

TAKING CARE OF

Rivers

WHY AND HOW





Preface and Acknowledgements

This booklet is part of a series to support a capacity-building initiative for catchment forums and water users associations in the Olifants-Doring Water Management Area of the Western Cape. This initiative is a pilot, for possible implementation elsewhere in South Africa. The booklet is therefore designed to be used throughout the country. However, it serves a specific and limited purpose. It is a basic, practical introduction to rivers and their conservation, aimed at encouraging users to become involved in activities to better understand and manage a local river. As such the booklet is neither detailed nor comprehensive. It provides a bridge to more technical and regional materials.

This booklet should also be used with others in the series, specifically: *Taking Care of Wetlands; Taking Care of Estuaries; The Ecological Reserve and Water Resource Classification.*

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What Makes a River?

Rivers are courses of moving water. Rainwater can run off over the surface of the earth and feed directly into rivers (surface run-off). Rain also seeps into the soil where it is used by plants, or moves through the soil and between rocks into groundwater storage areas (aquifers). Rivers are also filled from these underground sources.

The catchment is the land area where a river is formed and through which the river flows. Also called a watershed, the catchment is a drainage basin which 'catches' surface run-off and any underground water which seeps to the surface. As run-off flows downhill, towards the lowest part of the catchment, it forms streams. As more water joins, the streams become larger, and form a river. Rivers all make their way to the sea, with smaller tributaries flowing into the main channel, or two channels flowing together, to make bigger rivers.

Some rivers are *permanent*, flowing all year round. South Africa has few of these! Of the 65 000 km or so of river channels in the country, perhaps 40% are subject to natural interruptions of flow (Davies & Day, 1998:43). Some of these intermittent rivers are *seasonal*, flowing only during the wet season. In very dry parts of the country most rivers are *episodic*, and flow only after really good rains.

Some of our rivers, such as those along the south-eastern, southern and south-western seaboard, have cut their channels deep into the surrounding land. Others flow through relatively flat land, and may fan out over the surrounding land in times of flood. When they do, they form *floodplains* which are very rich and dynamic environments and important to local people. Examples are the flood plains of the Luvuvhu, Pongolo and Mkuzi rivers in the north-east; the smaller floodplains of the Sundays, Swartkops and Gouritz rivers to the south-east; and of the Berg River in the south-west.

Another important feature of a river is its banks and surrounds, what scientists call *the riparian area* or riparian zone (see Figure 3). We must recognise this important strip of land as part of the river.

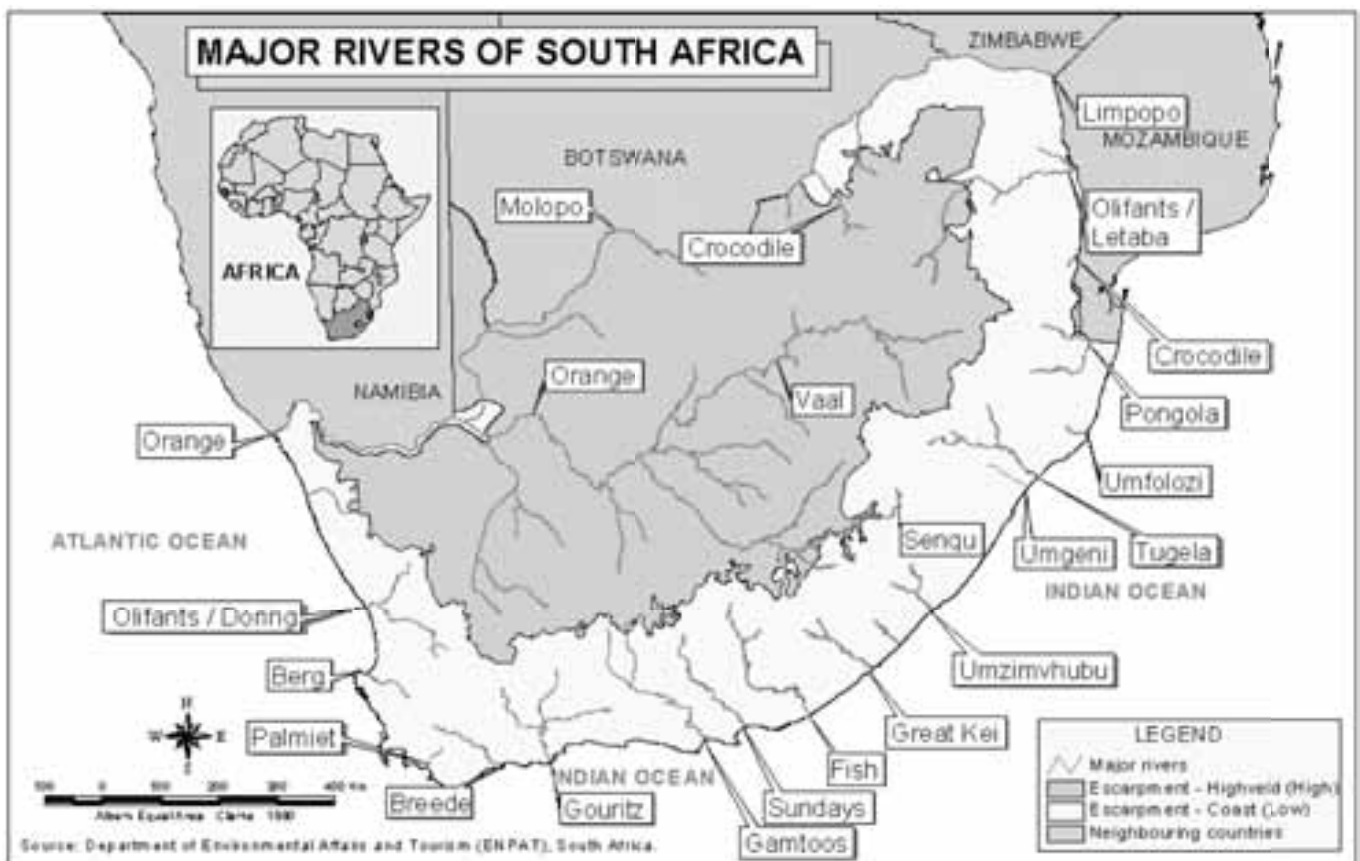


Figure 1: Map of the Major Rivers of South Africa

The riparian area, the strip of land next to a river (or wetland), often has sandy or muddy soils (alluvial soils which have been deposited there by water). The riparian can also be recognised by its distinct plant growth. Unless it has been damaged, the riparian area has plants which differ from those in the surrounding areas, both in terms of the types of plant, and in terms of their growth forms: riparian vegetation grows bigger, faster and stronger. Later in this booklet we note that looking after the riparian area is one of the best ways in which to take care of a river.

Some riverbanks also qualify as *wetlands*, as do, in fact, the river itself. It would therefore be useful to also read another booklet in this series, *Taking Care of Wetlands*, in relation to rivers.

How does a river differ from (other) wetlands? One key feature is the high energy associated with the flow of water, which leads to specific features of rivers, such as a susceptibility to erosion and flooding, particularly where riparian vegetation has been damaged or removed.

The classical view of a river (Davies & Day, 1998) is one of a mountain spring giving rise to a stream, cool and sparkling, which cascades down a mountainside, gradually slowing and widening as it enters the foothills where it is joined by other streams, becoming a larger, mature and meandering river which then deposits much of its nutrient-laden silt or mud on a floodplain and in an estuary, before entering the sea. (See Figure 2.)

The *estuary*, like the floodplain, is a busy, fertile and life-supporting environment, with particular features shaped by the interplay between fresh water and seawater. We discuss estuaries in a separate booklet in this series (*Taking Care of Estuaries*).

Not all rivers have the basic pattern described here. Some rivers start from seeps from low-lying areas, rather than in mountains. Those rivers that arise in coastal mountains may change from mountain stream to estuary with no middle zones. Mature rivers, on the other hand, may be 'rejuvenated' by flowing down a second mountain range nearer the coast, for example, the Orange River at Augrabies Falls.

Chemically, rivers vary naturally in mineral content and silt load, depending on the types of rock and sand over which they flow. The Orange River, for example, has a naturally high load of silt, in addition to that added by agriculture. This led to the theory that the sand dunes of the Namib had originated in the Drakensberg Highlands, having been washed down by the Orange River to the Atlantic Ocean, and then carried north to Namibia by the Benguela Current.

Our east coast rivers tend to be turbid and warm, with a neutral to alkaline pH. The majority of rivers in the southern and south-western Cape, on the other hand, are colder, acidic, and may have the colour of black tea. The 'black water' rivers flow through a unique vegetation type, mountain fynbos.

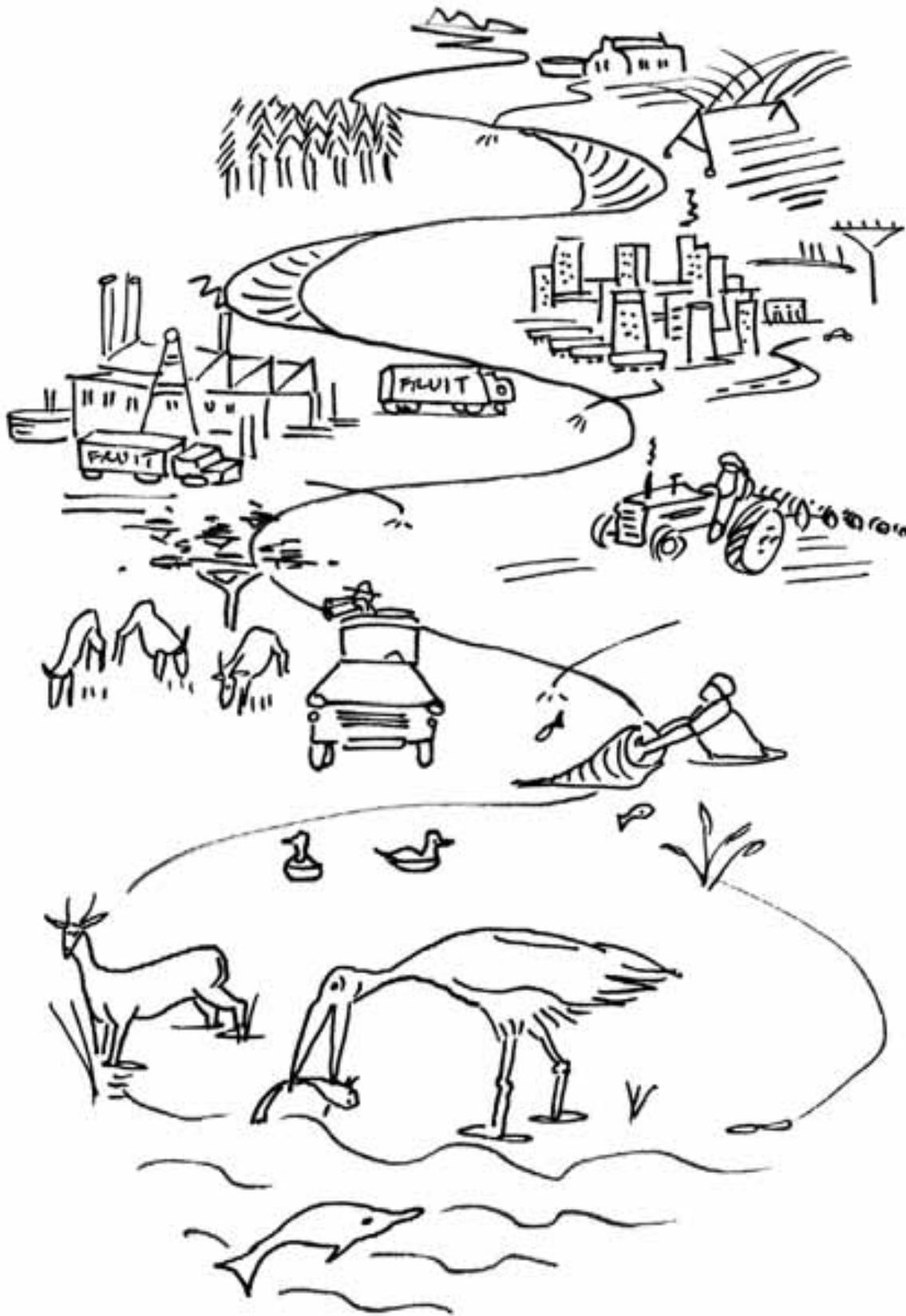


Figure 2: River – From Source To Sea

Fynbos plants produce chemicals called polyphenols to protect themselves from browsing. Polyphenols give plants like buchu their power as medicines. When these natural chemicals wash into the rivers, they make the water acidic and dark, just like the polyphenols in tea.

