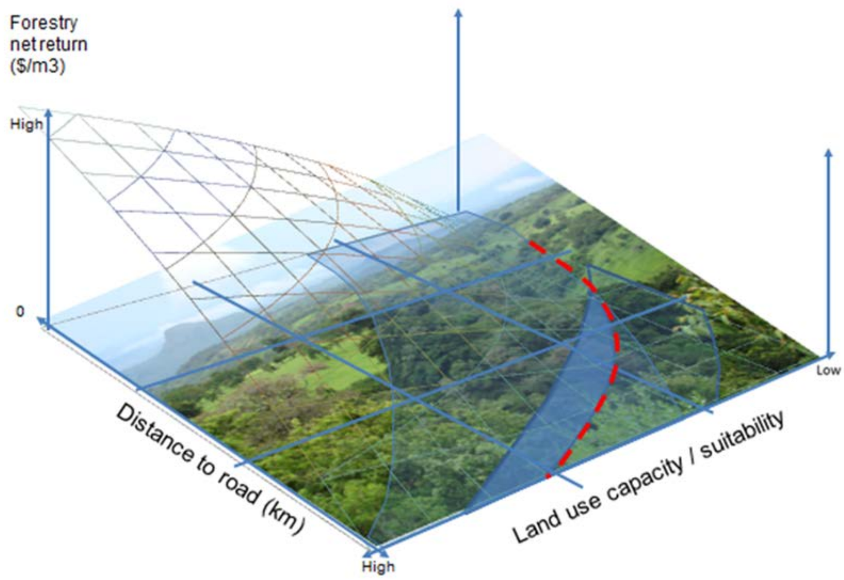
TECHNICAL BRIEF

Issue No. 11

POLICYMIX - Assessing the role of economic instruments in policy mixes for biodiversity conservation and ecosystem services provision



Guidelines for opportunity cost evaluation of conservation policy instruments

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About POLICYMIX. POLICYMIX focuses on the role of economic instruments for biodiversity conservation and ecosystem services provided by forest ecosystems. POLICYMIX evaluates the cost-effectiveness and benefits of a range of economic versus regulatory instruments in a variety of European and Latin American case studies.

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Abstract: This technical brief defines opportunity costs of conservation and provides examples of analysis and mapping of opportunity cost conducted in the POLICYMIX case studies. It complements POLICYMIX Technical Brief No. 10 “Guidelines for biodiversity valuation and benefits assessment of economic instruments”. Different conservation policy instruments impose different land use restrictions and hence entail different opportunity costs. The objective of the brief is to explain different approaches to quantifying opportunity costs, for the purpose of generating opportunity costs to be used in reserve site selection models. Four examples of opportunity cost mapping from POLICYMIX case studies – Portugal, Costa Rica, São Paulo and Norway – are discussed. Finally, we provide some take-home lessons. Maps of opportunity costs must therefore be calculated ‘fit-for-purpose’, specifically for the type of conservation policy instrument in question. The brief provides examples of how opportunity costs vary with land use capacity and accessibility. We caution that GIS-based mapping does not easily represent land user characteristics and preferences which also determine ‘percieved opportunity costs’. With these caveats we conclude that opportunity cost maps incorporate large variation and provide at best rough approximations of opportunity costs at any particular location. Such a rough approximation may nevertheless be useful for priority-setting using reserve site selection models and for illustrating the ‘production possibility frontier’ of conservation areas.

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1 Introduction

The Technical Brief on Guidelines for estimating costs and benefits of conservation policies (Brouwer et al. 2013): introduces the distinction between different concepts of the cost of conservation, including
-production costs of conservation (including monetary foregone net income and implementation costs)
-transaction costs (including decision-making costs, non-monetary costs)

Box 1. Steps in cost assessment (Brouwer et al. 2013):

1. Identification
2. Selection
3. Characterization
4. Quantification
5. Valuation of non-monetary costs
6. Aggregation
7. Assessment of uncertainty and sensitivity analysis

In this brief we define opportunity costs as foregone net income due to conservation, included in the production costs of conservation. Using several case study examples we illustrate how opportunity costs can be mapped as part of "Step 4. Quantification" of cost assessment (Box 1). The opportunity cost mapping deals with monetary estimates of opportunity cost that can be spatially extrapolated to different landuses.

2 Defining opportunity costs

Protecting biodiversity can be costly. One of the main reasons is the fact that the conservation and enhancement of nature often precludes the use of the protected area for various profitable economic activities or requires restrictions on such activities. The net benefits foregone due to these prohibitions and restrictions are the 'opportunity costs' of the biodiversity project or policy. Assessing opportunity costs will mainly be relevant if the biodiversity policy consists of measures and instruments that reduce the opportunities for land use and development without direct negotiations between the landowner (or user) and the biodiversity protection agency. Furthermore, it is important to have information on opportunity costs when the policy maker has to decide on areas and sites to be protected[1], and on the budget that will be needed to compensate landowners for their lost economic opportunities.

