

POLICY OBJECTIVES FOR CONSERVING FRESHWATER ECOSYSTEMS: HOW MANY RIVERS, WHICH ONES, AND WHAT LEVEL OF PROTECTION ARE REQUIRED

Dirk Roux¹, Jeanne Nel², Heather MacKay³ and Amanda Driver⁴

¹ CSIR Natural Resources and Environment, PO Box 395, Pretoria 0001;
Tel: 012 841 2695; Email: droux@csir.co.za

² CSIR Natural Resources and Environment

³ Water Research Commission

⁴ South African National Biodiversity Institute

ABSTRACT

A current initiative aims to develop a set of operational policy objectives for facilitating national-level coordination in the conservation of freshwater ecosystems and their associated biodiversity. This initiative draws from the relatively new discipline of “freshwater conservation planning”, which incorporates concepts from across the fields of systematic conservation planning, conservation biology, aquatic ecology (including hydrology, biology, geomorphology), water resources planning and management, and spatial information technology. The policy objectives are to provide guidance regarding:

- *The desirable proportion of freshwater ecosystems to be designated for the highest level of protection*
- *Which freshwater ecosystems should be targeted to conserve a representative spectrum of biophysical characteristics*
- *Achieving horizontal coherence and coordination across sectors responsible for biodiversity conservation, water resource protection, land management, and integrated development planning.*

The purpose of this paper is to present a set of policy objectives that would advance the practical implementation of the conservation of inland water biodiversity across multiple sectors and spheres of government. Five core objectives and 20 implementation principles are presented. These objectives and principles are the outcome of discussions between scientists, conservation practitioners, and officials from several government departments.

INTRODUCTION

In South Africa, the responsibility for conserving inland water ecosystems is shared between several sectors and departments of government, resulting in an overlap of mandates. Departments responsible for water resource protection and management, biodiversity conservation, land use management, and integrated development planning are key role players whose coherent and co-operative actions are required to effectively manage inland water ecosystems and their biodiversity.

All of these departments have undertaken rigorous revision of their policies and legislation during the past decade. Several enabling Acts exist, notably the National Water Act (NWA, Act No. 36 of 1998) and the National Environmental Management: Biodiversity Act (Act No. 10 of 2004), providing the legal environment to advance the practical implementation of inland water conservation across relevant sectors. These all express the need for

preventative measures such as the development of strategic forward looking spatial plans, focussing on proactive rather than reactive management.

However, an aspect that has not been addressed in national policy and legislation is the setting of national conservation targets for inland water ecosystems. There is no operational guidance regarding the desirable number of ecosystems to be conserved or the mechanisms through which conservation should be achieved. The present thinking is to deal with this issue on a case-by-case basis. A shortcoming of the case-by-case approach is highlighted through the monitoring results produced by the national River Health Programme (RHP – www.csir.co.za/rhp). The results of river surveys are expressed in health classes (natural, good, fair, poor). For each of the river systems the acceptability of the monitoring outcome may be argued in context of the social, economic and ecological considerations of the specific river basin. However, when the overall picture of the rivers of a province or the country is assessed, there is no guideline or answer for the question of whether these results are acceptable or not.

Trade-offs are inevitably required between protecting inland water ecosystems (achieving biodiversity conservation) and achieving economic development. All ecosystems cannot be maintained in natural or even good states. The question is, how many inland water ecosystems should reflect a high level of protection (natural and good states) in order to claim that South Africa is effectively conserving the biodiversity associated with these systems? A second question is, which ecosystems are most suited for, and will give the best returns when, included in a national design for inland water conservation?

The purpose of this paper is to present a set of policy objectives that would advance the practical implementation of the conservation of inland water biodiversity across multiple sectors and spheres of government.

