

Using return-on-investment to guide restoration: a case study from Hawaii

Joshua H. Goldstein^{1,2}, Liba Pejchar^{3,4}, & Gretchen C. Daily³

¹ Interdisciplinary Graduate Program in Environment and Resources, Stanford University, 397 Panama Mall, Stanford, CA 94305-2210, USA

² Department of Human Dimensions of Natural Resources, Campus Delivery 1480, Colorado State University, Fort Collins, CO 80523-1480, USA

³ Department of Biological Sciences, Stanford University, 371 Serra Mall, Stanford, CA 94305-5020, USA

⁴ Department of Fish, Wildlife, and Conservation Biology, Campus Delivery 1474, Colorado State University, Fort Collins, CO 80523-1474, USA

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Correspondence

Joshua H. Goldstein, Colorado State University, Human Dimensions of Natural Resources, Campus Delivery 1480, Fort Collins, CO 80523-1480, USA. Tel.: (970) 491-5220, fax: (970) 491-2255. E-mail: joshua.goldstein@colostate.edu

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Abstract

Restoring natural capital is essential for biodiversity and ecosystem services that support human well-being. Although ecological pathways for restoration are a major area of study, little is known about the economic pathways to which these efforts must be linked. This linkage, however, is important for maximizing return-on-investment (ROI) from restoration projects. We developed a general ROI framework to guide investments in restoration. We applied this framework to reforestation of montane pastureland in Hawaii, focusing on two specific conservation targets: native forest birds and understory plants. We found that restoring partial tree cover on pastureland is most attractive for birds, while understory plants require investment in full forest restoration. Nonlinearities in restoration pathways present in Hawaii, and likely elsewhere, generate these substantially different ROI profiles across potential projects. This information can guide the design of policies supporting cost-effective practices to help ensure that limited resources achieve the greatest impact.

Introduction

Ecological restoration is playing an increasing role in conservation, following new understanding of the values of natural capital (Aronson *et al.* 2007; Millennium Ecosystem Assessment 2003) and, in extreme cases, the human and ecological disasters precipitated by its loss (Danielsen *et al.* 2005; Zhang *et al.* 2000). Billions of dollars are currently being spent on restoration across the globe (Enserink 1999; Zhang *et al.* 2000), and this rate of investment is expected to increase with emerging conservation incentives and environmental markets (Davis 2005; Pagiola *et al.* 2002; Schuyt 2005).

Although practitioners draw heavily upon ecological information to set priorities or are instead primarily focused on project costs, few actively integrate both in decision-making (Brooks *et al.* 2006; Murdoch *et al.* 2007). Linking ecological and economic information is an essential next step for making efficient investments in restoration with limited funds. More subtly, so is identifying compatible revenue streams through time,

particularly for private landowners who must balance conservation and economic objectives (Holl & Howarth 2000; Schuyt *et al.* 2007). Given the great extent of human-modified lands that are candidates for restoration (Hobbs and Harris 2001), prioritizing between alternative restoration pathways is key to focusing efforts (Johnston *et al.* 2002; Macmillan *et al.* 1998; Murdoch *et al.* 2007; Naidoo *et al.* 2006).

Reforestation of transformed tropical forest landscapes is a major area of focus for restoration projects, because of the potential to realize benefits for conservation and people's livelihoods (Lamb *et al.* 2005; Schuyt *et al.* 2007). To ensure strategic use of resources, there is a need to identify the types of restoration actions that will generate the greatest benefit per unit of cost. In other words, we need to identify actions that will maximize return-on-investment (ROI) (Murdoch *et al.* 2007). In the context, for example, of forest restoration on degraded tropical lands, should restoration focus on far-reaching practices such as restoring diverse native forest cover? In contrast, would relatively smaller changes, such as restoring partial

tree cover, be an effective investment? These alternative options will have different cost and return profiles resulting in different ROI rankings, and therefore different management and policy opportunities with varying conservation outcomes.

The objective of our study is to address this issue by developing a return-on-investment framework to allocate limited restoration funds for management actions that can make the greatest difference. This framework addresses three questions: (1) what is the projected “return” of alternative restoration transitions? Quantifying this “return” requires determining the relationship between conservation targets (e.g., specific taxonomic groups or ecosystem services) and a land-use gradient along which restoration could proceed through time. (2) What are the financial costs of these transitions, and by how much can costs be offset through subsidy and revenue streams compatible with restoration? (3) By combining ecological and economic information, which transitions provide the greatest restoration ROI? How do ROI rankings change with different conservation targets?

