CHAPTER 4

COST-EFFECTIVE TARGETING OF PES

Katia Karousakis and Quiller Brooke
Organisation for Economic Co-operation and Development (OECD), Paris, France

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CONTENTS

ABSTRACT

Individuals or communities with the potential to influence the supply of ecosystem services will often differ in the magnitude of benefits they can provide, the risk that these services will otherwise be lost or the extent to which their management activities can enhance biodiversity and ecosystems, as well as the costs of service provision. This chapter discusses how PES programmes can be designed to address these issues and presents the tools and methods through which payments can be targeted to increase PES cost-effectiveness.

How payments for biodiversity and ecosystem services are targeted is critical in determining the cost-effectiveness of a PES programme. In most cases, the available budget for biodiversity and associated ecosystem services will be limited and competing with different demands. Cost-effective targeting of payments enables greater total benefits to be achieved with a given PES budget and can therefore also contribute to the long-term success of the programme.

Many PES programmes allocate uniform payments on a per hectare basis. This is cost effective if ecosystem service benefits and the costs of their provision are constant across space. In many cases however, this is unlikely. The more heterogeneous the costs and benefits are, the greater the cost-effectiveness gains that can be realized via targeted and differentiated payments. Indeed, more and more PES programmes are incorporating design elements to address this. This chapter examines the methods and tools that are available to target spatial heterogeneity in biodiversity and ecosystem service benefits, the threat of loss and the costs of their provision.

TARGETING ECOSYSTEM SERVICES WITH HIGH BENEFITS

The inherent complexity of biodiversity requires trade-offs between measurement accuracy and the cost of biodiversity assessments

Identifying areas with high biodiversity and ecosystem service benefits requires metrics and indicators to quantify them. Selecting an appropriate metric or indicator for PES that aims to enhance biodiversity conservation and sustainable use is not necessarily straightforward however. Unlike carbon, for example, which is measured in tonnes of carbon dioxide equivalents (tCO_2e), there is no single standardised metric to quantify biodiversity. The multidimensionality and the inherent complexity of biodiversity require trade-offs between the accuracy of a metric and the costs of development. The appropriate biodiversity metric or indicator selected for a PES programme may also depend on the specific objectives of the programme. Indeed, methodologies for constructing metrics and indicators tend to be tailored to specific local, regional and national programmes and their objectives. Examples of metrics and indicators used across two biodiversity PES programmes, namely the Victorian BushTender programme in Australia and the PES scheme implemented in the Assiniboine River watershed of east-central Saskatchewan province in Canada are presented in Box 1.

Box 1

Metrics and indicators used to target biodiversity benefits in the Victorian BushTender and a Canadian pilot PES

The Habitat Hectare methodology in the Victorian BushTender programme

The aim of Victorian BushTender programme in Australia is to improve the management of native vegetation on private land. To quantify biodiversity benefits, the BushTender programme uses the Habitat Hectare (HH) methodology. The HH is comprised of an assessment of the local benefits via the Biodiversity Benefits Index (BBI). The BBI is based on the proposed management practices; the conservation significance in terms of regional priorities through the Biodiversity Significance Score (BSS), the cost of conserving the land (*b*) and the size of the proposed land (ha). Potential plots are compared through an inverse auction, where landholders submit bids including information on the proposed area, the BBI and the required payment. The BSS is calculated separately to improve competition (DSE, 2009).

HH = BBI x ha
BBI = (BSS x HSS) *b*
where
HH = Habitat Hectare;
BBI = Biodiversity Benefits Index;
ha = area in hectares;
BSS = Biodiversity Significance Score;
HSS = Habitat Service Score; *b* = cost of bid

Targeting Waterfowl in a Canadian pilot PES programme

In Canada, a pilot PES programme initiated in 2008 to restore drained wetlands was undertaken in the Assiniboine River watershed of east-central Saskatchewan. The Environmental Benefits Index (EBI) was based on the incremental increase in predicted hatched waterfowl nests relative to the bid price. The EBI was based on the Ducks Unlimited Canada Waterfowl Productivity Model (DUC) which evaluated the potential of wetland restoration on each plot to increase the number of hatched waterfowl nests in the Assiniboine watershed. The EBI was based on wetland area restored, waterfowl density, existing wetland density and the percentage of cropland in a 4x4 mile block around the plot (Hill *et al.*, 2011).