Indeed, looking at a river tells us a lot about the catchment through which it flows. For this reason, rivers are mirrors of the surrounding land. If the land is healthy, the river is likely to be healthy. If the river shows signs of damage, it shows that things are going wrong on land.

And, given the key feature which makes a river a river – the flow of water in time and space – what happens upstream, affects what happens downstream. These are all factors we must take into account when we consider how best to take care of a river:

- the river reflects the nature and state of the surrounding land,
- the river consists of the stream, bottom, banks and the surrounding riparian area,
- rivers vary naturally from each other, depending on where they are situated,
- a river varies from reach to reach, but at the same time, and
- the river is a continuum.

Why Care?

What Makes Rivers Special?

If one wants to be poetic, one can compare rivers to the veins in the human body, through which life-giving blood flows, bringing nutrients to all the cells of the body, and removing wastes. But one doesn't have to be a poet to explain that rivers provide many kinds of benefits, which contribute to a society's well-being and economy. In a healthy state they supply fresh water, remove pollutants, regulate stream flow and provide unique homes for many land – and water creatures (terrestrial and aquatic ecosystems). When river corridors and stream banks are in a good condition, their abundant and strong plant growth also provide local people and wildlife with more resources than many other parts of the landscape.

Rivers supply water

In South Africa, the bulk of our freshwater supply comes from rivers. Most of the available fresh water (around 70%) is then used for irrigation farming to produce crops and other products, followed by industry, which also provides goods and services. Compared with these water uses, water for basic human needs – drinking, washing, cooking – is a small amount, but nonetheless critical. We are a water poor country, with a rainfall far below what we would like for our development and livelihoods. (See the booklet *Catchments and Sustainability*, for more on this topic.) Rivers carry water, when it is available, from wetter to drier areas, thus sharing the resource. Government and private users build dams in rivers to collect the resource and concentrate development.

Rivers process and dilute wastes

Water quality varies naturally, for example, we noted that rivers in the Western Cape are more acid, with more organic chemicals, than elsewhere in the country. Water is 'hard' in some rivers and 'soft' in others (it lathers more easily) because of naturally high or low levels of salts and carbonates.



Water in mountain streams is generally clear, while lowland streams can be muddy because of the soil washed into them when it rains. But human activity has the biggest impact on water quality. Our wastes like sewage, excess nutrients from fertilizers, various salts and poisonous substances, often make it into rivers, as well as, often, an extra silt load when ploughing, removal of indigenous vegetation, construction and other activities cause soil erosion. A healthy river can deal with a certain amount of waste, by diluting it, carrying it away, and even processing it. (See *Taking Care of Wetlands* for more on how our water resources provide this cleansing function, free of charge.) Dams and canalised rivers are far more limited in their capacity to purifying water.

Rivers supply natural products, food and materials



Rivers and riverine vegetation provide fish, thatching reeds, medicinal plants, fire wood and more. As long as the river ecosystem is healthy, and people do not harvest too much, a river can provide such natural products forever. Thousands of rural people are dependent on such resources for their livelihoods. Although the 'nature economy' is not well reflected on the official books of the country, it is critical. For individual families the availability of natural resources may be the difference between well-being and despair; on a national level it no doubt affects the number of poverty-stricken people who flock to urban areas hoping to find employment, putting pressure on land and services there.

Rivers sustain plants, animals and their habitats



Have you ever arrived in the cool shade on a river bank, after trekking across a hot, dry and dusty plain? Riparian corridors (definition?) have vegetation and soils which are quite different from the surrounding uplands. As a result they support a greater variety of different plant and animal species, higher numbers of individuals per species, and higher rates of biological productivity, than most other parts of the landscape. River streams themselves provide corridors for movement, and suitable homes, for a great variety of species, from invertebrates to fish and birds, amphibians such as frogs, reptiles like crocodiles, and mammals such as otters. The streams are also home to numerous specially adapted plants and micro-organisms. The micro-organisms are vital in a river's purification function mentioned earlier. Without the plants and animals of healthy ecosystems, rivers cannot continue to provide their benefits. Some animals (like crocodiles and mosquitoes) come in conflict with people, and we need to control them with care. But we also need to consider the existence of river plants and animals in their own right. They are part of the natural world, a legacy of wonder and learning for our children and theirs.

Rivers moderate stream flow and help with flood control

Rivers drain the catchment, so that the land does not become water logged during periods of heavy rain. Wetlands can reduce flood damage by soaking up floodwaters so that the water level does not rise very much or too rapidly. (See *Taking Care of Wetlands*.) Dams can also contain and store floodwater for later use. However, they have few of the other benefits provided by natural wetlands.

Rivers give opportunities for recreation, spiritual and cultural activities

Many South Africans use rivers for religious and traditional rituals such as baptism and cleansing, reflecting the ancient association between water and spirituality, which occurs throughout the world. A healthy river is also a good place to relax, and a source of opportunities to have fun, from bird watching to fishing, canoeing, swimming and other water sports. Based on this, and the beauty of many river landscapes, eco-tourism – and property developers value healthy rivers as sources of income and employment creation. But it is not just the wealthy and privileged who want to unwind in nature, and it is important for all our well-being to keep some places both beautiful, and accessible to all.



How Do Rivers Work?

Rivers provide their goods and services by performing a number of hydrological and ecological functions. Hydrology refers to the movement of water: Rivers drain water and deliver water, often to places far from where the rain fell. In the process they can dilute and wash away wastes. They also purify water by filtering out and even processing pollutants, making them less harmful. And, while they deliver water, rivers also deliver nutrients (food elements) that sustain life, and contribute to the fertility of the land.

Water purification and providing nutrients are *ecological* functions. To understand how a river provides these benefits, we need to think of it as an *ecosystem*.

A *river ecosystem* consists of the stream of water, in its stream bed, together with the river banks and what we described in Section 1 as the riparian zone. The river ecosystem thus comprises the water and that strip of the surrounding land where the soils and plants are closely influenced by the river. The river ecosystem is home to a community of living creatures which interact with each other and their surroundings.

Flowing water makes a river different from other water ecosystems. The energy or power of the river depends on the slope of the riverbed, and how much water flows through it. Rivers usually start in the high mountain areas, where there is the most rain - and snow fall. From these headwaters, a river passes through three zones on its way to the sea. These are known as:

- the headwaters or upper reaches,
- the middle reaches, and
- the lower reaches.

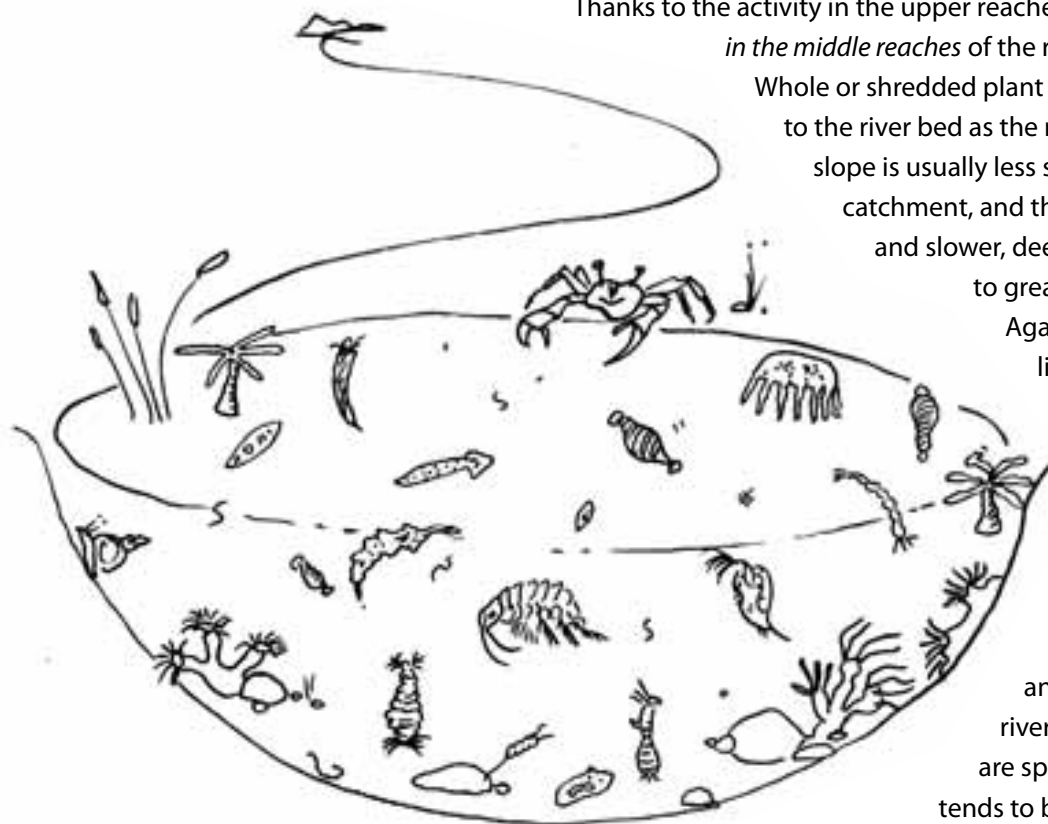
Although the river is in many ways a continuum, these three zones tend to have very different conditions. They each provide suitable homes (habitats) for different plants and animals. These include the insects and the micro-organisms, so small that one needs a microscope to see what they look like. In a healthy river it is the small creatures, insects and microbes, which, like other unsung heroes, prepare the food, and clean the place!

The key reference for the next sections is Davies & Day, 1998.

Food Preparation in the River

In the headwaters, the streams are quite shallow, flow fast, and are colder than lower down. The water is usually very clean, and also free of silt, except during floods. Because the water is churned up over boulders and stones, oxygen levels are high. Nutrient concentrations tend to be low, because the water which has just arrived on land has not yet been enriched with plant material. The creatures living in this part of the river are adapted to the cool, fast-flowing streams, and they can cope with the low nutrient levels. In fact, they help to improve the nutrient levels of the water. Shredders skid along the water surface and get working on leaves, twigs and other plant matter which drop into the streams from the surrounding riparian zone, and which form the main source of food here. Other insects are collectors which break down fine plant material even further. Grazer organisms feed on whole plants if these occur here, or on the layers of algae, fungi and other micro-organisms on the rocks. 'Scrapers' make a meal of the bacteria and fungi on the surfaces of decaying leaves. In turn the shredders, scrapers, grazers and collectors get eaten by the predatory insects, like dragonfly nymphs and beetle larvae.

