S. M. HASLAM

The Riverscape and the River

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The study of water in the landscape is a new and rapidly expanding field Rivers make riverscapes (even if the rivers are frozen) and riverscapes then determine the rivers: except for the ever-increasing human impact. Dr Haslam examines how the quantity, function and ecology of water changes as it moves from watershed to river. The development of river and riverscape, their ecology, the effect of human activities (such as water abstractions, flood control and management for recreational use) and water resources are described both in principle and using case histories. Contrasting examples are given from across the world, including Iceland, Hungary, Malta, Britain and the USA, which enables understanding of how water and riverscape interact with each other, and with human impact. The study, development and loss of water resources is also described, including the extreme example of Malta, whose clean water now depends solely on oil imports. This innovative book is aimed at undergraduate and graduate students and professionals, but is also accessible to anyone interested in how water and riverscape interact.

DR S. M. HASLAM is a fresh water ecologist in the Department of Plant Sciences at Cambridge University.

The Riverscape and the River

S. M. Haslam,
M.A., Sc.D.
Department of Plant Sciences
University of Cambridge, England

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To: Mr H. W. Haslam and Mrs J. M. Psaila who (more than others) drove the author hither and drove her thither, in England and Malta, respectively, so that she could study the riverscapes.

Thou makest springs gush forth in the valleys,
they flow between the hills,
they give drink to every beast of the field; . . .
the earth is satisfied with the fruit of Thy work.

Ps.104

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Preface

The study of landscape ecology has developed rapidly in the past two decades, though the limited area of riverscape has not received great attention as such. This book attempts to link river and riverscape in an integrated whole. It has more ecology (natural, cultural and historical) and less mathematics and modelling than is currently usual: reflecting my interests, and my preference for observation and synthesis.

I have worked for over 35 years on rivers, mostly on their vegetation, waters, channels and other contents. More recently I realised the interest of the wider ecosystem, of the river and the riverscape being inextricably joined, both by the water they share, and by the human impact (some interesting, most destructive) inflicted upon them. Changes have been made to allow people to survive, and indeed to live pleasantly. Great changes have also been made from ignorance or greed to remove and contaminate both water and natural heritage. *The Riverscape and the River* tries to reflect the interest and diversity of that natural heritage, and what has been done to it down the ages.

The book is primarily about Europe (with a little on North America).

S. M. H.
September 2006

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Finally, I would like to thank the publishers for their patience, waiting for me to recover from concussion caused by a continental lorry driver not knowing he had a 'blind spot' on English motorways.

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Introduction

> We belong to a time as well as a landscape
>
> (Storey, 1993)

> We seek order out of chaos.
> The more we discern, the less we seem to know.
>
> (Bell, 1997)

> Rivers . . . were made for wise men to contemplate, and for fools to pass by without consideration.
>
> (cited in Walton, 1653)

Introduction

The riverscape and the river share the sheet of water which covers the land: in whole or part, permanently or intermittently. The river is a stream of water flowing along a bed in the earth, to the sea (lake or river). The riverscape is that part of landscape which has (or had) a watercourse as its focus. Rain falls upon the riverscape. Some evaporates, some sinks below, gradually emerging as springs or flushes, and (usually) most runs down the slope, gradually collecting into the rivers and finally the seas. The hydrological cycle is finished by the evaporation of sea (and fresh) water into the air, and its precipitation back on the earth's surface.

Seeing that life on earth is based on water, and life on land, on fresh water, the river is essential to land life, as well as river life. The riverscape and, to a considerable extent all that grows on it or is put on it, depends on the river, since the river (or the ice-river of a precursor glacier) first formed the riverscape. The two are interdependent, both are modified by human impact (even in Antarctica, e.g. air and sea pollution, and climate change), and both are natural capital,

hence natural resources for people. They thus come from the interaction of natural elements such as flowing water and rising hills, and the interaction with these and the cultural dimension and its diversity. They are live archives, demonstrating the management of natural resources such as water and soil (Andressen & Curado, 2001).

The valley, according to *Chambers Dictionary*, is a stretch of country watered by a river, an elongated hollow between hills. How much can be seen, what is seen, and how it is seen, varies with the point of observation. From the river, looking out, the riverside grades up the slope, giving a fairly enclosed view, from large (to hills beyond) to small (the riverside bushes). The viewpoint can move anywhere up slope to the hill top, where the view is generally wide and open, and the overall pattern (not the river detail) can be seen better. Aerial photographs, of course, give a yet different view of the river basin. All are equally true, all showing different facets of the riverscape and river.

Riverscapes have three characters: structure, function and change.

Structure

Passing from centre outwards, first the size, shape, pattern of:

- the river and of what grows in it;
- the riverside, narrow or wide, what grows on it (e.g. wood, flooded wetland, grass, crops) and what has been put on it (e.g. houses, mills, wharfs, roads, towns, telephone wires);
- the land beyond, which may usually rise to well-marked hills or continuing lowland, or even flood plain for the extent of the riverscape view. This also has much put upon it, both vegetation and the associated animals. These may be native plants, varying from large, like trees and forests of oak, pine and so on, to small, like daisies or mosses. They may be meadow or pastures of traditional, rather than of native species. They may be agricultural crops, like cabbage or barley.

The underlying structure of topography and geology, soil and water has on it (and in it) the natural structure of vegetation, and the imposed structures of people, from isolated farms nestling in valleys to great port towns, from pilgrims' ways to radio-lines for mobile telephone masts, from canals to deep abstraction boreholes and sewage treatment works.

Function

The river and riverscape function in their own right, in the hydrological cycle and in the consequent perpetual erosion of the land and sedimentation of the sea: until the next earth movements! In the course of this, water, wetland, damp and dryland habitats appear, in which plants – and animals and

micro-organisms – can grow, spread and develop. For the past 800,000 years they have also functioned for people, to provide food, shelter, clothing, communications and much more (Table 1.1).

The river and riverscape are the basis of the human environment. They bear the plants and animals needed by people, and these are in communities influenced by people (e.g. Vink, 1983). They are working entities, places of many processes.

Change

Nothing on earth is permanent, but the scale of change varies from the long-term erosion of mountains to the short-term flood.

Interpretation

Nature, culture and history are complex, complex in themselves, and complex in their inter-relations. Few people can see and understand all, at one time. This author can visit a riverscape to look at one of (say):

river plants and channel
wetlands near rivers
river cultural patterns, past and present
settlement patterns
landscape elements
communications, for biota and people
heritage, visible and invisible.

These and more can be studied and (often) understood. But this author's head has difficulty in seeing and assessing two of these on one visit, and finds it impossible to see and interpret all. The same site yields quite different material, depending on the purpose of the visit. This factor underlies all such field study. The human brain is limited, while nature, culture and history are not – in the present state of knowledge.

Many different aspects and perceptions of river and riverscape can be, and have been, developed. Each brings out or enhances a different facet. Difficulties arise only when like is not compared with like, or when someone asserts there is only one method right and true. Looking at connectivity, for instance, that for surface water and that for the movement of herons may overlap, since both include shallow water, but the two patterns differ in content, in solidity, in time and, of course, in purpose. To call either or indeed both *the* connectivity of the riverscape is incorrect (what about hedges, woods, deer, badgers, otters, dragonflies, water lilies, roads, telephone lines . . .?) To use any to interpret part of the surface pattern is valuable. It would take a lifetime to work out total

communication lines in one place (anaerobic bacteria? nematodes? dispersion of wind-borne seeds? and to do so by species, topography, land use and season with the components thereof, winds, strength, direction; time of day; temperatures, etc. And so on, including the bird which arrives but once a century with alien seeds on its feet, and the people who walk at least 10 m from the path).

