

ECORISK Ecosystem Services Valuation for Environmental Risk and Damage Assessment

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ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: *We implement effective regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.*

Knowledge: *We provide high quality, targeted and timely environmental data, information and assessment to inform decision making at all levels.*

Advocacy: *We work with others to advocate for a clean, productive and well protected environment and for sustainable environmental behaviour.*

Our Responsibilities

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We regulate the following activities so that they do not endanger human health or harm the environment:

- waste facilities (e.g. landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g. pharmaceutical, cement manufacturing, power plants);
- intensive agriculture (e.g. pigs, poultry);
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- sources of ionising radiation (e.g. x-ray and radiotherapy equipment, industrial sources);
- large petrol storage facilities;
- waste water discharges;
- dumping at sea activities.

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- Supervising the supply of drinking water by public water suppliers.
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- Assessing the impact of proposed plans and programmes on the Irish environment (e.g. *major development plans*).

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- Monitoring radiation levels, assessing exposure of people in Ireland to ionising radiation.
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- Monitoring developments abroad relating to nuclear installations and radiological safety.
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- Providing advice and guidance to industry and the public on environmental and radiological protection topics.
- Providing timely and easily accessible environmental information to encourage public participation in environmental decision-making (e.g. *My Local Environment, Radon Maps*).
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- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

Awareness Raising and Behavioural Change

- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
- Promoting radon testing in homes and workplaces and encouraging remediation where necessary.

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The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

- Office of Environmental Sustainability
- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiological Protection
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

EPA RESEARCH PROGRAMME 2014–2020

ECORISK

Ecosystem Services Valuation for Environmental Risk and Damage Assessment

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EPA Research Report

End of project report available at <http://erc.epa.ie/safer/reports>

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The EPA Research Programme addresses the need for research in Ireland to inform policy and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

The Environmental Liability Directive [ELD (2004/35/EC)] applies a common liability approach to instances of environmental damage throughout the European Union. It aims to prevent and remedy environmental damage by holding those responsible financially liable for remediation.

ECORISK has the objective of exploring methods whereby the valuation of social and economic impacts can be used to supplement established methods of environmental damage assessment for the purposes of remediation.

The procedures of the ELD apply to:

- the contamination of land presenting a significant risk to human health;
- impacts to water bodies sufficient to cause a change in quality status as defined by the Water Framework Directive (2000/60/EC); and
- impacts to protected species and natural habitats covered by the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC) sufficient to cause a change in “favourable conservation status”.

Where damage has occurred, the ELD allows for three types of remediation:

- primary remediation to restore a damaged resource or an impaired service to its baseline condition;
- complementary remediation at an adjacent or other site in cases where primary remediation would fail to fully restore the original site to its baseline condition; and
- compensatory remediation where there are interim losses until primary or complementary remediation measures take effect.

Priority is given to primary remediation, but in cases where restoration is not possible or cannot be achieved within a reasonable timeframe, complementary remediation can be used to improve habitat at another site that is geographically linked in terms of species/habitats or human interactions. Compensatory remediation addresses interim losses and aims to compensate for the temporal loss of ecological

functions until recovery is achieved; this could take a prolonged period of time.

Definitions of complementary and compensatory remediation have been informed by EU Member States’ experience of implementing the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC). The scope of the ELD is somewhat different in that it applies both within and outside of designated sites where there is an impact on protected species or natural habitats. Furthermore, of relevance to the objectives of this report, the ELD acknowledges that, as well as species-to-species interactions, losses of ecological functions can impact on social and economic welfare too.

Ecological functions underpin “ecosystem services” of benefit to human beings. These include fundamental ecosystem supporting services, but with benefits realised from regulating services, i.e. services that maintain environmental quality (e.g. waste assimilation), provisioning services (e.g. the supply of natural products such as food and materials) and cultural services (e.g. settings for recreation and various non-use social or cultural values) (MEA, 2005; TEEB, 2010; Haines-Young and Potschin, 2013).

Remediation requires that the operators responsible for a negative environmental impact provide an amount of environmental good and a level of functionality equivalent to that which has been lost. However, while there are prescribed procedures for remediation, it can be difficult to achieve an equivalent level of environmental quality to that which existed before or to *scale* remediation sufficiently to compensate for interim losses, including any losses to social wellbeing. Recognition, and potentially valuation, of ecosystem service losses can complement methods of resource equivalency, specifically habitat equivalency analysis (HEA), which focuses on providing an equivalent amount of ecosystem processes or functions. The most important requirement for HEA is to identify the type and scope of ecosystem services that have been lost or damaged. A further step is to value these services where possible in economic terms.

ECORISK explored the potential to value ecosystem services in the context of the ELD using the example

of water. Water is one of the three foci of the ELD, but water quality also impacts directly and indirectly on many protected species and natural habitats. The project has identified the principal ecosystem services provided by freshwater, estuarine and inshore coastal water bodies. Estimates of their value were informed by a case study of the River Suir and Waterford Harbour.

