A RIVER HEALTH ASSESSMENT OF SELECTED SOUTHWESTERN CAPE RIVERS: RIPARIAN VEGETATION INDEX (RVI) APPLICATION, EVALUATION AND ALTERNATIVES

Melanie Jane Withers

Thesis presented in partial fulfilment of the requirements for the degree of Master of Science at the University of Stellenbosch

Dr C. Boucher
Dr K. Esler

December 2003

Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

ABSTRACT

This study focuses on riparian vegetation condition at sites along three rivers within the southwestern Cape, South Africa namely the Lourens, Hout Bay and Palmiet Rivers. The Riparian Vegetation Index (RVI) is used as a tool to assess riparian vegetation condition. Data from this study will be used in State of Rivers reporting for the River Health Programme in South Africa. This study highlights sites of high conservation status with regards to vegetation condition and indicates sites of concern due to poor vegetation condition. Deviations from expected vegetation condition scores at certain sites along the rivers have highlighted certain flaws in the RVI method.

Further, the repeatability and validity of the RVI method is tested. The method is tested for variability and validity across disturbance gradients at sites along the Eerste River. Results indicate that the RVI method produces repeatable results. The sub-index, Recruitment of Indigenous Riparian Species (RIRS), is the most variable in terms of assessor scores, while Structural Intactness (SI) is the most reproducible sub-index. This has important implications for the future development of the method, which should place more emphasis on reproducible sub-indices within the final RVI formula and should standardise those sub-indices that are highly variable. Statistical analysis indicates that the method does not reflect the perceived biological status of the vegetation. This may be due to the specified sampling duration, which should be increased in order to reflect more meaningful results.

Criticisms of and difficulties with the RVI method as well as suggestions to improve the method are dealt with and an alternative method to the Riparian Vegetation Index is explored. The Floristic Quality Assessment (FQA) method, used to determine vegetation integrity in Illinois USA, is adapted to assess riparian vegetation condition at sites along the Lourens, Hout Bay and Palmiet Rivers. Coefficients of conservatism, determined for the flora observed in the assessment, attempt to categorise species according to their response to levels of habitat degradation. These values are incorporated into the Floristic Quality Index (FQI) formula, which yields the final floristic quality assessment results. Correlation analyses indicate that RVI and FQA results are strongly correlated although the RVI at this stage best represents the perceived biological status of vegetation at sites. The FQA method, or a statistically modified alternative, may be a suitable and more objective alternative to the RVI method.

OPSOMMING

Hierdie studie fokus op die kondisie van die oewerplantegroei van verskeie studie gebiede langs drie riviere in die suidwes Kaap, naamlik die Lourens–, Houtbaai–en Palmietriviere. Die 'Riparian Vegetation Index' (RVI) is gebruik om die kondisie van die oewerplantegroei te ondersoek. Resultate van die studie sal gebruik word in 'State of Rivers' verslaggewing vir die Suid-Afrikaanse Rivier-Gesondheidsprogram (RHP). Hierdie studie op grond van oewerplantegroei, beklemtoon areas met `n hoë bewaringsstatus en dui ook gebiede aan wat aandag vereis as gevolg van swak oewerplantegroei kondisie. Afwykings van verwagte plantegroei kondisiewaardes by sommige studie areas langs die riviere, beklemtoon sekere swakpunte in die RVI-metode.

Verder, is die herhaalbaarheid en geldigheid van die RVI-metode ondersoek op versteuringsgradiente langs die Eersterivier. Resultate toon dat die RVI-metode wel herhaalbare data produseer. Dit is gevind dat die sub-indeks 'Recruitment of Indigenous Riparian Species' (RIRS) die meeste varieer in terme van assessor-waardes terwyl die 'Structural Intactness' (SI) die mees herhaalbare sub-indeks is. Dit het belangrike implikasies vir die toekomstige ontwikkeling van die metode, wat herhaalbare sub-indekse in die finale formule van die RVI moet beklemtoon en varieerende sub-indekse moet standardiseer. Statistiese analises dui aan dat die RVI-metode nie die waargenome biologiese status van die plantegroei reflekteer nie. Dit mag die gevolg wees van die tyd wat gespesifiseer word vir dataversameling. Meer beduidende resultate mag egter verkry word as die gespesifiseerde tydsduur verleng word.

Kritiek en struikelblokke met betrekking tot die RVI-metode, asook voorstelle om die metode te verbeter, word behandel. `n Alternatiewe metode om die toestand van oewerplantegroei te bepaal is ook ondersoek naamlik die 'Floristic Quality Assessment' (FQA) metode, wat ontwikkel is om die integriteit van plantegroei in Illinois in die VSA te bepaal. Hierdie metode is aangepas om die toestand van oewerplantegroei langs die Lourens–, Houtbaai–en Palmietriviere te ondersoek. `n Konserwatiwiteits-koeffient, wat bepaal is om die waargenome plantegroei te evalueer, poog om spesies te kategoriseer op grond van hul reaksie op verskillende vlakke van habitatdegredasie. Hierdie waardes word geinkorporeer in die 'Floristic Quality Index' (FQI) formule wat die finale kwaliteit van die plantegroei aandui. Analises toon `n sterk korrelasie tussen resultate verkry deur beide die RVI– en FQA-metodes. Huidiglik koreleer die RVI egter sterk met die waargenome biologiese status van die plantegroei die beste. Die FQA-metode of andersins `n statistiese

gemodifiseerde alternatief daarvan mag egter meer gepas en objektief blyk te wees as die RVI-metode.

AKNOWLEDGMENTS

Thanks to Dr C. Boucher and Dr K. Esler for their continued input and support throughout the project. The National Research Foundation must be acknowledged for providing financial assistance for the project. The Western Cape River Health Programme Provincial Committee particularly Toni Belcher and Dean Impson are thanked for their support. Thanks to Nigel Kemper and Neels Kleynhans for their participation in the training day at the onset of the project. Cape Peninsula National Parks and Nature Conservation officials as well as landowners are thanked for their assistance in permitting access to study areas. Finally to the fieldwork team, Emily, Dean and Johan, thanks for all your help.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

In South Africa and around the world there is considerable concern regarding the health of aquatic ecosystems (Norris & Norris 1995, Davies & Day 1998, Bunn *et al.* 1999). In developing countries there is often a lack of any detailed information and the time and manpower required to obtain data before the possible impacts of any additional developments can be assessed (Kleynhans 1996). Several, if not all, South African rivers are currently subjected to some form of alteration and deterioration due to water quality problems, water abstraction, catchment mismanagement and the alteration of aquatic habitats (Kleynhans 1996). The need for assessment methods is real and will grow as deterioration of aquatic ecosystems escalates. The ultimate aim of accurate ecosystem assessment is the dynamic and effective management of water resources (Roux *et al.* 1999). Because South Africa has such limited water resources, water resource management is critically important for the sustainable economic and social development of the country (State of Rivers Report 2001 a).

In terms of the National Water Act (Act No. 36 of 1998), the Department of Water Affairs has a commitment to ensure sustainable water resources for all the people of South Africa. According to Mr Kasrils, Minister of Water Affairs and Forestry, sustainable river systems benefit the most vulnerable of South Africa's communities, who are the first to feel the effects of deterioration in status of water resources because they live in close proximity to rivers and are directly dependant on these water resources (Speech given on the 31 January 2002, Kruger National Park for the second State of Rivers Report for Letaba & Luvuvhu Rivers Systems). A system was needed in South Africa to identify the present ecological state of rivers and their ecological reference conditions in order to set out ecologically sound and feasible resource quality objectives. This resulted in the development of the River Health Programme in 1994.

THE RIVER HEALTH PROGRAMME

The River Health Programme is a national monitoring programme that focuses on measuring and assessing the ecological state of riverine ecosystems in South Africa. The overall goal of the programme is to expand the ecological basis of information on aquatic resources to support the rational management of the systems (Roux 1997). The concept of the 'health' of a river originated within the aquatic scientific community as a way of describing its condition from the viewpoint of its ecological functioning. The term was seen to provide a holistic perspective of river condition. Healthy rivers are rivers that are close to their natural or undisturbed state, with the majority of characteristics relatively unmodified (Hart & Campbell 1994). A multitude of factors determine the health of a river ecosystem: its geomorphological characteristics, hydrological and hydraulic regimes, chemical and physical water quality, and the nature of in-stream and riparian habitats (State of Rivers Report 2001 b). The term 'riparian' means frequenting, growing on, or living on the banks of streams or rivers (Lawrence 1989).

The River Health Programme makes use of instream biological response monitoring (effects monitoring), in order to characterise the response of the aquatic environment to multiple disturbances (Roux *et al.* 1999). The rationale is that the integrity of the biota inhabiting the river and the in-stream and riparian habitats provides a direct, holistic and integrated measure of the integrity of the river as a whole and can therefore be used as a basis for measuring and assessing the ecological state of aquatic ecosystems (Roux *et al.* 1999). The primary indicators used in the programme include communities of fish [Fish Assemblage Integrity Index (FAII), Kleynhans 1999], aquatic invertebrates [South African Scoring System (SASS), Chutter 1998] and riparian vegetation (reviewed below) as well as abiotic indicators, [geomorphology (Rowntree & Ziervogel 1999), habitat (Kleynhans 1996), water quality (Moore 1990)] which provide a framework within which to interpret the biological results.

RIPARIAN VEGETATION

To reflect all possible changes, which are likely to occur in aquatic systems, integrated biomonitoring programmes need to consider and address riparian vegetation along with other aspects. This study forms part of a broader study of river health of selected rivers within the southwestern Cape. Other members in the study team were involved in aspects that included monitoring aquatic invertebrate and fish communities and establishing the habitat integrity of study sites, the ultimate aim being to integrate the results for a State of Rivers Report.

The riparian zone is the critical component in the linkage between stream ecosystems and their catchments (Bunn 1994). According to Gregory *et al.* (1991), riparian vegetation occupies one of the most dynamic areas of the landscape. Distribution and composition of riparian communities reflect steep environmental gradients (between aquatic and terrestrial ecosystems) and histories of disturbance. The riparian zone has been defined by Kotze *et al.* (1997) as that area located next to a stream or river, affected by stream processes such as flooding and deposition of alluvial soil, and supporting a fauna and flora different from the upland slopes.

Riparian vegetation is that which is found in close proximity to rivers in a clearly defined riparian zone and which is dependant on the river for a number of functions. It displays structural, compositional, and functional characteristics, which are clearly distinct from the fringing terrestrial vegetation and is distributed according to clear inundation and other functional gradients (Kemper 2001).

Riparian vegetation forms an integral and important part of any river ecosystem and is known to play a number of important geomorphological, ecological and social roles which have a bearing on the condition and long-term functioning and sustainability of the river itself and on regional biodiversity (Kemper 2001). These roles include stabilization of river channels, banks and floodplains; flood attenuation; maintenance of water temperature and quality; provision of habitat, refuge and migration corridors for terrestrial, avian and aquatic fauna; the interception and breakdown of pollutants; the interception and deposition of nutrients and sediments; and the provision of fuels, building materials and medicines for local communities. Some of these roles will now be discussed further.

Shading and temperature regulation

Vegetated buffer zones are important for shading the watercourse and improving the living conditions of fish and other animals (Large & Petts 1992). Shading influences both the rate of photosynthesis and community composition of stream primary producers (Bunn 1994). Riparian vegetation with a high cover has a limiting effect on the growth of water plants and algae. In the absence of riparian shade, large vascular plants and filamentous algae often proliferate resulting in changes of available habitat and lowered water quality because they restrict flow and trap sediment (Bunn *et al.* 1999).

One of the most important benefits of riparian vegetation is its ability to regulate water temperature (Dallas & Day 1993, LeBlanc & Brown 2000). Temperature is one of the primary factors influencing growth, metabolism and survivorship of stream invertebrates and fish and also has indirect effects of controlling oxygen saturation and microbial metabolism (Bunn *et al.* 1993).

Vegetated buffer strips in North America, with widths between 10-30 m, have been shown to maintain stream temperature effectively (Osborne & Kovacic 1993).

Exchange of nutrients and organic matter

Instream habitat structure and organic matter inputs are determined by local conditions such as vegetative cover of the riparian zone (Allan *et al.* 1997). The percentage cover of the riparian vegetation is a good general predictor of the relative abundance of the litter derived from the contributing species that will accumulate in the stream channel (Bunn *et al.* 1993). The supply of organic detritus is the most important fuel for running-water food webs (Large & Petts 1992). In fact, the organisation of life cycles of certain invertebrates, are keyed into the availability of litter as a nutritional resource by inputs from the streamside zone. Changes to the carbon dynamics of streams and rivers associated with riparian vegetation removal have a tremendous impact on ecosystem function and river health (Bunn *et al.* 1999).

Riparian zones effectively regulate the flux of nutrients and sediments to and from streams and can act as a buffer to catchment-scale disturbances. It has been shown that riparian zone restoration is an effective tool for reducing pollutant concentrations and loads from livestock grazing in agricultural watersheds (Meals 2001).

Habitat and stream bank stability

Riparian vegetation provides habitat for birds and animals in general. Within the stream, logs and branches from the riparian vegetation influence the transport of carbon and nutrients and provide important habitat for invertebrates and fish (Bunn 1994). The roots and stems of streamside vegetation prevent erosion by stabilising stream banks, ensuring that they do not collapse when undercutting by moving water takes place.

Landscape level functional roles

Riparian zones, too, play important functional roles at a much broader scale. On a landscape and global level they sustain biodiversity and act as corridors for dispersal for both plant and animal species (Gregory *et al.* 1991, Naiman *et al.* 1993, Hood & Naiman 2000).

The riparian zone supports higher levels of biodiversity because environmental gradients existing between the river and land create a heterogeneous area, which acts as important habitat for both plants and animals. The removal of riparian vegetation along the Sacramento River resulted in 95 %

fewer birds and 32 % fewer species in adjacent agricultural land (Large & Petts 1992). The riparian zone serves as a corridor because it follows the length of a river thereby connecting habitats in between, which may otherwise be isolated by land transformation. Animals use these corridors to disperse, and to find food and mates. Rivers themselves function as corridors for plant dispersal (Johansson *et al.* 1996). Gregory *et al.* (1991) note that riparian zones, being ameliorated microclimates, are very important dispersal corridors for plants especially during periods of rapid climatic change.

ANTHROPOGENIC INFLUENCES ON RIPARIAN VEGETATION

The anthropogenic impacts on riparian ecosystems, in South Africa, are profound especially in urban areas where the natural character of rivers is often totally lost due to canalisation (Davies & Day 1998, Downs *et al.* 2002). Impacts such as physical loss of the natural riparian vegetation can be caused by engineering activities such as canalisation, general infrastructure development, forestry and agricultural activities. Impacts such as dam and weir construction can also cause a change in the physical structure of riparian zones (Rowntree 1991). Regulated flows caused by impoundments can cause encroachment of vegetation usually downstream of the impoundment as well as a change in species composition (Bravard & Petts 1996, Kondolf 1997). Groundwater depletion can threaten riparian ecosystems (Stromberg *et al.* 1996). General disturbance in the riparian zone caused by grazing pressures, agriculture and forestry or over utilisation of riparian plants also has a major influence on the functioning on the system as a whole. This is because these activities encourage the establishment of exotic vegetation.

The presence of exotic species in the riparian zone can have adverse effects on the functioning of the system (Hood & Naiman 2000). Exotic plants may reduce food, habitat and nesting sites for terrestrial fauna and infestation of exotics can form barriers to movement of animals (CEAH & ID&A 1997). Exotic plant species may also contribute to bank collapse during flood events, as their ability to withstand flooding is poor (Macdonald & Richardson 1986). Some exotic species provide large leaf fall during autumn that indigenous ecosystems have not evolved to cope with or take advantage of (King *et al.* 1988; Davies *et al.* 1993). Exotic groundcover can hinder or prevent regeneration of indigenous species as coarse woody debris provided by exotic species generally rots more quickly than those from other species (Pidgeon & Cairns 1981). Exotic species also tend to utilise greater quantities of water than indigenous vegetation, which may have an impact on the river's natural flow regime (Davies *et al.* 1993, Dye *et al.* 2001).

In the southwestern Cape, important species invading lowland and riparian habitats include *Acacia* species (mainly *A. longifolia* and *A. mearnsii*), *Paraserianthus lophantha* and *Sesbania punicea*. Riparian habitats throughout the Fynbos Biome are heavily invaded by these species probably as a result of the efficacy of waterborn seed dispersal (Macdonald & Richardson 1986). Exotic riparian species have a particularly negative impact on nutrient inputs in rivers within the Fynbos Biome because the natural fynbos vegetation sheds leaves from spring right through summer, whilst the mainly European exotics rapidly shed their leaves in an autumnal pulse, causing desynchronisation of food inputs which impacts on the food chain (King *et al.* 1988; Davies *et al.* 1993, Boucher 1997). The exotic species also tend to be water hungry further exacerbating problems of water shortage in the southwestern Cape (Boucher & Marais 1995).

In order to determine whether anthropogenic influences are not continuing to cause deleterious effects on the natural functioning of riparian systems and to ensure that the quality of the services and goods provided by the natural riparian environment is maintained, it is necessary to ensure that effective riparian vegetation assessments are carried out. These assessments will indicate changes in condition and based on the data obtained, informed decision-making and management actions can be implemented to maintain the quality of riparian vegetation.

RIPARIAN VEGETATION ASSESSMENT

The use of riparian vegetation in monitoring river health has been neglected in the past but is now receiving more attention (Hart & Campbell 1994). Very few monitoring techniques have been developed specifically for riparian vegetation (Kemper 2001). The monitoring of riparian vegetation responses to water abstraction has received some attention by industries in the mining sector (Kemper & Coombes 1994). Remote sensing techniques have also been applied for the assessment and monitoring of riparian vegetation structure and health, although these are often expensive (Hart & Campbell 1994, Kemper 1994). Other techniques used in South Africa include the monitoring of riparian systems in response to managed releases of water and in response to changes in flow regime and geomorphology (Mackenzie *et al.* 1999). Riparian monitoring techniques that evolved from programmes designed to monitor general river health include the Australian Index of Stream Condition (CEAH & ID&A 1997) and the assessment and participatory management of riparian systems, RIPARI-MAN, which focuses on urban riparian systems (Kotze *et al.* 1997). The United States Environmental Protection Agency has also put a few methods forward (Adamus & Brandt 1990; Lazorchak & Klemm 1997). Other riparian quality assessments include the QBR index, developed by the Department of Ecology at the University of Barcelona, in Spain (Diputació de Barcelona 2000), the Riparian, Channel, and Environmental (RCE) Inventory, developed in Sweden, specifically for small streams in a lowland, agricultural landscape (Robert & Peterson 1992) and a method employed by Salinas *et al.* (2000) which evaluates riparian vegetation in semi-arid Mediterranean watercourses using species composition and community structure data.

The QBR index (Diputació de Barcelona 2000) and the RCE Inventory (Robert & Peterson 1992) are mentioned below due to their similarities to the RVI method. The QBR index considers four aspects, which are scored separately and then totalled at the end to obtain a final score. The four aspects considered include, total riparian cover, cover structure, cover quality (based on the geomorphological type of the stream) and naturalness of the river channel (based on morphological changes in the alluvial terraces). This index has similarities to the Riparian Vegetation Index (RVI) (discussed below) but differs in that geomorpholoical characteristics are built into the final score. The RCE Inventory considers sixteen characteristics, which define the structure of the riparian zone, stream channel morphology and the biological condition of the stream. Aspects pertaining directly to the riparian zone that are included are, width of the riparian zone, completeness of the riparian zone and type of vegetation (a measure of pioneers versus native tree and shrub species density). Stream channel structure forms a major part of the RCE Inventory but not in the RVI method (discussed below).

THE RIPARIAN VEGETATION INDEX (RVI)

The development of the site-based RVI in South Africa was based on an index used to determine the quantity and quality of streamside vegetation of Australian rivers. The index, known as the Streamside Zone Index, (SZI), a sub-index of the index of Stream Condition (CEAH & ID&A 1997), forms part of an integrated programme which monitors river condition in a similar way to the RHP in South Africa and is a rapid assessment of riparian vegetation condition. According to this index, indicators were selected which measured the streamside zone's condition to perform a number of roles (Table 1.1).

Table 1.1. Indicators considered for the Streamside Zone Index (CEAH & ID&A 1997)

Characteristic of the streamside zone	Possible indicator
Filter of inputs to stream (incl. light, sediment, nutrients)	Width of the streamside zone Longitudinal continuity Structural intactness Percentage of cover which is indigenous Cover Land-uses in catchment
Source of inputs to stream (incl. large woody debris, leaves)	Width of the streamside zone Longitudinal continuity Structural intactness Percentage of cover which is indigenous Diversity of flora Condition of billabongs
Habitat for terrestrial fauna	Width of the streamside zone Longitudinal continuity Structural intactness Percentage of cover which is indigenous Diversity of flora Regeneration of indigenous flora species
Scenery and landscape values	Ratio of streamside zone width to stream width Amount of trash e.g. cans etc. Landscape value indicators Regeneration of indigenous flora species

The Streamside Zone Index was adapted and refined by Kemper (1994) to form the Riparian Vegetation Index, which has since been updated (Kemper 2001).

The purpose of the RVI (*pers. comm.* N. Kemper 2002[1]) is: -

- To provide an indicator of riparian vegetation health and ecological status in response to the full range of disturbances typically common to riparian areas;
- to aid decision making by identifying sites of different riparian vegetation status and by providing clear indications of the type and extent of disturbances present and
- to be applicable nationwide to a range of systems and which can be rapidly undertaken by staff currently responsible for collecting other monitoring data.

[1] Institute for Water Research, Department of Water Affairs & Forestry, PO Box 122, Pretoria 0001

The RVI determines the condition of riparian vegetation within river segments based on the qualitative assessment of a number of criteria in the riparian zone. These include Extent of Vegetation Cover (EVC), Structural Intactness (SI), Percentage Cover of Indigenous Riparian Species (PCIRS) and Recruitment of Indigenous Riparian Species (RIRS) (refer to Chapter 2). These aspects are important indicators of riparian vegetation condition and provide information about river ecosystem health in general because they describe the riparian vegetations' ability to perform well-documented roles in river ecosystems (CEAH & ID&A 1997).

The RVI attempts to capture all of the above-mentioned functional roles on a local scale i.e. various sites along the river systems under study. The states of interactions occurring at the aquatic-terrestrial interface and at the landscape level are therefore captured using a site-based approach. This has certain problems. The success of such a biomonitoring approach relies on our understanding of how biophysical processes influence the structure and dynamics of stream and river communities, and the way in which they function (Bunn & Davies 2000). It is important also to consider that changes in patterns do not always equate to changes in ecological integrity and may be as a result of natural biological processes. Bunn *et al.* (1999) argue that direct measures of ecosystem attributes should form an integral component of river health assessments as this allows the health of rivers to be viewed at a larger spatial scale in the context of a catchment. These authors suggest methods like tracking the sources and fate of organic carbon and nitrogen. They argue that ecosystem-level processes are ideal measures of stream health because they provide an integrated response to a broad range of catchment disturbances like increased nutrient concentrations, alterations to light regime, sedimentation etc. (Bunn *et al.* 1999).

According to the RVI methodology, results of the assessment are expressed as the degree of modification relative to a natural, benchmark condition or perceived reference state. The natural benchmark is defined as the set of conditions, which can be expected in the absence of human impacts. These conditions are specific to a particular riverine ecosystem and should reflect natural variation over time. The benchmark condition does not imply a stable state (Roux *et al.* 1999). Because rivers are often so inherently variable, long time scales are often needed to identify trends from normality (Boulton 1999). Determining reference conditions is very difficult as studies are often not long enough to capture the natural temporal trends of these systems. This aspect of the method has been highlighted as problematic especially in the Western Cape where the natural condition has been lost along most of the river systems following perturbations since European colonization in 1652 (*pers. comm.* Dr C. Boucher 2002[2]).

