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Contents

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EDITORIAL

Working with nature, for people

Ecosystems are essential to human life. They provide a diverse range of services, from clean water to the air we breathe, that are vital to our wellbeing. Furthermore, ecosystems can also help us face changing conditions in the future. As the impacts of climate change are now being felt across the globe, robust and flexible methods of both mitigation and adaption are increasingly necessary. Ecosystem-based mitigation and adaptation, through the protection of healthy ecosystems, make use of the multiple services such natural capital provides, to help stabilise the climate system and support societal adaptation.

The importance of protecting and restoring healthy ecosystems to safeguard the many services they provide is increasingly recognised in EU policy, and both the EU Adaptation Strategy[1] and the strategy on Green Infrastructure: Enhancing Europe's Natural Capital[2] highlight the cost effectiveness and multiple benefits of ecosystem-based strategies. The integration of climate and biodiversity policy can now help to meet the challenges of a changing climate while also ensuring protection of vital ecosystems.

This Thematic Issue from Science for Environment Policy brings together the latest research on how protection of ecosystems and the services they provide can form an important part of climate change mitigation and adaptation strategies. The articles explore the different benefits of ecosystem-based approaches and consider the difficult question of how best to value them. They complement the articles published by Science for Environment Policy in the first volume of Ecosystem-based Adaptation earlier in 2013[3].

'Does preservation of biodiversity also protect ecosystem services?' is the central question explored by the first article in this issue. Researchers demonstrated that in a protected area in Spain biodiversity hotspots substantially overlapped with the provision of two ecosystem services key to climate change mitigation and adaptation: carbon storage and water flow regulation. This suggests that a synergy between climate and biodiversity policies can be created, as measures to protect biodiversity will also safeguard essential ecosystem services.

One key finding, confirmed by many of the articles in this issue, is that ecosystem-based approaches often provide multiple benefits. For example, the article **'Ecosystem-based adaptation can support food security'** explores a number of United Nations projects in Africa which demonstrate the great potential of ecosystem-based approaches to harness multiple ecosystem services, ultimately helping to alleviate food crises. A project to restore mangroves in Mozambique, for example, not only provided carbon storage and coastal protection, contributing to both climate change mitigation and adaptation, but also improved fish breeding grounds, increasing food supply to the local community.

Climate change adaptation and mitigation, while often considered separately, can be combined into a single, ecosystem-based strategy. This can be highly successful, as some of the research in this issue shows. The article **'Linking mitigation and adaptation could make forest projects more effective'** examines forestry projects in Latin America. A case study in northern Peru shows that through ecosystem-based approaches, including in agroforestry and reforestation, water regulation and soil fertility were improved, landslides were reduced, and carbon storage increased. **'Mangroves provide both climate change mitigation and adaptation services'** shows a similar finding, demonstrating that as well as providing protection from coastal erosion, mangroves bury 26.1 megatonnes of organic carbon per year worldwide, providing significant climate change mitigation benefits.

The benefits of considering mitigation and adaptation simultaneously are also highlighted by **'Constructing wetlands for multiple ecosystem services'**. The research highlighted in this article demonstrates that through careful design, constructed wetlands could capture and store carbon, while also helping reduce flooding and improving water quality.

Although the benefits of such ecosystem services are clear, mapping and evaluating them is far from simple, especially over the large scales needed to inform national and international policies. In the article **'Can ecosystems protect Europe's coastline?'** researchers provide a unique insight by mapping natural coastal protection across the EU's entire coastline. While they found that 42% of coastline is well protected by natural ecosystems, 31% shows insufficient capacity. Ecosystem-based approaches, restoring and conserving coastal ecosystems, could play a vital role in ensuring the resilience of these areas, say the researchers.

Once these ecosystem services have been mapped and assessed, their economic valuation can provide vital information for policy decisions. However, as the article **'Accuracy needed for economic valuations of ecosystem services'** shows, a lack of consistency in the definition and classification of ecosystem services has made it difficult to determine the reliability of such valuations. The authors of the study presented in this article call for increased clarity of evaluation methods.

One way of valuing investment in natural ecosystems is to assess the effects on the local economy. In the article **'Green jobs created by restoring blue infrastructure'** researchers demonstrated that for every US$ 1 million (€0.76 million) investment in restoration of coastal ecosystems, between 14.6 and 33.3 jobs were created across 44 projects in the USA. This is much higher than estimates for the coal (6.9 jobs per US$ 1 million), oil and gas (5.2) or nuclear (4.2) industries.