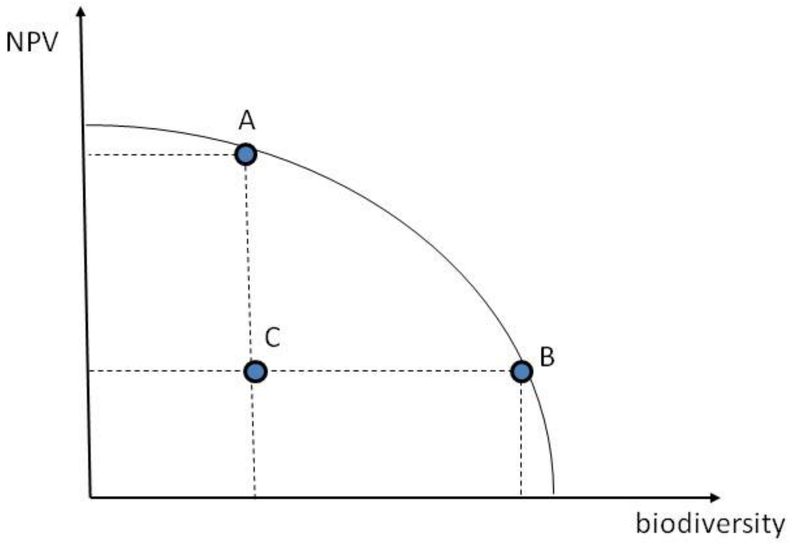
Opportunity costs can vary greatly, depending on the local situation. The highest values will be found where substantial opportunities exist for activities with a high added value per ha, such as mining and oil extraction. These values can be orders of magnitude higher than in situations where agriculture or forestry are the only feasible alternative land uses. For example, Schneider et al. (2010) calculated the costs of conserving the threatened woodland caribou in Alberta, Canada and arrived at values ranging from 10,000 to 11.5 million Canadian dollars (CAD) per km^2. The high end of the range was for areas with high potential for oil and gas development. The opportunity cost of protecting all herds would exceed CAD 100 billion. Given a total number of 3000 animals, this implied

[1] In this case, opportunity costs are an input to site selection models; see Blumentrath (2011).

a ‘cost price’ of more than CAD 30 million per single caribou. Grieg-Gran (2008) estimated the costs of avoiding deforestation for 8 different countries (Brazil, Indonesia, Papua New Guinea, Cameroon, Congo, Ghana, Bolivia and Malaysia) and provided national cost estimates of foregone land uses.

The amounts involved will in many cases be less extreme than in this example, but usually there will be opportunity costs involved in measures and policies aiming at biodiversity conservation. The tradeoffs involved can be made visible by means of a ‘production possibility frontier’ (PPF), depicting feasible combinations of biodiversity (measured by an appropriate indicator) and opportunity costs (expressed in the net present value (NPV) of the benefits associated with the alternative activity). Figure 1 shows a stylized example of a PPF. In point A, biodiversity can be further increased at relatively low opportunity costs (decrease in NPV of revenues from alternative activities). In point B, the opportunity costs are much higher. Point C represents an inefficient combination: biodiversity can be increased to the level of point B without any loss of revenue, i.e. at zero opportunity cost.

Figure 1: Production possibility frontier for biodiversity conservation



Source: Hauer et al. (2010).

If there are no alternative possibilities for the use of the area considered, there are by definition no opportunity costs of protecting it. Hence, in a country like Costa Rica, where forested land cannot be legally converted to other land uses, the opportunity costs of forestry will drop to zero over time as law enforcement increases (Barton et al., 2009). Obviously, at the time when the Costa Rica government decided on the forest protection legislation, opportunity costs *did* exist, and presumably they have been taken into account in that decision (either explicitly or implicitly). However, once such legislation is in force and enforced, the decision maker on, for example, a specific biodiversity project in a forest in Costa Rica can ignore the opportunity cost of non-forest alternatives, since that option does not exist anymore. In other words, the size of opportunity costs in a particular case depends on the prevailing institutional and legislative conditions in place (on the prevailing policymix). The PPF can be constructed using multiple simulations of increasing protected area using reserve site selection (RSS) models such as Marxan with Zones (Watts *et al.*, 2009). RSS models evaluate the least cost combination of areas that achieve specified conservation targets, using mapped conservation features and opportunity costs. Methods for generate opportunity cost estimates for mapping are discussed below.

<u>How to calculate opportunity costs?</u>

The opportunity costs of a biodiversity policy (project, measure) are calculated by first of all identifying the most profitable land use of all potential or conceivable land uses for each individual plot of land concerned. This is ideally done at a low spatial scale level, since land use options and associated benefits may differ even within a single farm. Next, the net present value (NPV) of all (expected) benefits and costs of this 'most profitable' land use is calculated, using an appropriate time horizon and discount rate. This NPV is then compared with the NPV of the scenario with the envisaged biodiversity conservation policy, in which the 'most profitable' land use is prohibited or restricted. The difference between the two NPVs gives the opportunity costs.

In practice, this procedure will hardly ever be feasible due to constraints on time and information availability. Therefore, opportunity costs are usually estimated using proxies. One option is to use data on land value. In a well-functioning land market, the price of a piece of land will reflect the NPV of the net benefits in its 'most profitable' use. Land values may often not always be readily available for the sites under consideration, so it may be necessary to use available values for comparable (neighbouring) sites, correcting for contextual differences if necessary. Sometimes statistical models are used to estimate the contribution of specific land and farm characteristics to land value (see for example Sinden, 2004). The degree of (infrastructural) development and proximity to existing agricultural markets usually also play an important role.

Alternatively, estimates can be made of the most profitable alternative land use in the area and its associated net benefits. However, also here in doing so one should be aware of significant differences that may exist between plots of land even within a relatively small area. This spatial variability of opportunity costs, as for instance found in a case study of the Mbaracayu Forest Biosphere Reserve in Paraguay (Adams et al., 2010), means that the cost-effectiveness of conservation decision-making can be enhanced by investing in the collection of complete cost data.

Geographical information systems (GIS) data on land use capacity may be used as a source of information on opportunity costs. At the end of this brief we provide a number of case study examples of this approach. Given the available resolution for these data (see Barton *et al.*, 2009, for an example on Costa Rica), we discuss potential and limitations for policy support using these kinds of maps.

In addition to spatial variation, the dynamics in land use and land markets may also complicate the task of opportunity cost estimation. For example, timber harvesting schemes in forestry will affect both the opportunity costs and the benefits in terms of wildlife habitat (see e.g. Nalle *et al.*, 2004).

