Towards evidence-based ecological restoration in South Africa

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Dissertation presented for the degree of Doctor of Philosophy
in the Faculty of AgriSciences
at Stellenbosch University

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December 2012

Declaration

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Abstract

Widespread, human-induced ecosystem degradation and the associated biodiversity loss pose a direct threat to human wellbeing. While there is no substitute for healthy, self-sustaining ecosystems, ecological restoration offers an attractive, and indeed inevitable, supplement where conservation alone is not sufficient to support ecosystem integrity. Restoration is undergoing a revolution, where evidence-based (EB) practice is emerging as a new approach to increase the chances of successfully achieving restoration goals. EB practice is based on the notion that implementation decisions need to be based on the appraisal and use of evidence of effectiveness of alternative options.

The point of departure of this thesis is the contention that EB practice need not be dependent only on research evidence. The work presented herein thus addresses the *production* and *use* of evidence of effectiveness in restoration *practice*. Using ten restoration programs in South Africa, the quality of evidence produced in practice was assessed. Three components of evidence production that were evaluated were (i) baseline condition measurement; (ii) goal setting and (iii) monitoring. Results showed poor definition of goals; a bias towards the use of socio-economic goals and indicators; more monitoring of inputs than impact; and inconsistent and short-term monitoring of biophysical indicators. Practitioners regarded the evidence base as adequate, but cited a few challenges associated with planning and resource availability as attributing factors to the gaps observed. I propose that practitioners' perception of the current evidence base poses an additional threat to the generation of a strong evidence base.

In addition to the production of evidence, access to said evidence is a vital component of EB practice. In an exploration of how evidence is made available by practitioners, it became evident in that a considerable amount of the information that was not easily accessible in documented form was known by the practitioners. This highlights the need for a shift in practice culture towards the valuing and rewarding of the dissemination of information.

An assessment of EB restoration would have been incomplete without a deliberate consideration of social factors. I thus conducted a case study of an invasive alien plant clearing program, to determine what drives the use of scientific evidence in decision making. I observed that organizational structure, policies, priorities and capacity influence, and even limit, the use of scientific evidence to inform decisions.

The challenges to making restoration evidence-based are diverse in nature, ranging from poor planning of restoration work, which points to limited appreciation of the need to produce a strong evidence base, to a lack of instruments and incentives to drive the generation, dissemination and use of evidence that spans both the biophysical and social aspects of restoration. These challenges are largely rooted in the conventional way of approaching restoration from individual disciplinary perspectives, thus artificially simplifying and compartmentalizing a naturally complex problem like degradation. I end by proposing transdisciplinarity, which focuses on a holistic world view and the production of knowledge that embraces complexity, as a possible vehicle to help move the practice of restoration towards being evidence-based.

Keywords: Information dissemination; monitoring; restoration practice; social assessment; transdisciplinarity.

Opsomming

Wydverspreide, mens-veroorsaakte agteruitgang van ekostelsels en die gepaardgaande verlies aan biodiversiteit hou 'n direkte bedreiging vir menslike welsyn in. Alhoewel daar geen plaasvervanger is vir 'n gesonde, selfonderhoudende ekostelsel is nie, bied ekologiese restourasie 'n aantreklike en inderdaad onvermydelik, vul waar bewaring alleen nie voldoende ekosisteem integriteit kan ondersteun nie. Restourasie ondergaan tans ‘n revolusie, waar bewys gebaseerde (BG) praktyk 'n opkomende nuwe benadering om die kanse van die suksesvolle bereiking van herstel doelwitte te verhoog. BG praktyk is gebaseer op die idee dat die uitvoering van besluite gebaseer moet word op die evaluering en die gebruik van bewyse van die effektiwiteit van alternatiewe opsies.

Die punt van vertrek van hierdie proefskrif is die bewering dat BG praktyk nie noodwendig afhanklik van navorsings bewys hoef te wees nie. Die werk wat hier aangebied word spreek tot die produksie en gebruik van bewyse van effektiwiteit in die restourasie praktyk. Deur die gebruik van tien restourasie programme in Suid-Afrika is die kwaliteit van die bewyse in die praktyk geassesseer. Die drie komponente van bewyse produksie wat geëvalueer is sluit in (i) basislyn toestand meting, (ii) doelwitstelling en (iii) monitering. Resultate toon 'n swak definisie van doelwitte; 'n vooroordeel ten gunste van die gebruik van sosio-ekonomiese doelwitte en aanwysers; meer monitering van insette as die impak; en teenstrydige en kort-termyn monitering van biofisiese aanwysers. Beofenaars het die gebruik van bewys gebaseerde inligting as voldoende beskou, maar 'n paar uitdagings wat verband hou met die beplanning en die beskikbaarheid van bronne is aangehaal as kenmerkende faktore in die gapings wat tans waargeneem word. Ek stel voor dat beoefenaars se persepsie van die huidige bewysbasis praktyk 'n bykomende bedreiging vir die generasie van 'n sterk bewybasis praktyk inhou.

Benewens die produksie van bewyse, is die toegang tot bewyse 'n belangrike komponent van die BG praktyk. In die verkenning van hoe bewyse beskikbaar gestel word deur beoefenaars, is dit duidelik dat 'n aansienlike aantal inligting wel bekend is aan beofenaars maar nie maklik toeganklik in gedokumenteerde vorm is nie. Dit beklemtoon die behoefte vir 'n verskuiwing in die praktyk kultuur tot die waardering en beloning van die verspreiding van inligting.

'n Beoordeling van die BG herstel sou onvolledig wees sonder 'n doelbewuste oorweging van sosiale faktore. Ek het dus 'n gevallestudie van 'n indringerplant verwyderings program uitgevoer om vas te stel wat die gebruik van wetenskaplike bewyse in besluitneming aandryf. Ek het opgemerk dat die organisatoriese struktuur, beleid, prioriteite en kapasiteit die gebruik van wetenskaplike bewyse kan beinvloed, en selfs beperk.

Die uitdagings om herstelwerk bewys-gebaseerd te maak is uiteenlopend van aard, dit wissel van swak beplanning van herstel werk, wat dui op beperkte waardering van die behoefte om 'n sterk bewyse basis te produseer, 'n gebrek aan instrumente en aansporings vir die generasie van besyse, verspreiding en gebruik van bewyse wat strek oor beide die biofisiese en maatskaplike aspekte van die restaurasie. Hierdie uitdagings is grootliks gegrond op die konvensionele manier van restaurasie wat gebaseer is op individuele dissiplinêre perspektiewe,wat lei tot die kunsmatige simplifiseering van ‘n uiteraand komplekse problem soos agteruitgang. Ek eindig af deur die gebruik van transdissiplinariteit, wat fokus op 'n holistiese wêreldbeskouing en die produksie en kennis van kompleksiteit insluit voor te stel, as 'n moontlike voertuig om die skuif in praktyk van restourasie na n bewys-basis te vergemaklik.

Sleutelwoorde: verspreiding van inligting, monitering, restoarasie praktyk, sosiale assessering; transdissiplinariteit.

"We cannot afford to repeat our mistakes and to continue using methods that could be improved. Just because a given method worked adequately in one ecosystem or in one bioregion is no guarantee that it will work in another context."

Clewell A. & Reiger J. P. 1997.
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Acknowledgements

The pursuit of a PhD is not only an intensely academic endeavor, it is also a deeply personal journey. Many people and organizations have helped me get to the point where the journey ends.

On the academic side…

Someone once said doing a PhD is like giving birth to a roll of barbed wire. If that is so, then one needs a really good midwife or two. To the two women who helped me birth my own roll of barbed wire, Dr Belinda Reyers and Prof. Karen Esler, I am eternally grateful. This work would never have been realized without their skillful supervision. From conceptualization to publication, they have been pillars of support, providing guidance and helping me clarify my thoughts. Many a times when I was ready to quit, they would tell me, "You can do it". Thank you for your unwavering belief in me, even when I had momentarily stopped believing in myself. I was truly blessed to have such wonderful supervisors.

I also thank Prof. James Blignaut, who, at the beginning of the study, was helpful in refining my thoughts and the direction I wanted to take. The free copy of *"Ecological Restoration: Principles, Values, and Structure of an Emerging Profession"* he gave me also came in very handy. Prof. Heidi Prozesky guided a completely clueless me through the unfamiliar waters of social science. For her encouragement and positive feedback I am grateful.

I am also thankful to all the people who took part in the surveys and interviews I conducted as part of this study. The staff of the Working for Water program, especially senior management, deserve special mention for their patience with my incessant questions in my quest to understand the program. Thanks as well to Mr John Dini of Working for Wetlands.

The following people helped with different aspects of design and/or analysis: Dr Sally Archibald, Dr Sonali Das, Ms Thandulwazi Magadla, Ms Michelle Reyers, Ms Nadia Sitas, Ms Wilma Strydom and Mr Matt Zylstra. Colleagues at the CSIR assisted me in many and varied ways: Mr Ryan Blanchard, Dr Luthando Dziba, Mrs Antoinette Crafford, Mr Greg Forsythe, Ms Ilse Kotze, Ms Hlengiwe Mbatha, Dr Jeanne Nel, Dr Abel Ramoelo, Mrs Lindie Smith-Adao and Dr Brian van Wilgen.

Financial and logistic assistance was provided by the following institutions: Council for Scientific and Industrial Research (CSIR); the National Department of Science and Technology (DST); the National Research Foundation (NRF) and Stellenbosch University (SU).

On a personal note…

My husband, Bonke Simelane, supported me in every way conceivable. Thank you for everything, and having to play the role of mother to our daughter when I was buried so deep in this work I couldn't be anything to anyone.

My five-year-old daughter Ayomide, seeing how swamped I was with work, once said "If you can teach me how to use your other computer I can help you with your PhD mama". Thank you my angel… for the back massages too, when my back was on fire after sitting in front of the computer for hours on end.

What does it take to embark on the PhD path and complete the journey? An enquiring mind and truck-loads of endurance. My parents, Lindile and Nomonde Ntshotsho, instilled those qualities, respectively, in me. I know that my mother, together with my sisters Linda, Nomkhitha, Hlumela and Zandile, as well as my spiritual sister, Thulie Mdluli, carried me with their prayers and petitions. I can never thank them enough. My friends, who are too many to mention by name, also supported and encouraged me.

God made it all possible. He gave me the skills and ability, and provided all the people I have mentioned above to help me on my way. I dedicate this work to Him.

Table of Contents

List of figures

List of tables

List of addenda

Chapter 1

Setting the scene

In the beginning…

As an undergraduate student at the dawn of the 21st century I was alarmed by news of "the sixth major extinction", which was partially blamed on humans' destruction of ecosystems (CBD 1992; Pimm *et al.* 1995; Chapin III *et al.* 2000; Novacek & Cleland 2001). When I heard about ecological restoration I knew there was hope (Gann & Lamb 2006). Restoration is the acknowledgement by humans that we have used too much natural capital and that – for our own good – it is now time to 'give back' to nature and to nature's functions on which we depend (Aronson *et al.* 2006). Restoration, which is officially defined as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER 2004), has been globally adopted as a supporting tool to conservation efforts. Some have gone as far as hailing restoration as essential to ensure the future survival of human society (Cairns 1998; Hobbs & Harris 2001). While this view represents the anthropocentric value of restoration, several other motivations for restoration exist (Clewell & Aronson 2007).

The practice of ecological restoration is a field of management practice in its own right (Lake 2001), with a firm scientific foundation in restoration ecology (Cairns & Heckman 1996; Palmer *et al.* 2006). Similar to conservation practice, ecological restoration has its problems, chief among which is the need to demonstrate impact. Considering the substantial cost associated with restoration (Holl & Howarth 2000), demonstration of impact, which can only be achieved through monitoring and evaluation (M&E), is paramount to ensure continued investment. M&E allows restoration practitioners to demonstrate what they have achieved through their successes and what they have learned through their failures (Field *et al.* 2007), which advances the practice of ecological restoration. Additionally, knowing how effective (or not) different restoration interventions are arguably makes decision making easier, as the choice of intervention is based on each intervention's likelihood to achieve the specified restoration goal.

Enter evidence-based practice

Conservation literature abounds with calls for evidence-based (EB) practice (Sutherland *et al.* 2004; Ferraro & Pattanayak 2006; Pullin & Stewart 2006; Roberts *et al.* 2006; Pullin & Knight 2009). An important feature of this EB approach is the systematic review and collation of evidence of effectiveness of actions in a comprehensive and objective manner, weighted by quality, then disseminated effectively into practice and policy (Pullin & Knight 2001; Stewart *et al.* 2005). An implicit inference in some literature is that EB practice is solely dependent on *research* evidence, with practitioners being portrayed merely as recipients of information produced by researchers. Throughout this thesis I challenge this view, building my work on the premise that restoration practice can be regarded as a global experiment, with the different projects/programs in various regions and ecosystems representing replicates of an experimental design. As such, restoration practice has the potential to generate evidence in the same way that research does.

Hence this study

Living in South Africa, with its wealth and diversity of restoration initiatives, I realized that I have the ideal opportunity to explore the possible contribution of restoration practice to the EB movement by developing my argument that restoration practice be considered a global, long-term experiment. The overall objective of this project was thus to investigate the prospect of mainstreaming EB practice into restoration. In addition to the introduction and synthesis, the thesis is arranged into five core chapters, each one addressing a sub-objective, as outlined in Table 1.1.

Table 1.1. The objectives of and techniques applied in the five core chapters of this thesis.

Chapter	Objective	Technique(s) and tools
2	To provide a context for evidence-based restoration To appraise evidence generated in practice	Literature review Web-based questionnaire
3	To describe obstacles to building an evidence base	Document content analysis Web-based questionnaire
4	To describe and quantify the information gap in restoration	Document content analysis Web-based questionnaire
5	To investigate the use of scientific evidence in practice	Case study Semi-structured interviews
6	To propose an approach for mainstreaming evidence-based restoration	Self-reflection Literature review

Experimental design goes beyond replicating treatments, to incorporate careful articulation of hypotheses and monitoring protocols. Consequently, restoration requires the same rigor used in experimental design in order to produce evidence of comparable quality to research. As illustrated in Fig. 1.1, restoration practice can contribute to the generation of evidence by aiming to answer the question "is intervention *x* effective in solving problem *y*?", where the problem is degradation, quantified through baseline condition assessment to enable the setting of a realistic goal. The implementation of an appropriate intervention, based on existing evidence of effectiveness, is then followed with monitoring, using relevant indicators, to track effectiveness of the chosen intervention in achieving the desired goal. I address the issue of evidence production in chapter 2, through a review of ten restoration programs. Chapter 3 deals with the challenges practitioners face in generating evidence. Using a web-based questionnaire survey, I ask practitioners about their perception of the current evidence base and the obstacles associated with its development.

The EB approach requires the *finding* of scientific evidence (see Fig. 1.1). The information gap between science and practice, which is characterized by limited access to scientific evidence, is often cited as the reason why managers of natural resources continue to base decisions on their own experience and that of peers, instead of the recommended research-based information (Pullin *et al.* 2004; Knight *et al.* 2008; Cabin *et al.* 2010; Esler *et al.* 2010). In chapter 4 I describe the information gap in restoration from a different perspective, highlighting the need to view practitioners as worthy contributors to the generation of knowledge. I thus propose that the documentation of information produced in practice could go a long way to bridging the information gap.

The generation and dissemination of evidence are important first steps in the EB approach. However, an exploration of the EB approach to restoration is not complete without an assessment of the extent to which said evidence is used. This is what I aim to do in chapter 5. Wading into the unfamiliar waters of social science, I conduct a case study of an invasive alien plant management program to try and find out what factors influence the use of scientific evidence in practice. Chapter 6 brings together the lessons learned in the preceding chapters, proposing and exploring transdisciplinarity as a way forward towards being EB in restoration.