The project demonstrated that the value of water for abstraction, recreation and fisheries could potentially be estimated in monetary terms. However, in many cases, primary data would need to be collected locally and, in other instances, is not readily available. The level of direct use associated with some natural environments in Ireland is modest, in particular for rivers, and is often mainly represented by angling. Passive use and the value placed on water in the landscape are significant, but more original stated preference (i.e. survey-based) studies are needed before value estimates can be reliably transferred to specific cases. The project also noted that one of the key ecosystem services provided by water bodies, namely the assimilation of waste, is difficult to value directly, although its importance could be valued indirectly through the amounts spent on wastewater treatment to maintain water quality and assimilative capacity.

Despite these issues, an identification of ecosystem services can form an important element of the indices of “beneficial use” that have been developed by the EPA for the purposes of prioritising investment to improve water quality in locations where direct and indirect uses are highest. This could provide the rationale for initiatives to collect data that can contribute to ecosystem services valuation or support future valuation studies. As such indices evolve, it would then be possible to incorporate more quantitative monetary estimates of the value of ecosystem services along with existing physical indicators.

This process could also inform more formal approaches to resource equivalency. Remediation under the ELD could form one component of a biodiversity offsetting programme that would not be limited to existing sites designated for nature conservation. The valuation of ecosystem services could also contribute to biodiversity banking, an extension of offsetting, which offers more flexibility, applied to pairs of sites using like-for-like remediation. Recognition of ecosystem services would help to ensure that a well-managed scheme would deliver “no net loss” as a minimum and, preferably, distinct gains to the wider environment.

In brief, the main findings for the study are listed in the box below.

Overall findings and recommendations

- Remediation should take account of impacts on ecosystem services of value to human beings. It should aim to restore these ecosystem services or compensate for interim losses.
- In some cases the value of these ecosystem services can be quantified in monetary terms.
- Various economic valuation methods are available including cost-based methods, revealed preference and stated preference techniques. As the last of these can be time consuming, benefit transfer methods are also recommended if the source study has been applied to a similar Irish or UK environment.
- Many ecological functions are not well understood, but often data on distinct environmental changes in outputs (e.g. in fish stocks, bird populations, etc.) are sufficient for environmental valuation.
- When valuing environmental damage, ecologists, the public and specific stakeholders are most probable to value avoidance of environmental thresholds or tipping points.
- Where monetary quantification is difficult or data are unavailable, the scale of these ecosystem services should still be assessed along with the number and type of recipients. Where ecosystem service losses have occurred in an interim period but cannot be quantified, remediation should aim to exceed a “no net loss” situation.
- Procedures should be put in place to improve the availability of data for local impact assessment, e.g. data on public and private water abstraction (location, quantity, recipients), data on water and waste water treatment, and data on visitor and tourist numbers.
- More primary economic surveys are needed to establish the value that the public places on the quality of freshwater and coastal water bodies and on wildlife and wildlife habitat.

On freshwater bodies

- Rivers and lakes supply a key ecosystem service in the form of waste assimilation and other service benefits in the form of water supply, angling and various types of recreational activities.
- The capacity of a body of water to assimilate waste is strongly related to the baseline water quality and is best valued through primary stated preference valuation or benefit transfer. It is important to define the extent of the population catchment in which values are held.
- Angling and recreational activity values can be measured through a combination of production function methods and revealed preference, i.e. monitoring participation, fishing permit sales, boat hire, travel cost and local expenditure.

On estuarine and inshore coastal water bodies

- Estuaries and coastal areas supply key ecosystem service benefits in the form of waste assimilation, finfish, shellfish and recreation, including wildlife-related recreation. However, ecosystem services valuation can be challenging because many of the relevant ecosystem functions are still poorly understood.

1 Introduction to the Environmental Liability Directive

The Environmental Liability Directive [ELD (2004/35/EC)] applies to the contamination of land presenting a significant risk to human health, to the quality of water bodies and to protected species and natural habitats covered by the Habitats Directive [HD (92/43/EEC)] and the Birds Directive [BD (2009/147/EC)].

Of these, ECORISK has focused on impacts to the natural environment, namely damage to water or to protected species and natural habitats. To qualify as a significant impact under the ELD:

- Damage to water must be significant enough to affect the quality status of a water body as defined by the Water Framework Directive [WFD (2000/60/EC)].
- Damage to protected species or natural habitats must be sufficient to undermine the achievement or maintenance of “favourable conservation status” as defined by the HD (92/43/EEC) and the BD (2009/147/EC).

The potential scope of the ELD is, in one respect, wider than for the HD in that it refers to protected species and natural habitats within or outside of Natura 2000 sites, and not just within the confines of designated sites.

Where damage has occurred the ELD allows for three types of remediation:

- primary remediation to restore a damaged resource or impaired service to its baseline condition;
- complementary remediation at an adjacent or other site in cases where primary remediation would fail to fully restore the original site to its baseline conditions using primary remediation alone; and
- compensatory remediation where there are interim losses until primary or complementary remediation measures take effect. This includes temporal loss of ecological functions.

