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Area of Outstanding Natural Beauty Ardal o Harddwch Naturiol Eithriadol

Wye Valley AONB Ecosystem Goods and Services



Report Compiled by: Stephen Parrett
MA in Sustainable Development Advocacy
Student Placement

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Summary

This report aims to identify the key ecosystem services provided by the Wye Valley AONB.

The report identifies the Broad Habitats present in the area, recognising Enclosed Farmland and Woodland as the two most significant habitats and detailing the ecosystem services they provide. The threats to ecosystems and strategic objectives for managing ecosystem services are also looked at.

The report then moves on to identify those ecosystem services which are unique to the area, focussing on the importance of geodiversity and the River Wye itself in providing cultural, economic and biodiversity value. Finally the report concludes with a look at the economic value of ecosystem services in the Wye Valley AONB.

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1. Introduction

The recognition of the importance of ecosystems and their contribution to human wellbeing have recently been popularised with the publication of the United Nations Millennium Ecosystem Assessment (MA) in 2004. It comprehensively demonstrated the extent to which humans rely on ecosystem services and how these services are often unaccounted for. It also showed that, at a global scale, many of these services are being degraded or lost. The most widely used definition of an ecosystem adopted by the MA is:

‘A dynamic complex of plant, animal and micro-organism communities and their non-living environment, interacting as a functional unit’.

Using this definition we can see therefore that ecosystems are the fundamental earth processes on land, in water and the air that involve all living things.

People are part of ecosystems and, like all other living organisms, affect the processes taking place there, as well as deriving welfare gains from them. Compared to other organisms, people have an enormous influence on ecosystems, both in the UK and elsewhere, as a result of population numbers and densities, patterns of consumption and use of technology.

2. Ecosystem Services

The UK National Ecosystem Assessment (NEA) published in mid 2011 is the first analysis of the UK’s natural environment in terms of the benefits it provides to society and the nation’s prosperity. The definition of ‘ecosystem services’ developed by the NEA is:

‘The outputs of ecosystems from which people derive benefits’

The NEA looks at the four ecosystem service areas identified by the MA. These are:

Provisioning Services

These are services which are represented by the outputs of products such as food, fresh water, fuel, fibre, biochemicals and genetic resources.

Regulating Services

These cover the mediating role that ecological systems have in affecting climate, hazards, disease, pests and pollination. It also includes the vital role ecosystems play in regulating soil, air and water quality.

Cultural Services

These include the non-material benefits ecological systems can provide in terms of their spiritual or religious significance, recreation and tourism, aesthetics, educational and scientific value and cultural significance.

Supporting Services

These are the processes that underpin all the other services, such as soil formation, nutrient cycling and primary production.

The extent to which ecosystems provide these four services will often depend on land use and the types of management practised. In general, the more natural and biodiverse an ecosystem is, the more stable the services provided by that ecosystem are (NEA 2011a). The activities in a landscape should take account the impacts they may have on the capacity of the landscape to maintain these services.

3. Broad Habitat Types in the Wye Valley AONB

In the UK and much of Europe, the classification of ecosystems can be considered as significantly overlapping with that of habitats. There are 8 'Broad Habitat' types in the UK identified by the NEA. The Wye Valley AONB has to a greater or lesser extent at least 7 of the 8 'Broad Habitat' types found

in the UK. Table 1 shows a list of the 8 habitat types with the approximate corresponding areas and features present in the AONB obtained from the Wye Valley AONB Management Plan (MP) 2009 – 2014 (2009).

Table 1: Broad Habitats present in the Wye Valley AONB

UK Ecosystem (Broad Habitat)	Examples in Wye Valley AONB
Enclosed Farmland	<p>Approx Farmland: 20 300 ha 62.3% of AONB area</p> <p>Major Agricultural Land Uses include: Crops & Fallow: (43%) Permanent Grass: (35.5%) Temporary Grass (9.5%) Other (including set aside) (12%)*</p>
Woodlands	<p>Approx Woodland: 8310ha, 25.4% of AONB area.</p> <p>Of which: Broadleaved: 3100 ha Mixed: 2400 ha Conifer: 2000 ha Scrub: 800 ha</p> <p>SSSI: 2267 ha Wye Valley Woods SAC: 916ha Managed by Forestry Commission: 5082ha</p>
Semi-Natural Grasslands	<p>Approx Grassland: 2300 ha, 7.1% of AONB area</p> <p>Small Fields: 1900 ha Parkland: 300 ha Marsh: 100 ha</p>
Urban	<p>Houses, Roads, Urban approx 1200 ha, 3.1% of AONB area.</p>
Freshwaters – Openwaters, Wetlands and Flood Plains	<p>River Wye, tributaries and pools, approx 1.5% of AONB area.</p>

	Flood Plain Habitat, particularly in Herefordshire Wye meadows.
Mountains, Moorlands and Heaths	Some Bog and Lowland Heath habitat such as Cleddon bog and Broad Meend Heath. Inland rock and scree habitats present in cliffs throughout the Wye Valley gorge as well as some limestone pavement.
Marine	Limited area of salt marsh and intertidal sediments on tidal reach of the Wye.
Coastal Margins	N/A

*approximate percentages in 2001 based on Statistical Digest of Wye Valley (Centre for Rural Research 2003)

The table shows that the majority of the Wye Valley AONB consists of two broad habitat types, Enclosed Farmland and Woodland which cover approximately 87.7% of the land area combined. Habitats such as semi-natural grasslands, freshwater and inland rock habitats, whilst not as widespread, contribute significantly to the overall character of the Wye Valley AONB.