We applied this framework in a case study of reforestation of montane lands on Hawaii Island (USA). Although these montane areas were historically covered in mixed, mesic *Acacia koa*/*Metrosideros polymorpha* native forest, substantial portions have been partially or fully cleared for cattle ranching, which remains a major land use (Cuddihy & Stone 1990). Pockets of opportunity for forest restoration are emerging, as ranchers face escalating production costs, alongside broadening public interest in restoring Hawaiian forest ecosystems (Cox & Bredhoff 2003; Wilkinson & Elevitch 2003).

We focused our ROI analysis on two taxa that are amongst the focus of many terrestrial conservation efforts in Hawaii: native forest birds and understory plants. Land-use change and other factors such as invasive species and disease have had widespread impacts on native species (Cuddihy & Stone 1990; Scott *et al.* 2001). In this context, habitat restoration, alongside continued efforts to conserve remaining high-quality habitat, is key to supporting both endangered and more abundant native species (Banko *et al.* 2001). Our case study in Hawaii illustrates an approach that can be used more broadly to guide strategic allocation of funds for restoration to inform management and policy decisions.

Methods

Land-use gradient and restoration transitions

We focused our research on montane lands in the North Kona and South Kona districts of Hawaii Island (Figure 1). Our analysis considered a gradient of four ma-

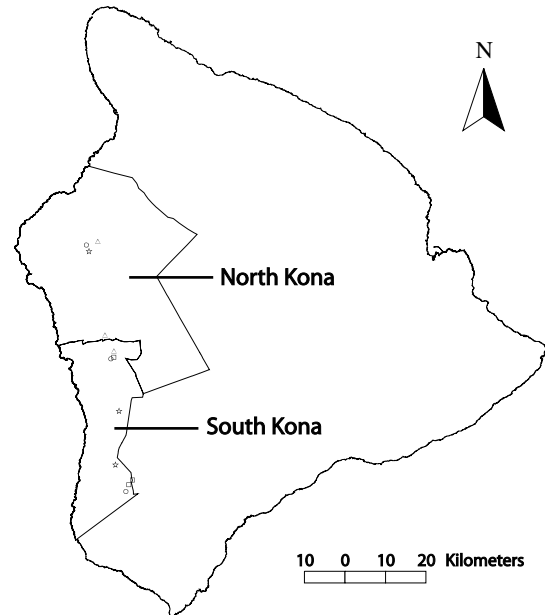


Figure 1 Map of Hawaii Island showing the 12 study sites in the North Kona and South Kona districts: open pasture (triangles), wooded pasture (squares), koa-dominated regeneration stand (circles), native forest (stars).

for montane land use types of biological and economic importance in Hawaii: open pasture (OP), wooded pasture (WP), *Acacia koa* (“koa”) dominated regeneration stand (KS), and native forest (NF). Detailed descriptions of each land use type are provided in Supporting Information (Appendix S1). Based on these land use types, we considered the six potential restoration transitions that convert a parcel from its existing state to one with increased native tree and understory plant cover. We abbreviate these transitions with the following notation, where the first land use type refers to the initial state and the second type refers to the target state resulting from restoration: OP→WP, OP→KS, OP→NF, WP→KS, WP→NF, and KS→NF.

Biological surveys and analysis

We surveyed for native forest birds and understory plants at 12 sites in Kona, with each land use type represented by three replicates (Figure 1). In choosing sites, we controlled for elevation and landscape context. All OP, WP, and KS sites were adjacent to lands with greater tree cover, and NF sites were bordered on at least one side by native forest. All sites were between 1300 and 1900 meters in elevation, and substrate age ranged from approximately 1,100 to 5,000 years before present.

We conducted variable circular plot counts with trained observers to measure native bird density and

richness (Reynolds *et al.* 1980) from January to March 2005, which overlapped with the breeding period for all bird species in our study area. Each site was sampled once and consisted of 16 points spaced 150 m apart. At each point, we performed an 8-minute point count in which we recorded the number of native birds of each species, the distance to each detection, the nature of the detection (aural and/or visual), and factors that could affect detection (e.g., sampling time, weather conditions).