AIM OF STUDY

The aim of this study is to assess the condition of riparian vegetation at sites along three rivers within the southwestern Cape namely, the Lourens, Hout Bay and Palmiet Rivers, using the Riparian Vegetation Index (RVI) (Kemper 2001) (Chapter 2 & 3). In doing so, the suitability of the RVI to measure the condition of the riparian vegetation within the Fynbos Biome is assessed and recommendations for adaptation are made (Chapters 3 & 5). The above mentioned rivers were recommended for study by the River Health Provincial Implementation Committee (DWAF) for the Western and Southern Cape Regions. The RVI has not been applied in the Winter Rainfall Region of South Africa and thus its applicability to this region is tested. The index is evaluated in terms of repeatability and validity (Chapter 4). A possible alternative method is also considered (Chapter 6).

Chapters 3, 4 and 6 have been written in a format suitable for publication in the South African Journal of Aquatic Sciences.

REFERENCES

ALLAN JD, ERICKSON DL and FAY J (1997) The influence of catchment land-use on stream integrity across multiple spatial scales. Freshwater Biology **37**: 149-161.

ADAMUS PR and BRANDT K (1990) Impacts on quality of inland wetlands of the United States: a survey of indicators, techniques, and applications of community level biomonitoring data. **EPA/600/3-90/073**. Environmental Research Laboratory, US Environmental Protection Agency, Corvalis, Oregon, USA.

BOUCHER C (1997) Riparian and instream vegetation. In THARME R, RACTLIFFE G and DAY E (eds) An assessment of the present ecological condition of the Lourens River, Western Cape, with particular reference to proposals for storm water management, Final Report. Unpublished report, Southern Waters Ecological Research and Consulting cc, Freshwater Research Unit, University of Cape Town, Rondebosch.

[2] Botany Department, Stellenbosch University, Private Bag X1, Matieland, 7602

BOUCHER C and MARAIS C (1995) Editors: Proceedings of a workshop on "Managing Fynbos catchments for water". Foundation for Research Development Programme Report Series **24**:124-127.

BOULTON AJ (1999) An overview of river health assessment: philosophies, practice, problems and prognosis. Freshwater Biology **41**: 469-479.

BRAVARD JP and PETTS GE (1996) Human impacts on fluvial hydrosystems. In PETTS GE and AMOROS C (eds) Fluvial Hydrosystems. Chapman and Hall, London, pp 242-262.

BUNN SE (1994) Riparian-stream linkages: A national R&D Program for Australian streams and rivers. In UYS MC (ed.) Classification of rivers, and environmental health indicators. Proceedings of a joint South African /Australian workshop. February 7-14 1994, Cape Town, South Africa. WRC Report No. **TT 63/94**. Water Research Commission, Pretoria.

BUNN SE, PUSEY BJ and PRICE P (1993) Ecology and management of streamside zones in Australia. LWRRDC Occasional Paper Series No. **05/93**.

BUNN SE and DAVIES PM (2000) Biological processes in running waters and their implications for the assessment of ecological integrity. Hydrobiologia **422/423**: 61-70.

BUNN SE, DAVIES PM and MOSISCH TD (1999) Ecosystem measures of river health and their response to riparian and catchment degradation. Freshwater Biology **41**: 333-345.

CEAH (Centre for Environmental Applied Hydrology) and ID&A (1997) An Index of Stream Condition: Reference Manual. Waterway and Floodplain Unit, Department of Natural Resources and Environment, University of Melbourne, Australia.

CHUTTER FM (1998) Research on the rapid biological assessment of water quality impacts in streams and rivers. WRC Report No. **422/1/98**. Water Research Commission, Pretoria.

DALLAS HF and DAY JA (1993) The effect of water quality variables on riverine ecosystems: A review. WRC Report No. **TT 61/93**. Water Research Commission, Pretoria.

DAVIES BR, O'KEEFE JH & SNADDON CD (1993) A synthesis of the ecological functioning, conservation and management of South African river ecosystems. WRC Report No. **TT 62/93**. Water Research Commission, Pretoria.

DAVIES BR and DAY JA (1998) Vanishing Waters. University of Cape Town Press, Rondebosch, Cape Town.

DIPUTACIÓ DE BARCELONA (2000) Riparian quality: QBR index. Available online: www.geographyfieldwork.com (Accessed on 03/09/2002).

DOWNS PW, SKINNER KS and KONDOLF GM (2002) Rivers and Streams. In PERROW MR and DAVY AJ (eds) Hand Book of Ecological Restoration. Volume 2. Restoration in practice. Cambridge University Press, Cambridge, pp 267-296.

DYE P, MOSES G, VILIKAZI P and ROYAPPEN M (2001) Comparative water use of wattle thickets and indigenous plant communities at riparian sites in the Western Cape and KwaZulu-Natal. Water SA **27(4)**: 529-538.

GREGORY SV, SWANSON FJ, MCKEE WA and CUMMINS KW (1991) An ecosystem perspective of riparian zones: focus on links between land and water. Bioscience **41(8)**: 540-550.

HART BT and CAMPBELL IC (1994) Assessment of river health in Australia. In UYS MC (ed.) Classification of rivers, and environmental health indicators. Proceedings of a joint South African /Australian workshop. February 7-14 1994, Cape Town, South Africa. WRC Report No. **TT 63/94**. Water Research Commission, Pretoria.

HOOD WG and NAIMAN RJ (2000) Vulnerability of riparian zones to invasion by exotic vascular plants. Plant Ecology **148**:105-114.

JOHANSSON ME, NILSSON C and NILSSON N (1996) Do rivers function as corridors for plant dispersal? Journal of Vegetation Science **7**: 593-598.

KEMPER NP (1994) An Assessment of the Conservation Status of Riparian Vegetation on the Luvuvhu River and Selected Tributaries. TPA Chief Directorate for Nature and Environmental Conservation, Pretoria.

KEMPER NP (2001) Riparian Vegetation Index: Final Report. WRC Project No. **K5/850**. Institute for Water Research, Pretoria.

KEMPER NP and COOMBES PJ (1994) Incorporating the water requirements of a diamond mine and a natural riparian system in South Africa. Proceedings of the International Wildlife Management Congress, Costa Rica.

KING JM, DAY JA, HURLEY PR, HENSHALL-HOWARD M-P and DAVIES BR (1988) Macro-invertebrate communities and environment in a southern African mountain stream. Canadian Journal of Fisheries and Aquatic Science **45**: 2168-2181.

KLEYNHANS CJ (1996) A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). Journal of Aquatic Ecosystem Health **5**: 41-54.

KLEYNHANS CJ (1999) The development of a fish index to assess the biological integrity of South African Rivers. Water SA **25(3)**: 265.

KONDOLF GM (1997) Hungry water: effects of dams and gravel mining on river channels. Environmental Management **21**: 533-551.

KOTZE DC, STEYTLER NS and KIRKMAN S (1997) RIPARI-MAN, assessment and participatory management of riparian systems. World Wildlife Fund Report, Parts 1 & 2.

LARGE ARG and PETTS GE (1992) Buffer zones for conservation of rivers and bankside habitats. National Rivers Authority, Almondsbury.

LAZORCHAK JM and KLEMM DJ (1997) Environmental monitoring and assessment program surface waters: Field operations and methods for measuring the ecological condition of wadeable streams. **EPA/620/R-94/004**. National Exposure Research Laboratory, US Environmental Protection Agency, Cincinnati, Ohio, USA.

LAWRENCE E (1989) Henderson's dictionary of biological terms. 10th Edition. Longman Scientific & Technical, United Kingdom.

LEBLANC RT and BROWN RD (2000) The use of riparian vegetation in stream temperature modification. Journal of the Chartered Institution of Water and Environmental Management **14(4)**: 297-303.

MACDONALD IAW and RICHARDSON M (1986) Alien species in terrestrial ecosystems of the Fynbos Biome. In MACDONALD IAW, KRUGER FJ and FERRAR AA (eds) The ecology and management of biological invasions in southern Africa. Oxford University Press, Cape Town.

MACKENZIE JA, VAN COLLER AL and ROGERS KH (1999) Rule based modelling for management of riparian systems. WRC Report No: **813/1/99**. Water Research Commission, Pretoria.

MEALS DW (2001) Water quality response to riparian restoration in an agricultural watershed in Vermont, USA. Water Science and Technology **43(5)**: 175-182.

MOORE CA (1990) Classification systems and indices for reporting and determining the effect of managing water quality in South African waterbodies. Summary report. CSIR Division of Water Technology, Pretoria.

NAIMAN RJ, DECAMPS H and POLLOCK M (1993) The role of riparian corridors in maintaining regional biodiversity. Ecological Applications **3**:209-212.

NORRIS RH and NORRIS KR (1995) The need for biological assessment of water quality: Australian perspective. Australian Journal of Ecology **20**:1-6.

OSBORNE LL, and KOVACIC DA (1993) Riparian vegetated buffer strips in water quality restoration and stream management. Freshwater Biology **29**:243-258.

PIDGEON RWJ and CAIRNS SC (1981) Decomposition and colonisation by invertebrates of native and exotic leaf material in a small stream in New England (Australia). Hydrobiologia **77**: 113-127.

ROBERT C and PETERSON JR (1992) The RCE: a Riparian, Channel, and Environmental Inventory for small streams in the agricultural landscape. Freshwater Biology **27**: 295-306.

ROUX DJ (1997) National Aquatic Ecosystem Biomonitoring Programme: Overview of the design process and guidelines for implementation. NAEBP Report, Series No. **6**. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

ROUX DJ, KLEYNHANS CJ, THIRION C, HILL L, ENGELBRECHT JS, DEACON AR and KEMPER NP (1999) Adaptive assessment and management of riverine ecosystems: The Crocodile/Elands River case study. Water SA **25(4)**: 501-511.

ROWNTREE K (1991) An assessment of the potential impact of alien invasive vegetation on the geomorphology of river channels in South Africa. South African Journal of Aquatic Sciences **17(1/2)**: 28-43.

ROWNTREE KM and ZIERVOGEL G (1999) Development of an index of stream geomorphology for the assessment of river health. NAEPB Report, Series No. **7**. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria.

SALINAS MJ, BLANCA G and ROMERO AT (2000) Evaluating riparian vegetation in semi-arid Mediterranean watercourses in the south-eastern Iberian Peninsula. Environmental Conservation **27(1)**:24-35.

STATE OF RIVERS REPORT (2001 a) Letaba and Luvuvhu River Systems. WRC Report No: **TT 165/01**. Water Research Commission, Pretoria.

STATE OF RIVERS REPORT (2001 b) Crocodile, Sabie-Sand & Olifants River Systems. WRC Report No: **TT 1147/01**. Water Research Commission, Pretoria.

STROMBERG JC, TILLER R and RICHTER B (1996) Effects of groundwater decline on riparian vegetation of semi-arid regions: the San Pedro, Arizona. Ecological Applications **6(1)**: 113-131.

CHAPTER 2

RIPARIAN VEGETATION INDEX (RVI) METHOD

This chapter introduces the Riparian Vegetation Index (RVI) method (Kemper 2001) and explains how the final score is derived. This chapter is not intended to be an analysis of the method but provides the necessary background to the analysis chapters that follow (Chapters 3, 4 and 5).

The development of the RVI in South Africa was based on an index used to determine the quantity and quality of streamside vegetation of Australian rivers. The index, known as the Streamside Zone Index, (SZI), a sub-index of the Index of Stream Condition (ISC) (CEAH & ID&A 1997), forms part of an integrated programme that monitors river condition in a similar way to the River Health Programme in South Africa and is a rapid assessment of riparian vegetation condition. The modification and derivation of the RVI index took place during a pilot study on the Sabie and Olifants River systems in Mpumalanga during 1998 and 1999 (Roux *et al.* 1999).

The RVI is achieved by the determination of four sub-indices, which make up the final RVI score. The RVI formula is as follows:

RVI = [(EVC) + ((SI x PCIRS) +(RIRS))]

Where:

EVC = Extent of Vegetation Cover

SI = Structural Intactness

PCIRS = Percentage Cover of Indigenous Riparian Species

RIRS = Recruitment of Indigenous Riparian Species

Extent of Vegetation Cover (EVC)

This is a measure of the extent to which the site is covered by riparian vegetation of any description as opposed to bare ground. It is calculated by determining the average of two different methods (EVC 1 and EVC 2). EVC 1 is a direct assessment of the percentage vegetation coverage by the assessor on a six-point scale and is a qualitative estimate made by the assessor (Table 2.1).

Table 2.1. Six-point scoring system employed for calculating EVC 1, a direct assessment of percentage vegetation cover

Total vegetation cover (%)	0	1 - 5	6 - 25	26 - 50	51-75	76 - 100
EVC 1 score	0	2	4	6	8	10

EVC 2 is an indirect measure of cover based on the extent of site disturbance (Table 2.2).

Table 2.2. EVC 2 scores assigned to different levels of disturbance (where: 0 = no disturbance; VL = very low disturbance; L = low disturbance; M = medium disturbance; H = high disturbance; VH = very high disturbance) at a site

Disturbance score	0	VL	L	M	H	VH
EVC 2 score	10	8	6	4	2	0

The total EVC score out of 10 is determined by the formula:

EVC = [(EVC1 + EVC2)/2]

Structural Intactness (SI)

Structural Intactness determines how closely vegetation growth forms are distributed within the riparian zone relative to a perceived reference state. The reference state is that which refers to the natural condition or characteristics of a site. Because no real botanical evidence of this state of rivers often exists one has to perceive such a state based on historical and expert knowledge. It is therefore referred to as a 'perceived reference state'. SI employs a four-scale density/distribution rank utilising a comparison matrix between the Perceived Reference State (PRS) and Present State (PS) for five vegetation growth forms. It is scored for trees (SI1), shrubs (SI2), reeds (SI3), sedges (SI4) and grasses (SI5) (Table 2.3). Values in parentheses refer to derived scores for each structural component, which are used within the formula to calculate the final SI score.

Table 2.3. A comparison matrix between the Perceived Reference State (PRS) and Present State (PS) using a four-scale density/distribution rank (sparse to continuous) to derive scores for each structural component (SI1-SI5), which are used within the formula to calculate the final Structural Intactness (SI) score. Continuous refers to the situation where the structural component of interest is distributed continuously from one side of the site to the other. Clumped refers to the situation where the component is evident in distinctive clumps within the site. Scattered refers to the situation where individuals of a vegetation type are dotted throughout the site, but in reasonably large numbers without displaying clumped or continuous distributions. Sparse refers to the situation where a small number of individuals of a component are present but in different areas within a study site

	PRESENT STATE (PS)			
PERCEIVED REFERENCE STATE (PRS)	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

The final SI score out of 1 is derived from the following formula:

SI (score out of 1) = [((SI1+SI2+SI3+SI4+SI5)/5) * 0.333]

Percentage Cover of Indigenous Riparian Species (PCIRS)

This is an indirect measure of the cover of indigenous riparian species and is calculated by subtracting the sum of the weighted cover scores for the exotic, terrestrial and reed species from the total EVC score by using the following 6-point scoring system (Table 2.4).

Table 2.4. Six point scoring system employed to calculate Percentage Cover of Indigenous Riparian Species (PCIRS) sub-scores for exotic, terrestrial and reed species, which are used in the formula to calculate Percentage Cover of Indigenous Riparian Species (PCIRS) (where: 0 = no cover; VL = very low cover; L = low cover; M = medium cover; H = high cover; VH = very high cover)

Cover	0	VL	L	M	H	VH
PCIRS sub-score	0	1	2	3	4	5

PCIRS is derived from the following formula:

PCIRS = [(EVC / 2) - ((exotics x 0.7) + (terrestrial x 0.1) + (reeds x 0.2))]

A final PCIRS score out of five is produced.

Recruitment of Indigenous Riparian Species (RIRS)

This is a measure of the extent to which recruitment of indigenous riparian species is present at the site relative to the recruitment of exotic species. A score out of five is attained using a 6-point scale (Table 2.5) and information table (Table 2.6).

Table 2.5. A 6-point scale used to calculate Recruitment of Indigenous Riparian Species (RIRS)

Extent of recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

Table 2.6. Information table pertaining to the scoring of RIRS (Table 2.5) relative to exotic species (Kemper 2001)

SCORE	Indigenous species	Exotic species (if present)
0	No evidence of recruitment	Only exotic recruitment evident
VL	Evidence of recruitment of any species is rare	Large quantities of recruitment evident
L	Recruitment mainly of most abundant dominant species	Moderate quantities of recruitment evident
M	Recruitment of moderate numbers of both abundance and biomass dominant species	Recruitment common
H	Recruitment of large quantities of biomass dominants species	Limited recruitment is evident
VH	Extensive recruitment of the majority of mainly biomass dominant species	No recruitment evident

The RVI will provide a final score out of 20, which is comparable to the six Ecological Reserve assessment classes (Table 2.7). The six assessment classes from A to F are utilised in the Ecological Reserve process of the National Water Act (Act No. 36 of 1998).

Table 2.7. RVI scores rated according to the six Ecological Reserve assessment categories

RVI SCORE	ASSESSMENT CLASS	DESCRIPTION
19-20	A	Unmodified, natural.
17-18	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
13-16	C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
9-12	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
5-8	E	The loss of natural habitat, biota and basic ecosystem functions are extensive.
0-4	F	Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

REFERENCES

CEAH (Centre for Environmental Applied Hydrology) and ID&A (1997) An Index of Stream Condition: Reference Manual. Waterway and Floodplain Unit, Department of Natural Resources and Environment, University of Melbourne, Australia.

KEMPER NP (2001) Riparian Vegetation Index: Final Report. WRC Project No. **K5/850**. Institute for Water Research, Pretoria.

ROUX DJ, KLEYNHANS CJ, THIRION C, HILL L, ENGELBRECHT JS, DEACON AR and KEMPER NP (1999) Adaptive assessment and management of riverine ecosystems: The Crocodile/Elands River case study. Water SA **25(4)**: 501-511.

CHAPTER 3

A FIELD ASSESSMENT OF RIPARIAN VEGETATION CONDITION OF SELECTED SOUTHWESTERN CAPE RIVERS USING THE RIPARIAN VEGETATION INDEX (RVI)

ABSTRACT

This study focuses on three rivers within the southwestern Cape, South Africa, namely, the Lourens, Hout Bay and Palmiet Rivers. Riparian vegetation condition is assessed at sites along these rivers using the Riparian Vegetation Index (RVI). The data collected in this study, during April and September 2002, will form part of the State of Rivers Report for these rivers, which is the product of the River Health Programme in South Africa. Deviations from expected vegetation condition scores at certain sites along the rivers have highlighted certain flaws of the RVI method. These include the underscoring of sites that are found in the fynbos-dominated Mountain Stream Zone and the overscoring of sites in certain circumstances due to a disproportionate contribution of the sub-index Extent of Vegetation Cover (EVC) to the final RVI score. This study highlights sites of high conservation status with regards to vegetation condition and indicates sites of concern due to poor vegetation condition.

Keywords: river health, riparian vegetation, Fynbos Biome Rivers, land-use, Riparian Vegetation Index

INTRODUCTION

The River Health Programme in South Africa is a monitoring programme designed to establish the ecological state of riverine ecosystems by making use of biological indicators (Roux 1997, refer to Chapter 1). Because riparian vegetation plays many important roles which have a bearing on the condition and long term functioning and sustainability of rivers (Bunn 1994, Bunn *et al.* 1999, Large & Petts 1992, Meals 2001) it is necessary to incorporate assessments of vegetation condition in projects aimed at determining river health (Uys *et al.* 1996, Kemper 2001, State of Rivers Report (2001b), refer to Chapter 1). This study focuses on the condition of riparian vegetation along three southwestern Cape Rivers namely the Lourens, Hout Bay (or Disa River) and Palmiet Rivers. The Riparian Vegetation Index (RVI) (Kemper 2001) is used as a method to assess riparian vegetation condition in the context of the Western Cape. The RVI determines the condition of riparian vegetation within river segments based on the qualitative assessment of a number of criteria in the riparian zone. These include Extent of Vegetation Cover of the riparian zone (EVC), Structural Intactness (SI), Percentage Cover of Indigenous Riparian Species (PCIRS) and Recruitment of Indigenous Riparian Species (RIRS) (refer to Chapter 2). Data from this study will be incorporated into State of Rivers Reports for these rivers. These reports aim to give guidelines on the management of these water resources for their sustainable use.

STUDY AREAS

Three rivers namely the Lourens, Hout Bay and Palmiet Rivers, within the southwestern Cape make up the study area (Fig. 3.1).

LOURENS RIVER CATCHMENT

River location and topography

The Lourens River rises in the Hottentots Holland Mountains at an altitude of 1 080 m and drains a catchment area of approximately 92 km^2. The source of this river is in Watervalkloof, within the Hottentots Holland Nature Reserve. Two minor tributaries arising in Landdroskloof and Sneeukopkloof join the river in its upper reaches. It has no major tributaries. The Lourens River flows in a south-westerly direction, through the town of Somerset West for about 18 - 20 km before reaching the coast at False Bay, just west of Strand, where it forms a small estuary at its mouth (Tharme *et al.* 1997).

Climate

The Lourens River lies within the Winter Rainfall Region with an annual precipitation of 1 260 mm. Approximately 13 % of the mean annual runoff occurs in summer, and 87 % during the winter, from April to October (Cliff & Grindley 1982).

Catchment geology and soils

The Hottentots Holland Mountains, at the source of the Lourens River, are made up of Table Mountain Group sandstones. Pre-Cape Granites with diorites and porphyritic quartzites occur lower down in the Mountain Stream Zone. Soils overlying the granites and the shales and greywacke of the Malmesbury Group in this area, are shallow (Tharme *et al.* 1997). The river passes through a shallow valley in its foothills, largely overlain by sediments of alluvium and wind-blown sands, which were deposited during the Tertiary to Quaternary periods. These sediments reach a depth of more than two metres in many places (Cliff & Grindley 1982). On the flat coastal plain, near the

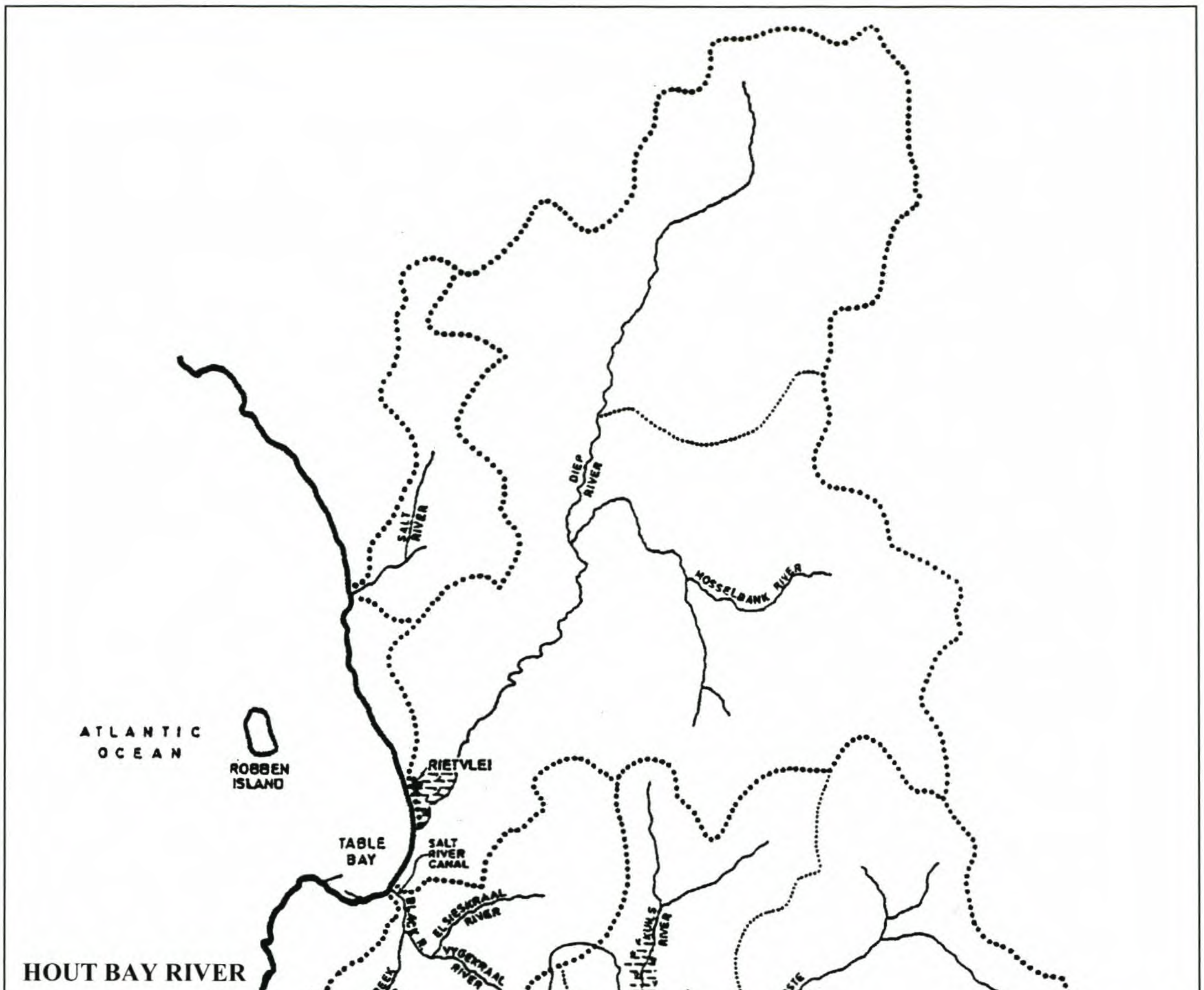

Figure 3.1: Map showing the location of the study areas. These include the Lourens, Hout Bay and Palmiet Rivers (Cape Town City Council 1994).

estuary, aeolian sandy soils occur. Malmesbury Group bedrock controls the river channel in parts over these flats.