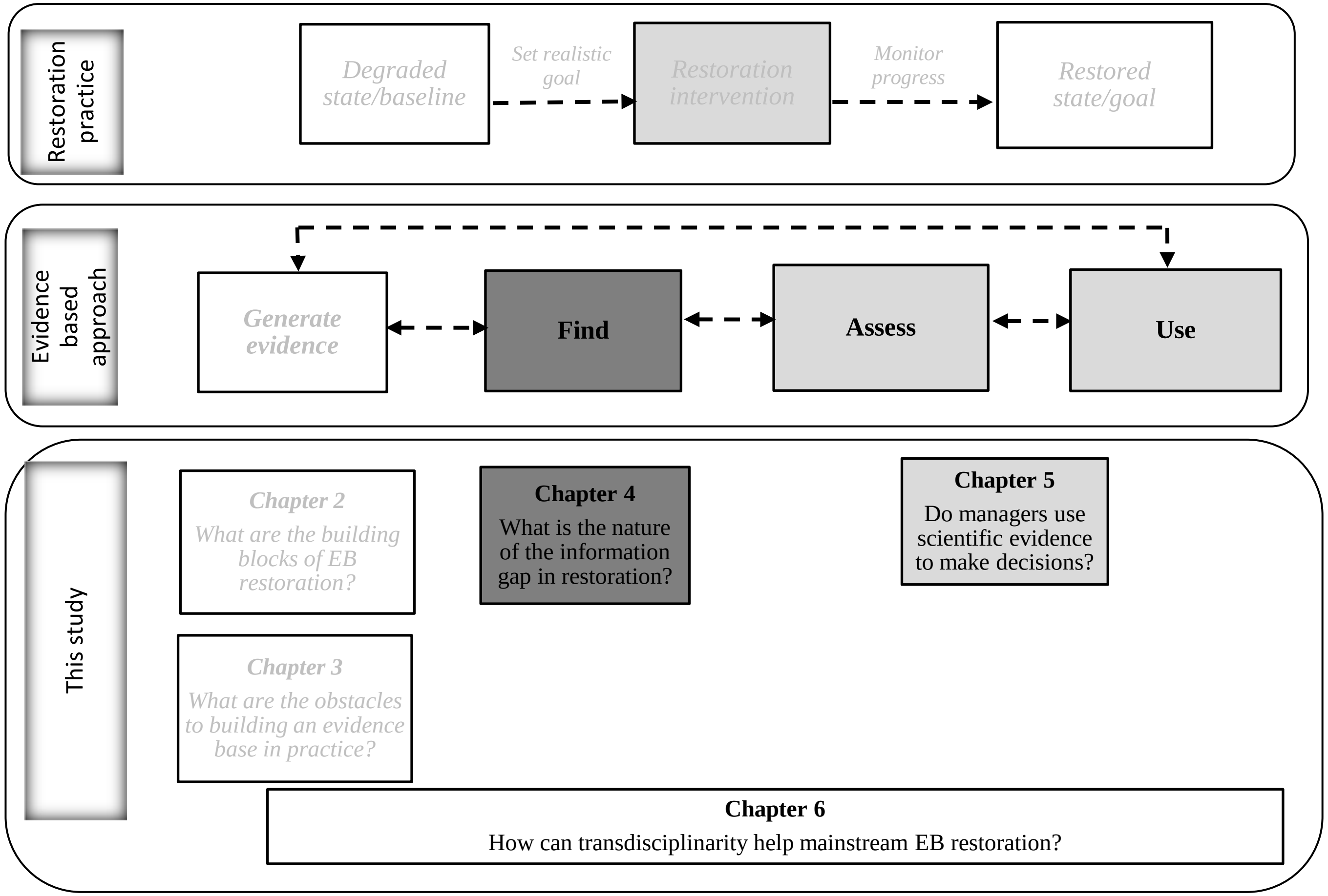

Fig. 1.1. A schematic presentation of the key questions addressed in the five core chapters of this study and how they relate to restoration practice and the evidence-based approach. Relationships are portrayed with the use of differing fonts and text box colours.

Definitions of commonly-used terms

Some terms are used often throughout this work. As such, brief definitions are provided to aid the reader's understanding.

(i) Evidence-based practice: An approach to decision-making that involves a process of systematically finding, appraising, and using evidence to demonstrate the effectiveness of a specific intervention (Rosenberg & Donald 1995). As such, the term evidence-based restoration, as repeatedly used throughout this work, does not refer to a specific form or method of restoration, but rather an approach to restoration that involves the use of evidence, irrespective of type of intervention. The phrase "being evidence-based" is thus used to mean restoration that follows the evidence-based approach.

(ii) Restoration: The Society for Ecological Restoration (SER) defines restoration as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER 2004). For the purposes of this thesis, I include, within this broad definition, activities such as post-mining rehabilitation, invasive alien species clearing, as well as assisted regeneration.

(iii) Knowing-doing gap (used synonymously with the phrases science-practice gap and information gap in this thesis): It is the gap between research and implementation, characterized by a lack of, or limited, transfer of information from research to practice, resulting in reduced implementation of research findings in practice (Knight et al. 2008; Sunderland et al. 2009).

(iv) Transdisciplinarity: There is no universally accepted definition of transdisciplinarity. In this thesis I adopt the definition of transdisciplinarity as an *approach* to knowledge production and implementation that not only spans various research disciplines, but also includes non-research knowledge spheres, communities and governments, for the management of complex societal problems (Luks & Siebenhuner 2007; Apgar et al. 2009). I specifically reject the notion of transdisciplinarity purely as a research strategy.

Note to reader

The next five chapters of this thesis have been prepared for submission to different journals. As such, they are written as standalone manuscripts, and therefore there is some overlap in the introductions of each chapter. The manuscripts are multi-authored, with me as the primary author and the two supervisors, Dr B. Reyers and Prof. K. J. Esler, co-authors. Chapter 5 has an additional co-author, Dr H. Prozesky, who was instrumental in the design and execution of the case study into the use of evidence in restoration practice.

Chapter 2 has already been published in the journal *Restoration Ecology* (see Ntshotsho *et al.* 2011). The article generated debate, in the form of a comment article by Guldemond and colleagues (2012). A response to their comments was published soon afterwards, in the same journal and is included in this thesis as Addendum C.

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Chapter 2

Assessing the evidence base for restoration in South Africa

This chapter has been published as Ntshotsho P., B. Reyers and K. J. Esler. 2011. Assessing the evidence base for restoration in South Africa. *Restoration Ecology* **19(5):** 578-586.

Abstract

If restoration is to become effective, able to compete for limited funds, and truly adaptive, it must become evidence-based. Three of the conditions essential for the establishment and advancement of evidence-based restoration are: (1) collection of baseline information; (2) setting clearly-defined goals; and (3) relevant and adequate monitoring. Using a literature review, complemented with an online survey, I reviewed ten restoration programs in South Africa to assess whether current restoration practice meets these conditions. The review showed good collection of baseline information and the setting of restoration goals that span ecological and socioeconomic considerations. However, to a large extent goals were poorly defined, there was more monitoring of inputs than outcomes, and monitoring of ecological indicators was inconsistent. These shortcomings can undermine restoration impacts, as well as the future sustainability of these expensive programs. I conclude with recommendations on how to mainstream the requirements of evidence-based restoration into current and proposed restoration programs.

Keywords: baseline information, evidence-based practice, goal setting, monitoring.

Introduction

Evidence-based practice emerged in the 1980s in medicine (Rosenberg & Donald 1995) and is defined as the process of systematically finding, appraising, and using evidence to demonstrate the effectiveness of a specific intervention in decision making. Calls for evidence-based practice have been made in conservation (Salafsky *et al.* 2002; Pullin *et al.* 2004; Sutherland *et al.* 2004; Ferraro & Patanayak 2006). The need for evidence-based conservation has never been more pressing than currently, when several nations have set themselves the ambitious target of halting or significantly reducing the current rate of biodiversity loss at various scales by 2010 (UNEP 2002). In order to achieve this and other related conservation targets, some pertinent questions need to be addressed: (1) What should our goals be and how do we measure progress in reaching them? (2) How can we learn to do conservation better? (Salafsky *et al.* 2002) and (3) How can we benefit and adapt management approaches from the experience gained from success and failure? (Folke *et al.* 2005; Knight 2006; Hobbs 2009). These questions essentially lay the foundation for evidence-based conservation.

Restoration can benefit from being evidence-based. Because the practice is inherently expensive, for it to compete for funding with other budgetary priorities practitioners need to justify the expense with solid evidence rather than anecdotes. In addition, the provision of ecosystem services is often stated as one of the rationales for undertaking restoration. The aim is usually to tap into the emerging global market for ecosystem services, the payments for ecosystem services (PES) market. PES compensates individuals or communities for undertaking actions that increase the provision of ecosystem services (Jack *et al.* 2008). Sellers of “enhanced” ecosystem services need to demonstrate to the buyers that there has indeed been an improvement in the provision of the ecosystem service being bought, and that the improvement is directly attributable to the intervention. Such demonstration of effectiveness can be achieved through adopting an evidence-based approach to restoration.

Restoration is widely practiced in South Africa, at scales ranging from local to landscape. The cumulative associated annual expenditure ranges in tens of millions of US dollars (Preston & Williams 2003; Kotze & Ellery 2008). For example, the Working for Water program, a national restoration program aimed at simultaneously controlling alien invasive plant species to provide water benefits while creating employment (van Wilgen *et al.* 1998), has an annual budget of about $US 59 million (DWAF 2007). It has been hailed internationally as a success (Hobbs 2004), has received various awards (Common Ground 2003), and has been used locally as a model for newer, related programs. South African restoration programs thus provide a good platform from which to assess the evidence base for restoration. This study does that by examining the relationship(s) between restoration goals and the monitoring data collected to assess progress towards their achievement, using ten restoration programs. I ask the following key questions: (1) what are the primary goals of restoration? (2) What baseline data are collected prior to restoration efforts? and (3) What types of indicators are used in monitoring and at what temporal and spatial scales?

Methods

Restoration program review

Names of restoration programs that were known to the authors were used to search for information using the following search engines: ScienceDirect; GoogleScholar and Google. These programs included Working for Water; Working for Wetlands; Working for

Woodlands; LandCare South Africa and one post-mining restoration program[1]. The Working for Woodlands program was disaggregated into its six constituent sub-programs, each of which had different goals and approaches. I chose to assess three of these sub-programs, treating them as individual programs *viz:* the Subtropical Thicket Restoration Project (STRP); the African Rural Initiatives for Sustainable Environments (ARISE) project; and the Matiwane forest restoration project. I deliberately excluded the Fynbos Riparian Restoration project and the St. Francis Thatch project because they were not aligned with the primary focus of the Working for Woodlands program, which is to regain woodland composition, structure and function. I also excluded the Sekhukhune Lands Intervention Programme because I was unable to obtain sufficient information on it.

The same search engines were used to find more restoration programs for possible inclusion in the assessment. The search phrases were different combinations of terms from the following groups of terms: group one (ecological; post-mining; rangeland); group two (restoration; rehabilitation; revegetation); group three (project/s; program/s). The phrase "South Africa" was used as a suffix in all the search combinations. Relevant results from the first 20 hits of each search were considered further, e.g. if a result referred to a restoration program in South Africa, more information on the program was sought and the program was included or excluded from the assessment based on the inclusion criteria listed below. Where insufficient information was available from the sources found during the information search, contact was established with program managers and/or coordinators to seek further information on those particular programs. I ended up with a total of ten restoration programs for the assessment, the descriptions of which are contained in Supplementary file S1 (Addendum A), together with sources of more information on these programs.

Program inclusion criteria

Only programs that met the following criteria were included in the assessment:

- terrestrial restoration
- aimed to fulfill (a) socioeconomic and ecological goals and/or (b) legal obligations
- had been operational (i.e. had been implemented) for two years or more.

I included both assisted regeneration (McDonald 2000) and active restoration programs. Assisted regeneration, in this instance, referred to the removal or exclusion of the degrading

[1] For confidentiality reasons, the name of the mining companies undertaking restoration programs assessed in this study cannot be publicized.

agent, without subsequent active manipulation to stimulate system recovery. System recovery was assumed to have happened through ecological succession. Examples in this category included alien plant removal and erection of fences around degraded areas to reduce trampling by animals. Active restoration referred to intentional, physical manipulation of the system to kick-start recovery. This is what the Society for Ecological Restoration referred to as ecological restoration in its Primer on Ecological Restoration (SER 2004).

I deliberately excluded research-driven restoration projects (that is, restoration projects whose only goal was research) from the assessment for two reasons: (i) by their very nature, such projects have well-designed monitoring programs, which could give the impression that monitoring is widespread, which may not necessarily be the case in non research-based projects; (ii) research-driven projects generally lack long-term, wider socioeconomic goals and tend to focus on testing specific biophysical hypotheses. However, research projects that were associated with, and formed part of, larger restoration initiatives were included under their "parent" programs.

Information sources

Information sources used included online newsletters; electronic databases; technical reports; periodic (primarily annual) reports; business plans; student dissertations and published research papers.

Information extracted

The following information was extracted from the information sources: type of restoration (e.g. active or assisted regeneration); goals of restoration; commencement (year); baseline data collected; indicators monitored; monitoring intervals and associated research component.

Web-based survey

To supplement the information gathered through the desktop study, I conducted a survey among managers and researchers closely involved in the programs I was going to assess. A computerized, self-administered questionnaire (CSAQ) was sent to respondents by e-mail (Addendum B). I used this method to do the survey because it is cheaper and quicker than conventional techniques (Babbie & Mouton 2001), and secondly because the target respondents were able to understand the questions and therefore complete the survey unassisted. The respondents were required to answer the following questions: (1) what are the goals of the restoration program you are involved in? (2) What baseline data are collected prior to restoration? and (3) What indicators are monitored and at what temporal and spatial scales?

I used responses from two or three respondents in each program except for the Matiwane forest restoration project, rangeland restoration and community-based restoration. For each of these three programs I only had one respondent who had completed the survey.

Data analysis and presentation

In order to analyze the data and present the results I grouped projects using the rules below. Projects that did not fall within a recognized formal restoration program were subjectively categorized based on administrative/land use context: commercial farming land; protected areas; mined areas and communal areas. In order to be included in the analysis, goals and indicators used had to be cited in literature and by all respondents from a particular program. Distinction was made between indicators used at all project sites and those used only at selected sites. If there was disagreement between the respondents from a single program and/or literature about the spatial scale at which an indicator was monitored, that indicator was classified as "inconsistently monitored". Such indicators were classified together with those that were monitored at selected sites or only as part of short-term studies.

Program goals and indicators were classified as either "socioeconomic" or "ecological". "Socioeconomic" goals and indicators were those that had an economic/financial and social basis, while the "ecological" category included ecological; biological; chemical; physical and hydrological considerations. Indicators were also categorized as either input- or outcome-based. Input-based indicators were those that focused on the intervention and not on its outcome. Typically, these indicators answer the question "what was done?", and can only be used for the duration of the active stage of a restoration program. In contrast, outcome-based indicators can be used to assess the impact of the intervention past its active stage, and can be used to address the question "what are the sustained impacts of the intervention"?

I further distinguished between "implementation" and "impact" monitoring, where the former was defined as monitoring where input-based indicators were used, while the latter was where outcome-based indicators were used. To assess the extent of impact monitoring, I used the most directly relevant indicator in instances where there was more than one outcome-based indicator per goal. For example, the goal "soil conservation" could be monitored using both "plant survival/establishment" and "soil erodibility". In this instance I used the latter indicator.

Data were used to produce histograms in Microsoft Office Excel 2003 (Microsoft Corporation, UK).

Results

Goals of restoration

There were 14 goals of restoration cited across the ten restoration programs I assessed, eight of which were of an ecological nature (the uppermost eight), while the remaining six were socioeconomic (Table 2.1). The sum total of goals across all ten programs was 99, implying that each program had, on average, about nine goals. The most common ecological goal was ecosystem productivity improvement, stated in nine of the ten programs. This was followed by soil conservation, stated in eight programs. Water resource improvement, biodiversity conservation and restoring natural capital were each cited in seven programs.

Table 2.1. Goals of restoration, together with baseline information and indicators that aligned to them. Numbers in parentheses denote the number of programs for which each parameter is valid. Asterisks denote input-based indicators. PES and IAS stand for payment for ecosystem services and invasive alien species, respectively.