FRESHWATER CONSERVATION PLANNING

State of inland water ecosystems

The development and utilisation of water resources to meet human demands generally happens at the expense of the structure and functions of inland water ecosystems (1, 2). Consequently, pressures arising from social-economic aspirations have resulted in a worldwide and progressive degradation of inland water habitats in recent decades. This is reflected in the index of the world's freshwater species that shows a decline of 50% between 1970 and 2000 – a more rapid decline than for terrestrial and marine indices (3). Similarly, South Africa's first National Spatial Biodiversity Assessment (NSBA), dealing with the terrestrial, river, estuarine and marine environments, highlights the fact that the country's river ecosystems are in a much poorer state overall than its terrestrial ecosystems (4).

The NSBA for rivers considered main rivers only, which make up less than 45% of rivers in South Africa. The river assessment highlighted the following problems (5):

- River integrity: The majority of main rivers (47%) are moderately modified, whilst 23% of them can be considered irreversibly transformed in terms of their ability to support biodiversity, and are deemed unsuitable for conservation.
- Ecosystem status (based on a 20% conservation threshold): Of the 112 main river ecosystem types (based on biodiversity surrogacy) that were identified, 84% are threatened – 54% critically endangered, 18% endangered, and 12% vulnerable.

- Protected area gap analysis: Over 90% of all main rivers in South Africa fall completely outside Type 1 protected areas (National Parks, Provincial Nature Reserves, and Department of Water Affairs and Forestry Nature Reserves). Half of the remaining rivers form boundaries of protected areas; thus less than 5% of main rivers in the country fall within protected areas, receiving protection on both sides.

Emergence of a new discipline

Conservation planning began as a discipline developed specifically for the purposes of selecting formal protected areas, focussing on terrestrial biodiversity. Over the years this narrow focus has broadened in two significant ways that have made the field more accessible to conservation planning for inland water ecosystems (Figure 1). Firstly, areas selected began to consider a full range of conservation management options as opposed to focusing on formal protected areas only, supporting the concept of maintaining and utilising biodiversity within a multiple use landscape (6). This paradigm shift is more appropriate in the context of conserving inland water ecosystems, as conserving these ecosystems requires management of whole catchments, and it is seldom feasible to incorporate entire catchments into protected areas. Secondly, it became clear that representing a sample of all biodiversity patterns needed to be supplemented with explicit incorporation of biodiversity processes. This notion is particularly applicable to conserving inland water ecosystems which are highly reliant on maintaining processes dependent on longitudinal, lateral, and vertical connectivity.

Conservation planning also requires that biodiversity be depicted in some operational way, generally requiring the use of biodiversity surrogates which serve as proxies for biodiversity pattern. Deriving meaningful surrogates for inland water biodiversity has been one of the main challenges in this newly developing field. There are inherent problems with using species data alone as biodiversity surrogates, which are even less complete than the data available for terrestrial species. Problems with incomplete data, collection bias and incomplete taxonomic understanding can drive conservation plans to select areas that are well sampled, whilst ignoring areas that may well be important but have no data. Terrestrial conservation plans have circumvented this by classifying the landscape according to vegetation types or broad habitat types and using this as the primary biodiversity surrogate in selecting areas (although ideally this should be supplemented with species data). However, classifying inland water ecosystems across the landscape has remained illusive mainly because it is more difficult to depict inland water ecosystems in a spatially explicit manner owing to the highly dynamic nature of water resources in both time and space. It is only in recent years that hierarchical procedures for systematically classifying inland water ecosystems have been developed, such as the ecoregions of Omernik (7), and the hierarchical and systematic framework of Dollar et al. (8). Deriving such classifications to depict biodiversity has further aided the application of conservation planning principles and tools to inland water ecosystems.

A common conservation goal

It is not possible to allocate a high level of protection to all resources throughout the country without prejudicing social and economic development. Equally it is not desirable for all resources to be classified at a uniformly low level of protection so as to permit maximum use. The NWA provides, through the water resource classification system, a framework for assessing and managing water resources in terms of a selected class, level of protection, or "ecological state". Each ecological state has implications to the way and extent to which that water resource is utilised. This paper is concerned with the identification of those water resources that should receive a high level of protection in order to serve the objective of effectively conserving inland water biodiversity.