Complementary and compensatory remediation require an operator or regulating agency to *scale* the level of remediation to compensate for the loss of environmental resources. In practice, where restoration is not feasible, complementary remediation has involved improvement

to habitat at another site that is geographically linked in terms of species/habitats or human interactions. Measures have generally been decided on a case-by-case basis by environmental protection agencies.

The definition of complementary and compensatory measures has been informed by Member States’ experience of implementing the HD, often following legal debate on specific cases. The HD is strict in its interpretation of remediation. Priority is firmly placed on the avoidance of impacts. Impacts are only conceded for planned projects of “imperative reasons of overriding public interest” (IROPI) and, even then, only after an “appropriate assessment” of the implications for the site’s conservation objectives. According to guidance provided by the Commission on Article 6(4) (EC, 2007) of the HD, compensatory measures are independent and additional to any mitigation required for a project; they are intended to offset certain negative consequences while restoration is undertaken to return a site to the reference biological integrity that justified its designation.

By its nature, a key distinction between the ELD and the HD is that the former deals with unplanned environmental impacts. A further distinction is that the ELD acknowledges both the importance of environmental functions (services between habitats and species) *and* services to human beings. The ELD states that, where restoration of these services is not possible, “alternative valuation techniques shall be used” to ensure that the environmental resource is remediated to a level equivalent to that which has been lost. This distinction is important in that it permits resource equivalency to be pursued through a hierarchy of resource-to-resource, service-to-service and value-to-value approaches. Emphasis is placed on remediating the ecological resource by means of resource equivalency analysis (REA) expressed in physical units such as bird or animal species. A consideration of ecosystem functions and services is relevant to the service-to-service approach, which is addressed by habitat equivalency analysis (HEA) and refers to the ecological functions provided by specific habitats. A value-to-value approach applies a monetary metric to the estimation of the ecosystem service element.

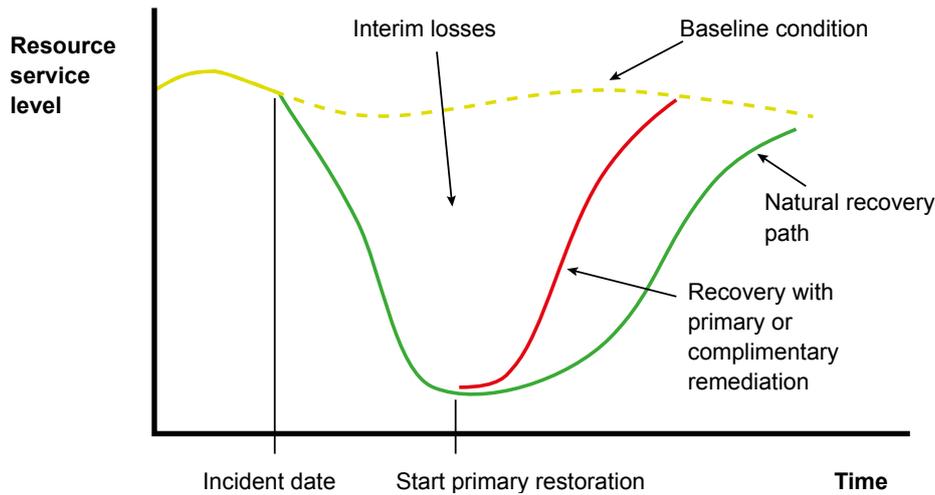


Figure 1.1. Stylised example of remediation [from REMEDE project (Lipton *et al.*, 2008)].

A case for compensatory remediation emerges where there are interim losses, including where physical remediation is prolonged or not possible within a meaningful timeframe. These situations will probably to occur for many habitats that are complex or which have evolved over long periods of time. Figure 1.1 helps to demonstrate how interim losses can be relatively significant. Whatever approach is taken, the ELD addresses physical remediation rather than financial compensation; where interim losses occur, remediation will probably differ from just the replacement of a damaged resource and should be quantified in terms of an equivalent level of ecosystem function or service or social losses.

In principle, calculating resource equivalency in either physical units (REA) or services (HEA) is straightforward: it involves the calculation of resource or service losses (debits) due to the damage, followed by estimating the expected benefits per unit of remediation (credits) and then dividing the debit by the per-unit credit to determine the total amount of remediation required [Resource Equivalency Methods for Assessing Environmental Damage in the EU (REMEDE) (Lipton *et al.*, 2008)]. This analysis proceeds in five steps:

1. an initial evaluation;
2. determination of the damage (debit);
3. determination of the gains from remediation (credits);
4. scaling the complementary or compensatory remediation; and
5. monitoring and reporting.