Goal	Baseline	Indicator/s
Ecosystem productivity improvement (9)	Soil chemical quality (6) Plant species composition (9)	Biomass accumulation (3)
Soil conservation (8)	Geomorphology (7) Extent of erosion/bare patches (8) Levels of degradation (9)	*Solid structures built (3) Plant survival/establishment (6) *Area revegetated (8) Soil erodibility (5)
Biodiversity conservation (7)	Density/cover of indigenous species (9) Plant species composition (9)	Biodiversity indicators (5) *Area revegetated (8)
Water resource improvement (7)	Water quality (8) Water quantity (7) Aquatic diversity (7)	Water quality/quantity (2)
Alien plant control (5)	IAS identity, distribution and/or density (8)	*Area cleared of IAS (5) Soil seed banks (3)

		*Post-clearing follow-up treatment (1)
Carbon sequestration (4)	Carbon stocks (7)	Carbon sequestered (2)
Increasing resilience (6)		
Restoring natural capital (7)		
Job creation (9)	Unemployment rate (7)	Number of jobs created (7) *Person hours worked (8)
Poverty alleviation (8)	People living in poverty (6) Household income (6)	
Livelihood improvement (8)	Household income (6) Informal harvesting (1)	Livelihood impacts (3)
Capacity building (8)	Literacy (5)	*Training provided (8)
Development of a market for PES (4)	Carbon stocks (7)	Carbon sequestered (2)
Environmental awareness creation (8)	Environmental awareness levels (7) Medicinal use of plant species (1) Informal harvesting (1)	*Awareness campaigns held (3) Environmental awareness levels (3)

The broad goal, "increasing resilience", was cited in six programs. In terms of socioeconomic goals, job creation and capacity building were the most common goals, stated in nine of the ten programs. Poverty alleviation, livelihood improvement and environmental awareness creation ranked second, stated in eight programs, with development of a market for PES considered in four programs. Overall, of the 14 goals listed, 7 were qualitative in nature.

Baseline data

Baseline information collection appeared to be common practice, evidenced by the proliferation of types of baseline data collected in association with each goal (Table 2.1). Two of the goals, however, had no baseline data associated with them. Some goals were each associated with up to three types of baseline data.

Ecological baseline data were collected in more programs than those which had ecological goals aligned to them. For example, baseline data on invasive alien species (IAS) parameters were collected in eight programs, while only five programs cited IAS management as a goal. In contrast, socioeconomic baseline data were collected in fewer programs than those which cited the associated goals.

Monitoring and indicators used

Indicators used to monitor progress towards the achievement of goals are listed in Table 2.1 . There were 17 types of indicators. The higher number of indicators relative to the number of goals (17 vs 14) can be attributed to the occasional use of more than one indicator per goal. For example, the indicators "solid structures built" and "areas revegetated" could both be used for the "soil conservation" goal, while "number of jobs created" and "person hours worked" could both be used for the "job creation" goal.

Overall, socioeconomic indicators were monitored more consistently than ecological indicators (Fig. 2.1). For example, the most common ecological indicator, "area revegetated" was used in eight programs in total, but was only monitored consistently in three of those eight programs. In contrast, the most common socioeconomic indicators "person hours worked" and "training provided" were also used in eight programs, but were monitored consistently in six and five programs, respectively. In addition, the most common ecological indicator was input-based, making it of limited use in determining the success of restoration efforts. Indeed, 50% and 36% of socioeconomic and ecological indicators, respectively, were input based.

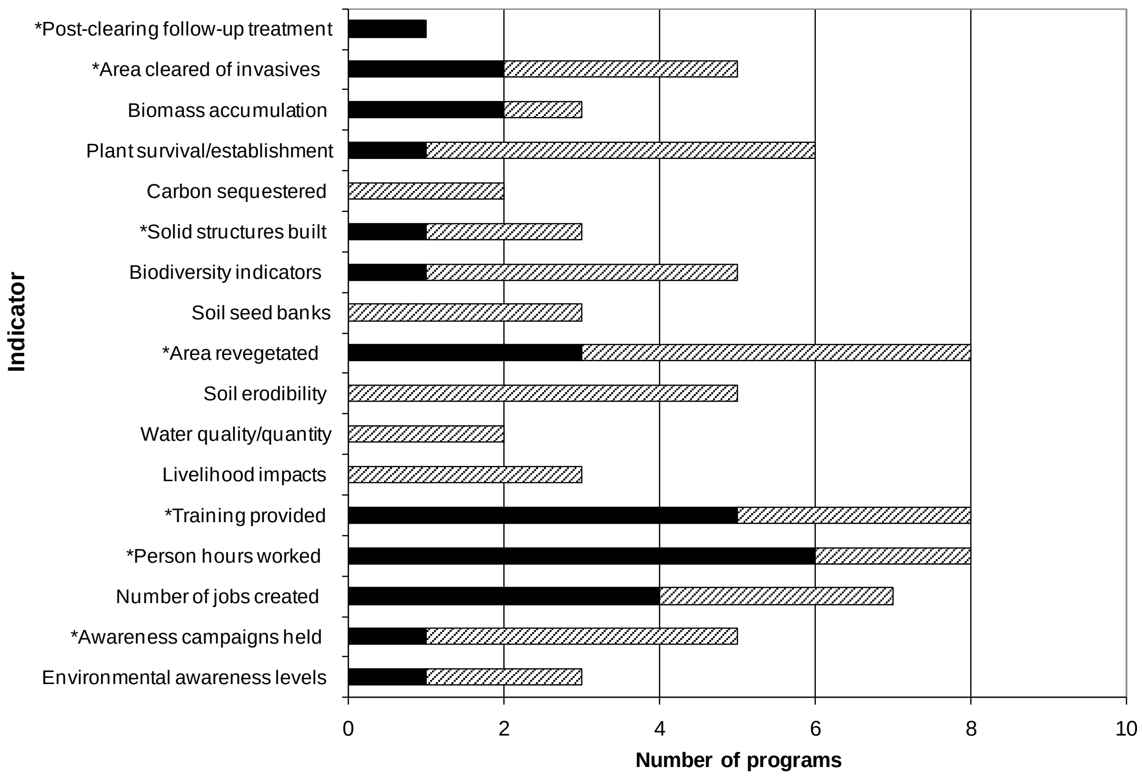

Fig. 2.1. Types of indicators monitored (y-axis) and the number of programs in which they were monitored (x-axis). Solid black bars denote indicators that were monitored at all project sites within a particular program, while cross-hatched bars denote indicators that were monitored inconsistently, i.e. at selected sites and/or as part of short-term studies. Asterisks denote input-based indicators.

Removing the “noise” created by the use of input-based indicators revealed that impact monitoring was very limited (Fig. 2.2). None of the 14 goals were monitored using outcome-based indicators in all programs where they appeared. In 64% of the cases, less than 50% of the programs backed their goals with impact monitoring. Five goals had no outcome-based indicator associated with them in any of the programs in which they were cited.

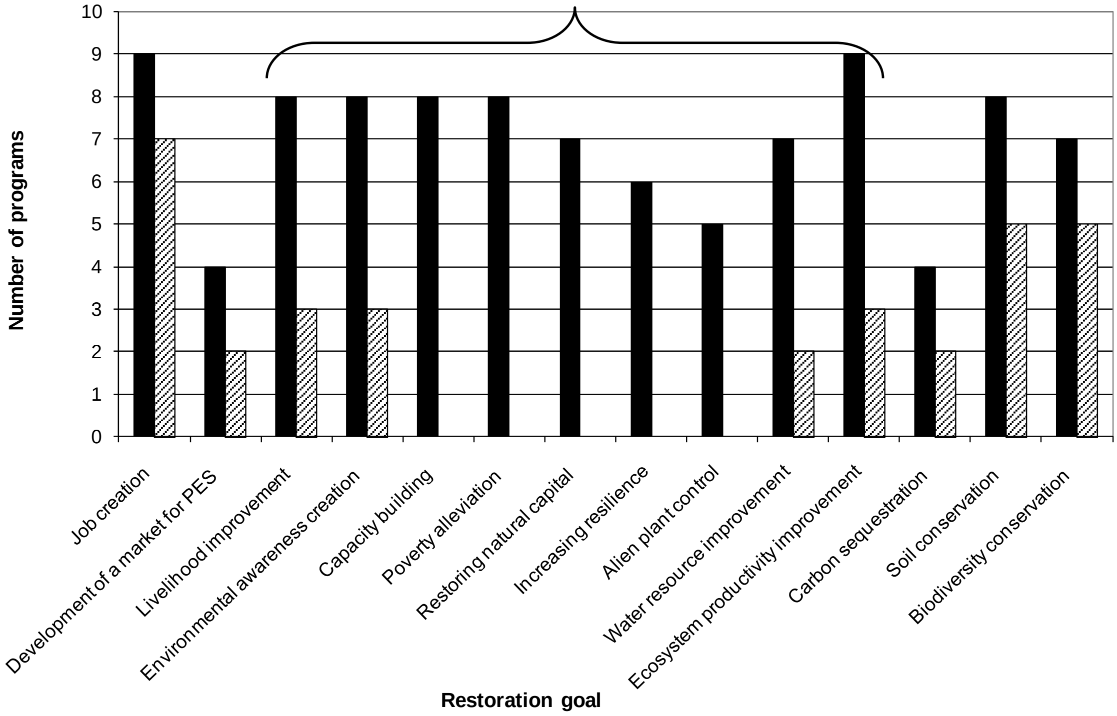

Fig. 2.2. Incidence of impact monitoring. The black solid bars denote the number of programs (y-axis) citing the goals (x-axis). The cross-hatched bars denote the number of programs in which a corresponding, outcome-based indicator was monitored. Goals underneath the downward-facing brace were associated with impact monitoring in less than 50% of the programs in which they appeared.

Discussion

Goals of restoration

Restoration in South Africa is undertaken in a variety of contexts, driven by different socioeconomic and environmental agendas. As such, the goals of restoration incorporate both socioeconomic and ecological considerations. This is not surprising, considering the country’s problems of widespread poverty and unemployment (Magadlela 2001), severe land degradation (Hoffman & Ashwell 2001) and the need to conserve biodiversity (Biggs *et al.* 2006). However, the setting of broad and/or qualitative restoration goals arguably poses the biggest problem to designing and implementing proper monitoring protocols. For example, the broad goal of “restoring natural capital” (RNC) was cited in 70% of the programs assessed herein. Clewell and Aronson (2007) define RNC succinctly as the replenishment of natural capital stocks in the interests of long-term human well-being and ecosystem health. Clearly, this is a complex goal, with multiple facets, the achievement of which would be very challenging to measure. Likewise, the qualitative goal of environmental awareness creation would be difficult to measure.

Moreover, the setting of a multitude of goals within single programs is also potentially problematic. This problem is often brought about by the setting of broad goals that inherently include some of the quantitative goals that have also been set. For example, in most of the programs assessed, poverty alleviation and livelihood improvement were meant to be achieved through job creation, but these were all stated as separate goals. Setting and attempting to achieve many goals within limited resources may result in insufficient monitoring of some, or even all the goals. It is however important to note that in order to secure funding goal setting is often a politically driven process. As a result, these sorts of catchy multiple and broad goals will occur (Funke & van Wyk 2007). The tension between broad politically appealing goals and narrow clearly defined goals desired by scientists can potentially be resolved by perhaps using the broad goals as 'parent/header' goals for more detailed underlying aims in funding applications. The use of hierarchical goals (Tear *et al.* 2005) might avoid goal redundancy which can result from setting a broad goal such as increasing resilience in conjunction with the goal of biodiversity conservation when the former can be reasonably expected to result from the latter (Chapin *et al.* 2000).

Baselines and input-based indicators

The widespread collection of baseline information appeared to be one strong point in the practice of restoration in South Africa. However, I noted that sometimes this collection did not tie into the assessment of impact. For example, baseline information on water quality and/or quantity was collected in at least seven programs but the impact of restoration on those indicators was only assessed in two programs. Moreover, the collection of more than one type of baseline indicator in association with a single goal suggests that some of the baseline data are either complementary or even redundant. This redundancy is evidenced by the fact that some of the baseline data were not related to any of the indicators monitored post-intervention. This common collection of redundant baseline data suggests inefficient use of resources.

Some redundancy was also observed in the types of indicators used in monitoring. This was apparent in instances where there were many indicators associated with a single goal, with the additional indicators being input-based. Indeed, the use of input-based indicators was widespread, thereby contributing to the incidence of what I termed “implementation” monitoring. When indicators are expressed in terms of implementation rather than post-implementation impact, the likelihood of perceiving the intervention as having been successful is high if implementation was done according to the set implementation plan. Alexander and Allan (2007) found this to be the case in some river restoration projects in the United States of America, where restoration was claimed to have been successful in more instances than was actually the case. This is a problem in South Africa too, with successful program implementation being confused with positive program impact (Beater *et al.* 2008; Holmes *et al.* 2008) or program success. The Society for Ecological Restoration lists some attributes of restored ecosystems (SER 2004). Despite having originally been described purely for ecological systems, it is my conviction that these attributes can be applied to socio-ecological systems, the arena within which restoration is practiced. One attribute of major importance is the ability of the restored system to self-sustain in the long-term. This also implies that if benefits accruing from restoration are used to gauge success, then these should also accrue in a sustained manner for restoration to be regarded as having been successful. This requires monitoring well beyond the implementation or active phase of any restoration program. I recommend that managers, practitioners and researchers work closely together to promote a culture of long-term and relevant monitoring.

Bias towards better monitoring of socioeconomic indicators

The bias towards better and more consistent monitoring of socioeconomic indicators could be linked to the current absence of consensus surrounding the use of ecological indicators (Dale & Beyeler 2001). For example, biodiversity conservation is a common goal of most conservation and restoration programs globally, but a single method of measuring biodiversity status has not yet been agreed on and implemented, though several indices and approaches have been proposed (Noss 1990; UNEP 2003; Scholes & Biggs 2005). Similarly, there is no consensus on how to measure ecological integrity or ecosystem health (Cairns *et al.* 1993; Suter 1993; Andreason *et al.* 2001). In contrast, standard socioeconomic indicators (e.g. poverty; employment rate; household income) have been in use for decades, if not centuries, to measure attributes of social systems. This is probably because these indicators are arguably more important to national accounts and economies. In addition, socioeconomic indicators are rooted in social sciences, which originated in the eighteenth century (Ross 1992). As such, they have become refined over time and their use has become relatively easy and standard practice. Advances are being made, however, in the development of ecological indicators (Balmford *et al.* 2005; Pereira & Cooper 2006; Scholes *et al.* 2008), rapid assessment techniques (Turner *et al.* 2003; Kennedy *et al.* 2009) and proxy measures (MA 2005; Eigenbrod *et al.* 2010). With time, the ease with which these can be applied is likely to increase, while at the same time reducing their costs. In the meantime, the onus is on the restoration practitioners to pay particular attention to clearly articulating the questions that monitoring aims to answer and validate the relationships between the chosen indicators and the restoration goals.

Secondly, the reality is that in South Africa environmental degradation is a minor consideration compared to poverty and related socioeconomic problems (RSA 2009). As such, a lot of government spending is geared towards addressing these latter problems. Indeed, four of the programs assessed herein are primarily poverty-alleviation projects, with ecological considerations being of secondary importance. This implies that the implementers' primary responsibility is to deliver on the socioeconomic goals, hence the bias towards more consistent and entrenched monitoring of socioeconomic indicators. Government funded programs like the STRP are however an indication that the importance of environmental degradation, as well as its links to poverty and other socioeconomic targets, is increasingly being recognized and prioritized by national government. This program includes a government funded biome-wide plot experiment aimed to kickstart restoration on a biome-scale. To date, over 300 plots (50m x 50m) have been established spanning the entire biome, making it arguably the largest restoration experiment in the world, aiming to provide information to landowners across the biome on how to restore degraded land **(**Mills *et al.* 2010).

Monitoring constitutes continuous observation of an activity (or its outcomes) to keep track of trends and progress over time, and aims to identify the need for corrective action (Levendal *et al.* 2008). Although monitoring of ecological indicators was done in many of the programs assessed, it was mostly inconsistent in time and space, which could compromise its ability to detect trends and facilitate the implementation of corrective action where necessary. While recognizing that some systems take longer to recover, I advocate for monitoring at regular intervals in order to facilitate adaptive management. Careful attention therefore needs to be paid to the choice of indicators and monitoring intervals, depending on the system under consideration.

