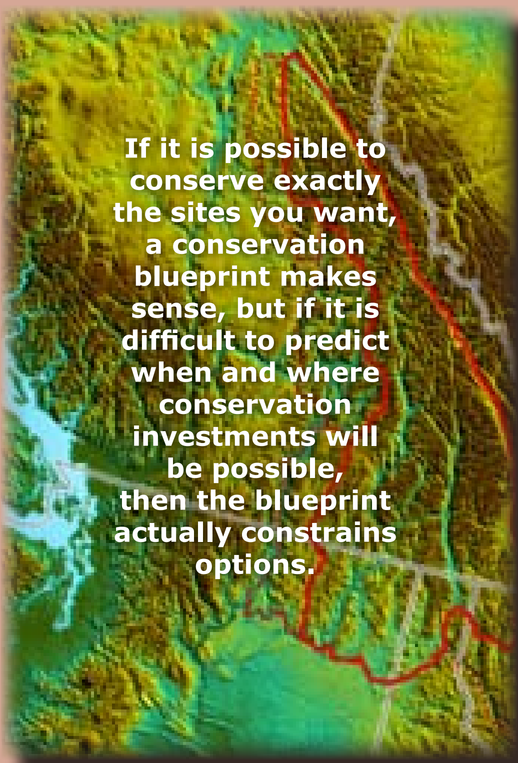
Planning conservation networks in a dynamic world

An AEDA *Info Sheet*

When should you stick with the original plan? And when should you do something else?

In recent times there's been a shift in conservation planning towards identifying optimal reserve networks. Research is suggesting that comprehensive reserve network design is best when the entire network can be implemented immediately. However, when conservation investments are staged over years, as is often the case, such solutions may be sub-optimal in terms of protecting species. Simple decision rules, such as protecting available sites with the highest irreplaceability or with the highest species richness, may be more effective.

Making plans in a changing world is always a challenge. You review your information, make your decision and implement it. But if that implementation takes some time, say several years, then you need to take into account that the conditions on which you based your original plan might have changed. And if your plan was about something important (ie, something big is at stake) then common sense suggests you review that plan from time to time to ensure it's still the right plan. On the other hand, making new plans can sometimes take a lot of effort. Sometimes it's less hassle to simply stick with the plan you've got, come what may.



Now, when it comes to big stakes, protecting biodiversity is one of the most important games in town, and it's a game at which government authorities and conservation agencies have been improving on all the time. These days considerable effort is usually expended in collecting the available biodiversity information and setting up systems of reserves that are believed to best protect that biodiversity. But most of this planning still has problems dealing with the reality that the world is constantly changing.

> "relatively simple rules for deciding which areas to protect outperform both ad hoc investment strategies and comprehensive conservation plans"

Traditional methods for conservation planning treat both biodiversity and human economic systems as static. They rely on a snapshot in time of the distribution and abundance of biodiversity, and they assume that once a reserve network is identified it can be implemented immediately.

But the real world doesn't operate like this. Conservation investments are constrained by budgets, and opportunities to implement conservation plans tend to be unpredictable. Indeed, reserve networks can often take decades to implement as pieces of land are sequentially set aside when property or money becomes available. In the interim, some biodiversity is lost and landscapes change.

Conservation researchers at the US National Center for Ecological Analysis and Synthesis (University of California) analysed and explored what the trade offs might be when a reserve network is set up over several years. In their analysis they considered a simple example involving 12 sites important for populations of 13 bird species in the Columbia Plateau region of the US. The reserves network aims to protect at least one population of each species.

The researchers explored a scenario that assumed because of budget constraints that it would take 10 years to build the reserve network. Each month there is a small chance (0.5% per month or 10% per year) that one of the sites becomes available for acquisition, and a small chance (from 0 to 1% per month) that one of the species at a site might disappear. Site cost is either 0.1 (cheap) or 1.6 (expensive). During the month a site is available, the players in this game must decide whether to add it to the protected network or wait for a better site to become available. Once a site is reserved, it's assume that the species at that site will persist. The challenge is to conserve as many species as possible for the least cost by the end of the decade.

Using a process called stochastic dynamic programming, the researchers compared the performance of three commonly used decision rules for assembling reserve networks: irreplaceability, richness, and the minimum set.

The minimum set identifies the complete network of sites that protects each species in at least one site for the least cost. To implement the minimum set decision strategy for this case study they used a simulated annealing algorithm to select the static comprehensive reserve network (the minimum set). Thereafter, they

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added a site to the reserve network only if it was identified at the outset as part of the minimum set of sites that would conserve each species in at least one site.

The richness algorithm prioritises sites based on the number of unprotected species that would be added to the reserve network if the available site were protected. This includes a calculation of the number of unprotected species that would be represented in the reserve network by acquiring each of the other unprotected (but currently unavailable) sites. Although currently unavailable, acquisition of some of these sites (better sites) might result in the protection of more species than would the available site.

Irreplaceability prioritises sites based on the proportion of biodiversity within the planning region that would be lost if the site were lost. To estimate irreplaceability, they calculated all possible sets of sites that could conserve each species at least once, and scored each of the sites based on the number of solution sets in which it occurred. Using an irreplaceability algorithm, a currently available site was added to the reserve network if it had a higher irreplaceability score than some threshold proportion of the other sites.

After running their simulations the researchers found that in almost all cases, decision making based on richness and irreplaceability performed better than did the strategy of only acquiring sites within the minimum set or comprehensive reserve network design.

Irreplaceability and richness also were more effective than simply being opportunistic.

Only when site availability and budget were both very high did the comprehensive reserve network design strategy do best. This makes intuitive sense. If it is possible to conserve exactly the sites you want, a conservation blueprint makes sense, but if it is difficult to predict when and where conservation investments will be possible, then the blueprint actually constrains options.

The research shows that comprehensive conservation plans may be worthwhile when the resulting reserve network can be fully implemented immediately after it's designed (eg, when the lands or waters involved are entirely in government ownership). However, when implementation is carried out over years such comprehensive planning may not be necessary (and may even be counter-productive). Their results suggest that relatively simple rules for deciding which areas to protect outperform both ad hoc investment strategies and comprehensive conservation plans. This is especially true when degradation rates and uncertainty are high. Further work is required on developing these rules to make then available to managers and decision-makers.

More recently, AEDA staff have been working to try and rebuild the tools and theory of conservation planning to deal with all these dynamics. Pressey et al (2007) have recently published a thought-provoking review in the high impact journal *Trends in Ecology and Evolution*. Their paper argues that human and natural changes in the landscape must to be accommodated into conservation planning theory and tools. And Reinaldo Lourival and Dr Martin Dreschler have manuscripts that use new methods to accommodate vegetation succession into conservation planning decisions. Their work is illustrated with the ecosystems of the South American Pantanal. Watch this space for reports on these papers, and many more, in what is a very dynamic (excuse the pun) field of conservation science.

Further reading

The ideas presented in this AEDA info sheet are based on the paper:

Meir, E, Andelman, S, and Possingham, HP (2004) Does conservation planning matter in a dynamic and uncertain world? *Ecology Letters*, 7:615-622

Pressey, BL, Cabeza, M, Watts, ME, Cowling, RM and Wilson, KA (2007) Conservation planning in a changing world. *Trends in Ecology and Evolution*, 22: pp583-592

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