In line with the aspiration of modern society to sustain the diversity of life on earth, the goal for inland water conservation was set to **conserve a sample of the full variety or diversity of inland water ecosystems that occur in South Africa, including all species as well as habitats, landscapes and rivers in which they occur, as well as the ecosystem processes responsible for maintaining and generating this diversity, for both present and future generations.** While it is one thing to share a common philosophy and goal, little will be achieved in reality unless the common goal is cascaded down into a comprehensive set of common operational objectives, where all agree on what must be done, and who will take responsibility and accountability for what tasks/aspects. These operational objectives must be commonly understood, collaboratively developed, and co-operatively implemented.

The remainder of this paper presents five core objectives and associated implementation principles as imperatives to achieving the inland water biodiversity conservation goal as stated above. Objectives one to three deal with planning and design issues, and objectives four and five deal with implementation issues.

OBJECTIVE 1: SET AND ENTRENCH QUANTITATIVE CONSERVATION TARGETS

This objective addresses the setting of minimum requirements for inland water biodiversity conservation in order to: allow an evaluation of whether existing conservation efforts represent the biodiversity of a region adequately; provide guidance for planners who are balancing a number of competing demands for natural resources in a region; and provide water resource management and biodiversity conservation agencies common quantitative measures for which to aim (9).

There are three implementation principles associated with this objective:

Set and endorse national targets

This implementation principle acknowledges that there is a need for explicit and quantitative conservation targets at national level. Provincial and local governments make daily decisions about land use. It is only natural that these decision-makers have a decision-making agenda that is determined by the political boundaries of their particular jurisdictions (9). These political demarcations rarely if ever follow natural patterns of biodiversity occurrence or the natural paths and spatial extent of ecological processes. Without appropriate information at relevant spatial scales, provincial and local governments may unknowingly make decisions that result in the degradation or destruction of some of the best examples of the country or region's ecosystems. Furthermore, the country's obligation to adhere to and give effect to international agreements is a national responsibility. As such, a target for conserving inland water biodiversity should be set and endorsed at national level.

Cascade the national targets differentially to sub-national implementation levels

This implementation principle acknowledges the need for ownership and achievement of the conservation target at levels of operational responsibility. It also acknowledges that it may not be feasible to achieve targets uniformly across the administrative landscape because of current levels of ecological transformation, and that different inland water ecosystems do not contribute uniformly to the overall biodiversity of the country. In practice, the informed judgement of specialists needs to be evaluated against attainability in a specific region to allow setting of realistically achievable targets (9).

There are essentially two implementing agencies responsible for ownership and achievement of sub-national conservation targets for inland waters, namely provincial conservation agencies and Catchment Management Agencies (CMAs). Nineteen Water Management Areas (WMAs) have been delineated in South Africa to serve as the sub-national units within which integrated water resource management takes place under the auspices of CMAs. WMAs can be subdivided along topographical features into catchments or drainage regions, which are areas within which rainfall will drain into the watercourse(s) through surface runoff to a common point.

The main advantage of cascading the national conservation target to the 19 WMAs is that these areas correspond with hydrological boundaries, which is the most meaningful boundary for managing inland water resources. The main advantage of cascading the conservation target to the nine provinces is that the provincial authorities, as key implementing agencies for biodiversity management, for the most part have biodiversity and conservation planning expertise and experience. Furthermore, district and local municipality boundaries, nested within provinces, are key areas for biodiversity management interventions through the integrated development planning and spatial development frameworks, and ideally they should be provided the resources necessary to meet national biodiversity objectives.

Improve and refine national and sub-national targets over time

This implementation principle acknowledges that, at the landscape level, it may not be possible to determine a direct relationship between a percentage target and the degree to which the overall conservation goal is achieved. It also acknowledges that knowledge and understanding related to ecological thresholds and conservation targets should increase over time, as the science of setting conservation targets advances, based partly on information fed back from implementers to scientists.