Box 2: Opportunity costs of labour

Certain types of biodiversity conservation policies may bring employment opportunities for the local rural population. For example, farmers and their family members may be involved in tasks relating to the management of landscape elements, biodiversity conservation, pest control, monitoring etc. The relevant costs of these activities are the opportunity costs of their labour. These opportunity costs or 'shadow price' of labour can be substantially lower than the market wage rate for equivalent labour, especially in situations where unemployment is high. The difference can easily be some 50% (see for example Campbell, 2008). When estimating the costs of a biodiversity conservation policy it is important to have at least some basic information on the alternative (potential) sources of income for the people to be employed. In this respect, one should also keep in mind that the availability of labour in agriculture tends to vary strongly by season. The opportunity costs of labour can be minimized if the activities necessary for biodiversity conservation are planned during periods of low farm activity.

Whether or not the issue of opportunity costs and their estimation arises depends to a certain extent on the type of policy instruments used. Purchasing land for protection 'automatically' reveals the opportunity cost since the seller may be expected to want at least to be compensated for the benefits foregone. Hence, if purchasing the land is one of the instruments in the biodiversity policy mix, this land price determines the actual cost and the decision maker will not have to think about opportunity costs. The same holds for policy instruments involving restrictions on land use a nd other obligations for which a price is agreed between the landowner and the biodiversity protection agency, as well as for economic instruments such as auctions, tenders and subsidy schemes. Such instruments convey information *ex post* on the opportunity costs of the participating landowners: their opportunity costs will be lower than the compensation they receive for the restrictions and obligations to which they voluntarily subscribe.

Why a policymix causes spatial variation in opportunity costs

Figure 2 provides an illustration within a framework developed by Pannell (2008) where landuse changes have net benefits or costs to the private landowner and to the public at large. Starting with the existing situation of a location with untouched forest, a number of landuse changes could be possible, including conversion to annual crops and fallow, followed by conversion to pasture, or possibly abandonment and reversion to forest after some time. Other land uses such as harvesting of non-timber forest products (NTFB) or being submerged in a hydropower reservoir could also be envisaged depending on the location's characteristics. Each landuse change has its own combination of private and public net benefits/costs, which are also specific to the location's spatial and physical characteristics. The private opportunity costs of forest conversion when annual crops is the most profitable alternative, is equal to the foregone net benefits of what the landowner would have obtained from the timber removed and then from cultivating annual crops (and any further landuse changes after that).

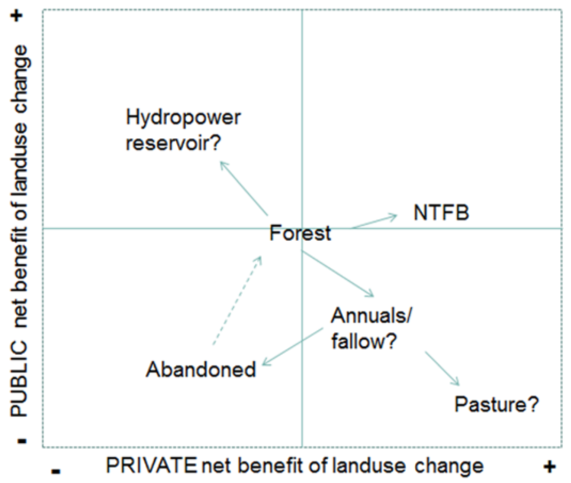


Figure 2 Examples of landuse change paths within a public-private benefits framework

Landuse policies include incentives to discourage and encourage landuse change – also called “negative” and “positive” incentives respectively by Pannell (2008). PES for forest protection and public protected areas are examples of negative incentives to discourage landuse change away from forest. In this brief we assume that these incentives have some level of effectiveness and hence incur opportunity costs. We focus on mapping opportunity costs to private landowners. Costs/benefits of conservation instruments are both public and private (Pannell 2008) and may be further detailed into acquisition costs, management costs, transaction costs, damage costs and opportunity costs (Naidoo et al. 2006). Pannell(2008) proposes a normative framework for targeting of conservation incentives(Figure 3). The opportunity cost mapping in this brief discusses how to quantify the private (horizontal) axis in this framework.

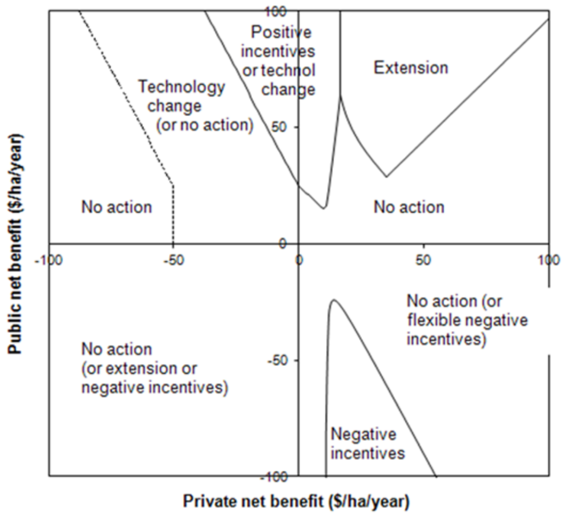


Figure 3 Conservation incentives in the public-private benefits framework. Source: Pannell(2008)

3 Opportunity cost mapping examples

The ideal approach to calculating opportunity cost is calculating the difference between the net present value (NPV) of any uses permitted under conservation and the NPV of the best alternative landuse that is foregone with conservation. This 'net opportunity cost' approach is challenging due to resource limitations and difficulties in assessing also the benefits from the conservation land use. Land use values based on property prices is another approach. A third approach, based on the use of geographical information system(GIS) to capture spatial variation in net revenues from landuse is illustrated in this section using examples from the POLICYMIX case studies.

Why do we focus on mapping and GIS? Mapping opportunity costs is necessary

Ex ante: to conduct strategic cost-effective spatial planning of conservation policies using reserve site selection methods (Rusch et al. 2013). Opportunity cost mapping can be seen as an indicator for an expected level of conflict.

