value weights agreed on, they can be combined into a decision support tool (described in greater detail in Section 3.3.3). The tool is best employed by developing simple but powerful programs (e.g., using database software, such as Microsoft Access) that help to manage the vast amount of property information in a data base (e.g., make it easy to get to and update). More importantly, the information can be used for a range of potential decisions, adding organization and a logic to the decision process. Information structured in this way provides program-specific insights into tradeoffs that need to be made in the identification of priority acquisition decisions.

3. Case study: the development of a property evaluation tool for BC parks

In 2001, British Columbia Parks asked one of us (Trousdale) to help in designing and implementing an evaluation framework and decision support tool for ranking potential biodiversity conservation acquisitions throughout British Columbia. They requested a framework and tool that would be easy to understand, user friendly, flexible, make use of existing information and incorporate professional judgment as well as help to set priorities for future research. The second author (Gregory) provided advice on the model development process.

3.1. Understanding the context: private land and protected areas in BC

The Protected Area Strategy (PAS), as implemented by BC Parks, is an important component of biodiversity conservation in British Columbia. Under PAS, the amount of area protected in BC has more than doubled in the past decade, with over 12% of the land base now sheltered from development through the creation of parks and reserves. Most of this land was formerly under provincial jurisdiction, facilitating the park or reserve designation. However, private land also plays a prominent role in achieving successful protected area management, especially if the private land is located inside the protected area boundaries (in-holdings) or on adjacent holdings. For instance, whenever protected area values are threatened by a change in use on private land (e.g., logging), then the purchase of private lands may provide an opportunity to enhance these values (e.g., provide wildlife corridors) or address key management challenges (e.g., access).

Currently, BC Parks is actively involved in acquiring interests in priority properties through direct purchase, easement, land and timber exchanges, donations and through cost sharing partnerships with all levels of government, as well as with non-governmental organizations. Over 200 properties already have been identified, with new properties added regularly. In the face of limited budgets, greater scrutiny from a variety of interests, and an increasingly complex decision context, BC Parks made the decision to review their property selection process.

BC Parks had several goals that helped to shape the development of an appropriate evaluation tool. First, it recognized that the ability to justify the effective use of limited resources could be achieved through a more transparent system of property prioritization. This in turn would increase accountability, making it easier to defend property acquisition decisions in terms of the values mandated in the Parks Act and designed to reflect the values of BC citizens. Second, due to the large number of properties and the speed of industrial development on private land, BC Parks sought to improve efficiency in the review of alternative sites. Third, the organization wanted to create a strong institutional memory in order to reduce duplication of effort, a result of unsystematic data collection and management. Fourth, BC Parks wanted an evaluation framework that would be responsive to evolving situations and enhance their ability to develop more proactive strategies by crafting budgets reflecting the needs of the protected areas and the values of the public. Finally, the agency recognized that any new system would require the support of employees before being implemented and that, as with other agencies, there would be resistance to change and concerns about the implications on work schedules (and total effort) due to the introduction of a new system. Part of this resistance was expected to derive from the shadow side of many of the same aspects that would create benefits: greater transparency might bring greater scrutiny, and a more open system might bring a loss of control over information.

3.2. Criteria and performance measure development

Criteria and performance measures were constructed through a series of meetings with BC Parks directors, managers, planners and scientists. The criteria were developed with appreciation to other existing policy frameworks (e.g., Private Forest Biodiversity Framework, see Trousdale et al., 2000), existing legislation (the Park Act and the Ecological Reserve Act) and other biodiversity initiatives (e.g., The BC Parks Protected Area Systems Overview, The British Columbia Conservation Data Centre). Multiple rounds of value elicitation uncovered additional criteria and validated the evaluation structure. Value elicitations were done through a process of asking what is important and why is it important (for more detail on value elicitation, see Keeney, 1992). This process of value elicitation is essential in establishing a practical structure for the decision problem and provides insight into how decisions are being made by different parties. In this way, the value elicitation process determines more precisely what it is that is being promoted and it helps to establish value independence, important in avoiding double-counting and confounding results. It also sheds light on the usefulness of existing scientific data for property acquisition decision-making and helps direct future scientific research to address key data gaps. With BC Parks, the outcome of the value elicitation process was a two-stage evaluation framework.