Thus the majority of stream animals rely directly or indirectly on material which arrives from the surrounding land. These creatures have some amazing features which not only help them to survive in the fast flowing stream beds, but also to make the most of what little food is available. They grow slowly and tend to be small, and many species produce just one new generation a year. Many of the animals in mountain streams can survive only a narrow range of environmental conditions like temperature and acid balance, and are therefore easily affected by even small changes in their environment. These could include chemicals blown in from spraying in nearby orchards, or an increase in pH in rainfall, caused by air pollution (acid rain), as in the case of streams on the eastern highlands, affected by the power stations in Mpumalanga.



Thanks to the activity in the upper reaches, the water which arrives *in the middle reaches* of the river, is richer in nutrients.

Whole or shredded plant material tends to drop to the river bed as the river slows down. The slope is usually less steep in this part of the catchment, and the river becomes wider and slower, deeper but also warmer, due to greater exposure to the sun.

Again, the organisms which live here are adapted to these conditions. There are fewer shredders, and more grazers and collectors.

Bottom dwellers collect and feed on the remains of plants and animals (detritus) on the river bed. Grazers like snails are spoiled for choice. There tends to be more microscopic algae

growing on the rocks, which in summer may show up as the long green threads of *Spirogyra*

filaments, and more large in-stream plants (such as palmier

reeds), which are in turn also covered by algae. A whole nutrient cycle exists in the river bed itself, which can extend for many meters below the water, and which may release nutrient rich water during times of low flow.

Because of the warmer conditions and greater availability of food, organisms grow more quickly and abundantly in the middle reaches. Compared to the headwaters, this stretch of the river has a higher biomass of potential food for fish and birds, which tend to thrive here. However, the more exposed conditions in the middle reaches also mean that seasonal conditions like temperature vary more than they do in the headwaters. As a result, most species of invertebrates cannot survive year-round, but occur either in winter-spring, or summer-autumn. For example, some species become dormant during the hot summer conditions, which include low flow, high growth and low oxygen. This provides a natural mechanism for controlling overgrowths.

The lower reaches of the river generally meander across broad, flat areas of the landscape. Here the river is wide and deep. The water is warmer, and the amount of oxygen is lower. The lower reaches have had a long time to accumulate nutrients and other material (soil sediment, chemicals) from the catchment and the upper reaches, and in fact starts depositing this on its banks, on floodplains, in the estuary, and eventually the sea.

An example of the disruption of the cycle of seasonal limitations in the middle reaches of a river was seen in the Eastern Cape, when the Orange–Fish inter-basin transfer brought year-round cooler, higher flow conditions to the Fish River, leading to black fly infestations which severely affected livestock.

Dense communities of micro-organisms decompose the organic material deposited on the river bed, in the process consuming much of the available oxygen. The water is rich in nutrients, which have been leached from the rocks and soils all the way down the course of the river, released by plants and animals, and infiltrated through groundwater. It is an ideal environment for reeds and bulrushes, which may grow in dense stands along the banks. The sunny open stretches of river support the growth of algae. There is a rich food web, with zooplankton (microscopic animals) feeding on the phytoplankton (microscopic plants), filter feeders sifting the plankton and other particles from the water, grazers scraping algae off all available surfaces, an abundance of collectors gathering debris, and the meat-eaters feeding off everything else. The partly submerged plants provide shelter to the many bird species which feed on the aquatic life, and bottom-feeding fish add to the diversity of fish species.

When the balance tips and the nutrient levels become very high, the microscopic plants may grow so abundantly that the river turns green. Dead algal cells will drop to the river and be cleared away by the collectors, but when even they reach their limits, and oxygen levels drop even lower, noxious substances like hydrogen sulphide and methane may be generated in the river bed, and start killing off water life. This destroys the river's capacity to clean itself. Very high levels of sediment (for example from erosion in the catchment) increase nutrient loads and also make conditions difficult for those predators which rely on sight to catch their food.

Cleaning Up in the River

Microbes are the smallest organisms on earth. They include bacteria, fungi and yeasts, and protozoa. They are everywhere, inside our bodies and in rivers. While some microbes can cause diseases, others play an important role in making life on earth possible. As the microbes and invertebrates in the river convert dead plant and animal material to nutrients, they feed themselves, and make the nutrients available to other creatures. They also clean up the debris, and thus contribute to the vital cleansing or purification function of a river.

Without the bacteria and fungi, the filter feeders and the other miniature collectors, dead matter would clog up our rivers, turning them into stinking sewers. This in fact happens when a river channel is lined with concrete, to form a canal. In the process the tiny creatures lose the nooks, crannies and built-up of plant material which provided them with suitable habitats. They therefore disappear, and with them, the river's ability to clean itself. And because these creatures are no longer there, to contribute to a food web, much of the remaining river life disappears too. The canalised rivers

which run through our cities are by and large devoid of life, and often highly polluted waste streams.

Canals have also lost the benefit of the cleansing process associated with the soil and the roots of water-loving plants. In healthy rivers and wetlands, plants like reeds and sedges take up nutrients as they grow, in the process lowering high levels of nitrogen and phosphates. But they also provide a home to microbes which take the process further. Here, and in the anaerobic, water-logged soil, chemical processes can actually remove toxic pollutants from the water. This contributes to the amazing purifying capacity of rivers and wetlands. We discuss this in more detail in *Taking Care of Wetlands*, drawing on Kotze (*Wetlands and Water Quality Enhancement*, which you can find on the website www.wetland.org.za).

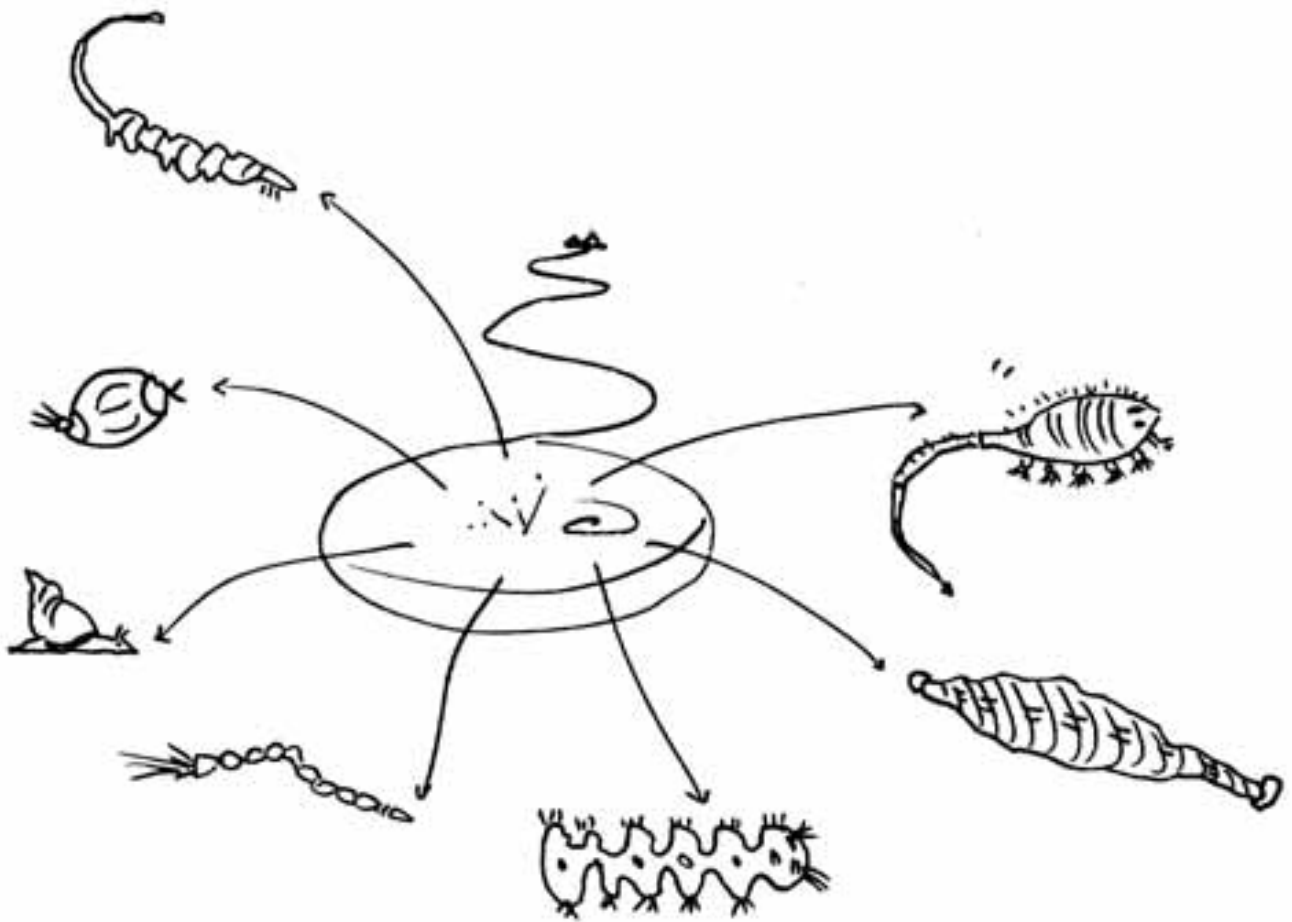


Figure 3: Some of the invertebrates living in mountain streams with stony beds

The Riparian Zone is Vital

The river is an ecosystem that distributes both water and nutrients, and processes wastes. But it is not just the stream bed and flow which provides these functions; the broader riparian zone is an integral part of this system. The vegetation on the river bank protects the water in the stream from excess pollution, and therefore helps the ecosystem to maintain and cleanse itself. For example, by binding the soil, indigenous vegetation in the riparian zone keeps erosion and the silt load in a river to a minimum. These plants can also buffer the river from pollution arriving from the surrounding land, for example from high levels of nitrates and phosphates put into the system from animal feeding lots, or the over-use of fertilizers.

Riparian areas, if they are not eroded and have a cover of indigenous vegetation, help to:

- store water and reduce floods,
- stabilise stream banks, prevent erosion and maintain the shape of the river,
- improve water quality by trapping sediment and excess nutrients,
- provide shelter and food for birds and other animals,
- provide corridors for movement and migration of different species,
- act as a buffer between the river and nearby land use activities like ploughing, irrigation and the application of fertilizer and biocides,
- provide recreational sites, and
- provide material for building, medicine, crafts, curios, etc.

This helps to explain why looking after a river also involves looking at the riparian zone.



What Can Go Wrong?

Rivers provide eco-services when the ecosystem is healthy. The healthier the system, the more it provides, and the quicker it can bounce back after natural catastrophes like floods and droughts. Things go wrong when:

1. Rivers run dry or receive much less water than before, e.g. during long droughts or when too much water is extracted by users, for irrigation, industrial or domestic use; high use during droughts creates particularly stressed conditions.
2. Rivers become so overloaded with pollutants that they can no longer clean themselves. A worst-case scenario is a combination of factors – when the flow is reduced while the amount of pollution arriving in the river increases at the same time.
3. River bank vegetation is destroyed.
4. Invasive alien plants start to take over rivers, riparian zones and broader catchments.
5. River banks collapse, because of earth works, the removal of riparian vegetation, or the overgrowth of invasive alien plant species.
6. Loss of biodiversity – when plant and animal species start to disappear from the river and its surrounds.
7. Aquatic weeds clog rivers.
8. Rivers are turned into canals, often in attempts to control flood damage.
9. Inter-basin transfers change the natural flow of a river, or introduces foreign species.
10. Exotic or alien species are introduced to the river, for example, exotic fish species, which out-compete the local species, or set off other negative chain reactions.