Consequently, when looking at a river and riverscape, what is seen is confusion of these and many more elements. To understand, one thread is disentangled, then another. . . But those doing the interpreting should be quick to explain these threads and how they relate to the whole riverscape: they should be very slow to condemn others working in a different way. It is better to discuss how using a different method sheds new light.

A working entity

The riverscape is a working entity, generally managed for the welfare of those living on or near it. This cultural identity has made the riverscape fascinating in its variety, pattern and processes, or dreary, in their loss. Conservators need to claim and arrange to leave the old unless a new good (not a new greed!) cannot be met without change. Then change blends with the old, the past moulding the present, and the present exhibiting the past, say:

- the village wharf, where once boats came with coals, candles and luxuries, and left with malt and vegetables;
- the holy well up the hill with the deep-set path worn by thousands of pilgrims;
- and the old wood, now belonging to the Wildlife Trust, once the source of timber for ship and manor, of charcoal, withies and fuel, and of food for pigs and deer.

Unfortunately, the destruction of the old after 1945, the Second World War, has been extreme. England has been one of the worst-damaged countries. The land has been drained, water has been abstracted, rivers and ponds have been lost, hedges and woods have been removed, wild flowers and song birds have diminished greatly under the still-increasing pressure (including Directives) to Grow More, Grow More, Grow More, More Cheaply. While conservation organisations thrive, damage thrives more and faster. Indeed, Rackham (1986) finds more destruction, in England, between 1945 and 1986 than in the previous thousand years. Malta has moved to destruction even faster, since wealth came in around 1980. Rackham & Moody (1996) consider wealth more pernicious to the country and landscape than war or earthquake. A chilling, though true, observation. For two millennia it has been written that the love of money is the root of all evil (1. Tim., 6:10). Certainly, money is at the root of most destruction of natural and

cultural heritage: the love of it, the gaining of it, and the spending of it without knowledge.

Population increases have not helped. Since 1800, Britain has increased from about 16 to nearly 60 million, Malta from 100,000 to 400,000 (including much emigration).

Riverscape elements

Landscape, riverscape, can be divided (Countryside Commission, Swanwick, 2002) into:

1. The natural: geology, land form, water, air and climate, soils, flora and fauna.
2. The cultural and social, which are superimposed on the natural; land use, from fisheries and grouse moors to huge mono-specific regions of grain, from paths to trains and motorways, from isolated farms to great dormitory suburbs. People need food, clothing and shelter, but want infinitely more than that: a never-ending stream of luxuries from baths to computers, crockery to cars (and the petrol to run them), food from half way across the globe. . . The combination of a huge population and its never-ending wants places intolerable and unsustainable pressure on the water and on the land, and degradation ensues.
3. Perceptual and aesthetic, the invisible heritage and causes of patterning. This is the history associated with the place, from a famous battle to 'I picnicked here as a child', the birthplace of great people, the inspiration for painting or writing; and love, often love enduring for centuries, for a landscape, sounds, smells and touches; farming patterns of texture and colour. It is perceptions that turn land into landscape, and so give Sense of Place. Riverscapes are distinctive parts of landscapes.

Various terms describe different scales or perceptions. One group is *Character*, a consistent pattern of elements that make a riverscape distinctive, e.g. Alpine valleys. A *Characteristic* is an element or combination making a particular contribution to the whole, e.g. Alpine meadows. *Elements* are components which make up the landscape, e.g. little valleys and woody features outlining the meadows. *Features* are prominent and eye-catching, e.g. mountains on the skyline, villages clustered round churches in the valley. *Types* occur in many broadly similar parts, e.g. flat valley bottoms with former wetland, roads and development. (Similar ties are in geology, topography, drainage, vegetation, history, settlement pattern

and land use.) Finally, *Areas* are discrete geographical areas of a particular landscape type, e.g. the chalet-farm areas of various different mountains.

Patterns in the riverscape are separated, so defined, firstly by what can be seen. It is the eye, which looks for pattern, which seeks unity and order, and finds it by omission as much as by presence. The eye recognises and categorises distinctiveness before the brain defines it. The eye flows across skylines, and notes the lines of visual force, such as hedge patterns, before the brain has recognised 'field shapes and their boundaries'. For instance:

- land form, vertical form (sheer cliff, rolling lowland to horizon), horizontal form, altitude;
- land pattern; mosaics, connections, corridors, matrix, scale, shapes random, organised, repeating, or formal;
- structural pattern, scale (small-large), enclosure (exposed, open, tight pattern, scattered), diversity (uniform, complex), texture (smooth, rugged), unity (all fields with dry stone walls, only the hill tops with these, complete jumble of field and settlement types);
- local form; shapes and patterns of fields, streams, woods, hedges, roads, settlements;
- diversity; uniform to complex (sub-divided into the above);
- line (straight, angular, curved, braided, sinuous);
- special separation; isolation, rarity, crowded, confused; it is possible to define these, but more difficult for:
- colour; monochrome, muted colours, bright ones, contrasts (e.g., conifer wood, white-stoned village, oilseed rape in flower);
- beauty, pretty, attractive, sublime, majestic, dreary, etc.;
- sound and movement; noisiness, tranquillity, calmness, busyness;
- coherence, mystery; remembrance of past fact or fiction influencing interpretation of the present (e.g. Dracula country, Transylvania; Battlefield of Waterloo, Belgium; the filmed valleys of *The Lord of the Rings*, New Zealand; Saga country, Iceland; Black Forest, Grimms' fairy tales, Germany; Yorkshire Dales, Herriot (Vet.) country, England;
- balance; harmonious, disruptive;
- holiness; sacred feature, history, building.

All of these, and more, make up the Sense of Place, more, the *Genius loci*, which is so easily recognised, so difficult to define (after Bell, 1999; Swanwick, 2002).

Catchments and their diversity

The catchment or river basin is a unit of area down which the run-off from its rain flows (or once flowed), gathering together to leave the basin at

(usually) a single point. This flow ends in the sea, but for some purposes parts of basins may be treated separately, e.g. catchments of tributaries, reaching their mouths when flowing into the main river or into a lake. A riverscape is part or all of a catchment.

Catchments vary greatly, and in a goodly diversity of features, from scale (e.g. R. Armier, Malta, 0.25 km to, say, the mighty Mississippi, USA, 15 000 km and more, even excluding tributaries) to human impact (e.g. R. Fleet, London, completely built-over and a river near Thingvellir, Iceland, with only minor alterations). Catchments vary in type. Streams may gather run-off in flowery meadows, and run through gorges. All, by definition, have (or had) a stream running through. That is their unifying characteristic.

The 'bones' of the riverscape are its rocks, underneath, or also outcropping. The jagged peaks of the Alps are outcropping rock. The gentle agricultural lowlands have their rock padded/upholstered by soil and subsoil, on which tall vegetation (not just lichens, mosses, etc.) can grow. Catchments can be Alpine or near-plain, large or small, moderately uniform to highly diverse (mountains, torrents, gorges, lowland, plateau, plain; forested, agricultural, urban). Rivers may be in a traditional state with minor or major management of them, even with them put underground; 'streams' can resemble those of a millennium ago, or can be greatly polluted or dried. More detailed culture is superimposed, the particular way of altering streams is characteristic of the country and can indicate history: the Danish dyke patterns of now-German Schleswig Holstein, for instance. The shape of *Salix alba* riverside bands varies from east to west across Europe. Neolithic field patterns may still be traced or may indeed have been incorporated into a later field pattern (re-arranged anything up to the twenty-first century).

> Still round the corner we may meet
> A sudden tree or standing stone
> That none have seen but we alone
> Hill and water under sky
> Pass them by! Pass them by!
>
> (J. R. R. Tolkien)

Round the corner the riverscape may differ sharply, in topography, land use, settlement and water use: or it may be very similar.