Ultimately, however, the classic market economic framework may not support the protection of these vital ecosystem services. The final article in this issue **'Market framework not appropriate for most ecosystem services'** shows that some key features of the market framework, such as the assumption that society is aware of the value of ecosystem services, may not hold true. Researchers call for alternative frameworks which consider the local and global value of ecosystem services to build a sustainable, fair and efficient system.

In summary, the research presented in this issue demonstrates that ecosystems play a vital part in human life, and can ultimately provide substantial benefits which need to be fully appreciated and valued. There is now a real opportunity to develop effective policies that promote green infrastructure and ecosystem-based approaches to climate change, and that recognise the potential for synergy between climate change adaptation and mitigation, and biodiversity protection. Biodiversity loss cannot be fully prevented without addressing climate change, but equally climate change cannot be confronted effectively without drawing on the many benefits of ecosystem goods and services and maintaining and restoring the ecosystems which provide them.

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1. http://ec.europa.eu/clima/policies/adaptation/index_en.htm
2. http://ec.europa.eu/environment/nature/ecosystems/
3. http://ec.europa.eu/environment/integration/research/newsalert/pdf/37si.pdf

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Theme(s): Biodiversity, Climate change and energy, Water

Does preservation of biodiversity also protect ecosystem services?

Measures to protect biodiversity can also improve carbon storage and water flow regulation, research indicates. In a Spanish protected area, researchers mapped biodiversity, carbon storage and water flow regulation, and found there was substantial overlap between the three.

"...measures to protect biodiversity will strengthen these vital ecosystem services and vice-versa."

The link between biodiversity and ecosystem services is not well understood, and different studies have found varying levels of ecosystem services in relation to biodiversity in different habitats. Although recent research has confirmed that both biodiversity and the provision of ecosystem services declines with land use intensification, there is still much discussion among the scientific community about the different strategies that may be required to protect both biodiversity and services.

This study, in Spain's Urdaibai Biosphere Reserve, examined the relationship between biodiversity and two ecosystem services vital to climate change adaptation and mitigation: carbon storage and water flow regulation. As well as being a highly biodiverse area the reserve also supports commercial pine and eucalyptus plantations for timber production. There is, therefore, a need to develop a conservation management plan for the reserve which maintains biodiversity and ecosystem services, while also supporting commercial activity.

Researchers identified 'hotspots' of biodiversity, carbon storage or water flow regulation as well as areas with medium scores for these three attributes, called 'ranges'. They also determined the extent to which hotspots and ranges for the different attributes overlap. The habitats surveyed were natural evergreen oak forest, natural mixed forest, and pine and eucalyptus plantations.

Most biodiversity hotpots (53%) were found within natural oak forests, with natural mixed forest contributing 41%. Plantations contained no biodiversity hotspots. Per unit area, natural forest was also found to have the highest levels of stored carbon, although 90% of the plantation forest surveyed was included in the 'range' of this service.

Pine plantations contained 67% of hotspots for water flow regulation and 25% of carbon storage hotspots. Overall, biodiversity, carbon storage and water flow regulation overlapped by 45%, which is 4% of the study area. All overlaps fell within natural forest areas.

The authors conclude that measures to protect biodiversity will strengthen these vital ecosystem services and vice-versa. However, they caution that the relationship between the two is likely to vary under different conditions in different areas and ecosystems, so research is needed at a local level to better understand the relationships and possibly adapt and improve conservation measures.

They also warn that although plantation forest can play a role in providing ecosystem services, it has significant negative environmental impacts, including soil acidification and loss of biodiversity.

Source: Original paper: Onaindia, M., Fernandez de Manuel, B., Madariaga, I., *et al.* (2012) Co-benefits and trade-offs between biodiversity, carbon storage and water flow regulation. *Forest Ecology and Management.* 289: 1-9. DOI: 10.1016/j.foreco.2012.10.010.

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Theme(s): Climate change and energy, Biodiversity

Ecosystem-based adaptation can support food security

Ecosystem-based adaptation (EbA) to climate change could help avoid future food crises in Africa, a new review suggests. By examining United Nations EbA projects implemented across Africa, the authors demonstrate that such approaches help improve the climate change resilience of production systems and the communities dependent upon them.