I also observed that sometimes ecological monitoring was not embedded within the programs themselves, but rather apportioned to the research projects associated with these programs. The problem with this approach is that in many instances, research is conducted over short periods and monitoring is site-specific. Results from such inadequate monitoring can be misleading and have the potential to create the illusion that something substantial has been achieved at a wider scale. On the flip side however, it is a positive thing that researchers are involved in these programs. Indeed, research projects have been used as an excellent way of providing periodic and detailed assessments of the effectiveness of operations carried out by the likes of Working for Water (Magadlela 2001; Levendal *et al.* 2008; Buch & Dixon 2009) and Working for Wetlands (Kotze & Ellery 2008). However, I recommend that researchers also get engaged in the social process of strategy development and management, where they can ensure that long term ecological monitoring is built into the restoration programs rather than being treated as an auxiliary activity. In addition, the involvement of local people in voluntary participatory monitoring could bring down the cost usually associated with monitoring done by professionals (Danielsen *et al.* 2007). Collaboration between managers, researchers and volunteers would promote adaptive management, where monitoring would be linked back to management to ensure that results of monitoring are used to change approaches where necessary (Folke *et al.* 2005; Carpenter *et al.* 2009).

Evidence-based restoration makes sense because it reduces trial and error; facilitates learning from previous successes and failures; and subsequently leads to more efficient use of scarce resources through encouraging decision makers to weigh existing evidence for the effectiveness of a particular restoration intervention before implementing it. Proper goal setting, underpinned by knowledge of baseline conditions and adequate monitoring are some of the basic building blocks of evidence-based practice. I propose three avenues that could be investigated to improve the current short-comings in evidence-based restoration in South Africa:

(i) Decision makers need to pay careful attention to how many goals a single program aims to achieve and whether these goals are focused and measurable, while recognising the need for political buy-in and funding for restoration (e.g. through the use of hierarchical goals and aims).

(ii) Funders of restoration need to build in requirements for baseline information collection that is connected to relevant impact monitoring into their proposal processes. This would not necessarily require a significant commitment of funds if simple indicators, appropriate proxies and rapid assessment techniques are used.

(iii) There needs to be widespread merging of the science and practice of restoration, where practitioners and managers participate as scientists taking part in a real-world experiment and take interest in the science behind the practice, while scientists get involved in all aspects of the practice, especially planning. Positive strides have been made towards this ideal, with programs like the STRP and post-mining restoration having scientists, practitioners and managers who do not draw a line between the science and the practice (Botha *et al.* 2008; Marais *et al.* 2009; Mills *et al.* 2010). Ultimately, the advancement of evidence-based restoration will require a mind-shift among the decision makers; funders; practitioners and researchers in restoration practice.

Implications for Practice

- Keep it simple. The setting of a few, clear and realistic goals makes monitoring easier, and ultimately improves chances of success.
- Provisions for the collection of relevant baseline information and monitoring should be made during the planning stage of a restoration project.

Acknowledgements

Research was funded by the National Research Foundation (NRF) and the Council for Scientific and Industrial Research (CSIR). I thank James Blignaut for his input into the planning of the study. I also thank three anonymous reviewers of this MS for their insightful comments that greatly improved the quality of the original manuscript.

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Chapter 3

Obstacles to building an evidence base for restoration. A survey of practitioners in South Africa

This chapter is intended for submission to the journal *Conservation Letters* as:

Ntshotsho P., Esler K. J. & Reyers B. Obstacles to building an evidence base for restoration - a survey of practitioners in South Africa.

Abstract

A central tenet of evidence-based practice is being able to answer the question "Does intervention *x* work better than intervention *y*?" using evidence, not intuition. A strong evidence base is thus necessary to make evidence-based restoration a reality. Such evidence can be generated experimentally or in practice, and needs to comply with the requirements of baseline information collection, setting of clear goals and monitoring of impact. Using restoration programs in South Africa, I looked at the strength of the evidence generated in practice. I also surveyed practitioners to assess their perception of the evidence base as well as any challenges they may encounter in building it. The survey highlighted some weaknesses in all three requirements. Respondents, however, perceived the evidence base as adequate and cited few obstacles, mostly associated with planning and resource availability. I suggest that the disparity between practitioners' perceptions and observed weaknesses in the evidence base poses a threat to the advancement of evidence-based restoration.

Keywords: long-term monitoring, project design, resource limitations.

Introduction

Conservation is undergoing a revolution, where evidence-based practice is emerging as a new approach (Ferraro & Pattanayak 2006; Pullin & Stewart 2006; Roberts *et al.* 2006; Pullin & Knight 2009). Effective conservation requires knowledge of which actions do and do not work, or how effective a given action has been in achieving objectives (Pullin & Knight 2001). Evidence-based practice is the process of systematically finding, appraising, and using evidence of effectiveness to inform decision making (Sutherland *et al.* 2004). Such evidence is usually available in the form of published research findings. It has been documented, however, that decision-makers in conservation do not often use such scientific evidence to inform their decisions (Pullin *et al.* 2004; Cabin *et al.* 2010; Cook *et al.* 2010). Though experiential knowledge continues to play a role in decision-making, the inherent limitations due to its "personal experience" nature necessitate that such knowledge is used in conjunction with other types of knowledge, e.g. evidence-based knowledge (Cowling *et al.* 2003; Fazey *et al.* 2006).

Adopting an evidence-based approach in conservation makes sense because it facilitates learning from both failures and successes (Salafsky *et al.* 2002; Knight 2006; Hobbs 2009). In addition, this approach seeks to address the question "Do we have the data to show we are making a difference rather than simply assuming we are doing some good?" (Pullin & Knight 2009). Answering this question provides credibility, which in turn may promote public and financial support for conservation activities. As an activity with high implementation costs, ecological restoration could do with such support. Working with a limited budget, decision makers may need compelling evidence to allocate and sustain adequate funding for restoration activities. Moreover, when decision makers in restoration are faced with the question "how to restore?" they may have to choose from a wide range of interventions. For example, a manager in an invasive alien plant management program could choose to tackle the problem using mechanical or chemical means, or even a combination of treatments (Holmes *et al.* 2008). The best decision would be one that takes into account all existing evidence of effectiveness of alternative strategies. Such evidence could be generated experimentally, or could come from real-world applications of the strategies in question (e.g. Fule *et al.* 2002).

Evidence-based restoration requires availability of evidence of impact. In order to fulfill this requirement, managers and implementers of restoration projects need to document (i) the problem they aim to address through restoration, in terms of the current state and the desired state; and (ii) the progress towards the achievement of the desired state. In a case study of South Africa, Ntshotsho *et al.* (2011, Chapter 2 of this thesis) disaggregated the first item into the need for "baseline information collection" and "proper goal setting"; and the second item was defined as the need for "relevant and adequate monitoring". Using a review of 10 restoration programs across South Africa the study found poor goal definition and widespread, but not necessarily relevant, baseline information collection as key challenges. In reviewing monitoring within the programs, a bias towards the monitoring of activities rather than impacts was found, together with inconsistent monitoring of ecological indicators. These findings are not unique to restoration in South Africa and have been a challenge in many forms of conservation globally (Bash & Ryan 2002; Ferraro & Pattanayak 2006; Christian-Smith & Merenlender 2010).

These challenges have been attributed to obstacles such as imperfect knowledge, resource constraints, and short project time spans (Coughlan & Oakley 2001; Havstad & Herrick 2003; Legg & Nagy 2006; Field *et al*. 2007; Hobbs 2007; Morton *et al*. 2009). Most of these obstacles have been put forward by scientists working in the field of monitoring and evaluation, rather than practitioners actually implementing the projects. Because scientists and practitioners often operate in different cultural environments, with different goals and motivations (Roux *et al.* 2006; Gibbons *et al.* 2008), obstacles cited by scientists may not necessarily reflect those encountered by practitioners. I propose that an improved understanding of the obstacles encountered by practitioners and managers in the actual generation of evidence will help to advance evidence-based restoration. This study builds on to a previous study (Ntshotsho *et al.* 2011; Chapter 2) by exploring practitioners' and managers' perceptions of the evidence base for restoration and the obstacles they encounter in the actual generation of evidence. An understanding of these challenges is likely to help with the formulation of strategies and methods to overcome them.

Methods

Questionnaire design and administration

A computerized, self-administered questionnaire (CSAQ) was used to gather information for Ntshotsho *et al.* (2011) and for this study (Addendum B). The three sections of this questionnaire relevant to this study focused on role player perceptions and obstacles around baseline information collection, goal setting and monitoring. I classified baseline and monitoring indicators and goals as either socio-economic (e.g. jobs created, poverty alleviation) or biophysical (e.g. species richness, water flows). Respondents were asked to:

- rate the adequacy of collection of baseline indicators used in their projects (adequacy, in this instance, referred to whether sufficient information was collected for a particular baseline indicator in order to measure subsequent success/effectiveness of the intervention);
- identify obstacles to adequate baseline indicator collection;
- comment on what could be done to increase the adequacy of baseline indicator collection;
- identify obstacles to the documentation and quantification of goals in their projects;
- comment on the setting of goals of restoration;
- identify obstacles to monitoring and comment on what is needed to increase the incidence of long-term monitoring.

In addition, respondents were asked to name their primary role in their chosen projects.

The questionnaire was piloted among 11 respondents, and completed by seven. The final questionnaire was sent as a link by e-mail to a total of 85 potential respondents. Follow-up reminders were sent at three week intervals for two months.

Sample selection

I primarily used purposive sampling (Babbie & Mouton 2001), choosing the sample on the basis of my knowledge of the population. In using this method, I approached individuals involved in the same projects that were evaluated in an earlier study (Ntshotsho *et al.* 2011; Chapter 2). In addition, I used snowball sampling (Babbie & Mouton 2001) to make the sample more representative. I asked the initial respondents to suggest other potential correspondents, either within or outside their projects.

Data analysis

Data were imported from the collector into Microsoft Office Excel 2003 (Microsoft Corporation, UK). Data were coded and analyzed. Analysis included histograms, probabilities and testing for associations. The Z test was used to test whether observed values were significantly different from that expected from chance alone. Because I was interested in the responses of practitioners and managers, I excluded responses from people who had classified themselves as researchers from the analyses.

Results

Response rates and roles of respondents in restoration

Forty four out of 85 people completed the survey. This response rate was more than the 50% recommended as adequate for analysis and reporting (Babbie & Mouton 2001). Almost half of the respondents were coordinators and/or facilitators, a quarter of them were researchers, 16% were practitioners, while 11% classified themselves as having other roles. Henceforth the term "respondents" will refer to the 33 non-researcher respondents.

Baseline information collection, goal setting and monitoring

For nine of the 17 baseline indicators significantly more than half of the respondents who had identified them as applicable to their projects rated their use as adequate to very adequate (Fig. 3.1). Only the baseline indicator "belowground carbon stocks" was rated as adequate to very adequate by significantly less than 50% of the respondents in whose projects it was applicable.

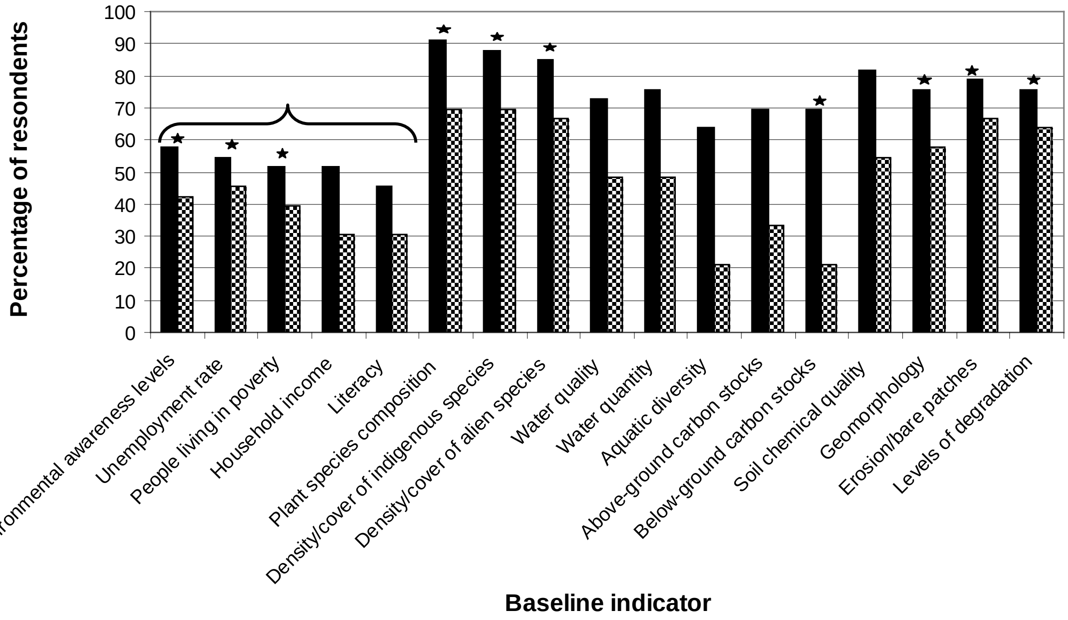

Fig. 3.1. Percentage of respondents who indicated that, in their respective projects, baseline information was collected (solid black bars) and that the collection thereof was adequate to very adequate (checker board bars) for 17 selected indicators. Stars denote that the proportion of respondents who rated the collection of baseline information for a particular indicator as adequate to very adequate was significantly different from an expected 0.5. The bracket denotes socio-economic baseline indicators.

Of the 14 goals, only four were said to be stated in writing by 70% or more of the respondents (Fig. 3.2.). Even lower percentages (less than 62% in all cases) of respondents indicated that the goals applicable to their projects were quantified. For example, 82% of the respondents said job creation was an applicable goal in their projects. But 70% and 61% respectively said this goal was stated in writing and quantified.

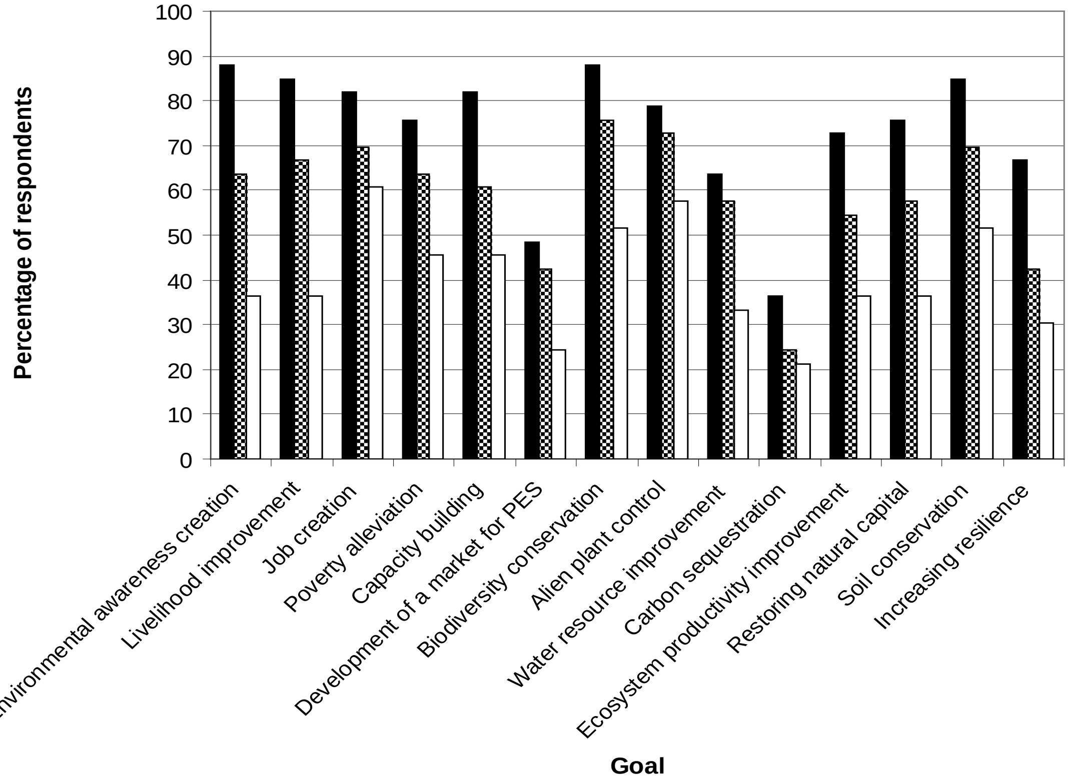

Fig. 3.2. Percentage of respondents who identified different restoration goals as applicable to their projects (solid black bars); stated in writing (checker board bars) and quantified (clear bars).

When reviewing monitoring of the restoration programs, consistent monitoring (defined here as monitoring at all project sites) was relatively more common than long-term monitoring (monitoring beyond the implementation phase), especially in the case of socio-economic indicators and indicators of activities (Fig. 3.3).