Where rocks outcrop, these may be vertical or craggy (e.g. some hard limestone, dolomite) or non-obtrusive or smooth, not obstructing part of the general hilly structure (e.g. Scottish gneiss). Where the rock is blanketed (soil, peat, alluvium, etc.), the blanket softens and smooths the riverscape, it may be from a few cm to many metres deep. The vegetation or buildings above add diversity,

in their shape, colour, position, height, etc., and illustrate not just present, but often past cultural, religious and social land use patterns also.

Natural capital

The term 'natural' was used a century ago, to describe habitats and ecosystems untouched, unaffected by human impact. At that time human impact was less, and, more importantly, the extent of this impact was unknown. Ancient woodlands could be described as natural, despite being originally planted and having centuries of human use. The 'natural' river Rhine had borne boats for at least two millennia. The Somerset Levels (England) wetlands were 'natural' before drainage, despite having Neolithic villages and continuous use. Although such places, if not greatly degraded, are now better described as 'traditional', the concept remains in Natural Capital. This is what the riverscape originally provided, and most, some or hardly any may now remain. The riverscape provides potential energy, the energy of the water, sediment and debris flowing down. This may be unused, lessened by drainage and drying, or harnessed for human use (e.g. water, hydropower, fisheries). The riverscape provides a surface, a space, which vegetation and buildings may use. The choice of vegetation may be, say, forest, traditional wetlands, wildflower (nutritious and sustainable) grassland, ley grass, arable and of buildings, e.g. old, fitted to landscape, bridges, wharfs; or new, ignoring past patterns. The natural capital of the medieval town (historical interest, tourism, culture, beauty, etc.) can be all too easily lost: and lost to future generations. We hold the past in trust for the future. Loss of riverscape productivity may take decades or centuries to replace. Soil may take millennia to develop. Polluted groundwater could take millennia to clean. Polluted soil and surface water is probably quicker, being on a shorter hydrological cycle. But pollution removes sensitive biota. Lost biota may be irreplaceable. For human use, the cost of cleaning increasingly dirty water for mains supply constantly increases.

The natural capital also includes the clean air, the wind, its energy and its environmental effects.

The European Union Water Framework Directive is intended to alter the thinking of all authorities and agencies dealing with river basins. If this succeeds, the idea of sustaining, while using, natural capital may also be part of maintenance and planning.

Intangible values of riverscapes

These may well also have commercial and economic value, it all depends how they are seen. Culture is the hidden hand of land use planning, it marks

boundaries, selects the valued and the useless, leads to maps, place names, artists. Something is more valuable in a cultural or historic context – the whole is more than the sum of its parts. There are traces of different eras, overlapping layers, local and regional values, written in age-old spiritual and symbolic meaning (One person's home is another's discovery) (Alumäe *et al*., 2001).

The English early nineteenth-century painter, John Constable, painted countryside river and riverscape pictures, particularly in the Dedham part of Essex. This is now marketed as 'Constable Country', and those living there are now profiting by the vision and talent of a great man. They do so while continuing to degrade the original riverscape, losing the non-enduring natural capital. The same applies in many areas: and those areas where tourists will pay because a great person lived there are (a little) more likely to preserve that which people will pay to see.

> Man's wonder-making hand had everywhere
> subdued all circumstance of stubborn soil
> Of fen and moor reclaimed, rich gardens smiled
> And prosperous hamlets rose, amidst the wild.
>
> (R. Southey)

Every riverscape settled by people becomes a blend of the natural and the human. There is a surface fabric made by people, and this book attempts to analyse the materials of the construction and the patterns of its design (after Williams, 1970).

Riverscapes, rural and urban, private and public, are and were and have been designed for human life, comfort, convenience, prosperity and delight. Old-settled riverscapes developed over centuries (and the few quick-growing towns had far fewer people than now), and developed in relation to the natural features on which they depended. These were likely to be 'good' riverscapes. In recently developed riverscapes, where dependence on natural features is less or absent, and – as often – design is absent, the environment develops for short-term, perhaps greedy purposes (see, for instance, the 'industrial farmland' fringing Milan, new housing estates by rivers in Malta and nineteenth-century towns elsewhere). This can be said to be uncivilised, and the term 'progress' merely means loss. As with government, society shall have the environment it deserves (Edwards, 1962).

Places come into being through being named, and the name encloses a place. Hence countries, mountain passes, lakes and rivers (Feld & Basso, 1996). The limits of the name enclose a place. Artistic appreciation may need only paint and canvas, but for others, words are needed, words to describe, interpret and illuminate. They may also (Feld & Basso, 1996) give a poetic overlay, geography, above

the literal meaning (e.g. Altnacealgach, the burn of the deceivers, R. Rihana, the river of the myrtle tree).

The intangible can be classed as (Baker 1992):

nature (humanity insignificant)
habitat (people adjusted to nature)
artefacts (from shops to telephone wires)
systems (interacting processes from erosion and sedimentation, to food production and sustainability)
problems (from making better roads to making their effects on ecology minimal)
wealth (from the quality of farming and ownership of land, to the architecture of the old centre of the river port town and of the modern bridge)
places (mountains, historic trees, villages and fields of different ages, and their names and meanings)
history (dating and changes – and features visible or findable – from twentieth century backwards, and historical 'blocks', from different periods of history, as a Mediaeval village with ex-open field system of pasture and arable and a modern village independent of the land around, except for roads in and out)
aesthetics (artistic quality, or the 'good feel' from just looking at riverscapes, and the extreme variety, from green and pleasant lowland with winding streams, to mountains with raging torrents, to Rhine barges, to beauties of Amsterdam)
ideology (cultural values and social philosophy. This is where Monet painted the water lilies. These are the valleys worked by the vet known by the fictional name of James Herriot. Here, in the marshes of Maldon, the Saxons, defeated by the Danes, gained a moral victory and an undying poem. This Gozo cave valley and river mouth is (perhaps) Calypso's cave in the *Odyssey*. This defunct railway above Huy is the last remains of the once-thriving iron valley town. This riverscape shows settlement and farming by independent farmers, that, by local social patterns, the other, dictated by central government. That land is sacred, from the lives of the saints who lived here.

Ideas and feelings come from within (Peterken, 1996) are evoked differently by different people. The same view can bring 'Look at that church on the horizon with its ray of light.' and 'What a long walk home.' The future of the riverscape

may depend on temperament and luck evoking the first, if a new housing estate is proposed.

Yet all these integrate, and no one perspective is 'better' or 'truer' in itself,. Those who plan the maintenance and change of riverscapes do well to remember all, however, since now change can so easily destroy the value created by centuries of culture, and the unique habitats of the riverscape resulting from this, superimposed on the natural.

Riverscapes have been the inspiration of artists, e.g. Beaumont, Boudin, Constable, Cuyp, Matisse, Millais, Monet, Ninham, Pissarro, Rembrandt, Renoir, Rossetti, Symoens, Turner, van Ruysdael, Siberechts, Watteau, and of the innumerable 'ordinary people' who understand beauty similarly, but who are not great painters.

Poets also have been inspired, though rather less often, e.g. Arany, Blake, both Brownings, Jukasz, Petöfi, Swift and Wordsworth.

Composers, perhaps pre-eminently Grieg, have been inspired to high art by landscapes (but, unlike artists, these have tended to have, and compose for, city life). The two can combine, e.g. Handel's Water Music, composed for a royal procession on the Thames.

Prose authors have not been missing. Many in the English-speaking world have their first encounter with the cultural value of water with Jeremy Fisher (Beatrix Potter), following it with *The Wind in the Willows* (K. Grahame), the watery adventures of Arthur Ransome's children and others. Adult fiction is more likely to include riverscapes in passing, from Shakespeare and Spenser onwards, though the Arthurian cycle has water scenes of primary importance. Dickens in *Our Mutual Friend* used the Thames to good effect, as did George Eliot, for a country river in *The Mill on the Floss*.