The ecosystem services provided by these habitats are likely to vary depending on how the land is managed. The following sections look at the ecosystem services provided by these broad habitats in relation to the Wye Valley AONB.

4. Enclosed Farmland Ecosystem Services

Enclosed Farmland is a hugely significant part of the Wye Valley AONB consisting of around 62% of the land area. Much of this land is located in the Herefordshire part of the AONB as well as a large proportion of the Trellech and Dean plateaux either side of the Wye gorge. Rapid changes in modern agriculture have overwhelmed and threatened many of the traditional habitats

and practices that have created some of the distinctive features of the AONB. According to the Wye Valley AONB MP, around 54% of the AONB area is farmed intensively (86.7% of total farmland). That is farmland which is:

‘Characterised by the high inputs of capital, labour, or heavy usage of technologies such as pesticides and chemical fertilisers relative to land area’ (Encyclopædia Britannica 2011)

Intensively farmed land is largely managed to produce food, using practices that result in some undesirable losses of nutrients and sediments into water, and greenhouse gases and ammonia into the atmosphere, as well as some that have caused large losses in biodiversity (NEA 2011b).

However, Enclosed Farmland is often also managed to provide positive outcomes or benefits, especially by providing landscape character, habitats for wildlife and opportunities for leisure (NEA 2011b). Table 2. details the positive and negative effects Enclosed Farmland has on ecosystem goods and services.

Table 2. Enclosed Farmland effects on Ecosystem Services (after NEA 2011b). Note: the impact values range from ++ to --, depending on the magnitude and direction of influence.

Ecosystem Service	Positive	Negative
Provisioning	++Provisioning of food for human consumption or to feed livestock. +Provisioning of wild food and game. +Energy crops such as <i>Miscanthus</i> and oilseed rape.	- Nutrient loss/removal from harvesting crops etc.
Regulating	+ Water quantity, important for catching ground and surface waters.	- - Climate Regulation negative due to emissions of GHGs (mainly nitrous oxide and methane) and depletion of

	<p>+ Waste breakdown and detoxification. Ability to compost green waste, anaerobic digestion and sewage disposal.</p> <p>+ Carbon Sink, especially permanent grassland.</p> <p>+ Pollination. Positive effects where habitat enhancement is practiced.</p> <p>+ Biological pest control. Positive effects where habitat enhancement is practiced.</p>	<p>carbon in arable soils.</p> <p>- - Hazard regulation. Impact on sediment loss to watercourses, increasing flood risk downstream.</p> <p>- - Waste breakdown and detoxification. Diffuse pollution leaving farmland.</p> <p>- - Water quality. As a result of diffuse pollution.</p> <p>- Water quantity, flood risk mitigation potential often compromised by management.</p> <p>- Pollination. Decline in wild pollinators due to loss of flower-rich semi-natural landscapes.</p>
<p>Cultural</p>	<p>++ Socially valued landscape. Farming management is largely responsible for landscapes that many people cherish. Especially significant for AONB.</p> <p>++ Leisure. Public rights of way, bridleways and cycle paths through Enclosed Farmland. Horse riding and ownership. Visits to farm open days. Game shooting.</p> <p>++ Human health. Safe nutritious food. Exercise associated with recreation.</p> <p>+ Employment. Agricultural workers have decreased since the 1960's however there are beneficial impacts to local economy through spend of employees.</p> <p>+ Benefits to local economy from selling food locally.</p>	<p>- Health risks. Mechanical injury. Airborne particulates from intensive livestock housing and field operations can cause human respiratory problems.</p>

Supporting	<ul style="list-style-type: none"> + Wild species diversity enhanced by Agri-Environment schemes. + BAP priority habitats: hedgerows and arable field margins. + Soil Formation + Nutrient Cycling + Primary Production (supporting food production). 	<ul style="list-style-type: none"> - - Wild species diversity including microbes. Affected by intensive management techniques. - Soil Erosion (impacts soil formation and nutrient cycling) - Nutrient loss/removal from harvesting crops etc.