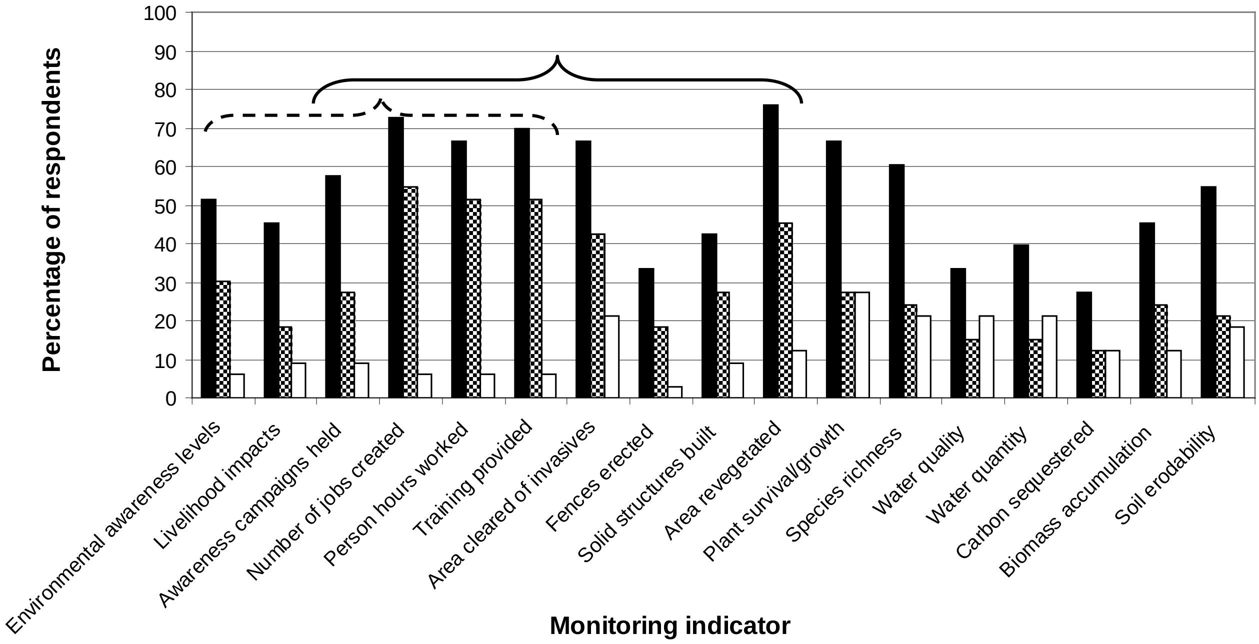

Fig. 3.3 Percentage of respondents who indicated that the 17 indicators shown were monitored (black bars) consistently (checker board bars) and in the long term (clear bars). Indicators underneath the solid line bracket are based on activities undertaken (and not on outcome and impact) and those underneath the dashed bracket are of a socio-economic nature.

The three most consistently monitored indicators (cited by over 50% of the respondents) were indicators of activities associated with employment creation and capacity building. Long-term monitoring was limited, with none of the indicators being cited by more than 30% of the respondents as monitored beyond the implementation phase. For all the socio-economic indicators, less than 10% of the respondents indicated that they were used in long-term monitoring. Overall, the percentage of respondents identifying any indicator as applicable to their project was always higher than the percentage who indicated that such indicator was monitored consistently and in the long term.

Perceived obstacles

Overall, the proportion of respondents (0.42) who did not identify any obstacles to the three components of evidence generation was not significantly different from 0.50, i.e. from chance alone (Z = -1.02, $p \leq 0.05$). However, when I disaggregated the three components it became evident that significantly more than half of the respondents did not perceive any obstacles to the collection of baseline information and monitoring (0.84, $Z = 6.45$, $p \leq 0.05$ in both cases), while about 0.52 did not perceive any obstacles to goal setting ($Z = 0.20$, $p \leq 0.05$).

This perceived lack of obstacles to the collection of baseline information and monitoring was also reflected in the numbers of obstacles identified in association with these variables, four and three, respectively (Table 3.1).

Table 3.1. Types of obstacles associated with the collection of baseline information, goal setting and monitoring, as identified by respondents. ToRs stands for "terms of reference".

Variable	**Obstacle**	**Percentage of respondents citing obstacle**
Baseline indicators	Not part of ToRs	9
	Lack of funds	6
	Lack of time	6
	Lack of expertise	3
Goals	Not all goals can be quantified	36
	Stakeholders are vague about what they want	15
	Lack of resources	12
	Not necessary to specify and quantify goals	12
	Goal not part of ToRs	6
	Goals change all the time	3
Monitoring	Lack of funds	12
	Lack of capacity	12
	Lack of knowledge	9

The major obstacle identified with baseline indicators was their not being part of the terms of reference. Though few respondents perceived obstacles to monitoring, when asked what could be done to increase the incidence of long-term monitoring, 21% stated that provisions for monitoring should be entrenched in the decision-making process. Another 24% mentioned that adequate provision of funds would assist, which is double the percentage of respondents who cited lack of funds as an obstacle. In reviewing obstacles associated with goal setting six obstacles were identified, including lack of resources and not being included in the terms of reference. Almost 40% of the respondents asserted that "not all goals can be quantified" and this was the single most cited obstacle to goal setting. Despite this, when asked to agree or disagree with the statement that for ease of measurement it is preferable to set quantitative goals instead of qualitative ones, 88% of the respondents agreed.

Discussion

Adequacy of the evidence base

The limitations observed in both this study and the previous one (Ntshotsho *et al.* 2011) in terms of baselines, goals and indicators were not reflected in the responses of the practitioners I surveyed. The respondents perceived the evidence base to be largely adequate. One source of this incongruence could be a mismatch between scientists' and practitioners' views of the need for a strong evidence base. It may be that practitioners think the evidence is adequate, because they don't actually use it often in their decision-making. There have been several studies about the use evidence versus intuition by managers (Pullin *et al.* 2004; Cook *et al.* 2009). The challenge is to find out whether the activities of goal setting, baseline information collection and monitoring are really undertaken in order to build an evidence base for use in subsequent decision-making. If, however, these things are done solely for compliance and record-keeping purposes, then they do not contribute to the advancement of evidence-based restoration.

In light of the mismatches in perceptions stated above, it was perhaps not surprising to observe that few respondents identified obstacles to building and strengthening the evidence base. For example, the ratings of high adequacy of baseline information collection, coupled with the mentioning of few obstacles by an insignificant proportion of respondents, imply that respondents are either not aware of, or do not perceive any problems. Similarly, the fact that few respondents identified any obstacles to monitoring may imply that respondents do not perceive the low incidence of long-term and consistent impact monitoring as a potential problem. Though the case for the adoption of an evidence-based approach towards conservation has been strongly made in scientific literature, if practitioners perceive the current status of the evidence base as adequate, then there is little motivation for improvement. Why fix something if it's not broken?

Obstacles to building the evidence base

While few respondents identified obstacles, I feel that the types of obstacles identified are important. Resource constraints, which included funds, time and human resources, were the dominant category of obstacles to baseline information collection and monitoring. Though only 12% of respondents cited a lack of funds as an obstacle to monitoring, costs are a central issue in long-term monitoring (Coughlan & Oakley 2001). Short-term grants, which translate into short project time-lines, may therefore be partially responsible for the low incidence of long-term and consistent monitoring of impact. Because some outcomes and impacts of restoration may only become apparent years after implementation, it may be considered worthless to monitor them in projects with short life-spans. It has been suggested that funding commitments should be sufficiently long-term (a minimum of ten years) in order to allow detection of ecological change (Field *et al.* 2007). I also suggest that voluntary participatory monitoring, which has been shown to yield reliable data (Danielsen *et al.* 2007; Everson *et al.* 2007), be adopted to perpetuate impact monitoring beyond the active phase of projects. Implementing these two suggestions would address all three resource constraints (i.e. funds, time and workforce).

The second category of obstacles, which centered around planning and management of restoration projects, dominated goal-setting. Clear enunciation of goals is essential for success and the ability to assess progress towards success (Hobbs & Harris 2001; Ryder & Miller 2005; Hobbs 2007). The obstacles cited (e.g. vague goals; goals changing all the time) therefore pose a direct threat to restoration success. One way of ensuring that goals are clear, realistic and achievable is to state them quantitatively. However, while quantification of goals is sometimes necessary for ease of evaluation, I am also cognizant of Einstein's wisdom: "Not everything that counts can be counted (quantified), and not everything that can be counted counts", a sentiment reiterated by many respondents. As such, I am not advocating for the discarding of qualitative goals such as "increasing resilience". Rather, I recommend a hierarchical approach to goal-setting (Tear *et al.* 2005), with overarching goals stated and supported by several measurable targets.

While I concur that the resource constraints and management challenges identified are a threat to building a strong evidence base, I propose that the observed practitioners' perception of the evidence base is an even bigger threat. If we are to exploit the potential of practical restoration to generate valuable evidence, then practitioners need to appreciate the need thereof in order to facilitate it. To build a strong evidence base, practitioners would need to apply the same scientific rigor that goes into testing hypotheses. Although this may seem like a tall order, it is necessary to "ensure that limited (financial) resources make a difference"

(Ferraro & Pattanayak 2006). Support of this ideal by practitioners would reduce the supposed reliance on experimental evidence and thus change the way we currently view evidence-based practice (i.e. as a one-way transfer of information from research to practice).

Acknowledgements

The financial assistance of the National Research Foundation (NRF) and the Council for Scientific and Industrial Research (CSIR) towards this research is acknowledged. I also thank survey participants for their input.

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Chapter 4

Practitioners are the missing link in restoration's "knowing-doing" gap

This chapter is intended for submission to the journal *Ecology and Society* as:
Ntshotsho P., Esler K. J. & Reyers B. Practitioners are the missing link in restoration's "knowing-doing" gap.

"Good environmental science develops out of a diverse effort.
People with many different kinds of expertise contribute to
building bodies of knowledge" (M. Ingram 2009).

Abstract

The gap between science and practice is a key challenge in the field of ecological restoration. While there are multiple drivers behind this gap, and many potential solutions proposed, most focus on mainstreaming scientific knowledge and information into practice. However, considering how little is known about the impacts of restoration interventions, I propose that information generated through practice can also be valuable in bridging the science-practice gap. Using eight restoration programs in South Africa, I explored this gap in restoration. I compared information available in documented sources with information I obtained through a survey of practitioners in restoration. The results show that a considerable amount of the information that is not easily accessible in documented form is known by the practitioners. I thus emphasize the need for the documentation of practitioner knowledge and the formation of platforms to promote information sharing between and among all role-players in restoration. A mind shift towards the acknowledgement of the value of evidence generated through practice, and the recognition that the knowing-doing gap can be narrowed by regarding all role-players as important contributors is needed.

Keywords: Evidence-based practice; information sharing; knowing-doing gap; restoration.

Introduction

The "great divide" (The Voice of Nature 2007) between the science and practice of conservation and ecological management has received a lot of attention recently. The reasons for, and the implications of, this great divide have been widely discussed (Shackleton *et al.* 2009, Sunderland *et al.* 2009), a key culprit often being cited as the lack of knowledge and information transfer between scientists and practitioners, with the former writing and publishing information-packed articles that are seldom, if ever, read by the latter (Sutherland *et al.* 2004, The Voice of Nature 2007, Arlettaz *et al.* 2010). This has resulted in several efforts to bridge this divide through the dissemination of pertinent information packaged as user-friendly products in recent years, making scientific information and knowledge more accessible to practitioners (Pierce *et al.* 2005, Knight *et al.* 2006, Reyers *et al.* 2007, Gallo *et al.* 2009, Banks and Skilleter 2010).

The way in which the science-practice gap has often been discussed, however, implies a one-directional flow of information, where science is often depicted as "informing" practice, and scientists and practitioners are referred to as "experts" and "information users", respectively (Pullin *et al.* 2004, Roux *et al.* 2006, Knight *et al.* 2008, Sunderland *et al.* 2009, Esler *et al.* 2010). This implies no potential for reciprocal sharing of information from the practice to science. If, however, we consider practice as a long-term experiment (Carpenter *et al.* 2009), we will appreciate the knowledge generation capacity thereof. Globally and locally, practical strides that are cognizant of the need for co-learning between science and practice (Roux *et al.* 2006) in order to bridge the great divide have been taken (e.g. CEBC 2003, Pierce *et al.* 2004, Knight and Cowling 2006, Shackleton *et al.* 2009, CEE 2010). Such information sharing networks serve as reference points for information seekers. For example, someone looking for information on practical conservation and/or research activities in the Fynbos or Thicket biome in South Africa can contact the Fynbos and Thicket Forums, respectively (Fynbos Forum 2007; Thicket Forum 2010).

The science-practice gap is a challenge in the field of ecological restoration (Young *et al.* 2005, McDonald and Williams 2009, Aronson *et al.* 2010) and has been cited as an important factor limiting the science and practice of restoration (Cabin *et al.* 2010). This gap has been blamed on the "unwillingness of ecologists to acknowledge the literature of practitioners" (Clewell 2009) and the practitioners' continued reliance on their own experience instead of scientific publications (Bernhardt *et al.* 2007). Attempts at bridging this gap have been made (Barac *et al.* 2004, Jenkinson *et al.* 2006), with the biggest global attempt being that of the Society for Ecological Restoration (SER) in establishing the Global Restoration Network (GRN) (SER 2010). The GRN aims to collate information and individual experiences into a substantial dataset that could be used as a body of evidence to support decision making in restoration.

However, the question remains whether such a data set is the right mechanism to not only facilitate information transfer from scientists to practitioners, but the other way too. For example Seavy and Howell (2010) and Bayliss *et al.* (2012) have demonstrated that practitioners rated web-based tools and databases lower than direct interactions with scientists and colleagues in terms of decision support. Indeed, it has been suggested that an effective way of promoting mutual exchanges between scientists and practitioners would be events that bring together stakeholders from both sides (Cabin *et al.* 2010). Such in-person interactions could foster the formation of social networks, which are an important determinant in the flow of information within communities (Crona and Bodin 2006) and have proven effective in bridging the gap in the field of conservation (Shackleton *et al.* 2009).

It would thus seem that the bridging of the science-practice gap relies strongly on fostering relationships between and among all stakeholders, which in turn facilitates the flow of information, which would otherwise not happen as easily. Indeed, in previous work assessing the evidence base status of restoration practice in South Africa (Ntshotsho *et al.* 2011; Chapter 2), I could not find sufficient sources of information using document databases (e.g. journals, websites and internet searches) alone. I subsequently contacted practitioners in restoration to find more information on the programs they were involved in. This prompted me to further examine the information access gap in order to understand how this might impact on the evidence base and its use in restoration practice.

Methods

I compared information available on the web and from the restoration programs in sources such as reports and other available literature (hereafter referred to as documented evidence) with information gathered through a survey of role-players (hereafter referred to as known evidence). I asked the following questions: 1) How different is the documented information from the information that is known by practitioners? and 2) What are the opportunities for, and constraints to, moving towards better sharing of information and therefore improved learning and management practices in restoration?

Documentation survey

I used ScienceDirect, GoogleScholar and Google to search for documented information on the following restoration projects and programs (henceforth programs) based in South Africa: Okhombe rehabilitation project; LandCare South Africa; post-mining restoration[2]; Working for Water; Working for Wetlands; the African Rural Initiatives for Sustainable Environments (ARISE) project; the Matiwane forest restoration project and the Subtropical Thicket

[2] We focused on the rehabilitation programs of three anonymous mining companies.

Restoration Project (STRP), the last three being sub-programs of the Working for Woodlands program (see Addendum B for short descriptions of programs). These programs were chosen because they represent a range of types and scales of restoration programs, including the biggest restoration programs underway in the country. The search phrases I used were different combinations of the program names and the following terms: ecological; post-mining; restoration; rehabilitation; revegetation; project/s and program/s. I only considered results from the first 20 hits of each search because generally, web search results are arranged in order of decreasing relevance. I thus decided to limit ourselves to the 20 most relevant hits for each search phrase set. I also searched the websites of programs, where available, and contacted program managers and/or coordinators to seek further sources of documented evidence. Sources obtained included online newsletters; electronic databases; technical reports; periodic (primarily annual) reports; business plans; student dissertations and published research papers. The following information was extracted from these sources: goals of restoration; baseline measures used and indicators monitored. I focused on these variables as they are central to improved understanding of the effectiveness of restoration interventions (e.g. Ntshotsho *et al.* 2011)

Practitioner survey

I conducted a survey among managers, practitioners and researchers (hereafter referred to as practitioners) involved in the eight programs I were assessing in order to extract the same information I had searched for in the documented sources (i.e. goals of restoration, baseline measures used and indicators monitored). However, instead of being asked to name applicable items, the respondents were asked to choose these from given lists, which had been prepared using information gathered from documents and a pilot survey. In addition to asking about baselines, goals and indicators, I also asked the respondents to tell me about information dissemination needs and challenges (Addendum B for the questions). I used both purposive and snowball sampling (Babbie and Mouton 2001), first targeting practitioners who were known to me and then asking them to suggest other potential respondents.