In view of the amount of great culture given to humanity from riverscapes, they surely deserve protection and enhancement! Surely as much and more can come in the future: provided the source of inspiration is not destroyed.

For the less talented, riverscapes can appeal for beauty, artistic, intellectuality, scientific, historic, interest, familiarity or strangeness, exercise, exploration. People appreciate surroundings in which they enjoy themselves. To simplify, a gatekeeper remarked, 'When our visitors leave, they look much happier than when they came in'. Such value can hardly be overstated. Those who destroy riverscape value would say they do it for human welfare (living, working, communications, shopping). Happiness is also part of welfare: and should be part of social policy, and given to all. It also diminishes crimes of boredom, and crimes to get money for the 'happiness drugs' of alcohol and cannabis or cocaine.

Table 1.1 *Lower riverscape values (modified from Haslam, 2003)*

Hydrological and physical

1 *Water supply (for mains)*. Aquifers, bogs, flood plains, rivers, brooks. Use is too often overuse and leads to drying.
2 *Water supply for irrigation*. Rivers, brooks, etc. Wetter habitats can be used, but again this leads to drying unless only the collected natural run-out is used.
3 *Storage, dispersal and regulation of flood flows*. Flood water, dispersed on to a flood plain, and released slowly as the waters go down, reduces storm damage downstream (compared to a constricted river channel carrying the whole flow). Bog, fen, marsh and reedswamp outside larger flood plains may trap storm rainwater, and release it much more slowly. Little (and dry) flood plains, allowed to flood, may have a cumulative or local importance. (As with anything ecological, there are exceptions: wetlands that increase flash flooding.)
4 *Long-term water storage* on and in flood plains at various levels, which contribute to stream flow in drier periods (just as regulation, reservoirs, etc., mediate flows).
5 *Lessening erosion and stabilising river banks*. By lessening the force of storm flows and the amount of sediment and detritus carried, damage is reduced when the flood plain is flooded (see 3 above).
6 *Aquifer recharge or discharge*. Aquifers require to be refilled with water (particularly when used or overused for supply), and maximum water soaks in from surfaces above the aquiferous rock that are both porous and continuously wet. Alluvial deposit wetlands are the most porous, but fens and other marshes may also be good sinks. Groundwater-fed rivers and wetlands are, of course, where water discharges up from the ground. The same river or wetland, however, can have water entering by springs and also leaving by soaking down. Although it is obvious that aquifers need to be refilled, the fact is often forgotten: and folk wonder why the water supply is running short when not only is abstraction excessive, but its catchment has been built on or so converted to intensive agriculture that most rainwater runs off to the stream rather than soaking into the ground.
7 *Trapping and deposition of sediments*. When flood waters spill on to a flood plain, the sediment they carry is largely deposited. In modern terms this part-cleans the water though part-pollutes the plain. In traditional terms this made flood plain grassland the most fertile and valuable farm crop. Sediment within the river causes blockages and so dredging.

Landscape

1 *Water economy*. Because of the functions above, landscapes with wetlands have evolved, with those wetlands playing a crucial, perhaps the most crucial, part in the water economy of the region. Upsetting the balance may cause major difficulties and shortages, floods, or both.
2 *Vulnerability*. Wetlands are easily damaged or destroyed by simple land management techniques such as draining, which may have hydrological consequences distant from the treatment in both time and space.
3 *Landscape diversity*. Flood plains, variable in size and type, contribute substantially to landscape diversity, so to biotic, geomorphic and other habitat diversity.
4 *Areas of building soils*, whether bog peat, fen peat or by sedimentation.

Table 1.1 (*cont.*)

5 *Maintaining topographical variation* due to stream meandering, building soils, altering water level and hence terracing, etc.
6 *Trees and shrubs* form lines of pollards, other trees, wet or dry woodlands along streams, and woodlands and hedges beyond, contributing greatly to landscape character. They can also abate noise in urban areas.

Chemical and biochemical

1 *Clean water passing through soil*.
2 *Nutrient source and sink*.
3 *Immobilising contaminants, e.g. heavy metals, pesticides*.
4 *Provide buffer zones* to maintain water quality, and give habitats for wild flora and fauna.
5 *Constructed wetlands for pollution purification*. The chemical transformations are vitally important.
6 *Air quality improvement*, particularly by trees (which have the largest leaf area) but also by shorter vegetation, filtering particles, and degrading contaminants lifted from agricultural and urban areas (also see 1–4).
7 *Accumulating organic matter*, and so providing a sink for atmospheric carbon dioxide. The total carbon store in peat is enormous. Drainage and those other impacts affecting organic-rich soils may alter the balance of carbon cycling. Release of sufficient quantities of carbon as carbon dioxide aids global warming (carbon dioxide is a 'greenhouse gas').
8 *Storing history*. Accumulating soil also stores and preserves the history of the time, such as artefacts showing human presence and activities, pollen showing vegetation of the time, plant remains showing the vegetation of the site, animal remains, etc..

Plant and animal

1 *Accumulating organic matter* (see above).
2 *Habitat for* endangered as well as common *plant and animal species*, as refuges for species from elsewhere, and, where relevant, as corridors for animal (and plant) movement.
3 *Gene pools* for species present.
4 *Higher primary productivity* than surrounding drier lands (unless drained dry!).
5 Until overexploited, have *high secondary productivity* supporting fowl, fur, leather, feather, fish and other meat.
6 *Produce organic matter* for aquatic and floodplain food chains.
7 *Export organic matter* to downstream ecosystems.
8 *Food chain support*.
9 *Maintenance of biological integrity*. Integrity is defined as having no part or element wanting, a material wholeness, an unimpaired or uncorrupted state. Such a biological integrity of wetland is of ethical and biological – and water resources, etc. – value. It is shown by the diversity, abundance, representativeness, naturalness and rarity of the plants and animals present.
10 *Medicinal plants and leeches*, to disinfect, prevent infection and inflammation and reduce pain and tumour (Neori *et al*., 2000).

Table 1.1 (*cont.*)

11 *Crafts*, including thatching (reeds sedges, heather, other small shrubs, tall grasses, rushes), baskets, matting, woven goods with innumerable uses especially from *Salix alba, S. purpurea, S. triandra, S. viminalis*. There are numerous local varieties for different purposes, e.g. *S. alba caerulaea* for cricket bats. Clogs (e.g. alder). Construction (large plants, soils). Stuffing (feathers, fruits, e.g. *Typha*, reed). Candle wicks (rush dips). Bedding, insulation, strewing floors. Timber, etc.

12 *Food and drink*, e.g. watercress, berries, reeds, *Typha* in uncultivated parts, flower-rich meadow and other grassland and, if drained enough, grain and vegetables.

13 *Fuel*. Peat, charcoal, wood.

14 *Timber and withies*.

Economic crops

1 *Plant crops from traditional habitats*, e.g. reeds, cranberries, rushes, withies.

2 *Animal crops from traditional habitats*, e.g. deer, otter, fish, beaver, waterfowl.

3 *Peat, for energy production*, traditionally from both bog and fen. For the quantities needed for power stations, mostly bog, both raised and blanket bogs. Gas production is also from both fen and bog. Quick-growing willows and other species (incorrectly termed 'biomass') are now also used.

4 *Peat, for horticulture*. For the large quantities needed, mostly from bog.

5 *Sand and gravel*, for construction, from alluvial deposits; and for their other constituents, where relevant, e.g. alluvial tin, Dartmoor; gold, Wales.

6 *Cleaning of water*, see above.

7 *Grazing and hay* from converted wetland, marsh hay (tall species) being perhaps the wettest type. Production increases with increasing drainage and intensity of management. As diversity decreases with these and re-sowing, diet may become less balanced, so less valuable.

8 *Arable*, from conversion to drained, tilled ground. Fen peat and silt wetlands are usually particularly fertile, with high yields.