The use of such metrics to better target ecosystem service payments can substantially enhance PES cost-effectiveness. In the Tasmanian Forest Conservation Fund programme, for example, a comparison of using the AUD/CVI[1] metric with a simpler AUD/ha[2] metric indicated an 18.6 percent gain in conservation outcomes. Comparing the additional conservation gains (valued at approximately AUD 3.3 million) with the costs of achieving those benefits (AUD 0.5 million), illustrate that the ratio of benefits to costs from investing in the CVI is 6.9:1. Similarly, Wunscher *et al.* (2006) simulated different targeting approaches for the Costa Rican PES and estimated that a scenario selecting highest scoring sites with the given budget would have resulted in 14 percent higher benefits than the current system of selecting sites (see Case Study 5 "PES in Costa Rica").

SPATIAL MAPPING TOOLS

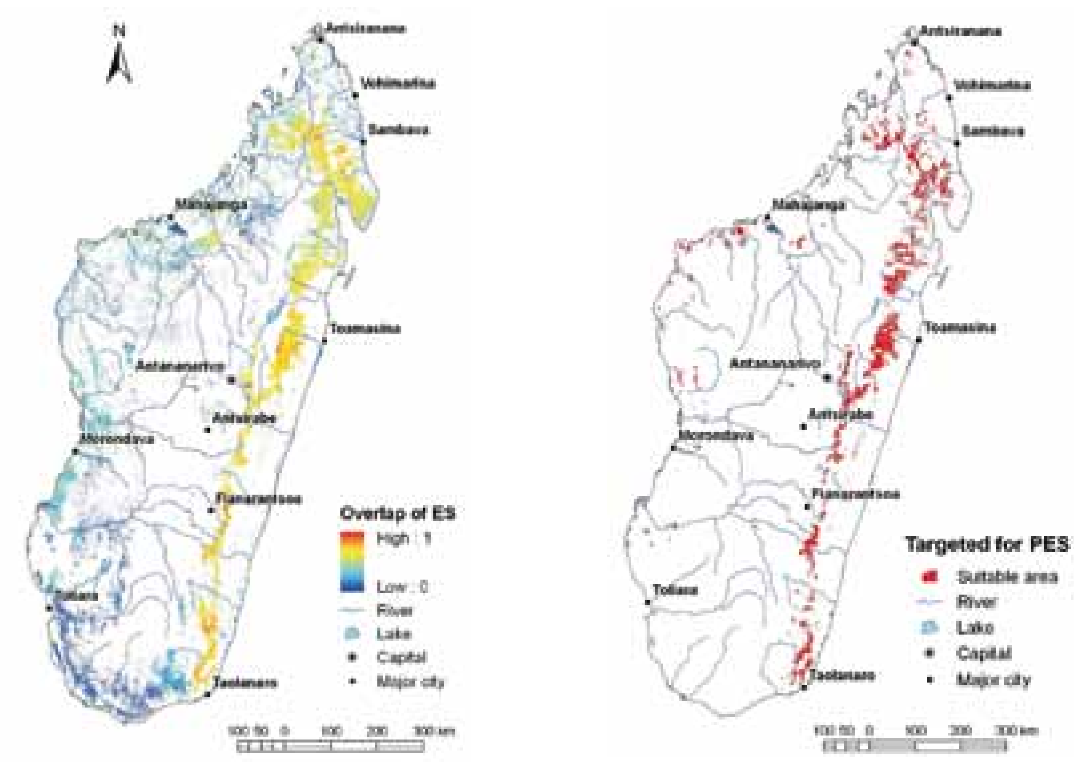
Spatial mapping tools are increasingly being used to discern the spatial heterogeneity in ecosystem costs and benefits. Several of these tools are emerging to help design PES systems at the regional and national level; however, there are increasingly initiatives of spatial mapping tools that are being developed at the international scale, including the UNEP-WCMC Carbon and Biodiversity Demonstration Atlas, ARtificial Intelligence for Ecosystem Services (ARIES),[3] the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST)[4] and SENSOR.

Spatial mapping tools are increasingly being used to discern the spatial heterogeneity in ecosystem costs and benefits

To target ecosystem service payments in Madagascar, Wendland *et al.* (2010) examined the spatial distribution of biodiversity (proxied by vector data on species ranges of mammals, birds and amphibians), carbon and water quality. The left panel of Figure 17 depicts the degree of overlap between these three ecosystem services. The right panel further incorporates information on the probability of deforestation and the opportunity cost of the land to identify where payments could be most cost-effectively targeted. One example of a spatial mapping tool developed at the international level is the Carbon and Biodiversity Demonstration Atlas, produced by the UNEP World Conservation Monitoring Centre (UNEP-WCMC) (Kapos *et al.*, 2008). The Atlas includes regional maps as well as national maps for six tropical countries showing where areas of high biodiversity importance coincide with areas of high carbon storage. Figure 18 illustrates the national map for Panama, indicating that 20 percent of carbon is stored in high carbon, high biodiversity areas.

