Essay

The Gaps between Theory and Practice in Selecting Nature Reserves

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Abstract: *Over the last three decades a great deal of research, money, and effort have been put into the development of theory and techniques designed to make conservation more efficient. Much of the recent emphasis has been on methods to identify areas of high conservation interest and to design efficient networks of nature reserves. Reserve selection algorithms, gap analysis, and other computerized approaches have much potential to transform conservation planning, yet these methods are used only infrequently by those charged with managing landscapes. We briefly describe different approaches to identifying potentially valuable areas and methods for reserve selection and then discuss the reasons they remain largely unused by conservationists and land-use planners. Our informal discussions with ecologists, conservationists, and land managers from Europe and the United States suggested that the main reason for the low level of adoption of these sophisticated tools is simply that land managers have been unaware of them. Where this has not been the case, low levels of funding, lack of understanding about the purpose of these tools, and general antipathy toward what is seen as a prescriptive approach to conservation all play a part. We recognize there is no simple solution but call for a closer dialogue between theoreticians and practitioners in conservation biology. The two communities might be brought into closer contact in numerous ways, including carefully targeted publication of research and Internet communication. However it is done, we feel that the needs of land managers need to be catered to by those engaged in conservation research and that managers need to be more aware of what science can contribute to practical conservation.*

Distanciamiento Entre Teoría y Práctica en la Selección de Reservas Naturales

Resumen: *Durante las últimas tres décadas se ha canalizado una gran cantidad de investigación, dinero y esfuerzo en el desarrollo de teorías y técnicas diseñadas para hacer la conservación más eficiente. Mucho del énfasis reciente se ha enfocado en métodos para la identificación de áreas de alto interés de conservación y en diseñar redes eficientes de reservas naturales. Los algoritmos de selección de reservas, análisis gap y otras aproximaciones computarizadas tienen un gran potencial para transformar los planes de conservación, sin embargo estos métodos son poco usados por los responsables del manejo de paisajes. Describimos brevemente las diferentes aproximaciones para identificar áreas y métodos potencialmente valiosos para la selección de reservas y posteriormente discutimos las razones por las cuales estos permanecen sin ser usados por las comunidades de conservación y uso del suelo. Nuestras discusiones informales con ecologo, conservacionistas y manejadores de Europa y Estados Unidos sugieren que la principal razón del bajo nivel de adopción de estas herramientas sofisticadas es simplemente que los manejadores las desconocían. Cuando este no era el caso, elementos tales como bajos niveles de financiamiento, carencia de entendimiento sobre su propósito y una antipatía general hacia opciones de conservación prescriptiva estaban involucrados. Reconocemos que no hay una solución simple y hay que hacer un llamado para un diálogo cercano entre teóricos y prácticos de la biología de la conservación. Existen numerosas formas para traer estas dos comunidades a un contacto cercano, incluyendo la cuidadosa publicación de investigación mediante Internet. De cualquier modo, sentimos que las necesidades de los manejadores necesitan ser atendidas por aquellos involucrados en la investigación sobre conservación y que los manejadores necesitan estar más pendientes de lo que la ciencia puede proveer para las prácticas de conservación.*

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Introduction

Most conservation of threatened wildlife is achieved via networks of protected areas in the form of national parks, wilderness areas, and nature reserves. We refer to them generically as "reserves." The first reserves were sited on a biologically ad hoc basis. But reserves selected in this way, and hence the reserve networks to which they contribute, are likely to be suboptimal for protecting biodiversity (Pressey 1994). For the reserve approach to be efficient and cost-effective, not only must individual reserves be sited accurately, but reserve networks must also be configured to optimize their conservation potential. This idea has spawned numerous methods for selecting the most effective (network of) reserves in a given region, and their development is now a sizeable sub-discipline of theoretical conservation biology.