In media res: to target conservation proposals from year to year based on cost-effectiveness

Ex post: (i) to compare the cost-effectiveness of an existing spatial distribution of conservation effort with an optimal 'benchmark' defined by conservation planning tools (Rusch et al. 2013); and (ii) to find properties with similar economic characteristics in a 'conservation treatment group ' and 'no treatment, control group'. These groups are then used to estimate the spatial effectiveness of conservation instruments after their implementation.

The examples below were generated as input to the conservation planning tool software Marxan with Zones(Watts *et al.*, 2009) applied to the cost-effective spatial targeting of different voluntary conservation policy instruments

3.1 Portugal

Box 3. Key assumptions

- Opportunity costs consider only foregone agricultural returns due to constraints on agricultural practices
- Agricultural returns vary by land cover, slope and soil type
- Average production costs and returns
- Static analysis

The focus in the Portuguese case-study was to assess the trade-offs between biodiversity conservation and socio-economic activities in the left margin of the Guadiana river, due to land use constraints imposed by conservation classified areas.

Agri-environmental measures (AEM) designed for the Moura-Mourão-Barrancos Natura 2000 impose a series of constraints on agriculture practices. The foregone returns to agriculture due to these production constraints are considered as an estimate of opportunity costs resulting from the conservation policy. The overall cost map considered three spatial variables: 1) land cover (based on COS2006, level III), 2) slope, 3) soil classes (maps obtained at the 'Agência Portuguesa do Ambiente, I.P., 2013). Agricultural returns to different types of landcover were based on data from previous studies on the Natura 2000 area (Santos et al., 2006) and from a National Forestry Strategy report (Estratégia Nacional para a Floresta, 2006). GRASS GIS 6.4.2 software was used to generate combinations of the classes in the land cover map (38 categories), combined with the slope of the system (6 categories, ranging between 0 to 5% and >25%), and with the soil classes (from A to E). Net economic returns to each of the land-cover-slope-soil combinations was assigned by crossing these maps, creating an average value (€) per hectare per year (Figure 4).

This combination resulted in an opportunity cost map for the study region, with a resolution of 200x200m corresponding to the planning units cells (Figure 4). The results obtained show that opportunity costs associated with AEM implementation, in terms of foregone benefits of, mainly, provisioning services, differ substantially between regions within the study site, with values ranging between 0.63 and 987 €/ha.

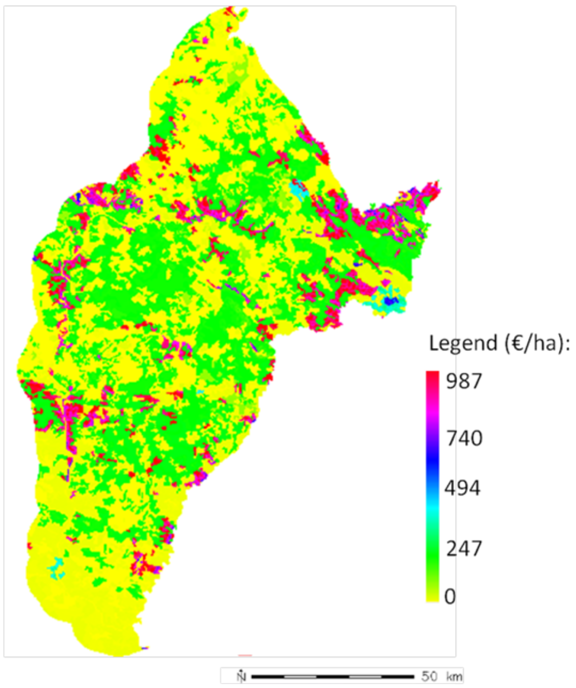


Figure 4. Cost map for the left margin of the Guadiana River, Portugal.

Source: Pinto, R., P. Antunes, R. Santos, P. Clemente, T. Ribas(forthcoming) Conservation planning in a multifunctional landscape: targeting biodiversity, costs and policies outcomes

3.2 Costa Rica

Opportunity cost maps were developed to be used in an analysis of cost-effective spatial targeting of conservation, sustainable forestry and plantation PES contracts, using a reserve site selection model. GIS maps of landuse and landuse capacity (LULUC) are available for most parts of the world, as are regional level agricultural statistics. The approach in the Costa Rican case study was to combine detailed LULUC maps with estimates of regional average net returns to crops and forestry. All values were converted to an average per hectare per year basis in order to be comparable with average annual payments for environmental services (PES) available to landowners. Two scenarios for opportunity costs were considered, reflecting

Box 4. Key assumptions

- Only net returns to production
- Returns to agriculture and forestry based only on current landuse capacity.
- Accessibility costs not accounted for
- Returns to agriculture based on average crop productivities for the whole peninsula
- Financial returns based on average regional prices
- Land use capacity classes assigned an average returns to agriculture weighted by the relative area of each crop per landuse capacity class for the whole peninsula
- Average forest and plantation harvesting
- Land market prices not considered