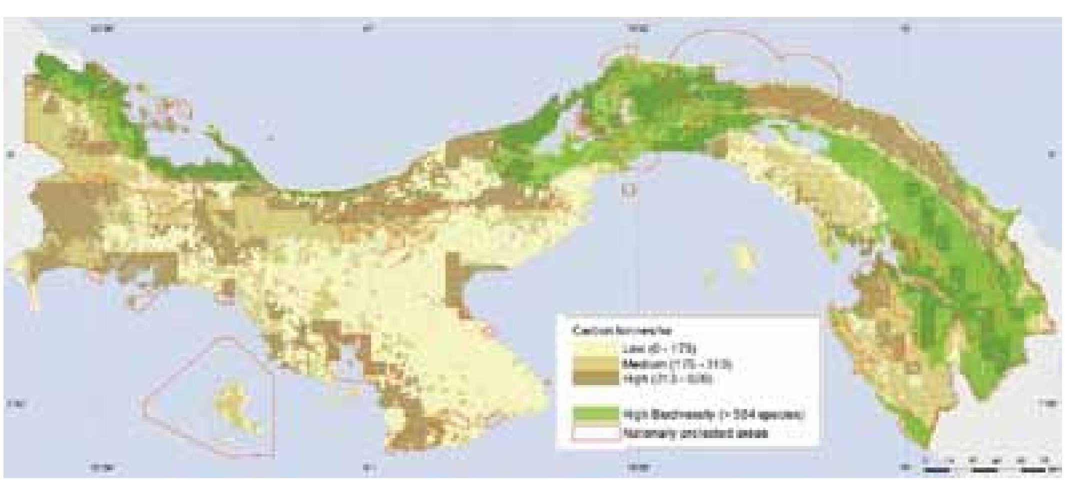
1 AUD/CVI: ratio of Australian Dollars (AUD) to the Conservation Values Index (CVI)
2 AUD/ha: ratio of Australian Dollars (AUD) per hectare of land
3 http://esd.uvm.edu/
4 http://www.naturalcapitalproject.org/

Figure 17
Targeting PES in Madagascar



Source: OECD, 2010

Figure 18
Example of a UNEP-WCMC national map: Panama



Source: OECD, 2010

To identify areas of high biodiversity importance for the regional maps, UNEP-WCMC uses six indicators for biodiversity, namely Conservation Internationals' Hotspots, WWF's Global 200 ecoregions, Birdlife International's Endemic Bird Areas, Amphibian Diversity Areas, Centers of Plant Diversity and the Alliance for Zero Extinction Sites. Areas of high biodiversity, as determined by UNEP-WCMC, are areas where at least four of the above-listed biodiversity conservation priority areas overlap, with areas in dark green indicating a greater degree of overlap.

The maps identify the different areas with high biodiversity importance. The maps do not necessarily identify areas with high biodiversity benefits in economic terms. Ideally, spatial maps on biodiversity benefits would incorporate the total economic value of these sites, with an assessment of both direct and indirect use values.

A number of spatial mapping initiatives are currently underway and are in different stages of development. These include ARtificial Intelligence for Ecosystem Services (ARIES) (Villa *et al.*, 2009); InVest (Tallis *et al.*, 2010); the United States Geological Survey (USGS) Global Ecosystems initiative;[5] and SENSOR (Sustainability Impact Assessment: Tools for Environmental, Social and Economic Effects of Multifunctional Land Use in European Regions).[6]