We briefly describe the most common approaches to reserve selection and then focus on selection algorithms because a great deal of research effort has been devoted to them and they dominate the recent literature. We examine their utility for the organizations and individuals who make decisions about nature reserve acquisition (hereafter referred to as "managers") and ask whether site selection algorithms have proven useful in practical conservation and, if not, why not?

Techniques for Reserve Selection

The first stage of most conservation planning is to identify areas that warrant protection (including areas that are already reserves). The main criteria used to identify such areas are biodiversity (the broad equivalent of taxonomic richness), rarity, population abundance, environmental representativeness, and site area. Among these criteria, taxonomic richness has pre-eminence, even where nonbiological (e.g., socioeconomic) criteria for reserve selection are used (Margules & Usher 1981; Goldsmith 1991). Where distribution data are both comprehensive and accurate, it is possible to identify areas of high species richness (hotspots) for certain taxa, focusing on threat level (e.g., endangered species) or biogeographical status (e.g., endemic species) (Diamond 1986; Myers 1990; International Council for Bird Preservation 1992; Prendergast et al. 1993; Dobson et al. 1997). The simplicity of the species richness approach to reserve selection is both its strength and its weakness (Prendergast et al. 1993; Williams et al. 1996).

Easily censused groups like birds or butterflies aside, it is actually proving much more difficult to measure biodiversity than previously thought (Lawton et al. 1998). A refinement of the species richness approach would be to quantify character (genetic) diversity (Morrone et al. 1996). It is a logical extension of counting individual species to incorporate a measure of how different they are, but this approach requires a level of resources and technical expertise that make it impractical.

The availability of reliable species richness data for any taxon usually lags far behind conservation threats, and future reserve selection may have to rely on easier-to-collect surrogate data. This is the rationale behind the use of indicator taxa: areas occupied by many species from a well-studied indicator taxon are also considered species-rich for other taxa (Landres et al. 1988; Pearson & Cassola 1992). But recent evidence suggests that, at spatial scales relevant to practical conservation, the covariance in species richness between pairs of taxa (i.e., indicator and indicatee, in this context) is highly variable, both geographically and taxonomically (Oliver & Beattie 1993; Prendergast et al. 1993; Dobson et al. 1997; Prendergast & Eversham 1997; Pimm & Lawton 1998). An alternative to using pairs of taxa is to use one taxonomic level to predict another, and at large scales (possibly too large to be of practical use) generic or familial diversity can be a reasonable correlate of species diversity in some taxa (Williams & Gaston 1994).

In the past the protection of individual—usually rare—species has figured prominently in reserve siting. Preoccupation with biodiversity and reserve efficiency has fostered hopes that areas of rare species and high biodiversity can be protected simultaneously (Thomas & Mallorie 1985; Renner & Ricklefs 1994). These hopes appear unjustified because of the low spatial concordance of rare species and high diversity (Prendergast et al. 1993; Curnutt et al. 1994; Pimm & Lawton 1998). Furthermore, not only may rarity be defined in several ways but some rare species are often intrinsically hard to locate (McIntyre 1992; Gaston 1994), creating considerable practical difficulties for this approach. Nevertheless, the single-species formula for siting potential reserves appears to have been widely used (World Wildlife Fund 1982; MacKinnon & DeWulf 1994), although it has received comparatively little attention in the formal scientific literature (but see McIntyre 1992; Rebelo & Tansley 1993).

Ecologists have always been fascinated by the idea of quantifying nature, although endeavors to develop diversity indices that incorporate measures of both species number and individual abundance have now largely subsided (Magurran 1988). They are not generally thought to be useful in reserve selection (Hurlbert 1971; Gotmark et al. 1986; Haila & Kouki 1994) mainly because different indices often rank the same sites differently (Magurran 1988; Turpie 1995). Nevertheless, they have occasionally been used to prioritize sites for conservation (Chanter & Owen 1976). Measured separately, abundance on sites has been used to evaluate British Sites of Special Scientific Interest (Hodgetts 1992).