Table 2. shows that Enclosed Farmland exploits the natural supporting services of ecosystems in order to produce provisional services, often at the detriment to regulating services. Lost nutrients are reintroduced using organic and inorganic fertilisers; however these are not taken up at perfect efficiency which creates conflicts with those ecosystem services that are best delivered by ecosystems subject to much less intervention (Henle *et al.* 2008). The table also shows that Enclosed Farmland has the potential for positive or negative effects on ecosystem services depending largely on how it is managed.

The main contribution of Enclosed Farmland to the Wye Valley AONB and wider society is the provisioning of food. However the cultural benefits of Enclosed Farmland are especially important to the Wye Valley AONB as it helps contribute to the characteristic landscape associated with the area. This landscape is an important part of the tourism and recreation sector which is the largest employer in the AONB. Agriculture is also one of the most important industries in the area and despite a reduction in farm workers and incomes; there has been a growing interest in locally produced foods and farmers markets.

4.1 Challenges Facing Enclosed Farmland in the Wye Valley AONB

The primary purpose of the Wye Valley AONB is to conserve and enhance natural beauty. This must be carried out whilst taking into account the needs of agriculture and rural industries as well as the economic and social needs of the local community.

There are many challenges likely to influence Enclosed Farmland in the future which could threaten the purpose of the Wye Valley AONB. As Table 2 shows, there are already considerable pressures on farmland to produce provisional services. These pressures are likely to increase for a number of reasons such as:

- Climate Change – This will introduce increased uncertainty and risk to ecosystem service delivery due to less predictable precipitation and temperatures.
- Demographic Change - It is envisaged that the global demands for agricultural production of food, energy and materials will increase greatly in the coming decades as a result of increased UK and global population and changing diets. This could also lead to land use change such as the growing of more energy crops and pressures to develop farmland for housing.
- Economic Pressures - A substantial increase in the price and/or availability of fossil fuels could force farming systems to optimise or replace tractors, road transport and inorganic fertilisers.

For these reasons it is likely that agriculture in the area will need to become more productive in terms of food and energy, more efficient in terms of resource utilisation, more productive in terms of other ecosystem services, and more resilient to climate and other changes (NEA 2011b). Enclosed

Farmland will need to adapt to these challenges whilst continuing to provide and regulate essential ecosystem services in a sustainable fashion.

4.2 Strategic Objectives for Enclosed Farmland in the Wye Valley AONB

Farming systems in the UK have proved extremely resilient to date, not least due to the mild climate, good soils and a highly adaptive farming industry (NEA 2011b). It is clear that sustainable management techniques must seek to reduce the negative and enhance the positive impacts detailed in Table 2. The Wye Valley AONB MP aim for farmland is:

‘To foster viable farming enterprises that manage land in ways that conserve and enhance the natural resources and local distinctiveness of the AONB.’

The Wye Valley AONB is therefore playing an active role in ensuring that the beneficial ecosystem services provided by Enclosed Farmland are sustained. Some of the key strategic objectives in the MP include:

- WV-F2 – Helps promote the key supporting and regulating services offered by enhancing biodiversity in Enclosed Farmland through encouraging the uptake of agri-environment schemes.
- WV-F4 – Supports the cultural services offered by Enclosed Farmland through promoting farm-based activities and skills.
- WV-F7 – Promotes the economic viability of provisional services offered by Enclosed Farmland by encouraging the production and consumption of local produce.

Strategic objective WV-F1 also encourages the development of sustainable management practices. These practices may include:

- Enhancing biodiversity - Biodiversity plays a wide range of functional roles in ecosystems helping to sustain essential supporting services such as soil formation, nutrient cycling, the water cycle and primary

production as well as regulating services such as pollination and biological pest control. Agri-environmental schemes provide financial incentives to encourage biodiversity and also support the enhancement of natural beauty. Maximum uptake of the schemes will therefore benefit biodiversity significantly. This policy is reflected in the Wye Valley AONB MP strategic objective WV-F2.

- Reduction fertilisers – 53% of agricultural emissions are from nitrous oxides which are especially associated with the oxidation of nitrogen in fertilisers (NEA 2011b). Over the past 25 years there has been an ongoing decline in inorganic fertiliser applications, continued reduction will therefore result in the reduction of a significant greenhouse gas. Nitrogen can also cause eutrophication of watercourses and soil acidification.
- Reduction of pesticides - Modern pesticides tend to be more environmentally benign than the ones they replaced, however there are still significant unwanted affects caused by their application. This may include soils and water contamination resulting in a loss of biodiversity. Reduction in their use would therefore limit the harmful effects associated with their application.
- Carbon sequestration – This is the removal of carbon dioxide from the atmosphere in order to reduce the impact of climate change. Permanent grassland soils are already close to carbon saturation (Bradley *et al.* 2005), making them important carbon stores. Arable soils however tend to be depleted in carbon (Smith *et al.* 2000). Conversion of temporary grassland or arable to permanent grassland or woodland will therefore lead to an increase in carbon sequestered.