For bird species with sufficient detections (> 75–100 detections, which accounted for 98.6% of total detections; Buckland *et al.* 2001), we generated density estimates by fitting statistical detection functions in program DISTANCE (Thomas *et al.* 2006) following methods described in Buckland *et al.* (2001) (see Appendix S1). For other bird species, we estimated density by including all detections within a 50-m cut-off radius (Martin *et al.* 1997).

We surveyed for native tree and understory plant density and richness at all odd-numbered bird-survey points. We walked the length of a 50-m transect tape, with the 25-m mark at the center of the point, and recorded the number of native understory plants of each species within 1 m on both sides of the transect (Goldman *et al.* 2008). We included ferns in this count but not grasses or sedges, which were mostly exotic species. We also recorded native tree density by measuring the diameter-at-breast-height of each tree (DBH > 10 cm) in 10 × 5 meter plots located every 10 m along the transect.

To determine if tree cover influenced native bird or understory plant density, we performed a regression using total native bird or understory plant density and tree basal area for each site. We used a Kruskal-Wallis test and a nonparametric means comparison test (Zar 1999) to determine whether the mean bird and understory plant density values for each land use type differed. For each restoration transition, we calculated the expected increase in mean density of native birds and understory plants by subtracting the density in the initial land use type from the density in the final land use type.

Financial modeling

We developed a financial model for each restoration transition that incorporated the costs of management practices for a representative 200-ha parcel located at ~1,500 m elevation, a focal region for montane reforestation projects in Kona. We modeled costs over a 50-year time horizon, which we expect to be sufficiently long to undertake restoration practices and to allow for potential future selective harvest of *A. koa* timber, described below. We present model results as net present value (NPV) us-

ing an 8% real discount rate with sensitivity analysis to 4% to 24% (Goldstein *et al.* 2006).

We defined management activities and associated costs based upon the literature and discussions from January 2005 to July 2006 with scientists, land managers, government employees, and other professionals knowledgeable about restoration in Hawaii. Major cost categories included: general operating costs, site establishment (including scarification for *A. koa* regeneration, an ecologically important endemic tree with well-established regeneration techniques; Baker *et al.* 2008; Scowcroft & Nelson 1976), additional canopy and understory plantings (to supplement *A. koa* regeneration), and forest stand thinnings. Detailed information on these cost components is provided in Appendix S1 and Tables S1–S4. Our primary analysis focuses on the direct management costs of restoration, modeling the situation where a montane Hawaiian landowner has already decided to undertake restoration on a small portion of his/her total landholding (often large, ~5000 ha or more) (see Appendix S1). Previous research has shown that landowners committed to conservation and seeking to leave a legacy on the land are interested in restoration (Pejchar & Press 2006). We discuss results incorporating opportunity cost in Appendix S2.

Incorporating subsidy and revenue streams

The question of how to pay for restoration is rarely addressed, yet it is required for initiating projects and partnering with landowners (Holl & Howarth 2000). We examined this issue by quantifying the degree to which three existing subsidy and revenue streams could offset costs for landowners, thereby enhancing the financial viability of restoration: (1) cost-share assistance through the State of Hawaii's Forest Stewardship Program (Hawaii Department of Forestry and Wildlife 2006). This program is representative of various government conservation programs in the United States, Europe, and elsewhere; (2) volunteer labor to assist with native outplantings, an important labor source for restoration projects (Holl & Howarth 2000); (3) limited silvopastoral cattle grazing for landowners interested in continuing in ranching for cultural or economic reasons. We only considered grazing for OP→WP, OP→KS, and WP→KS, because active grazing is known to conflict with understory plant regeneration for native forest restoration (Cuddihy & Stone 1990).

Harvesting high-value native timber species could provide another revenue stream to pay for restoration (Lamb *et al.* 2005). Hawaii's endemic tree, *A. koa*, is economically valuable and would be regenerated through restoration actions (Baker *et al.* 2008; Goldstein *et al.* 2006). As a

point of reference, we calculated the percent of the total 200-ha parcel that would need to be harvested to generate a breakeven NPV for the landowner. We only considered timber harvest in transitions that do not end in NF, since harvest is less compatible with this target. The one exception was KS→NF, because harvest could occur in the starting KS stand in year 0 followed by restoration of the entire parcel. Detailed information on all subsidy and revenue components is provided in Appendix S1 and Tables S1 and S5.

Return-on-investment calculation

We calculated the ROI ranking of each restoration transition by dividing the projected increase in mean native bird or understory plant density by the NPV of restoration costs. These values provide a measure of the expected increase in density for native birds or understory plants supported through the restoration project per dollar spent on restoration.

