# You can't always get what you want: Conservation planning with feedback effects

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Without careful thought, policies to promote a goal can end up doing less good than intended and, in extreme cases, can do more harm than good. Actions lead to reactions, namely, changes in human behavior or in biological or physical processes. Such reactions often cause unintended consequences that can render policies inefficient and ineffective. Some unintended consequences are hard to anticipate and incorporate into planning. Others are almost entirely predictable, although recognition of unintended consequences may require a shift in perspective, either from new insights or from the combination of knowledge from separate disciplines. In this issue of PNAS, Armsworth *et al.* (1) combine economic analysis of land markets with conservation planning to show how the unintended consequences of buying land for conservation lead to negative feedbacks on conservation objectives. Buying land for conservation increases land prices. With the consequent changes in behavior of other land buyers and landowners, development may not be forestalled as much as shifted. In the extreme, these feedbacks may lead to the paradox of less conservation being accomplished with conservation land purchases than without.

Unintended consequences frustrating good intentions are not uncommon in conservation and environmental policy. When logging was curtailed on public lands in the Pacific Northwest to conserve old growth habitat for the northern spotted owl, there was a consequent increase in logging on private forests in the region and increases in timber production outside the region (2). Another example of unintended consequences is furnished by the Endangered Species Act. Section 9 of the Endangered Species Act prohibits causing harm to listed species, which may prevent otherwise legal development, logging, or other activities on private lands. Landowners who want to pursue such activities have an incentive to engage in preemptive habitat destruction that prevents listed species from becoming established on their property (3). These examples illustrate the possibility that policies meant to conserve species may end up harming them instead.

## Conservation Planning

Conservation planning, i.e., applying systematic approaches to biodiversity conservation, is a relatively new field (an overview is contained in ref. 4). Although rapid advances have been made in data availability, methods, and thinking, the approaches used by researchers are still rudimentary in some respects. This point is especially applicable when considering economic or social analysis that incorporates the reactions of people affected by conservation planning.

Because a primary threat to biodiversity is loss of habitat, conservation planning focuses on policies of protecting land in biological reserves. Simply stated, the goal of conservation planning is to assemble a biological reserve system capable of conserving all species: a sort of modern day Noah's Ark. In reality, it may not be possible to conserve all species given human population pressures and desires for economic growth, but effective conservation planning would protect as much biodiversity as possible given the constraints. One approach to conservation planning is to maximize the number of species contained in a network of biological reserves subject to a constraint on the total area included in reserves (5, 6). This approach implicitly assumes that all land is equally costly to set aside and that areas outside of biological reserves contribute nothing to conservation goals. Both assumptions are obviously false. More recent work has incorporated differences in land costs (7, 8) and the contribution of "working lands" outside of biological reserves to conservation objectives (9, 10). In all of these cases, however, land prices were treated as constant. In other words, feedbacks between conservation actions and land prices were ignored.

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## Land Market Feedbacks

As noted by Armsworth *et al.* (1), feedbacks through the land market can have important effects on the success or failure of conservation policy. Taking account of land market feedbacks in conservation planning need not be difficult. Armsworth *et al.* (1) embed a simple economic analysis of land markets within conservation planning, allowing them to predict the effect of conservation land purchases on land prices and the consequent reactions of other land buyers and sellers. The simplest version of the analysis involves nothing more than analysis of supply and demand for land. The more sophisticated version of the analysis incorporates ecological heterogeneity in the spatial patterns of species occurrences. With the purchase of land for conservation, the increase in land price, which is reflective of increased development pressure, results in the conversion of some previously undeveloped land. When undeveloped lands have high conservation value and the change in amount of developed land is small, the net impact on conservation from land purchase will be limited.

How important land market feedback effects are for conservation planning is largely an empirical question. Setting aside a relatively small amount of land will mean that feedback effects are likely to be negligible. Similarly, feedback effects from setting aside agricultural or forestry land making up a small portion of a particular crop's production or timber production are also likely to be negligible. In contrast, as the authors note, buying land in coastal sage scrub habitat in Southern California, where development pressure is high and available land is limited, will likely lead to substantial land market feedback effects.

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Conflict of interest statement: No conflicts declared.

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## Additional Issues

There are, of course, additional issues that remain for future research. Spatial linkages among land units, either for ecological or for economic reasons, can be important. Many species need large areas of habitat to support a sustainable population. The conservation value of setting aside a land parcel will depend on whether there is other conserved land nearby. On the economic side, the value of land for development may be enhanced by being adjacent to conservation land that cannot be developed. Perhaps of greater importance is explicit incorporation of timing (dynamics). Conservation land purchases, as well as development, do not happen all at once but unfold over time. Such dynamic considerations make analysis much more difficult but allow consideration of many additional issues that cannot be captured in a static analysis.

The work of Armsworth *et al.* (1) takes an important step in integrating economic analysis and conservation planning. Such integration will likely make conservation planning much more effective. In a book about economic policy, Blinder (11) noted that accomplishing worthwhile policy objectives requires not just the desire for accomplishing social good (a soft heart) but careful analytical thinking to understand the consequences of proposed policies (a hard head). Economic, social, and ecological systems all have interconnecting parts. An action in one part of the system will lead to reactions elsewhere in the system. Whether proposed policies attain the intended objective requires analysis not only of the direct consequences but also of the unintended indirect consequences of the policy. Conservationists clearly have soft hearts. Effective conservation, however, also requires hard heads.


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