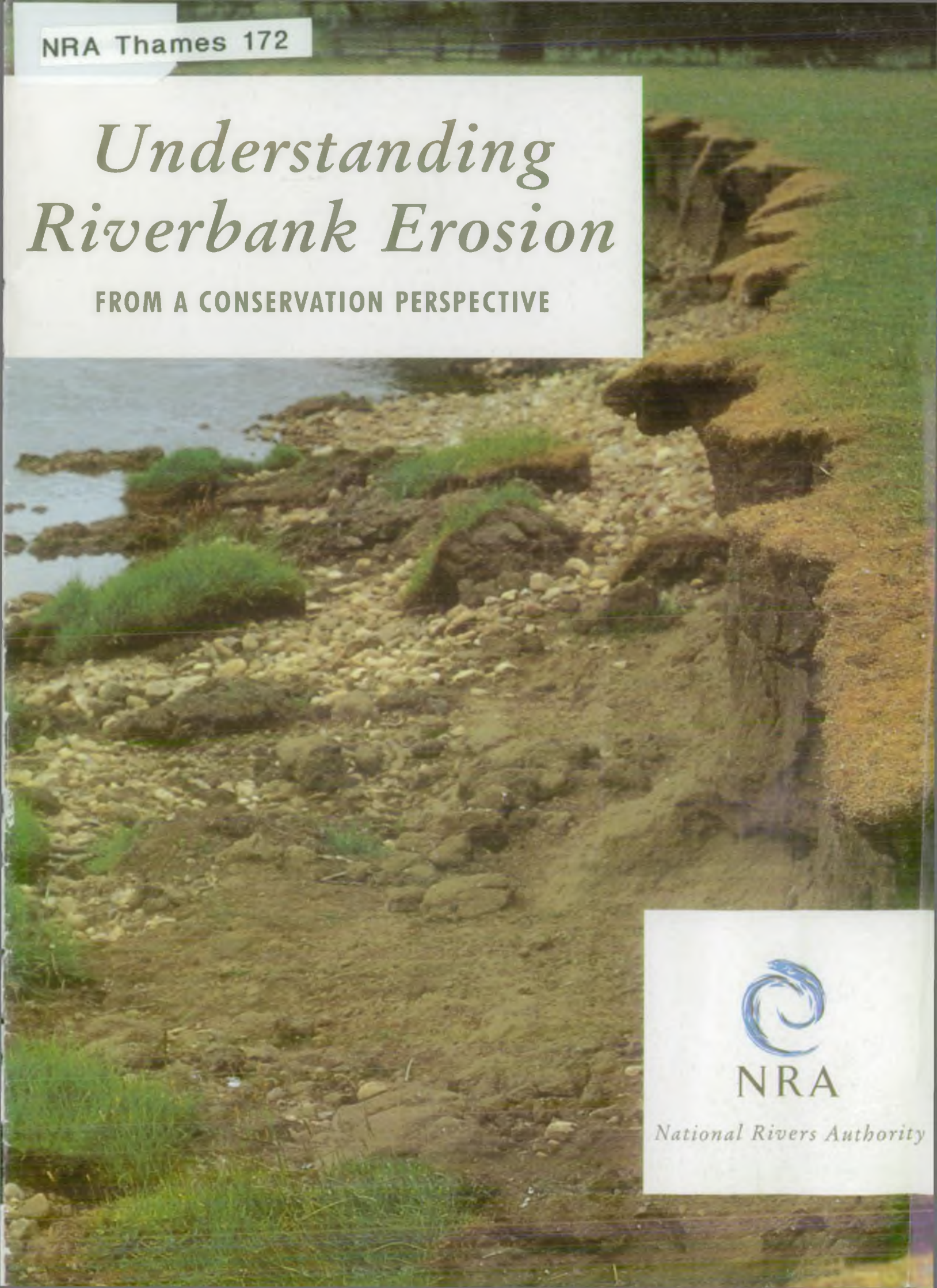
Understanding Riverbank Erosion

FROM A CONSERVATION PERSPECTIVE



NRA

National Rivers Authority

Understanding Riverbank Erosion
- from a conservation perspective

INTRODUCTION

The Authority has a statutory duty to further and enhance conservation in all its functions with respect to the water environment (Flood Defence, Water Quality, Water Resources and Fisheries) and to encourage others to do the same. The purpose of this document is to encourage landowners and managers to contribute to this process by creating habitats for wildlife as one method of combatting erosion. Riverbank erosion cannot be prevented completely, but this booklet will help to explain why it occurs, and provide guidelines on environmentally friendly and cost effective ways of coping with the problem - where it is feasible.

WHAT IS EROSION?

Erosion is most commonly caused by the process of soil washing away after the protective layer of vegetation has been weakened, damaged or removed. As soon as soil is exposed to the elements wind and water, erosion is likely to occur. The erosive power of water, and particularly the power of a river in flood is formidable. However the ability of healthy vegetation (grassland, scrub or trees) to withstand these forces should not be underestimated. Other factors play a part; the slope and structure of the bank, the soil structure, weathering (of steep cliffs for example), and the dimensions of the river channel. For the purposes of this booklet, vegetation is the most important key to bank protection and that largely depends on the use of the adjacent land.