Some of these factors are more important than others in contributing to poor river health. In a river near you, a combination of any number of these factors may be present. As the state of a river deteriorates, the services it is able to provide also deteriorate, and may eventually stop altogether.

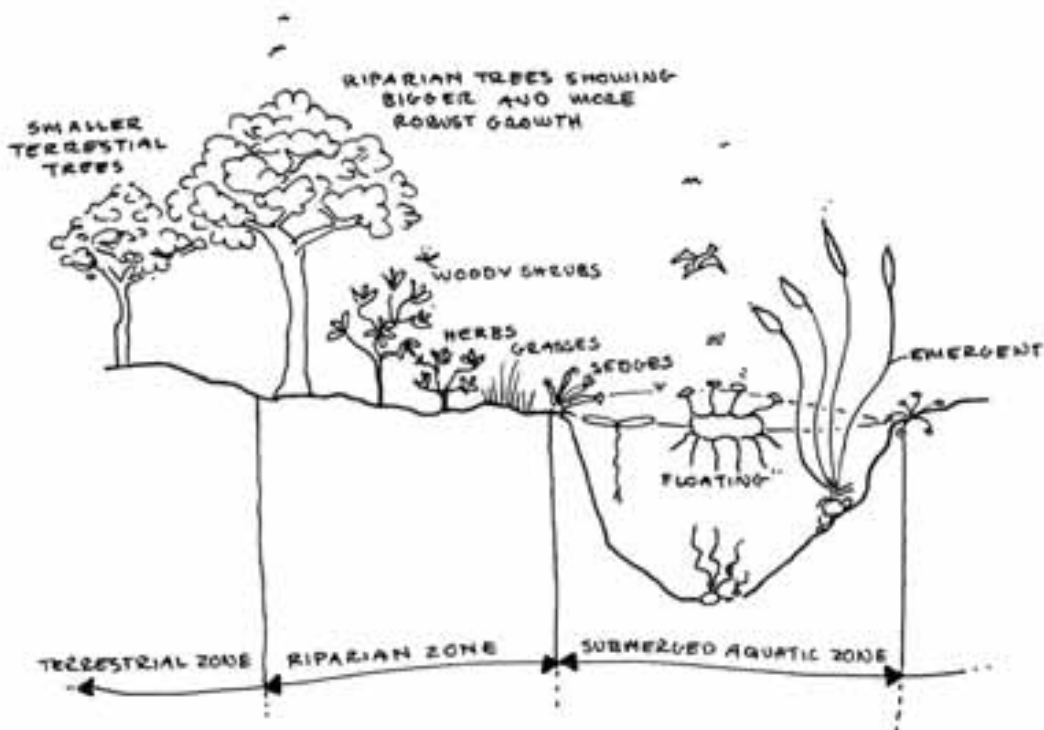
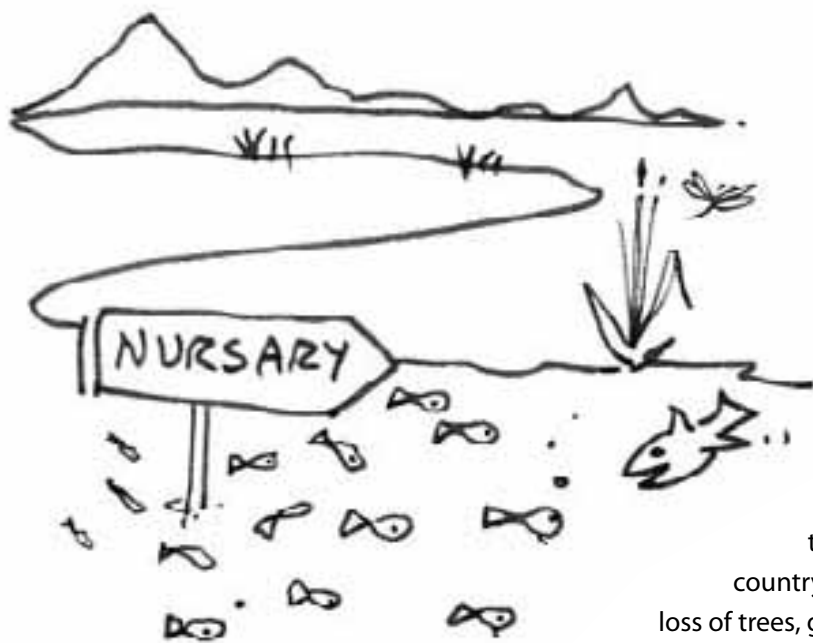


Figure 4: Cross Section of a Typical River Channel, with Riparian Zone

Rivers Running Dry

To water users – a farmer wanting to irrigate crops, a municipal manager with a new township development on the cards, a homeowner wanting to fill a pool or a developer with big plans – a full river running past can look like wasted water. But even if all water is not captured and used immediately, it cannot be said to be wasted. It might be used somewhere downstream, for basic needs – to prepare a meal, clean the dishes or wash a child. Underground water sources which are used for agriculture or domestic purposes, are often replenished by rivers, and when these rivers start to run dry, areas much further away might be affected, not just by less water, but also by deteriorating water quality. (See *Taking Care of Groundwater* in this series.)



When rivers which previously flowed all year round start to flow only intermittently, and when intermittent rivers dry up altogether, the wildlife dependent on these life-giving features of the landscape are affected. In Mpumalanga, where the reduced flow in the major rivers of the Kruger National Park due to increased upstream extraction is said to threaten tourism, and on the West Coast where a dramatic drop in the water table is putting potato production at risk, the over-use of the available water receives publicity. But there are similar or worse impacts around the country, where reduced flows in rivers lead to the loss of trees, grass, fish and other resources, affecting the livelihoods and food security of rural communities.

'Wasted' water running past is also used to dilute pollutants, to allow the proper functioning of sewage works, and to keep the river's own purification system going. Without enough water, a river cannot provide its cleansing functions. It is for these reasons that the National Water Act includes provision for a Reserve: an amount of water which should be allocated to a river ecosystem, in order to allow it to continue functioning as a river and providing its benefits – including the provision of water for basic human needs. (See the booklet on *The Ecological Reserve* in this series.)

Too Many Dams

Dams, big and small, have an impact on rivers. Generally the impact is greater the more dams there are in-stream, and the closer they are spaced, as rivers require a certain distance to recover from the effects of the dam (a 'reset' or recovery distance). The effects of dams on rivers include:

- **A great reduction in the river's water level**, with knock-on effects on water life, the riparian vegetation and wildlife, the river's ability to dilute pollution and purify water, downstream water users' access to water, and on the estuary, which may close up (affecting the populations of fish which spawn or raise their young in estuaries) or change when sea water flows higher into the dwindling river (see *Taking Care of Estuaries*).
- **Changes in the flow regime**, when water is released from the dam at inappropriate times: Some rivers which are naturally seasonal may now become permanent, and permanent rivers may become seasonal. This leads to loss of biodiversity or changes in species composition, for example the outbreak of black flies leading to livestock losses (see Inter

Basin Transfers below). When dams fill up after the dry season, without any releases, downstream river life is deprived of water at a time when it is most needed.

- **Temperature changes**, when water is released from the surface of the dam (hotter than river water) or the bottom of the dam (colder than river water).
- **The loss of nutrient-rich sediment** which gets trapped in the dam, which affect food webs in the river but also in the marine ecosystem. The prawn industry in Mozambique suffered significantly when the Kahora Bassa dam was built.
- **The natural scouring and cleansing function of floods** is reduced or lost, leading to an overgrowth of reeds.
- **Fish are prevented from travelling** between their feeding and spawning grounds.

Some of these effects are so great that rivers are unable to recover from them.

Pollution Overload

A river can cleanse itself, but the load of pollutants to which it is subjected, can simply become too high to be processed. This situation is reached more quickly when the river is already compromised in other ways, for example, when the flow in the river has been reduced (see point 1), or when it has been canalised.

How are rivers polluted? People often think of **litter** when they think of pollution, and the broken bottles, TV sets, tires, dead dogs and plastic bags which make their way into rivers, are only too obvious. These indeed have an impact, and plastics washed down rivers contribute significantly to the death of sea creatures and the poisoning of marine food chains.

Another visible form of pollution in a river is **soil erosion**. It is important to recognise that a certain amount of soil washing into the river is natural and beneficial, as it contributes nutrients to the system. But several events and activities can increase erosion and thereby the sediment load in a river. An isolated event such as a flood, a burst dam wall or a release of water from the bottom layer of a dam, can kill many animals and their eggs. An otherwise healthy river may be able to bounce back from such an event. Other activities can create a continuous load of sediment in a river, for example: non-contour ploughing, clearing of forests and other indigenous vegetation for new lands or orchards, clearing riparian zones, over-grazing, roads and other construction work. In such cases rivers may be badly affected by the extra silt load. The effects may include:

- lower levels of photosynthesis in the river and therefore less available food from plants and phytoplankton

To compromise: To put in danger through unwise action.

- the coating of micro-habitats and food sources so that small creatures can no longer make use of them
- reduced visibility in freshwater and marine ecosystems, affecting predators which hunt by sight
- silting up of dams, which shortens their useful lifespan
- increasing the load of toxicants in the river, given that these substances often adsorb onto soil particles.

Toxicants like heavy metals (e.g. mercury and large concentrations of otherwise safe elements like copper) and biocides (insecticides, herbicides, fungicides) are *invisible* pollutants, but very dangerous. They can kill water life at concentrations so low that they cannot be detected by laboratory tests, and they also have an effect on human health. Biocides are used to grow blemish-free fruit and vegetables. These synthetic organic pollutants (POPPS) are persistent – meaning they don't easily go away – and, as the bumper sticker says, *pesticides don't know when to stop killing*. Rivers can to some extent process these toxicants, and 'bury' them in the silt on the riverbed. Whenever the silt is churned up, however, and when water levels drop, they are released again.

Where do these dangerous sources of pollution come from? The waste products of mining and other heavy industries often contain heavy metals. On farms one cause of pollution is the over-application of biocides by farmers who understandably don't want their crops being rejected by exacting buyers. But the careless or uneducated storage, handling and disposal of biocides may be an even bigger problem. OXFAM estimated that while Third World countries (under which they counted South Africa) use only 15% of the pesticides in the world, they were responsible for 50% of pesticide poisonings per year, and more than 75% of resultant deaths.

Other sources of river pollution are **nitrates, phosphates and ammonia**, which are present in natural systems as nutrients, but have increased hugely in the world's freshwater systems. The causes of this artificial nutrient overload includes discharges from sewage works, run-off from areas without proper sanitation, run-off from animal feedlots, the dumping of crop residues near rivers, and the over-use of fertilizers to grow crops, and to green gardens and golf courses.

According to the Millennium Ecosystem Assessment (World Resources Institution, 2005):

“Over the past four decades, excessive nutrient loading has emerged as one of the most important direct drivers of ecosystem change in terrestrial, freshwater and marine ecosystems. While the introduction of nutrients into ecosystems can have both beneficial effects (such as increased crop productivity) and adverse effects (such as eutrophication of inland and coastal

waters), the beneficial effects will eventually reach a plateau as more nutrients are added (that is, additional inputs will not lead to further increases in crop yield), while the harmful effects will continue to grow. ... World consumption of nitrogenous fertilizers grew nearly 8-fold between 1960 and 2003, from 10.8 million tons to 85.1 million tons. As much as 50% of the nitrogen fertilizer applied may be lost to the environment, depending on how well the application is managed. Since excessive nutrient loading is largely the result of applying more nutrients than crops can use, it harms both farm incomes and the environment."