"Despite the importance of ecosystem services, such as the provision of water, maintenance of soil fertility, or the pollination of crops, their value is not built into the costs of food production."

By 2050, the population of Africa will represent almost a quarter of the world's population: greater than either China or India. Under climate change, efforts to increase food production to meet this rise in numbers are threatened, posing risks of famine and social instability. Indeed, recent droughts around the world, including in the Horn of Africa, have led to increases in food prices and rioting.

This review summarises the food security problems facing Africa, and suggests that EbA will be one of the most effective ways of meeting these challenges. This approach, which makes use of ecosystem services to help people adapt to climate change, also helps tackle issues such as resource scarcity and ecological degradation.

Despite the importance of ecosystem services, such as the provision of water, maintenance of soil fertility, or the pollination of crops, their value is not built into the costs of food production. As a result, ecological functions are commonly degraded by agriculture, resulting in a loss of these services and an increased vulnerability to climate change impacts such as drought and flood. This review reports on the potential for EbA to reverse this trend of degradation and instead establish agricultural systems resilient to climate change that are able to protect these vital ecosystem services.

The review proposes four kinds of actions to improve agricultural ecosystem services and climate change resilience: 1.) careful soil management (through minimum tillage, permanent cover and crop rotation); 2.) improvement of agricultural biodiversity; 3.) the development of programmes using expert scientific knowledge as well as local knowledge; and 4.) providing farmers with better access to new technologies and establishing 'payment for ecosystem services' schemes to ensure ecosystem services are accounted for and valued within agricultural systems.

The authors examine three United Nations Environment Programme projects as case studies to demonstrate the potential of EbA in helping alleviate food crises. A project in Mozambique worked with families reliant on fishing, and who were experiencing food shortages for several months of every year. This led to overexploitation of coastal resources. The project focused on rehabilitating mangroves as fish breeding grounds and establishing crab-farming and fish ponds to supply food and alleviate pressure on ecosystems. Sufficient food was produced for locals as well as surplus for trade, and ecosystems recovered. In total, 98 local households benefitted from this innovative project.

In Uganda, a project promoting agro-forestry and conservation agriculture resulted in more fertile soils and increased yields. This in turn reduced time and cost in preparing land for farming, leaving more time available for diversification, for instance, into livestock rearing. The project also resulted in less use of agrochemicals and improved biodiversity.

In Togo, small dams were restored combining EbA techniques, such as tree planting to reduce evaporation, with 'hard adaptation' approaches, including the digging of dykes and insertion of pipes to channel dam water into fish ponds. The result was improved water security and health, and increased food production through fish production and crop irrigation, as well as generation of hydro-electric energy.

The review concludes that EbA projects are cost-effective, broadly applicable, and their spread would help reduce the occurrence of food crises and face the multiple challenges of climate change.

Source: Munang, R., Thiaw, I., Alverson, K., *et al.* (2013). Using Ecosystem-Based Adaptation Actions to Tackle Food Insecurity. *Environment: Science and Policy for Sustainable Development.* 55 (1): 29-35. DOI: 10.1080/00139157.2013.748395.

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Theme(s): Climate change and energy, Forests

Linking mitigation and adaptation could make forest projects more effective

Forests play an important role in both mitigating and adapting to climate change, although current policies tend to isolate the two approaches. A recent study suggests that mitigation and adaptation are complementary and linked, and that forestry management that integrates the two can successfully provide both of these important services.

"...climate change mitigation projects also have the potential to enhance adaptation of the forest."

Mitigation strategies, such as afforestation and reforestation, target the cause of climate change, i.e. greenhouse gases. This approach provides global benefits; however, these may take a long time to be realised.

In contrast, adaptation projects address the impacts of climate change and the benefits are realised in the short- term and on a local scale. For example, adaptation strategies aim to help forests maintain their functioning status, ensuring that they continue to provide important services. This can reduce the vulnerability of local communities to the impacts of climate change, for example, by providing sources of food when droughts cause agricultural crops to fail.

This study explored links between adaptation and mitigation using Latin American forests as case studies. The authors demonstrate that climate change mitigation projects also have the potential to enhance adaptation of the forest. For example, the Return to Forest project in Nicaragua proposes planting drought-resistant tree species to help forests adapt to water stress, while at the same time increasing carbon capture.