Implementing these management strategies will however involve a level of trade off that may affect provisioning services. Enclosed Farmland must ultimately be part of a viable agricultural business and must therefore be managed accordingly. If implemented however, these management options

should help contribute to the sustaining of ecosystem services which ultimately the agricultural industry, and the wider public, rely on.

5. Woodland Ecosystem Services

Woodlands in the Wye Valley are one of the dominant landscape features with significant connectivity across the landscape. They provide a multitude of ecosystems services (see table 3) as well as environmental, social and economic benefits. The majority of woodlands in the Wye Valley AONB are ancient woodland of high nature conservation value, and therefore irreplaceable. However there are also sizable conifer plantations.

Forestry and woodland occupies 8310ha of the AONB which is just under 26%. Over 900ha, about 3% of the AONB, are internationally protected as a Special Area of Conservation (SAC). The highest proportions of ancient and semi-natural woodland (ASNW) and planted ancient woodland sites (PAWS) are in the Wye Gorge, Dean Edge Limestone Hills (Highmeadow) and Woolhope Dome. The productive areas of woodland in the AONB are on the flatter land of the Dean and Trellech plateaux and the Woolhope Dome. The majority of the woodland in productive management is in the Public Forest Estate managed by the Forestry Commission, which covers 4,962ha or 15% of the AONB. A further 1,650ha of private woodland (5% of the AONB) are in some level of grant scheme.

Table 3. outlines the ecosystem services provided by woodlands in the context of the Wye Valley AONB.

Table 3. Woodland Ecosystem Services (after NEA 2011c)

Ecosystem Service	Benefits
Provisioning	<ul style="list-style-type: none"> • Wild food including meat from deer culling etc. Some grazing in AONB woodlands. • Provision of raw timber materials for use in commercial and domestic enterprises; provision of chips for boards and pulp for paper.

	<ul style="list-style-type: none"> • Use of timber as an alternative for other building materials such as steel and concrete in order to reduce use of fossil fuels and enhance building standards. • Timber products (e.g. harvesting residues, stumps and roots, recycled wood) as fuel for heat and power plants, as domestic firewood, for charcoal, biochar and as raw material for processed hydrocarbon fuels.
<p>Regulating</p>	<ul style="list-style-type: none"> • Avoidance of climate stress. Tree cover can help dampen the climatic effects experienced in the open, thus protecting soils, animals and humans from extremes of temperature, strong winds and UV light. • Carbon sequestration. Woodlands and their soils are important reserves of terrestrial carbon, and timber products can also be considered. • Soil protection. Tree cover can offer protection from soil erosion and slope failure. Forest management will reduce exposure to chemicals and pesticides and likelihood of soil compaction compared to agriculture. • Flood and water protection. Woodlands moderate rainfall events and river and stream hydrographs, delaying and reducing flood events. • Woodland dwelling organisms can help in regulating the incidence and spread of insect pests of crops and pathogens of importance to humans, livestock, crops and ecosystems. • Water quality. Because of minimal use of pesticides and fertilisers, woodlands managed under sustainable principles also offer benefits to water quality. • Soil quality. Woodland cover can stabilise contaminated brownfield land and hinder the pathways between source and receptors. • Air quality. Capture of atmospheric pollutants in tree canopies can lead to consequent reduced exposure for humans, crops, buildings etc. • Woodlands provide habitat for diverse wild pollinator communities of importance to trees, crops and other plants.

<p>Cultural</p>	<ul style="list-style-type: none"> • Biodiversity. Forests, including plantations, provide habitat for a wide range of fauna and flora. Wye Valley Woods Special Area of Conservation (SAC) is internationally recognised for its rich variety of wild species. The majority of the AONB's 45 SSSI sites cover ancient semi-natural woodland. 4 National Nature Reserves including Lady Park Wood and The Hudnalls. • Employment. A wide range of professions in the AONB are connected to woodlands such as forestry workers, arboricultural advisors, coppice workers, charcoal makers, game dealers, carpenters etc. Many tourism and recreation jobs are also linked to woodlands. • Trees and Woodlands are valuable for personal enlightenment and as places or catalysts for social activity and cohesion. • Increasing acknowledgement of forests educational benefits such as 'Forest Schools'. There are at least 7 Forest Schools in the Wye Valley AONB area. • Many forests in the AONB are open to the public and are used for outdoor pursuits and recreational activities such as walking, cycling and horse riding, in turn benefitting the local economy. Their access facilitates exercise and benefits human health and longevity. • Trees and woodlands increase the diversity of landscape character.
<p>Supporting</p>	<ul style="list-style-type: none"> • Soil formation, nutrient cycling, water cycling, and oxygen production. Forests facilitate soil formation and other biogeochemical processes essential to life. • Deciduous woodland represents the climax habitat type for most of lowland Britain and can support a wide range of associated species.

The table shows that woodlands in general are highly beneficial to ecosystem services. However, like Enclosed Farmland, the extent to which Woodlands provide these services very much depends on how they are

managed. Ancient woodland for instance will benefit biodiversity more than a conifer plantation; however may not provide certain provisional services such as timber to the same extent. Woodland managers therefore have to satisfy many different needs, balancing the needs of wildlife with the productive services offered by forests.