Results

Biological survey results

We found that native forest birds and understory plants responded differently to tree basal area along the land use gradient. Our results show a concave relationship for native birds and a convex relationship for understory plants (Figure 2).

We recorded seven bird species across all sites from a total possible set of 10 remaining native terrestrial species

found at montane elevations in Kona (Table S6); the remaining three are endangered species that are highly localized in distribution. Because species richness is low and nearly homogenous across sites, we used bird density as our index for the conservation objective in ROI calculations. Using density places equal value on each individual bird meaning more abundant species are disproportionately represented. No single species, however, was dominant across all sites. For understory plants, we recorded 58 species (Table S6). Because plant species richness and density were positively correlated (linear regression, $R^2 = 0.78$; $P = 0.0002$, $n = 12$), we again chose density as our metric to be consistent with birds and because richness will be determined in part by restoration outplantings. Although one would eventually expect diminishing returns to conservation of increasing density, the substantial extent of modification of Hawaiian ecosystems means that increases in abundance and range area of many native species is needed to sustain what remains today (Banko *et al.* 2001).

We found evidence for differences between land use types for mean native bird density (Kruskal-Wallis test, $\chi^2 = 9.51$, $df = 3$, $p = 0.02$) and mean understory plant density (Kruskal-Wallis test, $\chi^2 = 9.97$, $df = 3$, $p = 0.02$). Using a nonparametric means comparison test, we found that KS and NF have higher mean bird and understory plant densities than OP; NF also has a higher mean understory plant density than WP. Our small sample size makes it difficult to test adequately all differences between land use types. The observed trend of increasing mean bird and plant density along the land-use gradient, however, is supported by the observed positive relationships of bird and plant density with tree basal area (Figure 2). Across all restoration transitions, the largest projected increases in mean native bird density occur by restoring OP to any target with greater tree cover (Figure 3). For understory plants, however, the largest projected increases occur for the three transitions ending in NF.

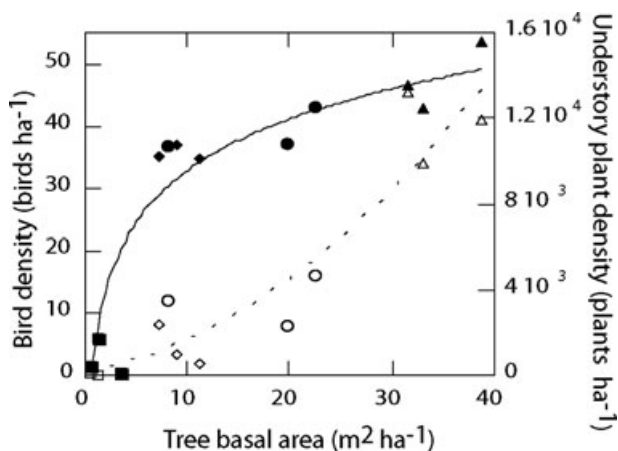


Figure 2 The relationship between native forest bird (filled symbols; $R^2 = 0.83$, $P < 0.0001$, $n = 12$) and understory plant density (open symbols; $R^2 = 0.88$, $P < 0.0001$, $n = 12$) and tree basal area. Open pasture (squares), wooded pasture (diamonds), koa-dominated regeneration stand (circles), native forest (triangles).

Financial results

The results of the financial model show that the three transitions ending in NF have the highest projected NPV of costs ranging from \$4,361/ha for KS→NF to \$6,317/ha for OP→NF (Figure 4). This is not surprising, given that restoring NF involves substantially greater effort than just restoring tree cover. Of note is that native understory plantings account for a large fraction (56–80%) of total costs. The remaining three transitions, which focus solely on restoring tree cover, have lower projected NPV of costs ranging from \$1,866/ha for WP→KS to \$2,615/ha for OP→KS. Although our base analysis used an 8%