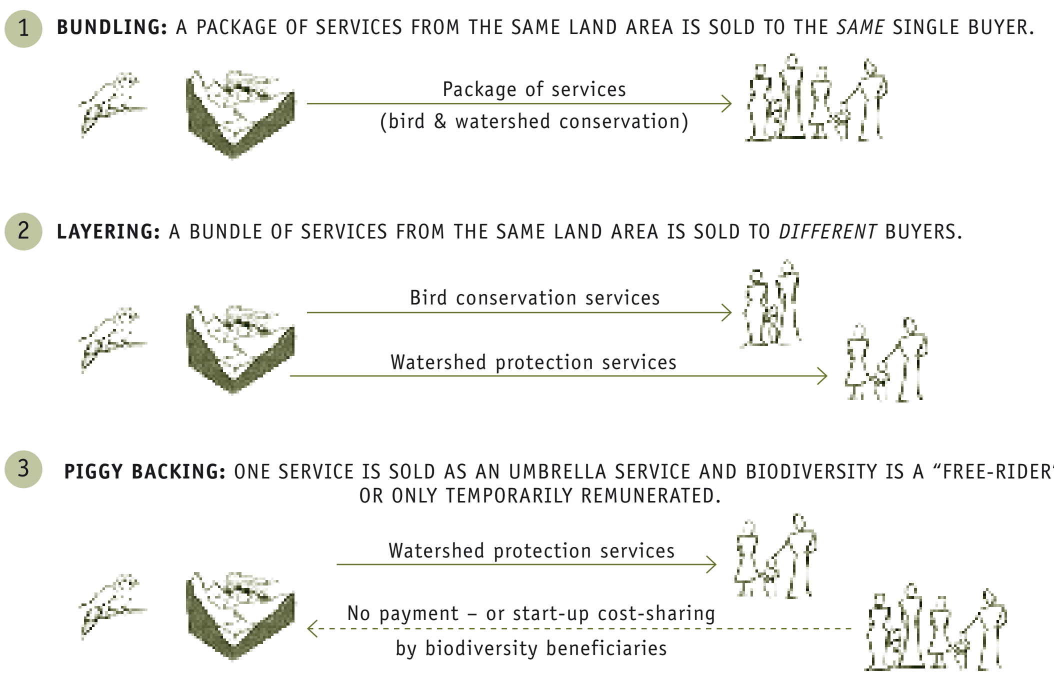
PES objectives must be clear, potential trade-offs recognised and safeguards developed to prevent adverse collateral impacts

As suggested in the Madagascar example above (Figure 17), PES programmes can simultaneously target multiple ecosystem service benefits. Bundling or layering (Figure 19) can allow a broader range of ecosystem service benefits to be obtained in a cost-effective manner, avoiding the need for multiple programmes, reducing transaction costs and programme overlap. Multiple ecosystem service provisions can help ensure that all aspects of an ecosystem on enrolled land are properly managed, increasing the asset value of the ecosystem. PES targeting multiple ecosystem services can enable the landholder to maximise potential payments received, such that conservation becomes more economically feasible, enabling greater ecosystem service provision.

The feasibility of targeting multiple ecosystem services simultaneously depends on the degree of spatial correlation between different types of ecosystem services. Spatial mapping tools help to identify where multiple service benefits coincide. Though there may often be synergies in service provision (e.g. avoided deforestation results in both biodiversity and carbon benefits), there are cases when trade-offs can also arise (Nelson *et al.*, 2008). For example, whereas native and mixed crops provide biodiversity benefits, monocultures of fast-growing tree species such as *Eucalyptus* may provide more rapid carbon sequestration benefits. Farley *et al.*