Where existing species distribution data are inadequate for reserve planning, other approaches have been attempted. Island biogeography theory (MacArthur &

Wilson 1967) has been applied to questions of reserve selection. The debate between a single large reserve versus several small reserves (SLOSS; e.g., Diamond 1975) yielded no satisfactory conclusion, probably because there is no single answer. Depending on the taxa and the geographical locality and position of the reserve(s), various sizes and numbers of reserves may, at least on paper, maximize the number of species within a reserve system. In Norway the species-area equation for breeding birds has been used to assess the conservation value of differently sized river catchments (Bevanger 1987). A test of reserve selection based on area found the approach to be seriously flawed (Lomolino 1994). Reed (1983) counseled great caution in relying on a single relationship, such as that between species number and area, for conservation planning.

Another approach is to classify sites according to how well they represent the climatic and physiographic variables of a region, rather than their biological attributes (Belbin 1993). The most representative sites of their class are taken to be the most appropriate candidates for protection. But if maximizing number of species protected is the conservation goal, sites on ecotones *between* biogeographic units may harbor more species (Brown 1991; Prendergast 1994). Significant cases of practical site selection for conservation on the basis of representativeness are scarce. An exception is Australia (C. R. Margules, personal communication), where representativeness is explicitly incorporated into the requirements of the forest reserve system. Less objectively, numerous nature reserves have been established in Britain at sites that represent examples of rare or declining habitat types.

As the science of conservation ecology matures, so does our appreciation that no single procedure for identifying areas of conservation interest is likely to be universally appropriate. In most planning scenarios there are more sites of biological value than it would be possible to declare as reserves. Therefore, it is usually necessary to identify a subset, but how to know which is the best subset?

Reserve selection algorithms (e.g., Kirkpatrick 1983; Pressey & Nicholls 1989; Bedward et al. 1992; Rebelo & Siegfried 1992; Nicholls & Margules 1993; Possingham et al. 1993; Margules et al. 1994*a*; Pressey et al. 1994, 1997, and references therein) have been developed primarily in Australia and South Africa. They select, from a pre-determined collection of land parcels, the minimum area (or cost) subset that embraces the greatest amount of diversity, or whatever metric of biological value is applied (Cousins 1991; Haila & Kouki 1994; Dobson et al. 1997). The algorithms have been continually refined since they first appeared. Recent versions, for example, preferentially select sites that are close together, an arrangement recommended (in theory) for metapopulation persistence (Nicholls & Margules 1993). To ensure that the protection of large populations is favored, some algorithms take into account species abundances rather than presence/absence data (Turpie 1995). Other variants incorporate commercial attributes such as land availability and market price to increase their utility in real planning scenarios (Bedward et al. 1992; Ando et al. 1998; Pimm & Lawton 1998).

In spite of its apparent simplicity, the process of optimal reserve selection subject to constraints presents formidable computing problems, and sophisticated mathematical methods have been developed to address it (Underhill 1994; Pressey et al. 1996). But no universal algorithm exists to handle all reserve planning scenarios. Pressey et al. (1997) subjected 30 different algorithms to exhaustive testing, concluding, unsurprisingly, that individual circumstances dictate which algorithm is the most appropriate.

Gap analysis is a useful means of identifying sites that ought to be protected but that currently fall outside existing conservation networks (Burley 1988; McKendry & Machlis 1991; Scott et al. 1993; Caicco et al. 1995 and references therein). The technique, developed and widely tested in the United States, uses geographic information system (GIS) technology to identify gaps in the existing reserve network. Of all the approaches discussed in this paper, gap analysis appears to offer the most practical guidance for reserve selection. Being able to identify gaps in an existing network is a simple and appealing concept that could easily be adopted by managers. Its rationale is implicit in the conventional approach to reserve selection, and recommendations that stem from it are likely to take the less drastic form of addition to, rather than reconfiguration of, existing reserve systems.