When remediation is based on physical units or services this can facilitate negotiation between a polluter and the regulating agency (Dunford *et al.*, 2004). These approaches may also be sufficient where the social value of a specific site is evidently small or where it is assumed that people derive benefits from the site in proportion to the supply of ecosystem services (Roach and Wade, 2006). The situation is more problematic where there are significant interim social losses, for instance where a site provides numerous services to people or to a larger network of environmental resources. Social losses could, for example, be associated with a loss of productive or cultural resources, such as a harvest of fish, the loss of recreation opportunities, or a loss of sense of place. An accurate assessment of the amount of a replacement resource requires the regulating agency to identify and, where possible, quantify the temporal and spatial relationships that exist between ecosystems, ecosystem services and people.

Where service losses occur over an extended period, there is a need to discount these to present values with the objective of compensating society with sufficient units of a resource to ensure that the aggregate change in social wellbeing is zero (Jones and Pease, 2007). This compensation can be accommodated within HEA by requiring that a larger spatial extent of a replacement resource is provided based on an estimate of "acre years". In other cases, the social values of a site could be sizeable and heterogeneous, such that particular interest groups incur higher losses than others. In these circumstances, a simple service-to-service

remediation approach would be insufficient, and estimation of appropriate compensatory remediation could require a value-to-value approach based on an estimate

of the loss of ecosystem service benefits. Further details can be found in the main report at <http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=3126>.

2 Ecosystem Services

Ecosystem services are the contributions that natural ecosystems make to human wellbeing. Economic valuation methods can be used to measure wellbeing through estimates of utility (or the satisfaction of individual preferences). Ecosystem service benefits (and losses) can thereby be valued in monetary terms. They can be measured in physical flows too, but monetary estimation provides for units common to debits and credits and facilitates trade-offs where these are realised at different times (as with interim losses) or by various stakeholders.

A conceptual framework was introduced by the Millennium Ecosystem Assessment (MEA, 2005), which categorised these flows into supporting, regulating, provisioning and cultural services.

- **Supporting services** underpin other ecosystem services and include such ecological processes as primary production or soil formation, and other services that provide habitat or metabolic energy.
- **Regulating services** are those that maintain the quality of the environment and include such services as the carbon cycle, waste assimilation or protection against erosion.
- **Provisioning services** provide materials and goods consumed by human beings, e.g. fish, timber, etc.

- **Cultural services** include such benefits as settings for recreation as well as certain non-use goods that are valued for their existence (e.g. iconic landscapes) or because they are perceived to contribute to quality of life.

Recent definitions of ecosystem services (TEEB, 2010; CICES, 2013) have concentrated on the final products or benefits provided by the regulating, provisioning and cultural ecosystem services. These definitions will inform the environmental accounting required by the EU Biodiversity Strategy (EC, 2011).

Ecosystem services are linked to biodiversity through ecological functions. High levels of biodiversity are, in general, associated with high levels of ecosystem processes or functions. However, the relationship is not inevitable due, in part, to the presence of species redundancy (where a species provides the same functions as another), or conversely, keystone species that are critical to certain functions or habitats (Naeem *et al.*, 2002). Ecological functions provide for ecosystem services, but not all ecological functions are valuable to ecosystem services. On the other hand, some functions may contribute to more than one ecosystem service (see Figure 2.1).

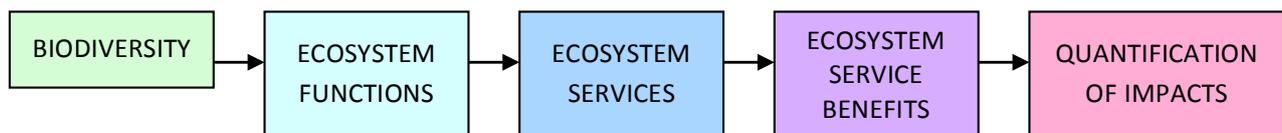


Figure 2.1. The relationship between biodiversity, ecosystem services and quantification of impacts.

3 Ecosystem Services Valuation

3.1 Biodiversity Offsets and Banking

Resource equivalency can also be realised through a process of biodiversity offsetting. Offsets provide for a formalised process of like-for-like complementary remediation and aim to achieve “no net loss” of biodiversity. Biodiversity offsets are distinct from environmental damage as defined by the ELD and can be used to, for example, compensate for environmental losses due to new greenfield development. Conservation banking is an extension to offsetting that allows for more flexibility than the bespoke exchange of habitats. Conservation banking involves the purchase of credits in exchange for environmental damage. These credits are then matched against one or more receptor sites or consolidated with others to achieve an equivalent level of remediation. The Environment Bank, which is being supported under the pilot offsetting scheme¹ in the UK, has emphasised the role of ecosystem services in biodiversity. Biodiversity banking has the potential to “mainstream” biodiversity (Crowe and ten Kate, 2010) and deliver new habitats additional to those protected by designation (McManus and Duggan, 2011). This does not have to be limited to remediation after damage to protected species or natural habitats, although remediation under the ELD could be facilitated by a functioning offsetting programme where this has the support of stakeholders.