5 http://rmgsc.cr.usgs.gov/ecosystems/
6 http://www.ip-sensor.org

Figure 19
Marketing biodiversity joint service provision

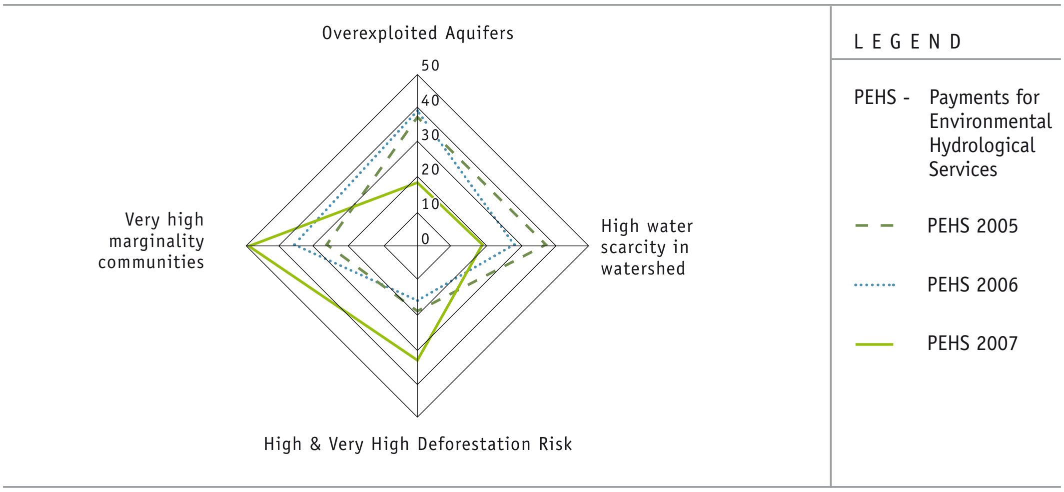


Source: OECD, 2010

(2005) highlighted this problem in West Africa, where carbon sequestration (i.e. afforestation/ reforestation) projects can negatively affect water regimes and biodiversity. The ultimate objective of the PES programme must therefore be clear, potential trade-offs recognised and safeguards may be needed to prevent adverse impacts on other ecosystem services (Karousakis, 2009). In this context, environmental benefit indices and scoring approaches become not only a way of evaluating the quality of potential contract benefits, but are also mechanisms through which discrete ecosystem service priorities are traded off against each other. Any weights associated with an Environmental Benefits Index (EBI) or scoring mechanism can also be modified in sequential PES sign-up rounds to reconcile trade-offs. This has been done, for example, in the Mexican PEHS[7] programme (Figure 20) where weights have been adjusted over time to better address the policy priorities. Similar targeting methods have been used to allocate payments in the Socio Bosque programme in Ecuador. Based on a system of scores,

7 Payments for Environmental Hydrological Services (*Pago de Services Ambientales Hydrologicas - Mexico*)

Figure 20
Targeting PEHS in Mexico



Source: OECD, 2010

land area has been classified into three categories of priority: priority 1 (scoring from 12.1 to 25); priority 2 (7.1 to 12) and priority 3 (0 to 7). The scores are based on high deforestation pressure, storage of carbon in biomass, water supply and poverty alleviation.

Though these types of targeting approaches entail higher transaction costs, experience with their use suggests that the resulting cost-effectiveness gains are improved. There are also other types of PES design characteristics that can be introduced into the programme to reduce transaction costs. In the Costa Rican PES, for example, private forest landholders are required to have a minimum of one hectare to receive payments for reforestation and two hectares in the case of forest protection. The maximum area for which payments can be received is 300 hectares (and 600 hectares for indigenous peoples' reserves) (Grieg-Gran *et al.*, 2005). Aggregating small projects is also possible to help reduce the transaction costs associated with a payment contract. These types of PES design elements can help to ensure more equitable participation in the PES programme and help to reduce administrative costs.

TARGETING ECOSYSTEMS SERVICES AT RISK OF LOSS OR DEGRADATION

In addition to targeting payments to ecosystem services with the highest benefits, it is essential to ensure that any payment leads to additional benefits relative to the business-as-usual scenario. For example, payments for habitat protection are only additional if in their absence the habitat would be degraded or lost. Information on the business-as-usual or baseline scenario is critical in ensuring PES additionality. Clear understanding of whether or not ecosystem services are at risk of loss or degradation is therefore needed. Historical and current trend data on biodiversity and ecosystem service loss are a starting point and are needed to develop future reference projections. Though this can be a complex task, there are different ways this can be undertaken. For example, to target PES in Madagascar, Wendland *et al*. (2010) estimate the probability of deforestation (via a multivariate probit model) by examining distance to roads and footpaths, elevation, slope, population density, mean annual per capita expenditure and other characteristics. A similar approach is used to assess deforestation risk in the Mexican PEHS programme. In this case, the variables used to estimate deforestation risk include distance to the nearest town and city, slope, whether it is an agricultural frontier and if it is located in a natural protected area.

Information on the baseline scenario is critical to ensuring the additionality of PES projects

TARGETING PROVIDERS WITH LOW OPPORTUNITY COSTS

Finally, PES programmes can increase their cost-effectiveness if, given sites with identical ecosystem service benefits and risk of degradation or loss, payments are differentiated and prioritised to those sites where landholders have lower opportunity costs of alternative land uses. In the Costa Rican PES, for example, Wunscher *et al.* (2006) illustrate that differentiating payments according to opportunity costs could allow the enrolment of almost twice the area of land, representing more than double the environmental benefits per cost (see Case Study 5 "PES in Costa Rica").