9 *Forestry*, usually conifers on bog and hill peatlands, and poplar and willow on more fertile lowland areas. These are now grown primarily for timber and paper, but – especially willow – also for electricity generation, craft and general farm and country uses. Wood for electricity generation is currently and incorrectly known as 'biomass' production. (Biomass is the total mass of the plant, under as well as over ground. 'Biomass' shoots are cut near ground level, so the stump and root remain to reshoot, while the wood is burnt.) Forestry of native species on naturally wooded wetlands is a valuable sustainable use. These include drier bogs, fens and marshes, and allow mature stands supporting a high and appropriate diversity of woodland plants and animals. Exotic tree species that usually support a poor fauna and flora, and forests frequently harvested the same year over large areas, are not satisfactory, and neither is draining or fertilising wetland so that it will bear trees.

10 *Turf*. The old and traditional meaning of 'turf' was peat, hence the many Turf Fens. However, turf in the modern sense (grass and the top soil it is growing in) can be grown in a grassland habitat, and sold for gardens, parks, etc.

Table 1.1 (*cont.*)

Societal
1 *Important natural heritage*, particularly when scarce.
2 *Representative of personal intangible values*. Wetlands, for an increasing number of people, have a charm, an attraction of their own, one that differs with the wetland type; the vast expanse of brownish bog; the reedbed where visibility is 2–3 m and the sense of isolation is profound; the grassland by the river bank, with the green and diverse land; the flowing water of the river, winding through the valley or cascading down a mountain; and the panorama of the heavens above. These much benefit those who experience them.
3 *Aesthetic values* in a more abstract way, sensory experience.
4 *Education, research and teaching*.
5 *Art and literature*.
6 *Heritage*, natural and cultural (see above).
7 *Recreation and relaxation*, other than the above: active forms of leisure such as walking, birdwatching, sports; quiet ones such as picnicking, visitor centres, car parks.
8 *Sites for impoundments* for water supply, flood relief, recreation, etc.

Values

To sum up, Table 1.1 lists the primary values of the riverscape. The consumptive value of water, and clean water at that, is pre-eminent, but food, fur, feather, timber are important. The non-consumptive ones are easy to pay lip-service to: philosophy, learning, spiritual dimensions and humanitarian concerns (Patten 1994), but they are also easy to ignore, to suppose degradation is really enhancement, or a tenth of the area is as valuable as the whole. In Malta, there was a series of ancient slab bridges over the rivers around Mdina, the capital and main garrison centre up until the sixteenth century. Of five in being in the 1980s, two have been left to rot and fall, one was removed for its stones by a local farmer, one (beside a newer bridge) was removed by the highways authority to show off a brand-new bridge, and the last is likely to go the same way when the existing main bridge is replaced. But Progress is Great!

A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.

2

The natural river and its destruction

Force not the course of the river

Eccl. 4, 26

The threshold to change is lowered by impact

(Evans, 1993)

The concept of naturalness

A straightforward definition of natural is 'untouched by Man'. By this definition, no rivers on earth are now natural: even the polar caps suffer from air pollution, climate change, and more people. Human impact, however, varies from being trivial to catchments totally built over with grossly polluted near-sterile rivers.

River systems are (excluding glaciation) as old as the land on which they flow. Precipitation falls, gathers into streams through gravity. Some evaporates, while the filter of the ground surface, the characters of that surface, and the underground storage all determine the channel flow. Its base flow depends on climate, season (and, regrettably, abstraction). Added to this is short-term storm flow (Petts & Foster, 1985). Older continental land masses, earth movements and climates also influence drainage patterns and how far a river travels. Separating Britain from the continent after the last Ice Age much disrupted river patterns! Sinking Malta, some people consider, has left 20 km streams where these were once the heads of large rivers

River systems are in a constant state of change; change in erosion, in deposition, in patterns horizontally, in patterns vertically, in temperature and precipitation, and in biota. The Icelandic river in the northern tundra (Fig. 2.1), is perhaps as close as can now be found to a natural river: but it has had some

Fig. 2.1. Iceland. Tundra, snow on mountains in summer. River pristine, not far from natural, with meanders, gentle wide banks with numerous niches, steep backs, spurs, variations in depth and flow. The harsh climate precludes the fringes of tall plants found further south. Light grazing (picture from some Icelandic organisation in the 1960s).

human impact for over a millennium, and undergone climate change from warmer than now to colder, during this time (Table 2.1). Climate change alters plant and animal life (and, less, river features).

Two concepts can, though, be used where 'natural' is untrue. In much of North America, and a little of Europe (e.g. parts of central Corsica, Iceland, Sardinia) impact has been light, and Americans term this 'pristine'. Strictly, this means ancient or primitive, but its use here is acceptable. The second concept that can be used is that of a 'traditional river', which, of course, is a concept rather difficult to define. Traditional of what? Change is continual, and has been happening at different rates at different times. For many rivers it is difficult to find documentary evidence of conditions in 1950, let alone in more distant times. We know the period *c.* 1850–1950 was moderately stable, coming after the first round of river and riverside drainage, and before the second round and the coming of extreme traffic and agrochemical pollution, abstraction and channelisation (deepening, steepening, straightening and rendering uniform). At any point in time, though, some rivers are severely impacted and others are not. It is possible, even now, to find European rivers in a traditional state or near enough, e.g. R. Scorse, Normandy, Friedbergerau, Germany, R. Ribe, Denmark, and upper R Clyde, Scotland, among very many (e.g. Haslam, 1982, 1987, Haury & Gouesse Aidara, 1999, Kohler, 1978, Kohler & Janauer, 1995, 2000).

The traditional vegetation of rivers was remarkable for its diversity of niches and species. With little drainage, river level was near ground level, and flooded. The bank edges were irregular (shelter, exposure, different depths), and spits, bars, islands and braided channels, common. Fallen trees added niches (shelter

Table 2.1 *Climate and geomorphic changes of the post-glacial era in Britain (from Gilman, 1994; Godwin, 1978; Higham, 1986; Rieley & Page, 1990)*

(a) General			
AD	1900	Warmer	
	1600	Maximum cold, climatic upturn	
	1400	Broads peat pits flooding	
	1200	Cooler, moister	
	1000	Warm	
	500	Wetter	Anglo-Saxon
BC	55	Drier, warmer, hospitable climate	Roman
	500	SUB-ATLANTIC, wetter, warmer. Much peat development	Iron Age
	2500	Climate much as now. *Sphagnum* covering sub-boreal bogs	Bronze Age
	3000	SUB-BOREAL, cooler, drier, *c.* 2 °C warmer than now, more continental. Settled agriculture. Peat decline, pine spreading over bog	Neolithic
	5500	ATLANTIC, warm (2–4 °C above present), wet blanket bog spreading over hills, replacing pine and birch Raised bog growing in lowlands	Mesolithic
	7000	BOREAL, cool, dry. Pine forest spreading over peat bog Sea level rise, Britain an island.	
	9000	PRE-BOREAL, bogs spread (e.g. Teesdale)	
	10,000	Post-glacial. Cold	Upper Palaeolithic

(b) One area, the Fenland of eastern England	
1900	Becoming dry and intensely cultivated.
1650	The Drainage of the Fens (more intermittent than would appear from the simple literature).
Mediaeval, Early Modern	Some drainage, particularly in drier eras.
Anglo-Saxon	Huge fens
Roman	Man-made watercourses, drainage
Iron Age	Build-up of silt, giving the present division of Silt and Peat Fens
1000 BC to AD 0	Sea incursion, extensive waterlogging, open sedge fen
To *c.* 2000 BC	Sea level drop, freshwater fen spread, and fen passing via carr to wood. Peat increase, trees invaded from the margin. Raised bog developing where alkaline flooding least (Middle Fens, and fen edge)
c. 2500–2000 BC	A vast brackish lagoon, 1–2 m deep, coastal silt deposited, followed by *Phragmites* then inland sedge and woods far inland
c. 2500 BC	Rapid peat development, sedge fen, recent black peat. Sedge fen leading to carr then woods
c. 3000 BC	Sea incursion, waterlogged, freshwater ponded inland. Black peat developed in this
4000–3000 BC	Dry acid peat, south fens remained alkaline, middle, to raised bog (only marginally affected by fen clay)

altered flow patterns) and organic carbon. Woods added variations in shade and the full light of glades. Flow, depth, substrate texture (and so nutrients) all varied. So plants doing well in silt or gravel, shallow or deep water, slow or rapid flow, disturbed and undisturbed, and so on, could all inhabit the river. Species richness was high. Even some nutrient variability was included, since most nutrients are found in silt, least in washed coarse particles. With little impact near the river, damage from flash floods and excess erosion was very much less: the river was adjusted to the incident rainfall.

