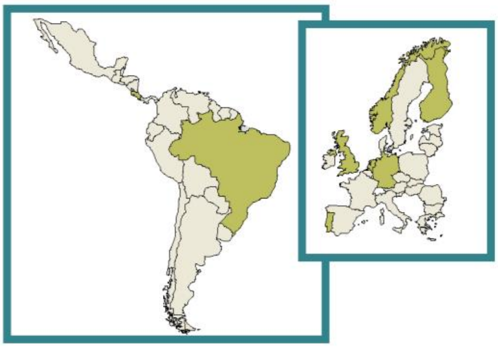

TECHNICAL BRIEF

Issue No. 7

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

POLICYMIX WP3 Best practice guidelines for assessing effectiveness of instruments on biodiversity conservation and ecosystem services provision

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The POLICYMIX Technical Brief series presents work in progress. It summarises intermediate project results addressing project partners, as well as other researchers dealing with similar issues.
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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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Executive summary

The dramatic loss of species since industrial times and particularly in the past 60 years, gives strong indications of a severe degradation of biological systems worldwide; and the failure to attain the Convention on Biological Diversity 2010 goals of halting the loss of species shows that the efforts that have been dedicated until now have proved to be insufficient. There is therefore a need to design policies that in a more effective way address the problems that derive from the changes forced on nature due to human activities. The evaluation of existing policies provides the basis to improving existing policies.

Typical for the nature conservation problem is that multiple protection objectives encompassing different geographical scopes are necessary. These are more likely to be addressed successfully by a variety of complementary and synergetic instruments, the policymix, rather than by single instruments. This complexity needs to be addressed both when formulating and designing conservation policies, and in their evaluation.

One important step in the evaluation process is to identify the indicators and metrics that permit tracking improvements as a result of the instruments that have been implemented, thereby enabling to assess their different roles and to evaluate outcomes, for instance in terms of cost-effectiveness.

Challenges in assessing nature conservation policy outcomes In policy evaluations, conservation gains are often assessed through simple indicators such as number and/or area of protected areas, but attention to more refined ecological criteria can more adequately evaluate impacts, and contribute to better design of policy instruments. Indicators and metrics of ecological state and conservation value need therefore to match conservation objectives which in turn, must reflect the conservation problem that is addressed. One important consideration is that different ecological processes are threatened at different spatial scales. For instance, problems of population decline associated with population dispersal, migration and meta-population dynamics often need to be addressed at the landscape scale, whereas representation of ecological variability and of evolved adaptations to ecological conditions, require a regional perspective. A tiered approach to assess gains at different nested levels of governance and of ecological scale is therefore needed.

The complexity of the conservation problem sets further limits to how the outcome of policy instruments can be assessed. An overall measure of biodiversity, i. e. the organisms and the ecological processes involved in maintaining populations, is practically not feasible, but appropriate indicators, combined with reference values, make the assessment of relative changes possible, which are very useful when comparing different points in time and/or different instruments or modalities in a policymix.

Conservation planning tools (CPTs) to assess cost-effectiveness of policy instruments CPTs have typically been designed for effective conservation planning, taking into account several conservation criteria that are grounded in ecological knowledge. Thereby, they offer opportunities for conservation policy analysis based on indicators such as the representation of ecological diversity, and the spatial coherence and size of areas under conservation actions. The algorithms compare gains in conservation in terms of these indicators with the costs associated with the conservation actions thereby, enabling cost-effectiveness analysis. In addition, CPTs enable to address the spatial structure of the conservation problem.

Particularly suitable to the conservation problem is that CPTs can support the analysis of a policymix by evaluating conservation gains attributed to the various instruments through a common 'currency of effect', the instrument's contribution to the achievement of conservation targets. Both *ex-post* analysis and prospective, *ex-ante*, analysis for instrument design or improvement can be conducted with CPT methods.

Conservation of Conservation Planning Tools and Programme Impact Evaluation methods Programme impact evaluation using Before-After and Control-Impact (BACI) designs and econometric/statistical techniques can be used for *ex-post* analysis of the effectiveness of conservation instruments. These methods are based on parametric statistic models, are generally univariate and therefore use a unique broad proxy for conservation effectiveness – e.g. forest cover – to evaluate the effectiveness. They also make all the assumptions of parametric statics in the models that describe the relationship between effect and the 'treatement', i. e. the areas on which the conservation actions either have or have not taken place. The method is not spatially explicit in the sense that it does not address each spatially co-occurring costs and biodiversity values in the analysis.