Nutrient overload in rivers results in eutrophication, the overgrowth of plants such as algae (algal bloom) and exotic aquatic weeds (see below). Algal blooms can produce toxins which can kill fish, and harm humans, too. Eutrophication also considerably increases the cost of purifying water so that it is again suitable for use. High levels of nitrogen in drinking water has been associated with cancer and other chronic diseases (World Resources Institution, 2005).

Another instance where pollution is the result of excessive quantities of natural substances is salt pollution, also known as **salination**. The water quality of many South African rivers, including the Great Berg, Breede, Fish and Sundays rivers, has declined considerably as a result of irrigation-induced salination. Salts such as sodium, chloride and sulphates can become very concentrated in water or on land when a big portion of water evaporates, such as when pivot irrigation is used to water crops, especially under very dry and hot conditions. Other sources of salination are mine effluent, and the recycling of treated effluent from sewage works, particularly during dry periods. Salination increases the cost of water purification. It also becomes more difficult and ultimately impossible to grow crops on land with high salt levels. It has been estimated that over a million hectares of land have been lost to agriculture worldwide, as a result of the salination of soils by inappropriate irrigation.

Untreated sewage is also a direct cause of river pollution. The sources are informal settlements without proper toilets and the failure of existing sewage treatment plants to cope with increasing loads. Sewage outflow into rivers contributes to eutrophication and salination. It also spreads **pathogens causing diseases** such as cholera. More children die in South Africa each year from water-borne diseases than anywhere else in Africa, if per capita income is considered.

From the above, it is clear that river pollution can take many forms, several of which are not visible to the naked eye. Often the effects, too, are hard to observe, or only become evident much later, or further away. These effects vary, but all require our attention.

Pollution lowers the quality of water for agricultural use, and damages water life. It reduces the services rivers can provide, from aesthetics, property development, recreation and eco-tourism, to rural livelihoods and food security. It adds significantly to the cost of water purification and hence the cost of water for economic and domestic use. Pollution kills. Children die of diarrhea caused by contaminated water. A number of South Africa companies have been taken to court for the contamination of water with poisonous metals, which affected human health and livestock production.

Riparian Vegetation Destroyed

The removal or damage of vegetation in riparian zones, is probably one of the most common occurrences along the length of a river. It has major impacts.

When discussing the food web in the upper reaches of a river, we noted that the main source of food in this fast flowing, clear water environment is the plant material which falls in from the surrounding trees or other vegetation. The quality and quantity of food falling into the stream determines not only the number of animals – from invertebrates to birds, fish and mammals – that can be supported by the stream, but also the type and complexity of the whole food web. Changes in land use, like plantations, deforestation, the spread of alien plants, and river bank clearance, can thus affect the whole system in the headwaters.

But the plants in the riparian zone have other important roles, too. They provide some buffer to streambeds from the excess nutrients in the runoff from farmlands, discarded crop residues, golf courses and informal settlements. By taking up some of the phosphates and nitrates, they can reduce eutrophication and the overgrowth of indigenous river species like reeds, as well as algae and water weeds. When vegetation is removed by ploughing, earthworks, construction, over-harvesting, fires, overgrazing and trampling of the veld, the streambed is more exposed to these and other pollutants.

Plants also prevent erosion of the river banks – a process described by some catchment dwellers as the river ‘biting back’. The removal of indigenous vegetation, the over-growth of invasive alien plants, and earth works can cause river banks to collapse. This increases soil erosion and the sediment load in the river (see page 26) and opens up the area to greater damage in times of flood. Indigenous riparian plants are particularly well adapted to the conditions along our river banks. Their deep and extensive roots are well suited to the erosive forces of water and preventing the undercutting of banks.

To summarise, the indigenous plants that grow in the riparian zone have the following benefits (River Health Programme, 2006):

- help bind river banks with their roots, and prevent erosion,
- slow runoff in the groundcover, increasing the absorption of water,
- reduce the effects of floodwaters,
- trap sediment and pollutants, helping to protect water quality,
- provide suitable homes and food for animals, fish and aquatic insects,
- contribute to species richness,
- provide cover to rivers exposed to extreme temperatures, and
- provide an aesthetically pleasing environment.

Invasion by Alien Plants

Alien plants have effects everywhere, but perhaps most significantly in the upper parts of mountain catchments. In the Western Cape, for example, protected mountain catchments constitute only 9% of the surface area, but provide 60% of the available fresh water in the province. A survey in the Kogelberg reserve and Palmiet Valley near Cape Town (quoted by Davies and Day, 1989) showed that alien vegetation had spread from a cover of about 5% in the 1930s to about 40% in the 1980s. The study estimated that if the spread was not controlled, the aliens would cover 80% of the area within 50 years and would reduce the water available to this water-stressed city by 30%.

Although there are different opinions on how much water can be saved (or 'generated') by clearing invasive alien plants from a catchment, it makes sense that if there are fewer thirsty exotic species (like pine, eucalyptus and wattle), there would be more run-off to the river. It was found, again in the Western Cape, that alien acacias and pine trees intercepted between 12% and 61% of the rainfall which would otherwise have appeared as stream flow, compared to indigenous fynbos, which intercepted only 5% of the rainfall. Research in KwaZulu-Natal found that establishing plantations on the slopes previously covered by grasslands significantly reduced the run-off to the local wetland.

Where alien plants like lantana, bug weed and oleander invade rivers, they cause a host of other problems. They out-compete and displace indigenous plants; they are not ideal habitats for indigenous animals; and a single species tends to dominate. As a result of all this, they reduce local biodiversity. They are often not as good as indigenous trees and grasses at binding the soil, in which case they don't control erosion that well.

Some alien plants provide materials for building and crafts, and firewood, but well managed indigenous forests and woodlands can do this, too. Aliens, on the other hand, prevent riparian zones from providing rivers and people with the many other benefits they have to offer (see page 24).

Overgrowth of Water Weeds

A number of weeds have been introduced into our water systems, and where river health deteriorates, these weeds thrive and create problems of their own. Examples of aquatic weeds are Kariba weed, the water hyacinth, parrot's feature and Azolla. They are weeds because they have the potential for what Davies and Day call "explosive growth". This growth is triggered when the nutrient levels in the water rise too high, for example when the run-off from farmland or golf courses bring nitrates and phosphates from artificial fertilizers into the river. The Hartebeespoort Dam was taken over by water hyacinth, fed by the inflow of treated sewage effluent from the Crocodile River. It costs the country tens of millions of rand to get rid of these weeds, but we are at best just keeping them in check, at worst giving them the run of the river. They prevent fishing and water sports, disrupt the flow in irrigation channels and block pipes and sluices. They create breeding places for bilharzia snails and mosquitoes. Water weeds also contribute to water losses from transpiration.

Turning Rivers into Canals

Municipalities are often moved to line river channels with concrete, in an effort to speed up the run-off and so to control floods. In the process the river as an ecosystem is killed. It loses the micro-habitats or biotopes (the footholds and crevices of rocks, plants, the shelter and rich food sources of a sandy river bed and muddy banks) where the various smaller organisms of the ecosystem can live. The river also loses the ability to cycle nutrients between a sandy riverbed and stream, and between muddy river banks and stream. Thus food webs are affected, most river organisms die out, and water birds take flight. Biodiversity is lost, and so is the river's ability to cleanse itself.

By losing plants and microbes, the river loses its water purifying agents, and a municipality's job becomes harder. Canals are still able to dilute and wash away waste, but only if the flow is maintained, which is often not the case. When urban rivers are canalised they therefore typically turn into a trickle of dirty water amid a stream of litter, posing considerable health risks, and demonstrating the difference between a healthy, functioning river, and one that has ceased to function as an ecosystem.

Inter-basin Transfers

South Africa is a world leader in the technology of inter-basin transfers. These schemes, which channel water from one river to another, connect two different ecosystems. They have an effect on both rivers, taking away water from the one and adding water to the other, often at times when it would not naturally receive much water (dry season).

The limited available research has shown that at least fish and algae have been transferred through these tunnels, withstanding both high pressure valves and 'dumping'. These transfers become uncontrolled experiments in genetic mixing.

In the Orange-Sundays-Fish Scheme, researchers found that the black flies which occurred in the Fish River before (*Simulium adersi* and *S. nigritarse*), were replaced with a more pesky species of Blackfly (*Simulium chutteri*), which irritates stock in spring to a point where they will abort or bleed to death. The change in the Blackfly species was due, it seems, to the now more permanent flow of the Fish River and the increase in fast-flowing water, which this species prefers.

Another feature of some basin transfers is open canals. These are prone to leaks and evaporation (up to 70% of the water in the Eastern National Water Carrier in Namibia is estimated to be lost to evaporation); they also cost the lives of thousands of animals and pose a danger to children.

Introduction of Exotic Species

People have introduced animals that are exotic or alien to various rivers (that is, animals that did not occur there naturally). These include trout and bass, which are good for sport fishing but have also been described as "voracious predators". Exotic fish species have, according to freshwater ecologists, caused havoc among the indigenous fish which occurred there before, and possibly to the invertebrates, too. For example, in the Olifants and Doring rivers and their tributaries, the presence of alien tilapia, sunfish, bass and carp have harmed several indigenous fish species. The introduced species either prey on the locals, or compete with them for food and habitat, resulting in both reduced numbers and localised extinctions.