1. As soon as vegetative cover is removed, the soil is exposed to water and erosion will occur.

LAND USE

Land use is the factor that dominates the sensitivity of the landscape to erosion: the 'wildwood' climax vegetation which covered Britain almost totally 7-8,000 years ago is the least sensitive to erosion and arable land is the most sensitive. Since this wildwood period, the landscape of Britain has been gradually deforested until today the landscape is largely agricultural. This change has

been brought about by man and his activities. At first man lived on the higher land which was easier to clear of trees. Later, as the population grew, more land was needed for food and livestock and the forests were gradually cleared so that the lowlands could be inhabited. During more recent times the very wet and boggy lowlands began to be drained, and run-off rates increased; water had to be 'got off the land' (95% of Britains wetlands have now been drained). As a direct result of this drainage, larger volumes of water began to flow in the rivers, particularly during floods, and flood defences were needed to prevent serious flooding. Rivers became 'engineered' and larger volumes of water were confined within smaller channels than would occur naturally; as a result the erosive power of rivers increased greatly. Man's influence continued to increase; mining, moor-gripping (upland drainage), afforestation, deforestation, agricultural changes, river engineering, urban development and recreational activities have all caused changes which can affect the scale and speed of riverbank erosion. Less than 10% of Britain is now covered by trees, and over 80% of it is agricultural land. For these reasons more of Britain is presently more sensitive to erosion than it has been at any time since woodland clearance began. It is this land use which is having the most impact on our riverbanks today.

WHAT IS A NATURAL RIVER?

Rivers are dynamic systems, and to understand the process of erosion it is useful to compare the state of the rivers in Britain today with their 'natural' state during the wildwood period mentioned earlier. About 10,000 years ago, Britain was coming out of the last ice-age and various types of forest were gradually covering all but the highest areas of land. During this wildwood period there would have been some large and some small scale erosion taking place and some major floods, but trees dominated the landscape and their roots helped to hold the soils of the hills and the floodplains together. A forest canopy can intercept up to 30% of the rainfall which then evaporates before it reaches the ground. In the summer transpiration from the trees would also have 'diverted' enormous quantities of moisture from the wooded wetlands into the atmosphere, and upland mires and bogs would have retained water during wet and dry periods. Less rain water reached the rivers in forested times than it does today. Another effect of all these factors was that run-off rates were much more constant, thus lessening the erosive power of floods. Wetland vegetation on the floodplains would also have helped to filter out silts and sediments brought down by floods upstream, and consequently the water in these natural rivers would generally have been crystal clear. During this wildwood period when woodlands were at their maximum extent in Britain, the land was less prone to erosion than at any other time in its history.

2. In Britain, forests were the climax vegetation after the last ice-age. Notice the moss and algae on the boulders of this river bed indicating that the channel bed and banks are stable.

WHY IS VEGETATION SO IMPORTANT?

Trees: In a survey of river widths, Hydraulics Research found that tree-lined rivers were on average 30% narrower than similar rivers from which the bankside trees had been removed. Well managed trees can reduce riverbank erosion by as much as 85 - 90%. Tree roots help to bind the bank materials together, whether they are loamy, silty soils, or boulders and cobbles. Trees have a remarkable capacity for surviving on and stabilizing what can, in times of flood, be a very hostile environment.

3. A small group of trees surviving in the River Ure at Aysgarth Falls in Wensleydale.

Other vegetation: all types of vegetation provide better protection against erosion than bare soil. For example, it is very important that the Authority makes sure that floodbanks are maintained to a high standard. Grass cover on floodbanks must be continuous because bare patches or holes caused by moles, rabbits and other pests can lead to a 'blow-out' with possibly devastating consequences. Grass cover can be mown, grazed or left long; the roots will bind the soil and the leaves help to protect the bank. Narrow sections can be fenced off from stock and either grazed less intensively or not grazed at all so that scrub and other vegetation can develop naturally. A mixture of naturally regenerated grasses, scrub and trees is likely to provide the best protection of all because of the range of rooting depths of the different species. These naturally regenerated areas are also likely to provide the most valuable habitats for a wide range of wildlife.

Trees and other vegetation have many advantages for wildlife:

- They provide shelter, nesting and roosting sites, and protection from predators.
- They provide shade, keeping the water cooler in summer and slowing the growth of algae.
- They provide food in the form of invertebrates and organic material which can fall into the water and provide food for other invertebrates and fish.
- Tree roots and low branches can help to protect fish from predators and floods. A stretch of river devoid of adjacent trees usually has only a small population of fish.
- Tree roots provide spawning areas for coarse fish.

Understanding Riverbank Erosion
- important considerations

I) What is the Authority's policy on riverbank erosion?

II) What are the legal aspects?