Constraints in the evaluation of conservation gains with spatially explicit approaches A first step to conduct a spatially explicit evaluation of policy instruments is that multiple conservation objectives need to be translated into indicators which have a spatial representation. This can be challenging because conservation objectives are not always associated with indicators that enable tracking changes, and generally these indicators are not geo-referenced or do not have full area coverage. Also, some common indicators of ecological state or conservation value are defined or sampled at very fine spatial scales, for instance the occurrence of rare or threatened species or of dead wood in a forest. In these cases, area coverage of conservation values is difficult and therefore the potential for comparison among areas, limited. High-resolution site-quality maps are costly but recent advances in high resolution remote sensing methods and modelling open new opportunities to complement this kind of mapping. Farm level survey data on landowner characteristics and perceptions are another example of fine-resolution data needed for cost-effectiveness analysis.

Regarding the use of CPTs for policymix analysis, the algorithm structure can impose limitations on exploring some kinds of instrument interactions, for instance, the extent to which policy instruments overlap or the degree of redundancy between them cannot be readily assessed. They are more appropriate to explore complementarity between instruments.

Also, the definition of the land unit may impose some constraints to the kind of instruments that are analyzed, as is the case of economic instruments directed to land-owners which are best assessed using property as the assessment unit, but cadastral data are often limited. Moreover, in the case of *ex ante* analysis, small land units may result in geographical dispersed and atomized solutions. Also, CPTs are less capable of capturing the effects of temporal path dependencies among instruments. Finally, the use of CPT software requires considerable technical skills for data acquisition, preparation and scenario modelling.

1. Introduction to the guideline

This technical brief summarizes the experience gained during the course of the POLICYMIX project regarding spatially explicit methodologies for the evaluation of the effectiveness of policy instruments in protecting biodiversity and the provision of ecosystem services. At the start of the project, Rusch et al. (2011) described different analytical options to assess the impact of conservation policies, presented a series of criteria and indicators to evaluate ecological effectiveness relevant at different levels of organisation and decision making, and showed examples of applications of different methods. POLICYMIX has acknowledged the relevance of spatially explicit analysis when evaluating policy instruments effectiveness, recognizing the spatial structure of the conservation problem with both costs and biodiversity and ecosystem service provision unevenly distributed in space. Another important tenet in POLICYMIX is that the conservation problem has many dimensions, and as a rule, different objectives and different instruments need to be considered simultaneously when evaluating conservations gains. Therefore, a 'common coin' to quantitatively evaluate impacts is necessary.

This 'best practice guideline' is a summary of reflections and experiences from the case studies when applying spatially explicit methods of analysis. We highlight why spatially explicit evaluation methods are important in the case of biodiversity and ecosystem service conservation policy mixes, we compare the pros and cons of different approaches, and the potential for complementary analysis, and we discuss some of the technical problems encountered in the case studies, and the limitations of the analysis. The guideline can be useful for scientists and/or practitioners working in the area of conservation policy evaluation and design.

2. Framing the conservation problem

The dramatic loss of species since industrial times and particularly in the past 60 years, gives strong indications of a severe degradation of biological systems worldwide (MA 2005, Rockström et al. 2009). Furthermore, the failure to attain the Convention on Biological Diversity 2010 goals of halting the loss of species (Butchart et al. 2010) shows that the efforts that have been dedicated until now have proved to be insufficient. The central tenet in nature conservation is to understand the direct factors underlying losses of biodiversity and habitat and to reverse loss trends (Armsworth et al. 2007). Policy formulation is therefore motivated by the need to halt the loss of forest biodiversity and to ensure the long term use of natural resources while maintaining the value of its natural capital.

Figure 1: A landscape mosaic on which conservation instruments are implemented. Source: Kartverket, Norway.

In addition to traditional biodiversity conservation paradigms, we propose the use of the ecosystem services framework (MA 2005) as a conceptual model that describes the interdependencies between human societies and life systems, thereby adding value to protection and wise use of nature. In recent conceptualizations, ecosystem services are biological structures (such as organisms and ecosystems) and functions (such as recruitment, dispersal, primary productivity) that underpin the provision of benefits to society. According to this concept, ecosystem services can be quantified as benefits received from ecosystems and in some cases can be valued in monetary terms. The case study in Costa Rica (Ramos-Bendaña et al. 2013) illustrates how ecosystem services can be incorporated to more evaluate more in depth the effectiveness of the national Payments for Ecosystem Services (PES) program, and include biodiversity conservation, water provision and carbon storage and sequestration in different policy scenarios that include various PES modalities and protected area designation.