5.1 Challenges Facing Woodland in the Wye Valley AONB

Lack of management

Currently only 30% of woodlands in the AONB are managed, partly because of low timber prices, meaning that many woodland's are becoming neglected. This lack of management has resulted in the general loss of biodiversity, particularly those species dependant on cyclic light to shade development in woods. Lack of management also facilitates the spread of invasive species such as cherry laurel and sycamore. An unmanaged woodland may not therefore be optimising its full ecosystem service potential.

Climate Change

Climate has an important influence in shaping the composition and character of woodlands. The main climatic factors affecting tree-growth in forests and Woodlands are:

- Temperature- growing season temperature affects tree growth; winter/spring temperature affects the degree of frost damage; and range of temperature (continentality) is also influential.
- Moisture Deficit- different tree species differ in their seasonal moisture requirements and drought tolerance; snowfall can physically damage trees or protect them from winter desiccation, especially when small. Droughts can lead to increases in wildfires.
- Wind- can cause physical damage to tree growth form.

Most tree species are long-lived and adapted to cope with considerable variability. Recent climate-related changes however have been documented in more mobile species, such as insects and birds from woodland and other habitats, and these variations are predicted to increase, leading to more rapid changes in the complement of species using woodland areas (NEA 2011c).

More research is needed into woodland management techniques required to adapt to climate change and may include recommendations on the 'most suitable' species for planting in different areas (NEA 2011c).

Woodlands can also contribute to the mitigation of climate change through carbon sequestration and localised reduction in the effects of climate such as dampening temperatures in the soil and beneath the canopy, and in providing shade and shelter for animals and human visitors (NEA 2011c). Commercially managed forests can sequester carbon at a rate of 3tC (tonnes of Carbon) per hectare per year (Forestry Commission 2011). The same commercially managed forest can maintain an average of around 100tC per hectare and up to 220tC if allowed to grow old naturally (see table (Forestry Commission 2011)). See section 7.2 for carbon sequestration.

5.2 Strategic Objectives for Woodland in the Wye Valley AONB

The Wye Valley AONB MP (2009) aim for woodlands is:

'To ensure woodland throughout the Wye Valley AONB is managed sustainably in a way that protects and enhances the outstanding ancient woodland character of the area, and provides environmental, social and economic benefits.'

The subsequent strategic objectives outlined for woodland in the MP all help ensure the sustainability of Woodland ecosystem services. Some of the key objectives include:

- WV-W1 - By providing best practice advice and support on sustainable multipurpose management, as well as gradual PAWS restoration, WV-W1 helps ensure key regulating and supporting services of woodland are maintained and improved.

- WV-W2 – Ensures that there is no net loss of semi-natural woodland cover unless there are overriding nature or heritage conservation benefits. This policy therefore protects the continued presence of Woodland ecosystems and their services in the area.
- WV-W5 & 6 – These policies promote the cultural and provisioning ecosystem services offered by Woodlands in the form of employment and woodland products. By promoting this use of woodland, their existence over other land uses continues to be justified.
- WV-W8 – Promotes awareness of the cultural value of woodlands to the wider public.

These strategic objectives show that the Wye Valley AONB is committed to protecting and improving the ecosystem services offered by woodland in the area.

6. Ecosystem Services unique to the Wye Valley AONB

Enclosed Farmland and Woodland, as the two most significant land uses in the Wye Valley, provide a wide range of beneficial ecosystem services to the area. They do not of course exist in isolation from one another and are part of an interconnected landscape of huge variability. The other Broad Habitat types, covering 12.3% of the AONB area, have not been looked at in great detail in this report. However it is clear that they play an essential role contributing to ecosystem services and the overall landscape character of the area. The following sections will focus on some of the unique features present in the Wye Valley AONB and the ecosystem services and habitats they support.

6.1 Geodiversity

The importance of Geodiversity to ecosystem services has not been covered by the NEA. However it is the underlying geology of the Wye Valley

AONB that ultimately contributes to the diverse landscape of the area. The combination of topography, soil, hydrology and lithology has created the unique character of the Wye Valley AONB. The action of ice at the end of the ice age and then the River Wye has carved out the valley from the underlying geology.

At the northern point of the AONB, the geology of the area around the village of Woolhope is largely made up of Silurian limestones, shales and sandstones. This is where the oldest rocks in the area can be found. To the south of this, the Herefordshire lowlands are largely underlain by red mudstones and sandstones, producing a fertile soil which has led to the Enclosed Farmland found here.

These rocks are softer than the limestones elsewhere, so the river has created more meanders, a wide floodplain, and a gentler and more rolling landscape. At Symonds Yat the Devonian red sandstones meet the Carboniferous limestones. Here the river has cut through the limestone and produced the impressive river cliffs so popular with tourists. The woodland on these steep sided cliffs may well have existed continuously since the last ice age (Peterken 2007).