The researchers also show how ecosystem-based mitigation projects can influence community adaptation to climate change. The Chinchina watershed forestry project in Colombia, for instance, has used reforestation to control soil degradation, and will increase the potential for agroforestry, creating new income for local communities.

In addition, forest adaptation projects can also provide mitigation. For example, the project AdapCC in northern Peru uses agroforestry in coffee production zones and upstream reforestation. This will help coffee production by improving water regulation, soil fertility and reducing landslides, but will also increase carbon storage.

International climate change policies tend to focus on mitigation, whereas local and national policies focus on adaptation. To date, few climate change or forest policies have integrated mitigation and adaptation, despite their synergies.

A review of the EU Forestry Strategy, published in 2011[1], highlighted climate change mitigation and adaptation as a major challenge. It also discussed the need to strengthen the link between science and policy and the importance of effective information campaigns.

The authors of this study suggest including adaptation measures in national guidelines and approval procedures for mitigation projects, to encourage a more integrated approach. Adaptation projects that incorporate mitigation by also enhancing carbon uptake and storage could benefit from financial incentives in the form of carbon funding.

The researchers recommend effective sharing of knowledge between forest policy and practice communities to ensure that opportunities to integrate adaptation and mitigation into projects are fully exploited.

Source: Locatelli, B., Evans, V., Wardell, A., *et al.* (2011). Forests and Climate Change in Latin America: Linking Adaptation and Mitigation. *Forests.* 2: 431-450, DOI: 10.3390/f2010431

1. *http://ec.europa.eu/agriculture/fore/events/15-04-2011/index_en.htm*

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Theme(s): Climate change and energy, Marine Ecosystems

Mangroves provide both climate change mitigation and adaptation services

Rates of carbon storage by mangroves are substantially higher than previously thought, research suggests. Using new data, researchers have estimated that worldwide, mangroves bury 26.1 megatonnes of organic carbon per year, which is 42% more than the estimations made in 2008.

"...mangrove wetlands are storing more organic carbon than previously recognised and represent an important carbon sink."

Mangrove wetlands provide important habitat for aquatic and terrestrial wildlife. Their protection and restoration can also play a valuable role in climate change adaptation and mitigation: they prevent erosion in the face of sea level rises and store carbon in their sediments.

In recent years, the value of mangrove wetlands as carbon sinks has become increasingly recognised and more research has been conducted in this area. Since 2003, the amount of available data on organic carbon in mangrove soils has more than doubled, but this has not been synthesised in a review. This study recalculated the amount of carbon stored per year, over the last 100 years (the burial rate), using the newly available data for mangroves worldwide.

Since 2003, data on organic carbon in mangrove wetlands was available for many more countries than previously, including Brazil, Colombia, Malaysia, Indonesia, China, Japan, Vietnam and Thailand. The figures for organic burial rates ranged from 22 g per m^2 per year in Japan, to 1020 g per m^2 per year in China. Figures at a local level were sometimes similarly varied, for example, rates in a single wetland in Australia ranged from 26 to 336 g per m^2 per year.

Considering all the relevant data, the researchers calculated an average burial rate of 163.3 g of organic carbon per m^2 per year. Mapping this to the total area of mangrove wetlands worldwide produces a global burial rate of 26.1 megatonnes per year, which is a 42% increase from previous estimates.

The results indicate that mangrove wetlands are storing more organic carbon than previously recognised and represent an important carbon sink. This has implications for the quantities of carbon that stand to be reintroduced to the atmosphere in the event of destroying mangrove wetlands or degradation of their soils.

If mangroves are not given suitable protection to ensure their health and resilience in the face of climate change, a vicious circle could arise, whereby rising sea levels and increased storm frequency will stress and damage mangrove wetlands. This will then affect their capacity to store organic carbon and the delivery of this ecosystem service will be jeopardised. If the carbon is released into the atmosphere as CO_2, this will exacerbate climate change further, which will have even greater impacts on this important ecosystem service.

Although data collection has improved, there is clearly a large variation in the amount of carbon stored in mangrove wetlands. Further work is needed to understand the local implications of this better, and to ensure that this valuable ecosystem service is maintained.