However, this conceptualization of ecosystem services does not capture the full range of conservation needs, neither all the benefits provided by nature. Particularly, benefits related with options offered by nature for future use (option value) (Chan et al. 2006), ecological and socio-economic resilience and insurance against risks (climatic fluctuations and extremes, disease and plague outbreaks, and production stability (Balmford et al. 2008) are at the moment not adequately captured. Multi-scalar conservation objectives targeting representativeness of natural variability, and genetic and functional diversity are an attempt to fill this gap. The Norwegian case (Barton et al. 2013) illustrates that current forest conservation efforts are skewed towards areas of low land-opportunity costs, which leads to a narrow representation of the ecological ranges of the forest in the country (Framstad et al. 2010).

Another peculiarity of the conservation problem is that the characteristics of the socio-ecological system vary in space. Biodiversity conservation values, the capacity of the ecological system to provide ecosystem services, the perceptions about the use of nature, its benefits and the foregone opportunities for economic activity, among other properties, have a spatial structure. The spatial explicit analysis in the Costa Rican case (Ramos-Bendaña et al. 2013) provides a nice example about how acknowledging the spatial structure of the conservation problem leads to a better assessment of effectiveness. It shows that when considering social criteria (e.g. farms smaller than 50 ha) the selection frequency of some areas increase although these areas are not necessarily of high conservation priority.

Because of the many aspects of the nature protection problem, multiple protection objectives covered at different geographical scopes are necessary. These are more likely to be addressed successfully by a variety of complementary and synergetic instruments, the policy mix, rather than by single instruments. This complexity needs to be addressed both the formulation and design of conservation policies and in their evaluation.

One important challenge consists in identifying when the different policy instruments are complementary, synergetic, in conflict or redundant (Ring et al. 2011). Another task is to identify the indicators and metrics that permit tracking improvements as a result of the instruments that have been implemented, assessing their different roles and the evaluation of outcomes in terms of cost-effectiveness.

3. Challenges in assessing policy outcomes

One criterion of evaluation of one or more instruments is their cost-effectiveness, a form of economic analysis that compares the relative costs and outcomes (effects) of two or more courses of action. In the case of conservation policies, one methodological challenge is to quantify the magnitude of the effects, or in other words, the conservation gains. In this context, conservation gains are often assessed through simple indicators such as number and/or area of land under protection, without considering that the conservation problem usually encompasses multiple goals and that attention to ecological criteria in the design of an instrument can contribute to more effective actions.

Conservation objective	Tiered indicators of conservation gains (outcomes)
Increase the representation of forest types in the **regional** conservation network	**Tier I - Regional** Diversity index (e.g. Shannon-Wiener, Gini) based on forest types calculated at regional level. Regional level of conservation targets achievement (calculated with CPT software).
	Tier II - Watershed Diversity index (e.g. Shannon-Wiener, Gini) based on forest habitats calculated at a watershed level. Relative contribution of the watershed to the conservation of regional forest habitat diversity. Contribution of the watershed to the achievement of the regional conservation targets (calculated with CPT software).
	Tier III - Site Uniqueness of a particular conservation site (the contribution of the site to represent habitats not represented elsewhere, calculated with CPT software).

Table 1: Examples of indicators of conservation gains tiered at 3 spatial levels.

Indicators and metrics of ecological state and conservation value need to map conservation objectives which in turn, must reflect the conservation problem that is addressed (**Table 1**). The Costa Rican case gives an example of how conservation objectives have been translated into spatial indicators. The GRUAS project (SINAC & MINAE 2007) has identified and mapped ecosystems and habitats that have national and regional conservation importance because they are rare or little represented in the existing protected areas network. These priorities are meant to guide the allocation of PES contracts to landowners. Furthersmore, the PES programme consists of various modalities which in addition of targeting biodiversity representation, focus on the enhancement of ecosystem services such as climate change mitigation (carbon sequestration and storage) and water provision. The POLICYMIX study has used maps of habitats and of these ecosystem services to analyse the effectiveness of the program in the Nicoya Peninsula (Ramos-Bendaña et al 2013).

It is also important to define the geographical scope of the conservation problem. This determines the spatial domain within which the conservation policy instruments are implemented. The case of the analysis of the instrument Tradable Development Rights (TDR) in the state of Sao Paolo in Brazil (Bernasconi et al. 2013), illustrates the delimitation of the geographical area defines both the scope of the development rights market and the conservation objectives that are feasible to pursue (i.e. water-shed restoration vs. high-priority biodiversity conservation areas at the State level).