Geodiversity also provides the storage of water in aquifers, as well as providing extractable minerals. Limestone has been quarried in the area for millennia with limestone scowles found throughout the valley. The Wye Valley AONB still has two limestone quarries within its boundaries with another on the periphery, providing local jobs and physical materials. There are also carboniferous coal measures which are still exploited on a small scale in the Forest of Dean as well as an ochre mine at Clearwell just outside the AONB. There are historical remains of iron smelting and lime kilns throughout the lower Wye Valley which provide considerable cultural interest.

The legacy of geological industrial relicts such as quarries and mines as well as the natural cliffs and cave systems today create opportunities for tourism and recreation in the form of climbing, abseiling and caving as well as the natural aesthetic viewpoints which attract walkers and sightseers.

There is also significant educational interest in the geology of the area with several good examples of karst features such as sink holes, limestone pavements and dry valleys. There are also several geological Sites of Special Scientific Interest (SSSIs) and Regionally Important Geological and Geomorphological Sites (RIGS). The AONB aims to conserve and enhance sites that are important for scientific and general understanding and the enjoyment of the geodiversity heritage of the area (Wye Valley AONB MP). Table 4 shows a list of the ecosystem services provided by the geology of the Wye Valley AONB.

Table 4. Geological Ecosystem Services in the Wye Valley AONB

Ecosystem Service	Benefits
Provisioning	<ul style="list-style-type: none"> • Physical materials such as limestone, coal and ochre.
Regulating	<ul style="list-style-type: none"> • Water storage and filtration.
Cultural	<ul style="list-style-type: none"> • Tourism opportunities created by natural aesthetic viewpoints. • Recreation opportunities such as climbing, abseiling and caving. • Educational and scientific value in the form of several geological SSSI sites and Regionally Important Geological and Geomorphological Sites (RIGS). • Historical cultural significance such as industrial relics including lime kilns and iron works.
Supporting	<ul style="list-style-type: none"> • Geology is vital to the water cycle and soil formation and underlies all habitats and subsequent biodiversity.

It is unlikely that environmental change will have a significant effect on geodiversity itself although direct changes by people to landforms can affect local geodiversity. The MP strategic objectives for geodiversity help to support

and promote the ecosystem services provided by the AONB's geodiversity. These include:

- WV-G1 & 2 – Help to support, conserve and identify important geological sites in the area.
- WV-G4 & 5 – Recognise and promote the importance of geodiversity in providing cultural services to the Wye Valley AONB.

6.2 The River Wye

The River Wye itself is of huge value to ecosystem goods and services in the area. It provides an important resource in the form of water supply for agriculture and human consumption as well as regulating the water cycle. The Wye's cultural services are especially important to the area, providing opportunities for tourism and recreation, with canoeing and fishing two very popular activities with large economic impacts. The Wye itself has been designated as a SSSI and internationally important SAC due to its wide variety of biodiversity. There are also biodiverse riparian and floodplain habitats along the length of the river. Table 5 lists the ecosystem services provided by the River Wye.

Table 5. Ecosystem Services provided by the River Wye

Ecosystem Service	Benefits
Provisioning	<ul style="list-style-type: none"> • The river provides a water source for private supply and crop irrigation. • The Wye also provides a limited supply of wild fish for human consumption.
Regulating	<ul style="list-style-type: none"> • Flood & Flow Regulation. The Wye helps to regulate floods by allowing natural flooding to occur, dissipating the effects of large flood events. • Water Quality Regulation. Rivers can dilute, store and detoxify waste products and pollutants, however there are threshold levels and pollution levels can accumulate.

Cultural	<ul style="list-style-type: none"> • Tourism and Recreation. The Wye is popular with fishermen and canoeists. These industries are very important to the local economy. There are rowing clubs at Ross and Monmouth. Also of tourism value are scenic river tours and 'hand' ferries connecting river banks at Symonds Yat. • Sense of place. The Wye is important in defining specific landscape character and features strongly in art and local culture. • Historical importance. The river is historically significant to the early tourism industry and industrial heritage of the area. Also historically important as a transport link with public right of navigation in place since 1662.
Supporting	<ul style="list-style-type: none"> • Biodiversity. Species depend on conditions such as, temperature, oxygen level, depth and velocity of water. The River Wye itself is a SSSI and internationally important SAC. • Important for contributing sediment to floodplain soils.

Threats and Conflicts to the River Wye

There are a number of threats posed to the ecosystem services offered by the River Wye. These include:

- Invasive Species such as Japanese Knotweed and Himalayan Balsam reduce the biodiversity of riparian habitats and can make riverbanks more susceptible to erosion. Other species such as mink and the American signal crayfish can also outcompete indigenous wildlife.
- Diffuse pollution from farmland and other land uses can enter the river system causing negative effects to biodiversity and human health.
- Positive and adaptive management is required in order to reduce the effects of flooding such as soil erosion and property damage.
- Heavy use of the river for recreation can put pressure on local infrastructure and facilities and cause conflict between users.