Current reserve selection algorithms and gap analysis, the two major approaches to reserve siting, can be fully applied only when species distributions are known and the contents of (potential) reserves deduced. Efforts to predict, rather than detect, the spatial occurrence of species, to identify reliable environmental surrogates for biological diversity, and, fundamentally, to map the biodiversity potential of landscapes (e.g., O'Connor et al. 1996) could in theory supplant the need for extensive biological surveys. These approaches are still in the early stages of development but are beginning to be integrated into gap analysis and reserve selection algorithms (Kiester et al. 1993).

Reserve siting involves more than locating and delineating sites with valuable biological content. Wilson and Willis (1975) advocated minimizing the ratio of reserve perimeter to area to reduce edge effects. In contrast, Game (1990) suggested maximizing it to increase the interception rate of propagules from passive dispersal. Either way, there is scant evidence of such ideas having been put into practice. Reserve infiltration by unwelcome visitors has also been addressed. Peres and Terborgh

(1995) suggest, for example, that Amazonian forest reserves be sited away from navigable rivers and roads so that they are less vulnerable to poaching. In countries where conservation typically takes place on small reserves within a heavily populated urban-agricultural matrix, and increasingly in developing countries too, negative impacts from outside reserves may relate not only to illegal activity but also to land use in adjacent areas. Buffer zones around reserves have been prescribed as a palliative measure (Nepal & Weber 1994; Hunter 1996), but although reasonable in theory, pressures on land availability (especially in Europe) are likely to preclude their use. The same constraints may apply to corridors for linking reserves, also the subject of much debate (Harrison 1991; Simberloff et al. 1992; Mann & Plummer 1995).

Use of Reserve Selection Theory

The objective and scientifically rigorous techniques we have mentioned have the potential to transform the way in which we allocate and protect land for conservation. But despite more than 20 years of development (Diamond 1975; Pressey 1994; Turpie 1995), during which the logic has been well tested and the approach well established, their impact on practical conservation planning has been minimal. Few reserves or networks have been established or designed using reserve selection and design techniques (Pressey 1994). Hard data are lacking, but we were prompted to address the issue after informal discussions with 23 conservation researchers, conservation organizations, and planning departments in Britain, Scandinavia, and the United States. Our conclusions were unequivocal: most theoretical work on reserve selection remains theoretical. Exceptions are Australia and parts of the United States (e.g., California), where reserve selection algorithms are being used in conservation decision making. Crucially, at least in Australia, reserve planning theory and the associated computer techniques have been developed mainly by the conservation agencies themselves, and this is probably the key to their adoption in that country. This is unusual; in most other countries there is a clear dichotomy between academic conservation research and applied land-use planning.

Given their rigorous, objective approach, there is no doubt that reserve selection programs are able to configure reserve networks that are efficient in terms of land allocation (Pimm & Lawton 1998). So why, when they clearly have such potential to inform planning decisions, are they rarely used by managers? We focus on site selection algorithms because of their current high profile in conservation research, but much of the following might also be said of gap analysis and other GIS approaches.

Although the more sophisticated reserve selection algorithms incorporate information on land values (Ando et al. 1998) and availability (Dobson et al. 1997), they are unable to handle the complexity of land ownership, status, and control that exists in some countries. In Britain, for example, nature reserves and wildlife sites carry levels of protection that range from local to European. Reserves are procured by many different agencies including the statutory government conservation agencies, (e.g., English Nature), the voluntary general (e.g., County Wildlife Trusts) and taxon-specific (e.g., Royal Society for the Protection of Birds) conservation sector, and private landowners. The degree of control that these agencies are able to exercise over reserves also varies considerably and depends on (1) whether the site is fully owned, leased, or rented or whether it is managed under an agreement with the owners and (2) local, regional, or national planning regulations. It would take a remarkable feat of cooperation for the various statutory, voluntary, and private reserve owners or managers to coordinate a common policy of reserve acquisition based on scientifically objective criteria such as size, shape, proximity to other reserves, representativeness, or complementarity. In practice very little scientific cross-referencing takes place. Historically, reserve acquisition has been driven by threat and opportunity (Thomas 1991), irrespective of the characteristics or location of reserves controlled by other parties. This situation is now changing, albeit slowly.