3.1. How to compare changes in conservation gains in time and space?

It is convenient to compare policy instruments outcomes in terms of ***marginal changes***, namely from a reference point in time or based on differences between scenarios or kind of instruments. For example, the cost-effectiveness of one or more conservation instruments is assessed by comparing the change in the indicators of conservation gains and of the associated costs between two states. If the analysis is '*ex-post*', the comparison can be made between the actual state of biodiversity conservation gains and costs and a benchmark defined as the optimised or 'best-solution' in terms of cost-efficiency (Fig. 3). In the case of '*ex ante*' or prospective analysis, the reference point in time is the present situation, and the second point is a predicted or modelled scenario that would result after the implementation of the instrument. Here also, the optimised cost-efficient solution can be used as a benchmark to compare among scenarios (Rusch et al. 2012).

In this way a **relative** measure of impact can be obtained, which can also be compared with a **relative** change in terms of costs for the calculation of cost-effectiveness. Decisions can then be made based not on absolute values but by comparing different alternatives in which relative changes in conservation gains and costs can be compared.

Because of the multi-scale nature of the conservation problem, ***a tiered approach*** to assess gains at different nested levels of governance and of ecological scale is also needed. In this way, the geographical scale can match particular ecological properties and functions, and ecosystem services provision and the corresponding conservation objectives aimed at maintaining them.

3.2. How to assess cost-effectiveness of policy instruments?

Conservation Planning Tools (CPTs) and the policymix

CPTs are a useful methodological framework for the analysis of conservation policy cost-effectiveness; and bring in various opportunities for a quantitative and spatially explicit assessment of conservation policy outcomes.

One advantage of using CPT as a policy evaluation methodology is that CPTs take into account several **ecologically grounded conservation criteria** to analyse policy outcomes such as the representation of the ecological diversity, the spatial coherence and size of land under conservation actions. CPTs are designed to address multiple conservation objectives and costs (economic and others). Thereby, the analysis provides solutions that consider both multiple benefits and costs.

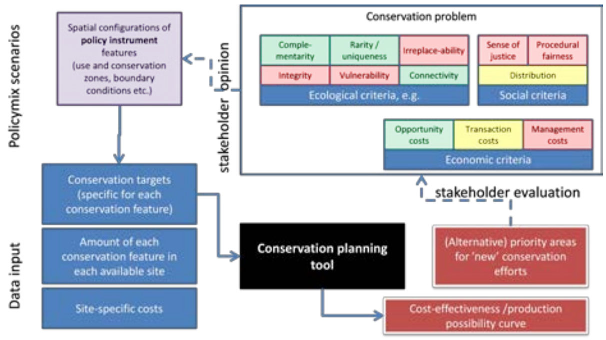


Figure 2: Diagram indicating the structure of a spatially explicty conservation policy evaluation using conservation planning tools

Taking into account the **spatial structuring of the conservation problem** is important because both ecological features and costs vary in space. Therefore, one aspect of the conservation effectiveness resides in the extent to which the policy mix targets different conservation objectives that vary in space. In other words, CPTs explicitly address the spatial structure of the conservation problem.

One challenge for the evaluation of policy instruments is that actions do not take place in isolation, but often several instruments, the **policymix**, operate at the same time and need to be analysed simultaneously. Among the available CPTs, Marxan with Zones (Watts et al. 2009) was identified as the most appropriate tool for this kind of analysis because the idea of policy mixes can be reflected in the zoning concept of the software (Blumentrath 2011). Here the **assessment of the conservation gains can be attributed to the different instruments through a common 'currency of effects'**, the instrument's contribution to the achievement of conservation targets. Both *ex-post* analysis (Barton et al. 2009) and prospective, *ex-ante*, analysis for instrument design or improvement can be conducted with CPT methods. CPTs are also decision support tools on questions about conservation and territorial planning in which the spatial criteria involved in decision making are made explicit, therefore the planning and evaluation processes can be useful for management. The process of analysis provides several additional opportunities to improve conservation decision-making by stimulating the formulation of more precise definitions of the conservation objectives and setting quantitative conservation targets. The process also raises awareness about the selection of indicators of conservation values and of their underpinning ecological functions, which in addition, need to match the conservation objectives and be spatially explicit.