Vegetation and land-use

The natural vegetation of the catchment is partly determined by the underlying geology. In the mountainous areas of the upper catchment, the natural vegetation is classified as Mountain Fynbos (Low & Rebelo 1996). Immediately downstream of the Hottentots Holland Reserve, Fynbos has largely been replaced by plantations of *Eucalyptus* sp. and *Pinus* sp. Afforestation covers about 17 % of the catchment. The main agricultural crops include apples, pears, plums, lemons, grapes, kikuyu grass for lawns and pasture for sheep and cattle. In the lowland area, including the coastal plain downstream of Somerset West, the natural West Coast Renosterveld vegetation (Low & Rebelo 1996) has mostly been transformed or eliminated by extensive agriculture and urban development. Even the indigenous vegetation along the river course has been largely transformed and is heavily invaded by exotic species (Tharme *et al.* 1997).

HOUT BAY RIVER CATCHMENT

River location and topography

The Hout Bay River rises on the western slopes of Table Mountain and drains the Back Table into two streams: Disa Stream which cuts deeply into Disa Gorge and is the longer perennial tributary and Original Disa Stream, which flows from Klaasenkop. The streams join in the Orange Kloof Nature Reserve where the river then follows a course through farmlands and residential areas before entering the sea at Hout Bay (Brown *et al.* 1997). The main stem of the river is 12 km long, while approximately 26 km of tributaries join the river along its course (Grindley 1988). The total area of the catchment is 33.8 km^2. Many of the tributaries are dry for most of the year but flow strongly after the winter rains. The river is typical of the rivers of the Fynbos Biome, being acidic, short, steep and fast flowing (Davies & Day 1998).

Climate

The catchment lies within the Winter Rainfall Region, which receives most of its rain in winter (60.6 % during the months May to August) when temperatures are cool. Summers are hot and dry. Mist adds to the total precipitation in the mountainous areas during the summer (Grindley 1988).

Catchment geology and soils

The Hout Bay River catchment is made up of Table Mountain Group sandstone overlying a granite base with a narrow shale band at about 200 m (Grindley 1988). Sandstone weathers slowly and the narrow kloofs, like Disa Gorge, have followed faults that have fractured the horizontal bedding planes. Underground springs are located on the contact zone of the sandstone deposits within the Hout Bay valley. Several deposits of manganese and iron oxides occur within the catchment. Alluvial deposits of soils belonging to the Dundee and Oakleigh Forms, with unconsolidated underlying material, form a broad strip running the length of the valley to the 100 m contour elevation and along the main drainage pathways (Grindley 1988).

Vegetation and land-use

The vegetation in the Hout Bay River catchment is described as Mountain Fynbos (Campbell 1985) with restioid, ericoid and proteoid elements being present. Closer to the coast the vegetation grades into a mosaic of Dune Fynbos, Dune Thicket and Dune Forest (Lubke 1996). This vegetation has been severely invaded by exotic species such as *Acacia cyclops*. A general shift in land-use from agriculture to residential has occurred in the Hout Bay area. The upper part of the catchment falls within the Cape Peninsula National Park where the vegetation is largely indigenous and remnants of the originally widespread Hout Bay Afromontane forests are protected. However, *A. melanoxylon* and *Quercus robur* are numerous along the river banks. Glyphis *et al.* (1978) described the forest community as the *Ilex-Blechnum* Forest community consisting of typical, wet kloof forest species such as *Cunonia capensis* and *Ilex mitis*, which form the canopy and *Blechnum attenuatum* dominating the ground cover. Remnant *Prionium serratum* patches also exist in the upper reaches of the catchment (Brown *et al.* 1997). In its middle reaches, the valley is characterised by large, quasi-rural properties, with gardens or paddocks extending down to the river banks (Brown *et al.* 1997). Most of the natural vegetation has been removed in this section and in parts, passage down the river is completely blocked by exotic species especially *A. longifolia* and *Lantana camara* (Brown *et al.* 1997). Extensive reedbeds (*Phragmites australis*) flank the lower reaches of the river. A high incidence of instream vegetation, mainly consisting of *Pennisetum clandestinum*, *Persicaria* sp. and *Typha capensis*, occurs in this section. The estuary is bordered by public open space, public amenities and single residential dwellings before spilling across Hout Bay beach into the Atlantic Ocean.

PALMIET RIVER CATCHMENT

River location and topography

The Palmiet River rises at an altitude of 1 322 m AMSL in the Hottentots Holland Mountains in the vicinity of Landroskop Peak. The river is 70 km long and is fed by eleven perennial tributaries as well as numerous smaller, seasonal streams. The Palmiet River catchment covers an area of 500 km^2. The river flows as a mountain stream in an easterly direction and then turns south into the Elgin Valley where it is impounded first by Nuweberg Dam and then by Eikenhof Dam in its Foothill Zone, before passing through the town of Grabouw. Three large dams (Kogelberg, Applethwaite and Arieskraal) occur along the channel further downstream. The river is met by the Klein Palmiet and Krom Rivers before leaving the Elgin Valley. Once within the Kogelberg Biosphere Reserve, the river flows in a southwesterly direction passing through a deep steep-sided valley between the Dwarsrivier and the Perdeberg Mountain ranges and is met by the Dwars and Louws tributaries, which contribute clean water to the system from unimpacted catchments. The river then flows in a southeasterly direction towards the Atlantic Ocean assuming the features of a 'Transitional River' (refer to Dawson (2003) for a more detailed description of river zonation delimitations) in its lower reaches. It then flows across part of a narrow coastal plain, for a very short length, before entering its small estuary, just west of Kleinmond (Day 1998).

Climate

The catchment falls within the Mediterranean Climate Region, with most rain falling during the Austral winter (May-August). Orographic rainfall occurs with the mountain slopes receiving more rainfall than the valleys. Rainfall varies from 700 mm per annum in the low-lying central, eastern and coastal regions and increases to 1 500 mm per annum in the higher-lying areas inland. Summer maximum temperatures range between 20-30 °C in the mountainous regions where higher altitudes result in cooler temperatures. Summers are hot and dry and southeasterly winds are dominant (Day 1998).

Catchment geology and soils

The upper and lower areas of the catchment have weathered rocks of the Table Mountain Group, which are low in nutrients and are highly leached. The more erodible shales and sandstones of the Bokkeveld Group occur in the middle catchment and release higher concentrations of nutrients and salts than the Table Mountain Group sandstones (Day 1998).

Vegetation and land-use

The upper areas of the catchment fall within the Hottentots Holland State Forest Reserve, which has Mountain Fynbos vegetation (Low & Rebelo 1996). The riparian zone is invaded by exotics such as *A. melanoxylon*. Natural vegetation gives way to pine plantations and agriculture (mainly fruit farming) further downstream. The lower area of the catchment forms part of the Kogelberg State Forest which is the core area of the Kogelberg Biosphere Reserve and has relatively undisturbed fynbos vegetation (Boucher 1978). Natural fynbos vegetation occupies nearly half of the total catchment area. Industry associated with fruit-derived products occurs in the vicinity of Grabouw (Day 1998).

METHOD

Sampling sites along the Lourens, Hout Bay and Palmiet Rivers (Figs. 3.2, 3.3, 3.4) were chosen *a priori* based on their longitudinal zonation patterns (Rowntree, *et al.* 2000). These rivers were recommended for study by the River Health Provincial Implementation Committee (DWAF) for the Western and Southern Cape Regions. For further explanation of zonation patterns, refer to Dawson (2003). Sites chosen, based on longitudinal zonation patterns, were then ground-truthed and the criteria considered when selecting specific sites within the defined longitudinal zones, included the following:

- accessibility,
- range of habitat types,
- how representative the site was of the geomorphological zone,
- how representative the vegetation was of the river in the specific geomorphological zone,
- how representative the site was is in terms of all potential impacts in the zone and,
- links with existing literature and background data.

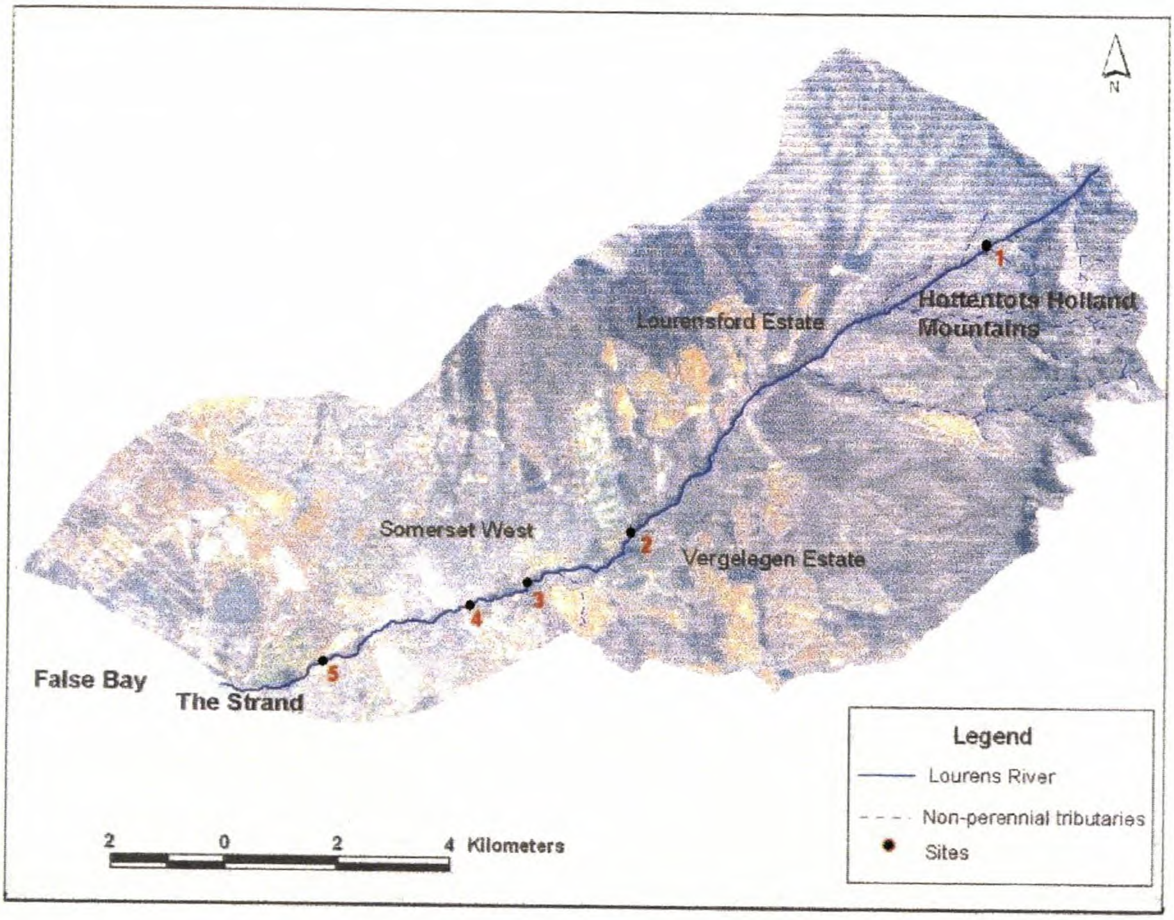

Figure 3.2: Map of the Lourens River catchment indicating the location of study sites (A1=1; A2=2; A3=3; A4=4; A5=5) along the river (Figure adapted from Dawson 2003).

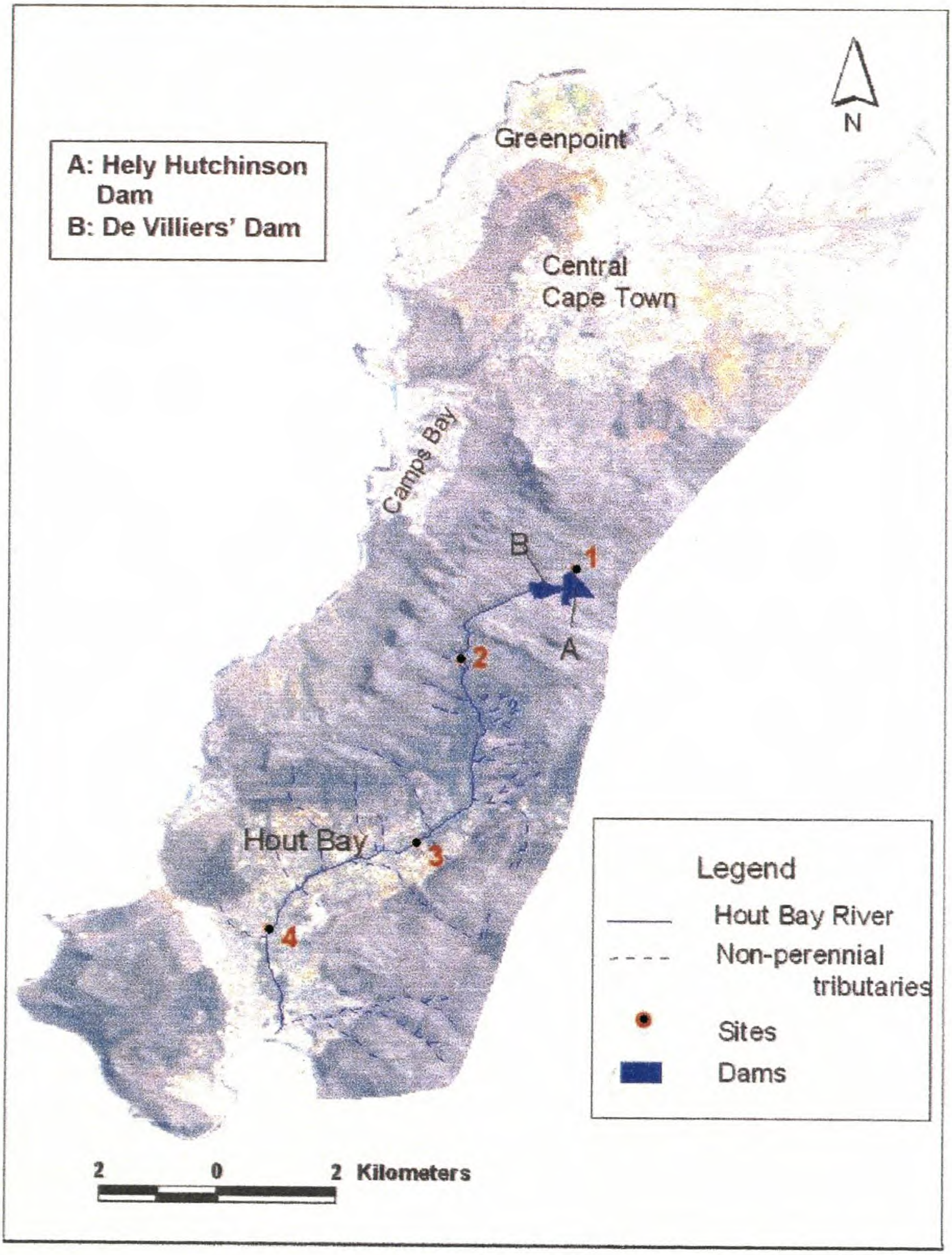

Figure 3.3: Map of the Hout Bay River catchment indicating the location of study sites (B1=1; B2=2; B3=3; B4=4) along the river (Figure adapted from Dawson 2003).

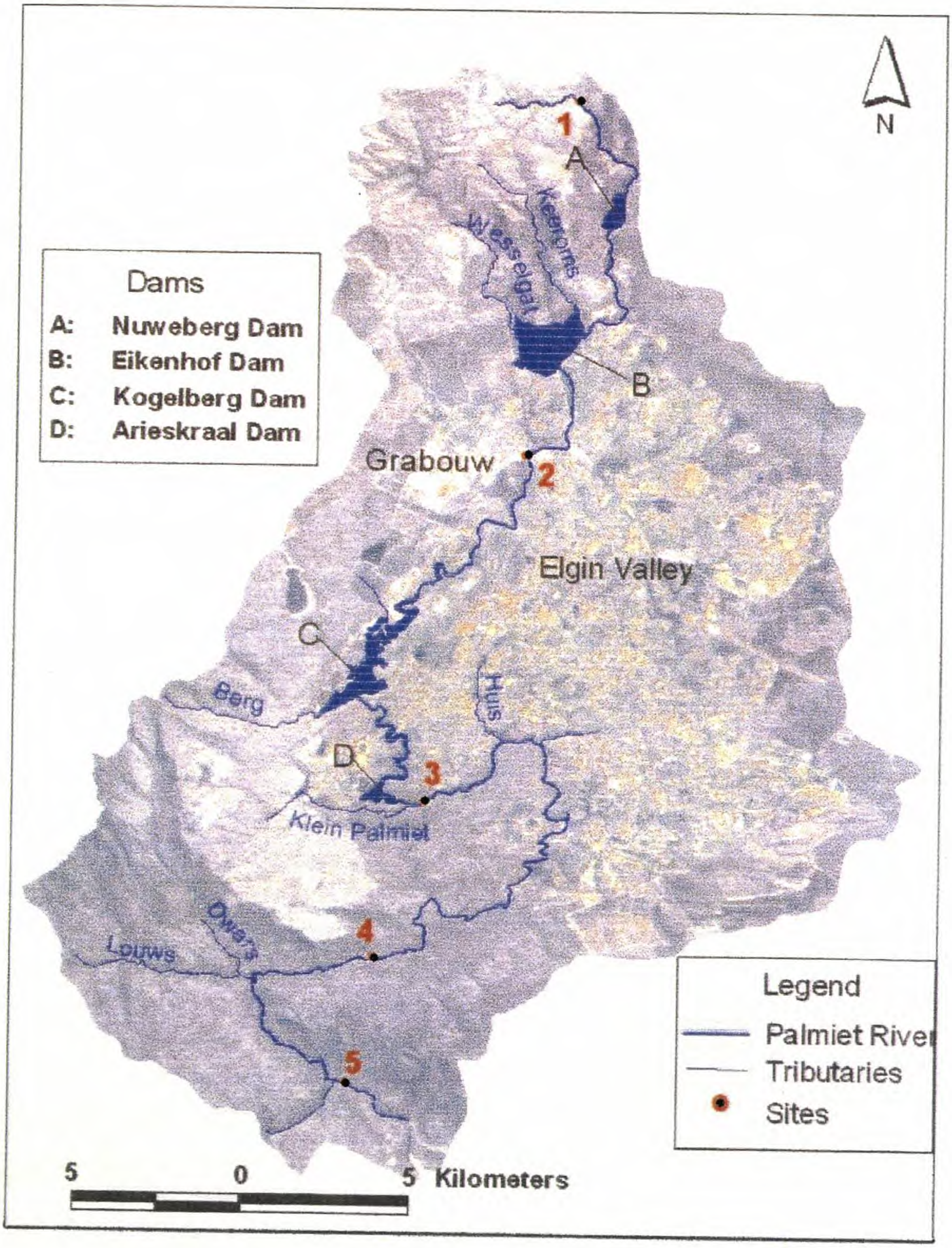

Figure 3.4: Map of the Palmiet River catchment indicating the location of study sites (C1=1; C2=2; C3=3; C4=4; C5=5) along the river (Figure adapted from Dawson 2003).

The positions of these sites were determined with the use of GIS and 1: 50 000 topographical maps and recorded using a hand-held Garman III Geographical Positioning System (GPS). The precise location of each site and their zonation categories (Rowntree *et al.* 2000) is listed in Table 3.1.

Table 3.1. Location of study sites along the Lourens, Hout Bay and Palmiet Rivers and their zonation categories (Rowntree *et al.* 2000)

River	Site	Location (GPS co-ordinates)	Zone
Lourens	A1	S 34° 01.741', E 18° 57.407'	Mountain Stream
	A2	S 34° 04.502', E 18° 53.341'	Upper Foothill
	A3	S 34° 04.983', E 18° 52.144'	Upper Foothill
	A4	S 34° 05.212', E 18° 51.480'	Upper Foothill
	A5	S 34° 05.775', E 18° 49.772'	Lowland River
Hout Bay	B1	S 33° 58.449', E 18° 24.601'	Mountain Stream
	B2	S 33° 59.287', E 18° 23.353'	Mountain Stream
	B3	S 34° 00.931', E 18° 22.863'	Upper Foothill
	B4	S 34° 01.758', E 18° 21.230'	Lowland River
Palmiet	C1	S 34° 03.351', E 19° 02.465'	Mountain Stream
	C2	S 34° 09.102', E 19° 01.481'	Upper Foothill
	C3	S 34° 14.641', E 18° 59.666'	Rejuvenated Upper Foothill
	C4	S 34° 17.185', E 18° 58.715'	Rejuvenated Foothill
	C5	S 34° 19.217', E 18° 58.174'	Rejuvenated Foothill

All sites were assessed during April and again in September 2002. The methodology employed for the assessment of riparian vegetation condition followed that stipulated by the RVI (Kemper 2001, Chapter 2). Components assessed included: channel description, riparian zone description, distribution and extent of vegetation cover, invasion of the riparian zone, species composition and recruitment of indigenous riparian species. The stipulated sampling time for the method was extended from 45 minutes to 2 hours per site. It was felt that a longer time period would aid a more thorough assessment especially since the vegetation had to be sampled because of a lack of botanical knowledge of the plants. Specimens were collected from those species that could not be identified in the field. The Stellenbosch University field herbarium, housed in the Botany Department, was consulted to identify common widespread species, while unusual specimens were sent to the National Botanical Institute at Kirstenbosch for identification. Nomenclature is according to Goldblatt and Manning (2000).

Data collected from the field visits were entered into the Rivers Database software package (*pers. comm.* J. Ewart-Smith 2002[1]) to calculate RVI scores, so that sites could be placed within the appropriate assessment class.

An assessment of the 'gut feel' condition of riparian vegetation was made at each site. This was based on expert opinion (*pers. comm.* Dr C. Boucher 2002[2]). The RVI and 'gut feel' scores (taken as the mean value within each final category) were then compared, to determine whether or not the final RVI scores reflected the perceived biological status of the riparian vegetation.

RESULTS

The vegetation condition results at sites along the Lourens, Hout Bay and Palmiet Rivers will now be discussed. A comparison of the RVI scores and the 'gut feel' scores will be made and suggestions given where deviation from the expected exists.

LOURENS RIVER CATCHMENT

SITE A1

General description

This site is situated on Lourensford Estate, in the headstream of the Lourens River. It is positioned in a ravine above the confluence of the Picnic Bush stream with the Lourens River and about 40 m upstream of where a dirt road crosses the river. It lies upstream of the zone of commercial forestry within an area of natural indigenous vegetation.