Human impact

The movement from natural to traditional rivers began in Europe with the significant human intervention of the Romans, who altered rivers by draining land, making canals (e.g. Foss Dyke, England) and by building bridges. They also used ferries and long-distance boats (which cause disturbance, and need wharves). They introduced watermills, which impact the river both through construction and subsequent pollution when used for fulling, tanning and the like. Fisheries, often associated with mills, bring weirs, ponds, channels, disturbance. Flood banks, to protect towns, and navigation banks, to keep flow in specified channels are recorded from, e.g. Rome itself, and over the centuries these spread (twelfth-century records in France, etc.). As cities developed, quantities of concentrated human wastes developed also, so city rivers downstream became polluted.

While populations were still low, and when technology was poor (Roman standards were not maintained) direct interference with rivers was local.

Agriculture became more intensive over the centuries, at different speeds and setbacks, and with river pollution, settlements, industry and communications increasing; altering river position, size and shape; removing water increased, and rivers deteriorated.

Since people were present in Europe early, and followed the retreating ice in the north from 10 000 BC, there was impact (though still local) on the rivers, more from agriculture than from other influences. Felling forests increases flash floods, erosion and sedimentation, through failing to halt and slow precipitation movements. Cultivation has a similar effect and brings increased nutrients with eroded silt and when the land is sufficiently fertilised.

Impacts decrease variability and diversity. A flood bank by the river gives a uniform and steep bank. City pollution gives water in which no, or a few tolerant plant species, can grow.

Human impacts typically reduce available niches, with a consequent loss of species. *Oenanthe fluviatilis* was a species common in the deeper and siltier areas of English chalk streams only 70 years ago (Butcher, 1927, 1933), but is now

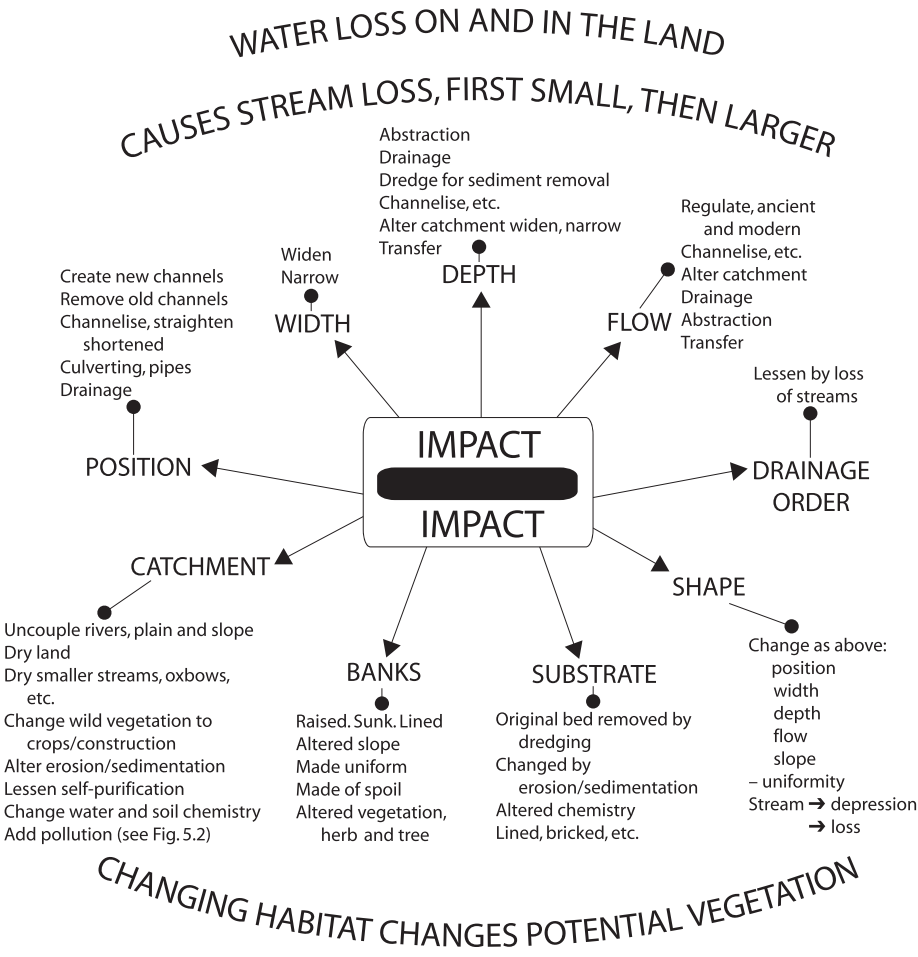


Fig. 2.2. Human impacts: effects on river size, shape and position. (Representative, not including all types and variations.)

rare: because abstraction and drainage have caused shallowing of the rivers and suitable habitats are now rare. When streams in the lower Cairngorms (Scotland) were dredged, *Juncus articulatus* communities, found on gentle, gravelly edges, vanished because the edges became steep, earthen and nutrient-rich because of the disturbed soil. When R. Lark (England) was deep dredged, *Ranunculus fluitans*, able to tolerate the moderate pollution because it could anchor in the hard gravel bed (twining its roots around firm particles), disappeared because there was no hard bed. Impacts decrease niches, so decrease species.

The rate of change has become ever greater since 1950, even given the great impacts of the previous century. There have been near-blanketing impacts of hard surface and agricultural run-off, intensive agriculture, expanding settlements, abstraction and drainage, channelling and effluents (Figs. 2.2, 2.3).