III) The effects of work on other areas of the river

IV) Aesthetic values

V) Access

VI) Rivers and wildlife

I) WHAT IS THE AUTHORITY'S POLICY ON RIVERBANK EROSION?

The erosion of riverbanks is the responsibility of the riparian owner. The Authority has no responsibility or liability for the erosion of riverbanks except where their erosion could threaten flood defences or hinder drainage. Only then may permissive action be taken by the Authority, but each case has to be judged on its merits.

II) WHAT ARE THE LEGAL ASPECTS?

Riparian owners can, through Common Law, take action to prevent erosion provided that in doing so they comply with planning legislation and byelaws, and do not alter the flow of the watercourse or cause injury to other parties.

Planning legislation - if a permanent structure of any sort is to be built on the river bank then planning permission will be required. If material which has originated outside the bounds of an individual land holding is to be placed on the riverbank then planning permission will be required. These regulations come under the Town and Country Planning General Development Order 1988 and the Environmental Protection Act 1991. In 1992 a new law on waste, the duty of care, means that all reasonable steps must be taken to look after any waste and to prevent its illegal disposal by others. Check with your County Council or the Department of Environment, as a failure to comply may result in an unlimited fine.

The Authorities Legislation - the Water Resources Act 1991, the Land Drainage Act 1991 and the Land Drainage Byelaws enable the Authority to carry out its duty to protect life and property from flooding. To fulfil this role, the Authority issues 'Works in Rivers' consents which protect its obligations to other river users and encourage landowners to take account of the wildlife value of the area. These consents are for the landowners own protection. Through this process the

Authority can ensure that any works do not endanger life or damage property by increasing the risk of flooding. The Authority is unable to give grants for the prevention of erosion but it does have a wide range of expertise - engineers, fisheries and conservation staff - who may be able to give advice.

III) THE EFFECTS OF WORK ON OTHER AREAS OF THE RIVER

A fluvial geomorphologist would be needed to predict accurately the effects that one engineering scheme, new floodbank or other work might have on other reaches of the river, either up-stream, downstream or on the opposite bank. However, any scheme is almost certain to have some effect somewhere. Never interfere with or remove material from the river bed without first taking professional advice; the bed of the river may be de-stabilised by the removal of the armour covering of rock/sediment and a new erosion problem may be initiated. Groynes built into the channel to deflect the flow of water away from the bank may have the opposite effect and contribute to the erosion. Unless it is very carefully designed any structure placed in the channel may cause problems. Be considerate to neighbouring farmers and other river users. Building a floodbank on your land may push flood water further over to the opposite side, and may spoil crops on a neighbours land and upset neighbourly relations. Always ask the Authority for advice and apply for a 'Works in Rivers' consent before starting any work.

4. A groyne was built into the channel to deflect the current away from the bank.Unfortunately the opposite effect occurred and the erosion was exacerbated.

IV) AESTHETIC VALUES

One all too common do-it-yourself method of trying to prevent erosion is fly-tipping. It does not seem to matter whether the area is within a National Park or in other areas designated for their beauty, tipping still occurs. The Authority is very concerned about tipping because, although the material tipped is usually inert and causes no pollution problems, it is aesthetically displeasing and upsets many people; furthermore, it is illegal and totally ineffective. Bank protection materials need to be either compact and integrated with the bank or extremely heavy to be effective. The tipped material often ends up on the river bed in the

5. Tipping is illegal, unsightly and unneccessary.

6. This 'hard engineered' scheme was costly and is being undercut after only two years.

7. Examples of pitching can be seen in the Yorkshire Dales today, still in a good condition after 150 years or more.

next flood, and it is then likely to cause more erosion as it is carried downstream. The material may damage fish spawning grounds, or even in serious cases block the flow of water. Tipping will also prevent any vegetation growing which may then help to stabilize the bank. If you know of areas that have been recently tipped or see fly-tipping taking place, please report the details to your County Council immediately.

Stoning riverbanks with large boulders is a method being increasingly used to try to prevent erosion. Stoning is very expensive, is often unsightly and has little wildlife value. In situations where stoning is being considered, it may be that only the 'toe' (where the riverbed meets the bank) needs to be protected and willow planting could be used on the bank above the toe. Stoning is also a 'hard engineered' surface with none of the energy absorbing properties of vegetation, it will be buffeted by wave action and water will ricochet off it downstream on to another possibly unprotected riverbank. The success rate of stoning work is also likely to be limited because the stones are easily undercut. In situations where stoning is necessary, a combination of both 'hard' and 'soft' (vegetative) techniques is likely to be far more successful.

One traditional way of protecting riverbanks was using a method called 'pitching'. Pitching was a type of dry stone walling carried out at the toe of the bank. Vegetation, including trees was then encouraged to protect the bank higher up. In the past when estates were wealthy, labour cheap, and survival depended on the crops grown on the floodplain, full time 'river keepers' were employed to maintain the riverbanks. This tradition provides evidence on how important toe protection and riverbank maintenance are if riverbanks are to be successfully stabilized.