Obtaining accurate information on ecosystem providers' opportunity costs is not straightforward as they have an incentive to overstate these costs in an effort to extract information rents via higher payments. Programme administrators have a number of options to assist revelation of the landholder's true opportunity costs. Specifically, they can gather additional information in the form of costly-to-fake signals or they can use inverse auctions.[8]

Information on ecosystem supplier attributes and activities which are correlated with their opportunity costs can be used to infer the correct price. The information should be based on costly-to-fake signals, for example, distance to markets, current land use, assessed value, or labour and production inputs. Readily available market information can also be used and incorporated into a model to estimate opportunity costs. In the USA Conservation Reserve

8 Screening contracts can be used in theory, but this is complicated in practice; see Ferraro (2008)

Program, for example, local land rental rates are combined with information on field soil types, a proxy for productivity, to give a reasonable indication of the opportunity costs of retiring agricultural land. This is then used as a maximum acceptable price, removing the landholders' ability to claim unreasonably high payments. To proxy for opportunity costs in Madagascar, Wendland *et al.* (2010) use data on the opportunity costs of agriculture and livestock produced by Naidoo and Iwamura (2007). Naidoo and Iwamura compiled information on crop productivity and distribution for 42 crop types, livestock density and estimates of meat produced from a carcass and producer prices to measure the gross economic rents of agricultural land across the globe. Wendland *et al.* (2010) clipped this global data to Madagascar's boundaries. Gross economic rents ranged from USD 0 to 529 per hectare for Madagascar, with a mean value of USD 45 per ha, per year. The value of USD 91 per ha, per year (one standard deviation) was used as the cut-off to exclude areas of high opportunity costs.

However, obtaining information on costly-to-fake signals still incurs research costs. The efficiency of the payment will directly depend on the quality of this research and the strength of the correlation between the signal and the opportunity costs, which must be assessed on a case-by-case basis.

Exploiting competition between ecosystem service suppliers for conservation contracts through inverse auctions can provide an effective cost-revelation mechanism. Where suppliers are heterogeneous in their opportunity costs and demand for contracts exceeds supply (i.e. the conservation budget), competitive procurement auctions are possible.

The recognition of the potential gains from the use of inverse auctions as a payment allocation mechanism has stimulated heightened interest from policy-makers. Though their use in PES programmes is not yet common, they are becoming more widespread in developed and developing countries. Inverse auctions have been used to allocate PES contracts in Australia, Canada, Finland, Germany, Indonesia, Tanzania, the United Kingdom and the USA (Claassen, 2009; DSE, 2009; EAMCEF, 2007; Hill *et al.*, 2011; Jack, 2009; Juutinen and Ollikainen, 2010; Latacz-Lohmann and Schilizzi, 2005).

REFERENCES

Claassen, R. 2009. *USDA briefing room - Conservation policy: Background* (available at http://www.ers.usda.gov/briefing/conservationpolicy/background.htm).

DSE (Deparment of Sustainability and Environment). 2009. *ecoMarkets, Virginia, Australia*, Vol. 11, pp. 1565–1576 (available at http://www.dse.vic.gov.au).

EAMCEF (Eastern Arch Mountains Conservation Endowment Fund). 2007. *Welcome to the Eastern Arc homepage* (available at http://www.easternarc.or.tz/).

Farley, K., Jobbagy, E. & Jackson, R. 2005. Effects of afforestation on water yield: A global synthesis with implications for forestry. *Global Change Biology*, 11.

Ferraro, P. 2008. Asymmetric information and contract design for payments for environmental services. *Ecological Economics*, 65(4): 810–821.

Grieg-Gran, M., Porras, I. & Wunder, S. 2005. How can market mechanisms for forest environmental services help the poor? Preliminary lessons from Latin America. *World Development*, 33(9): 1511–1527.

Hill, M., McMaster, D., Harrison, T., Hershmiller, A. & Plews, A. 2011. A reverse auction for wetland restoration in the Assiniboine River watershed. *Canadian Journal of Agricultural Economics*, 1: 1–14.

Jack, B.K. 2009. *Auctioning conservation contracts in Indonesia: Participant learning in multiple trial rounds*. CID Graduate Student and Research Fellow Working Paper, No. 35. Center for International Development at Harvard University.

Juutinen, A. & Ollikainen, M. 2010. Conservation contracts for forest biodiversity: Theory and experience from Finland. *Forest Science*, 56: 201–211.

Kapos, V., Ravilious, C., Campbell, A., Dickson, B., Gibbs, H., Hansen, M., Lysenko, I., Miles, L., Price, J., Scharlemann, J.P.W. & Trumper, K. 2008. *Carbon and biodiversity: A demonstration atlas*. Cambridge, UK, UNEP-WCMC.

Karousakis, K. 2009. *Promoting biodiversity co-benefits in REDD*. OECD Environment Working Paper Series, No. 11. Paris, OECD.

Latacz-Lohmann, U. & Schilizzi, S. 2005. *Auctions for conservation contracts: A review of the theoretical and empirical literature*. Report to the Scottish Executive Environment and Rural Affairs Department.