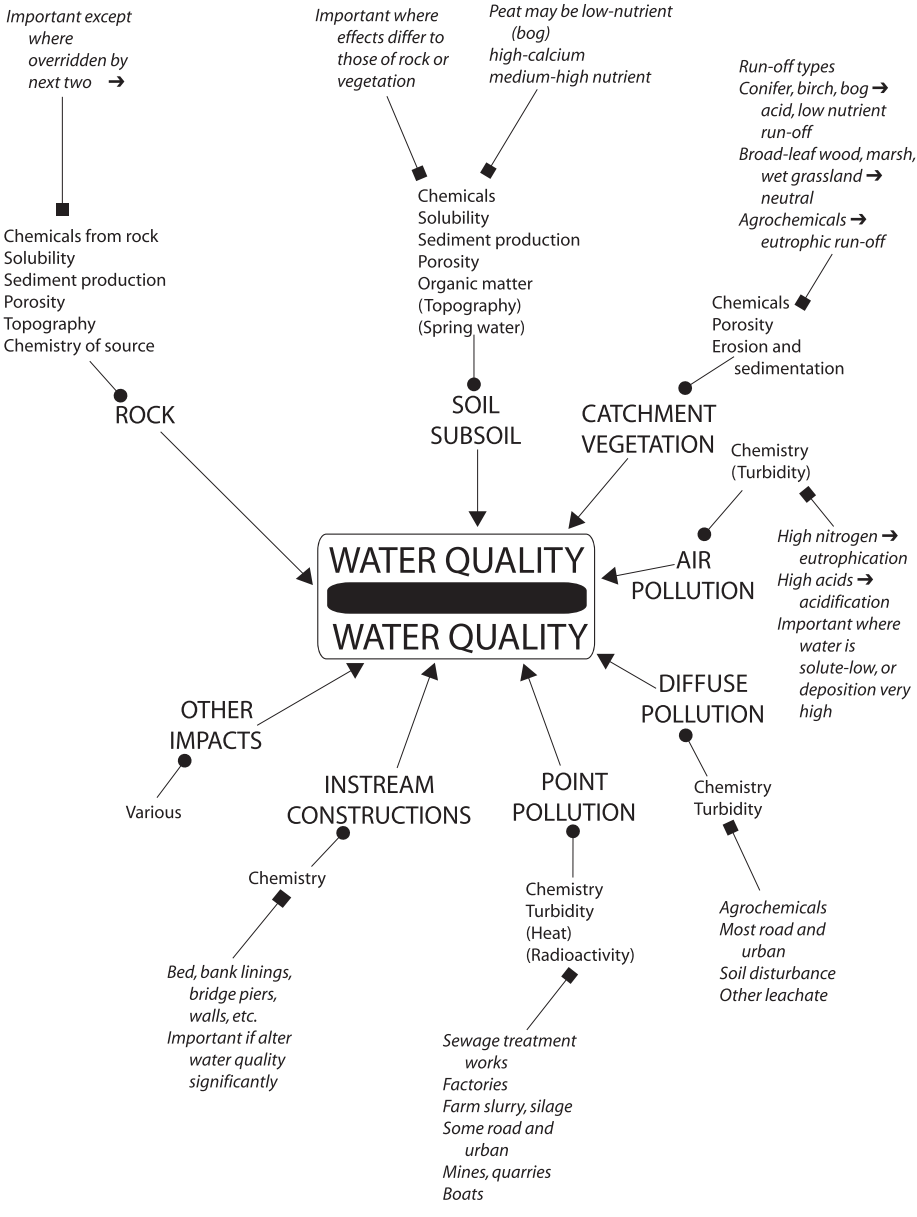


Fig. 2.3. Water quality: principal determining factors. (Representative, not including all factors and variations.)

Traditional vegetation still exists, but is hard to find, and is disappearing fast. For instance, pre-1980 the R. Yare (Norfolk) resembled rivers described by Butcher (1933). Then there was deep dredging and niches, depth and species richness diminished. Before, 20 river plant species in a 25 m stream length was normal. This richness now is very unusual, and has gone from R. Yare. Twenty species

usually means a traditional (and non-mountainous) stream. It also occurs in a site with more impact but with two chemical influences, both providing nutrient niches (e.g. clay rock below with chalk water and silt, or brackish and freshwater influence).

River vegetation

River vegetation, being part of the natural heritage of creation, is of ethical and intrinsic conservation value. It helps make the habitat for river animals. It is an important component of the carbon and nitrogen cycles, and the geochemical pattern and processes of the river. River vegetation cleans and purifies water and soil, this is the most important way freshwaters are cleaned naturally. Larger numbers of micro-organisms live on the plant surface than in water, and it is these micro-organisms which are the main chemical factory (e.g. Haslam, 1987, 1990, 1997, 2003, 2006, Seidel 1967, 1968). River plants provide stability, protecting bank and bed to some extent from erosion. They have many uses for people (Chapters 4, 8–10, 14).

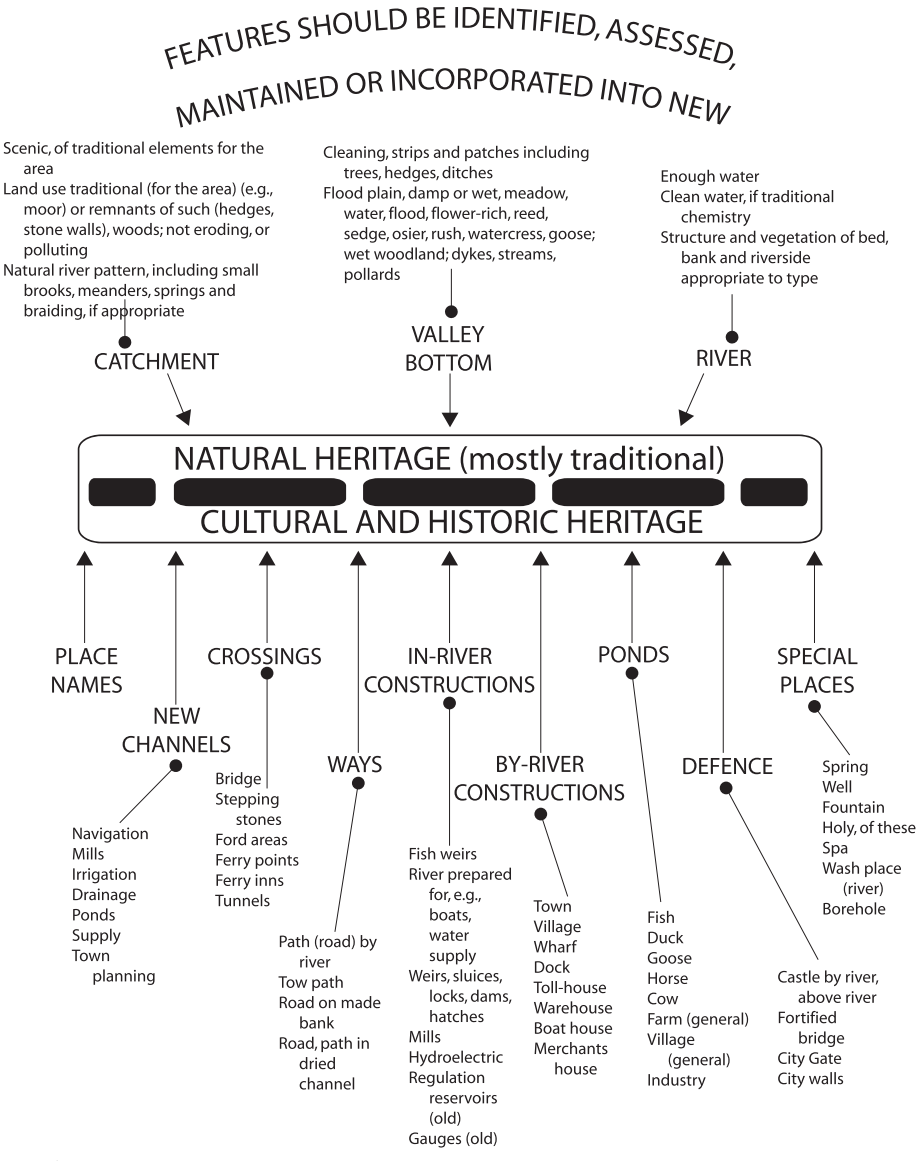
For both ethics and ecology, the vegetation should be as close as possible to the traditional or pristine (Fig. 2.4). And at least when new schemes are planned, the planning should aim towards this, not assume (as happens too often) that either any plants will do, or that the planner's favourite species should be planted!

River habitat is complex, an integrated entity of many different features.

Water plants may be entirely under the water, on the water surface, or grow through the water column and emerge above the water. Often those supported by the water may show two or all habits, such as floating leaves on stalks growing up from the soil (e.g. *Nuphar* spp.), or having submerged, floating and emerged leaves (e.g. *Sagittaria sagittifolia*). Many water-supported species have aerial flowers.

Nevertheless, habit does differ with habitat. Emerged species, photosynthesising mainly in the air, are in shallow water, at river edges, or in shallow streams. Water-supported species need space under (or on) water, so are usually in stream centres (Table 2.1, Figs. 2.5, 2.6, 2.7).