3.2 Valuing Ecosystem Services

The ELD acknowledges the relationship between the natural environment and human wellbeing. However, many environmental goods and ecosystem services are public goods that are not priced by the market. As a consequence, their value may not be appreciated and there is the prospect that they will be mismanaged or adversely impacted in a manner to which the directive would apply. The overt acknowledgement of this relationship by the ELD strengthens the incentive for good environmental management.

¹ Piloted by the Department for Environment, Food and Rural Affairs.

Non-market economic valuation methods that can be used to estimate the value of environmental goods exist. The main non-market valuation methods are:

- Productivity or production function methods. These are useful where some market data are available: for example, for production function methods that price an ecosystem service input in terms of its contribution to a marketed output.
- Cost-based approaches: damage avoided or replacement costs. The damage avoided approach provides a measure of the benefit of protecting an ecosystem service. A related value is provided by the cost of replacing an ecosystem service with an artificial alternative, or of supplementing or strengthening the capacity of the ecosystem to provide a service.
- Revealed preference methods. These are based on the observation of behaviour associated with the environmental good, e.g. travel costs or property prices.
- Stated preference. These are used to establish willingness to pay directly through the use of surveys, e.g. contingent valuation or discrete choice experiments.

Production function methods are useful where an ecosystem provides a provisioning service to a market good, e.g. timber. Cost-based methods such as that of replacing an ecosystem service relate to investments such as flood or storm defences that were previously supplied by the regulating services of, for example, wetlands or dunes. Travel costs to a natural destination provide evidence of revealed preference for the cultural service of recreation, and can be complemented with data on local expenditure. Of all the methods of non-market valuation, only stated preference methods can capture non-use values. Stated preference methods have typically been used for cultural services, but sometimes for regulating services too. However, they are time consuming to apply, need to be undertaken thoroughly and are vulnerable to potential biases or various limitations of scope.

Sometimes local data are available for ecosystem services valuation, as illustrated by the project's case study of the River Suir. However, in other cases, it can be challenging to obtain such data. These challenges may be of a temporal or spatial nature, such as when ecosystem damage may not be realised in the short term or where the benefits of ecosystem services supplied at one location are realised at another.

Fundamentally, the study found that for some freshwater, estuarine and coastal environments there is often limited ecological evidence on how environmental conditions contribute to ecological functions and how these in turn contribute to ecosystem services. Ecological research has often focused on dose–response relationships of the impact of specific pollutants on particular species. Much of this research has been conducted at single locations or under controlled conditions (Moore and Robinson, 2004). However, the link between the mix of species present in a natural environment and ecosystem services is often poorly understood. This lack of knowledge particularly applies to the role of invertebrates and microbes in aquatic environments: there is a lack of knowledge regarding the regulating ecosystem services that this fauna provides for water quality compared with physical factors, such as the mix of turbulent or slow-flowing sections of rivers and their role in introducing oxygen or light.² Moreover, ecological damage can often take years to play out with impacts on higher order species and associated ecosystem services, being realised long after a critical threshold has been passed (Findlay and Bourdages, 2000).

Ideally, economic analysis requires information on marginal changes to construct a demand or supply function. In practice, this information is not always available for ecological functions and economists must settle for more discrete data. On the demand side, various stated preference surveys referenced in the report demonstrate that the public can be rather insensitive to marginal ecological changes where these are subtle or gradual rather than sudden or visual. For these purposes, it is often sufficient to present information on gains or losses of ecosystem service benefits rather than on underlying ecological processes. The CICES (Common International Classification of Ecosystem Services) focuses on the need to identify the final service provided to avoid double counting (Haines-Young

and Potschin, 2013). In practice, the benefits associated with provisioning or cultural services can be easier to describe to the public in surveys than some types of intermediate regulating services.

Economic valuation methods most readily capture utility values as perceived by the individual, e.g. through expressions of willingness to pay in a stated preference survey. However, the environment can also be of cultural or ethical value to people, at a communal as well as individual level. Where these values are perceived to be prevalent, economic methods could fail to represent the total value that people place on environmental goods. In these circumstances, alternative qualitative or semi-quantitative methods may be more effective for indicating the amount of rehabilitation required. Where an insight is needed from the public into non-economic socio-cultural values, these can take the form of deliberative analytical approaches, such as participatory multi-criteria analysis (Karjalainen *et al.*, 2013).

In addition, behavioural research has demonstrated that people tend to place greater value on losses than on gains, i.e. they are more averse to losses (Kahneman and Tversky, 1979, 1984). HEA assumes that society values damaged and restored resources equally. However, such an assumption of perfect substitutability is not probable (Flores and Thatcher, 2002; Zafonte and Hampton, 2007; Shaw and Wlodarz, 2013). The ELD addresses environmental losses, but stated preference valuation studies have often been directed at environmental protection or enhancement. This is because asking people for their willingness to pay for change can be less problematic than asking for their willingness to accept compensation as the latter introduces a risk of answers containing a strategic bias. If the former approach is used, it may be necessary to interpret responses as representing a minimum estimate of the value of a resource that has been damaged or lost. This adds support to the argument that remediation should go beyond *no net loss* to provide for more than a one-to-one replacement.