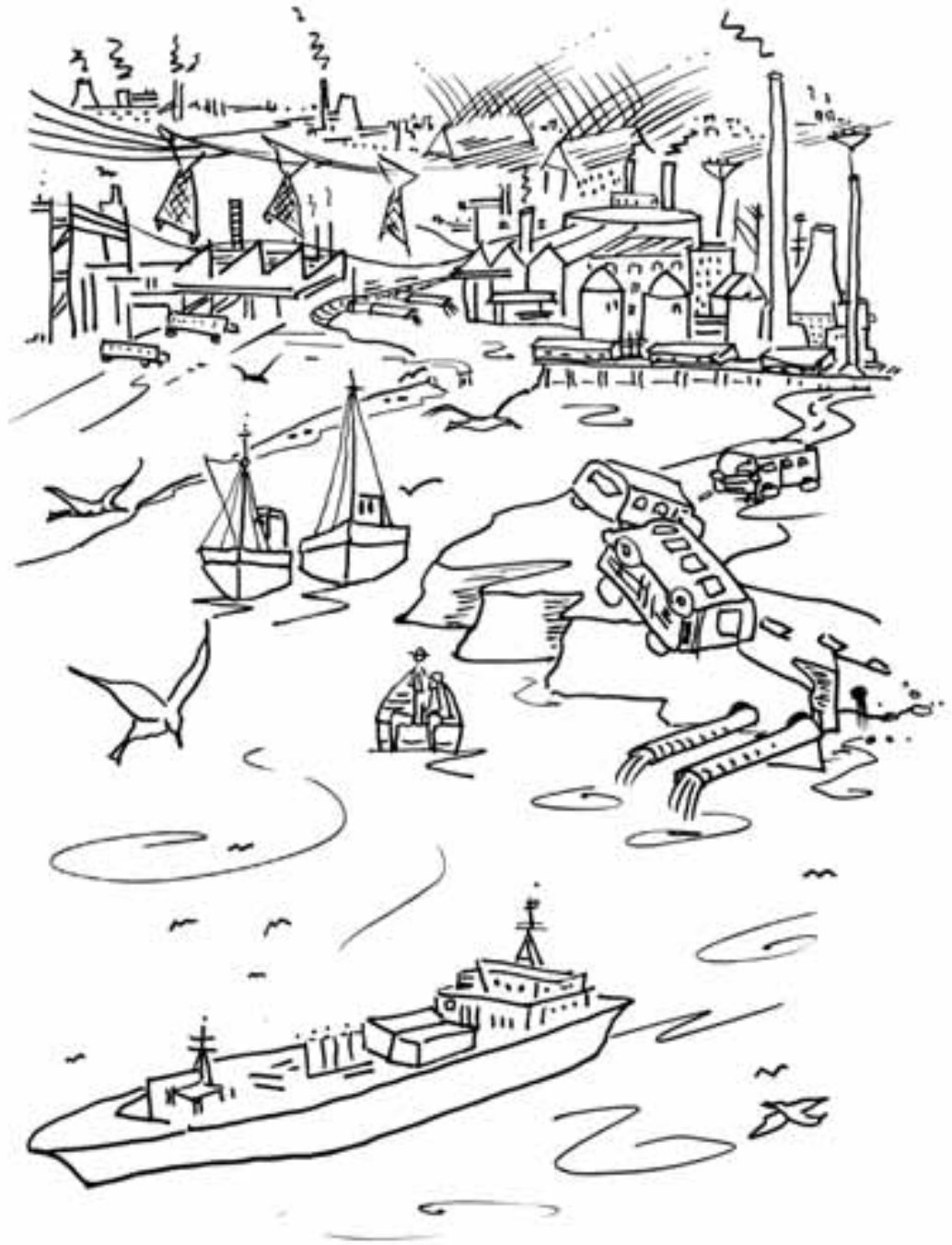
Loss of Biodiversity

Many of the factors listed above result, either directly or indirectly, in the loss of biodiversity, as some species of plants and animals die out in a particular stretch of the river. We call this 'local extinctions'. A local extinction is also a total extinction in the case of endemic species, because an endemic species occurs *only* in a particular area, and nowhere else. In other cases, the loss of biodiversity applies to only part of a river, as plants or animals which occurred in an area before, are no longer to be found there.

One has to ask: Does this matter?

Some would argue that it does matter if nature is destroyed, and people have various reasons for this argument: We may see it as part of a creation, part of the greater whole or web of which humans, too, form a part, or part of what people would like to leave behind for future generations. We could also argue that nature changes all the time and that unless human beings

Does it matter if a small fish, an insect, or an obscure plant that few people have even seen, no longer occurs in a place? Especially if other members of the species might still survive somewhere else?



or economic opportunities are affected by such changes, they are not of particularly great concern.

Scientists warn that many of the changes we see in nature *do* have an impact on people and our current or future development opportunities. Some such changes have been mentioned in this booklet. Other changes, like species losses, might have an impact in future, but it is usually very

difficult, if not impossible, to predict the impacts. For this reason, scientists have proposed a precautionary principle as an underpinning of sustainable development.

We have already seen ample evidence, however, that ecosystems which are rich in biodiversity are more able to bounce back after disasters (such as floods, droughts, tsunamis). Biodiversity contributes to resilience. Ecosystems which have suffered biodiversity loss are less resilient, less able to recover from extreme events, and more unpredictable. This makes them, their benefits for humankind (like water supply and cleansing) and their potential negative impacts (like floods), all the more difficult to manage. It is wise to take care while we still have a number of options for doing so.

How Do We Take More Care?

Actions, Contacts and Tools for the Job

Use Water More Wisely and Efficiently

Extraction from rivers, either directly, or more commonly, through small and big dams built in or along rivers, is the main cause of rivers running dry. It is clear that we need to rethink our patterns of water use: we might not be able to use less water, because we need to develop and provide benefits for a growing population. But we must learn how to use *less water per activity*, if we want to both extend development benefits to all South Africans, and sustain our development. (Also see *Catchments and Sustainability* in this series.)

This means that we must find ways to use water more carefully and more efficiently. An example is the new trend among gardeners, to adopt water-wise practices such as using mulch and planting indigenous species suited to local conditions. This trend is an example of how the way we do things, can change. In another context, some Eastern Cape citrus farmers have reduced their use of herbicides. Instead they allow the growth of some weeds in the orchards, as a kind of mulch. They find that the presence of the weeds helps water to better penetrate the soil. As a result, they get more value for the water they buy.

The actions water users and managers can take include:

- Repairing and maintaining pipes and canals, to minimize losses to leaks.
- Installing more efficient irrigation systems, and monitoring them more closely, particularly in dry regions.
- Find ways other than irrigation, to cool the soil and prevent soil losses to wind, and/or plant only crops that are suitable to a particular area and its natural limitations.
- Influencing markets accordingly, e.g. using 'water wise crops' as a marketing advantage.

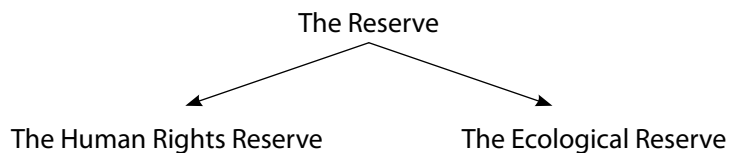
- Monitoring and reporting irresponsible water use (this is a mandated function of Water User Associations).
- Monitoring borehole use, given that groundwater systems are often connected to rivers.
- Controlling aquatic weeds.
- Looking after water quality (see page 33).

Determine and Maintain a Reserve

How do we know if we're using too much water? Or, how much more we can extract, before we put a river at risk of failing?

The National Water Act has introduced a tool for water management designed specifically to support sustainable development. It is called the Reserve.

The Reserve has two components: An amount of water allocated for basic human needs, and an ecological reserve.



The Human Rights Reserve is an amount allocated to provide for the basic needs (drinking, cooking, cleaning) for each person in the catchment.

The Ecological Reserve is the amount of water, the quality of water, and the timing and flow of water, which is necessary to maintain the river as a functioning ecosystem which can provide additional goods and services to society.

The Reserve differs from river to river, depending on how many people live in the catchment, and the ecological character of the river. Some rivers are

'by nature' drier than others, and will therefore have a smaller Reserve. (See the booklet on *The Reserve*, for more detail.)

The Ecological Reserve is determined by scientists (who may work with knowledgeable local people). To calculate it, they consider the communities in the catchment of the river, and their economic activities and development needs. They also consider the kinds of habitats, wildlife and ecosystems in a particular river, and use their knowledge of what these creatures and habitats need, in the form of water quality, quantity and flow, in order to survive.

It is therefore easy to think of the Ecological Reserve as water for the goggas and the fish, or that the National Water Act is treating the river as a water user, more important than commercial water users like farmers or industry. This is inaccurate. The river is not a water user. It is a *provider* of water. It requires water, in order to stay functioning as a river. As we argued earlier, the river needs to stay functioning in order to keep providing both water, and its other eco-goods and services. The Ecological Reserve is therefore less an allocation of water to the river as a water user, and more *an investment* by us in our future water provision and related goods and services.

It is also important to note that the Ecological Reserve is not seen as more important than the Human Rights Reserve. *Both* are included in the concept of the River Reserve, in the National Water Act. DWAF is committed to providing for the basic water needs of all citizens. *Both* human rights and the river ecosystem must be satisfied before water can *then* be allocated for commercial and other purposes.

Commercial water allocations, which are no longer (as in the previous dispensation) regarded as rights associated with ownership of property, are done by license. How many licences can be allocated, and for how much water use, is now determined by the Reserve.

To maintain the Reserve in a particular river reach, ecological flow releases might be required, from upstream dams in the river or its tributaries.

Determining the Reserve depends on the class of river health that residents in the catchment have chosen for their river. This is explained next.

Choosing a river class, allocating water licenses and managing ecological flow releases are all processes introduced by the National Water Act to help us to look better after what is perhaps our most vital natural resource, so that all South Africans can benefit from sustainable development, now and in the future. All stakeholders have an opportunity to participate in these processes (see page 34).



Choose a River Class

As part of the process of determining an Ecological Reserve for a river, and of river management, river reaches are to be classified according to three broad classes:

Class I: Minimally used

The ecological aspects of the river are in a natural or almost natural ('pre-development') condition.

Class II: Moderately used

The ecological aspects of the river have been moderately changed from their natural condition.

Class III: Heavily used

The overall water resource condition has been significantly altered from its pre-development condition.

What is the point of river classification?

Classing rivers or river reaches is part of the Water Resource Classification System, which is an outflow of the National Water Act of 1989. This system has been developed to help us:

- understand the current condition of all our water resources
- decide, as a collective, how best to manage them.

According to this system we need to determine a 'Management Class' for each major resource in our catchment, including all the significant rivers. Choosing a river class means identifying the condition we would like the river to be in, and it will determine how we manage that river or river reach.

Usually a chosen management class will reflect the current condition of the river, or it will be a better class. *Classes are there to help us maintain a river's condition, or to improve it.*

The chosen Management Class is a factor in determining the Ecological Reserve. So the levels of pollution and extraction which will be allowed in that river, or river reach, will be determined according to the chosen class for that river or river reach.

Who decides on the Management Class?

A wide range of stakeholders must be involved at different stages in the classification process. This includes:

The original set of classes proposed included finer categories. These are described in *Water Resource Classification*, a separate booklet in this series, where you can also find more detail on the three classes identified here.

Each of the river classes has a different Ecological Reserve.



Different stretches of river in the same river (reaches) can be treated as different units of analysis, and can therefore be classed differently. The upper reaches would generally be in a higher class than the lower reaches, which tend to be more heavily used and polluted.

Canals are not classified. We cannot determine their health because they are no longer functioning as ecosystems. They can supply water and transport (but not process) waste, if the flow in the canal is sufficient.

- Appropriate government departments at the relevant levels, e.g. DWAF, the Department of Agriculture and local government
- Water Management Institutions (see Point ...) like CMAs, WUAs, Advisory Committees and non-statutory bodies such as Catchment Forums, Water Service Authorities (municipalities), Water Service Providers, Water Boards.

Each of these must give input into the process according to their interests and responsibilities. DWAF must oversee and guide the process. Qualified and experienced specialists will be needed to support the process, including social scientists, economists, ecologists, water quality specialists, hydro-geologists, irrigation specialists and community participation facilitators.

What is involved in choosing a Management Class?

The procedures follow seven generic steps, which are described in detail in the booklet, *Water Resource Qualification*. Here we will simply note that the classification process includes:

- deciding on the unit of analysis (which may be a particular river reach, or an estuary, or wetland) and establishing the current status of the water resource,
- consulting with stakeholders to arrive at a future desired state for the water resource,
- setting the Management Class on this basis,
- then determining a quantitative Reserve, and
- determining Resource Quality Objectives, which will meet the requirements of the class.

At the end of the classification process all important water resources in the catchment must have a Management Class, a Reserve, and Resource Quality Objectives. These must then be Gazetted so that they are enforceable in law.

Reduce Levels of Pollution

One of the most critical actions we can take to safeguard rivers is to reduce the levels of pollution which affect them.

Many of the other areas of action suggested here are helpful in this process.

For example, the process of classifying rivers and river reaches provides a basis on which a river and the surrounding catchment can be managed, including the levels of pollution which will be tolerated. Similarly with the determination of the Ecological Reserve, which refers to both the quantity of water in the river, and water quality. Part of maintaining a reserve, is therefore about maintaining the required water quality, in relation to the Management Class which has been chosen for the river, or particular river

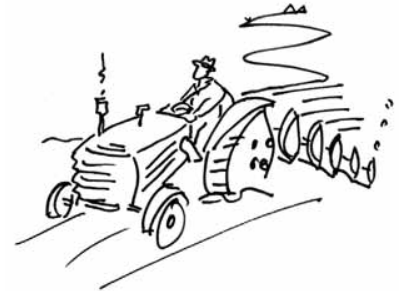
reach. (See Resource Quality Requirements, in the booklet *Water Resource Classification*).