Stage 1 represents BC Parks' core values (fundamental criteria and sub-criteria). As with all government agencies and organizations, BC Parks has a specific mandate that extends beyond the narrow objective of biodiversity conservation. It also includes recreation-related objectives as well as protection of heritage and culture. Additionally, interviews revealed that private land plays a critical role in management efficiency of the provincial park system. At BC Parks, biodiversity is more commonly referred to as ecological integrity, which is reflective of the recent convergence of thought in biodiversity conservation that includes ecosystem function and process as well as biological entities. Clearly, BC Parks' land acquisition program is meant to serve a broad range of values and four Stage 1 fundamental criteria emerged: ecological integrity, experiential integrity, cultural integrity and management efficiency. Table 1 shows the fundamental criteria and sub-criteria that were developed for BC Parks' land acquisition strategy as well as a description of the performance measures that define the criteria. Stage 2 criteria capture the key factors constraining any land acquisition decision-cost and availability. Stage 2 criteria are discussed in Section 3.4.

The second column in Table 1 provides a description of the sub-criteria performance measure that captures the meaning of the criteria and permits the framework to become operational. To avoid 'data bias', performance measures were not limited to available data or to criteria that have obvious attributes. In our experience, too often the availability of data—rather than values—drive decisions: criteria that are that are easy to measure (e.g., existence of old growth, visitor arrivals) or are readily available (e.g., large mammal studies) are used in the decision process where as criteria that are more difficult to measure (e.g., variability, aesthetics) are often ignored (Failing and Gregory, 2002). As described earlier, the current process made extensive use of problem-specific "constructed" attributes (see Table 2), which

Table 1
Stage I criteria (core values) for the land evaluation framework

Criteria	Performance measure description
Promote ecological integrity	
Promote representativeness and naturalness	• Level of ecosection/biogeoclimatic ecosystem classification (BEC) variant represented • Level of viability as indicated in the PASO manual • State of naturalness
Promote protection of rare and endangered species and communities	• Element occurrence of red and blue listed species and rare plant communities • Professional judgment related to emerging inventories and scientific work (consider marine and aquatic)
Promote protection of biologically exceptional areas	• Highly productive and/or unique ecosystems capable of supporting species of management concern (transition zone areas; habitats at the periphery of species ranges, mineral licks, caves, critical seasonal or migratory concentrations of species of high management concern-wintering ground, staging area, seabird colonies, marine environments) • Quality of education and research opportunities
Promote connectivity or buffers	• Ability to fill key ecological integrity systems gaps by establishing protective buffers and corridors
Promote experiential integrity	
Promote recreational opportunities	• Ability to accommodate priority recreational opportunities (high demand, low supply)
Promote aesthetics and landscape quality	• Enhance sensual experiences: sight (e.g., views), smell, sound, feel, etc. • Includes old growth forests and other species/communities highly valued by public • Also includes physically exceptional sites such as outstanding landforms (sand dunes, eskers, canyons), geological anomalies, unique hydrological features
Protect *existing* experiential integrity	• Protect *existing* recreational opportunities and/or aesthetics and landscape quality from the threat of non-conforming use
Promote cultural integrity	
Promote protection of archeological sites	• Existence and importance of culture or archeological site(s)/features exist on subject property (e.g., burial mounds, cemeteries, middens, pictographs, prehistoric artifacts, traditional harvesting site, abandoned village, pictographs, petroglyphs)
Promote protection of historic features	• Existence and importance of historic features on subject property
Promote management efficiency	
Promote management flexibility	• Administrative, legal, public safety and access concerns (e.g., trespass, nuisance property, unwanted easements, safe highway access)
Promote effective use of capital and operating budgets	• Project feasibility: affect on capital and operating budgets from property acquisition
Promote consistency with public interests	• Demonstrated public interest from general public, government agencies, other governments, other stakeholders (approved land use or management plan, demonstrated general public support (letter writing campaigns), demonstrated strong partnerships (including donations)

Most criteria also incorporate the level of threat *to the specific criteria* from current and/or proposed non-conforming use (e.g., logging or other resource use/extraction, subdivision application, urbanization, agriculture, etc.).

often took the form of a scale outlining the possible range of impacts for the problem at hand. Thus, the use of constructed attributes both extends the realm of the analysis (by incorporating concerns that lack widely understood measures) and tailors it to the special needs of the problem at hand (by developing explicit measures for the diverse concerns driving stakeholders' interest in the problem). In many cases, the performance measures also drew on expert judgments—structured discussions with knowledgeable individuals—in order to formally capture the full extent of relevant expertise and knowledge.