Source: Breithaupt, J.L., Smoak, J.M., Smith T.J., *et al.* (2012). Organic carbon burial rate in mangrove sediments: Strengthening the global budget. *Global Biogeochemical Cycles.* 26: 1-11. DOI: 10.1029/2012GB004375.

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Theme(s): Climate Change and Energy, Biodiversity, Water

Constructing wetlands for multiple ecosystem services

Constructed wetlands can regulate stormwater flows and improve water quality, helping humans to adapt to a changing climate. New research has now shown that, if carefully designed, they can also be used for climate change mitigation by storing carbon, while also providing biodiversity and cultural ecosystem services.

"Constructed stormwater wetlands and ponds offer ecosystem services beyond water regulation."

Constructed stormwater wetlands and ponds offer ecosystem services beyond water regulation, but these further benefits have never been fully examined. This study evaluates the carbon sequestration, biodiversity and cultural services of constructed wetlands, and identifies design features to optimise these benefits.

The researchers surveyed forty stormwater wetlands and ponds in North Carolina, USA. Carbon accumulation was assessed in sediments, and the number of species and a measure of diversity (the number of species multiplied by abundance) of invertebrates (such as insects and worms) and plants was recorded. The cultural value of each location was graded according to educational value (such as proximity to and known use by schools), accessibility and presence of recreational infrastructure, such as paths.

Carbon accumulation was highest (160 grams of carbon per square metre per year ($C/m^2/yr$)) in areas with the highest plant growth and the greatest carbon input, in the form of leaf litter or dead insects, for example. This compares favourably to other land uses, for instance, 90 g $C/m^2/yr$ accumulates in soils of highly managed grasslands, and 70-80 g $C/m^2/yr$ in soils of forests re-establishing on formerly cultivated lands.

For both plants and invertebrates, similar numbers of species were found in stormwater wetlands and ponds, but diversity was greater in wetlands. Shallow areas were important for the presence of floating plants and also 'emergent' plants, which are rooted underwater but grow leaves above the surface. These are especially important because they provide habitat for invertebrates, such as dragonflies and damselflies. Shallow areas in ponds that had been planted to ensure a mix of plants were more diverse than naturally colonised ponds, which were often dominated by a few invasive species.

Stormwater wetlands averaged higher cultural value than ponds, as they were more often on publically accessible lands, such as parks, or on the premises of educational establishments. Many already featured recreational infrastructure.

The authors acknowledge that the study focuses on a sub-set of ecosystem services and does not include potential 'ecosystem disservices', such as the generation of methane and nitrous oxide greenhouse gases which might reduce carbon sequestration benefits.

They make several recommendations to enhance the design of constructed wetlands. For example, shallow areas should be provided to allow floating and emergent plants to grow and a mixture of species should be planted to prevent colonisation by invasive plants. Recreational value could be enhanced by integrating stormwater bodies with cultural features, such as picnic areas and trails, and landscapes that have high visibility and therefore feelings of safety, containing, for example, scattered trees and grassland.

Source: Moore, T. L. C. & Hunt, W. F. (2012). Ecosystem service provision by stormwater wetlands and ponds – a means for evaluation? *Water Research*. 46, 6811-6823. DOI: 10.1016/j.watres.2011.11.026.

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Theme(s): Biodiversity, Marine ecosystems

Can ecosystems protect Europe's coastline?

Nearly a third of the EU's coastline has insufficient protection from erosion and flooding, according to recent research. The study presents a method for assessing coastal ecosystems' capacity to provide vital protection from these threats, and highlights the need to protect key habitats which safeguard coastal resilience.

"Preventing the loss and degradation of such natural capital can play a vital role in ensuring the resilience of coastal areas."

Despite the importance of ecosystems in providing coastal protection, planning authorities often neglect this natural capital, partly because it is difficult to map and assess such services. In this study, partly-funded under the EU PEGASO project[1], researchers provide a map of natural coastal protection across the EU's entire coastline.

The researchers identified three key indicators to assess levels of natural coastal protection. The first is 'capacity', defined as the natural potential of an area to provide protection, excluding artificial structures. This includes factors such as geology and seabed habitats.

The second is 'exposure', defined as the need for coastal protection given local climatic and oceanographic conditions. For example, local tidal and wave conditions may increase the risk of erosion and therefore the need for protection is greater. The final indicator, 'human demand' represents the need for protection based on the size of the human population on the coast or cultural assets, amongst others.