The Wye Valley AONB unit plays an important role in managing and mitigating some of these negative impacts on the River Wye's ecosystem services. This includes conservation work in removing invasive species and the monitoring of the adverse impacts of tourism.

6.3 Biodiversity

The diverse variety of Broad Habitats created by unique geodiversity and combined with past and present human management has led to a high concentration of designated biodiversity sites covering 10% of the AONB. As has been shown, biodiversity is a key supporting ecosystem service and the more biodiverse an ecosystem is, the more stable the services provided by that ecosystem are (NEA 2011a).

Designated sites include:

- 4 National Nature Reserves (NNR's)
- 204 County Local Wildlife sites
- 3 Special Areas of Conservation (SAC's)
- 45 Sites of Special Scientific Interest (SSSI's) (some geological)

These sites, as well as providing key supporting and regulating services to the AONB, also provide cultural services in the form of tourism, recreation and educational value.

Biodiversity sites also have important non-use value. That is value which is derived simply from the knowledge that the natural environment is maintained.

There are three main components to non-use value (Defra 2007):

- Bequest value: where individuals attach value from the fact that the ecosystem resource will be passed on to future generations.
- Altruistic value: where individuals attach values to the availability of the ecosystem resource to others in the current generation.
- Existence value: derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it.

6.4 Tourism and Recreation

The cultural services provided by ecosystems such as tourism and recreation are highly important to the Wye Valley AONB. The combination of different Broad Habitats and land uses provided by the underlying geology and centuries of management by mankind has created the unique 'picturesque' landscape seen today. This landscape attracts large numbers of visitors to the area, providing an important source of income for many local businesses.

Estimated visitor figures to the Wye Valley AONB range from between 750,000 a year to 2.5million. The value of tourism to the local economy is significant; in terms of local employment and visitor spend which is between £20 and £40 a day. The canoe industry is particularly valuable with a recent study suggesting that canoeists spend an average of £90 per visit to the area (Parrett 2011).

It is the services provided by ecosystems that continue to attract tourists to the area, particularly those who come to witness and experience the 'picturesque' landscape. If these services were degraded in any way, it could severely affect the attractiveness of the Wye Valley for tourism with negative consequences to the local economy.

The Wye Valley AONB MP therefore seeks to find a balance between encouraging and promoting tourism based on the conservation, enhancement and enjoyment of the area (WV-S1) and encouraging the reduction of the adverse impacts of existing tourism activity (WV-S4).

7. Economic Value of Ecosystem Services in the Wye Valley AONB

The underlying case for the valuation of ecosystem services is that it will contribute towards better decision-making, ensuring that policy appraisals fully take into account the costs and benefits to the natural environment. Ecosystems can be characterised as environmental assets that, like other

capital assets, provide a flow of services over time. If these services are consumed in a sustainable manner, the capital can be kept intact (Defra 2007).

Putting an exact economic value on the ecosystem services is an extremely complex and inexact science. The following attempts to attach economic values to ecosystem services in the Wye Valley AONB using existing literature on the subject.

7.1 Economic Value of Enclosed Farmland in the Wye Valley AONB

Due to the Wye Valley AONB's location covering 3 counties, figures for the economic value of the agricultural sector in the AONB are difficult to obtain. The majority of Enclosed Farmland in the AONB is located in Herefordshire. Key figures relating to the agricultural industry from the recent 'State of Herefordshire 2009' (Herefordshire Partnership 2009) report include:

- Gross Value Added (GVA) by the agriculture, forestry and fishing industry in Herefordshire was around £191 million which is 7% of the total GVA in the county (compared to 1% GVA in the West Midlands as a whole).
- Herefordshire's total agricultural labour force has increased by 23% since 2000 and stood at 11500 in 2007 with a high proportion of casual workers (34%).
- Farm Business Income for Herefordshire in 2006-2007 was £18 800 per farm (over 50% lower than the national average).
- Herefordshire's net farm income has seen a steeper increase compared to regional and national gains; increasing from an average £3900 per farm in 2005/06 to £10 500 in 2006/07 but is still below that of the West Midlands region (£16 500) and England (£26 700).

These figures, whilst not specifically covering the Wye Valley AONB, give an idea of the value of the cultural ecosystem services of Enclosed Farmland to the local economy. 6.93% of the area of Herefordshire is within the Wye Valley AONB, a basic calculation therefore puts the value of agriculture,

forestry and fishing industry in the Herefordshire part of the Wye Valley AONB at **£13.2 million** (6.93% of £119million). The Gloucestershire and Monmouthshire areas are not likely to be as high as this due to lower levels of Enclosed Farmland, however are still likely to contribute significantly to this number.