---

[1] The Freshwater Consulting Group, 5 Bognor Road, Rosebank, 7700
[2] Botany Department, Stellenbosch University, Private Bag X1, Matieland, 7602

Riparian zone description

The riparian zone substratum largely comprises rock and cobble interspersed with soil, gravel and sand. The width of the riparian zone is approximately 2 m on the left bank and 3 m on the right bank. Both the right and left banks support typical Western Cape indigenous riparian mountain stream vegetation (Boucher 1997). Dominant trees recorded include *Brabejum stellatifolium*, *Cassine schinoides*, *Cunonia capensis*, *Ilex mitis*, *Maytenus acuminata*, *M. oleoides*, *Olea capensis*, *Platylophus trifoliatus* and *Podocarpus elongatus*. The dominant shrubs are *Brachylaena neriifolia* and *Diospyros glabra*. The vegetation on the left bank is generally sparser than the right bank, supporting Mesic Mountain Fynbos (Campbell 1985) vegetation. Dominant species include *Cliffortia cuneata*, *C. ruscifolia*, *Diospyros whyteana*, *Podalyria calyptrata* and *Psoralea pinnata*. The riparian vegetation on the right bank grades into tall scree forest vegetation. The herbaceous vegetation found between the rocks lining the stream edges is sparse and consists of the following species: *Blechnum attenuatum*, *Ischyrolepis subverticillata*, *Isolepis prolifer*, *Pteridium aquilinum* and *Schoenoxiphium lanceum*. The vegetation at this site is called the *Brabejum stellatifolium-Hartogiella schinoides* Community, by Boucher (1997).

Riparian vegetation condition

The RVI score of 19 reflects the perceived biological status or 'gut feel' score attributed to the riparian vegetation (Fig. 3.5). The RVI score places this site into Class A, which means that the vegetation is undisturbed and natural. This condition is unchanged from Boucher's (1997) assessment that the vegetation is in a good condition, in its natural state and that little to no disturbance has occurred.

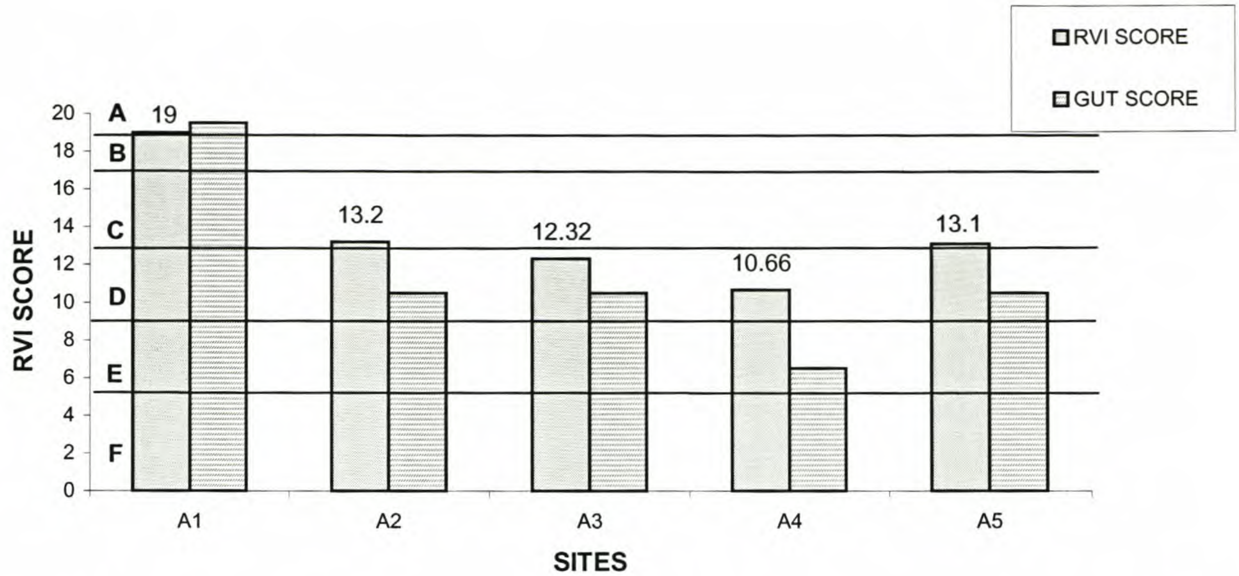

Figure 3.5: RVI and 'gut' scores for vegetation condition at five study sites (A1-A5) along the Lourens River. **A-F** refers to the assessment class according to the six ecological reserve assessment categories (Chapter 2).

SITE A2

General description

The site is situated upstream of the wooden pedestrian bridge which crosses the Lourens River at Vergelegen Estate, opposite the farm buildings. The surrounding land-use is mainly agriculture, including orchards and livestock.

Riparian zone description

The riparian zone substrate is mainly soil with a few rocks and cobbles scattered between thesoil. The riparian zone stretches approximately 10 m on either side of the river. Both banks have been modified by the construction of paths and levees. The vegetation on the left bank is mainly exotic vegetation and is an extension of the Vergelegen Estate garden. The exotic trees recorded here include *Cinnamomum camphora*, *Eucalyptus camaldulensis*, *Populus canescens*, *Quercus robur* and *Salix babylonica*. Many exotic shrub species are recruiting on this bank, particularly, *A. longifolia* and *A. melanoxylon*. The dominant herbaceous layer consists of *P. clandestinum* with *Thunbergia alata* and *Ipomoea nil* climbers being abundant throughout. The vegetation on the right bank is more intact than that on the left bank containing remnants of the indigenous elements found at Site A1, namely, *B. stellatifolium*, *D. whyteana*, *Erica caffra* and *I. mitis*. The edge of this bank, however, is covered by dense stands of the exotic, *Colocasia esculenta*. The instream vegetation is dominated by the exotic grasses *Paspalum distichum* and *P. urvillei*. The description of the vegetation at this site corresponds to the *Brabejum stellatifolium-Digitaria sanguinalis* Foothill Zone Scrub Forest Community described by Boucher (1997).

Riparian vegetation condition

The RVI score is 13.2, which places the site at the lower end of Class C (Fig. 3.5). This suggests that the site is moderately modified. This score is a reflection of the poor cover of indigenous riparian species and the low recruitment of indigenous riparian species (Fig. 3.6). The 'gut feel' score indicates that this site is possibly in a worse condition or, rather, is modified to a greater extent than that indicated by the RVI score ('gut feel' score = 10.5). The right bank, however, is in a surprisingly good condition and possibly the 'gut' score should be slightly higher. This site marks the upper most part of what Boucher (1997) recorded as the most densely infested stretch of the river, with all types of exotics, particularly escaped exotic garden plants, as dominants.

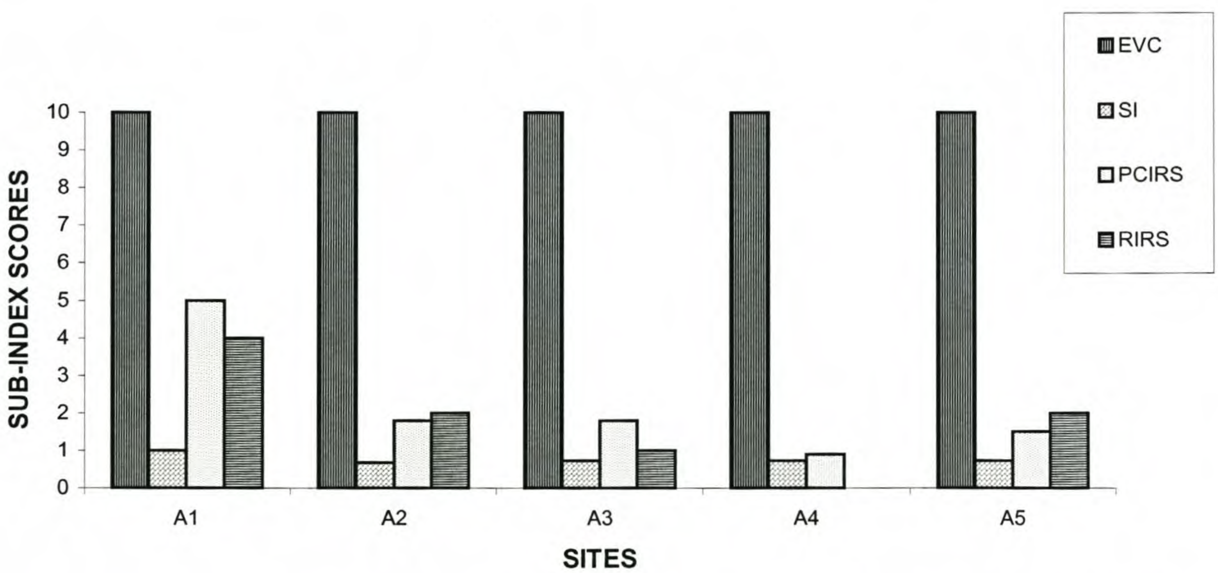

Figure 3.6: RVI sub-index scores for vegetation condition at five study sites (A1-A5) along the Lourens River. **EVC** = Extent of Vegetation Cover, **SI** = Structural Intactness, **PCIRS** = Percentage Cover of Indigenous Riparian Species and **RIRS** = Recruitment of Indigenous Riparian Species.

SITE A3

General description

This site is situated at the lower end of Radloff Park on the eastern outskirts of Somerset West town. This section of the river is built up in places along its bank where residential housing borders the river. The site is accessible due to it being a public open space and it also has a walking trail frequented by residents of Somerset West.

Riparian zone description

The riparian zone substrate is made up of cobble and soil with exposed sandy patches along the river margins. It was difficult to establish the width of the riparian zone due to dense infestations of weedy exotic species on the left bank and a highly modified and disturbed right bank. The right bank vegetation is heavily invaded by exotic species. Exotic trees include *A. mearnsii*, *A. longifolia*, *Pinus* species, *P. canescens*, *Q. robur* and *S. babylonica*. Shrubs were not common and a single indigenous shrub species, *D. glabra,* was recorded. The herb layer consists mainly of the exotic grass, *P. clandestinum* and an indigenous grass species, *Setaria megaphylla*. The left bank is infested with weedy exotic species, such as *Chenopodium ambrosoides* and recruiting alien trees of *A. longifolia*, *A. mearnsii* and *P. canescens* with dense tangled mats of the exotic climber *I. nil* climbing through them. The instream vegetation consists of the exotic species *Commelina benghalensis, P. distichum* and *Persicaria serrulata* with *C. esculenta* dominant on the river margins.

Riparian vegetation condition

The condition of the riparian vegetation is poor at this site. The RVI score places this site into Class D (RVI = 12.32), which means that the site has been largely modified and that a loss of habitat, biota and ecosystem functioning has occurred (Fig. 3.5). The RVI score is the same as the perceived biological status ('gut feel' score) of the riparian vegetation condition at this site (Fig. 3.5). The cover of indigenous riparian species is very low and very few indigenous species were observed to be recruiting (Fig. 3.6). Exposed sandy patches along the margins of the river serve as a habitat for the establishment of weedy exotic species.

SITE A4

General description

The site is situated adjacent to a public open space and residential townhouses in the centre of Somerset West, upstream of the old bridge. The right bank has gabions to protect developments bordering the river from stream bank erosion.

Riparian zone description

The riparian zone mostly comprises soil with patches of sand present. The right bank has gabion structures that are covered by garden herbaceous species, such as, *T. alata* and *Tropaeolum majus*. The left bank is a landscaped pathway, mainly supporting exotic grass species, such as, *Avena sativa*, *Briza maxima* and *P. clandestinum*. The exotic trees found at this site include *A. longifolia*, *A. mearnsii*, *A. saligna*, *Pinus pinea*, *Pittosporum undulatum*, *P. canescens*, *Q. robur, S. babylonica*, *Sesbania punicea* and *Schinus molle*. The very few indigenous trees that exist include *Canthium inerme* and *Kiggelaria africana*. The shrub, *D. glabra*, was also present. Vegetation along the margins of the river includes *Commelina africana*, *Cyperus textilis*, *Juncus kraussii* and *S. megaphylla*. The presence of the exotic reed, *Arundo donax*, along the Lourens River was recorded at the site. This section of the river marks the start of the *Salix babylonica-Phragmites australis* community described by Boucher (1997).

Riparian vegetation condition

According to the RVI this site fits into Class D, which means that the site is largely modified (Fig. 3.5). The RVI score is 10.66. The very low cover of indigenous riparian species and the fact that no recruitment of indigenous riparian species was observed should result in a lower RVI score (Fig. 3.6). It is felt that the RVI is over-scoring this site by at least one category, probably because of the sub-index, Extent of Vegetation Cover (EVC), which has a disproportionately high contribution to the final RVI score (this aspect will be discussed further in Chapter 5).

SITE A5

General description

This site is situated below the N2 on the Strand side after the industrial area on the outskirts of Somerset West. The surrounding area is public open space or what seems to be old agricultural lands and a residential suburb.

Riparian zone description

The riparian zone substrate consists of soil, gravel and sand. The indigenous riparian vegetation has mostly been removed in this section and exotic vegetation has invaded the banks. Exotic tree species include *A. longifolia, A. mearnsii, A. saligna, P. canescens* and *S. babylonica*. Indigenous trees and shrubs found at the site include *Cliffortia hirsuta, C. strobilifera, Freylinia lanceolata, K. africana* and *Olea europaea* subsp. *africana*. The herbaceous layer covering the banks mainly consists of the exotic grass, *P. clandestinum* with *T. majus* scattered throughout. The instream vegetation mainly consists of the following species, *Rorippa nasturtium-aquaticum, P. distichum, Persicaria lapathifolium* and *P. serrulata*. Many exotic weedy annual species like *Xanthium strumarium* and *Rumex crispus*, are establishing where exposed sandy bars are present. *Phragmites australis* occurs in patches throughout this section of the river. The vegetation at this site corresponds to Boucher's (1997) *Salix babylonica-Phragmites australis* Community.

Riparian vegetation condition

The condition of the riparian vegetation improves at this site, compared to the previous site in Somerset West (Fig. 3.5). The improvement is due to an increase in indigenous riparian species at the site and a higher occurrence of recruitment (Fig. 3.6). The RVI score is 13.1, which places the site into Class C. This indicates that the site is moderately modified. The 'gut feel' class is a D, which means that the RVI is over-scoring the site by a category. This is once again probably attributed to the EVC contributing a disproportionately high amount to the final RVI score.

HOUT BAY RIVER CATCHMENT

SITE B1

General description

This site is situated above the Hely-Hutchinson Dam near the top of Table Mountain. The Mountain Fynbos (Low & Rebelo 1996) vegetation found along the river was found to be in a near-pristine state.

Riparian zone description

The natural terrestrial fynbos vegetation extends to the water's edge in this section of the river, as is the case in many southwestern Cape Mountain streams, where there is no distinct belt or riparian zone along the edges supporting typical riparian species. Very few tree species occurred in this section because typical fynbos vegetation is generally depauperate of trees (Campbell *et al.* 1981). *P. pinnata* and *P. aphylla* along with a few recruiting *Pinus pinaster* individuals, were the only tree species that were observed. The dominant shrub species on the stream's edge include *Berzelia lanuginosa*, *Erica* species, *C. hirsuta*, *C. ruscifolia* and *Osmitopsis asteriscoides*. Restionaceae and Pteridophyta were dominant within the river channel along with the sedge, *I. prolifer*.

Riparian vegetation condition

The RVI score for this site is 16.2, which places the site into a high C class, meaning that the site is moderately modified (Fig. 3.7). This is not a true reflection of what is perceived to be the present condition of the riparian vegetation. The 'gut feel' is that this section of the river supports a near pristine Mountain Fynbos vegetation type. The RVI score is certainly under-scoring the site by two categories. This under-scoring is attributed to the low Recruitment of Indigenous Riparian Species (RIRS) sub-index score (Fig. 3.8). Low recruitment is not necessarily an indication of poor vegetation condition in the fynbos situation, especially in its mature state. This is because fynbos vegetation needs disturbance to initiate recruitment. Fire, at an interval of 14-20 years (Cowling & Richardson 1995), is a natural stimulant for episodic recruitment in the Fynbos Biome. Another point to consider is that this reach is dominated by low shrubs, restios and sedges, which are difficult to assess in terms of recruitment when the vegetation is in a young stage of regeneration because seedlings of these elements are notoriously inconspicuous. For the RVI to be applicable to the vegetation found in the higher mountain stream situations in the southwestern Cape, the weighting of RIRS needs to be adjusted to lend far less weight to the overall score, or the relevant tolerant riparian species require a maximum rating in this situation (refer to Chapters 5 & 6).

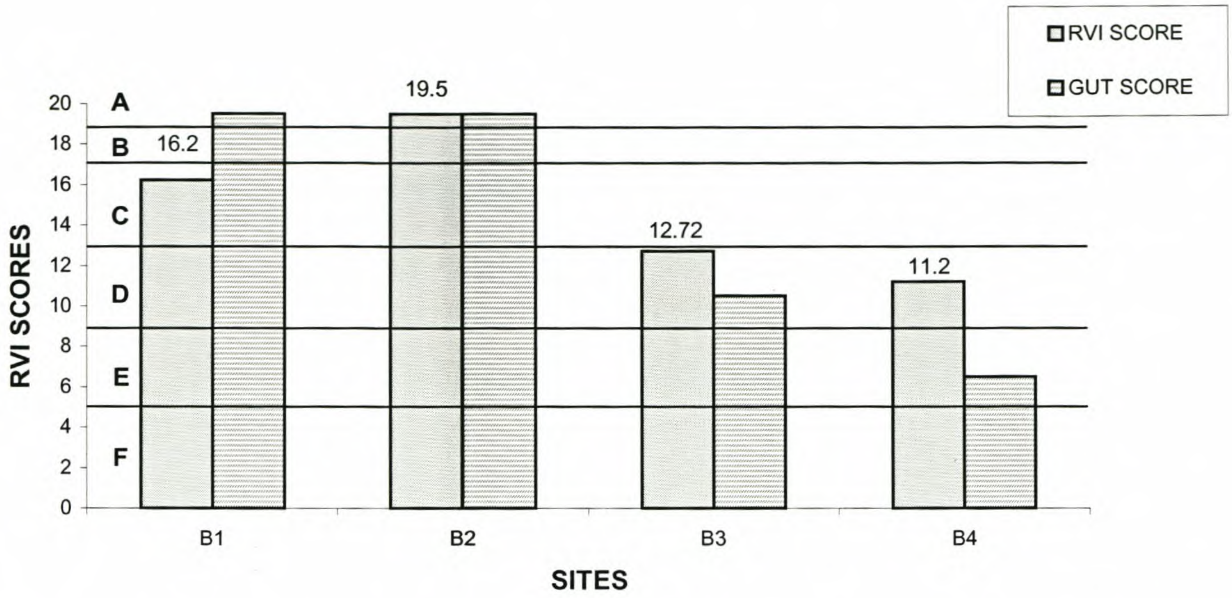

Figure 3.7: RVI and 'gut' scores of vegetation condition at four study sites (B1-B4) along the Hout Bay River. **A-F** refers to the assessment class according to the six ecological reserve assessment categories (Chapter 2).

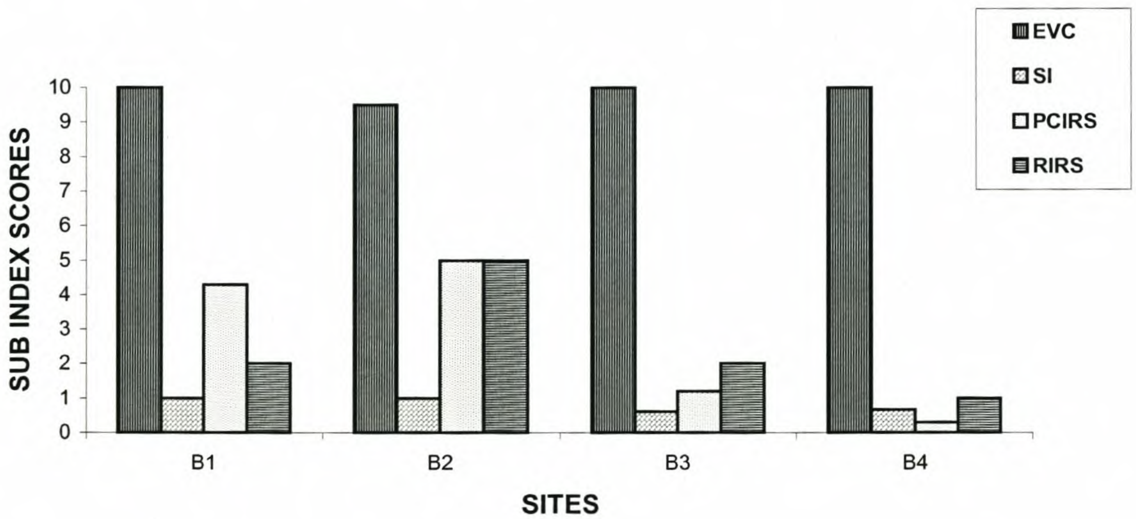

Figure 3.8: RVI sub-index scores of vegetation condition at four study sites (B1-B4) along the Hout Bay River. **EVC** = Extent of Vegetation Cover, **SI** = Structural Intactness, **PCIRS** = Percentage Cover of Indigenous Riparian Species and **RIRS** = Recruitment of Indigenous Riparian Species.

SITE B2

General description

This site is situated within the Orange Kloof Nature Reserve, upstream of the access road, which crosses the river. This section of the river is in a near-natural condition, although the upper reaches of the river are heavily impounded (Brown *et al.* 1997).

Riparian zone description

The riparian zone substrate comprises rock and cobble with soil in between. A small area of bedrock is present. The riparian zone is difficult to distinguish because the riparian vegetation grades into the surrounding Afromontane Forest vegetation (Low & Rebelo 1996). The vegetation along the banks here forms a closed canopy of trees up to 10 m tall. Indigenous tree species present include *B. neriifolia, C. capensis, Curtisia dentata, D. whyteana, K. africana*, *M. acuminata* and *Podocarpus latifolius*. The herbaceous layer consists of the tree fern, *Cyathea capensis*, the hard fern, *B. attenuatum* and the forest grass, *S. lanceum*.

Riparian vegetation condition

The RVI score (19.5) places this site into Class A, which indicates that the vegetation is in its natural state and that no disturbance has occurred (Fig. 3.7). This score adequately reflects what the condition of the vegetation at present is perceived to be by 'gut feel' (Fig 3.7). The sub-index scores reflect maximum values except for the Extent of Vegetation Cover (EVC) sub-index, which has slightly less than a maximum value, due to the right bank not having 100 % vegetation cover (Fig. 3.8). This is a natural feature as the vegetation cover is constrained by the geomorphology of this bank, which is partly bedrock.

SITE B3

General description

This site is found just upstream of the Disa Road bridge crossing. The surrounding area is mainly public open space and small holding properties.

Riparian zone description

The riparian zone in this section of the Hout Bay River has been modified to form terraced banks, which are mostly overgrown with *P. clandestinum*. The potential width of the riparian zone is

20-30 m. A sandy soil is present. Very few indigenous trees and shrubs remain in this part of the river. The following species were recorded: *I. mitis, K. africana, Metrosideros angustifolia* and *Morella serrata*. Dominant exotic tree and shrub species include *A. longifolia, A. mearnsii, A. melanoxylon, A. saligna, Eucalyptus* species, *Lantana camara* and *Q. robur*. The river margins are particularly heavily invaded by the exotic grass, *Echinochloa crus-galli* and in sections by *A. donax*. A few sedge and rush species were observed within the wet bank zone. The instream vegetation mainly comprises *P. distichum* and *P. lapathifolium*.

Riparian vegetation condition

The RVI score is 12.72, which places this site at the top end of a Class D, meaning that the vegetation is largely modified (Fig. 3.7). This derived score is consistent with the 'gut feel' score. The low RVI score can be explained by the dominance of exotic vegetation, low recruitment of indigenous riparian species and a loss of structure within the riparian vegetation due to the low density of trees and shrubs and unnaturally high cover of grass in this section of the river (Fig. 3.8).