In order to select the most relevant factors for each indicator (for example, tides or habitats), detailed questionnaires were given to a group of 20 coastal research experts.

The resulting coastal maps revealed that the shores of Denmark, Germany, the Netherlands, some UK estuaries and the Gulf of Lion in France all had low coastal protection capacities. Capacity was determined mainly by the geological nature of the coast, but habitats, such as seagrass meadows and reefs, also provided important protection.

The shores of Denmark, Germany and the Netherlands also had high exposure values, and these were mainly determined by wave action in the regions, as well as the likelihood of storm surge. Exposure was lowest for the relatively sheltered shores of Greece and southern Italy.

Together, these two indicators can be used to determine the 'ecosystem service flow', i.e. how well the coast is able to protect itself from erosion or flooding. For 28% of the EU coast, exposure was greater than capacity with the worst affected areas across Atlantic and Baltic shores. Across 33% of coastline, capacity outweighed exposure, mainly in areas around Greece, the western coast of Italy, and Scotland.

Human demand for protection reflected the locations of coastal cities with high population densities, particularly Dublin, London, Bilbao, Malaga, Barcelona, Nice, Genoa, Patra and Athens. The researchers combined this measure with that of service flow to estimate whether coastal protection could meet demand. Although 42% of coastline could easily meet demand, 31% was classed as deficient.

The researchers highlight that natural habitats, such as coastal wetlands and oyster reefs, which can provide important protection, are being threatened across Europe by human activities. Preventing the loss and degradation of such natural capital can play a vital role in ensuring the resilience of coastal areas.

Source: Liquete, C., Zulian, G., Delgado, I. *et al.* (2013). Assessment of coastal protection as an ecosystem service in Europe. *Ecological Indicators*. 30: 205–217. DOI: 10.1016/j.ecolind.2013.02.013.

1. *PEGASO (People for Ecosystem-based Governance in Assessing Sustainable development of Ocean and coast) is supported by the European Commission under the Seventh Framework Programme. See: www.pegasoproject.eu*

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Theme(s): Environmental economics, Forests, Water

Accuracy needed for economic valuations of ecosystem services

Economic valuation of ecosystem services, from good quality water supplies to cooling cities in the face of climate change, can provide vital information for policy decisions. However, the definition and interpretation of ecosystem services need to be clarified to ensure accurate valuations, suggests new research.

"...some economic valuations value ecosystem functions (e.g. water flow) separately from the final service (e.g. water supply), but this raises the problem of double counting."

A lack of consistency in the definition and classification of ecosystem services, particularly when used to assess economic value, makes it difficult to determine the reliability of such valuations. This study identified four main areas of inconsistency in the interpretation and classification of ecosystem services used in valuation:

1.) Definitions. Some definitions differentiate between ecosystem services (such as water flow regulation) and derived benefits (such as protection from floods or generation of hydroelectricity), and value them separately; some only value the service itself.

2.) Which services to value? For example, some economic valuations value ecosystem functions (e.g. water flow) separately from the final service provided (e.g. water supply), but this raises the problem of double counting (or twice valuing) the benefits.

3.) The nature of services. For example, should both ecological and cultural services (such as recreation) be included?

4.) The types of values to use. That is, whether, and how, to include non-market and non-use values in the valuation.

The researchers used information from 36 previously-published studies that valued water services provided by forests in Central and South America to compare the outcomes of using either the Millennium Ecosystem Assessment[1] (MA) framework or an output-based classification system, for valuation.

For the MA framework, ecosystem services are divided into: provisioning services that provide goods; regulating services that regulate the environment; cultural services, or non-material benefits; and supporting services necessary to maintain other ecosystem services. An output-based classification defines services only by their outputs, for example, the in-stream water supply.

Potential problems for valuations include 'service overlapping' or 'service ambiguities'. Service overlapping results from valuing ecosystem functions and services separately; this potentially leads to a double valuation. For example, within the MA framework, water flow is classified as a regulating service, with the generation of hydropower as an output of the process. If economic values were attributed to both water flow and hydropower, this could lead to double-counting in the valuation.

Service ambiguity is caused by inadequately defining the ecosystem services. In this case, there is the potential for different outputs to be valued together under the MA framework. For example, it is not clear exactly which water services provided by forests are covered by 'hydrological services' and therefore the output cannot be clearly identified.