The complexity of reserve ownership is compounded further by the multiple demands placed on land. In Britain, for example, reserves are now expected to fulfill educational, cultural, and amenity roles as well as that of conservation (Goldsmith 1991). In both developed and developing nations, it is increasingly necessary to integrate conservation with regional development (which may include tourism, urban planning, road building, waste management, agriculture, mineral extraction, and job creation) within the same conservation area (Boza 1993). Each potential reserve is geographically unique, and for each the acquisition of the site or the development of an integrated management strategy in multiple ownership may be a complex process involving questions of price, tenure, availability, present and future use of adjacent land, access, management, and protection regimes. All of these are likely to predominate over what might be perceived as minor biological differences between sites.

Not all landscapes are like Britain's, of course. In some countries, not only may the landscape be simpler but so may be the administrative structure that regulates land use. In these places computerized reserve planning programs may be useful. But unless the algorithms are applicable to a range of landscape and ownership scenarios, are able to handle multiple sites with varying amounts of data, and are able to accommodate the demands of multiple land use, it is difficult to see how they can be brought quickly into widespread use.

Possibly because they have been developed in countries where resources tend not to be a critical issue, reserve selection algorithms are comparatively resource-hungry. In most countries conservation is grossly under-funded, and for many organizations the cost of hardware, an expert operator, and the experimentation required may inhibit the use of reserve selection algorithms (even if the software itself is free). And to work effectively, sophisticated methods of site selection usually require higher-quality data than most managers can ever expect to have. Data collection can be prohibitively expensive (Belbin 1993), and the absence of systematic species recording schemes in many countries usually means that species distributions must be inferred from fragmentary occurrence records.

Most theoretical approaches to reserve selection, whether by algorithm or not, are insensitive to variation in landscape and habitat scale. The conservation value of different patch sizes is likely to depend crucially on the type of habitat they contain. Where species' distribution data are summarized in a grid—and they often are—there may be a considerable scale difference between grid dimension and the area of land available for conservation purposes. In England, for example, even the largest National Nature Reserve (9899 ha) is smaller than the standard 10×10 km (10,000 ha) unit used to map national species distributions. This problem is likely to be mirrored in other countries because although reserves may be larger elsewhere, few countries can match Britain in the resolution and taxonomic breadth of their national species distribution data. Any approach to reserve selection that relies on identifying a subset of areas from a regional or national survey is critically dependent on the scale of the survey. In highly fragmented European landscapes this is especially important because reserves typically will be small. Where data are poor, the use of indirect methods and novel statistical or taxonomic approaches to incomplete sampling or inappropriate sampling scale (O'Connor et al. 1996) may eventually help to overcome these problems.

There are also other major potential difficulties with the application of selection algorithms that need to be borne in mind. In their critique of gap analysis, Conroy and Noon (1996) question whether species occurrence data collected at coarse spatiotemporal scales can be used as surrogates for community and ecosystem representation and persistence. Given the dynamic and spatially discontinuous nature of most species' distributions, usually intensified where human pressures apply, selecting areas of present-day occurrence for reserve sites may be highly misleading and may give rise to an unsustainable protection regime (Margules et al. 1994*b*) because many species become confined to marginal and suboptimal habitats (Cramp & Simmons 1980; van Wilgen et al. 1992; Lawton 1993). Even if reserve selection algorithms are used, they need to be interpreted and applied with great care. They are not a panacea.