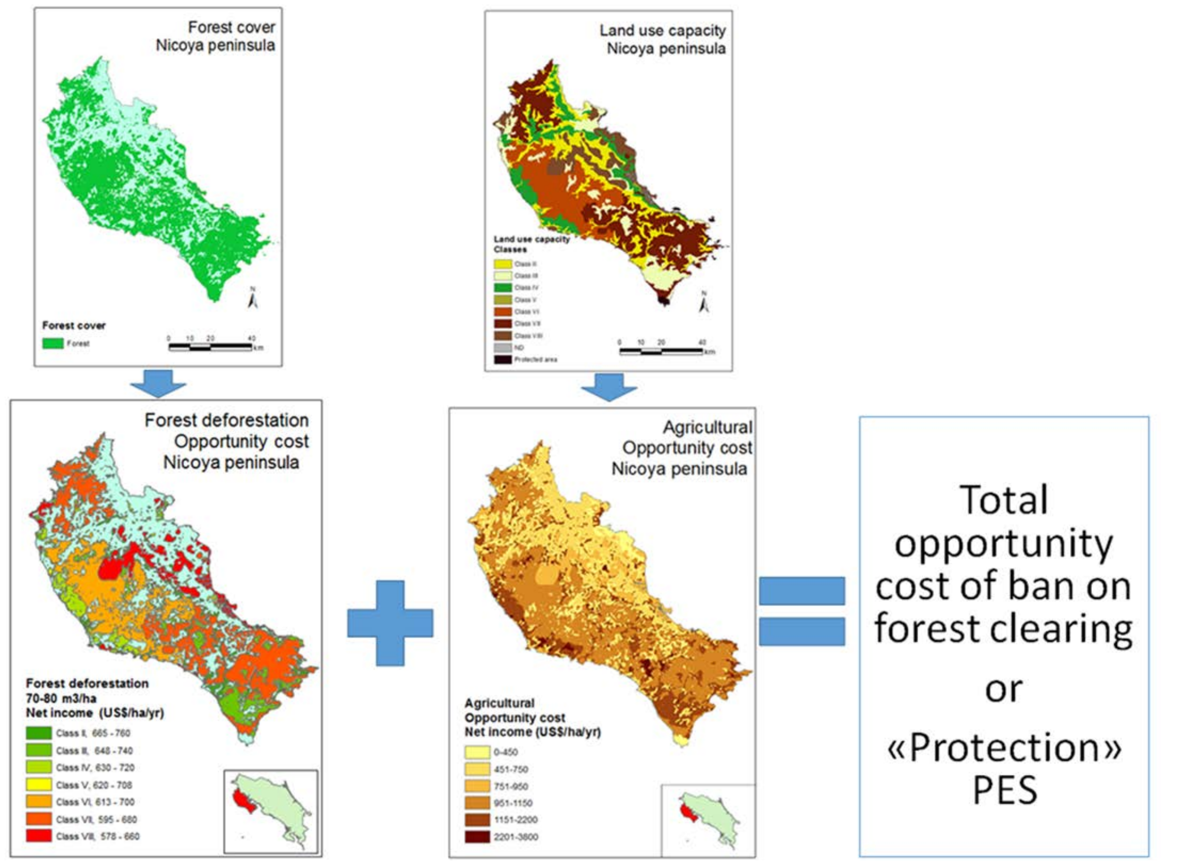


Figure 5 Total opportunity costs in Nicoya Peninsula of absolute forest conservation / clearing

uncertainty about the effectiveness of the ban on landuse change in the 1996 Forest Law. Figure 5 shows how the assumption of ineffective self-compliance and enforcement of the ban raises the opportunity cost of other conservation instruments such as PES. If enforcement is not effective opportunity costs are equal to foregone net returns to forest clearing plus net returns to subsequent alternative landuse. In figure 5 this is assumed to be agriculture and pasture. With the alternative assumption of 100% effective enforcement or norm-based self-compliance all areas in green(forest) have zero opportunity costs, while opportunity costs of forest regeneration are equal to foregone return to agricultural(lower left hand map).

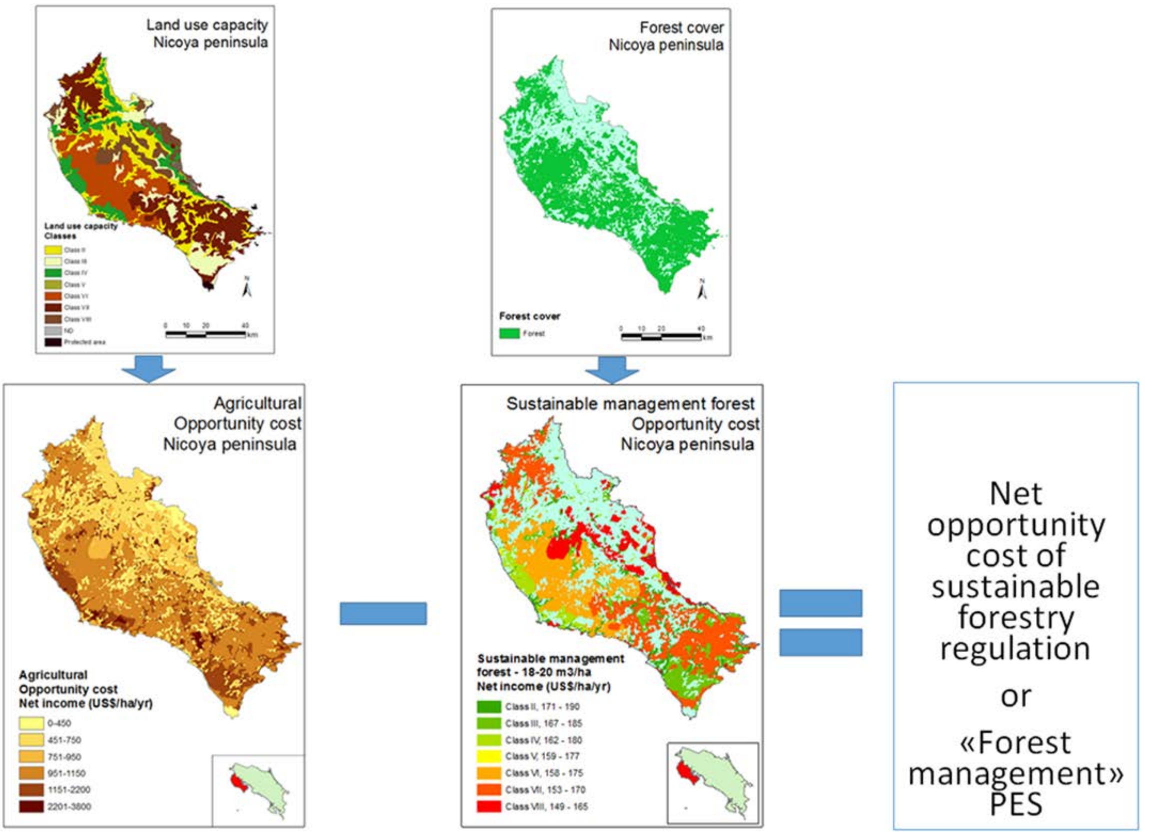


Figure 6 Net opportunity costs in Nicoya Peninsula of sustainable forest management

Figure 6 represents an intermediate scenario, where sustainable forest management is carried out in natural forests while respecting the ban on landuse change. In this scenario opportunity costs are the foregone agricultural/pasture returns minus net return from the sustainable forestry. In practice transaction costs of obtaining and certifying sustainable forestry have been so high that very few forest management permits and " forest management" PES modalities are applied for at present (Porras *et al.*, 2012).