Setting of conservation targets reflects scientific best judgement, and the adoption and implementation of these targets is a reflection of societal norms and values. At best, setting and adoption of these targets should be informed through our evolving understanding of the effect of anthropogenic activities on the structural, compositional and functional elements of biodiversity. A set target should therefore be subject to review over time.

OBJECTIVE 2: PLAN FOR REPRESENTATION

The objective of representing inland water biodiversity is to ensure adequate representation of the full spectrum of inland water biodiversity, based on the systematic description and depiction of the inland water biodiversity within the region of concern. Three implementation principles inform the achievement of this objective:

Use surrogates to describe and classify inland water biodiversity

This implementation principle acknowledges the need for systematic conservation planning as opposed to *ad hoc* identification of conservation priorities. It furthermore acknowledges that it is impractical to identify and classify all the elements of biological diversity.

Due to a general shortage of uniform biological data at species, population or community levels, landscape and ecosystem parameters are commonly used as surrogates for overall biodiversity. In essence, surface water resources are a manifestation of the landscapes that they drain. Catchment geology, climate, vegetation types, and landscape change

dictate the character of inland water ecosystems in terms of flow pattern, channel morphology, temperature and nutrient regimes, and substratum. These variables in turn control the biological attributes of water resources (10). Accordingly, inland water biodiversity can be represented, at least at a coarse level, by the heterogeneity of the landscape in which they occur.

In addition to landscape patches, the diversity of inland water ecosystems (especially lotic or river systems) are characterised by multi-dimensional environmental gradients. For example, rivers heterogeneity is engendered by interactions and transitions between surface waters, subsurface waters and riparian systems, all of which are integral components of river ecosystems.

Define the appropriate scale

This implementation principle acknowledges that the spatial scale of conservation interest will determine the resolution at which inland water biodiversity could and should be described. The finer to scale of interest, the finer the resolution of the data layers will need to be. Coarse-filter surrogates (e.g. landscape classification) may be sufficient to answer the general questions of broad-scale plans. However at finer scales, where conservation plans are used to inform conservation action or management intervention at the site level, it may be necessary to increase the resolution of the landscape classification as well as supplement these coarse-filters with fine-filters (e.g. species data).

Incorporate local ecological knowledge

This implementation principle acknowledges the value and importance of local ecological knowledge to supplement the uniform data layers required by a systematic conservation planning approach, especially at the fine scale. Systematic conservation planning is an explicit rather than an objective process. Expert judgement plays an important role in the rationale for identifying, selecting and implementing conservation options. Although computer models do extend analytical abilities of large data sets, the systematic approach should encompass/integrate the judgements of experts and dialogue with affected communities (11). In fact, the systematic approach and the expert workshop approach should be seen as complementary, and the value of both approaches should be combined.

Local ecological knowledge (12) is crucial for mapping biodiversity surrogates and special features within the planning region. Special features can often be captured from the knowledge of experts or local inhabitants, even though such knowledge is not uniform over time and space. This information should be used to *supplement* coarse filter biodiversity surrogates, which represent the systematic landscape classification of biodiversity, rather than as the primary data that drives the planning exercise.

OBJECTIVE 3: PLAN FOR PERSISTENCE

The objective of planning for biodiversity persistence addresses the need to conserve the ecological and evolutionary processes that generate and maintain inland water biodiversity. Conserving species and habitats, as considered under biodiversity representation, provides a snapshot of the biodiversity that currently exists. If we wish this biodiversity to persist and naturally evolve over time, we also need to make sure that: populations, communities or ecosystems that are both viable and of high ecological integrity are selected; natural ecological processes (functional elements) and disturbance regimes such as floods, droughts and fires are operating within their natural ranges of variability; and the size of a conservation design is sufficient to allow recovery from natural disturbances.