These biodiversity-focused property evaluations also grappled with the issue of vulnerability related to the perceived urgency of a possible purchase due to the threat of potential development (e.g., industrial,

Table 2
Example of constructed scale used to score a property

Promote ecological integrity	
Promote representativeness (protect habitat at risk) • Percentage of ecosystem type already protected • The level of threat to this value from current and/or proposed change in the intensity of human use (e.g., logging or other resource use/extraction, subdivision application, urbanization, agriculture, etc.) • State of naturalness • Viability as described in the PASO manual Note: To scale between high (10), medium (5) and low (1) scores, use professional judgment related to state of naturalness, viability and level of threat. Indicate confidence level in regards to information source in qualitative comments.	(10) High = the ecosection/BEC variant on the site is not well represented (< 2%) ■ It is in a natural state *and* ■ There is a high threat (protect now or never) (5) Medium = the ecosection/BEC variant on the site is partially represented elsewhere (>2% and < 8%) ■ It is disturbed with recovery likely *and* ■ There is a definable threat to this value from proposed changes (within 5 years) (1) Low = the ecosection/BEC variant on the site is well represented elsewhere (>8%) *or* site is excessively disturbed and permanently altered (2) Not advisable=excessive current use, acquisition will be ineffectual

Information sources: Refer to BC Park's Protected Areas System Overview (PASO), Ministry of Forest Terrain Ecosystem Mapping (PEM/TEM) and local sources/studies. NOTE: Please check Conservation Data Center (CDC) Site Record information in PASO for overlap if available (e.g., see Protection Urgency, Biodiversity Significance Rating, etc.).

commercial or residential) or other incompatible uses (e.g., invasive species). However, for multiple objective evaluations of specific sites, threat is only relevant as it pertains to a specific value or criteria. For example, consider the sale of a large privately held property where there is potential for future agricultural development. If the property has a wetland that is an important staging area for migratory waterfowl, and this part of the property would be well protected through land use regulations, the threat would be considered low. However, if this same property were also poorly represented in terms of ecosystem types (or variants), then it would be considered more urgent to acquire it. Therefore, broadly applying threat to all performance measures equally as a post evaluation exercise may cause significant redundancies in the evaluation. To appropriately incorporate threat and the associated urgency of conservation action, the BC Parks project concluded that it should be applied to each performance measure.

3.3. Operational considerations

Three types of input must be available to operationalize the decision support tool. First, both technical and value-based information are needed. Technical information is a representation of the facts, including scientific data and professional judgments related to a property (e.g., number of red-listed species, demand for a recreational opportunity). Value-based information reflects the importance of the data in the context of private land acquisition: How important is the potential change in criteria X compared to the change in criteria Y as a result of purchasing private land? For example, other things being equal, would purchasing a property that included a productive estuary be more important than purchasing a property that provided vehicle beach-camping opportunities and riparian habitat? Second, both types of information must be quantified. For the BC Parks decision support tool, this is done by scoring properties using technical information and establishing criteria weights that reflect the importance of the values associated with the program. Third, simple algorithms must be developed whereby the quantified information can be used to generate defensible and comparative rankings of priority properties.

3.3.1. Quantifying technical evaluations

To quantify the technical information, a property evaluation workbook was developed allowing each property to be evaluated by Stage 1 sub-criteria and scored using a constructed scale associated with the high, medium and low performance measures ("1" for low, "5" for medium and "10" for high). The constructed scale employed technical information of two types. The first included measures that are more straightforward, such as the occurrence of red-listed species or the percent of an ecosystem variant that is protected elsewhere. These established a starting point for the scoring. The second type of technical information required professional judgment, such as viability, probability of persistence, geographic significance or threat. In this case, professional judgment is essential in the technical evaluation of the sites. For example, a property in a natural state with less than 2% biogeoclimatic (BEC) representation and that is under immediate threat of development (e.g., protect now or never) would receive an evaluation score of "10" for the sub-criteria "promote representativeness" under the fundamental criteria "ecological integrity". If this property was in less than a natural state and the threat of development was not imminent or complete, then a score between "5" and "10" would be more appropriate. District planners, managers and resource officers filled out a property evaluation form that was developed for this purpose.

