The Feasibility of Valuing Woodland's Contribution to Regulating Water Quality and Quantity

SUMMARY

1. This note summarises work by an ADAS-Eftec consortium for the Forestry Commission to assess the feasibility of valuing the contribution of woodland to regulating water flows and water quality in Great Britain. The study focuses on valuing the water quality and quantity benefits of existing woodlands across GB but also considers local assessments of woodland creation in specific catchments.

2. Woodlands provide a number of water-based ecosystem services[1] which can benefit people in four main ways:
    - **A reduction in the costs of public water supply**
    - **Alteration of the quality of water and of wetland environments**
    - **A reduction in flood risk and associated damages**
    - **A reduction in service interruptions (e.g. water supply) during droughts (i.e. hosepipe bans)**

    The study focuses on valuing the contribution of ***existing woodland***; however, it also suggests ways in which to value the benefits of ***woodland creation*.** The study is multidisciplinary, combining economics, forestry, ecology, hydrology and GIS (Geographic Information Systems) analysis.

3. Any method to value the benefits of water-based ecosystem services must be based on a *scientific understanding of woodland as an ecosystem*. Natural systems are complex and it is necessary to construct *models* to simplify these processes and *quantify* the physical effects of woodland on the water environment. The models available vary widely depending on *data* availability and the assumptions made in their construction. The final step is to use economic techniques to *value* the benefits provided. The report **proposes four options for carrying out a valuation study.**

4. Valuing existing woodlands requires estimating a '*baseline*' scenario where those woodlands have not been planted. This requires making a judgement of the land-use that would be most likely if the woodland was not there. The study proposes using two **land classification systems**[2] which assess the potential productivity of land across the UK. This gives an indication of the likely land-use in the absence of woodlands. The value of existing woodland is the difference between the current situation and the baseline scenario.

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[1] An ecosystem service is defined as an attribute of the natural environment which can provide a benefit to society. For woodlands, these can include slowing the flow of pollutants into water bodies and the capacity to store greater volumes of flood water compared to other land uses.

[2] These are separate systems for each country rather than alternatives: The Agricultural Land Classification system (England & Wales) and the Macaulay Land Capability for Agriculture system (Scotland)

5. **ECOSYSTEM SERVICES**

The report identifies two main ways in which woodlands influence ecosystem services.

- **Replacement effects:** The existence of woodlands on an area of land directly replaces any alternative use of that land. A change in land-use from agriculture to woodlands leads to direct changes in ecosystem services. These changes may include a reduction in the pollution of water bodies from sources such as nitrates, sediments and pesticides. They also include changes in water use – which can be positive in terms of increasing the soils water storage capacity or negative in terms of reducing water resources.

- **Interception (and retention) effects:** Woodlands intercept and retain water flowing from adjacent land. For example, woodlands can impede the flow of pollutants from adjacent land into water bodies, which is of particular importance on land with steep gradients.

Woodland located on steep slopes is typically at a small scale. Larger scale afforestation is more typically found on less steep land. Therefore, replacement effects are potentially more important in national or regional valuations of existing woodland but interception effects may be significant at a more local level.

6. **MODELS**

The study evaluates a range of models that can quantify either the replacement effects or both the replacement and interception effects of woodland. These are divided into four categories:

- **Pollutant models:** These models estimate the loads of pollutants which are transferred into water bodies from areas of land with and without woodland. Pollutant models only estimate replacement effects of woodland and also cannot model flood risk reduction.

- **Ecosystem Service Models:** These models, such as inVEST and TIM, quantify many different ecosystem services at the same time and can therefore be expanded to value more than just the water-related ecosystem services of woodland. They have also been specifically developed with monetary valuation as a long-term goal. Some of these models, such as inVEST, are capable of modelling the interception effects of woodlands. Some models can model flood risk reduction to an extent.

- **Catchment Scale Water Models:** These models analyse aspects such as water quality and water flows in a particular catchment area (i.e. where surface water following rainfall converges to a single point at a lower elevation, usually it joins another body of water) and can provide more accurate results than the pollutant or ecosystem service models due to the finer scale at which they operate. Certain models can model flood risk reduction.

7. **DATA**

The study reviews and evaluates potential data sources. It identifies wide-ranging data needs on land-use/land cover, soil, geology, topography, catchments, pollutant sources, climate, crop management, river flows, water quality, stream networks, floodplain size and spring/well location. There is at least one suitable or potentially suitable dataset for each type of data need above. However, the **cost of acquiring certain datasets may be prohibitively expensive.**

8. VALUATION

Valuation approaches are proposed for each of the four benefits that people gain from water-based ecosystem services from woodlands and summarised below. These approaches are based on techniques widely used by economists to estimate values for benefits which are not fully valued in markets.