There are four implementation principles associated with achieving this objective:

Select inland water ecosystems of high integrity

This implementation principle acknowledges that ecosystems currently of high integrity should ideally be selected for the purposes of conserving biodiversity, since these are the ecosystems that accurately represent the biodiversity of the region and within which ecological and evolutionary processes operate within their natural ranges; i.e ecosystems of high integrity protect all components of biodiversity (1). From a practical point of view, selecting ecosystems currently of high integrity also (a) facilitates operational management since ecosystems operating close to natural conditions tend to be more self-sustaining, requiring less conservation management, and (b) improves the cost efficiency of conservation management as no rehabilitation is required.

Ensure connectivity

A loss of longitudinal, lateral and vertical connectivity reduces inland water biodiversity by interfering with successional trajectories, habitat diversification, migratory pathways and other ecosystem processes. Connectivity refers to the transfer of energy and matter (including biota) across ecotones. This implementation principle aims to ensure ecological connectivity along all three dimensions (longitudinal, lateral and vertical).

Include large-scale ecosystem processes

This implementation principle acknowledges that natural disturbance regimes and ecological and evolutionary processes are responsible for generating and maintaining nature's diversity. These processes operate over differing and varying spatial and temporal scales that should be taken account of in planning and conservation efforts.

In past decades, biodiversity was viewed largely in terms of species richness, and the ecosystems supporting these species were seen as static and predictable (13). More recent non-equilibrium theories of community structure and ecosystem processes identify environmental regimes and disturbances as major contributors to the maintenance of biodiversity on ecological time scales (14). Environmental regimes include hydrologic and water quality regimes, geomorphic processes, climatic regimes (temperature and precipitation), fire regimes and many kinds of natural disturbance. Natural disturbance, as a key aspect of environmental regimes, can be defined as any relatively discrete event in time that disrupts ecosystem, community or population structure and that changes resources, availability of substratum, or the physical environment (15). When environmental regimes and natural disturbances are pushed outside their natural ranges of variability by human influences, changes in ecosystems and species will follow.

Select areas of sufficient size

Any inland water conservation area should be sufficiently large to allow biodiversity features to recover from natural disturbances and have populations of species of special concern that are large enough and reproduce sufficiently to remain viable. The actual extent of what constitutes "sufficient size" will vary between systems and should be assessed on a case-by-case basis.

Conservation of biodiversity at multiple levels of biological organisation and spatial scales requires (a) explicit identification and protection of the focal ecosystem and species in a given area, and (b) adequate identification and protection of the associate multiscale ecological processes that support and sustain those ecosystems and species. Poiani *et al.* (13) define "functional conservation areas" as geographic domains that maintain focal

ecosystems, species and supporting ecological processes within their natural ranges of variability.

OBJECTIVE 4: ESTABLISH A NETWORK OF INLAND WATER CONSERVATION AREAS

The objective of designing inland water conservation areas addresses the incorporation of the first three objectives into spatial configurations that will constitute the network of inland water conservation areas (IWCA) of South Africa. There are five implementation principles associated with achieving this objective:

Legislate IWCA through complementary legal mechanisms

Due to the *ad hoc* nature and terrestrial bias of historic conservation efforts, inland water ecosystems are drastically underrepresented within the network of formally protected areas (5). For those inland water ecosystems that are represented in protected areas, many (especially the longitudinal river systems) lack the assurance of conservation persistence due to the partial inclusion of their ecological process ranges. To satisfy the representation component of the conservation target, ecosystems from outside formally protected areas should be selected as part of a network of IWCA. It should be noted that IWCA are not analogous to formal protected areas where no use of the resource is allowed, but rather are based on a philosophy of multiple land-use options that support a conservation objective.

In order to satisfy the objectives of achieving targets for representation and persistence of inland water biodiversity, it is necessary to use complementary legal mechanisms. Such mechanisms should link the conservation of inland water ecosystems through both public (national, provincial and local) and private protected areas, as well as land-use management plans and strategies (e.g. integrated development plans and catchment management strategies).

This guiding principle also speaks to the need for vertical and horizontal coherence in inland water conservation policy and actions. Vertical coherence refers to the need for coordination and harmonisation between spheres of government (national, provincial and local) as well as between political and operational levels. Horizontal coherence refers to coordination and harmonisation, at any one of these levels, across sectors. Of special importance is the coordination between land and water sectors. Since inland water ecosystems are impacted by activities that happen throughout their entire drainage areas, their integrity and effective conservation is critically dependent on good land management practices.