The obvious potential shortcomings of this system are that information and knowledge are rapidly advancing and professional judgments may vary among individuals or over time. These concerns are offset by three advantages of the methodology described here. First, the information management system is easy to update as information changes. Second, all evaluators base their judgments on the same descriptive performance measures. Third, judgments are transparent and supported by comments. When combined with a group evaluation or workshop, the approach focuses dialogue and promotes clear communication regarding technical scores across properties, encouraging consensual and consistent scores (discussed more in Section 5). This final point is critical. The purpose of any land evaluation decision tool is to promote good decision-making. The accuracy of the measure in technical terms is important, but so is the assurance that the same bias is consistent across measures as applied to the properties. So long as there is uniform application of uncertainty and common interpretation regarding technical scoring, then it should not affect decision quality because it is applied consistently to all property evaluations.

3.3.2. Quantifying values (establishing criteria weights)

Not all criteria (values) equally reflect the priorities of BC Parks in the context of private land. Therefore, the land evaluation decision tool explicitly incorporates priority areas into the evaluation by establishing numerical "value weights" for each criteria and sub-criteria. A separate set of exercises with a specific workbook was used to solicit value weights. A single set of value weights was generated through two rounds of assessment that combined independent thinking with group dialogue. The first round asked all BC Parks managers and planners to respond to the worksheet, designed as a swing-weighting exercise (von Winterfelt and Edwards, 1986). The worksheet asked the participants to consider a range of possible outcomes, from worst to best, for each fundamental and sub-criteria. The participants were asked first to rank order the criteria, then to weight them on a scale of 1–100. Over half of the BC Parks' districts responded. Considering impact ranges rather than directly weighting the criteria is a prerequisite for valid weight in assessments. The second round of assessment involved a workshop with a select 'core group' of BC Parks personnel experienced with land acquisition and park management. They independently developed their own set of value weights, then reviewed the responses from the first round of participants and discussed the differences. Finally, based on this information, the core group generated a single set of value weights that could be applied to the decision tool.

The final set of value weights is intended to reflect the mandate of BC Parks and the role of private land acquisition within that mandate. For example, the core group determined that private land plays a significant role in the overall ecological integrity of the province and the PAS. Therefore, the 'ecological integrity' criteria received the highest weight of 0.38. On the other hand, promoting cultural integrity is seen as the primary responsibility of the Ministry of Heritage and Culture, and important archeological sites and historical features are already protected under the law. Therefore, the cultural integrity criterion was weighted the lowest at 0.09. Sub-criteria were also weighted based on their contribution to the fundamental criteria and the mandate of BC Parks. For instance, under 'experiential integrity', 'aesthetics and landscape quality' was weighted higher than 'recreational opportunities' because it was felt that the impact from BC Parks actions would be more significant and reflective of their mandate and that many private businesses that help fulfill the demand for recreational opportunities.

3.3.3. Combining technical scores and the value weights

Once value weights are quantified and value independence is established, the combination rule for additive functions is applied. An additive function, given criteria $x_1,\ldots,x_N$, $N \geq 2$, can be written as:

$$U(x_1,\ldots,x_N) = \sum_{i=1}^{N} k_i u_i(x_i)$$

where U is the overall value (in this case, the weighted property evaluation score) and the k_i are value weights showing the relative contribution to the overall value from a change in a specific criteria, x_i. The u_i are technical scores (or the single attribute utility functions), one for each of the x_i criteria (Keeney, 1992).

Three steps are required. First, the sub-criteria for each of the fundamental criteria are normalized on a 0–1 scale that reflect their contribution to the overall weight. Second, the technical scores given for each sub-criterion are multiplied by the value weights for the corresponding sub-criteria. Because the measures for all criteria scores are on a common 1–10 scale, there is no need to establish scaling constants for u_i. For example, if a property received a technical score of "8" for promoting recreational opportunities and the overall value weight is "0.07", then $8 \times 0.07 = 0.56$. If the same property also received a technical score of "8" for promoting protection of biologically exceptional areas where the value weight is "0.12", then $8 \times 0.12 = 0.96$. Finally, the weighted scores for each sub-criteria are added together to provide the overall weighted score for a property (e.g., property evaluation score $= 0.56 + 0.96 + \ldots$). A total overall value is thus obtained for each of the properties under consideration and can be prioritized relative to each other. Once priority properties are established based on fundamental criteria (core values), additional key factors of cost, size and availability must be considered.