SITE B4

General description

The bottom site along the Hout Bay River is situated immediately upstream of the Victoria Road bridge crossing. This section of the river has been identified as the depositional zone of the river, by Grindley (1988). The river has steep levees, which are the result of periodic dredging of the river channel (Brown *et al.* 1997). Small-holdings with horse paddocks flank the river on its left side. A horse trail and path are found on the right bank, which separates the adjacent floodplain from the active river channel.

Riparian zone description

The remaining width of the riparian zone is between 20-30 m. The substratum comprises gravel and sand. The indigenous vegetation has been virtually completely removed. Steep levees lining the banks support mostly exotic vegetation, in which the dominant exotics are, *A. longifolia, A. saligna, L. camara, Paraserianthus lophantha, P. clandestinum* and *S. punicea*. Instream vegetation includes *C. benghalensis, P. clandestinum, P. lapathifolium* and *P. serrulata*.

Riparian vegetation condition

The RVI score for this site is 11.2. This places the site into Class D, which reflects a largely modified state (Fig. 3.7). The very poor score is attributed to the very low cover of indigenous vegetation and the low recruitment of indigenous riparian species (Fig. 3.8). It is felt that the RVI score does not reflect the perceived condition of the site namely, an E Class river. An E Class indicates that the loss of natural habitat, biota and basic ecosystem functions are extensive. This 'gut' condition is supported by Brown *et al.* (1997). The disparity between scores is probably due to the high contribution of 'Extent of Vegetation Cover' (EVC) to the final RVI score.

PALMIET RIVER CATCHMENT

SITE C1

General description

This site is situated within the Nuweberg State Forest, which forms part of the Hottentots-Holland Mountain Range, above a causeway that crosses the river.

Riparian zone description

The vegetation within the Mountain Stream Zone is Mesic Mountain Fynbos (Boucher 1998). There is no clear distinction between the riparian vegetation and the surrounding fynbos vegetation. As mentioned earlier this seems to be the case in the Mountain Headwall Zone of most southwestern Cape Rivers (refer to Chapter 5). A fine gravel and sand substratum on the edge of the stream, in this situation, however, does serve as a suitable habitat for the obligate riparian species to establish. Common indigenous riparian species include *B. neriifolia, E. caffra, I. subverticillata, Prionium serratum* and *Pseudopentameris macrantha*. Restios and sedges were also common in this section. Instream vegetation consists of *I. prolifer* and *Juncus lomatophyllus*.

Riparian vegetation condition

The condition of the vegetation is good at this site and is reflected by the high RVI score (RVI=19), which places the site into Class A (Fig. 3.9). This means that the vegetation is natural and unmodified. No exotic species were observed and there was a high rate of recruitment of indigenous riparian species (Fig. 3.10). The distribution of structural components was also to be expected for this section of the river.

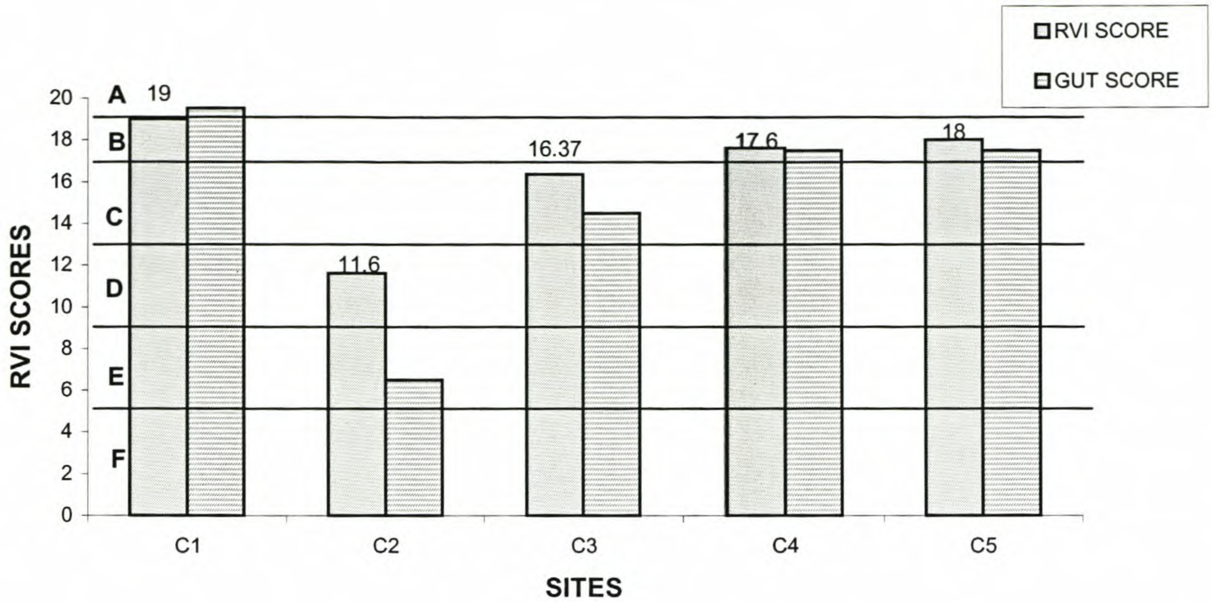

Figure 3.9: RVI and 'gut' scores for vegetation condition at five study sites (C1-C5) along the Palmiet River. **A-F** refers to the assessment class according to the six ecological reserve assessment categories (Chapter 2).

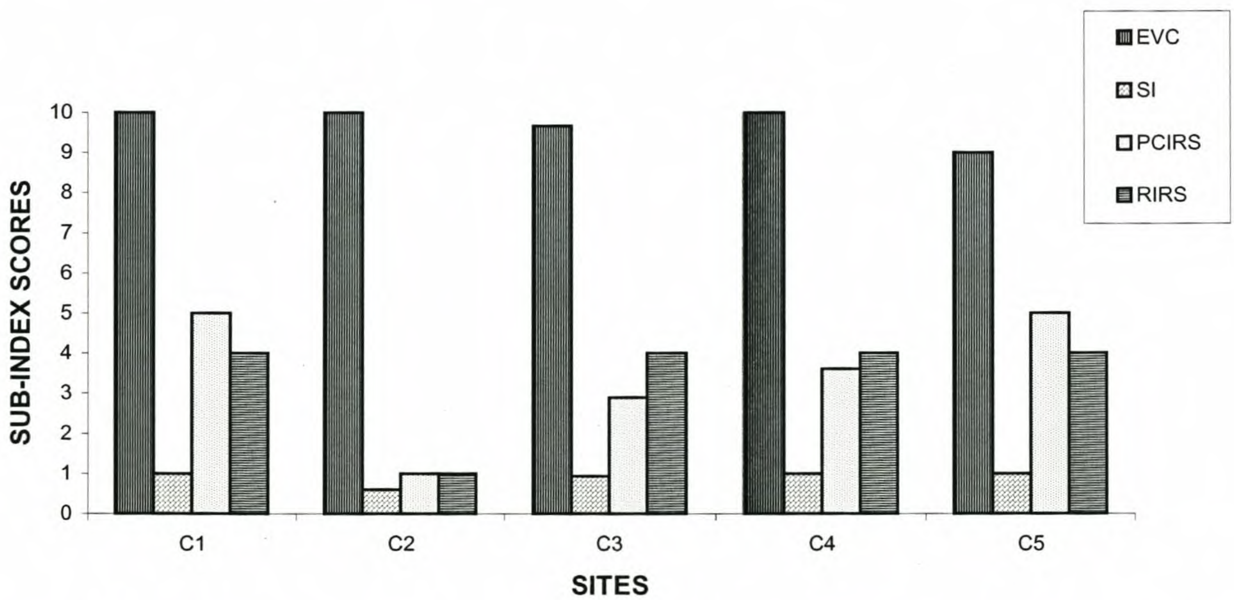

Figure 3.10: RVI sub-index scores for vegetation condition at five study sites (C1-C5) along the Palmiet River. **EVC** = Extent of Vegetation Cover, **SI** = Structural Intactness, **PCIRS** = Percentage Cover of Indigenous Riparian Species and **RIRS** = Recruitment of Indigenous Riparian Species.

SITE C2

General description

This site is situated on the outskirts of the town of Grabouw, below the main bridge. The surrounding land-use comprises agriculture, mainly fruit farming and associated industries, as well as the residential area of Grabouw.

Riparian zone description

The riparian zone in this section of the river spreads out to form a wetland situation with interspersed low and high-lying areas. The active river channel in this section is braided and changes in width according to the season. The wetland area is probably about 150 m wide. The substratum comprises soil, gravel and sand. This section of the river is heavily invaded by exotic vegetation due to the impacts from the surrounding developed area. The invasions have exacerbated the problem of silt deposition in the riparian zone, causing a shift in the species composition from indigenous trees and shrubs to exotic annual and perennial weedy herbaceous species. The dominant exotic species include *A. longifolia, A. mearnsii, P. canescens, S. babylonica, S. punicea* and *X. strumarium*. Only a few indigenous riparian species were recorded namely, *C. strobilifera*, *P. pinnata* and *Salix mucronata*. *I. subverticillata* and a mix of different rushes and sedges were common throughout the wetland. Instream vegetation mainly consisted of *Persicaria* species, *P. clandestinum* and *P. distichum*. The exotic water fern, *Azolla filiculoides*, was present under low flow conditions during the May site visit.

Riparian vegetation condition

The RVI score (11.6) indicates that the site is largely modified (Class D) (Fig. 3.9). The 'gut feel' is that the vegetation condition at this site is probably in a worse state than the RVI score reflects. It is felt that there has been a significant loss of the natural habitat, biota and ecosystem functioning and that the site should probably fall within Class E. This feeling is supported by the low PCIRS and RIRS scores (Fig. 3.10). The disparity between 'gut' and RVI scores is once again attributed to the disproportionate contribution of the high EVC score to the final score (Fig. 3.10).

SITE C3

General description

This site is situated immediately upstream of the causeway, below Arieskraal Dam. The surrounding land-use is mainly forestry with some fruit farming (mainly apples) and indigenous fynbos vegetation associated with the Bokkeveld Group Shales (Boucher 1998, Rode 1994).

Riparian zone description

The width of the riparian zone in this section is approximately 20 m on the left bank and 15 m on the right bank. The riparian zone substratum is mainly rock and cobble with sand and gravel interspersed between the boulders, while shallow soil occurs in places. The very large rocks along the right bank prohibit the establishment of dense stands of riparian species and therefore vegetation cover is less than 100 % due to natural features. The low cover on this bank further along the river is also due to the clearing of invasive exotic species from the area during the last three years. Islands of *P. serratum* occur throughout the active channel. Indigenous tree species occurring include *B. stellatifolium, B. neriifolia* and *C. schinoides*. Indigenous shrub species include *B. lanuginosa, D. glabra, M. angustifolia, M. serrata* and *Penaea mucronata.* Although the riparian vegetation is invaded by exotic vegetation, mainly *A. longifolia* and *P. pinaster*, there were many indigenous seedlings within the riparian zone, which could indicate that the vegetation is recovering and adapting to the modified flows brought about by the Arieskraal Dam. Species common along the water's edge include, *Calopsis paniculata, Cyperus denudatus, Ehrharta erecta, I. subverticillata, Merxmuellera cincta* and *Platycaulos callistachyus*. Instream vegetation consists of *Isolepis* species and *P. lapathifolium*.

Riparian vegetation condition

The RVI score (16.37) reflects the 'gut feel' score, which places this site into a high C Class meaning that the site is moderately modified (Fig. 3.9). The riparian vegetation is impacted from the upstream Arieskraal Dam with the indigenous tree flora being depauperate as a result of reduced flows (Boucher 1998) and alien invasion from the surrounding forestry area. However, the vegetation does have natural elements within it and alien removal in this section has allowed the natural indigenous species to re-establish themselves as is evident from the large number of indigenous seedlings (Fig. 3.10).

SITE C4

General description

This site is situated within the Kogelberg Biosphere Reserve, approximately 2 km downstream of Stokoe's Bridge. The surrounding land is a nature reserve for the preservation of the natural fynbos vegetation.

Riparian zone description

The width of the riparian zone is difficult to ascertain in this section of the river because the left bank is not easy to access and the right bank has riparian vegetation which grades into surrounding seepage fynbos vegetation. The substratum of the riparian zone is a mixture of soil, cobble, gravel and sand with a small section of bedrock. An extensive deposition of silt and sand occurs along the water's edge on the right bank. *P. serratum*, sedges (e.g. *Cyperus* species) and grasses (e.g. *Aristida junciformis*) were found on these sandy patches. Both banks are steep and have 100 % vegetation cover. The left bank has a closed canopy of indigenous riparian tree and tall shrub species. Dominant indigenous tree and shrub species include *B. stellatifolium, B. neriifolia, D. glabra, Halleria elliptica, M. angustifolia, M. serrata, Penaea cneorum* subsp. *cneorum* and *Rhus angustifolia*. A rare shrub, *Cryptocarya angustifolia*, was also found. Moisture-loving fynbos species, found at the site include *B. lanuginosa, I. subverticillata* and *Pseudobaeckia africana* as well as common seepage plants, such as, *P. aquilinum.* The instream vegetation was sparse although *I. prolifer* was recorded in samples. The *P. distichum* mats mentioned by Boucher (1998) were not observed during either sampling trips. A few seedlings of the exotic species *A. longifolia, A. mearnsii* and *S. punicea* were observed on the left bank. Larger woody exotic invasive species have not been able to mature in this section of the river because of their annual removal due to the protection afforded the area.

Riparian vegetation condition

A definite improvement in riparian vegetation condition occurs as the river enters the Kogelberg Biospere Reserve. The vegetation in this section of the river is in a near-pristine condition. According to Boucher (1998), the riparian vegetation serves as an example of what used to occur along the lower reaches of many rivers in the southwestern Cape before human intervention. The RVI score reflects the 'gut feel' score, which places the site into Class B (Fig. 3.9). This means that the site is largely natural with few modifications. The occurrence of many indigenous riparian seedlings and hence the high RIRS score (Fig. 3.10) is probably due to the recent fire that occurred in November 1999 on the right bank. Another possibility is the readjustment of the riparian vegetation following abstraction from the Kogelberg Dam, which was completed by 1987.

SITE C5

General description

This site is situated within the Kogelberg Biosphere Reserve, downstream of the Nature Conservation offices, towards the bottom end of the reserve. This site is positioned on the borderline between the rejuvenated foothill and transitional sections of the river.

Riparian zone description

The riparian zone is very difficult to delineate at this site as the main channel is braided and is traversed by rocky islands and bedrock slabs. The natural geomorphological character of this site therefore inhibits the establishment of tall riparian species. Soil, gravel and sand are found interspersed between the boulders and bedrock. The riparian zone is more distinguishable on the left bank than the right bank because the surrounding fynbos seepage vegetation grades into the riparian vegetation on the right bank. A clearer example of the vegetation that represents this section of the river can be found just upstream of this site. The dominant species at the site is *P. serratum*. The available instream habitat at this site is step cascades over boulders and bedrock with alternating pools. This is the preferred habitat of the plant (Withers & Boucher 2000). Other dominant indigenous tree and shrub species include *B. stellatifolium, B. neriifolia, D. glabra, E. caffra* and *M. angustifolia.* No exotic species were observed during the spring and autumn site visits, however, a trip to the site in February 2003 revealed otherwise, with a few *A. longifolia* and *A. mearnsii* individuals being recorded. Instream vegetation remained inconspicuous.

Riparian vegetation condition

Although not many mature tree species were found at the site, the vegetation remains in a near-pristine condition. The RVI score reflects the 'gut feel' score, which places the site into Class B (Fig. 3.9), meaning that the site is largely natural with few modifications. The occurrence of many indigenous riparian juvenile plants (Fig. 3.10) suggests that the site is in a good state.

DISCUSSION AND CONCLUSIONS

The application of the RVI in this study has highlighted flaws within the method. Although these flaws will be discussed further in Chapter 5, the main problems, which have affected riparian vegetation condition scores and have caused a deviation from the expected condition will briefly be summarised. Generally where deviations of the RVI score has occurred (Fig. 3.5, sites A4 & A5; Fig. 3.7, site B4; Fig. 3.9, site C2) it has been the case that the RVI has over-scored sites from what is expected. As mentioned, the probable reason for the score being higher than expected is the disproportionate contribution by the Extent of Vegetation Cover (EVC) sub-index to the final RVI score. EVC is a measure of the total vegetation cover at a site and does not distinguish between exotic and indigenous vegetation i.e. floristic quality is not taken into account. So even though the other sub-index scores may reflect a decline in overall condition, the high contribution of EVC tends to elevate the final score. It is felt that too much emphasis is being placed on the EVC value within the whole RVI formula, and that vegetation quality needs to be incorporated into this sub-index (refer to Chapter 5).

The other flaw of the RVI is its inability to reflect the true biological status of the riparian vegetation in the Mountain Fynbos Stream Zone (Fig 3.7, site B1). In this situation the RVI under-scored the vegetation condition. It is suggested that, where no riparian canopy exists and where recruitment is not a conspicuous phenomenon, when the vegetation is in its mature state, that recruitment is weighted less in the RVI formula or that alternatively, if the suggested method presented in Chapter 6 is accepted, that these fynbos riparian species are weighted higher in an assessment of this zone of a river (refer to Chapters 5 & 6).

The general trend of riparian vegetation condition scores along the length of the Lourens River is a deterioration in riparian vegetation quality. This has occurred because of the surrounding land-use pressures on the riparian zone and is typical of rivers, which degrade where they flow through major towns. Restoration projects aimed at improving the natural ecosystem functioning potential of the Lourens River would need to ensure that exotic vegetation is cleared and that indigenous riparian vegetation local to the area is reinstated along the length of the river.

The riparian vegetation along the Hout Bay River is pristine in the upper part of the catchment but decreases in quality in the lower reaches of the river. Restoration projects along the lower stretches should restore the natural connectivity of the active channel of the river with its floodplain thereby allowing the adjacent reedbeds in this section to perform their natural cleansing services, improving water quality and aesthetics. Alien invasive vegetation should be removed and indigenous riparian species re-introduced along its banks. The river as a whole should be afforded a higher conservation status, as it remains one of the few urban rivers in a relatively fair state.

Unlike the Lourens and Hout Bay Rivers, the Palmiet River improves in terms of vegetation condition in its lower reaches. This is because of a number of reasons. These include the fact that the river flows through the Kogelberg Biosphere Reserve, which affords the vegetation high protection, alien vegetation is regularly cleared within the Kogelberg State Forest, the presence of two large tributaries that drain pristine catchments rejuvenate the lower reaches of the Palmiet River and the large instream dams in the upper parts of the catchment act as a trap for alien seed. Alien clearing along the rivers' length as well as water releases, according to determined instream flow requirements from dams should ensure the persistence and recovery of natural riparian flora along the Palmiet River.

The results presented in this chapter will contribute to a State of Rivers Report for the Western Cape Region. These findings highlight areas of concern in terms of badly degraded riparian vegetation condition and areas of high conservation worth, thus contributing to the effective management and utilisation of these resources within the region.

REFERENCES

BOUCHER C (1978) Cape Hangklip area. II. The vegetation. Bothalia **13**: 455-497.

BOUCHER C (1997) Riparian and instream vegetation. In THARME R, RACTLIFFE G and DAY E (eds) An assessment of the present ecological condition of the Lourens River, Western Cape, with particular reference to proposals for storm water management, Final Report. Unpublished report, Southern Waters Ecological Research and Consulting cc, Freshwater Research Unit, University of Cape Town, Rondebosch.

BOUCHER C (1998) Flora and Vegetation. In BROWN C and DAY E (eds) Palmiet River Instream Flow Assessment, Final Report. Unpublished report, Southern Waters Ecological Research and Consulting cc, Cape Town.

BROWN CA, DAY E and KING JM (1997) Van Oudtshoorn Farm Development, Hout Bay River. Draft Report. Unpublished report prepared for Plan Trust Development. Southern Waters Ecological Research and Consulting cc & Freshwater Research Unit, University of Cape Town.

BUNN SE (1994) Riparian-stream linkages: A national R&D Program for Australian streams and rivers. In UYS MC (ed.) Classification of rivers, and environmental health indicators. Proceedings of a joint South African /Australian workshop. February 7-14 1994, Cape Town, South Africa. WRC Report No. **TT 63/94**. Water Research Commission, Pretoria.

BUNN SE, DAVIES PM and MOSISCH TD (1999) Ecosystem measures of river health and their response to riparian and catchment degradation. Freshwater Biology **41**:333-345.

CAMPBELL BM, COWLING RM, BOND W and KRUGER FJ (1981) Structural characterization of vegetation in the Fynbos Biome. South African National Scientific Programmes Report No. **52**. Council for Scientific and Industrial Research, Pretoria.

CAMPBELL BM (1985) A classification of the mountain vegetation of the Fynbos Biome. Memoirs of the Botanical Survey of South Africa **50**: 1-121.

CAPE TOWN CITY COUNCIL (1994) Status and management of Cape Town's waters. Inland Waters Management Team and Town Planning Branch, Cape Town.

COWLING R and RICHARDSON D (1995) Fynbos: South Africa's Unique Floral Kingdom. Fernwood Press, Vlaeberg.

CLIFF S and GRINDLEY JR (1982) Estuaries of the Cape. Part II: Synopses of available information on individual systems. Report No. **17**: Lourens (CSW 7). CSIR Research Report No. **416.** CSIR, Stellenbosch.

DAVIES B and DAY J (1998) Vanishing Waters. University of Cape Town Press, Rondebosch.

DAWSON EK (2003) River Health Assessment of Selected Southwestern Cape Rivers: Index of Habitat Integrity (IHI), Water Quality and Land-use. Unpublished M.Sc. thesis (in prep.), Botany Department, University of Stellenbosch, Stellenbosch.

DAY L (1998) Description of the Palmiet Catchment. In BROWN C and DAY E (eds) Palmiet River Instream Flow Assessment, Final Report. Unpublished report, Southern Waters Ecological Research and Consulting cc, Cape Town.

GLYPHIS J, MOLL EJ and CAMPBELL BM (1978) Phytosociological studies on Table Mountain, South Africa. South African Journal of Botany **44(3)**:281-289.

GOLDBLATT P and MANNING J (2000). Cape plants. Strelitzia **9**: 1-743.

GRINDLEY SA (1988) Estuaries of the Cape. Part II: Synopses of available information on individual systems. Report No. **29**: Hout Bay (CW 27). CSIR Research Report No. **428**. CSIR, Stellenbosch.

KEMPER NP (2001) Riparian Vegetation Index: Final Report. WRC Project No. **K5/850**. Institute for Water Research, Pretoria.

LOW AB and REBELO AG (1996) Vegetation of South Africa, Lesotho, and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

LARGE ARG and PETTS GE (1992) Buffer zones for conservation of rivers and bankside habitats. National Rivers Authority, Almondsbury.

LUBKE R (1996) Dune Thicket. In LOW AB and REBELO AG (eds) Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

MEALS DW (2001) Water quality response to riparian restoration in an agricultural watershed in Vermont, USA. Water Science and Technology **43(5)**:175-182.

RODE E (1994) Die plantegroei van die plaas Solva in die Elgin-kom, Suidwes-Kaap. B.Sc. (Honours) project, Botany Department, University of Stellenbosch, Stellenbosch.

ROUX DJ (1997) National Aquatic Ecosystem Biomonitoring Programme: Overview of the design process and guidelines for implementation. NAEBP Report, Series No. **6**. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

ROWNTREE KM, WADESON RA and O' KEEFFE J (2000) The development of a geomorphological classification system for the longitudinal zonation of South African rivers. South African Geographical Journal **82(3)**: 163-172.

STATE OF RIVERS REPORT (2001 b) Crocodile, Sabie-Sand & Olifants River Systems. WRC Report No: **TT 1147/01**. Water Research Commission, Pretoria.