Source: Barton, D.N., D.Tobar, A. Chacón-Cascante (forthcoming) Opportunity cost mapping as a management tool - evaluating alternative calculations methods in Peninsula de Nicoya and Osa, Costa Rica"

3.3 São Paulo

Opportunity cost maps were generated in order to evaluate the cost-effectiveness of a scheme for tradable development rights(TDR) under the Brazilian Forest Code. In this scheme landowners are required to set aside a minimum percentage of property in legal reserve, with the possibility to offer the excess as a TDR. The case used summary statistics on market price per hectare from the "bare land value" (BLV) database, compiled semi-annually as a proxy for the opportunity cost. In this database, for groups of municipalities (EDR) maximum, minimum and average land values are reported for different categories of land use suitability.

Box 5. Key assumptions

- Market price ranges (min-max) of non-forest "bare" land value (BLV) differentiated by categories of land suitability
- Land values match with land use capacity classification system
- The range of land value was assigned proportionally to a friction measure of land accessibility
- Benefits from standing forest were not accounted for
- Static analysis

In order to create an opportunity cost map for forest conservation from that database we applied the information there to existing map data. In a first step, a map on administrative units and a map from the Ministry of Agriculture on the lands suitability for agriculture were intersected so that the result matches the entities in the land price database. Within these spatial units maximum, minimum and average land prices were distributed spatially assuming their correlation with the accessibility of the land. Given the lack of more detailed information the distance to infrastructure (roads, urban areas and buildings) was used as a proxy for accessibility. A cost distance measure of accessibility constraints of the landscape was calculated using the r.cost module in GRASS GIS 6.4.2. This "friction map" of the landscape was defined as follows: (a) rivers were treated as "barriers" and (b) the friction of the terrain is defined as the squared slope in degree (which was added to the euclidean distance (in xy direction) defined by the resolution of the grid cells (100m x 100m)).

For each combination of municipalities and suitability classes the 1st and 3rd quartile of cost distance to infrastructure was calculated. Then land prices were assigned proportionally as follows: the 25% of the area closest to infrastructure was assigned the max-value; the 25% of the area with the largest distance to infrastructure was assigned the min-value, and the remaining intermediate cost distance locations were assigned average land market prices. This resulted in a map (Figure 7) with costs per hectare varying from R$1,2 thousand to R$50 thousand.

The resulting cost layer is based on potential agricultural returns and does not account for any forestry values that may be realized on properties.

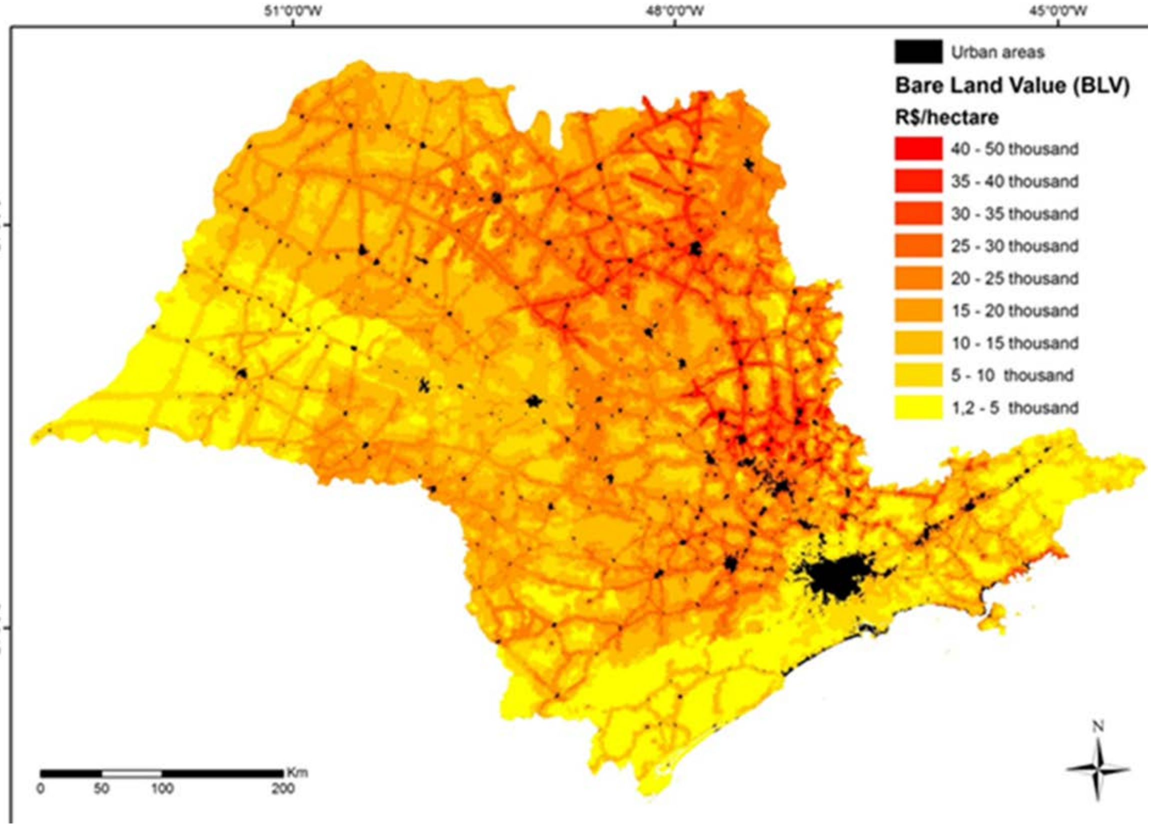


Figure 7. Distribution of Opportunity costs of forest conservation in São Paulo base on "Bare Land" Values per hectare (BLV)/
Source: BLV- IEA, 2012, Elevation model (SRTM- GLCF), (IBGE), Urban areas (EMBRAPA)