3.4. Stage 2 criteria and performance measures

In contrast to Stage 1 criteria, which reflect BC Parks' core values relative to property acquisition, Stage 2 Criteria were needed to understand the key constraining factors in the decision process. Explicitly structuring these factors in the land evaluation decision tool establishes a process that helps narrow the range of available choices and establish a structure to make key tradeoffs and address uncertainties.

3.4.1. Cost and size

The cost of a property appears to be a straightforward measure. However, there are many ways to acquire an interest in property and there are many ways to consider property costs. Should it be the total cost or should it be broken down into units such as cost per hectare? Should it be the estimated land value, assessed land value, appraised value or the asking price? What if there are cost sharing opportunities: partnerships, programs, land exchange, easements or donations? All these measures may be useful at different stages of the evaluation process. As a practical measure and to maintain perspective, the framework provides information on the total cost in dollars, the total cost in dollars to BC Parks and the cost in hectares to BC Parks using the latest available information and indicating the source of the information. Professional judgment may be required to keep estimated costs realistic and current, and this information is updated as it becomes available.

3.4.2. Availability

Availability contributes significantly to the complexity of property evaluation, adding risk and uncertainty to current decisions and future acquisition strategies. For example, if a moderately high ranking property is for sale now but a very high ranking property may come up for sale by year end, do you spend your budget on what is available now or wait until year end for the high ranking property that will satisfy program objectives better but may or may not become available? The first challenge is to structure the information in a way that allows for these uncertainties to be acknowledged and systematically assesses the outcome likelihood and the impacts to the land acquisition programs core values. Then, insight into the uncertainties should provide a stronger, more rational and transparent basis for selecting an alternative. To measure availability in the BC Parks Framework, five descriptors were identified: (1) an exclusive offer, (2) currently on the market, (3) willing vendor, (4) may be available next five years and (5) not likely available.

4. Discussion

One measure of the success of any proposed decision-making approach is its acceptance by individuals in the client agency or organization and whether it is readily applied. Initially, the development of the decision criteria tool for BC Parks was met with a mix of resistance and collaboration. Previous efforts within the agency that focused solely on a private land database had failed, and the logic of bringing in outside consultants was challenged by several employees. Although it was agreed that sound theory supports the comparison of different values (e.g., ecological vs. recreation property attributes), some staff members were not comfortable being involved with making these hard choices. In addition, the use of mathematical modeling, no matter how simple, was viewed as a deterrent. However, several BC Parks personnel who work with this type of decision and frequently provide recommendations to resource managers and politicians saw value in formalizing their previously informal, common sense approach. Decision-makers, from their perspective of needing to make defensible decisions, viewed the process as a natural extension of their thinking and a way to access and communicate existing and evolving information. As one manager commented during the framework design, it was hoped that the decision support tool would allow them to make more informed, consistent and defensible decisions—these objectives, along with making better decisions, were all important.

The first test of acceptance of the decision support model took place in a workshop with data management and property acquisition experts from BC Park headquarters, as well as BC Parks district mangers and planners. The workshop was designed to validate the evaluation framework and effectiveness of the decision support tool. Although all the participants were involved to some extent in the evaluation framework process, this was the first time they had the opportunity to test the model with actual properties. Sample evaluations of thirty-one properties worth over $15 million dollars were received from districts across the province. Some discussion took place regarding the evaluation process, the value weightings and the math used to calculate rankings.

Once comfortable with the approach, actual ranked properties were displayed. Surprisingly, several ‘hot’ properties that had received a great deal of political and media attention scored lower than expected. One well-known property, in particular, fell to near the bottom of the ranking list. It turned out that a small but active group was promoting this particular property. Through political pressure and media savvy, this group was able to grab attention and possibly secure scarce provincial resources intended for the PAS. The example proved to be an excellent opportunity to test the model, because BC Parks’ leadership was concerned that crisis and pressure, rather than good decision-making, might be corralling funds better used elsewhere. In this case the decision support tool was able to quickly provide a clear rationale (and an answer to pressure groups) regarding BC Parks priorities. Interestingly, the district manager where the property was located was a participant in the workshop. Although disappointed that, in this specific case, the decision tool might lead to a missed opportunity for solving a problem in his district, the manager agreed with the evaluation and fully supported both the approach and the results.