A computerized, self-administered questionnaire (CSAQ), containing mostly closed-format questions, was used to conduct the survey (Addendum B). I asked the respondents to: (1) choose from the given lists, baseline measures; restoration goals; and indicators used in monitoring (henceforth indicators) that were applicable to their programs; (2) list the communication mechanisms used to share information pertaining to their programs and their impacts with other parties; and (3) rate how likely they were to use an information sharing platform to disseminate information about their programs and to learn about other programs, and what would influence the likelihood of using such a platform.

The questionnaire was piloted among 11 respondents, and completed by seven. The final questionnaire was sent as a link by e-mail to 85 respondents, 55 of whom belonged to the eight programs I selected for this assessment. Follow-up reminder mailings were sent at three week intervals for two months and a response rate of 49% was obtained from the 55 relevant to this study.

Data analysis

In order to prepare the two different data sets for analysis, results had to be standardized and made comparable for assessment of significant differences. For the data obtained from documented sources, each item (i.e. a particular baseline measure, goal or indicator e.g. species richness) was scored once for each program in which it appeared, irrespective of how many times it appeared in different sources. For example, the baseline measure "unemployment rate" was only counted once for program X, even if it was mentioned in five information sources from that program. This was done in order to correct for reporting rate effects. The final score for each baseline measure, goal and indicator was the count of programs in which it appeared (varying from 1 - 8).

The role-player survey data were imported from the collector into Microsoft Office Excel 2003 (Microsoft Corporation, UK). I coded and analyzed responses as follows: for baseline measures, goals and indicators the responses "yes" and "no" were coded as "1" and "-1", respectively, while the code "0" was assigned to the responses "I do not know/blank". It was necessary to code the responses in this way because they belonged to three distinct categories (positive; negative; and ambiguous) and each had to be given a score, unlike the data from documents where the only "response" was a mention of a particular item, which was equivalent to "yes". Disregarding negative ("no") and ambiguous ("I do not know/blank") responses from the survey would have biased the results. For each program coded responses from all the respondents within that particular program were averaged to provide the final score. Thus, if within a program one respondent answered "yes" (equivalent to 1) and another one answered "no" (equivalent to "-1", the average for these responses would be "0" (equivalent to an ambiguous response). For each baseline measure, goal and indicator, the final count (i.e. the number of programs for which each item was applicable) was a sum of positive averages.

Because the original prediction was that frequencies for known evidence would be higher than those for documented evidence, I performed a one-tailed Z-test, at 90% confidence interval (due to the small sample size), to test for differences. Data were used to produce tables and charts in Microsoft Office Excel 2003.

Results

The discrepancies between documented and known evidence are shown in Tables 4.1 to 4.3. In total, 15 known baseline measures were used in the restoration programs, while only ten of these baseline measures appeared in the documented evidence (Table 1). Moreover, eleven of the known baseline measures were used in significantly more programs than indicated in the documented evidence.

Table 4.1. Number of restoration programs in which the baseline indicators were used, as indicated by documented and known evidence. Asterisks denote significance at 90% confidence level (N = 8).

Baseline indicator	Documented	Known	Z-value
Environmental awareness levels	0	3	1.28*
Unemployment rate	0	4	1.73*
People living in poverty	0	3	1.28*
Household income	0	3	1.28*
Literacy	1	2	0
Measures of biodiversity	4	8	1.73*
Density/cover of alien species	3	7	1.55*
Water quality	2	7	2.02*
Water quantity	2	6	1.50*
Aquatic diversity	0	6	2.58*
Carbon stocks	2	6	1.50*
Soil chemical quality	2	5	1.01
Geomorphology	1	6	2.02*

Erosion/bare patches	5	7	0.58
Levels of degradation	6	8	0.76

While all listed goals were found in both the documented and known evidence, 11 of the 13 goals were used in more programs according to the practitioners than was stated in documents, but the differences were only significant for three of the 13 goals (Table 4.2). Biodiversity conservation and water resource improvement were the only goals that appeared more frequently in the documented evidence than in the known evidence, but this difference was not significant.

Table 4.2. Number of programs in which the listed restoration goals were used, as indicated by documented and known evidence. Asterisks denote significance at 90% confidence level (N = 8). PES = payment for ecosystem services.

Restoration goal	Documented	Known	Z-value
Environmental awareness creation	3	7	1.55*
Job creation	6	8	0.76
Poverty alleviation	6	8	0.76
Capacity building	7	8	0
Development of a market for PES	3	4	0
Biodiversity conservation	7	5	0.58
Alien plant control	5	6	0
Water resource improvement	8	6	0.76
Carbon sequestration	3	4	0
Ecosystem productivity improvement	5	8	1.28*
Restoring natural capital	1	7	2.50*
Soil conservation	6	7	0
Increasing resilience	4	6	0.52

Fourteen indicators were used in monitoring. However, according to the known evidence, more than half of these indicators were used in more programs than indicated in documented evidence, but these differences were only significant for two of the indicators (Table 4.3). Four indicators were cited equally in both documented and known evidence, while three indicators were cited in one more program in documented evidence than in the known evidence.

Table 4.3. Number of programs in which the listed indicators were used in monitoring, as indicated by documented and known evidence. Asterisks denote significance at 90% confidence level (N = 8). IAS = invasive alien species.

Indicator	Documented	Known	Z-value
Environmental awareness levels	1	4	1.08
Awareness campaigns held	4	4	-0.5
Number of jobs created	4	6	0.52
Livelihood impacts	3	4	0
Training provided	7	7	-0.76
Area cleared of IAS	3	5	0.5
Fences erected	2	2	-0.58
Solid structures built	2	3	0
Area revegetated	5	8	1.28
Plant survival/growth	2	7	2.02*
Measures of biodiversity	6	5	0
Water quantity	3	2	0
Water quality	2	2	-0.58
Carbon sequestered	3	2	0
Biomass accumulation	2	4	0.52
Soil erodibility	1	6	2.02*

According to the practitioners, a variety of mechanisms was used for information dissemination in the programs, ranging from written material to in-person interactions (Fig. 4.1). The most commonly used mechanism was conference presentations, as indicated by 85% of the respondents. Periodic organization reports and popular articles were also common, cited by 70% and 63% of the respondents, respectively. Journal articles were cited by 44% of the respondents, making them the least popular mode of communication.

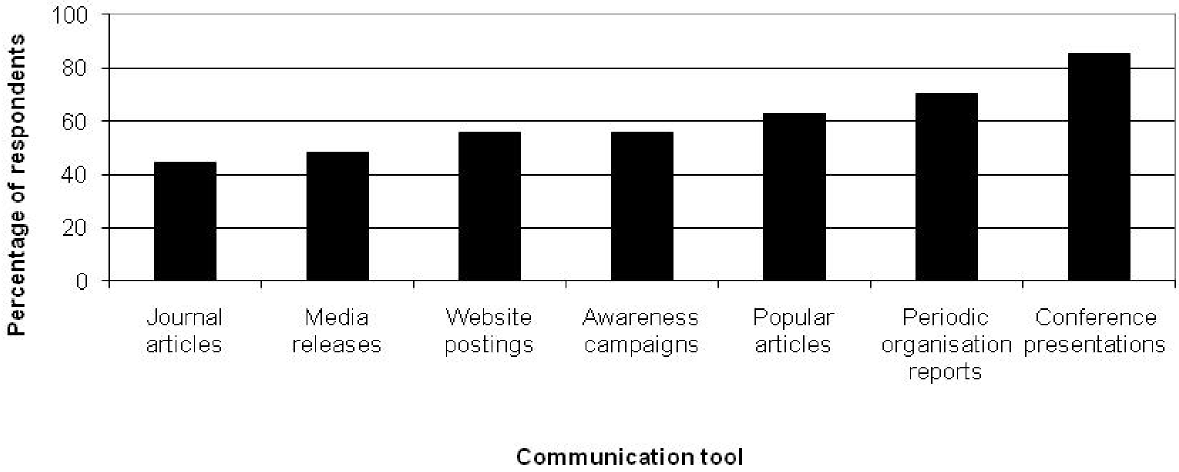

Fig. 4.1. Communication mechanisms used to share information pertaining to restoration programs (categories are not mutually exclusive).

A high proportion of respondents indicated that they were likely (48%) or highly likely (26%) to use a common platform (e.g. a web-based portal) to share information about their programs, and in turn, learn about others. Twenty two percent said they were unlikely to and four percent were unsure if they would use such a platform. Despite a high proportion (74%) of role-players having indicated that they were highly likely or likely to use the information sharing platform, 56% and 33% of all the practitioners indicated that their use of such a platform would be limited by time and funding constraints, respectively. Nineteen percent also indicated that their organization's privacy policy would limit their use of the platform, while 7% said they would not be interested. Concerns about standardization and quality control were also mentioned as potential limiting factors.

Discussion

The one-sided portrayal of the knowing-doing gap undervalues the knowledge generation potential of restoration practice. Contrary to this, my results show that information is generated in practice, notwithstanding that it is mostly undocumented and stored as experiential knowledge. Some of this information is rather crucial in determining restoration effectiveness (e.g. measures of plant survival and soil erodibility). Lack of documentation thus means that a lot of the information remains inaccessible for studies which assess intervention effectiveness, and therefore unusable in decision support. For example, the observed significant difference between documented and known use of baseline measures means that the end user cannot reliably assess the degree of effectiveness of an intervention, based on the documented indicators alone, because the starting point appears to be unmeasured.

Of course it should also be noted that the discrepancies between what is documented and what is known may be a result of factors other than the lack of information documentation. Such other factors could include a social desirability bias (Babbie and Mouton 2001), in that practitioners could have selected answers from the lists I provided not necessarily because they were currently true, but because they wanted them to be true. This raises concerns about reliability and validity of the information supplied by the practitioners. Indeed, this is one of the strongest criticisms against expert opinion (Kangas *et al.* 1998, Cowling *et al.* 2004). One way of addressing these concerns would be to verify the claims by requesting evidence of the assertions. I thus emphasize the need for translation of experiential knowledge into information that is documented in a quantitative manner, giving details of what, how and why an intervention was used (Fazey *et al.* 2006) and what its outcomes were. This is crucial to enable the use of such knowledge as evidence. Journals such as Ecological Restoration and Conservation Evidence actively encourage practitioners to publish their work in a format that can be used as empirical evidence.

My ability to access a wider evidence base, through surveying role-players in restoration, implies that eliciting explicit and implicit experiential knowledge (Fazey *et al.* 2006) is an important component of the science and practice of restoration. This highlights the importance of "networks" in the flow of information and knowledge and gives meaning to the expression "what you know is who you know" (Crona and Bodin 2006). But, the question arises whether this reliance on networks for information access tips the field back into anecdote, the very problem that evidence-based practice aims to cure. This, once again relates to concerns about validity and reliability, which can be resolved by backing claims with documented evidence. However, some of the differences I observed, between what the literature said and what the practitioners said, might not necessarily be about the lack of documentation of evidence, but rather a result of that documented information not being easily accessible to people outside the "network". For example, it is easier for one to be aware of, and gain access to periodic organization reports (the second-most popular communication tool identified by the respondents) if one is "connected" to others in the organizations concerned. Furthermore, the ties that bind network participants promote mutual trust and reciprocity (Bodin and Crona 2009), potentially providing a safety net against making false claims. Recognition of the significant role networks can play in learning about how to better manage natural resources is evident in the proliferation of publications on this subject (e.g. Gibbons *et al.* 2008, Muro and Jeffrey 2008, Cabin *et al.* 2010, Crona and Hubacek 2010, Reed *et al.* 2010, Seavy and Howell 2010, Rodela 2011). Society meetings and conferences already provide an opportunity for in-person interaction. Such events could be organized in such a way as to connect the right people and allow them to share specific information related to their needs. For example, special sessions and symposia, where a large portion of the time is dedicated to discussions and exchange of ideas around a specific topic, are often a prominent feature of conferences. Ideally, conferences should act as a breeding ground for the formation and or strengthening of social learning communities, partnerships and forums. Such information sharing networks, in turn, would not only serve as reference points for information seekers, but also enable the documentation of experiences and distilling of lessons, thereby facilitating co-learning between and among scientists and practitioners. Encouragingly, my results show that conference presentations are the most popular means of disseminating information among the practitioners I surveyed. One can only hope that the conferences are interactive and that conversations continue beyond the duration of the conferences.

The depiction of scientists and practitioners as “experts” and “information users”, respectively, in literature discussing the science-practice gap raises the question “who is the expert in restoration”? Is it the researcher or the practitioner who is involved, daily, in conducting real-world experiments usually at scales bigger than research grants allow? I suggest a move towards the recognition of practitioners as worthy contributors to the generation of knowledge. Furthermore, with the persistent importance of “expert opinion” in decision support (Pullin *et al.* 2004, Bayliss *et al.* 2012), it is imperative that the term “experts” becomes inclusive of those who have been “trained by practice”. The building of a useful body of knowledge requires that science starts listening to the people who have their feet firmly on the ground (Ingram 2009, Opdam 2010). In considering the need to build networks, organize interactions and share this body of knowledge, it is clear that while respondents expressed a willingness to share information and in turn to learn about other programs, this is constrained by time and funding. As such, a change in incentive schemes and recognition systems is called for. Currently, researchers are generally rewarded according to the number of publications of high ranking (but not necessarily high on-the-ground impact) produced (Born and Boreux 2009). Managers and practitioners, on the other hand, are rewarded for successful project implementation, and not the publication of its impact. The result is the perpetuation of the great divide, where one group is regarded as information producers, and thus more knowledgeable than the other group of "doers". This is where the institutions from within which practitioners operate become crucial. An industry-wide mind shift is needed, where the ongoing co-building and improvement of the body of knowledge will be high on the agenda of all involved. All stake-holders need to come to the realization that evidence-based restoration is not possible without a sound evidence base and that people with different kinds of expertise need to contribute to the building of the said body of knowledge (Ingram 2009).

Conclusion

The knowing-doing gap in restoration is not only characterized by the lack of, or limited flow of information from science to practice, but also by limited access to information generated in practice. My assessment of information potentially obtainable from practice revealed gaps between what the practitioners said and what was documented. The call for the consideration of practitioners and other role-players as valuable contributors to the body of knowledge is by no means meant to advocate for continued reliance on expert opinion, thereby ignoring these gaps. Instead, I suggest that practitioners step up to the challenge of conducting their business in a way that will produce information that is usable as evidence in decision making. Researchers, and indeed all other role-players, need to be receptive and appreciative of the contributions of practitioners to the body of evidence. Institutional support and social networks are identified as enablers of an inclusive community of "knowledge producers".

Acknowledgements

The financial assistance of the National Research Foundation (NRF) and the Council for Scientific and Industrial Research (CSIR) towards this research is acknowledged. The time of all role-players participating in the survey is also greatly appreciated.

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Chapter 5

Exploring the use of scientific evidence in decision making in the Working for Water program

This chapter is intended for submission to the journal *Biological Conservation* as:
Ntshotsho P., Esler K. J. E, Prozesky H. & Reyers B. Is scientific evidence used in decision making? We asked managers in the Working for Water program.

Abstract

Do decision makers in conservation and restoration rely on anecdote and experience for decision support, instead of scientific evidence, as has been suggested in literature? Using an invasive alien plant management program in South Africa, I sought to find an answer to this question, and any underlying explanations for a possible affirmative answer. The assessment showed that the use of scientific evidence may be limited by the fact that the management of natural resources is more than just about science. The social context, which includes organizational structure, priorities and capacity, plays an important part in the extent to which science informs practice. The gap between science and practice was identified as an obstacle to the use of scientific evidence in practice. As such, I highlight the importance of producing valid evidence in practice.

