Cost benefit analysis of woodland planting to protect water resources

Introduction

This collection of five case studies provides examples of cost benefit analyses of woodland planting to protect water resources in the USA, Denmark, Germany and Great Britain.

Case Study 1: Catskill watershed protection programme, New York

Description

Integrated water resource management to protect high quality drinking water supply (from phosphorus and microbial pathogens) and preserve natural catchment filtration, rather than constructing and maintaining expensive new water treatment facilities.

Approach

This local public payment scheme, administered by a non-profit organisation, was initiated with money from the city of New York, the State of New York and the Federal Government. The scheme is now financed by a tax included in New York water users' bills. Stakeholders involved in the development and implementation of the programme include foresters, landowners, farmers, government officials, technical agencies and business.

Protection and remediation programmes include the Watershed forestry programme – a voluntary pollution prevention and educational partnership between the city and the forestry community, which supports and maintains well-managed forests as a beneficial land cover for watershed protection.

Specific projects and programmes are implemented by the Watershed Agricultural Council (WAC) and its various partners, with the US Department of Agriculture Forest Service providing a major source of matching grants and project funding. The Department of Environmental Protection has provided funds to the WAC for four major forestry tasks, including implementing a forestry Basin Management Plan, covering 2841 acres (1150 ha) of riparian land. Model forests have been established at two locations including a range of forestry management practices. Land acquisition increased New York City ownership from 3.5% of the watershed to 10.9%.

Three types of payment are involved: compensation (subsidies/logging permits/property tax reduction) to landowners for better land management practices; property transfer (land development rights) to farmers and landowners in exchange for agreements to follow good management practices; and development of new markets for non-timber products and timber product certification).

The scheme has succeeded in reducing phosphorus loadings, chlorophyll *a* and water pathogens.

Payment/cost benefit analysis(CBA)

Total of ~ €1.35 billion ($1.5 billion) invested since 1991, equivalent to €3,257 ha^{-1} (catchment area = 1600 square miles).

Reference

Bureau of Water Supply (2006). New York City Department of Environmental Protection Long-Term Watershed Protection Program.

Case Study 2: City of Aalborg, Denmark

Description

Protection of groundwater resource from diffuse pollution (nitrate and pesticides) and provision of recreational facilities close to the city.

Approach

This public funded payment scheme purchased key land areas for water protection and recreation; farmland was bought from farmers, with those who wanted to continue conventional farming offered land outside the drinking water catchment area. The city worked with landowners, farmers and other members of the community to reduce use of pesticides, nitrogen and other chemicals.

Around 900 ha of intensive agriculture have been converted into 500 ha of forest (natural broadleaved woodland) and 400 ha of pasture. New methods for afforestation and sustainable agriculture have been developed. Local people have been kept informed of campaigns throughout the project.

Nitrate concentration in groundwater has decreased from >120 mg l^{-1} to < 10 mg l^{-1} and pesticide use has ceased on the converted areas.

Payment/CBA

Government funded: €402,000 per year from city of Aalborg for land purchase plus €805,000 from EU LIFE project between 1991 and 2001.
Actual costs: €14,000 – 21,000 ha^{-1} to purchase land, and €3000 – 6000 ha^{-1} for cultivation and woodland planting.

CBA for European Commission:
Loss of agricultural income = €290 ha^{-1} yr^{-1};
Leisure/amenity benefit = €750 ha^{-1} of forest per year for increased house property value and recreational activities (hedonic price method);
Carbon benefit = €108 ha^{-1} forest per year for first 90 years (assuming an absorption capacity of 8 tons C ha^{-1} yr^{-1} and a price of €13.5 ton^{-1} CO_2);
Drinking water benefit = cost saved estimated at a minimum value of €489 ha^{-1} yr^{-1} (€440,000 per year) for water treatment (cost of NO_3 removal estimated at €0.2 m^{-3} for > 50 mg l^{-1} NO_3).

Net social benefit (excluding drinking water cost saving) = €187 ha^{-1} yr^{-1} (€168,000 per year).

Reference

Water4all (2005). *Sustainable Groundwater Management: A Handbook of best practice to reduce agricultural impacts on groundwater quality* with Annex.

Case Study 3: Thülsfelde, Lower Saxony, Germany

Description

Afforestation to achieve good water quality by excluding further application of liquid manure and pesticides to the soil, thereby protecting local groundwater resource from diffuse pollution (from rising nitrate and pesticide concentrations).

Approach

This partnership between water and state forest agency operates a state administered payment scheme via local co-operatives (115 co-operatives throughout Lower Saxony, representing 300 000 ha).
Water companies levy a water abstraction charge on consumers ('water penny'); the money is passed to the state government who give it to the state forestry agency for afforestation, with conditions that the groundwater level is not lowered and pesticides are not applied. Other measures include provision of advice and compensation to local farmers and private foresters, promotion of best management practice measures, and organic farming.

The combined measures have led to a reduction in nitrate concentrations from over 100 mg l^{-1} to < 50 mg l^{-1} (drinking water decree level).