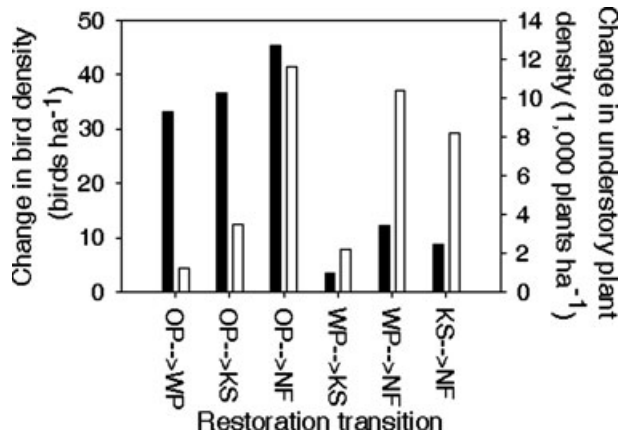


Figure 3 Projected mean increase in native forest bird (filled bars) and understory plant (open bars) densities for each restoration transition.

real discount rate, the cost ranking of transitions is preserved across a wide range of rates except WP→NF becomes relatively less costly than KS→NF above 11.2% (Figure 5).

When incorporating subsidy and revenue streams compatible with restoration, cost-share assistance provides the largest benefit with projected cost reductions of 24% to 28% across transitions. In comparison, volunteer planting labor could offset costs by 3% to 14% and cattle grazing by 10% to 14%. Combined, all three components account for 34% to 42% (Figure 4). The cost ranking of transitions remains unchanged.

When considering revenue from *A. koa* timber harvest, we found that the breakeven areas were large for

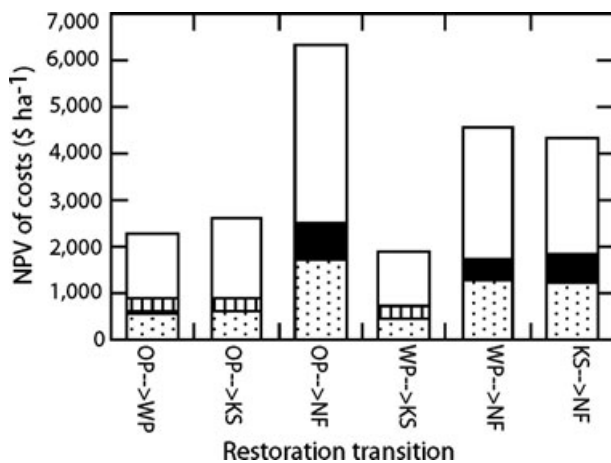


Figure 4 Net present value of costs for each restoration transition showing total cost (entire bar) with breakdowns showing: contribution of cost-share payments (dotted portion), volunteer planting labor (black), silvopastoral cattle grazing (striped), and remaining restoration costs not offset by these subsidy and revenue streams (white).

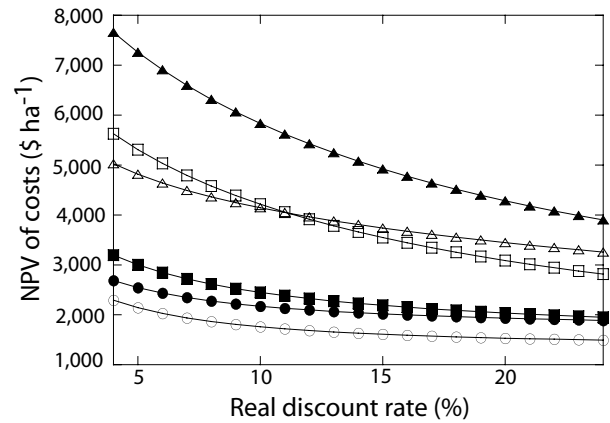


Figure 5 Sensitivity analysis of the NPV of restoration costs to the real discount rate for each transition: OP→WP (filled circles), OP→KS (filled squares), OP→NF (filled triangles), WP→KS (open circles), WP→NF (open squares), KS→NF (open triangles).

the OP→WP, OP→KS, and WP→KS transitions: 58% or greater when offsetting total costs and 43% to 73% for costs net of cost-share payments, volunteer labor, and silvopastoral cattle grazing (Figure 6). For KS→NF, only 6% is needed to offset total costs and 4% when incorporating revenue streams, because the KS stand is harvestable in year 0 versus year 40 for the other transitions (see Appendix S1).