THARME R, RACTLIFFE G and DAY E (1997) An assessment of the present ecological condition of the Lourens River, Western Cape, with particular reference to proposals for storm water management, Final Report. Unpublished report, Southern Waters Ecological Research and Consulting cc, Freshwater Research Unit, University of Cape Town, Rondebosch.

UYS MC, GOETSCH PA and O' KEEFFE JH (1996) National Biomonitoring Programme for Riverine Ecosystems: Ecological indicators, a review and recommendations. NBP Report Series No. **4**. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

WITHERS MJ and BOUCHER C (2000) An assessment of the influence of fires in the Silvermine Area on *Prionium serratum* and its distribution along the Silvermine River. Unpublished B.Sc. Project Report, Botany Department, University of Stellenbosch, Stellenbosch.

CHAPTER 4

RIPARIAN VEGETATION INDEX (RVI): VALIDITY AND REPEATABILITY ISSUES

ABSTRACT

The repeatability and validity of the RVI method is tested in this chapter to assess whether the method presents meaningful results. The RVI method is tested for variability and validity across disturbance gradients at sites along the Eerste River. This study indicates that the RVI method produces repeatable results. The sub-index, "Recruitment of Indigenous Riparian Species" (RIRS), is the most variable in terms of assessor scores, while Structural Intactness (SI) is the most reproducible sub-index. This has important implications for the future development of the method, which should place more emphasis on reproducible sub-indices within the final RVI formula and should standardise those sub-indices that are highly variable. T-test results indicate that the method does not reflect the perceived biological status of the vegetation, contrary to previous results (Chapter 3). This may be due to the specified sampling duration, which should be increased in order to allow the production of more meaningful results.

Keywords: repeatability and validity, Riparian Vegetation Index, Fynbos Biome, Eerste River, disturbance

INTRODUCTION

Boulton (1999) points out that the concept of river health only has strong scientific grounding if the indicators have been stringently evaluated and validated so that the reliability of the data and what they indicate is clear.

A good indicator should be cost effective, quick to measure, amenable to sampling, contain clarity of outputs, be repeatable and robust (Cairns *et al.* 1993, McGeoch 1998). There should also be a good knowledge of its natural variation where it is used (Boulton 1999). Ideal indicators should also deliver early warning, or check compliance, or diagnose causes of poor health (Boulton 1999). Within the framework of the River Health Programme, indicators should be acknowledged by experts to measure or represent important aspects of river condition, be capable of being measured using skills available to resource managers and should be sensitive to management intervention (Uys *et al.* 1996).

The Riparian Vegetation Index (RVI) (Kemper 2001) is currently under revision for the River Health Programme; testing and refining the method is taking place in a number of provinces within South Africa (e.g. Natal, Eastern Cape and Western Cape). The RVI in its present state has not been adequately applied and tested with real biomomitoring data across the country. This chapter reports on the validity and repeatability of the RVI within the Fynbos Biome of the southwestern Cape.

The original method was developed in Mpumalanga Province during a pilot study on the Sabie and Olifants Rivers in 1998 and 1999 (Kemper 2001). The major objectives of the RVI are to:

- be aimed at application on a national basis to a broad spectrum of rivers within South Africa; -
- be usable by technical personnel and
- be developed within a hierarchical framework. In the initial stages of the index development, the emphasis is on developing an index that provides a synoptic assessment of riparian vegetation condition. Later development is to provide a functional (output should describe the functioning ability of the riparian vegetation) and useful index, which can be applied or implemented on a wider or even national basis if necessary.

A workshop was held in Pretoria in August 2002 (Appendix A) to address criticisms of the method in its first draft state and to focus on the development of the RVI in order to fulfil its objectives in terms of being a functional and useful index. At the workshop it was highlighted that the method needed to be tested for its validity and repeatability as no data quality and consistency checks were as yet in place (*pers. comm.* Mr M. Graham 2002)[1]. Because the method was developed in Mpumalanga, where the vegetation falls largely within the Savanna Biome (Low & Rebelo 1996), which is dominated by large woody tree species, it was felt that too much of an emphasis was being placed on tree species within the RVI and that its application in other provinces had to be tested, especially those representing very different biomes like the Fynbos Biome in the southwestern Cape. The Fynbos Biome, which falls within a Winter Rainfall Region, is structurally very different from the vegetation associated with the Savanna Biome. The fynbos vegetation is typically tree depauperate (Campbell *et al.* 1981) and is characterised by the ericoid, proteiod, and restiod elements.

[1] Umgeni Water, PO Box 9, Pietermaritzburg 3200.

For the results of the RVI to be meaningful and to contribute significantly to management decisions, the data obtained has to be scientifically valid and reliable (Cairns *et al.* 1993, Boulton 1999). An attempt to answer the following questions will be made in this chapter: -

- What is the variability like in the data when the same technique is employed at the same sites by a number of equally trained assessors? How does subjectivity contribute to the overall outcome of the assessment?
- What is the variability in the data across extreme disturbance gradients?
- Which of the sub-indices are more variable? i.e. Which are more reproducible?
- Is the RVI reflecting the perceived biological status of the riparian vegetation?

METHODS

STUDY AREA

The study was conducted along the Eerste River (Fig. 4.1), which rises in the Dwarsberg, flows in a northwesterly direction through Stellenbosch and heads south towards False Bay where it enters the sea near Macassar. The river is 40 km in length. It lies within the Winter Rainfall Region of South Africa with a wide rainfall gradient from 3 300 mm on the Dwarsberg Plateau, through 1 000 mm in the foothills at Jonkershoek to 700 mm on the coastal plain at Faure (Brown & Dallas 1995). Near its source, the river flows through the Jonkershoek Valley, which forms part of the Hottentots-Holland Nature Reserve. Here the riparian belt is undisturbed and consists of indigenous fynbos (Sieben 2003).

Immediately upstream of the boundary of the reserve, the river is impounded by the Kleinplaas Dam, which receives water from the Riviersonderend-Berg-Eerste Government Water Scheme (inter-basin transfer scheme) and also serves as a site for an experimental cage-culture trout farm. From the dam the river runs out of the reserve, through areas mainly under vineyards towards Stellenbosch town. It is fed by many small streams along its way, such as, Jakkalsrivier, Langrivier, and Swartboskloof.

Immediately downstream of Stellenbosch, a principle tributary, the Plankenbrug River, joins the Eerste River. This highly polluted river (Brown & Dallas 1995) is about 10 km in length and runs through an agricultural region, formal and informal settlements of Cloetesville and Kayamandi, and

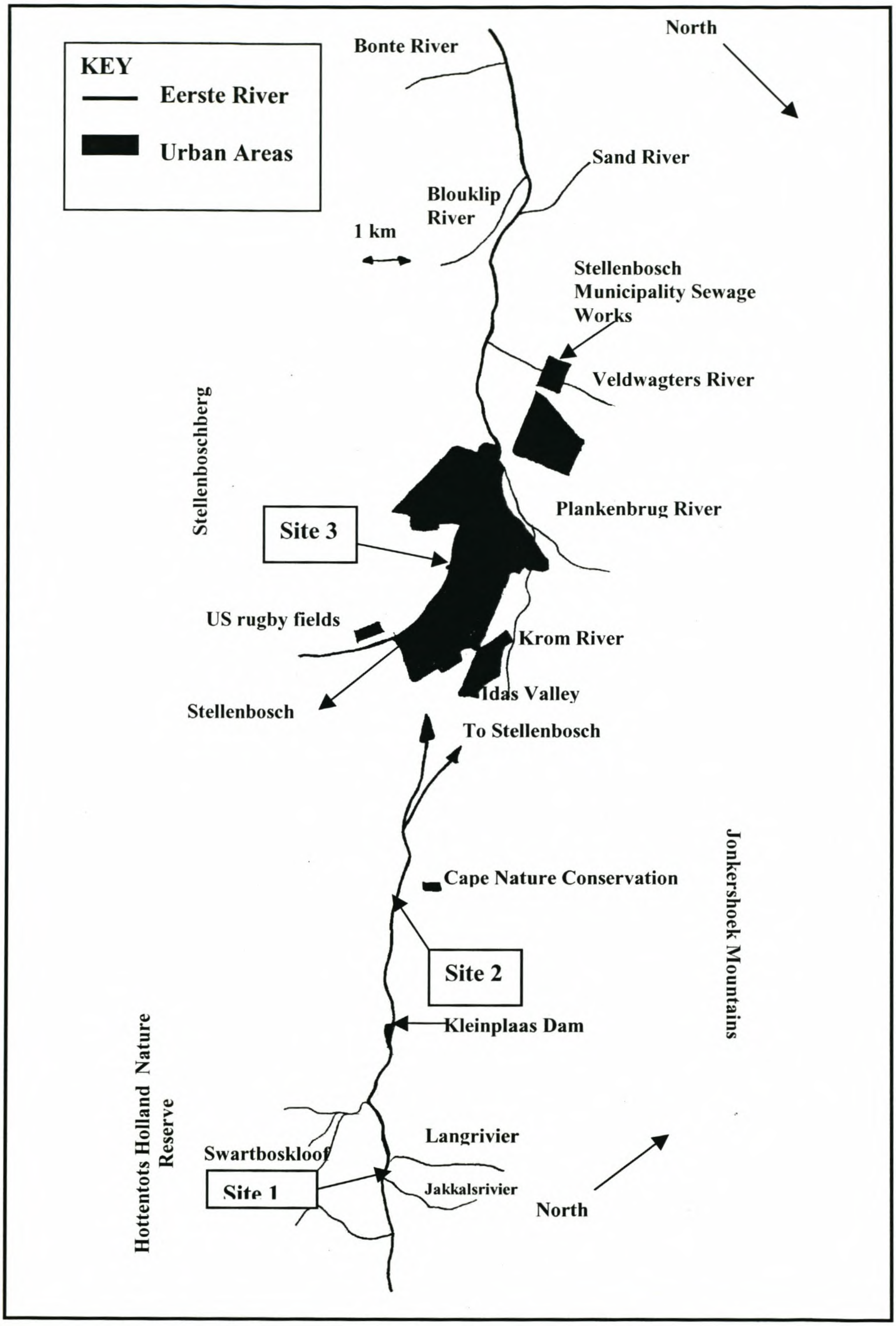

Figure 4.1: Map showing the study area and the location of sites along the Eerste River (Brown & Dallas 1995).

an industrial area, before joining the Eerste River. The Eerste River then flows past Stellenbosch Farmers Winery and is met by the Veldwachters River, which carries, *inter alia*, treated effluent from the Stellenbosch Municipality Sewage Works. The river then flows through vineyards and agricultural land past Vlottenburg, where it is met by the Sandrif, Blouklip and Kuils Rivers and then flows into False Bay through a punctuated estuary at Macassar (Brown & Dallas 1995).

Three study sites were selected for the purposes of the present research project. The sites represent varying degrees of disturbance from very low to no disturbance at Site 1, located in the Mountain Stream Zone to intermediate disturbance at Site 2, situated in the Upper Foothill Zone to high disturbance at Site 3, which is situated in the town of Stellenbosch also in the Upper Foothill Zone.

DESCRIPTION OF STUDY SITES

The precise location of each site and their zonation categories (Rowntree *et al.* 2000) are listed in Table 4.1 and a broad description of each site follows.

Table 4.1. Location of study sites along the Eerste River and their zonation categories (Rowntree *et al.* 2000)

Site	Zone	Location	Description
1	Mountain Stream	S 33° 59.521' E 18° 58.310'	Below Witbrug at the confluence with the Jakkals River, in the upper region of the Jonkershoek Valley.
2	Upper Foothill	S 33° 58.017' E 18° 55.593'	Assegaaibos (Western Cape Nature Conservation Board (WCNCB) property), above the bridge and gabion structures.
3	Upper Foothill	S 33° 56.252' E 18° 52.315'	Coetzenberg Bridge crossing, opposite the rugby fields.

SITE 1

General Description

Situated downstream of the bridge at the top of the circular drive in Jonkershoek State Forest and just below the confluence of the Jakkals River with the Eerste River. The site is undisturbed and in pristine condition.

Riparian Zone Description

The substratum of the riparian zone largely comprises rock and cobble interspersed with soil, gravel and sand. The width of the riparian zone is approximately 15 m on the left-hand bank and 12 m on the right-hand bank. The vegetation forms a closed canopy with an estimated cover of 100 %. There is no visible disturbance and the vegetation is considered to be natural with *Brabejum stellatifolium*, *Erica caffra* and *Metrosideros angustifolia* being largely dominant. *Prionium serratum* (palmiet) and the sedge, *Scirpus digitata*, make up the small amount of instream vegetation.

SITE 2

General Description

This site is situated on WCNCB property at Asssegaaibos. A fish aquaculture facility, run by the University of Stellenbosch, is also housed here. The small amount of water within a large macro-channel in this section is evidence of the huge effects of impoundment and water abstraction taking place upstream of the site. This site represents an intermediate level of disturbance.

Riparian Zone Description

The substratum of the riparian zone is mainly cobbles, with gravel and sand in between. The vegetation on each bank is distinctly different. This is because the land use on either side of the river has been different in the past and impounding the river has led to a shift in the active channel position hence the migration of the riparian zone. The right bank used to be under agriculture. The presence of recruiting exotic species, mainly of *Acacia saligna, A. longifolia and Quercus robur*, on this side is evidence of the disturbance in the past. Canopy cover is estimated at about 50% and there are also a large number of juvenile plants and recruiting individuals on the right hand bank. This is probably because there is more bank available for recruitment of riparian vegetation due to the active channel shifting to the left. The vegetation on the left hand bank is in good condition and canopy cover is estimated at 100%. Dominant species include *Brabejum stellatifolium*, *Freylinia lanceolata*, *Podalyria calyptrata* and *Rhus angustifolia.* This bank was not disturbed through agriculture and has remained in a reasonably natural state.

SITE 3

General Description

The site is situated opposite the rugby fields belonging to the University of Stellenbosch just below the bridge, which crosses the river to the rugby clubhouse. The surrounding landuse is recreational and residential. The river in this section is largely modified with the right hand bank having an almost vertical stone wall.

Riparian Zone Description

The substratum of the riparian zone is mainly comprised of soil, with some gravel and sand in between. Gabions along the sides of the wall create a small habitat in which riparian plants have established. Mainly exotic weedy species have established on this, the right bank of the river. The left bank is intact although it has a landscaped feel with exotics and garden escapees being dominant. Physical disturbance in this section of the river is high.

TESTING OF RVI SCORES

To test the reproducibility of RVI scores it was necessary to use several assessors, with similar riparian vegetation knowledge and river ecology experience to perform the RVI at the same sites, in the same time period. Six assessors were taken to the Eerste River and the three sites (described above) were sampled on 27 September 2002. The sites were chosen specifically for the purposes of testing assessment variability across disturbance gradients. The standard RVI method (Chapter 2) was employed at all sites and a sampling time of 1 hour was adhered to, to ensure that consistent sampling efforts were maintained. RVI scores were computed for all three sites in an excel spreadsheet. The mean RVI and 'gut feel' scores (taken as the mean value within each final category) were then calculated and compared, to determine whether or not the final RVI scores reflected the perceived biological status of the riparian vegetation. The variability of scores between assessors was expressed as the standard deviation around the mean. The mean sub-index scores were determined for each site and the variability around the mean was established by determining the standard deviation of assessor scores. This was done in order to determine how reproducible the sub-index scores of the RVI are.

Statistical Analysis

A paired two sample difference between means t-test (Zar 1974) was performed to ascertain whether or not there were significant differences between RVI scores and 'gut feel' scores at all three sites.

RESULTS

The mean RVI and mean Gut scores at three sites within the different disturbance categories are indicated in Figure 4.2. The variability around the mean RVI scores at all three sites is minimal. At site 1 (low disturbance) and site 3 (high disturbance) the variability in assessor RVI scores is sufficient at each site for the final score to fall into two different categories (Fig. 4.2). The only variability in Gut score between assessors existed at Site 3 (high disturbance). The variability is low enough, however, so that the scores all reflect the same final category. The greatest variability between assessor RVI scores exists at the site of intermediate disturbance (Fig. 4.2). The least variability in overall scoring was associated with the most disturbed site.

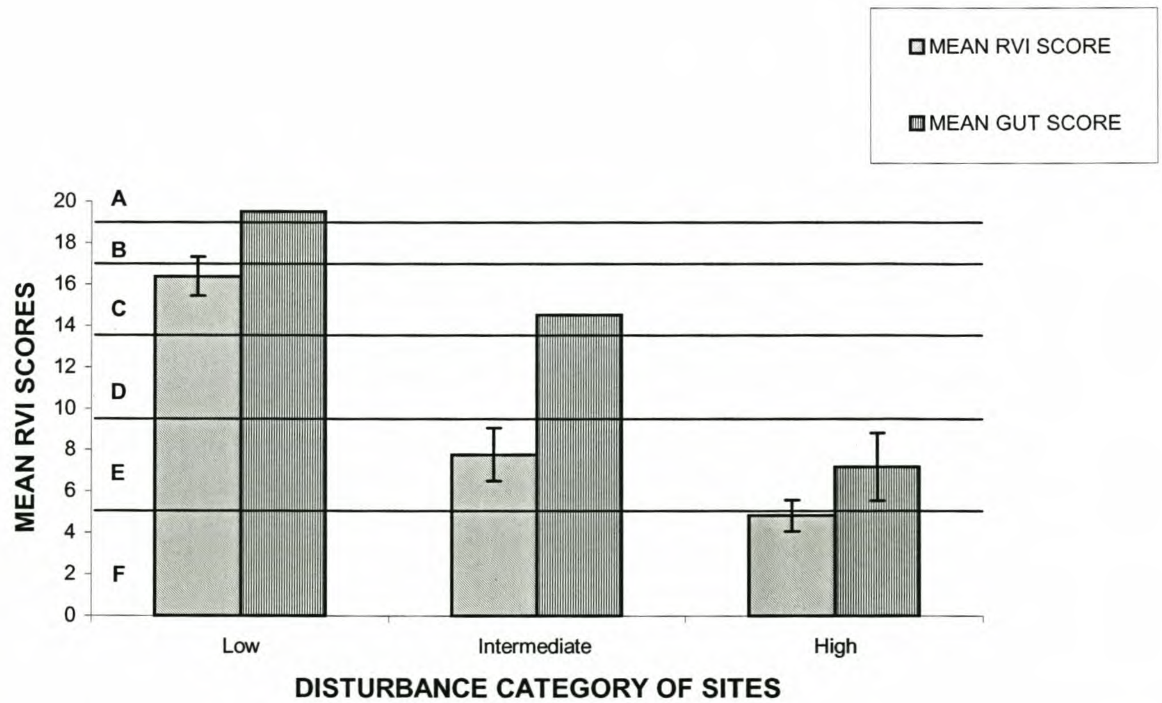

Figure 4.2: Variability of assessor RVI and Gut scores at study sites displaying different levels of disturbance (low to high) along the Eerste River. The standard deviation bars indicate the variability around the mean scores. **A-F** refers to the assessment class according to the six ecological reserve assessment categories (Chapter 2).

The RVI score is made up of several sub-index scores, which weigh differentially to the final RVI score (Fig. 4.3). The sub-index with the greatest variability between assessor scores, as indicated by the standard deviation bars, is Recruitment of Indigenous Riparian Species (RIRS) (Fig. 4.3). The sub-index with the least variability between assessor scores is Structural Intactness (SI) (Fig. 4.3).

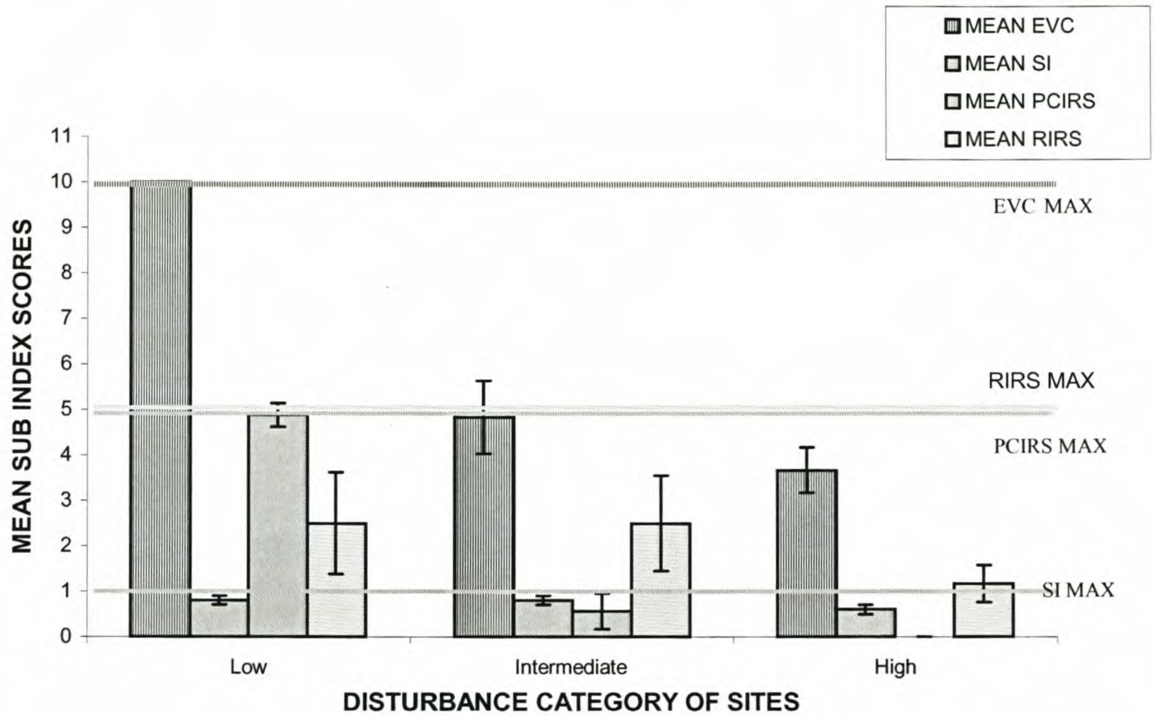

Figure 4.3: Variability between assessors' sub-index scores at study sites displaying different levels of disturbance (low to high) along the Eerste River. The standard deviation bars indicate the variability around the mean scores. **EVC** = Extent of Vegetation Cover, **SI** = Structural Intactness, **PCIRS** = Percentage Cover of Indigenous Riparian Species and **RIRS** = Recruitment of Indigenous Riparian Species.

At all three sites the RVI scores were significantly different to the expected site condition scores (Gut score). The differences were highly significant at Sites 1 and 2 and only slightly significant at Site 3 (Table 4.2).

Table 4.2: Results of t-test analysis of data collected from three sites along the Eerste River

Site	T stat	P two tail	Degrees of Freedom (df)
1	-6.276843157	0.001507287	5
2	-12.87562878	5.03264E-05	5
3	-4.88901207	0.004517414	5

DISCUSSION AND CONCLUSIONS

The results suggest that RVI scores are reproducible and are relatively consistent as variation around the mean RVI scores was minimal. Subjectivity, therefore, possibly does not contribute greatly to the overall outcome of the assessment. It is suggested that a greater number of sites be tested in the same way so that definite conclusions can be reached regarding the reproducibility of RVI scores.

In terms of variability of RVI scores across disturbance gradients, the site of intermediate disturbance showed the most variability amongst assessor scores. A possible explanation for this outcome has to do with the difficulty experienced by assessors when evaluating this site. The right hand and left hand banks were distinctly different in terms of riparian vegetation condition at this site (as discussed in the descriptions of the study area section above). The variability in assessor scores could, therefore, be linked to site-specific features and not to method design. Each bank should be assessed independently (refer to Chapter 5). The site with the highest disturbance showed the least variability between assessor scores. This is to be expected because sites of poor vegetation condition are usually much easier to assess as often monotypic stands of vegetation cover the banks and there is generally a lower species diversity, hence the greater the reproducibility of scores.