Despite these challenges or reservations, environmental valuation has the potential to demonstrate the impact of adverse environmental impacts on human wellbeing. This at least ensures that the social value of the environment is not ignored and can be accommodated by remediation. A key requirement is to avoid damage in the vicinity of environmental tipping points. Although we may indeed have a sparse knowledge of

² Some of these relationships are being addressed by ongoing EPA projects such as ESMange.

ecological functions, ecology and economics share an interest in identifying the extent of the ecosystem's resilience to change and the location of critical thresholds at which impacts would present serious ecological and social consequences. Identifying these thresholds is of great relevance to the ELD. Some of our most valued species and habitats, e.g. high-quality rivers, are very sensitive to anthropocentric impacts. Some wildlife

species associated with low-nutrient waters, such as eel and pearl mussel, are at risk of extinction nationally and individual populations may never recover should a pollution incident occur. Once pollution rises above certain thresholds, these species, along with the associated ecosystem services, may be lost or otherwise replaced by socially less desirable ecology, e.g. algal growth.

Key points – Remediation and ecosystem services

- The ELD allows for primary, complementary and compensatory remediation.
- Remediation must restore the lost resource or provide an equivalent nature, degree, area or extent of remediation to the resource lost.
- Compensatory remediation is especially relevant to interim losses of ecosystem functions and ecosystem services.
- There can be considerable uncertainty attached to the relationship between ecosystem functions and ecosystem services. Conventional ecological research has tended to address impacts on biodiversity rather than ecosystem services.
- Uncertainty also attaches to temporal and spatial discrepancies in the supply and demand of ecosystem services.
- People tend to value losses more than gains, but much valuation has addressed protection of the status quo or gains. Coupled with our limited understanding of ecosystem functions, this observation strengthens the case for remediation that delivers *no net loss* as a minimum.

4 The Case of Water: The River Suir and Waterford Harbour

To examine the practicality of ecosystem services valuation, Chapters 2, 3 and 4 of the final report focus on water. To demonstrate some of the issues involved, Chapter 5 of the main report examines the data that are available for the River Suir and Waterford Harbour. Subheadings are provided for:

1. sources of information;
2. nature of the ecosystem services; and
3. values for remediation.

The River Suir is 184km long and drains an area of 3546 km², or around 4% of the land area of Ireland. However, the total length of the river channel, including the significant tributaries, is about 530 km (Busch *et al.*, 2012). The river's source is in the Devil's Bit Mountains near Moneygall, County Offaly, and its tributaries flow mainly through Counties Tipperary, Kilkenny and Waterford. Waterford City is the largest urban centre in the South-East River Basin District.

The Suir is a typical Irish river. Its catchment contains areas of upland and forestry, but it mainly drains average to good agricultural land used for livestock and some tillage. It has some areas of adjoining wetland and alluvial woodland, but these are not substantial in size and do not play a very significant part in the ecological functions of the river. The number of direct uses of the river by which to demonstrate the value of ecosystem services is modest. Angling is arguably the most evident activity. Although the Suir does not attract the premium angling of rivers such as the Moy or Blackwater, it is nevertheless an important salmonid river. The economic value of angling can be estimated based on sales of angling permits for salmon or trout, which cost from €15 to €30 per day. If we were to assume that the Suir accounts for half the salmon angling effort in the south-east, then these sales could account for an income of €365,000 per year with a similar figure for trout. Estimates by Inland Fisheries Ireland (IFI, 2013) of the national value of angling expenditure would imply local expenditure of €5 million per year. The same report includes estimates of the approximate utility value of angling (IFI, 2013).

As with most of Ireland's rivers, the River Suir is used for water abstraction, mainly by the public authorities, and uptake of water by agriculture or private industry is slight. The value of the provisioning service could be partially estimated based on water charges, although these could fail to capture the value of ecosystem services that regulate water quality in the river itself. In general, in Ireland much abstraction occurs from reservoirs, lakes or groundwater and there is little use of irrigation. Although national and international studies (Ferrini *et al.*, 2008; EFTEC, 2010; Stithou *et al.*, 2011) have shown that clean water and wildlife sightings contribute to cultural ecosystem service benefits for passive recreational users, there are rather few locations where people can enjoy long walks beside the River Suir. Nevertheless, based on previous surveys (e.g. Heritage Council, 2007), it is probable that people place a high existence value on these services.

The River Suir, along with the Rivers Barrow and Nore, flows into Waterford Harbour. This transitional environment and its vicinity provide provisioning ecosystem services in terms of fish and shellfish production, for which catch and sales data are available. The area is thought to be an important nursery environment for fish caught at sea. Examples of the value of these ecosystem services are discussed in the final report, although there is typically too little information to estimate the value of these services at a local level. We also have an only limited understanding of the value of key coastal regulating services, such as waste assimilation and nutrient cycling by bacteria and invertebrates, bioaccumulation of metals by seaweed and carbon sequestration.