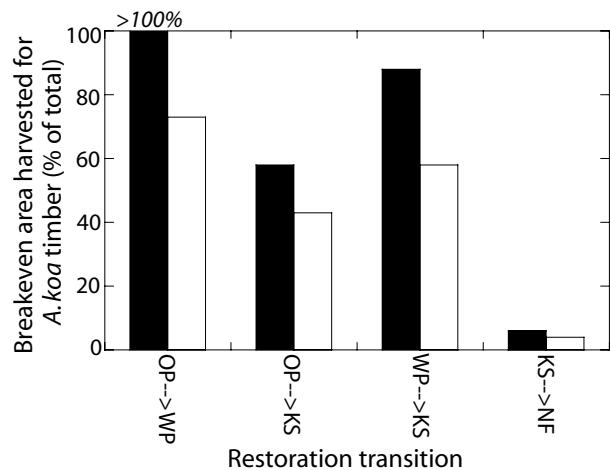


Figure 6 Percent of the total 200-ha parcel area that would undergo *A. koa* timber harvest to generate a breakeven NPV when offsetting total restoration costs (filled bars) or restoration costs net of cost-share payments, volunteer planting labor, and silvopastoral cattle grazing revenue (open bars) for each eligible restoration transition. When offsetting total restoration costs for OP→WP, an area greater than the entire parcel would need to be harvested to generate a breakeven NPV.

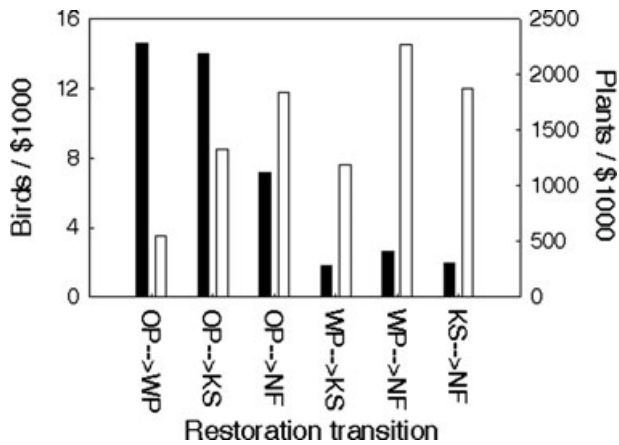


Figure 7 Return-on-investment ratio for each restoration transition for native forest birds (filled bars) and understory plants (open bars).

ROI rankings

We found that the ROI ranking of restoration transitions differed between our two conservation objectives. For native forest birds, the three transitions starting in OP have the highest rankings by a factor of 2.7 to 7.9 (Figure 7). For understory plants, the greatest return results from restoring NF from any starting land use (by a factor of 1.4 To 4.1). Incorporating cost-share payments, volunteer labor, and cattle revenue increases ROI values by 51% to 73%, though the ranking of transitions remains unchanged.

Discussion

We report a framework for evaluating alternative investments in ecological restoration along a land-use gradient, illustrating our approach through a case study of montane reforestation in Hawaii. Our results demonstrate two main findings that are broadly relevant: (1) Non-linearities in the biological and economic dimensions of each restoration transition (Figures 2–4) drive substantial differences in the relative attractiveness of alternative investments (Figure 7). An ROI framework provides an exploratory tool for discovering these nonlinearities, recognizing that investing strategically requires considering economic and ecological information (Murdoch *et al.* 2007; Naidoo *et al.* 2006); and (2) ROI rankings are goal-dependent, highlighting the need to specify conservation objectives explicitly (Figure 7). In particular, our Hawaii results suggest that across the full montane land-use gradient, funds targeting native forest birds would be most effectively allocated towards restoring (partial) tree cover, while understory plants would benefit most from investments in full forest restoration. Although these objectives

are not mutually exclusive, our results provide information to decision makers about the relative tradeoffs that would result from prioritizing one objective over the other. Interestingly, ROI analysis suggests that the most extensive restoration transition, OP→NF, provides the most attractive investment when considering both objectives equally (Figure 7).

Making restoration economically attractive remains an important, but challenging, goal to expand restoration projects, particularly on private lands (Daily & Ellison 2002; Milton *et al.* 2003; Schuyt *et al.* 2007). We examined a subset of existing subsidy and revenue streams and found that they could offset 34% to 42% of costs, with additional value potential from *A. koa* timber harvest, although the amount of harvest for income generation must be balanced with potential impacts on restoration goals. While substantial costs remain, this approach of identifying financial pathways by combining multiple, compatible income sources is key to creating a “menu” of options that can meet landowners’ diverse land management and financial goals (Goldstein *et al.* 2006). Future policy efforts should continue to focus on developing revenue streams (e.g., payments for ecosystem services) that allow landowners to capture privately a portion of the benefits that accrue more broadly to society from conservation (Davis 2005; Landell-Mills & Porras 2002; Pagiola *et al.* 2002; Schuyt *et al.* 2007).