Source: Bernasconi, P., S. Blumentrath, D.N.Barton, G. Rusch, A. Romeiro (forthcoming) The potential of Tradable Development Rights (TDR) to improve effectiveness and reduce the costs of biodiversity conservation: study case in Sao Paulo, Brazil

3.4 Norway

Key assumptions

No land use conversion considered (model and map are only valid forestry)

- Dynamic forest growth model
- Assumes optimal forest stand management across harvest cycles
- Future real prices and costs roughly reflect average roundwood prices in Norway over the last two decades
- Net present value calculation with a forest management horizon of 100 years
- Annual discount rate of 3%

The aim of the Norwegian study was to generate a map of predicted forest returns in the case study in South Eastern Norway that could be used to evaluate the opportunity costs of spatial targeting of different conservation policy instruments such as public protected areas, voluntary conservation, biodiversity offsets. The map of forest returns could also be used to evaluate the potential effects of subsidies for forest roads in wilderness areas.

The map was generated through the steps illustrated in Figure 7. The Gaya-J model is a forestry economics model developed by the Norwegian Forest and Landscape Institute. It calculates optimal returns to forestry given forest stand characteristics, using a dynamic forest growth model and linear optimization of forestry operations. The model was run on forest stand data for over 1400 plots in the national forest inventory (NFI) representing the study area. Detailed forest stand data from the NFI were spatially joined with available map data on forest characteristics in the whole study area. A generalised linear model was then estimated on Gaya-J predictions of returns to forestry and the forest characteristic variables available for the whole study area. The resulting GLM model was then extrapolated to the whole study area. This resulted in expected forest return values as shown in Figure 8. Maps were also generated for the lower 2.5% and upper 97.5% model predictions of NPV.

A set of maps was also based on Gaya-J predictions of undiscounted expected net revenues at the first harvest. Broadly speaking, the NPV approach predicts larger areas of forestry as being profitable because it assumes optimal forest management behaviour across harvest cycles. By comparison, in the net return approach forest stands may be currently

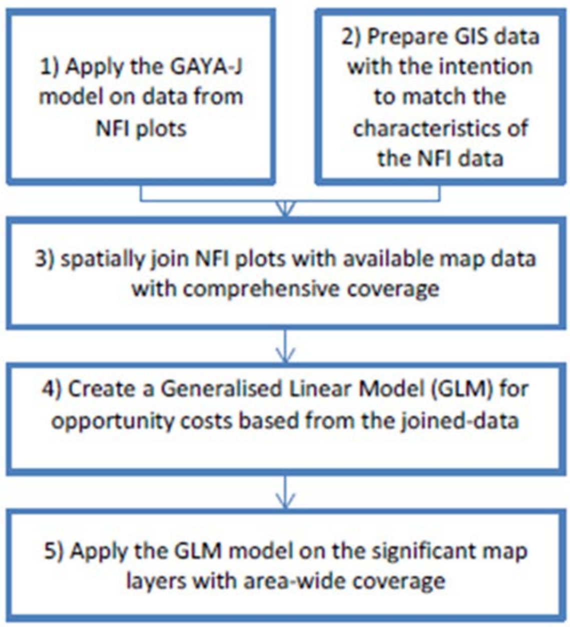


Figure 7 Steps to generating a map of returns to forestry

sub-optimally stocked until the first harvest. NPV might be a more correct opportunity cost criterion for long term conservation instruments, while net revenue may be more relevant in evaluating shorter term conservation measures such as 10 year designation of Woodland Key Habitats (WKHs) on forested land.