Payment/CBA

Local tax: 5 cents m^{-3} (water penny) used to finance preventative groundwater protection. Industrial and agricultural use is charged at lower rates, e.g. fishery users pay 0.25 cent m^{-3} water, while the nuclear energy industry pay 1 cent m^{-3} for cooling water.

Land purchase for afforestation cost: €15,000-40,000 ha^{-1}, equivalent to €600 ha^{-1} yr^{-1} over 25 years (minimum project period).
Planting cost averaged €5,000-6,000 ha^{-1}.
Agri-environment payments also made to farmers.

Reference

Water4all (2005). *Sustainable groundwater management: a handbook of best practice to reduce agricultural impacts on groundwater quality* with Annex.

Case Study 4: Slea catchment, Lincolnshire, England

Description

Assessing land-use scenarios to improve groundwater quality (reduce nitrate concentration).

Approach

These model simulations assess the effects of land-use change scenarios on nitrate concentrations.
Evaluation of costs associated with land-use change scenarios include:
land-use protection zones, e.g. low input grassland and/or woodland in targeted areas (such as well capture zones and in upper River Slea catchment); conversion of arable to grassland and woodland within water protection zones (total area of 3200 ha), moving from 2003 baseline of 14% grass and 3% woodland to 30% grass (960 ha) and 20% woodland (640 ha); simulation of the Danish Drastrup type scheme.
Protection zone scenario simulations suggest a reduction in nitrate concentrations from > 100 mg l^{-1} to below the regulatory 50 mg l^{-1} drinking water limit.

Payment/CBA

Conversion using average exchange rate for 2006: £1 = €1.47.

Cost of land-use change estimated at €1.96 million (£1.33 million) per year, equivalent to 0.068 cents (0.046p) per litre of water (based on an output of 8 Ml d^{-1}) or 12 cents (8p) per person per day (based on average per person use of 180 l d^{-1}) or approximately €44 (£30) per person per year.

Nitrate water treatment costs in the Sleaford WSZ are approximately €12 (£8) per person per year so the additional cost would be €44 - €12 = €32 (£30 - £8 = £22).

Biodiversity and amenity benefits provided by conversion to grassland and woodland need to be considered.

Land-use changes could produce substantial reductions in nitrate levels on a timescale of 10 to 20 years

Reference

Lovett, A.A., Hiscock, K.M., Dockerty, T.L., Saich, A., Sandhu, C., Johnson, P.A., Sandhu, C., Sunnenberg, G. and Appleton, K.J. (2006). *Assessing land-use scenarios to improve groundwater quality: a Slea catchment study.* Environment Agency Science Report SC030126/SR. Environment Agency, Bristol.

Case Study 5: Assessment of social and environmental benefits of forests in Great Britain

Description

The impact of forests and woodland on water supply, recreation, landscape, biodiversity, carbon sequestration and pollution.

Approach

The impact of woodland and forests on water supply was assessed from hydrological and ecological models of the effect of woodland on rainfall inception and transpiration rates compared to grassland. The cost of woodland on water supply can be estimated from marginal costs faced by different water companies for abstracting potable water supplies. Information from existing literature and discussions with water companies were used to assess the impact of forests on water quality.

Payment/CBA

Conversion using average exchange rate for 2003: £1 = € 1.45.
The marginal benefits of woodland were estimated to be:

- €2.41 to €3.99 (£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.

- 51 cents (35p) per household per year for enhanced biodiversity in each 12 000 ha (1%) of commercial Sitka spruce forest; €1.22 (84p) per household per year for a 12 000 ha increase in lowland new native broadleaved woodland, and €1.64 (£1.13) per household per year for a similar increase in ancient and semi-natural woodland.
- €9.67 (£6.67) per tonne of carbon sequestrated.
- €181,247 (£124,998) for each death avoided by 1 year due to PM_{10} and SO_2 absorbed by trees, and €873 (£602) for an 11-day hospital stay avoided due to reduced respiratory illness.
- A cost of 19 cents to €1.80 (3p to £1.24) per m^3 where water is lost to abstraction for potable uses, although for most areas the marginal cost is zero.

Whilst hydrologists point to the potentially large impact of forestry on water availability, British water companies perceive generally little impact of existing forests on water supply costs. However, there is no database on the opportunity cost of water supply and water quality improvements on a spatial unit basis. Hence the costs and benefits of forestry on water supply and water quality cannot at present be mapped in any accurate, robust and reliable manner. The externality cost of woodland on water quality has been internalised within forestry through the application of guidelines ('Forests and Water') on woodland planting and conditions attached to forest certification.

The value of all the benefits at a Great Britain level is approximately €2.2 bn (£1.5 bn) per year or, as a capitalised value (at a 3.5% per annum discount rate), approximately €62 bn (£43 bn). The single largest value is for biodiversity (49%) and then recreation (39%). Approximately 75% of the total benefits in Great Britain accrue in England.

Reference

Willis, K.G., Garrod, G., Scarpa, R., Powe, N., Lovett, A., Bateman, I.J., Hanley, N. and Macmillan D.C. (2003). *The social and environmental benefits of forests in Great Britain*. Report to the Forestry Commission, Edinburgh.