So far we have largely focused on the technical aspects of theoretical approaches to conservation planning. But their failure to find favor with managers may have more prosaic roots. Some conservation techniques, for example, have evolved from traditional estate and land management practices. Where these persist, in both a practical and in an administrative sense, there may be little enthusiasm for sophisticated technical approaches to assessing conservation effectiveness. And if managers consider that all the biologically valuable sites under their stewardship are already protected (and some do), again they are unlikely to undertake the reassessment of reserve siting, although in virtually all studies, areas that appear to be important yet have no protection are continually being discovered (Lomolino 1994; Pressey 1994). Of course, gap analysis has been devised specifically to reveal them.

Managers are also unlikely to devote time and money to identifying the most effective set of reserves (defined by whatever criteria) if they believe that conflicts between development and conservation could be resolved more readily in other ways—by translocation, for example (Falk & Olwell 1992). This expedient has been considered for populations of great crested newt (*Triturus cristatus*) and Desmoulin's whorl snail (*Vertigo moulinsiana*), whose presence threatens to impede housing and road developments in England (Tickell 1996). But translocation is seldom recommended. The success rate of single-species translocations is low (Griffith et al. 1989), and the relocation of entire communities has an abysmal record (Bullock 1998).

Bringing Together Conservation Science and Management

All reserve selection algorithms require reliable data. In their absence, the only solution is to acquire this data, often at considerable time and expense. It is a matter of judgement whether money is better spent on acquiring data or on land purchase based on imperfect (or sometimes no) data. Where data exist, the reasons for the modest adoption of reserve selection algorithms and, indeed, of ecological theory in general, fall into three groups, related to lack of knowledge or understanding, shortcomings in the new approaches (real and perceived), and lack of resources. Here we suggest some possible solutions.

Many of the problems identified above are symptomatic of a failure in the way that science informs the practical aspects of conservation. There is a wide communication gulf between scientists working in conservation research and the managers working at the level where most conservation planning takes place. There is an urgent need for greater dialogue between the two communities and for institutional structure to promote it. Managers need to know what science can deliver, and scientists need to deliver what managers need. The responsibility to foster this communion lies in both camps, and both camps need to want change.

Finch and Patton-Mallory (1992) point out that research results are scattered and fragmented throughout the literature, inevitably creating a communication gap between researchers and natural resource managers. Much of the published material on reserve selection appears in the pages of *Biological Conservation* (United Kingdom) and *Conservation Biology* (U.S.), but few managers seem to have regular access to these journals. Targeting the planning community directly via journals such as the *Journal of Environmental Planning and Management* and the *Journal of Environmental Management*, might be more effective, although we know that many voluntary conservation bodies cannot afford the high subscription costs of academic journals of any discipline.

Where the academic literature is unable to forge the essential link between managers and conservation theorists, other approaches are necessary. Short workshops could serve to (1) alert managers of the techniques available and (2) inform researchers of the types of problems facing practical conservation (Brussard et al. 1992; Finch & Patton-Mallory 1992). To be effective, workshops need to be held locally and must be adequately funded.

The unprecedented growth of the Internet has the potential to transform the way theorists and managers communicate, both between and among themselves. (For example, the CODA reserve selection algorithm [Bedward et al. 1992] and the WORLDMAP [Natural History Museum 1998] software are available through web sites.) For the first time there is now enormous scope for rapid and comprehensive communication between all interested parties. A logical extension of software distribution would be the provision of an Internet-mediated conservation planning capability to assist countries where conservation is critically under-funded. Given imagination, resolve, and appropriate funding, there seems little reason why the expertise for reserve selection and other types of highly technical analysis could not be made universally available.

Of course, modern conservation theory and computer algorithms may fail to find support even where managers are aware of them. Where this type of inertia exists, managers need to be able to consider and, if appropriate, implement them without preconceptions. This relies on their recognition that these packages are analysis tools to guide and inform rather than to prescribe planning decisions.