Design for optimal land-use efficiency

This implementation principle acknowledges that there are many conflicting demands for a limited natural resource. It supports the realisation of optimal conservation benefit for the least opportunity cost or conflict. Ecosystems are actually social-ecological systems, and in addition to ecological viability and resilience it is important to consider the social viability and resilience of a conservation design. Examples of "optimisation rules" are to: give priority to areas that contain the most inland water ecosystems (biodiversity hotspots); consolidate conservation efforts by selecting adjacent areas or through expanding existing protected areas (as opposed to selecting areas in spatial isolation); link existing protected areas through conservation corridors; and integrate terrestrial, marine, estuarine and inland water conservation where possible.

Prioritise and initiate conservation action timeously

Acknowledging that financial and human resources available for conservation are limited, this implementation principle promotes the identification of ecosystem vulnerability and the scheduling of conservation action in order to maximise the likelihood of achieving targets for representation and persistence of inland water biodiversity.

Practicalities may necessitate the gradual phasing in of conservation action over many years or decades, during which time the agents of biodiversity loss continue to operate. It is thus important that a plan for maximising representation on paper must be complemented by one that also maximises “retention” in the face of ongoing loss or degradation of habitat (16). The objective of this implementation principle is to minimize the extent to which representation targets are compromised by ongoing loss of habitat and species.

A crucial consideration in maximising retention is the assignment of priorities based on the availability of options (irreplaceability) for conserving a particular ecosystem and its vulnerability to biodiversity loss as a result of current and impending threatening processes. Areas with no or few options and high vulnerability may be regarded as the highest priority for conservation action. Or a case can be made for focussing on areas of high irreplaceability (low options) and low vulnerability – in order to conserve ecosystems before they become difficult to secure due to impending developments. There are many other management factors that should influence scheduling, for example areas where staff and resources are easily available, where implementation dovetails with existing activities and programmes, and where it is possible to pilot new approaches with low risk and high demonstration value.

Conserve first where appropriate, rather than restore later

Acknowledging that the loss of biodiversity is in many cases irreversible, that ecological restoration projects are in many cases excessively expensive, and that restoration efforts often do not achieve their ecological objectives, this implementation principle promotes the conservation of ecologically intact ecosystems where appropriate and possible rather than to allow short term degradation of such systems with the view that they will be restored later.

Many restoration initiatives fail despite tremendous expense and effort. Reasons include (17): extrapolation of the same method or recipe to a setting for which it is not suited; treatment of symptoms as opposed to true drivers of ecological change; unrealistic time expectations - ecological restoration cannot achieve in years what happens over decades or centuries in nature. These authors suggest that, due to the uncertainties associated with ecological restoration, adaptive restoration initiatives should allow for multiple approaches (to test multiple hypotheses) and regular assessments to allow further intervention options.

Provide explicit selection options and management actions

Acknowledging that natural resource planners and managers commonly have a multitude of conflicting user requirements to consider and that they often make decisions under extreme uncertainty, this implementation principle requires that these planners and managers should be presented with a range of explicit options to aid their decision-making and resource allocation.

OBJECTIVE 5: ENABLE EFFECTIVE IMPLEMENTATION

Acknowledging that the value of a conservation design is only realised through its effective application, the objective of effective implementation addresses the creation of an institutional environment that can ensure sustained conservation actions for all designated inland water conservation areas. There are five implementation principles underpinning this objective, namely to:

Facilitate stakeholder adoption of inland water conservation targets and priority areas

Operational adoption requires the translation of science into awareness, political will and capacities, where the adopter has both the absorptive capacity (critical level of related knowledge) as well as the emotional and financial commitments to allow sustained use of the acquired knowledge (e.g. associated with an inland water conservation design).