Our analysis explores ROI across a montane land-use gradient in the context of a single parcel of land, as a first step towards providing information to guide restoration investments. An important extension to this work is moving from the parcel level to the landscape level to consider how spatial heterogeneity (biophysical and economic) affects ROI rankings. Furthermore, while there is widespread recognition that reforestation efforts are needed to support Hawaii’s native species (Banko *et al.* 2001), answering the landscape-scale questions of how much land to restore and where to restore will require a more encompassing benefit-cost analysis and consideration of diminishing marginal returns to restoration. This analysis would provide further insight into the scale of the effort required to achieve stated conservation objectives.

Our approach uses a space-for-time substitution to project the “return” from restoration. Whether current lands will be representative of restored lands, however, will depend on uncertain biophysical factors such as species extinction or climate change. In addition, we implicitly assumed that restoring a particular land use type is possible. We recognize that certain targets may not be possible on severely modified lands. In places where these are formidable concerns, incorporating these factors would provide useful model extensions.

The ROI approach developed here provides a general conceptual framework for prioritizing investments in ecological restoration along a land-use gradient to maximize return-on-investment. This information is relevant to land managers, conservation investors, and policy makers for developing on-the-ground projects, as well as designing cost-effective policies targeting restoration. By more effectively allocating limited resources available for restoration, we will take an important step towards expanding the capacity of restoration projects to support broader conservation efforts.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Input values used in the financial model to estimate management costs and potential revenue for each restoration transition.

Table S2. Input values for the submodel used to estimate the costs of feral ungulate removal.

Table S3. Input values for the submodel used to estimate the costs of scarification during site establishment to regenerate *A. koa* seedlings.

Table S4. Input values for the submodel used to estimate supplemental native canopy and understory planting costs.

Table S5. Cost-share payment levels for the State of Hawaii's Forest Stewardship Program (Hawaii Department of Forestry and Wildlife 2006). Costs of approved practices are reimbursed at 50% of allowable cost levels with practice specific caps. Cost-share payments are available for up to 10 years after site preparation. The program handbook provides cost-share rates with units in the English system, which we have converted to the metric system in this table.

Table S6. Mean native bird and understory plant densities per hectare (arranged alphabetically) for each species in each land use type.

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References

- Aronson, J., Milton S.J., Blignaut J.N., editors. (2007) *Restoring natural capital: science, business, and practice*. Island Press, Washington, D.C.
- Baker, P.J., Robinson A.P., Ewel J.J. (2008) Sudden and sustained response of *Acacia koa* crop trees to crown release in stagnant stands. *Can J For Res* **38**, 656–666.
- Banko, P.C., David R.E., Jacobi J.D., Banko, W.E. (2001) Conservation status and recovery strategies for endemic Hawaiian birds. *Stud Avian Biol* **22**, 359–376.
- Brooks, T.M., Mittermeier R.A., da Fonseca G.A.B., *et al.* (2006) Global biodiversity conservation priorities. *Science* **313**, 58–61.
- Buckland, S.T., Anderson D.R., Burnham K.P., Laake J.L., Borchers D.L., Thomas L. (2001) *Introduction to distance sampling: estimating abundance of biological populations*. Oxford University Press, New York.
- Cox, L.J., Bredhoff S. (2003) The Hawaii beef industry: situation and outlook update. Livestock Management series LM-8, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Hawaii.
- Cuddihy, L., Stone C. (1990) *Alteration of native Hawaiian vegetation*. University of Hawaii Press, Honolulu, Hawaii.
- Daily, G.C., Ellison K. (2002) *The new economy of nature: the quest to make conservation profitable*. Island Press, Washington, D.C.
- Danielsen, F., Sørensen M.K., Olwig M.F., *et al.* (2005) The Asian tsunami: a protective role for coastal vegetation. *Science* **310**, 643.
- Davis, A. (2005) Mainstreaming environmental markets. Pages: 155–171 in J.N. Levitt, editor. *From walden to wall street: frontiers of conservation finance*. Island Press, Washington, D.C.
- Enserink, M. (1999) Plan to quench the Everglade's thirst. *Science* **285**, 180.
- Goldman, R.L., Pejchar Goldstein L., Daily G.C. (2008) Assessing the conservation value of a human-dominated island landscape: plant diversity in Hawaii. *Biodivers Conserv* **17**, 1765–1781.
- Goldstein, J.H., Daily G.C., Friday J.B., Matson P.A., Naylor R.L., Vitousek P. (2006) Business strategies for conservation on private lands: koa forestry as a case study. *Proc Natl Acad Sci USA* **103**, 10140–10145.
- Hawaii Department of Forestry and Wildlife. (2006) *State of Hawaii forest stewardship handbook*. Division of Forestry and Wildlife, Honolulu, Hawaii.
- Hobbs, R.J., Harris J.A. (2001) Restoration ecology: repairing the Earth's ecosystems in the new millennium. *Restor Ecol* **9**, 239–246.