V) ACCESS

Public rights of way often follow riverbanks, and erosion can make the path dangerous and make it necessary to move it to a safer site. This is a problem which faces both landowners and the highways authorities and the cost of moving the footpath to a safer place or rebuilding it in the same place can be prohibitive. The heavy use of a footpath is likely to damage the surface and

surrounding vegetation, expose the soil and make the path vulnerable to erosion. The surface of the path may need to be protected or it may be easier and cheaper in the long term to redirect the path. If the erosion is affecting the riverbank ensure that the bank is protected before the erosion threatens the path. In many cases all that may be needed is to fence the area from people and stock to allow the existing vegetation to recover.

VI) RIVERS AND WILDLIFE

It is important to remember that some degree of erosion is natural. Not every section of all rivers need to be tree lined, and it would be unrealistic and unnatural to stop erosion altogether; in fact dynamic reaches are important for wildlife because they increase the range of habitat types available. But it is necessary to limit erosion on stretches of river that are severely affected.

Listed below are some of the beneficial and detrimental effects of erosion as far as wildlife is concerned:

The beneficial effects of erosion:

- Rivers are formed by the flow of water and the transport of sediments. Erosion is part of the natural cycle of a river, creating and re-creating a variety of habitats along its length from source to estuary.
- A diversity of habitats generally means a diversity of species. The more diverse the river channel, the greater the variety of habitats and species there will be. The more varied the vegetation on the banks of the river the more different species are likely to occupy them.
- Many species have adapted to specific types of habitat that have been created by the processes of erosion eg.

  - Sandmartins and kingfishers nest in freshly eroding sandy cliffs.

  - Other ground nesting birds such as sandpiper and oystercatcher use gravel shoals to nest on.

  - Exposed soil or substrate is important for many invertebrate species.

  - Large trees with undercut roots may make excellent lying-up areas or breeding holts for otters.

8. Sandmartins find a nesting site in freshly eroding silty soil. In this particular case the field which is eroding away is a herb rich hay meadow in the Yorkshire Dales.

The detrimental effects of erosion:

- Large quantities of soils and sediments washed from river banks may cause long term damage to the gravel beds used as spawning grounds by trout and salmon and kill the eggs if the silt is deposited after spawning. Spawning grounds may be washed away completely.
- Valuable habitats on adjacent land may be damaged or lost by the processes of erosion.
- Turbidity caused by suspended solids carried in the water may smother plant life, decrease the rate of photosynthesis and adversely affect the food chain from the plants upwards.
- Large amounts of suspended solids may damage the gills of fish, reduce their rate of respiration and possibly lead to disease problems.
- Siltation is leading to a decline in the length of rivers and streams suitable for fish such as salmon and trout.
- Nutrients are washed into the rivers with the soil. These nutrients (particularly phosphates) lead to the eutrophication (nutrient enrichment or fertilization) of rivers, streams and lakes, which encourages fast growing plant species and/or algae and leads to a decrease in the diversity of both plants and animals. This effect can be noticed both in the river channel and on the riverbanks where nettles and other vigorous plants may out compete smaller species.
- In some river systems old lead mining areas may erode causing pollution downstream. Whilst this can lead to specialised vegetation types growing on these areas, if mammals ingest silt with a high lead content the results can be fatal.

Understanding Riverbank Erosion
- management practices

This booklet can give only a very brief summary of the management practices available. These practices are appropriate for sites where erosion is occurring on a small scale; their success depends as much on their continuing maintenance as on their initial design. Remember to take into consideration the character of the local landscape and use techniques which are appropriate for that area.

GRAZING LAND

Overgrazing: In the last ten years sheep numbers in Britain have increased by an average of 34%. In many areas this has contributed to a serious degradation or loss of wildlife habitats; riverbanks are no exception. All stock can cause damage by exposing the soil by overgazing or trampling. Where stock are allowed to the waters edge, the cover for wildlife may be non-existant because no vegetation can regenerate where regular grazing occurs. Drinking water is sometimes available only from the river, and because there is often continuous access, damage can occur along the whole length of a field. It is good practice to keep grazing densities as low as possible, especially during the winter and spring and during drought conditions, and to allow stock to the waters edge in only one or two safe areas. In general, if the stocking densities are low enough there should be no overgrazing or erosion problems. If damage to the bank has occurred, then the riverside should be fenced off except for the drinking areas. The fencing can be temporary, and removed once the vegetation has recovered, though stocking rates should be reduced thereafter. If bankside scrub or trees are to be encouraged then permanent fencing will be necessary.

Grants: The Countryside Commission's 'Countryside Stewardship Scheme' has an option for 'waterside landscapes'. Annual payments per hectare are available to offset the loss of income due to reducing the stocking rates and managing the land extensively, without fertilizers or chemicals. Buffer zone payments may be negotiable, depending on individual situations and the potential benefits for wildlife. Payments may also be available to help with fencing and other capital costs. Stewardship agreements run for ten years.