Although the MA system is useful for recognising the different types of ecosystem services, using output-based classifications would resolve double-counting and service ambiguity problems, the authors conclude.

They emphasise that although they did identify service overlapping or service ambiguity as potential problems, almost half the original studies that were analysed recognised the problem and did not contain double-counting. However, when these original studies are used as sources for other studies or valuations, double-counting could occur.

Source: Ojea, E., Martin-Ortega, J., Chiabai, A. (2012) Defining and classifying ecosystem services for economic valuation: the case of forest water services. *Environmental Science & Policy.* 19–20: 1–15. DOI:10.1016/j.envsci.2012.02.002

1. *http://www.unep.org/maweb/en/index.aspx*

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Theme(s): Environmental economics, Marine ecosystems, Sustainable development and policy assessment

Green jobs created by restoring blue infrastructure

Investment in restoring coastal habitats is an effective way of creating new jobs, recent research has found. The US study analysed 44 'blue infrastructure' restoration projects and found that, on average, 17 jobs were created for every US$ 1 million (€0.76 million) spent on these developments. This is more jobs than are created in the coal, gas or nuclear energy industries, where the same investment only results in 4-7 jobs.

"...these projects also lead to climate change adaptation via protection from storms and erosion, and create future jobs in the fisheries and tourism industries."

'Blue infrastructure' is the inshore habitat that forms the basis of valuable coastal ecosystems. As such, it provides important services, from recreation to commercial fisheries. It also protects coastal communities against the impacts of climate change, such as increasing storms and sea level rise. These ecosystem services lead to substantial economic benefits in the long-term, however, little is known about the immediate returns on investment, and how it can affect local economies.

In this study, researchers examined the economic impacts of 44 different state-funded coastal restoration projects in the US, completed or nearly completed since funding was granted in 2009. Together, these projects will preserve and restore approximately 8700 hectares of coastal habitats.

The impact analysis software IMPLAN was used to quantify the economic impact of three different types of effect. These were: 1.) direct effects, which relate to the immediate impacts of the investment in the industry; 2.) indirect effects, which describe the impacts on other industries that supply services or goods needed; and 3.) induced effects, which relate to the increase in spending in the local area, as a result of direct and indirect effects. For example, newly employed conservation workers will buy food from local cafés.

The results demonstrate that, overall, 951 direct jobs were created by the 44 projects. This figure increased to 1409 when indirect and induced effects were considered. The number of jobs created per US$ 1 million (€0.76 million) ranged between 14.6 and 33.3, depending on the type of project, with 17 being the average figure. Projects that were labour-intensive but did not require highly trained personnel, such as removing invasive plants, created the most jobs.

The researchers also compared the results with the numbers of jobs created by US$ 1 million investment in other sectors. This revealed that coastal restoration creates similar numbers of jobs to other 'green' sectors, such as park land conservation (20.3 jobs per US$ 1 million) and solar energy (13.7). However, the numbers of jobs created by investment in the coal (6.9 jobs per US$ 1 million), oil and gas (5.2) and nuclear (4.2) industries is much lower.

The researchers do highlight that the jobs created as a result of these projects are not likely to be permanent. However, they stress that there are many other longer-term economic benefits that may arise as a result of such projects, but which were not analysed in this particular study. For example, these projects lead to climate change adaptation via protection from storms and erosion, and create future jobs in the fisheries and tourism industries.

Source: Edwards, P.E.T., Sutton-Grier A.E. & Coyle, G.E. (2013). Investing in nature: Restoring coastal habitat blue infrastructure and green job creation. *Marine Policy.* 38: 65-71. DOI:10.1016/j.marpol.2012.05.020

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Theme(s): Climate change and energy, Environmental economics

Market framework not appropriate for most ecosystem services

Ecosystem services, such as coastal protection or water supply, form an integral part of ecosystem-based adaptation to climate change. However, preserving and restoring ecosystems and their services relies on the economic system that supports these efforts. Ecosystem services will not be best protected by the classic market framework, new research suggests.

"...frameworks must be applied that consider the local and global value placed on ecosystem services in order to provide a sustainable, fair and efficient system."

This study questions the suitability of classical economic frameworks for the protection of ecosystem services by considering three desirable goals of economic activity: sustainability, justice and efficiency.