- Holl, K., Howarth R.B. (2000) Paying for restoration. *Restor Ecol* **8**, 260–267.
- Johnston, R.J., Magnusson G., Mazzotta M.J., Opaluch J.J. (2002) Combining economic and ecological indicators to prioritize salt marsh restoration actions. *Am J Agric Econ* **84**, 1362–1370.
- Lamb, D., Erskine P.D., Parrotta J.A. (2005) Restoration of degraded tropical forest landscapes. *Science* **310**, 1628–1632.
- Landell-Mills, N., Porras I. (2002) *Silver bullet or fools' gold?* IIED, London.
- Macmillan, D.C., Harley D., Morrison R. (1998) Cost-effectiveness of woodland ecosystem restoration. *Ecol Econ* **27**, 313–324.
- Martin, T.E., Paine C.R., Conway C.J., Hochachka W.M., Allen P., Jenkins W. (1997) *BBIRD Field Protocol*. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana.
- Millennium Ecosystem Assessment. (2003) *Ecosystems and human well-being*. Island Press, Washington, D.C.
- Milton, S.J., Dean W.R.J., Richardson D.M. (2003) Economic incentives for restoring natural capital in southern African rangelands. *Front Ecol Environ* **1**, 247–254.
- Murdoch, W., Polasky S., Wilson K.A., Possingham H.P., Kareiva P., Shaw R. (2007) Maximizing return on investment in conservation. *Biol Conserv* **139**, 375–388.
- Naidoo, R., Balmford A., Ferraro P.J., Polasky S., Ricketts T.H., Rouget M. (2006) Integrating economic costs into conservation planning. *Trends Ecol Evol* **21**, 681–687.
- Pagiola, S., Bishop J., Landell-Mills N., editors. (2002) *Selling forest environmental services*. Earthscan, London.
- Pejchar, L., Press D.M. (2006) Achieving conservation objectives through production forestry: the case of *Acacia koa* on Hawaii Island. *Environ Sci Policy* **9**, 439–447.
- Reynolds, R.T., Scott J.M., Nussbaum R.A. (1980) A variable circular-plot method for estimating bird numbers. *Condor* **82**, 309–313.
- Schuyt, K. (2005) Opportunities for long-term financing of forest restoration in landscapes. Pages: 166–170 in S. Mansourian, D. Vallauri, N. Dudley, editors. *Forest restoration in landscapes: beyond planting trees*. Springer, New York.
- Schuyt, K., Mansourian S., Roscher G., Rambeloarisoa G. (2007) Capturing the economic benefits from restoring natural capital in transformed tropical forests. Pages: 162–169 in J. Aronson, S.J. Milton, J.N. Blignaut, editors. *Restoring natural capital: science, business, and practice*. Island Press, Washington, D.C.
- Scott, J.M., Conant S., van Riper C. (2001) Introduction. *Stud Avian Biol* **22**, 1–12.
- Scowcroft, P.G., Nelson R.E. (1976) Disturbance during logging stimulates regeneration of koa. Research Note PSW-306, USDA Forest Service, Berkeley, California.
- Thomas, L., Laake J.L., Strindberg S., *et al.* (2006) *Distance 5.0. Release 1*. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. Available from: <http://www.ruwpa.st-and.ac.uk/distance/>. Accessed July 1, 2006.
- Wilkinson, K.M., Elevitch C.R. (2003) *Growing koa: a Hawaiian legacy tree*. Permanent Agriculture Resources, Holualoa, Hawaii.
- Zar, J.H. (1999) *Biostatistical analysis*, 4th ed. Prentice Hall, New Jersey.
- Zhang, P., Shao G., Zhao G., *et al.* (2000) China's forest policy for the 21st century. *Science* **288**, 2135–2136.

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