Muñoz Piña, C., Guevara, A., Torres, J. & Brana, J. 2008. Paying for the hydrological services of Mexico's forests: Analysis, negotiations and results. *Ecological Economics*, 65(4): 725–736.

Naidoo, R. & Iwamura, T. 2007. Global-scale mapping of economic benefits from agricultural lands: Implications for conservation priorities. *Biological Conservation*, 140: 40–49.

Nelson, E., Polasky, S., Lewis, D., Plantinga, A., Lonsdorf, E., White, D., Bael, D. & Lawler, J. 2008. Efficiency of incentives to jointly increase carbon sequestration and species conservation on a landscape. *Proceedings of the National Academy of Sciences*, 105(28): 9471–9476.

Pagiola, S. 2006. Payments for environmental services in Costa Rica. *Munich Personal RePEc Archive.*

Tallis, H.T., Ricketts, T., Nelson, E., Ennaanay, D., Wolny, S., Olwero, N., Vigerstol, K., Pennington, D., Mendoza, G., Aukema, J., Foster, J., Forrest, J., Cameron, D., Arkema, K., Lonsdorf, E. & Kennedy, C. 2010. *InVEST 1.004 beta user's guide*. Stanford, The Natural Capital Project.

Villa, F., Ceroni, M., Bagstad, K., Johnson, G. & Krivov, S. 2009. *ARIES (Artificial Intelligence for Ecosystem Services): A new tool for ecosystem services assessment, planning and valuation*. Proceedings of the 11th Annual BIOECON Conference on Economic Instruments to Enhance the Conservation and Sustainable Use of Biodiversity.

Wendland, K. 2008. Rewards for ecosystem services and collective land tenure: Lessons from Ecuador and Indonesia. *Tenure Brief*, 9: 1–10.

Wendland, K.J., Honzak, M., Portela, R., Vitale, B., Rubinoff, S. & Randrianarisoa, J. 2010. Targeting and implementing payments for ecosystem services: Opportunities for bundling biodiversity conservation with carbon and water services in Madagascar. *Ecological Economics*, 69(11): 2093–2107.

Wunscher, T., Engel, S. & Wunder, S. 2006. Payments for environmental services in Costa Rica: Increasing efficiency through spatial differentiation. *Quarterly Journal of International Agriculture*, 45(4): 317–335.

Case Study 5

PES IN COSTA RICA

Katia Karousakis and Quiller Brooke
Organisation for Economic Co-operation and Development (OECD), Paris, France

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OECD, 2010. "Cost-effective targeting of payments for ecosystem services",
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In 1996, Costa Rica replaced an ineffective system of tax deductions for reforestation with a PES programme. Funded by oil tax revenues, the World Bank, the GEF and the German aid agency KfW, the programme enrols land to protect areas of natural forests, establish sustainable timber plantations, regenerate natural forests and establish agroforestry systems. The aim is to incentivise the provision of carbon sequestration, water quality, biodiversity protection and scenic beauty services on private land.

Between 1997 and 2005 forest protection was supported on 1.1 million acres and timber plantations on 67 000 acres. The programme gives a uniform per acre payment level irrespective of the quality or quantity of the ecosystem services provided. Contracts are prioritised according to predefined spatial criteria, including, officially acknowledged biological corridors, private property located within protected areas, zones with a low social development index and expiring contracts (Pagiola, 2006).

Wunscher *et al.* (2006) analysed the Costa Rican PES programme and demonstrated that there are potential gains from employing a more discerning contract selection process, together with differentiated payments. The study focused on the Nicoya Peninsula in northwestern Costa Rica. Plots were scored, giving equal importance to carbon sequestration, water quality, biodiversity protection, scenic beauty and poverty alleviation benefits (Figure 21). Three selection processes were simulated for comparison: a baseline scenario designed to match the current system and two scenarios selecting the highest scoring sites, one with uniform payments and one with differentiated payments relative to estimated opportunity costs (Table 6).

The uniform payment scenario enrolled 14 percent higher benefits than the baseline scenario, at the same cost, while the flexible payment scenario enrolled almost twice the land area (197 percent), giving more than double the benefits (203 percent). Moreover, the flexible scenario was able to use savings from the efficient pricing of low quality sites to fund the enrolment of higher quality sites.