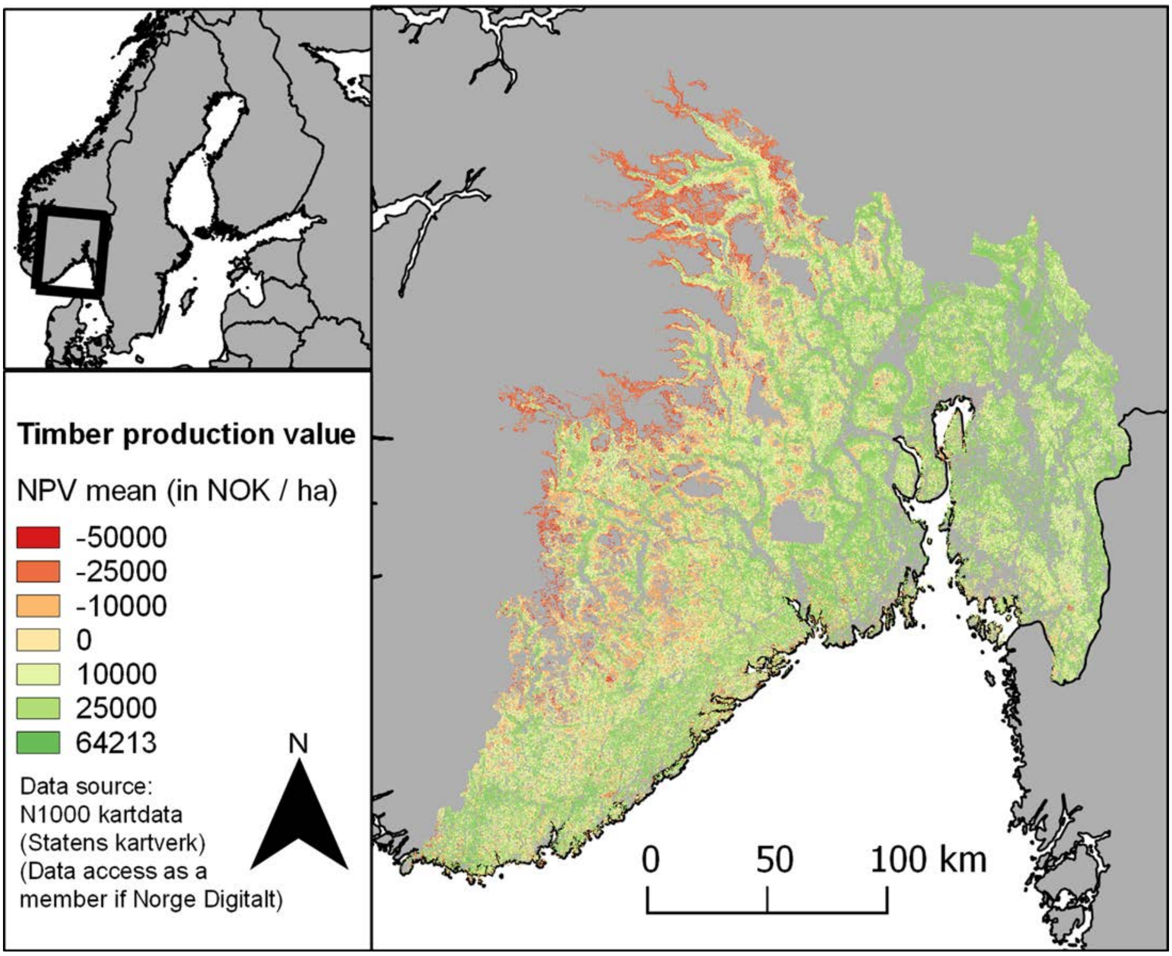


Figure 8. Expected net present value of forestry in south eastern Norway using Gaya-J predictions based on available landuse data

Source: Blumentrath, S., E. Bergseng, R. Astrup and D. N. Barton (forthcoming) Using National Forest Inventories and publicly available map data for geographical mapping of opportunity costs of forestry environmental considerations

4 Conclusions - policymixes and opportunity costs

POLICYMIX case studies are using opportunity cost maps to evaluate targeting of payment for ecosystem services (PES), tradable development rights (TDRs), biodiversity offsets, and public protected areas. The examples provided in this brief show that foregone returns to forestry and agriculture from conservation restrictions on land use have mainly been determined by variables for land use capacity and accessibility/distance (Figure 9).

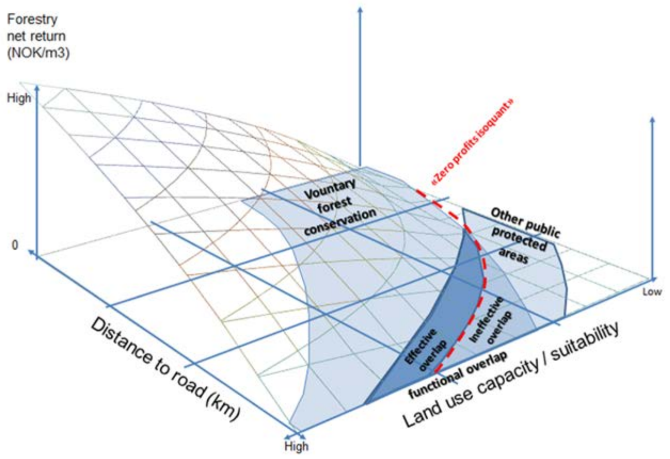


Figure 9. Analysing the cost-effectiveness of policymixes using opportunity cost maps

Opportunity cost maps can be used for spatial targeting of conservation instruments to low opportunity cost areas. If these are also high biodiversity land this may be the basis for 'win-win' strategies for conservation.

On the other hand, opportunity cost maps can also be used to formulate expectations and hypotheses about where conservation instruments are expected to be effective – where net opportunity costs of conservation are positive. This also means that areas where the returns to the best alternative land use to conservation are zero or even negative, there is no immediate risk to biodiversity of land conversion. Opportunity cost maps are useful in illustrating areas currently "at risk" as well as those which are "self protected" under current economic conditions.

Take home messages

- Different conservation policy instruments impose different land use restrictions and hence entail different opportunity costs

- Maps of opportunity costs must be calculated 'fit-for-purpose', specifically for the type of conservation policy instrument in question

- Opportunity costs are expected to vary with land use capacity and accessibility (observable), as well as with land user characteristics and preferences(not observable)

- Opportunity cost maps incorporate large variation and at best provide rough approximations of opportunity costs at any particular location

5 Further reading

The World Bank Training Manual 'Estimating the Opportunity Costs of REDD+[2] provides practical suggestions for dealing with opportunity costs (especially in Chapter 6). The emphasis is on projects that aim at carbon emissions reduction, but the method is suited for conservation projects as well.

The available information on the spatial variation in opportunity costs can be used as an input in site selection models such as Marxan[3] to arrive at optimum site selection.

Further examples of opportunity cost mapping in the literature can be found in:

- Barton et al. (2009) (using land use capacity maps, agricultural output prices and input costs)
- Polasky *et al.* (2001) (using land values);
- Nalle *et al.* (2004) (using calculations of NPV of consumer plus producer surplus from timber harvest);
- Naidoo *et al.* (2006) (using information on agricultural output prices and input costs);
- Schneider *et al.* (2010) (using estimates of net revenues from oil and gas drilling).

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