Introduction

Despite widespread acknowledgement that conservation actions are best based on evidence of effectiveness of particular interventions (Sutherland *et al.* 2004; Ferraro & Pattanayak 2006; Pullin & Stewart 2006; Roberts *et al.* 2006; Pullin & Knight 2009), conservation decisions continue to be based on anecdote and experience (Pullin *et al.* 2004; Mathevet & Mauchamp 2005; Cabin *et al.* 2010; Cook *et al.* 2010). This has been attributed to several factors, including lack of, or limited access to scientific evidence (Roberts *et al.* 2006; Gibbons *et al.* 2008). Mathevet & Mauchamp (2005) propose that scientific evidence has a minor role to play in the human processes involved in conservation action. Indeed, if we concur that conservation action takes place in a socio-ecological systems context, we cannot deny that social issues play a paramount role in how decisions are made. Simply put, conservation is less about science and more about people and the choices they make (Balmford & Cowling 2006). The socio-economic and political context, as well as the organizational or institutional confines within which decision makers operate would arguably influence the extent to which decisions are based on science (if at all). For example, it has been noted that deficiencies in institutional effectiveness and organizational capacity are major constraints in the implementation of conservation action (Cowling *et al.* 2008). Thus, a fuller understanding of the management of natural resources requires that we pay attention to social aspects.

Understanding the social aspects of decision and policy-making processes requires a new type of conservation science – one that moves away from a reliance on literature reviews and surveys of scientists (e.g. Knight *et al.* 2008) towards an engagement with key actors in the decision-making context, i.e. the implementers and managers. This should be paired with rigorous and repeatable methods to explore and measure the use of science in decisions and policy. To this end, I developed and conducted an assessment of a large and well-established conservation program: an invasive alien plant (IAP) management program that has been operational in South Africa for nearly two decades (van Wilgen *et al.* 2012). The Working for Water (WfW) program was specifically chosen as a case study because of its long history, which I anticipated would provide an understanding of how decision making processes within the program have changed over time, and the role, if any, of science therein. Moreover, I chose to focus on this program because of its strong socio-political roots, which allowed me to conduct a more integrated assessment, encompassing social considerations, of the evidence-based approach to conservation.

WfW was established in 1995 with the primary aim of clearing IAPs in order to increase water supply, while creating much-needed jobs. From an initial budget of R25 million in 1995, the program has grown to a budget of R1.09 billion in 2012/13 financial year (C. Marais, pers. comm. 2012). The size of the budget alone raises the question, "is the money being spent effectively"? Alarmingly, it has been stated that current rates of, and approaches to clearing are not sufficient to bring the invasion problem under control (Marais *et al.* 2004; van Wilgen *et al.* 2012). This, then, led me to question whether clearing decisions are based on the best available evidence of effectiveness of clearing approaches. WfW is a diverse program, incorporating both socio-economic and biophysical goals, but for the purposes of this study I focused only on the biophysical goals of the program.

The overall aim of the study is to explore the use of scientific evidence in decision making in the WfW program using a case study, a research design traditionally associated with the social sciences. I investigated the extent to which decision makers in the WfW program use scientific evidence to inform their decisions pertaining to the clearing of IAPs and identified opportunities and constraints to evidence-based practice by surveying the sources of information used. I further identified historical events that could have influenced the use of science in WfW.

Methods

Approach

As a research design, the case study approach is used to contribute to the knowledge of individuals, groups, organizations or social phenomena. The design is especially recommended when research questions seek to explain "how" or "why" some social phenomenon works (Yin 2009). In this instance I sought to establish which events or circumstances may have influenced the use of scientific evidence in the WfW program (i.e. "why" is science used [or not] in the program), and "how" scientific evidence is used. When conducting a case study it is recommended that multiple sources of evidence are used (Yin 2009), therefore I used interviews and document analysis in my study.

Management structure review

In any case study of a large program such as WfW, identifying potential respondents is a critical and often challenging task. WfW, while a national program, consists of many regional offices, areas, and projects where many decisions are made (with or without scientific input). Regional offices were contacted to obtain contact details of program leaders, implementation managers, area managers and project managers. Regional program leaders, who are the most senior managers at the regional level, were identified as key actors in decision making processes and were thus chosen as initial respondents.

Manager interviews

Semi-structured interviews were conducted telephonically, in English, with willing respondents. The choice of English was not a limiting factor in respondents' ability to take part in the study because they were competent English speakers. Pilot interviews were conducted with six respondents in order to refine the final interview schedule (Addendum D). Non-random snowball sampling was then used, as the respondents in the initial sample (i.e. regional program leaders) were requested to recommend other potential respondents, based on their own judgment of the potential respondent's ability to provide valuable input. During the course of the interviews it became clear that decision making is largely governed by program guidelines, strategy documents and operating documents (hereafter referred to as policy documents). After 21 interviews, data saturation had been reached (i.e. no new information was forthcoming), and it was decided to cease interviewing. The interviews were transcribed and converted to MS-word documents for analysis.

Document acquisition

Policy documents referred to by respondents were obtained from the following organizational websites: http://www.environment.gov.za/workingforwater/resources/index.htm and http://sites.google.com/site/wfwplanning. Some documents (e.g. a document containing the text of the Conservation of Agricultural Resources Act) were not available from these websites but were obtained via an internet search. Any other documents which were mentioned by respondents as having had an influence on the program's operations, without necessarily being adopted as policy documents (e.g. the article on the extent of invasion, emanating from the Southern African Plant Invader Atlas [SAPIA] project; and the prioritization reports recently produced by the Council for Scientific and Industrial Research [CSIR]) were also obtained, either from the program's websites or via internet searches.

Data analysis

Both the interview transcripts and documents were analyzed using computer assisted qualitative data analysis software (CAQDAS), namely ATLAS.ti (Version 7.0, Scientific Software Development, Berlin). CAQDAS searches, organizes, categorizes and annotates textual data, thus allowing the retrieval of relevant segments of text from large amounts of unstructured textual data (Smit 2005) using codes developed by the researcher. Careful thought needs to go into the coding process, which involves the labeling of selected segments of textual data by means of a summary term that expresses some essential quality of the phenomenon (Charmaz 2006). Below, a description of the coding process I followed is presented.

I primarily used deductive coding, supplemented with a limited amount of inductive coding. Two variables, "key event" and "decision making", were chosen for analysis. For the variable "key event" I used single-level coding and assigned the codes "date" and "event". The variable "decision making" required multi-level coding. Accordingly, the super-family code names "basis for decision making" and "scientific input" were used. The "basis for decisions" on what, where and how to clear IAPs was split into the families (a) historical and (b) current, which were further classified into the codes (i) intuition (which encompassed common sense, convenience, experience, trial and error, or any subjective motivation); (ii) expert opinion; (iii) literature (scientific literature not officially adopted as a guiding document of the program); (iv) policy (encompassing literature, legislation or any guiding document officially adopted for use in the program); and (v) social goals (which referred specifically the program's mandate of employment creation). Scientific input was analyzed in terms of (a) the type; (b) the organizational level at which it was provided (e.g. head office or regional office); as well as (c) the partners involved (these became the code families). Three categories under type of scientific input emerged during the coding, *viz:* (i) formal collaboration (encompassing formal partnerships and research funded by the program); (ii) literature (explicit reference to documented scientific information, whether solicited or not); and (iii) expert knowledge (meetings and consultation with experts, but not necessarily based on official agreements). A schematic representation of the coding levels used for the variable "decision making" is shown in Fig. 5.1.

Results

The timeline depicted in Fig. 5.2. shows events of potential scientific significance for the WfW program. When the program was launched in 1995 there was no comprehensive, up-to-date information on the extent of alien plant invasion in the country. This information became available in 1998, with the completion of the SAPIA project as well as another mapping exercise by Versfeld and colleagues (1998). In 2006 WfW formally partnered with SAPIA, providing it with much-needed funds to keep the mapping project going. Two other strategic partnerships have been formed since the inception of the program, *viz:* (i) the Biocontrol Consortium in 2002 between WfW, the Plant Protection Research Institute (PPRI) of the national Agricultural Research Council (ARC) and several South African Universities; and (ii) the Early Detection and Rapid Response (EDRR) partnership with the South African National Biodiversity Institute (SANBI) in 2010.

WfW underwent its first external review in 1997, after only two years in operation. The program was criticized for not having a national strategy in place to guide its operations – a shortcoming that was viewed as a likely threat to its effectiveness (WfW 1997). This deficiency was addressed with the introduction of a 3-year strategic plan in 2001, outlining the five strategic objectives of the program. Another weakness that was identified concerned the absence of a dedicated research program to address priority research issues. In response, funds were allocated towards research, resulting in an inaugural research symposium in August 2003, where the results of such research were presented. Funding of research is now an integral part of the program, with plans to increase said investment to 5% of the total budget (A. Khan, pers. comm. 2012).

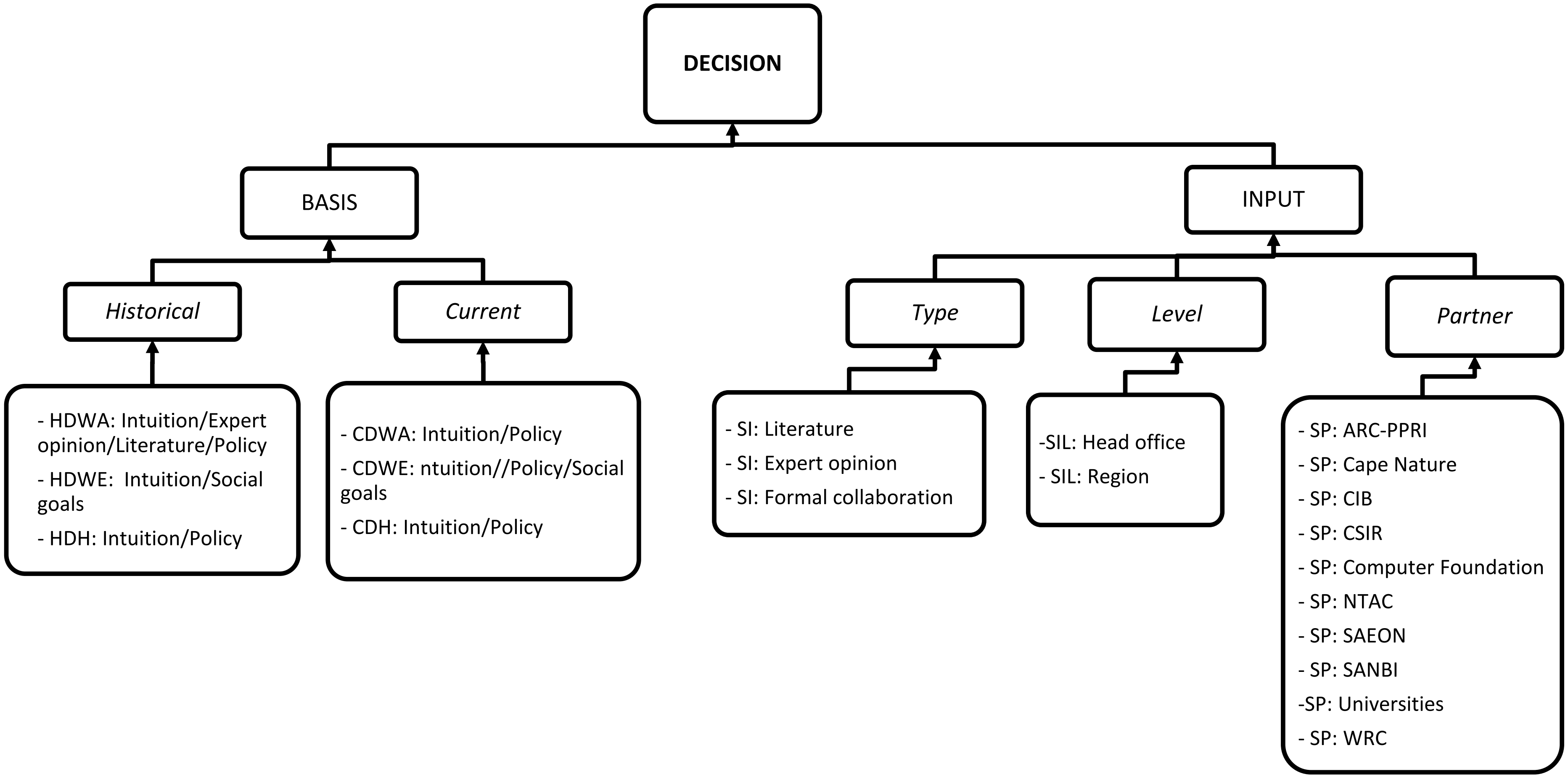


Fig. 5.1. A schematic representation of the coding used for the decision making variable. The lowest levels of the hierarchy (comprising lists) represent the codes. These were then grouped into families (italicized), which, in turn, formed super-families.

Furthermore, the program now boasts a detailed research strategy and action plan that was adopted in 2005, which makes specific allowance for the establishment of a research advisory panel comprised of experts in the field of IAP management. The number of research papers published through the financial support of the program bear testimony to the success of the research initiative. At least two special issues have been published (Issue 100 of the South African Journal of Science in 2004, and issue 74 of the *South African Journal of Botany* in 2008). Another highlight in terms of research collaboration was the establishment of the Centre for Invasion Biology (CIB), based at Stellenbosch University in 2004. The CIB has had close partnership with WfW since inception, and has generated a lot of the evidence base.

In a second external evaluation in 2003, the program was again criticized for having a poor strategy, with no provision for the monitoring and evaluation of ecological impacts and no prioritization of areas and species to target in order to maximize effectiveness. These issues were addressed between 2008 and 2011 in reports prepared for WfW by the CSIR.

Some respondents had been in the program for many years. As such, they were able to provide valuable insight on how decisions were made in the past. Examples of quotations related to the making of decisions both in the past and present are provided in Table 5.1. The findings show that, historically, decisions were mostly based upon intuition, especially when they concerned the locating of clearing operations. This has changed over the years, with policy currently the most important determining factor of what, where and how to clear. Social goals (e.g. job creation), however, still continue to influence where clearing should be done.

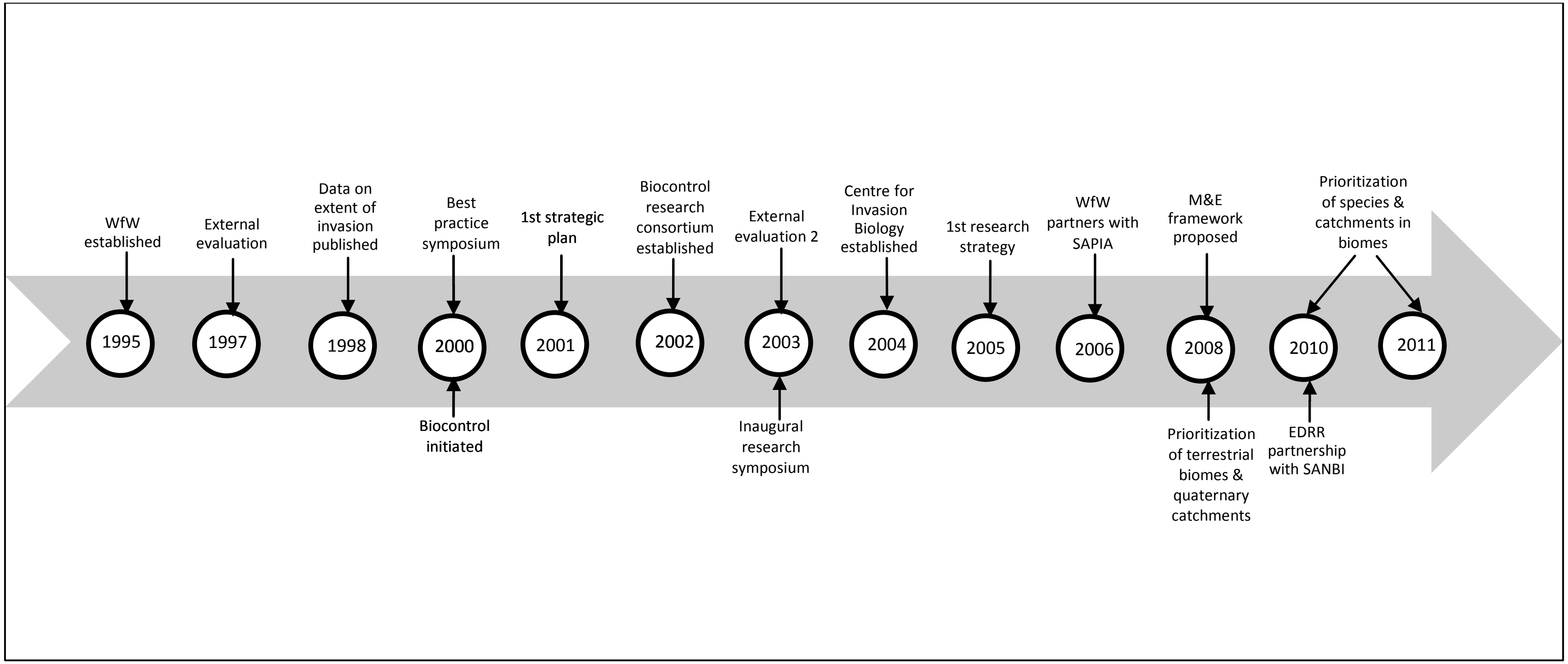


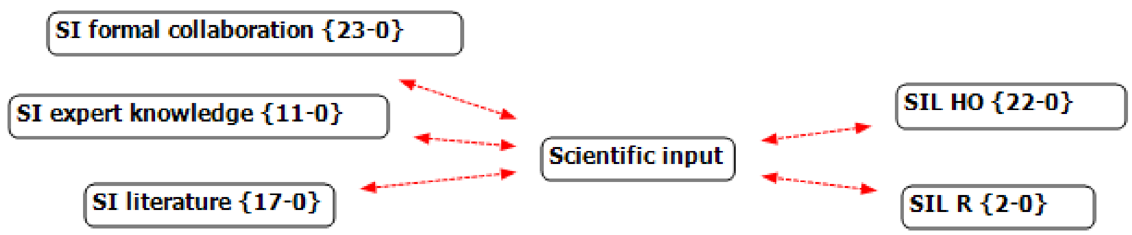
Fig. 5.2. Timeline of events resulting from, or with a potential bearing on, the use of scientific information in WfW. SAPIA = Southern African Plant Invader Atlas; M&E = monitoring and evaluation; EDRR = Early Detection and Rapid Response; SANBI = South African National Biodiversity Institute.