Conservation of Conservation Planning Tools and Programme Impact Evaluation methods

Programme impact evaluation using Before-After and Control-Impact (BACI) designs and econometric/statistical techniques can be used for *ex-post* analysis of the effectiveness of conservation instruments. These methods use a unique broad proxy for conservation effectiveness – e.g. forest cover – to evaluate the effectiveness of a single instrument on a group of 'treated' landowners, against a control group without the instrument 'treatment' (parallels to them pharmaceutical literature are clear). However, partial treatments and treatment mixes are not easily handled in BACI type studies. A summary of the approaches is presented in Table 2.

CPTs are likely more appropriate and flexible to evaluate effects in cases where multiple instruments have multiple conservation objectives, achieved over many different types of land-cover types. A CPT is used to evaluate a cost-effective "benchmark" allocation of protected areas (**Fig. 3**). This represents the best conservation solution one can achieve given a conservation target and opportunity costs of conservation. The 'distance-to-benchmark' of the actual forest conservation status is one measure of conservation effectiveness. A before-after-control-impact (BACI) approach has a baseline situation without policy as the basis for comparison with forests' actual status. BACI methods aim to identify the marginal contribution of individual conservation

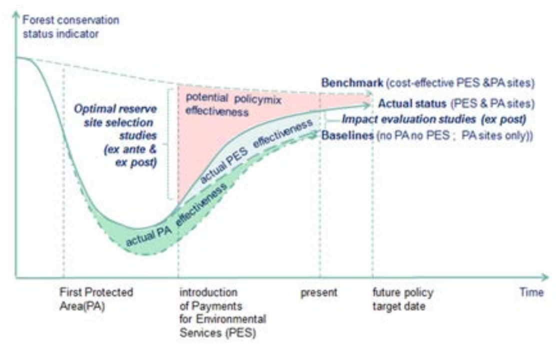


Figure 3: Diagram illustrating the principles behind the evaluation of policy instruments with CPTs and BACI approaches. CPT: comparison of current or modelled state with a benchmark, the optimal cost-effective solution. BACI: Baseline data compared to current state.

instruments such as PES or protected areas relative to the baseline. Both a 'benchmark' and 'baseline' approach to policy impact evaluation should consider that the basis for comparison is dynamic, and that there may be interactions between instruments in the policymix.

Constraints in the evaluation of conservation gains with spatially explicit approaches

Matching the scales of conservation objectives, ecological indicators and geographic representation

Spatially explicit evaluations of multiple-objective conservation instruments require the translation of conservation objectives into indicators which have a spatial representation. The identification of the ecological features which are relevant to protect at a particular spatial scale is crucial, as are the indicators of ecological state that match those conservation objectives and that can be represented spatially. The Costa Rican case described above, provides a good illustration of how national conservation objectives have been translated into indicators with spatial representation (SINAC & MINAE 2007). These are the first steps for conducting a spatially explicit evaluation of policy instruments (see Section 4).

One of the major constraints arise when the indicators of ecological state or conservation value are defined at very fine spatial scales, which can be the case of conservation objectives that are directed to maintain or enhance site quality. The experience in the Norwegian case illustrates this challenge. A series of indicators of forest stand conservation quality such as amount of dead wood and the presence of epiphytic lichens exist, but the geo-graphical representation on these attributes with adequate area coverage is not readily available.

High-resolution site-quality maps are costly because they have been until very recently primarily based on field observations. They are therefore available for small areas, but recent advances in high resolution remote sensing methods (Magnussen et al. 2012) and modelling (e.g. Gusian & Zimmermann 2000) open new opportunities to complement site quality mapping. Farm level survey data on landowner characteristics and perceptions are another example of fine-resolution data needed for cost-effectiveness analysis.

BACI models are more appropriate to evaluate policy interventions with other indicators of conservation gains that do not have good geographical coverage. On the other hand, baseline and monitoring data and/or large samples of quality data are expensive to acquire.