Reducing pollution levels often involve testing, to find out what the existing pollution levels are, to see whether our management actions are making a difference, and to monitor water quality on a regular basis. See Point ... below, for more information in this regard. Not all tests have to be complicated.

Water management institutions like Water Users Associations and Catchment Management Agencies have responsibilities with regard to water quality (see page 40). Catchment Forums also play an important role, particularly because pollution sources are usually on land, and often in parts of the catchment quite far from the river.

Table 1 is a reminder of some forms of pollution which affect rivers, and some broad suggestions on where to focus one's action:

Type of Pollution	Some sources	Actions to explore
Plastic	Litter, poor waste collection	Awareness campaigns; waste reduction, collection and recycling programmes
Siltation	Soil erosion from earth works, road construction, overgrazing, ploughing – particularly if too close to rivers, and if contours are not followed; loss of riparian vegetation	One of the best actions is to restore and maintain indigenous vegetation in the riparian area, in addition to making changes to land use practices in the wider catchment. Restore wetlands which filter out silt.
Toxicants	Mining, heavy metal industries, biocides used in agriculture and landscaping (herbicides, fungicides, pesticides)	Apply legal guidelines for toxic effluent; invest in bio-remediation of heavy metals; reduce and carefully manage the use of biocides (e.g. don't spray under windy conditions); handle, store and dispose of biocides with great care.



Type of Pollution	Some sources	Actions to explore
Excess nutrients	Sewage outflow into rivers (see below); excessive use of fertilizers (nitrogen, ammonium, phosphates) for agriculture and landscaping	Reduce the use of fertilizers; establish and maintain a buffer zone of indigenous vegetation in
Pathogens	Raw sewage from informal settlements or mal-functioning or inadequate sewage works	Put in place adequate sanitation, including toilets which do not rely on water – a system introduced from Britain, where it was more suited to local resources. Adequate non-water borne technologies exist and can do much to reduce the occurrence of disease. Expand and manage sewage works well, e.g. using bio-remediation techniques.
Salination	Irrigation of farmland, particularly in hot, dry conditions. Releases of treated effluent from sewage plants, particularly during dry conditions.	Reconsider crops which require irrigation, particularly in hot, dry areas; consider alternatives for keeping the soil cool and preventing wind erosion. Maintain an adequate flow in the river.

Table 1: Pollution Sources and Directions for Action

Note that most forms of pollution are considerably worse when *the flow in the river* has been reduced, as this concentrates pollutants. Any action which will increase the flow in the river, will help to reduce the levels of pollution. However, this action on its own is not an adequate solution. An increase flow also spreads pollutants further along a river's reach.

Clear Invasive Aliens

Clearing invasive alien plants helps rivers in a number of ways to better provide benefits to society.

Clearing large stands of water thirsty species like eucalyptus (gum trees), pine trees and black wattle from the catchment, can contribute to greater available run-off to the river, as well as more water and space for indigenous vegetation. More water in the river means more water which

can be delivered to users; more water to maintain ecosystems and process waste; more water

for riverine vegetation and associated resources like firewood, thatching reeds and medicinal plants.

Clearing invading species like lantana, prosopis and oleander from the river and its banks

helps to maintain an open flow channel and encourages indigenous species which have a myriad of benefits:

buffering the river from harmful chemicals being applied on surrounding land; establishing

habitats and corridors for birds and other animals; stabilising river banks; protecting surrounding land

from floods; minimising soil erosion, and more. These benefits can also be seen downstream from the clearing action. No wonder that alien clearing is taking place in so many catchments throughout South Africa.



Government is putting considerable resources into the process, which is recognised as an investment in our future, as well as an opportunity to employ relatively unskilled people in useful work, and equipping them with skills. There should therefore be no reason why a landowner, Water Users Association or river watch group would be unable to find the necessary resources to help clear a river and the surrounding catchment.

Agencies involved in alien clearing include:

- Department of Water Affairs & Forestry (DWAF) – Working for Water (WfW) Programme
- Department of Agriculture – Landcare Programme
- Department of Environmental Affairs & Tourism – Working for Wetlands Programme
- District municipalities
- Provincial conservation agencies.

Depending on who is active in your catchment or your part of the catchment, one or more of these agencies should be able to provide resources. A number of scenarios are possible. For example, in some cases

DWAF/WfW can provide alien clearing teams and fund them. In other cases, they might provide only equipment, with a landowner or conservancy contributing labour and supervision. In some areas Landcare provides funding which farmers administer, along with teams of hired people who work alongside the farmers' staff. In some stewardship agreements, conservation agencies provide resources, or facilitate the provision of resources, for landowners who pledge to conserve biodiversity.

A couple of pointers to consider:

- Coordinate your efforts with those already in place. In a catchment, everything is connected, and the river is the connector.
- Gain as much technical and logistical information as possible before starting out.
- Alien clearing operations have impacts on the environment – herbicides are poisonous, trucks drive along river banks, workers make fires and kill wildlife, trees are felled and dragged through the veld. Minimize these impacts through training and supervision.
- Some invasive species look similar to indigenous species – make sure that workers know what they do!
- The target species are not called 'invasive' for nothing. They re-sprout, and their seed banks are vast. You *must* take follow-up action, or the aliens will return, doubling their numbers.
- You are up against a formidable opponent. Work with a plan and look for partners.
- Monitor your progress. This includes a map and/or photos of the 'Before' scenario. Use evidence of progress to guide your next steps, and to motivate others, including possible future funders and other partners.

Restore and Maintain Riparian Vegetation

Key among the actions we can take to restore and maintain a river in a good state, is to protect or restore indigenous vegetation in the riparian area. This is particularly important where riparian areas have been cleared, for example for access, or to establish fields near the river, or where alien vegetation has recently been removed.

The benefits will include stabilised river banks, less flood damage and less erosion; a buffer to protect the river from harmful chemicals used on land; better water quality and lower purification costs; more wildlife and greater biodiversity; more resources like firewood, medicines, building and craft materials; beautiful places with potential for recreation and eco-tourism; a more resilient and less unpredictable ecosystem.

Certainly worth the investment! But how does one go about it?



If you are unsure where exactly the riparian area is, see our description on page ..., or the definition in the National Water Act (www.dwaf.gov.za), or follow the guidelines for delineating wetlands and riparian areas in *A Practical Guide for the Identification and Delineation of Wetlands and Riparian Areas* (2003), distributed by DWAF (Sub-Directorate Stream Flow Reductions).

Guidelines for how broad the buffer strip between the river and cultivation or plantations should be differ from 20-40 metres, depending on the activity.

You may need to start by stabilising existing erosion. Any number of methods could be considered. Consult with a Working for Wetlands team if one is active in your area, as they have a focus on rehabilitation, or the Department of Agriculture and in particular the Landcare programme.

When planting up a riparian area, your choice of species should be influenced by what would naturally have grown there. If some indigenous riverine vegetation in your area has remained relatively undisturbed, study these areas to see what grows there, bearing in mind that the species will tend to vary depending on the aspect and whether you are looking at the upper, middle or lower reaches of the river. In general, plant what is adapted to the soils, climate, available nutrients and water, and consult local experts where you can.

Also consider:

- A mix and range of species is best. This is closer to the natural species composition in most riverine areas, which may include a mix of trees, bigger and smaller shrubs, and groundcovers such as grasses. The species mix also makes your planting more robust; if some species don't take well, others will.
- Mix slower growers with fast-growing species. You will see some results quickly, and the early growth will start to bind the soil and protect the more valuable and often more vulnerable slow species until they are established.
- Be mindful of how the riparian area will be used by all potential users. In rural and urban areas people use rivers and river banks for a variety of purposes (reflecting how important these landscapes are to humans). Plan your planting and other features (like paths, boardwalks, bins, benches, jetties, etc) accordingly.
- People may need:
 - Access to resources like firewood, medicinal plants
 - Access to the river for religious rituals
 - Access to the river for fishing and water sports
 - Recreation on the river banks, e.g. picnic spots, walking, bird watching
 - For all these users, safety and the discouragement of crime are paramount. Indigenous vegetation is often destroyed because crime is associated with bushy areas – stolen loot is hidden and attacks take



place “in the bushes”. Any number of strategies can be applied, and might be necessary, to discourage criminal activity and at the same time restore river banks, river function and benefits.

Measure River Health

There are a number of tests and observations which can help us determine the state of a river (how healthy it is, or not). These tests and observations can be repeated over time to see how successful we are at improving river health.

The River Health Programme uses the following six ecological indicator groups that represent the condition of the larger ecosystem. The data is simplified and presented as indices (pointers or marks). Most of these tests are simple enough for non-scientists to join in, provided they have good guidance from a reputable scientist.

The Index or Marker	What is it about?	Why use it?
Index of Habitat Integrity	What habitats for aquatic life are available in the river and banks? To what extent has human activities disturbed these habitats?	The diversity and availability of habitats have a big influence on the aquatic plant and animal life.
Geomorphology Index	What is the condition of the river channel, and how stable is it?	Geo-morphological processes like erosion determine the size and shape of river channels, which in turn define the type of habitat available to plant and animal life.
Riparian Vegetation Index	How much has the riparian vegetation (plant growth in the riparian strip of land along the river) changed from its natural state? It might be invaded by alien species, or totally removed.	Healthy riparian areas help to maintain the river channel and to filter sediment and excess nutrients. They are also a source of plant material which serves as food for aquatic fauna.

Water Quality	How suitable is the water itself for aquatic ecosystems? What are the levels of phosphate, nitrogen, ammonia and oxygen in the water?	Water quality indicates how suitable the water is for aquatic ecosystems. While nutrients are important, too high levels cause overgrowth of some species which eventually suffocate others.
Fish Index	To what extent have the types and numbers of fish present, changed from the natural condition?	Fish are good indicators of the long-term influences on general habitat conditions within a stretch of river.
SASS – South African Scoring System	What invertebrate families (crabs, snails, insects) are found here? How pollution sensitive are these species?	Aquatic invertebrates require specific habitats (homes) and water quality conditions. They are good indicators of recent, localised conditions in a river such as the presence of chemical pollutants.

Table 2: River Health Indices

Levels of nitrates, phosphates and ammonia can be measured with commercially available kits. These are relatively expensive and if they are not available, you could simply look at obvious signs that levels of these nutrients are high, such as overgrowth of algae or water weeds. However, the test kits are useful for monitoring changes as a result of changes in management practices.

You will notice that the River Health Indices are ecological and that the plants and animals that are present in the stretch of river being assessed, feature prominently. Why not just do chemical tests for pollutants?

Chemical tests have limitations. They can be very complex, and expensive. Often they cannot pick up the very small quantities of poisons which are nonetheless harmful to life. And, by the time we arrive at the river to test, a pollution 'event' might have passed, the pollutants will no longer be present in this stretch of the river. However, their effects may be.

This is why the river life is such valuable indicators of pollution. As we noted in Section 3, many animals found in rivers are very sensitive to pollution and will either move away, if they can, or fail to reproduce, and/or die. Some species are more sensitive than others. For example, the larvae of the mayfly, found mainly in the upper reaches of rivers, are very sensitive to pollutants. Others can tolerate some levels of pollution, for example the larvae of the

syrrhids (a type of fly) can live naturally in water polluted by decaying carcasses of large animals.