9. This photograph clearly shows the difference between grazed and ungrazed banks. The land on the left is arable and the riverbank has been planted with willows. On the right the field is overgrazed and the soil is becoming exposed. The tree is also being damaged by stock.

ARABLE LAND

Where there is arable land adjacent to the river there may be good vegetative cover alongside the riverbank itself, (because of the lack of grazing), but the width of this area may be restricted. Modern agriculture often includes cropping right up to the hedgerow, wood, river or stream. Heavy machinery on the top of the bank may damage the soil structure and weaken the bank. The amount of cover available for wildlife is limited by the width of this 'corridor'. Widening these areas has many benefits, not just by helping to combat erosion, but also by increasing the wildlife and game potential of the land.

10. A lowland watercourse running through intensively farmed land. A healthy margin of vegetation helps to protect the bank from erosion and the stream from agricultural runoff.

Grants: The Countryside Commission's 'Countryside Stewardship Scheme' has a field margin option which aims to take arable land out of production and create species rich grasslands as habitats in their own right and to help to protect other wildlife habitats, for example alongside woodland, hedgerows or rivers. The payments are very generous; at the time of writing (1995) a two metre wide strip of grass margin receives £15 per 100 metres for the ten year agreement period (a rate of £750/ha/year for the area entered). There is also a six metre strip option which is eligible for a payment of £35 per 100 metres per year (£583/ha/year).

Set-aside land may be another area into which benefits for wildlife can be incorporated. The set-aside options change regularly, so contact either MAFF or the Farming and Wildlife Advisory Group for the most up to date information.

PUBLIC PRESSURE

Large numbers of people can cause damage to riverbanks, for example at 'honeypot' sites, or along the many footpaths which follow riverbanks. If damage is occurring, temporarily fencing off an area may help the vegetation to regenerate. Placing a sign explaining the situation will help people to understand why this action has been necessary.

Grants: The Countryside Commission's 'Countryside Stewardship Scheme' is designed to benefit both people and wildlife. If an area has public access and an erosion problem, it is possible that this scheme could help provide fencing to protect the riverbank and encourage cover for wildlife. Other grants may be available from County Councils to encourage a greater diversity of habitats along river banks, particularly if people are allowed access to the river and can see and benefit from the improvements.

11. Damage to a riverbank may be exacerbated by too many people.

ESTABLISHING VEGETATION ON THE RIVERBANK

Natural regeneration: Once stock have been removed from an area, the existing vegetation will be rejuvenated and other plant species will colonise naturally. This is likely to be the cheapest method of protecting a riverbank and also the most successful. Plants which colonise an area naturally are likely to thrive, a diversity of species will appear and within a few years an area of rich natural habitat will develop. These areas will protect the riverbanks most effectively, require the least maintenance, encourage the greatest diversity of animal species, and will look natural and enhance the visual quality of the river corridor.

12. A naturally regenerated, stable 'buffer zone' between the river and set-aside land. This photograph has been taken a few yards upstream from photo 4.

Willow stakes: Willow stakes are particularly suitable for planting on the riverbanks of fast flowing, spatey rivers. There are several species suitable; the osier (Salix viminalis); sallow (Salix cinerea) or hybrid combinations; some crack willow (Salix fragilis) and white willow (Salix alba) will produce many stemmed coppice if cut regularly. All these species are easy to grow from stakes cut from the parent tree, and any regrowth will be springy and pliant when young. Try to use locally available native species where possible and coppice a mature willow stool completely to allow it to regrow healthy shoots. In a flood when the willows are likely to be under water they will absorb some of the floods energy without being damaged and they will also provide cover for fish which may otherwise be swept downstream. The best time of year to plant willows is between November and February, and it is essential to fence the newly planted stakes from stock. Willow stakes are cut about a metre in length and 5 - 8 cm in diameter. With a bill hook, sharpen the end which grew nearest the ground (like a pencil), to expose the layer which will grow the new roots, and hammer the stake into the riverbank until two thirds are in the ground. The willow will die if it is not planted the correct way up, and the bottom of the stake should reach the water table level. If necessary trim a couple of inches from the top to remove any damaged wood and leave the stake to grow. The planting density will depend on the cover required and the subsequent frequency of management, but 1 - 1 1/2 metres apart will allow plenty of regrowth before the trees need coppicing. Willows should not be planted on the banks of smaller streams where they may grow to fill the whole channel unless they are coppiced every other year or so. (Healthy, coppiced willow can grow two metres a year). Remember that the future management of these willows is vital to ensure continued bank protection. Regular coppicing promotes vigorous, healthy growth of both roots and shoots.

13. Newly planted willow stakes. Willow kidding has been carried out to protect the bank toe. Notice the gentle gradient of the reprofiled bank. The area has also been sown with grass seed to protect the soil surface.