This is not to say there was complete consensus over the property rankings. In fact, there were important disagreements. These disagreements focused on different interpretations of property attributes and were facilitated by the structure of the framework. This transparency allowed the participants to quickly determine the reason why one property was ranked higher than another, resulting in clearer communication and a better understanding of property evaluations (e.g., should Property X be scored ‘8’, ‘7’ or ‘6’ and why?). In each case, the participants were able to reach agreement. As a result of this experience, it was suggested that annual meetings take place to review property evaluations in order to minimize the subjective influence of individual evaluators on property scores as well as to update the evaluations over time (e.g., due to a change in the level of threat or scientific advances). Finally, it also became clear that future research should focus on those areas of uncertainty that influenced scoring and decision-making and were often directly linked to ongoing management decisions (e.g., a property’s contribution to viability).

Shortly after this, the decision support tool was applied as part of implementing an agreement between the government of British Columbia and the federal government of Canada to establish a national park reserve in the southern Gulf Islands. A joint investment of over $30 million dollars had been committed; however, the range of properties under consideration was valued at more than twice that amount. BC Parks used the property evaluation framework and decision support tool to prioritize the properties to reflect the agency's core values.

5. Conclusion

This paper describes a practical approach for aiding managers and decision-makers in the identification and acquisition of priority properties for biodiversity conservation. Specifically, it describes the use of a value focused, attribute-based system for acquiring and protecting properties as part of aiding biodiversity conservation initiatives. The approach identifies and clarifies objectives and their relative importance, based on the values of stakeholders. Then this information is combined with existing scientific and technical knowledge to distinguish among available properties: the preferred properties are those that best satisfy the identified set of objectives. The functional output of the approach is a decision support tool and information management system.

Use of the approach to aid in property acquisitions by BC Parks is reviewed as part of the province of British Columbia's ongoing protected areas strategy. The case study of the BC Parks land acquisition program provided an opportunity to test the general applicability of this approach. The analytical approach and tools proved to be valid, practical and insightful suggesting that a similar methodology could benefit other land acquisition programs. The two keys to success of the approach are (a) obtaining stakeholder agreement on a small set of key objectives, with clearly identified performance measures or attributes for each, and (b) developing a simple scoring and weighting system for ranking all available properties in terms of these attributes.

However, in the case of BC Parks, context specific adjustments were required to meet the needs of the user, in this case involving phasing of cost and availability criteria as a second stage of the decision process. In addition, the case study presented opportunities to improve the approach and, possibly, the results as well. One clear improvement both here and in other contexts would be to expand the set of stakeholders involved in development of the decision support tool to include other agencies, NGOs and the general public (e.g., through workshops and focus groups). In the BC case, most of the work we have described took place with representatives of a single organization, BC Parks. More stakeholders could be included in all steps of the approach, from criteria development to eliciting value judgments, while still achieving the goals of BC Parks (albeit at a greater expense).

In other contexts, it may be critical to involve a more diverse set of stakeholders. This might result in the development of different, context specific criteria, attributes or value weights. In addition, alternative scoring systems and other decision process phasing (e.g., considering cost and availability simultaneously with other fundamental criteria) may be appropriate in different contexts. Some of these changes could make it more difficult to reach agreement on a single set of measures. However, any system of the type described here should be expected to evolve and change with repeated applications. The approach described in this paper is sufficiently flexible that it can successfully incorporate a variety of suggestions and ideas.

The use of a value-focused tool for aiding in biodiversity property acquisitions should: improve the quality of decision-making over time by facilitating clear thinking; provide a way to evaluate property acquisition options and design long-term strategies; encourage discussion of differences among stakeholders; promote learning; and (in those rare occasions) provide a sound basis for potential legal challenges. Further, it is hoped that the logical structure of the decision support tool will encourage advancements in science and scientific thought to be incorporated by more specifically defining performance measures, thereby reducing the role of judgmental biases and value uncertainty.

Nevertheless, it is essential to remember that a decision support tool is not a decision-making tool. In the BC case, the existence of a formal approach to property evaluation allowed for more informed decisions to be made in a multiple objective context, and highlights the distinction between technical and value-based information. It also established a way to organize and manage this information over time. However, the output of the approach was, and remains, purely advisory to the relevant decision-makers.