Cultural ecosystem services, such as water or beach-based recreation, have been shown to be of considerable economic value nationally (Williams and Ryan, 2003; O'Driscoll *et al.*, 2007). They are of significant economic importance along the coasts of Counties Waterford and Wexford and, while modest in value within the area of the estuary, do include some activities that are closely linked to biodiversity, including sea angling and birdwatching. Various studies demonstrate the strong relationship between coastal amenity

and water quality (Georgiou *et al.*, 1998; Eggert and Olsson, 2009). As with the freshwater environment, the physical characteristics of the estuary appear to play a fundamental part in determining the regulating services that contribute to good water quality for both fish populations and water-based recreation. The importance of this ecosystem service varies considerably, both within and between transitional and coastal environments, but there is little reliable evidence of the nature of the processes on which it is based.

A roundabout measure of the value that society attaches to a clean environment is represented by the considerable sums being invested in wastewater plants and treatment processes. Where the receiving environment is ecologically sensitive there is often a need for additional expenditure on treatment to protect water quality. The wastewater plant for Waterford City is located on the Lower Suir. The plant has an estimated

discharge of 250 million litres per year and had a capital cost of €38 million on its opening in 2011. Operating costs differ considerably between plants depending on size and the amount of treatment involved. Sewage loadings in Waterford have generally been around 10mg/L, suggesting actual costs of €0.63 per kilogram of sludge removed based on averages estimated for different sized plants in the UK (Oxera, 2006). On this basis, the treatment cost for biochemical oxygen demand (BOD) would be equivalent to between €1.1 million and €1.85 million per year given reported daily removal of up to 5000kg. Additional costs would apply to higher levels of tertiary treatment to remove nitrates and phosphorus. Although standards are set by the EU WFD, the household annual willingness to pay for good water quality in this catchment was estimated by Norton *et al.* (2012) at €40.60 using benefit transfer, equivalent to €730,000 for Waterford City's population or €1.7 million for the county.

Key findings – Ecosystem services and water

- Some data are available from Ireland on which to base economic estimates of the value of ecosystem services, but these are mainly for final provisioning and cultural services associated with a handful of direct use activities.
- Ecosystem functions and values are often spatially distinct. For example, the upper stretches of rivers provide spawning habitat for salmon, but the value is realised downstream in terms of angling numbers, capital values, permit revenue and local expenditure.
- Some ecosystem services vary from one location to another and for reasons that may be poorly understood. This means that value estimates can be location specific and not easily transferrable.
- Estuaries provide nursery habitat for fish, but little information is available on this function and mature fish may be caught in a different location. Even shellfish are mobile at the larval stage.
- Two locations may provide similar cultural types of ecosystem service, but this benefit may be more developed and valuable at one location than another.

5 Summary

An understanding of ecosystem services can be used to inform service-to-service approaches for HEA. Natural environments, including protected habitats and species, provide ecosystem service benefits for human beings. Information on these services can be used to demonstrate the ecological significance, but also the social importance, of natural environments that have been damaged by impacts listed by the ELD. Remediation should aim to account for these losses, but also for the interim losses that are incurred before the remediation is complete.

Interim losses can include economic losses, for example damage to fisheries or food crops. In principle, in these cases it is possible to estimate the extent of losses in income terms. However, there can also be impacts on individual utilities arising from a loss of cultural ecosystem services that contribute to amenity, recreation opportunities or other aspects of wellbeing, such as existence values. These losses can potentially be quantified in monetary terms using economic valuation methods, such as production function methods or cost-based methods, and survey-based revealed preference or stated preference methods. In other cases, where individual values cannot be aggregated in such a way to represent losses at a community level, or where economic values fail to represent the range of social and cultural values, methods such as multi-criteria analysis may be available to estimate an adequate level of compensatory remediation. In many cases, it will be sufficient to arrive at an estimate of the economic or social cost by estimating the impact on final ecosystem service benefits, such as those provided by some of the examples of provisioning or cultural services described above. However, in other cases, an accurate estimate of the relationship between an environmental impact and these final services depends on knowledge of supporting and intermediate services. For impacts to water, these include various regulating services for which we often have only a weak understanding. The ECORISK project describes our often limited understanding of the links between the functional diversity of aquatic flora and

fauna and its contribution to regulating services, such as the maintenance of good water quality. Similarly, we often know little about how impacts from environmental pollution play out over time, for instance at different stages in a species' life cycle, at different locations or at different levels in the trophic hierarchy (Mooney, 2002; Solan *et al.*, 2004; Perrings *et al.*, 2010).

The ECORISK project describes some of the key ecosystem services performed by freshwater, transitional and inshore marine water bodies. Appendix 2 presents some of the key habitats and species to be found in fresh and coastal waters along with the ecosystem services they support. The project is also accompanied by a database of environmental values for these environments or activities associated with them; most studies listed in the database are stated preference surveys. As ecosystem services have been formally conceptualised only in recent years, most of these studies address elements of total economic value, a tool used by environmental economists to categorise different value types.