Willow whips: Willow whips are the smaller branches and twigs which will be cut from the stakes. These can be trimmed and tied firmly into bundles. Lay the bundles of willows between the stakes and wire or stake them into the bank. The use of bundles will encourage the accretion of river silt so they are very useful where eroding banks need to be built up. The bundles will sprout forming a dense mat of root and shoot growth trapping more silt. With careful management the riverbank may gradually build up over several years. This traditional management technique is called faggoting. Willow bundles can also be used to protect the bank toe. The bundles are staked into the ground along the toe of the bank. Once they grow a dense mat of vegetation will give extra protection to the banks most vulnerable area.

14. Healthy growth of willow stakes and willow bundles, one year on from planting.

Willow management: Willows need to be coppiced regularly, on a five, ten or fifteen year cycle, to remain effective. Coppicing stops the willows becoming too old and brittle. If the willows become too large, water may wash behind them and damage the bank or they may collect brash and be torn away, exposing a new 'nick point' from which erosion can start. Willows which are regularly managed will provide plenty of healthy willow stakes with which to protect other areas. Do not coppice too large a proportion of the willows at any one time, always leave sections of cover for wildlife and fish.

Other more complicated techniques using willow are available, but specialist knowledge is required and this is beyond the scope of this booklet. An excellant reference book is The New Rivers and Wildlife Handbook, (1994) by the Royal Society for the Protection of Birds, National Rivers Authority, and Royal Society for Nature Conservation, and published by the RSPB (£19.95). This book has a whole section on management practices to benefit wildlife, including case studies and photographs.

15. In the foreground are freshly cut willow stakes ready for replanting. The riverbank is lined with willows a section of which have just been coppiced.

TREE PLANTING

Remember, tree planting is not appropriate for all landscapes, for example in some of the lowland grazing marshes and fenlands in Britain. In these areas a considerable amount of protection will still be afforded by using temporary fencing to keep stock away from the riverbank, allowing longer vegetation to grow, and grazing it occasionally to prevent the development of scrub and trees.

16. Erosion occurred on this site partly because trees and shrubs growing on an island to the left of the photograph were unmanaged and channel capacity was reduced. Coppicing some of the bankside trees will allow more light to reach the ground and reduce the weight on the top of the bank.

Single trees: Planting trees along riverbanks is not easy because of the difficulties in getting them established and to survive floods when they are young. Fencing is also essential to protect the trees from sheep and cattle and it will need to be repaired after floods to keep it stockproof. Care should also be taken to use the right species for the section of river in question. Only plant locally native species. Upland rivers often have birch and alder growing beside them. Alder is found in the middle reaches too, but willow is more often found in the lower reaches. The smaller the trees are when they are planted, the better chance they will have to withstand floods and become established. Often the simplest way of establishing locally native trees beside a river or stream is to fence off a margin and allow this to vegetate naturally.

Groups of trees: As a general rule never plant groups of hardwoods too close to a river or stream. Floodplain woodlands, shelterbelts and other planted areas should all be set well back from the riverbank. Densely planted trees will shade out the protective layer of vegetation on the surface of the ground and may expose the soil to erosion. The weight of trees growing on a bank may also destabilize it. Consider also the shading effect on the watercourse itself. Always leave a wide margin between the river and any plantation for access, shrub planting and natural regeneration. This type of design will also help to increase habitat diversity.

Tree management: Trees need to be managed if they are to continue to function as bank protectors. If neglected they can themselves contribute to erosion by toppling into the river and leaving a gaping hole which can easily be eroded. Pollard willows are no longer a common sight but overgrown willows with broken branches are; such trees are less effective as bank stabilizers and their life expectancy has also been reduced. Pollard trees are very valuable for wildlife and the management of neglected specimens and the planting of new ones is to be encouraged where appropriate. 'Instant' pollard willows can be created by planting giant willow stakes in the way described above; the stakes should be at least twenty centimetres in diameter and three metres long. About two metres should be left above ground level so that any regrowth will not be grazed by stock. Remember that stock will also eat the bark of trees particularly if there is not enough grass available. Trees growing on steep banks above a river may destabilize the bank once they grow too large for the slope to support their weight. These trees will start to slide or fall down the slope often taking other trees in their path. In this situation it is best to remove the oldest trees and replant so that the bank can become stable once more.

17. Several years of regrowth on an ancient pollard willow.

Understanding Riverbank Erosion
- some golden rules

18. This bank has eroded and slumped on the inside of a bend. The slump is now protecting the toe of the bank, but erosion is still likely to occur higher up. Fencing this bank from stock may help to protect the bank in the long term.

19. The field adajcent to this riverbank is a haymeadow and probably only grazed by stock once the hay crop has been removed. As a consequence the riverside vegetation is diverse, healthy and insensitive to erosion.

Prevention is better than cure: large scale erosion can be very destructive, so look out for vulnerable areas and protect them as soon as practicable. Erosion can occur on the inside and on the outside of bends, and on straight sections of a river, so never presume that an area is safe. It may only take a fallen tree, overgrazing or trampling to expose a 'nick point' which may then destabilize whole stretches of riverbank.