Acknowledgements

We acknowledge the support of BC Parks, especially Colin Campbell, Diane Moen and Dave Chater, and the financial support of Forest Renewal BC in preparing this paper. In addition, the BC Parks project received significant contributions from Ken Bragg and Trevor Simpson. Helpful comments on earlier drafts of this paper were received from Bruce Blackwell, Lee Failing, Tim McDaniels, Dan Ohlson, Terre Satterfield and Paul Williams.

References

Ando, A., Camm, J., Polasky, S., Solow, A., 1998. Species distribution, land values, and efficient conservation. Science 279, 2126–2128.

BCL, 2000. Biodiversity and Conservation Lab at The Natural History Museum, London. Biodiversity: measuring the variety of nature and selecting priority areas for conservation. Retrieved November 2000 from the World Wide Web: http://www.nhm.ac.uk/science/projects/worldmap/.

Csuti, B., Polasky, S., Williams, P.H., Pressey, R.L., Camm, J.D., Kershaw, M., Kiester, A.R., Downs, B., Hamilton, R., Huso, M., Sahr, K., 1997. A comparison of reserve selection algorithms using data on terrestrial vertebrates in Oregon. Biological Conservation 80, 83–97.

Failing, L., Gregory, R., 2002. Using decision analysis to encourage sound deliberation: water use planning in British Columbia, Canada. Journal of Policy Analysis and Management 21, 492–499.

Ferraro, P., Simpson, D., 2001. Cost effective conservation: a review of what works to preserve biodiversity. Resources (143), 17–20.

Freeman, M., 1993. The Measurement of Environmental and Resource Values Resources for the Future, Washington, DC.

Gaston, K.J., 1996. What is biodiversity? In: Gaston, K.J. (Ed.), Biodiversity: A Biology of Numbers and Difference. Blackwell, Oxford, pp. 1–9.

Keeney, R., 1992. Value-Focused Thinking Harvard Univ. Press, Cambridge, MA.

Keeney, R., vonWinterfeldt, D., 1991. Eliciting probabilities from experts in complex technical problems. IEEE Transactions on Engineered Management 3 (3), 191–201.

Martinez, N.D., 1996. Defining and measuring functional aspects of biodiversity. In: Gaston, K.J. (Ed.), Biodiversity: A Biology of Numbers and Difference. Blackwell, Oxford, pp. 114–148.

Metrick, A., Weitzman, M.L., 1998. Conflicts and choices in biodiversity preservation. Journal of Economic Perspectives 12 (3), 21–34.

Nicholls, A.O., Margules, C.R., 1993. An upgraded reserve selection algorithm. Biological Conservation 64, 165–169.

Pressey, R.L., Humphries, C.J., Margules, C.R., Vane-Wright, R.I., Williams, P.H., 1996. Beyond opportunism: key principles for systematic reserve selection. Trends in Ecology and Evolution 8, 124–128.

Trousdale, W., Adair, M., Crover, J., Erickson, R., 2000. Decision framework to select eligible projects. Report prepared for Forest Renewal British Columbia in coordination with The Nature Trust of British Columbia, in support of the Private Land Biodiversity Project, Vancouver/Victoria, BC.

Vane-Wright, R.I., 1996. Identifying priorities for the conservation of biodiversity: systematic biological criteria within a socio-political framework. In: Gaston, K.J. (Ed.), Biodiversity: A Biology of Numbers and Difference. Blackwell, Oxford, pp. 309–344.

Vane-Wright, R.I., Humphries, C.J., Williams, P.H., 1991. What to protect? Systematics and the agony of choice. Biological Conservation 55, 235–254.

von Winterfelt, D., Edwards, W., 1986. Decision Analysis and Behavioral Research. Cambridge Univ. Press, New York.

Williams, P.H., 1996. Measuring biodiversity value. World Conservation 1, 12–14 (formerly IUCN Bulletin).

Williams, P.H., Gaston, K.J., 1998. Biodiversity indicators: graphical techniques, smoothing and searching for what makes relationships work. Ecography 21, 551–560.

Williams, P., Gibbons, D., Margules, C., Rebelo, A., Humphries, C., Pressey, R., 1994. A comparison of richness hotspots, rarity hotspots and complementary areas for conserving diversity using British birds. Conservation Biology 10, 155–174.