But many of the problems seem to relate more to practicalities than to attitude, in that selection algorithms may not be appropriate for tackling the questions that many managers face. Nature conservation is often just one of the options open to planners for any given parcel of land. Here, paradoxically, the need may be for better algorithms. In Britain the Natural Environment Research Council–Economic and Social Research Council have developed a land-use modeling program (O'Callaghan 1995) that predicts the likely pattern of land use in individual river catchments under various political, economic, and climatic scenarios, with obvious potential for conservation planning.

In many countries, particularly where land for conservation is scarce, the procedures for land acquisition rarely follow the structured and logical path that conservation theory seems to prefer. In Britain the possibility of managers being able to take their pick from a selection of land parcels to develop an optimum network of reserves is negligible, even where multiple additional constraints (availability, cost, etc.) are built into the algorithm. Gap analysis takes as its starting point the existing reserve network, which may give it an advantage over other selection algorithms (although recommendations for land acquisition that stem from it may still be suboptimal if the aim is to minimize total reserve area while maximizing conservation performance [Pressey 1994]). Clearly, all effective conservation organizations need to set priorities, and computer algorithms may help them do this. But in some countries, in Britain for instance, in order to increase the total area of land under protection, managers are increasingly turning their attention to approaches such as habitat re-creation, ecological restoration, and the reconditioning of degraded habitats. Techniques like these may be especially effective when extending existing reserves because of the proximity of existing populations (P. Stirling, personal communication). They are not new and they are not perfect, but in some countries they may offer the best chance of acquiring land for conservation. Algorithms for reserve selection currently play little or no part in reserve extension via these practices.

The question of how to identify sites for nature conservation is complex. But it is subsumed within broader and even more difficult questions. In many situations, the setting aside of isolated habitat patches as reserves, whether singly or in networks, may not be the most effective and is certainly not the most subtle approach to nature conservation. In a world threatened by climate change, for example, the species composition of many reserves will inevitably change, and reserve networks themselves may require periodic reconfiguration to track species as they move. Conservation managers have barely begun to consider the implications of climate change for the siting and management of reserves (Lawton 1997). New thinking in Europe is moving away from the reserve mentality, in favor of a less isolationist approach to conservation. This requires that entire landscapes are made less hostile to wildlife and that the protection of habitat-creating processes rather than habitats themselves becomes the priority. Through this approach the needs of wildlife and human development will be ultimately integrated rather than differentiated. If this theoretical "landscape and processes" approach to conservation receives practical support, then the need to identify collections of disjunct habitat patches to fulfil certain taxon-specific conservation goals (whether selected by computer algorithm or not) is likely to diminish markedly.

We do not contend that research into the theoretical aspects of conservation planning is unnecessary; indeed it is often through research that new and innovative ideas gain currency. The reserve selection algorithms, and the other technical approaches to developing effective conservation areas we have mentioned, have their own individual characteristics. But beyond these technical details, the planners and researchers seem to be operating in different arenas. Conservation theorists move in a world of phylogenetic trees, habitat classification, species lists, and GIS technology. Practical conservationists, on the other hand, deal with planning regulations, the legal and economic minutiae of land purchase, local politics, fundraising, and practical problems ranging from cleaning ditches to anti-poaching security. We are, of course, generalizing to emphasize our point, but the two endeavors seem worlds apart.

Efforts are being made to make reserve selection algorithms more practical in their application, and these refinements are welcome (Pimm & Lawton 1998). But we believe it is important that theorists do not overestimate the contribution that conservation theory can make in a field that, whether we like it or not, is driven largely by socioeconomic imperatives. If opportunities for direct application are limited, our concern is that conservation theorists may appropriate resources better deployed elsewhere. In the case of Costa Rica, Boza (1993) called for funds for grassroots conservation and effective, broad environmental legislation rather than "more planning studies and documents to tell us what to do." This makes our point. Money is not a universal panacea for conservation problems, but in many areas we believe that it will be sensibly targeted funding, allied with informed policy and pragmatism, rather than theoretical optimization of reserve network design, that will have the greatest immediate effect on the most pressing conservation problems.

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