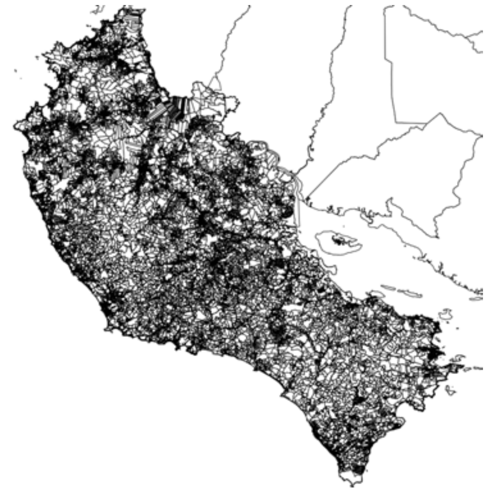
Other constraints of CPT that may impair their applicability in policy evaluation

In addition to the limitations imposed by the availability and quality of the geographical data there are other constrains of CPTs that may impair their applicability in policy evaluation. For instance, although CPTs tools such as Marxan with Zones enable the analysis of the complementarity of instrument mixes, the **algorithm structure imposes limitations on exploring some kinds of instrument interactions**. For example the extent to which policy instruments overlap or the degree of redundancy between them cannot be readily assessed. Also, the question of mutual dependence between selected sites such as in the case of biodiversity offsetting (spatial dependence) and habitat banking (temporal dependence) is not easily tackled.

Table 2: Main characteristics of spatially explicit methods for conservation policies evaluation

Feature	Conservation planning tools	Impact evaluation (BACI)
Conservation targets	Enables analysis of multiple conservation targets. Ecological criteria underlay the tool concept and algorithm.	Single conservation target analysis
Geographic scope	More appropriate for medium resolution data, regional scale.	High resolution data, appropriate for local, but also applicable to larger geographic ranges, although confounding effects can be a problem when area coverage increases.
Potential for analysis of policy mixes	Enables the analysis of different instruments simultaneously, and the assessment of complementarity. Uneven data availability associated to goals of different instruments is a challenge.	Limited potential for policy mix analysis due to data requirements.
Data requirements	Area coverage of geo-referenced indicators. Spatial representations of conservation targets indicators.	Empirical-ground data or high resolution remote sensing data. Baseline data required either in time (before and after instrument implementation) or in space (control and impact areas).
Reference level	Optimized, best-possible solution as a benchmark.	Baseline or control and intervention data.
Indicators of conservation gains	Enables use of multiple indicators at various spatial scales.	Single indicator, often forest/habitat cover as a proxy
Skills required	Advanced GIS skills for data preparation. Good knowledge of the tool for problem formulation and scenario building. Good tool developer /users group support available.	Basic GIS skills for data retrieval. Good statistical knowledge. Many applications in the literature.

The definition of the planning unit may impose some constraints to the kind of instruments that are analysed. For example, the impacts of economic instruments directed to land-owners are best assessed using property as the assessment unit (**Fig. 4**), but access to cadastral data is often limited. For instance, in the case of the example from Costa Rica (Fig. 4), cadastral information and maps have been prepared in recent years. Furthermore, existing experiences with CPT tools are primarily focused on territorial and conservation planning, and often conducted on relatively large planning units. Small planning units from cadastral data may result in geographical spread and atomized priority solutions, whereas larger synthetic 'planning units' may not be congruent with policy 'implementation units' as represented by property boundaries, as is the case of instruments such as Payments for Environmental Services (PES), that are directed to land-owners. In addition, processing performance of the software can limit the use of small planning units, e.g. from cadastral data.



Source: Programa de Regularización de Catastro y Registro, 2012-2013

Figure 4: Example of a map using property limits as conservation planning units in the Tempisque Conservation Area, Costa Rica. Unequal planning units requires normalisation. The analysis is more management relevant, but less permanent due to changing property limits over

CPT are spatially explicit but are **less capable of capturing the effects temporal path dependencies** among instruments although path dependency could be assessed using CPT through repeated simulation. Finally, the use of CPT software **requires considerable technical skills** for data acquisition, preparation and scenario modelling.

4. Steps to conduct cost-effectiveness evaluation of policy mixes using CPT

The following steps are generally needed to conduct an analysis using conservation planning methods.

1. *Problem definition*
   a. Delimit the geographical scope of the study
   b. Identify the instruments in the policy mix to be evaluated
   c. Define the evaluation problem in terms of a CPT analysis
2. *Data acquisition and preparation*
   a. Identify available spatial representations of conservation targets and of costs with area coverage.
   b. Evaluate the spatial resolution of the geo-referenced data.
   c. Choose the unit of analysis (e.g. water-shed, land property, grid-cell) and its size.
   d. Compile the geo-referenced data (ecological indicators and costs) in a GIS database.
   e. Designate conservation targets, e.g. through a deliberative process with decision-makers.

3. *Analysis*
    a. Format input data for CPT analyses following the problem definition in 1c
    b. Conduct the CPT analysis

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