There are also negative costs associated with Enclosed Farmland. According to the NEA, greenhouse gas emission cost between £89 - £108 per hectare of farmland in 2004, depending on the government region (see table 6) (NEA 2011d).

Table. 6 Cost of Greenhouse Gas Emissions per Hectare of Farmland in 2004. After NEA 2011d.

Region	Cost of GHG Emissions per Hectare
Wales	£89
West Midlands	£91
South West	£108

As the total area of Enclosed Farmland in the AONB is 20,300ha, the figures from table 6 would give a cost of between **£1,806,700 - £2,192,400** for greenhouse gas emissions in the area.

7.2 Economic Value of Woodland in the Wye Valley AONB

Due to low timber prices there is not currently a purely financial case for woodlands as a land use. However the case for woodlands is much stronger when the value of woodland in relation to ecosystem services are considered, with recreation and carbon storage values being particularly substantial (NEA 2011d). These services show that recognising the true value of woodland is crucial to the sustainability of the Wye Valley AONB. Table 7 shows the economic values of Woodland to the UK economy with estimated values of Wye Valley woodland.

Table 7 Annual social and environmental value of forests in UK and Wye Valley AONB (£ millions, 2002 prices) Adapted from: Willis *et al* (2003)

Environmental Benefit	Annual Value of Woodland in the UK	Estimated Annual Value of Wye Valley AONB Woodland
Recreation	392.65	1.14
Landscape	150.22	0.44
Biodiversity	386.00	1.12
Carbon Sequestration	93.66	0.27
Air Pollution	0.39	0.001
Total	1022.92	2.97

The Wye Valley AONB has approximately 0.29% (8310ha) of the nation's woodland within its area. An estimated figure for the value of Wye Valley woodlands was therefore obtained by determining 0.29% of the total UK figures. This crude calculation based on 2002 figures is likely to be very different from reality; however it gives some idea of the economic value of woodlands to the area. The actual figures for the Wye Valley AONB are likely to be higher than those shown in Table 7, as recreation, landscape and biodiversity are likely to be above the national average.

Carbon Sequestration

According to the Forestry Commission (2011), commercially managed forests can sequester carbon at a rate of 3tC (tonnes of Carbon) per hectare per year. The same commercially managed forest can maintain an average of around 100tC per hectare and up to 220tC if allowed to grow old naturally. Unmanaged forests are unlikely to sequester carbon at the same rate as timber is not removed; however they are significant carbon stores. Table 8 shows the potential carbon stored in Wye Valley woodlands using the two different figures. It is likely that the actual figure lies somewhere between the two.

Table 8 Estimated carbon stored in Wye Valley Woodlands.

	Area of	Carbon Stored	Carbon Stored

	Woodland (ha)	(100tC per ha)	(220tC per ha)
Forestry Commission Woodland	4962	496 200	1 091 640
Total Wye Valley Woodland	8310	831 000	1 828 200

Assuming that all Forestry Commission managed woodland in the Wye Valley AONB (4,962ha) sequesters carbon at a rate of 3tC a year, then 14,886tC of carbon are removed from the atmosphere every year. If we use the Willis *et al* (2003) value of £6.67 per tonne of sequestered carbon then the value of carbon sequestration in Forestry Commission woodland in the Wye Valley would be **£99 290 per year**.

Other values of woodland

Willis *et al* (2003) identifies a number of other economic values of woodland including:

The marginal benefits of woodland were estimated to be:

- £1.66 to £2.75 for each recreational visit.
- £269 per annum per household, for those households with a woodland landscape view on the urban fringe.
- 35p per household per year for enhanced biodiversity in each 12,000 ha (1%) of commercial Sitka spruce forest; 84p per household/year for a 12,000 ha increase in Lowland New Broadleaved Native forest, and £1.13 per household/year for a similar increase in Ancient Semi Natural Woodland.
- £124,998 for each death avoided by 1 year due to PM10 and SO₂ absorbed by trees, and £602 for an 11 day hospital stay avoided due to reduced respiratory illness.
- A cost of 13p to £1.24 per m³ where water is lost to abstraction for potable uses, although for most areas the marginal cost is zero. The

externality cost of woodland on water quality has been 'internalised' within forestry through the application of guidelines on woodland planting and conditions attached to forest certification.

8. Conclusion

To conclude, the ecosystem services offered by the Wye Valley AONB are essential to human wellbeing in the area. They provide the services we all rely on such as food and clean water; they provide opportunities for employment and recreation, culture and heritage. AONB designation itself demonstrates that the area has significant landscape value.

By recognising the importance of the services provided by ecosystems, it is possible to make more informed decisions of the effects on the natural environment of any proposed development.

The Wye Valley AONB unit has shown through its management plan that it is committed to ensuring the sustainable management of the area's natural resources. It also recognises that change is inevitable and when it does occur, it must happen in a manner which contributes to a better quality of life for current and future generations, without undermining the quality of the natural environment and the ecosystem services it provides.

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