This is why observations of the animal life in a river can be so useful. It is not because we are concerned about the animals' health (although we might be) ... but because the animals are such a good indicator of an ecosystem's health, and therefore of the state of the river itself, and the likelihood that it will be able to provide us with eco-services. Below we look at the SASS index in more detail.

South African Scoring System (SASS)

The SASS uses the presence or absence of riverine invertebrates as a means of estimating the degree of pollution of the water in a river.



The SASS is based loosely based on a system used in the UK, and adapted for South Africa by Mark Chutter, and for various parts of South Africa by various other scientists. A mini-SASS for schools has been developed by Somerset Education.

The SASS is based on two pillars:

First, the fact that some invertebrate families are much more sensitive to chemical pollutants than others. Scientists are able to tell which species are more sensitive to pollution and which are more tolerant. At a site in a natural river there could, at any one time, be a mix of families, some being fairly sensitive to, and others being fairly tolerant of, pollution. But the more polluted the water, the fewer of the sensitive families will be able to survive. Therefore, if we observe species at a polluted site, we will find fewer of the sensitive species.

Second, the mix of invertebrate families present at a particular site, at a particular time, depend on the water quality not just at that particular moment, but of the water quality throughout the lifespan of these species. If there has been low levels of pollution over a period of some months, therefore, or if there has been one single and passing incident of pollution, these will both be reflected by the invertebrate families – although our chemical tests might not be able to pick up this pollution.

Although the SASS is a relatively simple procedure and calculation that school children can undertake with good guidance, there are some guidelines that must be adhered to. The test requires one to collect invertebrates using techniques, but these are standardised, for example one collects goggas from particular parts of the river, for a set amount of time, before starting to score them. Temperature, pH and oxygen levels are useful supplementary information but not essential.

For the scoring, one needs a score sheet, which is the basis of the SASS. Score sheets have been drawn up for different parts of the country. They show the various invertebrate taxa or families one can expect in that part of the country, and the score which scientists have given this family, based on

their sensitivity to pollution: 1 being the score for the most tolerant families which will survive most conditions, and 15 being the score for the most sensitive families.

The test consists of identifying the animal families you have collected, and writing down their scores, then adding the scores for all the families (not the individual animals). The combined scores for all the families found at a particular site will be high if the families are mostly pollution-sensitive, and low if they are mostly pollution-tolerant. The highest scores can be expected at the cleanest sites in the upper reaches of rivers, and the lowest scores in severely polluted rivers.

The Total Score (for all the families in the sample) is then divided by the number of families, to get the Average Score Per Taxon (or family). This must be done, to compensate for the fact that some river stretches will naturally have fewer species (families or taxa), so the number of species present is not necessarily an indication of pollution levels.

For examples and a useful discussion of interpreting SASS results, see Davies and Day (1998) pages 400-408.

Apply the Law

A number of laws help to protect water resources. Some are directly related to water use, while others regulate activities in the catchment, which have an impact on water quality and quantity.

This is not the place to discuss these legal tools in detail; for that, please refer to the booklet *Summary of Legislation*, in this series. But some pointers are useful here:

The National Water Act is a departure from the Roman-Dutch law which previously regulated water use in South Africa. These laws were by and large inappropriate for a water stressed country with vast social and regional inequalities, as they sanctioned the private ownership of water (or rather, treated water as a freely available right in relation to ownership of land) and did little to encourage the protection of the resource. Under the NWA, water users and managers are required to use participatory, scientifically informed processes to decide on the quality of water resources required in a particular area, and the allocation of licenses for water use, once basic human rights has been met and the investment in the ecological reserve has been made.

Forestry regulations (under DWAF) have various implications that are relevant to rivers, as Forestry is classified as a Stream Reduction Activity. Foresters are required to adhere to regulations regarding roads through wetlands, for example, and not planting in wetlands.

CARA, the Conservation of Agricultural Resources Act, restricts land use practices which exacerbate soil erosion and the destruction of riverine vegetation, for example ploughing too close to the river bank. It also requires landowners to apply for permission before commencing with the building of a dam.

Similarly **NEMA, the National Environmental Management Act**, requires landowners to apply for permission to clear indigenous vegetation in order to open up new fields or orchards (under Environmental Impact Assessment regulations).

Adopt a River

Many schools and citizen groups have decided to adopt a stretch of river and take care of it. They clean the river and its banks of litter, plant indigenous plants, try to stop sources of pollution affecting the river, monitor river health, and lobby authorities for support. Such groups often operate with very little funding, or find funds from various sources such as local or national NGOs, municipalities or other government departments. Unemployed youth can learn useful skills and build helpful contacts by becoming involved as river guards.

Use tools like the water quality test kits and mini-SASS mentioned above, to find out how big the problem is and whether you are improving river quality. These tests do have their limitations, though, as mentioned. Often you would do well to search for scientists and organisations who can assist with more sophisticated tests. Scientists would benefit from 'giving away the tools of science', which is a far better way of getting citizens involved, than merely disseminating scientific information.



For more detail on the various bodies and their powers, roles and responsibilities, see *Summary of Water Management Institutions* in this series.

Use The Right Channels: Associations, Agencies and Forums

These bodies, for which provision is made in the National Water Act (NWA) of 1998, provide recognised channels through which everyone can be involved in the management of rivers and river catchments.

Water User Associations

Previously, irrigation farmers could address their needs through irrigation boards. The NWA has advised that these boards be replaced by Water Users Associations (WUAs) and broadened to include other needs and interests such as municipal water management. This means that various interests can be considered and addressed in relation to each other. WUAs are formal,

statutory bodies. They must appoint office bearers and draw up constitutions, which can then provide for the following functions, *several of which address the issues raised in this booklet, directly.*

Functions of Water User Associations

- To prevent water from any water resources being wasted.
- To protect water resources.
- To prevent any unlawful water use.
- To remove or arrange to remove any obstruction unlawfully placed in a watercourse.
- To prevent any unlawful act likely to reduce the quality of water in any water resources.
- To exercise general supervision over water resources.
- To regulate the flow of any watercourse by:
 - clearing its channel;
 - reducing the risk of damage to the land in the event of floods; and
 - changing a watercourse back to its previous course where it has been altered through natural causes.
- To investigate and record:
 - the quantity of water at different levels of flow in a watercourse;
 - the times when; and
 - the places where water may be used by any person entitled to use water from a water resources.
- To construct, purchase or otherwise acquire, control, operate and maintain waterworks considered to be necessary for:
 - draining land; and
 - supplying water to land for irrigation or other purposes.
- To supervise and regulate the distribution and use of water from a water resources according to the relevant water use entitlements, by erecting and maintaining devices for:
 - measuring and dividing; or
 - controlling the diversion of the flow of water.

Catchment Management Agencies

A Catchment Management Agency has a broader role than a WUA. The CMA's roles include the development of a Catchment Management Strategy and coordination among various interest groups. A Water Management Area (one or more catchments) may have several WUAs, but will have only one CMA.

A CMA has the following initial functions:

- To investigate and advise on the protection, use, development, conservation, management and control of the water resources in its water management area



- To promote co-ordination between implementation of its catchment management strategy with implementation of water services development plans by water services authorities (municipalities)
- To develop a **Catchment Management Strategy** for its water management area
- To co-ordinate the activities of water users and water management institutions within its water management area
- To promote community participation in the protection, use, development, conservation, management and control of the water resources in its water management area.

A **Catchment Management Strategy** is an important means of ensuring that resource protection measures such as the Reserve are practically implemented. The Catchment Management Strategy must, among other things:

- Set principles for allocating water to existing and prospective users
- Take into account all matters in terms of the protection, use, development, conservation, management and control of water resources
- Be in harmony with the national water resources strategy.

(For more, see *Catchments and Sustainability*, in this series.)

Government may also assign or delegate the following additional powers and duties to CMAs:

- Power to manage, monitor, conserve and protect water resources and to implement catchment management strategies
- Establishing rules to regulate water use
- Require establishment of management systems by water users
- Require alterations to waterworks
- Temporarily control, limit or prohibit water use during water shortages.

The Minister may also assign to a CMA certain powers or duties in terms of water uses and the allocation of water. This makes the CMA a responsible authority, with powers and duties related to the issuing of water licenses, enforcing licensing conditions and suspending or withdrawing entitlements to use water. These duties are clearly important in maintaining the Ecological Reserve and working towards the agreed-upon management class for the river.

CMAs can be assisted by **Catchment Management Committees, who can advise them on technical matters, help to broaden stakeholder representation, or perform** certain executive functions.

The types of activities that a catchment management committee may undertake include:

- making recommendations on water use authorisation
- monitoring water resources and water use
- implementing local water resources management projects, and
- mobilising people and resources.

Catchment Forums

Catchment Forums are not statutory and less formal than either Water Users Associations or Catchment Management Agencies. Anyone can join a Catchment Forum. A key purpose of the Forum is to enable the public to participate and have a say in water resources management. They provide a platform for stakeholders to share their views and to communicate with the CMA.

A Catchment Forum performs one or more of the following roles:

- **Consultation for water resources management:** A catchment forum is a vehicle for consultation around water resources management issues. It is the primary interface between the CMA and the body of stakeholders. All catchment forums should have a consultative-advisory role.
- **Institutional co-ordination:** Since catchment forums involve stakeholders from a variety of sectoral backgrounds, they may be required to engage in issues that are outside the mandate of water resources management. For example, they can play a coordinating role, or promote integrated planning and management (in support of integrated water resources management) through addressing issues such as water services, waste management, integrated environmental management and land development.

This role is vital in relation to river health, given that rivers reflect what happens in the catchment as a whole.



For More On Rivers

References and Further Reading

- Davies, B. and Day, J. 1998. *Vanishing Waters*. UCT Press, Cape Town. This book is widely regarded as a sound introduction to river ecology, and formed a key reference for this booklet. Unfortunately it is no longer in print, but some libraries will have copies.
- Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Synthesis*. World Resources Institute and Island Press, Washington, D.C.
- State of the River Reports. The *River Health Programme* has produced a series of *State of the River Reports* for a number of catchments throughout South Africa. These reports present a picture of various individual rivers in photographs, text, figures and symbols. They describe the state of the river's 'health', and suggest management actions that we can take to improve or maintain these states. It is highly recommended that you find out whether a River Health report has been compiled on your local rivers. Ask about its availability at a provincial office of the Department of Water Affairs and Forestry (for contact details see www.dwaf.gov.za or a telephone directory). Reports can also be viewed and downloaded from the website of the CSIR, www.csir.co.za/rhp.
- River Health Programme, 2006. *State of Rivers Report: Olifants/Doring and Sandveld Rivers*. DWAF, Pretoria.
- Palmer, T., Berold, R., Muller, N. & Scherman, P. 2002. *Some for All, Forever. Water Ecosystems and People*. Water Research Institute, Rhodes University. Water Research Commission Report TT 176/02. Using clear, basic English, this booklet introduces water catchments, with a particular focus on rivers, the new Water Law, the concept of the Reserve and of Water Resource Classification. The implications of different river classes are explained in some detail.
- Taking Care of Wetlands
- Taking Care of Groundwater
- Taking Care of Estuaries'

- Catchments and Sustainability
- The Ecological Reserve
- Water Resource Classification
- Summary of Water Institutions
- Summary of Water Legislation

These booklets, all in the same series as this publication, are available from WWF-SA. They all aim to introduce water users and – managers to concepts in an accessible way, with practical application. Each emphasise different water-related aspects in more detail, and therefore usefully complement this publication.