In terms of reproducibility of sub-index scores, RIRS is the least reproducible of all the sub-indices i.e. assessors' scores were highly variable for this component of the index. This is to be expected as it requires experience to pick up recruiting individuals especially when faced with dense vegetation at sample sites. It also requires the assessor to be meticulous, when assessing this feature, which is often difficult given the time constraints of the assessment. SI showed the least variability between assessor scores. This indicates that the distribution scores are highly reproducible, that is, if the perceived reference state is known. This aspect of the method has been highlighted as problematic especially in the western Cape where the natural condition has been lost in most areas following perturbations since European colonization n 1652 (*pers. comm.* Dr C. Boucher 2002[2]). In this assessment the perceived reference state was established by an expert independently. The assessors did not deviate from this state.

For the RVI as a whole to be more consistent and reproducible, it is important to consider the contributions of the sub-indices to the final score and to assess their consistency. The sub-indices

[2] Botany Department, Stellenbosch University, Private Bag X1, Matieland, 7602

that are more repeatable, e.g. SI, should have a greater weighting in the final score derivation to ensure overall consistency. In the same token, the sub-indices with the greatest variability, like RIRS, should be standardised more to increase the consistency and repeatability of the index (see Chapter 5).

The results of the statistical analysis reveal that RVI scores were significantly different to Gut scores at all three sites. This is a disappointing result as it highlights the inefficiency of the RVI to reflect the perceived biological status of the vegetation at the sites under consideration. In fact the RVI seems to be underscoring the sites by at least one or two categories. It is pertinent to point out that in my previous assessment of vegetation condition along the Lourens, Hout Bay and Palmiet Rivers (Chapter 3), the degree of accuracy of the RVI was a lot greater. This, I feel, has to do with the longer sampling period employed (approximately 2 hrs) in that study. In contrast the RVI scores obtained by assessors, where time constraints of 1 hr per site were imposed, showed a greater difference between RVI and Gut scores.

For the results of the RVI to be meaningful, therefore, it is suggested that the sampling period be increased from what is suggested in the initial description of the method. This would also improve the ratio between field time and travel time. It often takes a few hours to reach a site. These aspects require further testing.

REFERENCES

BOULTON A J (1999) An overview of river health assessment: philosophies, practice, problems and prognosis. Freshwater Biology **41**: 469-479.

BROWN CA and DALLAS HF (1995) Eerste River, Western Cape: situation assessment of the riverine ecosystem. Final Report, June 1995. Southern Waters Ecological Research & Consulting cc., commissioned by CSIR, Stellenbosch.

CAIRNS J, McCORMICK PV and NIEDERLEHNER BR (1993) A proposed framework for developing indicators of ecosystem health. Hydrobiologia **263**:1-44.

CAMPBELL BM, COWLING, RM, BOND W and KRUGER FJ (1981) Structural characterization of vegetation in the Fynbos Biome. South African National Scientific Programmes Report No. **52**. Council for Scientific and Industrial Research, Pretoria.

KEMPER NP (2001) Riparian Vegetation Index: Final Report. WRC Project No. **K5/850**. Institute for Water Research, Pretoria.

LOW AB and REBELO AG (1996) Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

McGEOCH MA (1998) The selection, testing and application of terrestrial insects as bioindicators. Biological Reviews **73**:181-201.

ROWNTREE KM, WADESON RA and O' KEEFFE J (2000) The development of a geomorphological classification system for the longitudinal zonation of South African rivers. South African Geographical Journal **82(3)**: 163-172.

SIEBEN EJJ (2003) The riparian vegetation of the Hottentots Holland Mountains, Western Cape, South Africa. Unpublished PhD thesis, Botany Department, University of Stellenbosch, Stellenbosch.

UYS MC, GOETSCH PA and O' KEEFFE JH (1996) National Biomonitoring Programme for Riverine Ecosystems: Ecological indicators, a review and recommendations. NBP Report Series No. **4**. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

ZAR J.H. (1974). Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, New Jersey.

CHAPTER 5

RIPARIAN VEGETATION INDEX: CRITICISMS AND SUGGESTIONS

This chapter deals with criticisms of and difficulties experienced with the RVI method as well as suggestions to improve the method. This should be viewed as a supplementary document to the Proceedings of the Riparian Vegetation Index Workshop, which was held in Pretoria on the 22 August 2002 (Unpublished document, Appendix A).

RVI SCORE DERIVATION ISSUES

- **Extent of Vegetation Cover (EVC)**

It is not clear when calculating EVC2 how disturbance should be assessed. Does a site with 100% vegetation cover automatically have a 0 disturbance score? i.e. EVC2 = 10. This aspect needs a better explanation within the RVI field guide. If this is the case then a site, which has 100% cover of weed species and exotics will get the highest total for EVC. This is nonsensical, as clearly the high EVC score does not reflect the quality of the vegetation at such a site. This is an important point to consider because the quality of the vegetation has a direct bearing on the functioning of the whole system and this has major consequences for the health of a system. If the RVI is to be a functional index then quality needs to be incorporated into total EVC. Looked at from this perspective it is evident that too much emphasis is being placed on EVC total within the whole RVI formula.

If the extent of vegetation cover is less than 100% because of the natural geomorphology at a site then this should be incorporated into the formula. In other words, the EVC total score should not decrease if the disturbance is a natural feature such as bedrock preventing the establishment of riparian species. At present, natural and anthropogenic disturbances are grouped together.

The six point scoring system for site disturbance (Kemper 2001) to calculate EVC 2 needs to be adjusted so that intervals between the six points are even i.e. employ an interval of 2 between categories. This must be addressed within the Rivers Database as well. The points system that was shown at the workshop in Pretoria 2002 (Table 5.1) employs the preferred scale.

Table 5.1. Preferred scale to be employed for the calculation of EVC 2

Disturbance score	0	VL	L	M	H	VH
EVC 2 score	10	8	6	4	2	0

- **Structural Intactness (SI)**

A weakness of SI is the reliance on a perceived reference state, which, as mentioned in Chapter 4, remains difficult to determine. An attempt at making definite and realistic benchmarks should be a major priority.

- **Percentage Cover of Indigenous Riparian Species (PCIRS)**

Currently the PCIRS exhibits a negative score when Total Cover subtract invasion is <0. The value cannot be <0 as the lowest value is 0. This aspect needs to be addressed.

ASSESSMENT DIFFICULTIES

- It is suggested that left and right banks be assessed separately as they are sometimes markedly different e.g., due to different land use or disturbance histories (refer to Chapter 4). Averaging the assessment by looking at both banks simultaneously has a danger in that the full story about the condition at the site is not told.

- Growth form categories like grasses and forbs (this category should be added) need to be assessed differently in the walkabout form. Capturing cover by the number of individuals is problematic. A possible cover scale needs to be considered. The Braun-Blanquet cover-abundance scale (Werger 1974) is an ecologically meaningful technique that is readily converted to a percentage scale and may serve as a more meaningful alternative approach.

- Contrary to the RVI results obtained at Sites C4 and C5 along the Palmiet River (Chapter 3), which indicated a near-natural to good condition, parallel studies (Dawson 2003, Ollis 2003) of river health (macro-invertebrate (SASS) and habitat integrity (HII) studies) indicated that the condition of the river was good to fair. This difference in result (not discussed in Chapter 3) indicates that the RVI may not be sensitive enough to pick up short-term changes in river health like the other indices (SASS and HII) do, but may function on a longer time scale indicating long term changes.

STANDARDISATION ISSUES

In order for the RVI method to be meaningful and for results to be repeatable certain aspects need to be standardised so that consistency between assessors is maintained.

- **Recruitment**

It is suggested that recruitment categories be incorporated into the walkabout form. This will encourage assessors to be more meticulous about recognising and assessing recruitment for all dominant plant species recorded. Instead of making an assessment of recruitment based on the number of individuals within the <1 and 1-2 m categories, columns under the heading of recruitment are suggested. Within the columns, the following categories could serve as an example of the kind of abundance scale that should be employed; none, rare, occasional, frequent.

- **Definitions** (Campbell *et al.* 1981, Edwards 1983, Lawrence 1989)

The following definitions may be incorporated into the RVI field guide to aid assessors in their interpretation of these growth categories, which are sometimes difficult to delineate.

Shrub: Multi-stemmed, and usually branching at or near the base. Usually below 2 m in height. If above 2 m in height then the widest stem must have a diameter of less than 10 cm.

Tree: Has a single main trunk and is usually above 2 m in height or if multi-stemmed any single stem must be at least 10 cm in diameter at a height of 1.3 m.

- **Sampling period**

In order for the assessor to gain a good feel of the vegetation and to facilitate the process of species identification, it is suggested that the assessment be undertaken in two seasons once a year each namely, Spring (common flowering time of most species) and one other season. This will also reflect contrasting conditions e.g. low flow state in the southwestern Cape.

CONSIDERATIONS WITHIN THE FYNBOS BIOME

- Site selection: In this study, site selection was based on longitudinal or geomorphological zonation patterns (Rowntree *et al.* 2000, refer to Chapter 3). Although geomorphologically the Mountain Stream Zone of a river is readily delineated, it needs to be noted that the vegetation type can further delineate this zone into two ie. Mountain Fynbos Stream Zone and Mountain Forest Stream Zone. The upper catchments in the western Cape tend to be dominated by open Fynbos of the Cape Floristic Kingdom (Davies *et al.* 1993). The Mountain Fynbos vegetation usually extends to the waters' edge. In a sense there is no true riparian zone or riparian canopy in this section, whereas lower down, a distinctive riparian zone is visible usually in a ravine situation with a closed canopy (Afromontane trees). These two subdivisions within the Mountain Stream Zone need to be explicitly separated and sites representing both these zones should be selected in river health assessments.

- Structural categories, which are conspicuous along Cape Rivers and need to be included in the walkabout form are, Cape reeds (restios) and forbs.

- Fire is a key process within the Fynbos Biome (Cowling & Richardson 1995). The influence of fire on vegetation in the Cape needs to be considered, as it will affect any assessment of vegetation condition. The following aspects need to be considered in light of the influence of fire:
    - Post-fire age of vegetation. Recruitment scores will be high following a fire as the vegetation recovers.
    - Recruitment is not conspicuous in mature fynbos vegetation hence the probable low recruitment score. Adjusting the weighting of the RIRS sub index score in the RVI formula, would ensure that the RVI score reflects a more accurate result concerning vegetation condition in the Mountain Fynbos Stream Zone.
    - Assessments should only be done in mature fynbos vegetation, at least five years after the last burn.
    - Site selection should be focussed outside of the fire influence.

REFERENCES

CAMPBELL BM, COWLING RM, BOND W and KRUGER FJ (1981) Structural characterization of vegetation in the Fynbos Biome. South African National Scientific Programmes Report No. **52**. Council for Scientific and Industrial Research, Pretoria.

COWLING R and RICHARDSON D (1995) Fynbos: South Africa's Unique Floral Kingdom. Fernwood Press, Vlaeberg.

DAVIES BR, O'KEEFE JH & SNADDON CD (1993) A synthesis of the ecological functioning, conservation and management of South African river ecosystems. WRC Report No. **TT 62/93**. Water Research Commission, Pretoria.

DAWSON EK (2003) River Health Assessment of Selected Southwestern Cape Rivers: Index of Habitat Integrity (IHI), Water Quality and Land-use. Unpublished M.Sc. thesis (in prep.), Botany Department, University of Stellenbosch, Stellenbosch.

EDWARDS D (1983) A broad scale structural classification of vegetation for practical purposes. Bothalia **14(3,4)**: 705-712.

KEMPER NP (2001) Riparian Vegetation Index: Final Report. Water Research Commission Project No. **K5/850**. Institute for Water Research, Pretoria.

LAWRENCE E (1989) Henderson's dictionary of biological terms.10th Edition. Longman Scientific & Technical, United Kingdom.

OLLIS D (2003) An assessment of the ecological health of the Hout Bay, Lourens and Palmiet Rivers (southwestern Cape, South Africa) using a rapid bioassessment method based on aquatic macro-invertebrates. Unpublished M.Sc. thesis (in prep.), Botany Department, University of Stellenbosch, Stellenbosch.

ROWNTREE KM, WADESON RA and O' KEEFFE J (2000) The development of a geomorphological classification system for the longitudinal zonation of South African rivers. South African Geographical Journal **82(3)**: 163-172.

WERGER MJA (1974) The Zurich-Montpellier method of vegetation survey. Bothalia **11(3)**: 309-323.

CHAPTER 6

FLORISTIC QUALITY ASSESSMENT (FQA): AN ALTERNATIVE APPROACH TO ASSESSING RIPARIAN VEGETATION CONDITION

ABSTRACT

An alternative method to the Riparian Vegetation Index (RVI) is explored in this chapter. The Floristic Quality Assessment (FQA) method, used to determine vegetation integrity in Illinois USA, is adapted to assess riparian vegetation condition at sites along the Lourens, Hout Bay and Palmiet Rivers. Coefficients of conservatism, determined for the flora observed in the assessment, attempt to categorise species according to their response to levels of habitat degradation. These values are incorporated into the Floristic Quality Index (FQI) formula, which yields the final floristic quality assessment results. Correlation analyses indicate that RVI and FQA results are strongly correlated although the RVI at this stage best represents the perceived biological status of vegetation at sites. The FQA method, or a statistically modified alternative, may be a suitable and more objective alternative to the RVI method.

Keywords: habitat degradation, riparian vegetation condition, Floristic Quality Assessment, southwestern Cape Rivers, species fidelity

INTRODUCTION

A criticism of rapid bioassessment methods is that they rely to a large degree on subjective, instead of objectively assessed, qualitative data. The Riparian Vegetation Index (RVI) method (Chapter 2) falls under this description. In this chapter an alternative method to the RVI is explored. The Floristic Quality Assessment (FQA) (Taft *et al.* 1997) is a proposed alternative and potentially more objective method to assess riparian vegetation condition along rivers in South Africa. This method has been used to determine the floristic integrity in Illinois. Keddy *et al.* (1993, in: Taft *et al.* 1997), identify a need for simple, sensitive, readily interpretable, and ecologically meaningful methods to classify vegetation according to levels of ecological integrity, particularly for use by the non-specialist. The FQA method attempts to satisfy these needs whilst maintaining a high level of objectivity.

The FQA Method

In the application of the FQA, each taxon in the Illinois vascular flora is assigned an integer from 0 to 10, which is termed a coefficient of conservatism. The coefficient represents two basic ecological principles: plants differ in their tolerance to disturbance type, frequency and amplitude, and plants display varying degrees of fidelity to habitat integrity (MacArthur & Wilson 1967, Grubb 1977, Grime 1974).

Hypotheses of mechanisms to account for these principles, among others, were Grubb's (1977) regeneration niche and Grime's (1974) regenerative flexibility for ecological amplitude. Grime (1974) proposed a trio of strategies: ruderals, competitors and stress tolerators. These strategies are considered to be shaped by an equilibrium among the ecological forces of competition, stress, and disturbance. These forces serve as axes for ordinating species' responses in Grimes 'triangles'. Ruderals are adapted to cope with habitat disturbance. Competitors are adapted to live in highly competitive, but benign environments like the tropics. Stress tolerators are adapted to cope with severe environmental conditions, such as salt marshes and deserts. The coefficients can, in part, be considered in terms of Grime's survival strategies. Species given a C value of 0-1 correspond to Grime's ruderal species and those with a C value of 2-3 correspond to ruderal-competitive species. Species assigned coefficients 4-6 correspond to Grime's competitors. Species having values of 7-10 are less clearly aligned with Grime's model (Taft *et al.* 1997).

The coefficient of conservatism is an attempt to categorise species according to their response to levels of habitat degradation. This information drew upon approximately 60 years of botanical and ecological field study throughout Illinois. Table 6.1 defines categories used to assess the co-efficient of conservatism.

Table 6.1. Coefficients of conservatism values and the categories delimiting these values based on species response to habitat degradation (derived from Taft *et al.* 1997)

COEFFICIENT OF CONSERVATISM	DESCRIPTION	SUB-CATEGORIES OF COEFFICIENT OF CONSERVATISM	DESCRIPTION
0-3	▪ Taxa adapted to frequent and severe disturbances ▪ Species with persistent seed banks, grow rapidly, wind-dispersed seed ▪ Longer-lived species capable of persisting with frequent disturbance e.g. Flooding or siltation	0-1	▪ Ruderal species
		2-3	▪ Ruderal-competitive species
4-6	▪ Many dominant or matrix species for several habitats ▪ Species expected to have high consistency in a community type ▪ Species can persist with light to moderate disturbances but may decline with an increase in intensity, frequency or duration of disturbance		
7-10	▪ Species that do not tolerate much habitat degradation ▪ Long-lived perennials	7-8	▪ Taxa associated with natural areas but can be found where habitat has been degraded somewhat ▪ Increasing disturbance can lead to local extirpation
		9-10	▪ Restricted to relatively intact natural areas

The FQA method uses a floristic quality index (FQI) (Swink & Wilhelm 1979, 1994, in: Taft *et al.* 1997) to enable scoring and ultimate description of vegetation. The FQI is a weighted index of species richness (N), and is the arithmetic product of the average coefficient of conservatism ($\overline{C}$) and the square root of species richness ($\sqrt{N}$) of an inventory unit. Thus:

FQI = $\overline{C}(\sqrt{N})$ where;

C = coefficient of conservatism,

$\overline{C} = \Sigma$ C / N, and

N = Number of taxa.

The final FQI score places the sites into categories, which describe their level of degradation (Table 6.2).

Table 6.2. FQI scoring categories indicating vegetation condition (Taft *et al.* 1997)

FQI SCORE	DESCRIPTION
<20	Degraded or derelict plant communities
>20 - <35	May be degraded but have potential for some level of recovery
>35 - <45	Regionally noteworthy and are often sharply distinct from the predominant heavily degraded matrix areas in the landscape
>45	State-wide significant natural areas

The FQA method also takes other factors into consideration, which are not incorporated into the FQI to derive a score, but are used in graphical depictions, in order to describe guild diversity. These factors include physiognomic classes and wetness ranks. Frequency distributions of species among these traits allow for comparison of guild diversity among sites and time periods. These factors will not be discussed further in this study. The aim of this study is not to describe guild diversity at study sites but to make correlations between the findings of two methods which both assess vegetation condition, namely the RVI (Chapter 3) and FQA.

METHODS

A list of dominant plant species observed at study sites along the Lourens, Hout Bay and Palmiet Rivers (refer to Chapter 3 for location of rivers) was compiled (Appendix B). Characteristics noted included physiognomy, wetness classification, rarity and whether the species was indigenous or exotic. Physiognomy refers to plant habit, life history and certain taxonomic classes (Table 6.3). Wetness classification is based on the National Wetland Category for Region 3 of the United States Fish and Wildlife Service (Reed 1988, in: Taft *et al.* 1997) (Table 6.4), which characterizes plants in terms of their hydrological distributions. Plants are designated as Obligate Wetland, Facultative Wetland, Facultative, Facultative Upland and Upland. These classes are further ranked by "+" and "-" values for the three facultative classes, thereby providing greater resolution (Table 6.4). Rarity refers to the conservation status of plants based on how threatened they are (Hilton-Taylor 1996).

Table 6.3. Physiognomic categories and the representative symbol used in this assessment (Campbell *et al.* 1981, Edwards 1983, Taft *et al.* 1997)

PHYSIOGNOMY CATEGORIES	SYMBOL
TREE	T
SHRUB	S
VINE (LIANES, CLIMBERS)	V
PERENNIAL GRASSES, SEDGES & RESTIOS	H
GEOPHYTE (CRYPTOPHYTE)	G
ANNUAL HERBS & GRASSES	A
BIENNIAL HERB	B
PERENNIAL HERB, FERNS	P

Table 6.4. Wetness Classification (Reed 1988, in: Taft *et al.* 1997)

WETNESS VALUES	CLASS	SYMBOL
-5	Obligate Wetland	OBL
-4	Facultative Wetland+	FACW+
-3	Facultative Wetland	FACW
-2	Facultative Wetland-	FACW-
-1	Facultative +	FAC+
0	Facultative	FAC
+1	Facultative-	FAC-
+2	Facultative Upland+	FACU+
+3	Facultative Upland	FACU
+4	Facultative Upland-	FACU-
+5	Upland	UPL

The coefficients of conservatism for each species are based on Taft *et al.'s* (1997) categories of species response to levels of habitat degradation (Table 6.1) and are based on 25 years of botanical and ecological field observations through the southwestern Cape by Dr C. Boucher (*pers comm.* Dr C Boucher 2002[1]). The FQI for each study site was determined according to Taft's (1997) method. For the purposes of this study the final FQI categories were modified on the basis of category descriptions, so that results obtained from both the FQA and RVI (refer to Chapter 3) methods could be compared. The output of the FQA therefore had to coincide with the six ecological assessment classes used in the RVI (Table 6.5).

[1] Botany Department, Stellenbosch University, Private Bag X1, Matieland, 7602

Table 6.5. Point-scoring system used in this study to determine the FQI assessment classes, which are comparable to the RVI assessment classes (refer to Chapter 2)

FQI SCORE	FQI ASSESSMENT CLASS	DESCRIPTION
>45	A	Unmodified, natural.
36-45	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
21-35	C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
13.4-20	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
6.8-13.3	E	The loss of natural habitat, biota and basic ecosystem functions are extensive.
0-6.7	F	Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

RVI and FQI classes for each site along the rivers were then compared and the correlations between RVI, FQI and 'gut' scores were determined (Excel correlation tool, Microsoft Windows 98, 2nd edition).

RESULTS

The results of the FQA method will be discussed separately for each river system assessed, although the comparative figures are presented together in Table 6.6 to simplify comparisons. For a description of sites, refer to Chapter 3.

Lourens River

The FQI scores obtained at Sites A1, A3 and A5 place the sites in a lower category than expected based on 'gut' score categories (Table 6.6). The FQI scores at Sites A2 and A4 are the same as the 'gut' category scores (Table 6.6).

Table 6.6. FQI, RVI and 'gut' score categories, determined for sites along the Lourens, Hout Bay and Palmiet Rivers (where: C = coefficient of conservatism)

	LOURENS					HOUT BAY				PALMIET				
Sites	A1	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4	C5
Total Number of Species (N)	25	37	18	26	29	27	9	33	29	23	23	21	27	11
C Total	183	106	38	35	52	163	73	57	26	135	46	106	134	69
Mean C	7.3	2.9	2.1	1.4	1.8	6.1	8.1	1.7	0.9	5.9	2.0	5.1	5.0	6.3
FQI Score	36.6	17.4	9.0	6.9	9.7	31.4	24.3	9.9	4.8	28.2	9.6	23.1	25.8	20.8
RVI Score	19	13.2	12.3	10.7	13.1	16.2	19.5	12.7	11.2	19	11.6	16.4	17.6	18
FQI Assessment Category	B	D	E	E	E	C	C	E	F	C	E	C	C	C
RVI Assessment Category	A	C	D	D	C	C	A	D	D	A	D	C	B	B
Gut Score Category	A	D	D	E	D	A	A	D	E	A	E	C	B	B

The general trend for RVI, 'gut' and FQI scores along the Lourens River is a decrease in vegetation quality from Site 1 to Site 4 and then an increase in quality at Site 5 (Fig. 6.1).