Weigh up the possibilities: the cost of protecting riverbanks against erosion by using engineering methods will continue to increase. Resources spent on habitat improvement to help stabilize riverbanks are likely to be far better value for money in the long term. It will not be practical to protect some sites of erosion by any means, and in these cases the river may be allowed to find its own equilibrium. Alternately it may be possible to stabilize areas on either side of the floodplain and allow the river to move between them.

Use your eyes: look at sections of the river and compare them with others. Are the sections similar, but one has been eroded and the other has not? What is the difference between these sites? How have they been protected or managed in the past? Has this protection worked or failed and why? Look at the trees; the other vegetation; the soil structure; the landuse and the landform. It will pay to copy nature wherever possible.

Beware bare soil: if a riverbank becomes denuded of vegetation, whether through severe floods, overgrazing or mechanical damage it becomes very prone to erosion. It is important to retain any kind of native vegetation and to encourage it to regrow as quickly as possible. This is particularly important on areas of coarse soils, sandy loams and gravels, especially if they are already showing signs of cracking. Heavier clay soils are more resistant to erosion.

The river channel: a stable river channel can very easily be de-stabilized and made more prone to erosion by taking a machine along the bed of the river, or by removing material from its bed for use in reconstructing the bank. Both these operations should be avoided. Fish spawning grounds may be damaged and gravel shoals which could be important for ground nesting birds may also be affected. Any material needed to reprofile the bank should ideally be taken from the bank itself or from adjacent land.

20. Bulldozing the river bed in this area to create gravel floodbanks has helped to destabilize the riverbanks immediately downstream. Photo 8 was taken just downstream of this site.

Protecting the bank 'toe': the toe of a bank is where the bank meets the river bed and it is particularly vulnerable to erosion. If bank work has been carried out without 'keying in' or giving extra protection to the toe then it is likely to be eroded first and undermine the protection higher up. Similarly it is important to 'tie-in' new work thoroughly at both ends by giving extra protection to these vulnerable points. During floods the river may erode the bank at higher levels, and these also need to have a protective layer of healthy vegetation. Do not leave a section half finished, because the uncompleted section may be more vulnerable than it was before and could jeapordise the survival of any completed sections.

Gradients: if any reprofiling is necessary as part of riverbank protection, try to make sure that the gradient is a maximum of 45 degrees, and preferably much less. This will take more land, but a gentle gradient will absorb energy from a river in flood better than a steep or vertical bank which will have to take the full force of the water. A gentle gradient is also much easier to plant with trees or grass, and is safer for people and stock. Carry out the work at a time of year when flooding is less likely and grass is easily established. Re-vegetate as quickly as possible.

21. This photograph illustrates what will happen to willow stakes if they are not fenced from stock. These were ready to plant but unfortunately they were left the wrong side of the fence.

Maintenance: there is no point in spending time and resources on stabilizing riverbanks if no follow up maintenance work is planned. This is probably the most important 'golden rule' of all, particularly where willow and other trees are being used to protect the bank. Trees must be managed regularly, (little and often is a good rule) and by so doing the life of the trees and of the bank will be lengthened many times over. Fences to protect areas from stock must also be maintained.

Buffer zones: if riverbank erosion is a problem instead of thinking "can I afford to put this land into a buffer zone?" ask yourself "can I afford not to?" Buffer zones and tree planting may save your field in ten or twenty years time. Sensitive management of the whole field adjacent to the river will increase the wildlife value of a larger area and help to improve the water quality as well. Vegetation alongside riverbanks is cheap to install, it is natural, it is effective and if managed very cheap to maintain.

Conservation management: in Britain man has been managing the countryside for thousands of years. As a result a diverse mosaic of landscapes and habitats have been created, all with the potential to support a rich variety of wildlife. Conservation today is about managing all land and water sensitively to maximise that potential - ie. not over managing it and not neglecting it either.

Grants and FWAG: if you are interested in improving the wildlife value, not just of your riverside areas, but your farm as a whole, then the Farming and Wildlife Advisory Group's 'whole farm' approach to conservation will help you. FWAG advisers can draw up Whole Farm Conservation Plans, advise on habitat management, environmentally sensitive farming techniques and advise on the many grants which may be available for habitat creation and management. Far from costing you money, conservation may save you money in the long term.

22. The field alongside this river is being grazed extensively under the Countryside Stewardship Scheme to benefit wildlife and water quality.

The river catchment: The Authority is implementing Catchment Management Plans for all the rivers in England and Wales. These will facilitate the effective management of each river system. Many rivers, or sections of river, suffer from erosion problems which cost the Authority (and therefore the taxpayer), landowners and managers tens of millions of pounds every year. 'Natural', sensitively managed rivers will require the least maintenance in the long term, provide the best value for the people who wish to enjoy them and give the most benefit to wildlife. The Authority needs landowners to help it to manage the whole environment of rivers. Please apply to the Authority for advice where necessary and, if possible, work together with adjacent landowners to protect the environment of your river.