- **Reduction in costs of public water supply:** A 'replacement cost' method is suggested which would estimate the cost of maintaining the quality of water supplied in the absence of woodland's role in pollution removal. Without woodlands, water may need to be treated (i.e. purified) via more expensive means. These values may be particularly sensitive because treatment costs can vary widely across catchment areas.

- **Change in quality of water/wetland environments:** A 'stated preference' method is suggested which requires data on people's willingness to pay (i.e. £X.XX per year per household to improve the water quality of a river) for improved water quality. Data of this nature is already collected by most UK water companies.

- **Reduction in flood risk and associated damages:** Two methods are suggested. One method combines estimates of the potential damage caused by a flood and the lower probability of flooding due to the presence of woodlands. The second method involves estimating the effect of flood risk on house prices.

- **Reduction in service interruptions during a drought:** Stated preference data is also collected by water companies on people's willingness to pay for fewer hosepipe bans and this could be used to value this benefit, or dis-benefit, of woodlands.

9. RECOMMENDATIONS

The study recommends four options to value the water-related benefits of woodlands. The table on the next page gives a breakdown of these options. Each option models the replacement effects of woodland but the options vary in terms of whether or not interception effects are modelled as well as ecosystem services, such as flood risk reduction. Option 4 is the only proposal to analyse the best place to plant new trees within a catchment in order to maximise their water related benefits. The first 3 options all propose ways to value the benefits of existing woodlands at a national scale or regional scale.

Option 1 proposes a pollutant loss model to estimate water quality changes. It can model pollutant changes but cannot be used for estimating flood regulation. The method is relatively simple to use and easy to apply and the model has already been adapted for use in England and Wales. The method cannot account for any interception or retention effects mainly because it works at a broad scale.

Option 2 suggests using inVEST, an ecosystem service model developed in the US, which can model nutrient, sediment, pesticide and drought regulation. The inVEST model is easy to use and, unlike pollutant loss models, is specifically designed to value ecosystem services but may require some technical adaptions to be used in the UK . Using inVEST would mean other, non-water, ecosystem services could also be valued. It would be a more costly option than 1 and similarly cannot model flood regulation.

Option 3 Proposes using Cas-Hydro, a catchment scale model, which would capture both flood regulation and interception/retention effects. A number of representative catchments would need to be modelled from which national results could be estimated. This option would be considerably more expensive than option 1 or 2 but provide more accurate results.

Option 4 proposes a method for optimising the placement of woodland creation within a catchment. The study suggests either using a spatial ecosystem model or a catchment level modelling approach similar to option 3. The costs of option 4 would be reduced if carried out in tandem with option 3.

Philip Duffy
Corporate and Forestry Support
Forestry Commission
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Woodland Valued	**Option**	**Ecological processes modelled**	**Benefits valued**	**Estimated Cost**	**Important Notes**
Existing Woodlands	APT (Pollutant Loss) model	• Pollutant loss from land use change (excluding pesticides). • Excludes all interception effects.	• Reducing costs of public water supply. • Quality of water environment.	£30k - £50k	• Parameterised for England and Wales, but not Scotland. • Does not model route flowing, essential for flooding benefits. • Models multiple pollutants under one framework. • Representation of woodland is relatively simple.
	inVEST model	• Pollutant loss from land use change. • Tier 2 model can capture interception effects.	• Reducing costs of public water supply. • Quality of water environment.	£40k – £60k	• Peer-reviewed model. • Supports scenario analysis and monetary valuation. • Can include other benefits. • Static model (unsuitable for flood modelling) • Not tested in the UK.
	Catchment Area Model (1)	• Pollutant loss from land use change. • Water stored. • Interception and retention effects.	• Reducing costs of public water supply. • Flood regulation. • Quality of water environment.	£220k-£330k or £370k-£480k	• Captures finer-scale effects. • More accurate valuations • Considerable effort and cost to develop this model in comparison with other options. • Not freely available software.
Woodland Creation	Catchment Area Model (2)	• Pollutant loss from land use change. • Water stored. • Interception and retention effects.	• Reduction in service disruption. • Reducing costs of public water supply. • Flood regulation. Quality of water environment.	£130k-£140k	• The only proposed option for valuing the creation of new woodlands, but harder to aggregate to a national level. • High variation amongst catchments, which might be missed in a model. • Potential for over-estimation of benefits and values