Effective stakeholder engagement is one intervention that would promote stakeholder adoption. Examples of effective stakeholder engagement are to: promote stakeholder readiness and buy-in through their effective engagement during target setting, prioritisation and design phases; and provide flexibility in how conservation targets are achieved through making options explicit. The latter would allow resource planners and decision-makers to consider the options in the context of trade-offs such as equity, socio-economic benefits, management practicalities and future development plans.

Reflect the conservation of inland water biodiversity as an explicit function of institutional design

This implementation principle acknowledges that the conservation of inland water biodiversity will not receive due attention and resources if it is not reflected as a line function in the business plans and budgets of responsible agencies.

A lead implementation agency can only maintain its leadership role within a cross-sector governance setting if it is perceived to have a certain level of competence credibility regarding inland water conservation. Competence credibility describes the degree to which an individual, group or organization is perceived to be knowledgeable or expert. It is a function of record of accomplishment, of originality, technological superiority and the relevance of their projects, as well as perceived experience and their ability to communicate (18).

This does not mean that any one agency needs to be self-sufficient in everything that needs to be done, but that it should be in a position to effectively coordinate, integrate where necessary, and evaluate various technical inputs from several sources.

Enable co-operative governance in the conservation and management of inland water biodiversity

No single organisation can claim the ability to implement an inland water conservation plan in all its facets on its own. The integrated nature of inland water conservation planning and implementation requires the combination of a highly diverse and specialised cluster of skills, and spans the mandates of a number of sectors and spheres of government. Achievement of sub-national conservation targets will rely on the combined efforts of various implementation agencies, coordinated at the level of a Water Management Area. This challenge is also an opportunity to give effect to co-operative governance.

Institute an adaptive management framework for the conservation of inland water biodiversity

This implementation principle acknowledges that development of cross-sector policy objectives and the execution of these objectives through the implementation of inland

water conservation designs are based on current understanding from within a scientific and planning discipline that is very young. It furthermore acknowledges that action based on available knowledge is better than no action.

Senge *et al.* (19) state that all learning integrates thinking and doing. A major advantage of doing or action is that it facilitates further learning or the acquiring of relevant knowledge and skills in a developmental and dynamic process of learning-by-doing. The dual need of theory and practical experience can be achieved through action research, where research is achieved through intervening in what is being researched. In fact, unless we intervene, we will not learn what some of the essential dynamics of the system really are. Through action research the development of a theoretical discourse enables new ways of understanding and doing, while reflective practice becomes a source of theorising (20).

Promote discovery, inventory and improved understanding of inland water biodiversity

Acknowledging that our understanding of inland water biodiversity is incomplete, this implementation principle promotes ongoing discovery, basic inventory and research into questions related to inland water biodiversity.

“Typing” of ecosystems based on ecological similarities is one attempt at making sense of the infinite complexity of the biological world. However, we cannot ignore the value of primary species-occurrence data. There is a substantial amount of observational and survey data held in universities and museum collections, by non-governmental organisations and by private individuals and these data add valuable additional knowledge about our environment. They are not competing data resources but complementary and each have their strengths and weaknesses in supplying the information the world needs (21).

Much of the available species-occurrence data have been collected opportunistically rather than systematically and this can result in large spatial biases – for example, collections that are highly correlated with road or river networks (Chapman, 2005). An important component to ensuring improved understanding and management of inland water biodiversity, is to improve the ways in which we collect, capture, management and make basic biodiversity data available.

CONCLUSIONS

In order to achieve horizontal coherence in the conservation of inland water biodiversity in South Africa, it is necessary to engage biodiversity and policy specialists as well as practitioners from across the water resource management, environmental and biodiversity management, land use, agriculture and integrated development planning sectors, in debating policy options. It is acknowledged that strategic direction can only become operational reality with the full participation of implementation agents, which are mostly operating within provincial and local spheres of government. This paper is seen as a first step of a longer process, working towards a situation where all the relevant parties can combine their skills and resources towards scientifically sound conservation designs and feasible implementation plans for managing water resources in general and inland water biodiversity in specific.

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