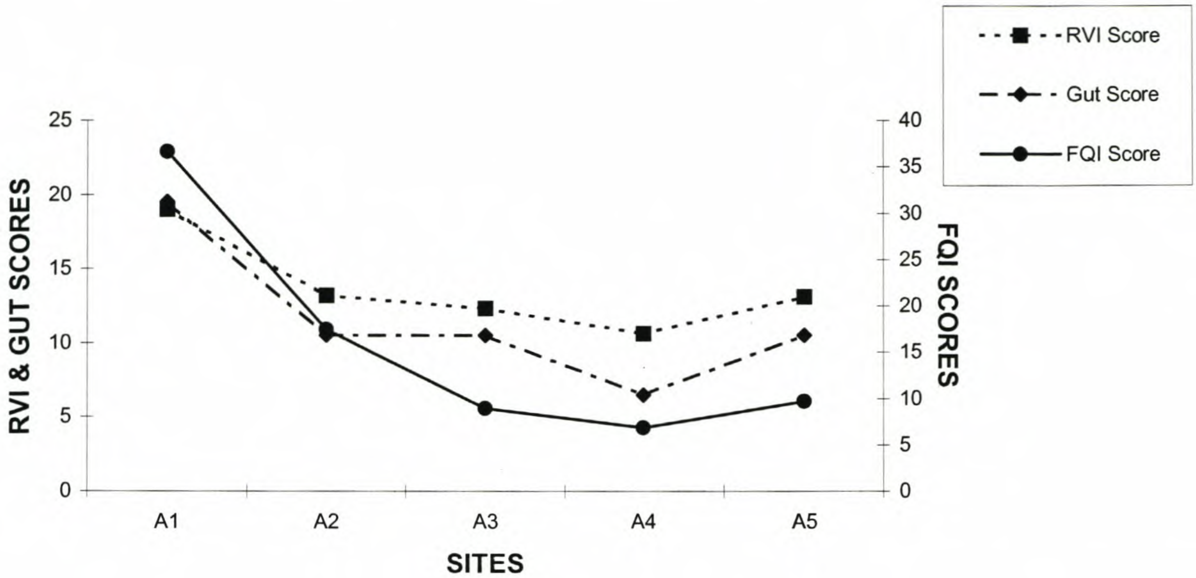

Figure 6.1: RVI, 'gut' and FQI scores indicating patterns of riparian vegetation condition at study sites (A1-A5) along the Lourens River.

The results of the correlation show that FQI and RVI scores at study sites along the Lourens River are 97 % similar (Table 6.6). The RVI scores are more closely related to the 'gut' scores (99 %) than the FQI scores are (95 %), although both are closely related.

Table 6.6. Results of a correlation analysis between RVI, FQI and 'gut' scores at study sites along the Lourens River

	RVI Score	Gut Score	FQI Score
RVI Score	1		
Gut Score	0.992422048	1	
FQI Score	0.968884189	0.947083444	1

Hout Bay River

The FQI scores for sites along the Hout Bay River all score lower than expected for these sites i.e. the FQI categories for all the sites are lower than the 'gut' categories (Table 6.5). The RVI and FQI assessment categories are the same for site B1, which are two categories lower than the 'gut' category (Table 6.5).

The general trend for RVI, 'gut' and FQI scores along the Hout Bay River is a decrease in vegetation quality from Site 1 to Site 4 (Fig 6.2).

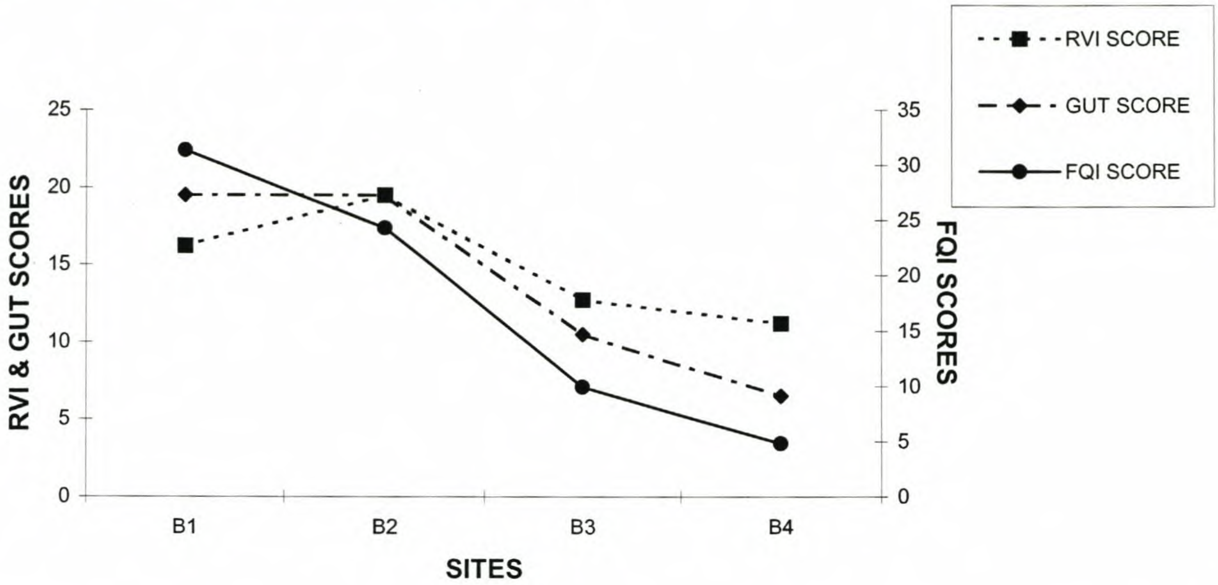

Figure 6.2: RVI, 'gut' and FQI scores indicating patterns of riparian vegetation condition at study sites (B1-B4) along the Hout Bay River.

RVI and FQI scores for sites along the Hout Bay River are 82 % similar (Table 6.8). The FQI scores are more closely related (97 %) to the 'gut' scores than the RVI scores (93 %).

Table 6.8. Results of a correlation analysis between RVI, FQI and 'gut' scores at study sites along the Hout Bay River

	RVI SCORE	GUT SCORE	FQI SCORE
RVI SCORE	1		
GUT SCORE	0.92937808	1	
FQI SCORE	0.821539189	0.969575224	1

Palmiet River

Three out of the five sites along the Palmiet River have lower FQI categories than expected (based on the 'gut' score categories) (Table 6.6). The FQI categories for sites C2 and C3 reflect the 'gut' score categories (Table 6.6).

The RVI, FQI and 'gut' scores all show a sharp decrease in vegetation condition from Site 1 to Site 2 and a general increase in vegetation condition from Site 2 to Site 5 (Fig. 6.3).

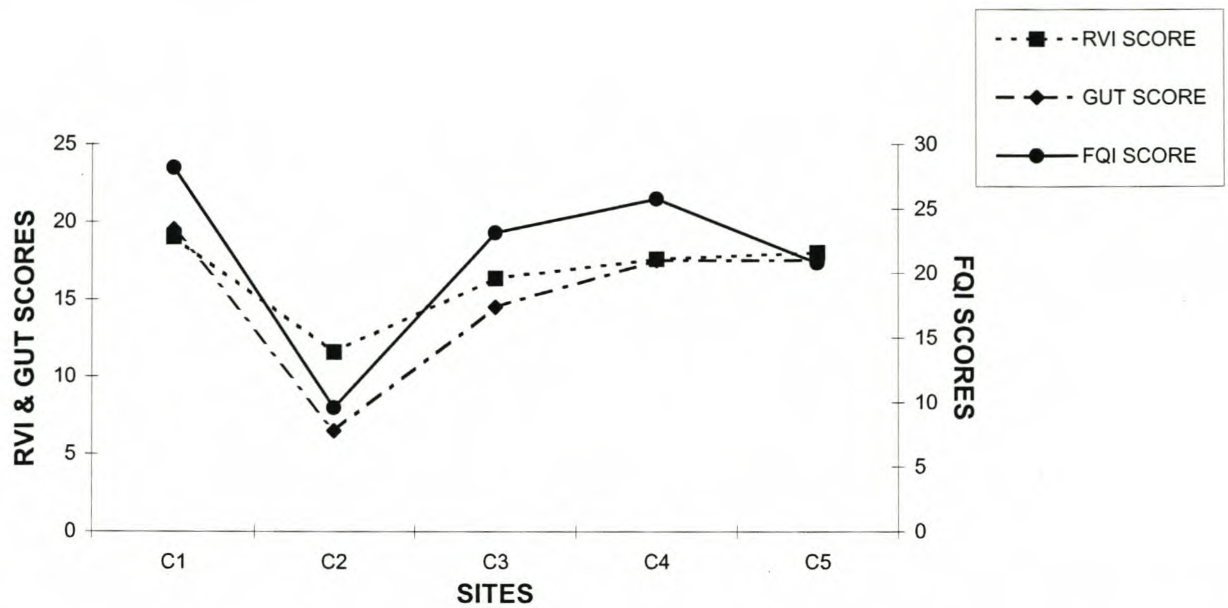

Figure 6.3: RVI, 'gut' and FQI scores indicating patterns of riparian vegetation condition at study sites (C1-C5) along the Palmiet River.

FQI and RVI scores determined at sites along the Palmiet River are similar by 94 % (Table 6.9). The RVI scores are more closely related to the 'gut' scores (99 %) than the FQI scores are (94 %) along this river.

Table 6.9. Results of a correlation analysis between RVI, FQI and 'gut' scores at study sites along the Palmiet River

	RVI SCORE	GUT SCORE	FQI SCORE
RVI SCORE	1		
GUT SCORE	0.998058845	1	
FQI SCORE	0.937269672	0.942718723	1

DISCUSSION AND CONCLUSIONS

A possible explanation for why the FQI is underscoring some of the sites along the rivers is that the FQI endpoints need adjusting. In other words the scores, which designate certain assessment categories need to be adjusted so that the final output of the FQI will reflect the perceived vegetation condition at a site. These endpoints may need to be adjusted so that they are specific to the Fynbos Biome. It must be noted that the top category scores (scores > 45) (Taft *et al.* 1997) were never reached at any of the sites. The whole scoring system probably needs to be lowered for the southwestern Cape situation or individual species scores (Coeffients of conservatism) could be raised.

Possibly Site B2 has a lower FQI score than expected due to the low number of species (N = 9) (Table 6.3) at the site. This may not be a true reflection of the status of the vegetation here as all the species present may not have been recorded because the trees were very tall and it was virtually impossible to get some specimen samples for identification purposes. Possible scoring errors can be attributed to the assessor's limited knowledge in the identification of trees.

It is interesting to note that the RVI and FQI categories were the same for site B1, which means that both methods are underscoring the site by two categories. The same problem exists for both the FQI and RVI methods at this site. The vegetation is totally different in this zone in that no real riparian zone exists. Remnant, highly tolerant, riparian species only are present and the natural upland terrestrial fynbos vegetation penetrates into the river margins (refer to Chapter 3). It may be necessary, therefore, to treat the Mountain Zone differently from the other zones along the river (refer to Chapter 5) by attributing typical riparian species higher scores here than in the other zones in which they might also occur.

The FQI, RVI and 'gut' score trends, along all three rivers, are very similar in their assessment of vegetation condition and show almost the same patterns.

The results of the correlation analysis indicate that the RVI, 'gut' and FQI scores show strong correlations (82-100 % correlation, mean = 91 %). RVI and 'gut' scores are more strongly correlated than FQI and 'gut' scores for two out of the three rivers. This indicates that the RVI is probably, at this stage, the more acceptable method to determine vegetation condition along our rivers. However, the FQA method, or a statistically modified alternative, given that the species scores also need some refining, does offer a suitable and more objective alternative to the RVI method. This is because value judgements (Coefficients of conservatism for species) are predetermined, supporting repeatable and objective application (Taft *et al.* 1997). The output of the FQI alone, however, is unlikely to be a sufficient predictor of vegetation condition and other attributes like structural and functional aspects probably should be included (Taft *et al.* 1997, Oliver *et al.* 2002) in assessments. Coefficients of conservatism for all riparian species in the country would need to be established, on a biome basis (e.g. *Phragmites australis* does not exhibit the same invasive tendencies into Riparian Woodland of the Fynbos Biome that it exhibits in the Savanna

Biome), for it to be applied more widely. Its robustness and validity within Southern Africa would also require testing. Certainly, all the inherent ecological attributes of each species can be expressed adequately by applying the FQA method.

REFERENCES

CAMPBELL BM, COWLING RM, BOND W and KRUGER FJ (1981) Structural characterization of vegetation in the Fynbos Biome. South African National Scientific Programmes Report No. **52**.

EDWARDS D (1983) A broad scale structural classification of vegetation for practical purposes. Bothalia **14(3, 4)**: 705-712.

GRIME JP (1974) Vegetation classification by reference to strategies. Nature **250**:26-31.

GRUBB PJ (1977) The maintenance of species-richness in plant communities: the importance of the regeneration niche. Biological Review **52**:107-145.

HILTON-TAYLOR C (1996) Red data list of southern African plants. Strelitzia **4**: 1-117.

MACARTHUR RH and WILSON EO (1967) The theory of island biogeography. Princeton University Press, Princeton, New Jersey.

OLIVER I, SMITH PL, LUNT I and PARKES D (2002) Pre-1750 vegetation, naturalness and vegetation condition: What are the implications for biodiversity conservation? Ecological Management & Restoration **3(3)**:177-179.

TAFT JB, WILHELM GS, LADD DM and MASTERS LA (1997) Floristic Quality Assessment for vegetation in Illinois: A method for assessing vegetation integrity. Erigenia (Journal of the Illinois Native Plant Society) **15**:3-48.

CHAPTER 7

GENERAL CONCLUSIONS

In this study the Riparian Vegetation Index (RVI) method was used to report on the condition of riparian vegetation along the Lourens, Hout Bay and Palmiet Rivers within the southwestern Cape, with the aim of providing an indication of the suitability of the present method for application in the Fynbos Biome. At the same time it was important to establish whether the method is repeatable and valid for quality control within the River Health Programme. The vegetation condition results presented in Chapter 3 have contributed to a State of Rivers Report for the Western Cape Region (River Health Programme , in press). The findings of the study have highlighted areas of concern in terms of badly degraded riparian vegetation condition as well as areas of high conservation value. These findings provide catchment managers with the necessary information to facilitate the effective management and utilisation of these resources within the region.

The application of the RVI along the rivers studied here (Chapter 3) has highlighted flaws within the method. Deviations from the expected site condition scores are attributed to the disproportionate contribution by the Extent of Vegetation Cover (EVC) sub-index to the final RVI score. Due to its high point allocation, this sub-index raises the final RVI score resulting in a final output which over-scores vegetation condition. It is felt that too much emphasis is being placed on EVC in the final score especially since this sub-index does not consider the quality of the vegetation cover, which clearly does have an influence on the ecological functioning of river systems. The other difficulty of the method is its inability to reflect the true biological status of the riparian vegetation in the Mountain Fynbos Stream Zone. The recruitment score needs to be adjusted in assessments of this type of vegetation as recruitment is not a conspicuous phenomenon and does not necessarily indicate good health in this vegetation type. These findings further highlight the importance of applying and evaluating the method in different bioregions of the country as results will indicate whether or not the method can be applied on a National basis to a broad spectrum of rivers. Future research should concentrate on a comparison of the results of similar studies applied in different bioregions within South Africa.

The study along the Eerste River (Chapter 4) was specifically designed to test the RVI method for variability and validity. Results indicated that the RVI scores are reproducible and are relatively consistent between assessors. It can therefore be concluded that subjectivity does not contribute greatly to the overall outcome of the assessment, although it is suggested that a greater number of sites be tested in the same way so that broader conclusions can be reached regarding the reproducibility of RVI scores.

In terms of variability of RVI scores across disturbance gradients (Chapter 4), the site of intermediate disturbance showed the most variability amongst assessor scores. This had to do with the difficulty experienced by assessors in evaluating the site due to the differing states of the river banks. The design of the method to assess both banks simultaneously has been highlighted as problematic and it is suggested that banks be assessed separately.

For the RVI as a whole to be more consistent and reproducible, it is important to consider the contributions of the sub-indices to the final score and to assess their consistency. In terms of reproducibility of sub-index scores, Recruitment of Indigenous Riparian Species (RIRS) was found to be the least reproducible of all the sub-indices. The suggestion made to standardise and emphasise the assessment of RIRS (Chapter 5) is that qualitative categories be employed (e.g. none, rare, occasional, frequent) and that these categories be incorporated into the site assessment field sheets. Increasing the repeatability of this sub-index will ensure that the RVI score is consistent and reliable. It is interesting to point out that Structural Intactness (SI) showed the least variability between assessor scores. This indicates that the distribution scores are highly reproducible, that is, if the perceived reference state is known. It is suggested in Chapter 5 that realistic benchmarks be established for river systems based on historical information and expert advice. It is also important to record the results of the first river health assessments undertaken along a river, as this data will form a baseline against which to measure change.

Statistical analysis of data collected along the Eerste River revealed that RVI scores were significantly different to 'gut' scores at all three sites. This is disappointing as it highlights the inefficiency of the RVI method to reflect the perceived biological status of the vegetation at the sites under consideration given that the sampling period employed was 1 hr (as suggested in the method field guide). Previous assessments along the Lourens, Hout Bay and Palmiet Rivers (Chapter 3), where a longer sampling period of 2 hrs was employed, revealed a greater degree of accuracy of the RVI to predict expected vegetation condition results. For the results of the RVI to be meaningful, therefore, it is suggested that the sampling period be increased. This would also improve the ratio between field time and travel time as it often takes a few hours to reach a site.

An alternative method to assess vegetation condition was considered. The Floristic Quality Assessment (FQA) method, introduced in Chapter 6 does offer a suitable and more objective alternative to the RVI method although certain aspects of the method clearly need revising (e.g. establishing endpoints and refining individual species scores as well as determining the robustness and validity of the method). This is because value judgements (coefficients of conservatism for species) are predetermined, supporting repeatable and objective application. Taft *et al.* (1997) point out that the output of the FQI alone, however, is unlikely to be an adequate predictor of vegetation condition and other attributes like structural and functional aspects probably should be included in assessments. Structural aspects (e.g. Structural Intactness (SI)) assessed within the RVI method may complement the findings of the FQA method.

Correlation analyses indicate that the RVI, Gut and FQI scores show strong correlations, but that RVI and Gut scores are more strongly correlated than FQI and Gut scores for two out of the three rivers. This indicates that the RVI is probably, at this stage, the more acceptable method to determine vegetation condition along our rivers.

In order for the RVI method to be evaluated in an international context, the acceptability and performance of other methods applied overseas to assess vegetation condition would have to be established (methods mentioned in Chapter 1). It is suggested that a detailed study of other methods applied overseas to assess riparian vegetation condition be undertaken to assess the shortfalls and strengths so that a comparison with the performance of the RVI can be made. The results of such a study may highlight ways of improving the RVI method used in South Africa.

It is hoped that the findings of this study and the suggestions made in Chapter 5 will contribute positively to the development of the RVI method in South Africa and will ensure that the goals of the River Health Programme to report reliable and scientifically sound data for the effective management of water resources will be reinforced.

REFERENCES

River Health Programme (in press) State of Rivers Report: Diep, Hout Bay, Lourens and Palmiet River Systems. Department of Water Affairs and Forestry, Pretoria.

TAFT JB, WILHELM GS, LADD DM and MASTERS LA (1997) Floristic Quality Assessment for vegetation in Illinois: A method for assessing vegetation integrity. Erigenia (Journal of the Illinois Native Plant Society) **15**:3-48.

Appendix A: River Health Programme (RHP)

RIPARIAN VEGETATION WORKSHOP

22 August 2002
CSIR Conference Centre
Pretoria

SUMMARY OF KEY POINTS RAISED AT THE MEETING

1. ATTENDANCE

The workshop was attended by 26 participants, from the various provinces and institutions involved in different aspects of the Riparian Vegetation Index (RVI). A full list of the attendants is appended as Appendix 1.

2. OBJECTIVES

The main objective of the workshop was for the key players in the development and implementation of the riparian vegetation monitoring to collectively scrutinize the RVI and other methods, determine the reasons for the methods not being more widely used and to put in place steps towards revising or changing the methods if and where necessary.

3. PRESENTATIONS

The following presentations were made:

- The Riparian Vegetation Index – Derivation, mechanics and experience *by Nigel Kemper, IWR Environmental*
- Experience with RVI in the Western Cape Biome and possible alternative approaches *by Charlie Boucher and Melanie Withers, University of Stellenbosch*
- Experience with riparian vegetation monitoring in KwaZulu Natal *by Simon Clark, University of Natal and Mark Graham, Umgeni Water*
- Riparian zone assessment in terms of the Habitat Integrity Index – purpose and levels of application *by Neels Kleynhans, Institute of Water Quality Studies*
- Quality control aspects for riparian vegetation monitoring *by Mark Graham, Umgeni Water*

All the above presentations are appended in full to these notes.

4. ASSESSMENT OF THE CURRENT RVI METHODOLOGY

The following strengths and deficiencies were identified during the discussion on the assessment of the various components of the current RVI method:

4.1 Current method

4.1.1 Deficiencies in the current method

The deficiencies in the current RVI methodology relate to the following:

- Representivity of site – does a single site adequately represent a river reach?
- Basal cover vs aerial cover (there is need for stratification, ie. into size classes in open areas, root cover and canopy cover)
- Perceived reference state – determination of the reference condition is highly subjective.
- Delineation of the riparian zone is subjective
- Rivers Database RVI black box conflicts with need to extract results in the field
- Marginal vegetation especially from the instream habitat component not adequately dealt with
- Lack of latitudinal zonation (however, if this is included it must be kept simple)
- Stream power could be incorporated as this influences marginal vegetation
- Depth of knowledge and competency of RVI assessor (at present, an assessor with wide experience is required because the method is subjective and qualitative)
- Time required to do the method – this must be kept short but sufficient to achieve meaningful result
- Consideration of left and right banks and islands not adequate
- Height/age/ development classification could be incorporated
- How to delineate a riparian zone (guidelines in the National Water Act and in the US wildlife Service are useful in this regard)
- Repeat visits/assessments in order to validate the method – this has not been adequately done.

4.1.2 Strengths of the current method

The strengths of the current method are:

- That there is already a first version of the RVI method on the table
- People have already been trained and are applying the method
- That the method is useful in that it provides an overall impression of the river system. It is particularly useful in the context of the RHP because it serves the objective of the RHP which is to flag problems in river systems
- That the method generates questions and interests

4.2 Current methodology

4.2.1 Deficiencies in the current methodology

The deficiencies in the current methodology relate to:

- The reference state does not have enough weighting. The reference state needs to be incorporated into each of the of the sub-indices
- Sensitivity analysis needs to be conducted
- Biome/ eco-region sensitivity needs to be evaluated
- Insufficient categories of growth forms are recognized for example reeds could be subdivided
- Species weighting need further consideration.
- Conflicting views on whether natural disturbances should score lower or should be considered as "natural"

4.2.2 Strengths of the current methodology

The current methodology has different sub-indices that provide different information to different levels of management.

4.3 Current field sheets

4.3.1 Deficiencies in the current field sheets

- There is much duplication of input to the different indices which needs to be reduced
- Definitions/glossary is lacking

- Zero value classes need to be included
- Different zones, strata, heights of plants are currently not included in the field sheet and must be incorporated
- Mandatory fields are not indicated.

4.4 General comments

The following general comments were noted during discussion:

- There is a lack of integration between the different indices. If all RHP indices are integrated then there will be a better understanding of the bigger picture and it will become clear that aspects such as stream power are covered by the geomorphological index.
- There is a need to define which is the most appropriate season to do RVI assessments in the different regions
- The Directorate Social and Ecological Services at DWAF is in the process of producing documents on wetland delineation and riparian zone delineation
- The published version of the RVI must be corrected
- Energy should be put into refining the current method rather than on obtaining certification.

5. THE WAY FORWARD

5.1 What needs to be done to get the RVI method working properly?

The next steps are to:

- Distribute the method in its modified form nationally
- Distribute the new version of the RVI to Rivers database users within the next month
- Examine the field sheet
- Formulae to be produced in Excel spreadsheet form
- Two current MSc projects are examining the performance of the RVI
- Version 2 of the RVI to include field guides for identification of regional riparian vegetation

5.2 What needs to be highlighted to make the RVI version 2 more powerful?

Version 2 of the RVI should include the following:

- Indicator species
- Regional identification field guides
- More certain determination of Reference conditions
- GIS database of reference conditions for the whole country (WRC as a possible source of funding for this component)
- Indication of trajectory of change in a once-off assessment
- A "red flag" alert on the database could be incorporated to pick up trends
- Lateral zonations
- Site classifications/site selections
- Weighting factors – must be examined on a biome basis
- Entire RVI method needs to be looked at on a biome basis
- Interact with customers for example the forestry sector, Working for Water, agriculture, consultants, users of RHP indices for EIAs, Reserve determinations etc. to determine if the method meets their needs
- Sampling time should be limited to one hour.

5.3 Conclusion

It is important for those interested in the revision of the RVI method to follow up and initiate the actions of their choice