FURTHER ADVICE

FWAG - The Farming and Wildlife Advisory Group. If you are interested in grant information and the whole farm approach to conservation, contact FWAG's head office at Stoneleigh (Tel: 01203 696699) for the name and address of your county adviser.

Countryside Commission - regional offices can be found in the local telephone directory. The Countryside Commission's headquarters are in Cheltenham on 01242 521381.

Forestry Authority - grants may be available from the Forestry Authority for planting large and small areas of broadleaved woodland. In some areas of the country 'floodplain woodlands' are being encouraged. Free advice is available on the suitability of sites for tree planting. Local offices can be found in the telephone directory, or contact the Cambridge office on 01223 314546.

MAFF - for the most up to date information on set-aside contact your local MAFF office.

BTCV - The British Trust for Conservation Volunteers carry out conservation management work at very reasonable rates. Work is carried out under skilled supervision on day, weekend or week long tasks. Contact the head office in Wallingford on 01491 839766 for the telephone number of your local group.

FURTHER READING

The New Rivers and Wildlife Handbook

RSPB, NRA, The Wildlife Trusts 1994.

Taming the Flood

A history and natural history of rivers and wetlands, by Jeremy Pursglove, 1988. Published by Oxford University Press.

Hydrology and the River Environment

Malcolm Newson 1994. Published by Oxford University Press.

Landscape Sensitivity

Edited by D.S.J. Thomas and R.J. Allison 1993. Published by John Wiley and Sons Ltd. See Chapter 12 'Sensitivity of the British Landscape to Erosion' by Robert Evans.

Waste Management - the Duty of Care, A Code of Practice

ISBN 011 75 25 57 X is published by HMSO. Available from HMSO bookshops or by telephoning 0171 873 9090.

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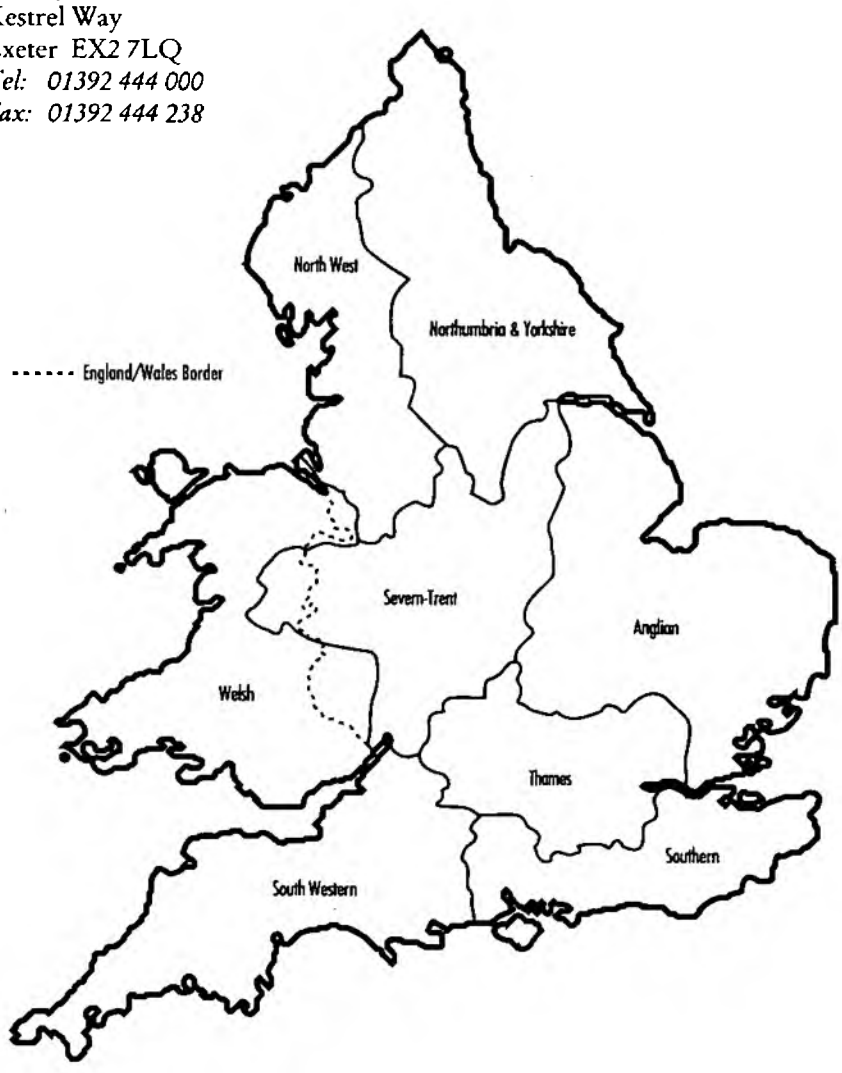

The NRA is committed to the principles of stewardship and sustainability. In addition to pursuing its statutory responsibilities as Guardians of the Water Environment, the NRA will aim to establish and demonstrate wise environmental practice throughout all its functions.

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