1. **Sustainability.** To achieve sustainability, humans should not degrade ecosystem services faster than they can be restored. Thresholds exist, above which ecosystems can flip into an irreversible state where they can no longer produce services. The economic concept of 'marginal value' suggests that the nearer the system reaches its threshold, the greater the rise in the value of the ecosystem service, which would automatically protect it.

   However, this assumes that society is aware of this threshold, and views natural capital as critical, which will depend on both global and local values assigned to that ecosystem service.

2. **Justice.** The fair allocation of resources among groups and individuals is important in economics. In the case of ecosystem services, there is potential for conflict between groups in accessibility to services, for example, one group's right to have timber provided by a forest may conflict with another's right to enjoy the water purification and recreational opportunities provided by the same forest. It is likely that the poor will stand to gain more from ecosystem services than the rich, especially at a local level.

   However, using the economic concept of market demand, if an ecosystem service becomes diminished, then its price will increase, which means the rich are more able to access it than the poor. A good example of this is the price of wheat. When an increase in biofuel demand led wheat prices to triple between 2006 and 2007, wealthy nations barely noticed because it accounted for a very small cost in a loaf of bread. However, grain is a direct source of food in poor nations, so the impact was felt more severely in these countries. A market demand approach may seem fair for some goods and services, but this may not be the case for ecosystem services.

3. **Efficiency.** At a very basic level, efficiency implies maximising output and minimising costs. Conventional economists focus on 'pareto' efficiency, which involves valuing nature in monetary terms, weighing up the financial gain or loss, and making a decision based on the final figure.

However, a more appropriate approach may be ecological-economic efficiency (EEE), which suggests that an overall figure cannot be put on ecosystem services. Instead, the trade-offs and ethical choices between ecological protection, human health and obligation to future generations must be considered.

EEE does not rule out the use of tools such as green taxes or 'cap and auction' schemes (in such schemes the ecosystem is protected from degradation by capping the amount it can be altered by use of services, and the rights to sustainable use are then auctioned off), as long as the revenue is dedicated to the common good.

The study concludes that most ecosystem services cannot be integrated into the classic market framework. Instead, frameworks must be applied that consider the local and global value placed on ecosystem services, in order to provide a sustainable, fair and efficient system.

Source: Farley, J. (2012) Ecosystem services: The economics debate. *Ecosystem Services*. 1:40-49. DOI: 10.1016/j.ecoserv.2012.07.002

A selection of articles relevant to Working with Nature, For People from Science for Environment Policy's News Alert.

Adaptive management needed to maintain forests' ecosystem services under climate change (July 2013)
Forests may need to be converted to more drought-tolerant mixtures of tree species to prevent significant die-off under climate change, predicts a new study which modelled German forests. The researchers indicate that climate change is likely to lead to significant forest damage, which could be reduced through adaptive management.

Trade-offs in ecosystem services in Central and Eastern Europe (July 2013)
Researchers have developed a new approach for identifying regions that are most suitable for expanding ecosystem services. This could be used to help inform spatial planning decisions. By modelling ecosystem services' opportunity costs in relation to agricultural revenue, the study provides a map of suitable areas of ecosystem service expansion in Eastern Europe.

Protect biodiversity to safeguard ecosystem services (January 2012)
Most species in an ecosystem could help supply essential ecosystem services, according to a recent study. The researchers found that 84% of species in the grassland ecosystems they studied contributed towards at least one ecosystem service. Losing any of these species would therefore degrade the ecosystem services such an environment could provide.

Payments for ecosystem services: lessons from around the world (May 2013)
'Payment for ecosystem services' (PES) has become a commonly used term in recent years, yet the concept is not well defined. A new study reviewing PES theory, concepts and practice from around the world provides a valuable overview, concluding that more can be done to share learning.

Assessing the potential of ecosystem services with land use data (July 2012)
A new study has developed a system to assess the potential of ecosystems to supply ecosystem services in the EU-25 plus Switzerland and Norway. It is one of the first to use historical and projected data on land use change at a continental scale to estimate the provision of ecosystem services and to assess possible trade-offs between them.

Valuing ecosystem services can boost business profits (December 2011)
A new tool allows European businesses to see how, through informed decision-making, conserving the ecosystems they depend on is not only environmentally responsible, but can also increase profits, reduce risk and boost the value of their product or services.

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