The report includes a review of the River Suir and Waterford Harbour to identify some of the ecosystem services that can be partially valued using indirect non-market valuation. There is also a role for revealed preference methods and direct valuation stated preference approaches to estimate the value of some services. However, while the quantification of ecosystem service values in monetary terms is feasible in many cases, this will often require lengthy on-the-ground data collection in areas where environmental impacts have occurred. Until more primary valuation studies are undertaken, it could be useful to compile lists of ecosystem services provided by various natural environments and to identify the locations where beneficial uses occur. In the case of the River Suir and Waterford Harbour, these would include information on the location and scale of water abstraction, fishing (commercial and angling), direct water-based recreational opportunities and bankside or coastal amenities.

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Abbreviations

BD	Birds Directive
ELD	Environmental Liability Directive
HD	Habitats Directive
HEA	Habitat equivalency analysis
REA	Resource equivalency analysis
REMEDE	Resource Equivalency Methods for Assessing Environmental Damage in the EU
WFD	Water Framework Directive

Appendix 1 Full Report

The main project report can be viewed on the EPA Safer Data website.

The project database of water valuation studies is also located on the EPA SAFER website.

Chapter 1 of the main report contains a description of the Environmental Liability Directive (ELD) beginning with its application in relation to impacts on land, water, protected species and natural habitats. This is followed by an introduction to the concept of ecosystem services, a discussion of environmental valuation methods and of the procedures used for biodiversity offsets. The chapters of the report that follow consider impact cost estimation in relation to water. Water is one of the

three foci of the ELD and is of evident relevance to protected species and natural habitats. Chapter 2 introduces the relationship between the ELD and the Water Framework Directive. Chapter 3 discusses impact cost estimation for freshwater environments and Chapter 4 discusses the same for estuarine and inshore coastal environments. Chapter 5 introduces a case example of the River Suir and Waterford Harbour. Chapter 6 summarises the study and findings.

The report includes a table of protected freshwater, transitional and coastal species and habitats, their vulnerability status and the ecosystem services they support.

Appendix 2

See over.

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL

Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaoil a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaoil a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gclóíonn leis na córais sin.

Eolas: Soláthraimid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírthe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.

Tacaíocht: Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaoil atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaoil inbhuanaithe.

Ár bhFreagrachtaí

Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaoil:

- saoráidí dramhaíola (*m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistriúcháin dramhaíola*);
- gníomhaíochtaí tionsclaíoch ar scála mór (*m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta*);
- an diantalmhaíocht (*m.sh. muca, éanlaith*);
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe (*OGM*);
- foinsí radaíochta ianúcháin (*m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíoch*);
- áiseanna móra stórála peitрил;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce poiblí, a mhaoirsiú.
 - Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhírú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúcháin.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídionn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaoil.

Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uisce idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéal uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaoil

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil (*m.sh. tuairisciú tréimhsiúil ar staid Chomhshaoil na hÉireann agus Tuarascálacha ar Tháscairí*).

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainnaint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeraíde, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaoil in Éirinn (*m.sh. mórphleananna forbartha*).

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéal radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaoil ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaoil (*m.sh. Timpeall an Tí, léarscáileanna radóin*).
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosaint agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- An Oifig um Cosaint Raideolaíoch
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair inní agus le comhairle a chur ar an mBord.

ECORISK Ecosystem Services Valuation for Environmental Risk and Damage Assessment



Authors: Craig Bullock and Robert O'Shea

Summary

The Environmental Liability Directive (2004/35/EC) (ELD) applies a common liability approach to instances of environmental damage to land, water and protected species and habitats throughout the European Union. It aims to prevent and remedy environmental damage by holding those responsible financially liable for remediation. The objective of ECORISK has been to explore methods whereby the valuation of ecosystem services can be used to supplement established methods of environmental damage assessment.

Identifying Pressures

As well as adverse impacts on the natural environment, environmental damage can also have an impact on human health and well-being. This report takes the concept of ecosystem services and focuses specifically on water and the importance of functioning aquatic ecosystems for economic and social well-being, the assimilation of waste, and the provision of water that is safe for recreation and human or animal consumption.

Informing Policy

The ELD allows for primary restoration, complementary remediation, and compensatory remediation. Primary restoration is the first priority, but there may be a need to consider complementary remediation with replacement habitat where this is not possible, and/or compensatory remediation to account for interim losses, including services to human beings who may depend on, or value, aspects of the impacted environment.

The report introduces the concept of resource equivalency using resource-to-resource, service-to-service and value-to-value approaches. It discusses the economic methods that are available to value the loss of ecosystem services due to adverse environmental impacts. These are relevant to determining the extent of liability and the resources that need to be invested in remediation of the environment to a level equivalent to the full social value of the resource and services that have been lost. It can be expected that there will be a distinction between the value of the original and remediated environment that implies that remediation should extend beyond simple replacement.