Table 6
Comparison of scenarios for different payment schemes

	Baseline	Uniform payment	Flexible payment
Payment	Uniform	Uniform	Differentiated
Selection criteria	Priority area	Environmental score	Environmental score
Total cost (USD)	69 476 (100%)	69 429 (99.9%)	69 471 (99.9%)
Area (ha)	1 736.9 (100%)	1 735.7 (99.9%)	3 417.8 (196.8%)
Environmental score	27 421 (100%)	31 325 (114%)	55 724 (203%)
Score per USD	0.395 (100%)	0.451 (114%)	0.802 (203%)

Source: OECD, 2010

REFERENCES

Pagiola, S. 2006. Payments for environmental services in Costa Rica. *Munich Personal RePEc Archive*.

Wunscher, T., Engel, S. & Wunder, S. 2006. Payments for environmental services in Costa Rica: Increasing efficiency through spatial differentiation. *Quarterly Journal of International Agriculture*, 45(4): 317–335.

Current pages (from left to right):

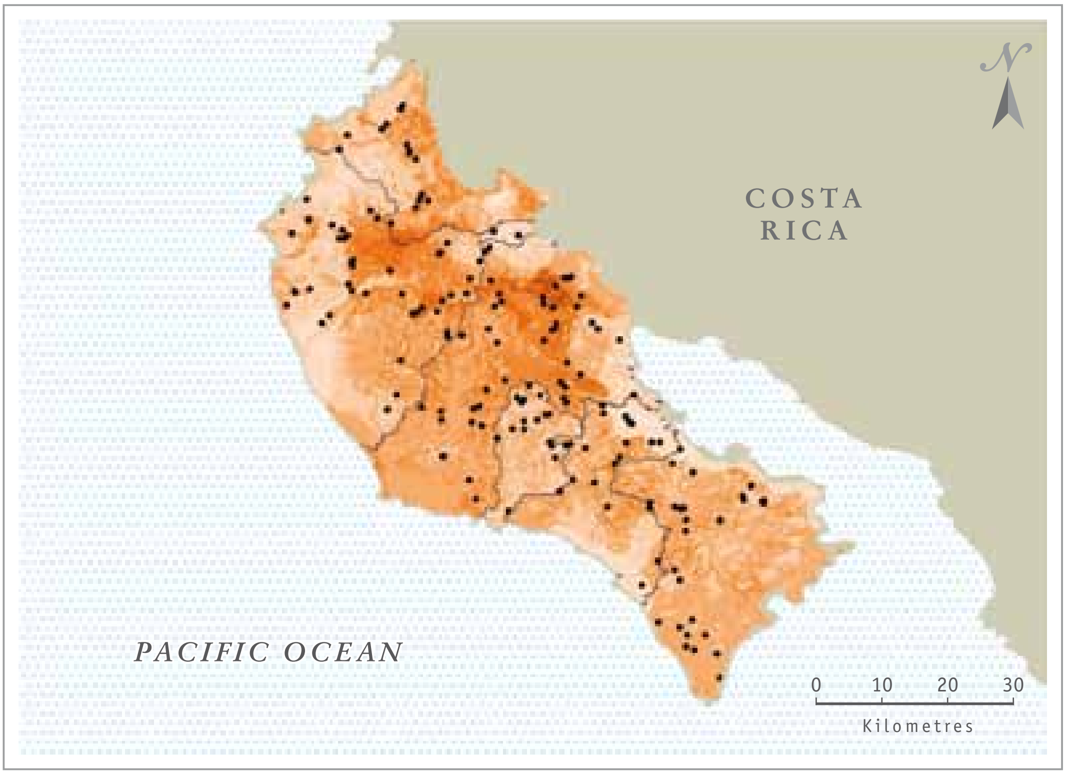
→ Coffee production in Costa Rica is suited to the soil and bio-climatic conditions of the central Meseta region, but increasing export demand has spread cultivation and consequent deforestation to the forested hilly areas.

→ Rainforest at Monteverde, Costa Rica, where a single tree can reach over 40 metres height.

→ The malachite butterfly (*Siproeta stelenes*), an example of the high diversity of Lepidoptera in Costa Rica, home to more than 1 200 butterfly species and more than 8 000 moth species.

Figure 21

Average cumulative score of different ecosystem services and poverty alleviation benefits together with coordinates of interviews carried out in different land properties within the Nicoya Peninsula



LEGEND

interview coordinate

administrative boundaries

Score

0–0.40	1.20–1.60	2.41–2.81
0.40–0.80	1.60–2.01	2.81–3.21
0.80–1.20	2.01–2.41	3.21–3.62

Adapted from original map by Tobias Wünscher (University of Bonn)