Alpine and steep mountainous streams have rapid and whitewater flow over boulders and rock, and river vegetation is either non-existent or limited to mosses on rock and emergents in sheltered edge niches. Vegetation is limited by water force, by flow. Water force depends firstly on topography (from Alps to alluvial plains) but also (a) on precipitation (as slopes steepen, increased rainfall greatly increases water force), (b) on how much of the run-off sinks to become groundwater or evaporates, and (c) whether water from underground springs – which stabilises – is a major source. The German mountains, for instance, mostly

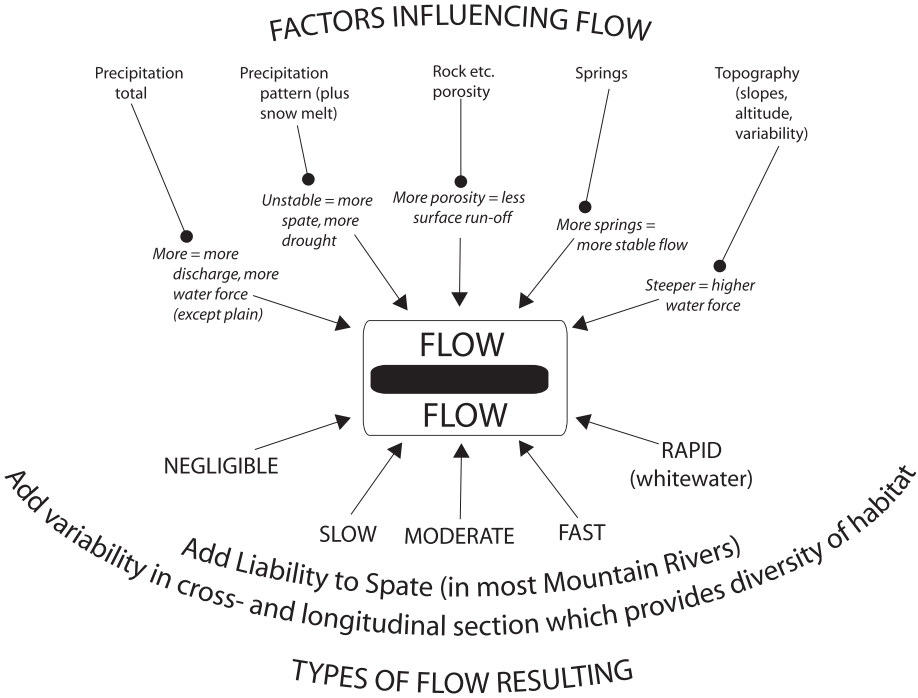


(See Haslam, 1987, 1990, 1991, 1997, 2003, 2006)

Fig. 2.4. Conservation: features of natural and historic heritage. (Some characteristic features only: incomplete.)

have high-force rivers: but not in the limestone Swabian Alps, where the river is spring-stabilised 'lowland limestone'. Water force is therefore a primary character determining river vegetation.

Anyone familiar with chalk or other lowland limestone streams knows they (if traditional, or nearly so) are full of plants, a pleasing pattern of shape,



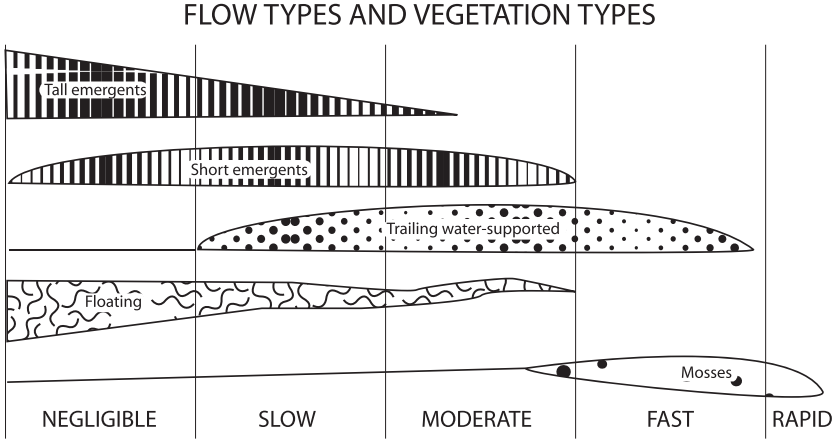


Fig. 2.5. Flow: determining factors and vegetation. (Representative, not including all types and variations.)

texture and colour, the main species having finely divided leaves (*Ranunculus* spp.). Other streams, though, may have water lilies and bulrushes, or little rosette plants under brown water. This is primarily dependent on rock type (Figs. 2.7, 2.8, 2.9 Haslam, 1987). There are many different kinds of rock type, all

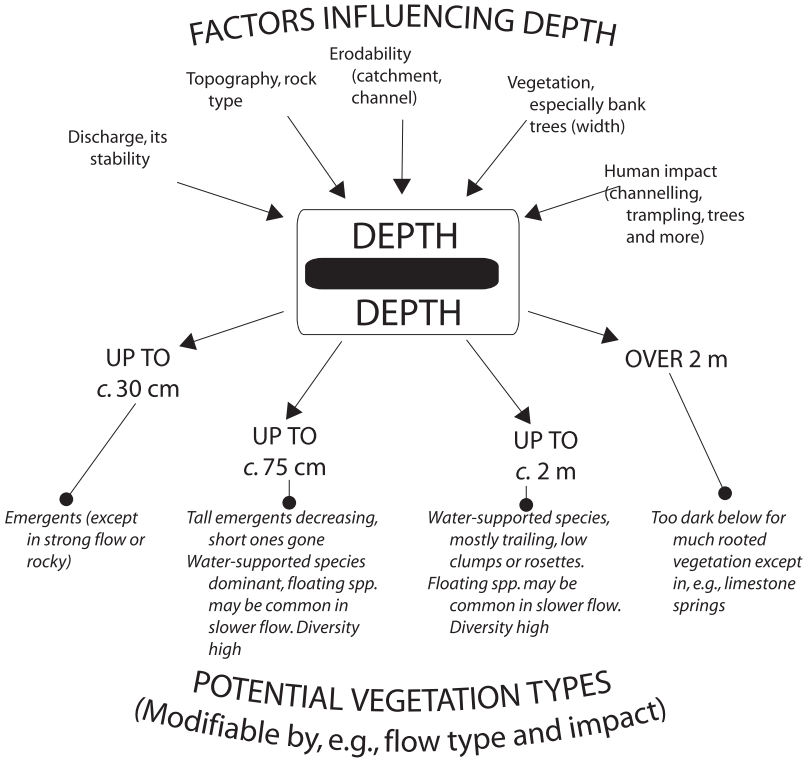


Fig. 2.6. (a) Depth and (b) width determining factors and vegetation types. (Representative, not including all types and variations.)

influencing their vegetation differently. Fortunately they may be summarised into a few major groups: limestone (high calcium, low other nutrients), sandstone (higher nutrients, more silt produced), clay (high nutrients, high silt) and resistant rock (low nutrients). River chemistry is due to these, plus the surface layers (such as subsoil, soil, peat, concrete, plants, if chemically different) (Table 2.2).

Another natural factor distinguishing river types is longitudinal, or upstream–downstream variation. Little rills 15 cm wide and 5 cm deep always differ in vegetation to deep rivers 200 m wide. For one thing, submerged plants cannot grow in a tiny rill! Going downstream, rivers generally become larger (width and depth), water force decreases if passing from steeper to gentler slopes, so substrate becomes finer, and the area of catchment increases. This results in an increase of nutrient status (more nutrient-rich silt in run-off), made much greater if farming becomes more intensive downstream and if other nutrient sources (e.g. sewage works effluents, farm slurry) also enter. *Pollution from hard surfaces increases with the area of used hard surfaces*. Even without the impact, in