Table 5.1. Basis for historical and current decision making in the WfW program as cited by respondents during interviews. HD = historical decision; CD = current decision; WA = what; WE = where; H = how; Intuition* = common sense, convenience, experience, trial and error; Policy# = guidelines, historical work, manuals, legislation, standards and strategic plans formally adopted in the program; Social goal$ = explicit reference to the social-development mandate of job creation.

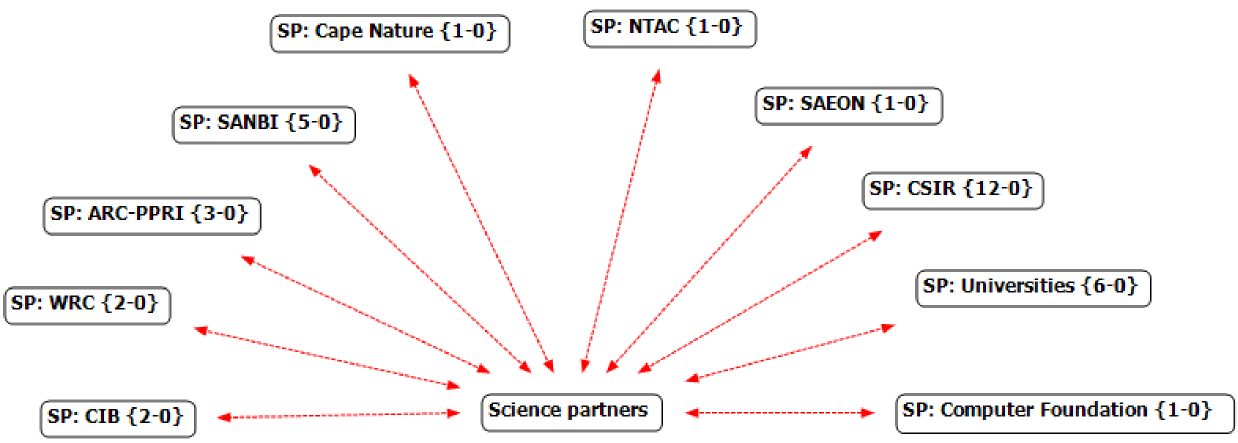
CODE (description) **Basis**	**Example of quotation**	**No. of times identified in transcripts**
HDWA (Decisions on *what* to clear *historically* based on...)		
Intuition*	"It was just: you see a tree, you know, you cut – as long as it's an alien"	1
Expert opinion	"That was also just a process of consultation with the experts".	1
Literature	"There's been a long history of studies actually documenting invasive species that they find around the country".	1
Policy#	"I think initially when the program started, they were just only dealing [with] or using the Conservation of Agricultural Resources Act".	1
HDWE (Decisions on *where* to clear *historically* based on...)		
Intuition*	"At first it was very *ad hoc*, you know, when it started out we would start projects where we had the best opportunity and the best sort of cooperation from private landowners".	9
Social goal$	"[...] also looking at where we've got most poverty in the province".	1
HDH (Decisions on *how* to clear *historically* based on...)		
Intuition*	"The program, a year after it began, I started as a project manager and those days it was trial and error and we had to draw up norms and standards and all these things over the years".	5
Policy#	"When the program was initiated most of the norms came over from the forestry industry".	3
CDWA (Decisions on *what* to clear *currently* based on...)		
Intuition*	"Basically there is no strategy for that […] as long as the area has been infested by alien species of any kind".	5
Policy#	"We've got a legislation which is called CARA".	11
CDWE (Decisions on *where* to clear *currently* based on...)		
Intuition*	"So one would also favor such areas where landowners would say, OK, Working for Water comes in and they do let's say 50% of the area and the landowner, him or herself, would do the other 50%. So we look also at landowner contribution".	9
Policy#	"We've got priority areas which are planned by our national office".	38
Social goals$	"For instance, I've worked in a community where there is not necessarily so many blue gum trees, but the community is a poor community and I recruit the workers from the community".	11

CDH (Decisions on *how* to clear *currently* based on...)		
Intuition*	"But we are a region, we have to decide which one works better for us".	1
Policy#	"The WIMS system would give you the methods, you know, deriving it from the type of plant and the size, etc."	62

Analysis of the interview transcripts identified formal collaboration with science partners as the most common source of scientific input, cited 23 times by respondents (Fig. 5.3a). Literature and expert opinion were also cited as sources of scientific input, but to a lesser degree. An examination of the scale at which scientific engagement occurred, showed that it mostly occurred at the headquarters of the program (right part of Fig. 5.3a). A variety of science partners was named (Fig. 5.3b).



(a)



(b)

Fig. 5.3. Code networks depicting (a) type of scientific input (left part); level at which it is located within the program (right part) and (b) science partners of the program identified by respondents and in documents. The numbers in braces refer to the number of quotations linked to each code. SIL HO = scientific input at head office level; SIL R = scientific input at regional level. Partner acronyms: CIB = Centre for Invasion Biology; CSIR = Council for

Scientific and Industrial Research; NTAC = National Technical Advisory Committee; PPRI = Plant Protection Research Institute; SANBI = South African National Biodiversity Institute; SAEON = South African Environmental Observation Network.

A review of the documents revealed limited reference to scientific literature. Of the seven documents reviewed, only three made explicit reference to scientific literature (Table 5.2). While the remaining documents lacked this clarity, scientific input into their formulation is implicit. For example, the WfW norms and Water Information Management System (WIMS) standards, which are referenced in some of the documents reviewed, are updated regularly as a result of field observations that are conducted in-house and new information that is acquired via various means (e.g. workshops with experts, literature, etc.). The national strategy documents (e.g. the National Biodiversity Strategy and Action Plan [NBSAP] and the National Water Resource Strategy [NWRS]) and relevant legislation from parent departments cited as sources of information are also based, in part, on scientific input.

Table 5.2. List of WfW policy documents analyzed and the sources of information used in their compilation**.** The year in which each document was written is provided in parentheses. Documents that make specific reference to scientific literature are marked with an asterisk. Document marked with "#" was previously known as the "Self-assessment standards".

AMP = Area Management Plan; DWAF = Department of Water Affairs and Forestry; MUCP = Management Unit Clearing Plan RSP = Regional Strategic Plan.

Document name	**Purpose of document**	**Source(s) of information**
Mapping standards (2003)	Sets out the standards for the collection and capture of data for the program's information management system	WfW norms table
Operational methods (2003)	Detailed instructions on how to use the different mechanical and chemical treatment methods	Experience; expert input; field observation
*Herbicide policy (2004)	Provides guidelines on the selection of appropriate methods of control	NDA's "*A guide to the use of herbicides*"; product labels and information brochures issued by suppliers
*Research strategy and action plan (2005)	Outlines the need, and a strategy and action plan, for the implementation of research within WfW	Peer-reviewed scientific literature

#Project operating standards (2007)	Sets out the standards according to which projects must be run and against which their performance must be measured	National mapping standards; Planning guidelines; Herbicide policy; WIMS standards; environmental legislation; WfW biocontrol policy; CARA species list
*Strategic plan 2008-2012 (2007)	Document that sets out a strategy to achieve the program's goals	The National Biodiversity Strategy and Action Plan (NBSAP); the then DWAF's National Water Resource Strategy (NWRS); various pieces of legislation; scientific literature
Planning guidelines (2009)	Specifies how planning documents (RSPs, AMPs and MUCPs) should be drawn up	Vegetation maps; stakeholder consultation; WIMS

Discussion

Science informing policy

An important step in tackling any problem is describing and quantifying it. The extent, as well as the negative ecological and economic impacts, of IAPs have been well-documented (van Wilgen *et al.* 1997; Binns *et al.* 2001; van Wilgen *et al.* 2001; Richardson & van Wilgen 2004). As a matter of fact, the Working for Water program was born out of a science-based realization that, if left uncontrolled, IAPs would have significant negative consequences for South Africa's water resources (van Wilgen *et al*. 2002; Marais & Wannenburgh 2008). The challenge with alien plant invasion is that it is a dynamic process: the picture is constantly changing, both in terms of area and invading species, as new invasions occur. It is thus paramount to regularly quantify the extent of invasions in order to set realistic management goals and monitor progress towards their achievement. In 2003, WfW was criticized for following a control strategy that lacked guidance from up-to-date and comprehensive mapping of IAPs (Common Ground 2003). In response, the program provided funds to revive the SAPIA project in 2006 (Henderson 2007).

Three successive steps – prevention, eradication and control – form the cornerstones of recommended best practices for managing IAS, with prevention widely promoted as the most desirable strategy (Hulme 2006). As early as 2003, WfW allocated funds towards the biological control of emerging weeds (van Wilgen *et al.* 2011). More recently, WfW has collaborated with SANBI in the implementation of the Early Detection and Rapid Response (EDRR) program. EDRR has now become a normal part of operations, whereby field workers are regularly trained in the identification of current and potential invaders. Such initiatives bear testimony to the program's continued reliance on science to optimize its prevention strategy. Tackling already established invaders, on the other hand, is proving a major challenge to the program, as evidenced by the increasing negative impacts of IAPs (van Wilgen *et al.* 2012).

In order to increase effectiveness of the program, it is necessary to pay attention not only to "how" operations are carried out, but also to the questions of "where" and "what" to clear. The program places much emphasis on operations, which addresses the "how". Indeed, this is the one aspect of the program where decisions are most informed by policy, which, in turn is informed by science. WfW has been criticized for initiating too many projects, and targeting too many species in too many areas, to be effective (van Wilgen *et al.* 2012). While the basis for the decision on what and where to clear has historically been intuition (this study), political expediency and/or logistical convenience (WfW 1997; Common Ground 2003), the trend is changing. A scientifically based strategy that takes cognizance of priority areas and species is now being widely adopted. It is particularly interesting to observe the program's drive towards increasing effectiveness through the roll-out of bio-control. Despite concerns, in some quarters, that effective biological control could replace the need for labor-intensive clearing (this study and van Wilgen *et al.* 2012), investment towards biological control has more than doubled: from 1% of the total annual budget in the 2009/10 financial year (van Wilgen *&* De Lange 2011), to 2.8% in the 2012/13 financial year (C. Marais, pers. comm. 2012). It is thus clear that science has had an influence on the WfW program and the formulation of an appropriate control strategy, which is essential to increase effectiveness. The use of reviews has helped to highlight weaknesses and resulted in the allocation of funds towards research to fill the gaps identified. What has emerged from this study, however, is that scientific input and/or collaboration tends to be a relatively high-level concern, dealt with primarily at the national office. That is, science is entering into the decision making process mostly through policy, rather than directly through individuals. While this may be necessary to avoid institutional memory loss as individuals leave the program, it tends to slow down the uptake of new scientific information, as new knowledge cannot be used unless policy is updated.

The need for science uptake at individual level

The program's herbicide policy clearly states that "[…] Working for Water management shall be responsible for determining areas and species to be controlled [...] (and) appropriate methods of chemical control". Thus, senior managers of the program who make major decisions on what, where and how to clear are the ones who engage with scientists. Decisions are then communicated to junior staff via various avenues. For example, project managers undergo regular training to familiarize them with new developments in the program. A negative consequence thereof is a lack among junior staff of understanding and/or appreciation of the science behind the practice, which is reflected in statements such as "My personal observation over the [>10] years is that sometimes the science of the work that we do is being portrayed as being aloof to, or rather at a higher level for a mere project manager to understand"; and "We get, you know, this thing stipulated to say 'this is what you must do'". This perceived exclusivity of science, in turn has the potential to jeopardize the adoption of "imposed" scientific advances at the operational level. As a case in point, one project manager mentioned that the uptake of biological control in his/her region had been slow due to project managers' lack of knowledge of how to implement the method. Indeed, sentiments such as "it takes away the jobs for the previously disadvantaged people" (see also van Wilgen *et al.* 2012) highlight the potential negative effect limited scientific awareness among some program staff can have on the program's effectiveness.

Some argue that levels of scientific literacy and the intellectual demands of accessing and using scientific information are prohibitive to conservation practitioners wishing to use scientific information (Bayliss *et al.* 2012). The history of the WfW program and its employment-creation objective are such that people without the desirable level of scientific training are sometimes appointed. Considering that the management of IAPs is, to a large extent, a scientific endeavor, a certain level of scientific literacy should thus be a prerequisite for working as a manager in the program. Alternatively, the program should encourage a culture of more in-depth scientific training for its employees. In addition to promoting the uptake of science-based policy, widespread scientific literacy could help increase WfW's capacity for collecting and appraising scientific evidence. Thus, instead of the whole program depending on a handful of scientifically trained top managers to obtain cutting-edge science to inform policy, there would be more people involved in the acquisition and use of science.

The need for practical scientific evidence

While access to scientific evidence is a crucial first step in the evidence-based approach (Ntshotsho *et al.* 2012), usability of said evidence is even more critical. Although there is a plethora of literature on the management of IAPs, most publications focus on furthering knowledge of invasive species rather than on implementing that knowledge (Esler *et al.* 2010). This research-implementation gap has been widely discussed in the academic literature (e.g. Roux *et al.* 2006; Sunderland *et al.* 2009), but it was interesting to hear it in the words of a frustrated practitioner:

> What happens is, the guys will have a whole paper, a 50 page document, where they've done all the research, all the calculations. Remember if you are an operator, if you are… call it a doer, you want to implement it. You are not really interested in all the stuff in-between. […] Now you need to write up a sort of an operating procedure on how to put that result into practice. How are we going to change our day-to-day approach to be able to […] do what the researcher thinks we must do.

WfW's research strategy and action plan (WfW 2005) emphasizes the need to invest most of the program's research funding at a level where the knowledge generated through basic research is translated into technologies which managers can then apply to solving the types of problems they face. A brief review of research articles published in a special issue of the South African Journal of Botany dedicated to the WfW program (see Esler *et al.* 2008) shows a trend towards the realization of this ideal. Several articles in the issue make recommendations and even propose tools that can be used to improve the program (see Holmes *et al.* 2008). An alternative way to address the research-implementation gap is through in-house generation of evidence. Evidence-based practice often places emphasis on the need to obtain (external) evidence, thereby essentially downplaying the potential value of generating evidence internally. A laudable strength of the WfW program is that it has, at least in part, followed this alternative approach: through solicited research and the scientific partnerships that have been forged over the years, the program has been growing a body of evidence.

Conclusion

Given the complexities inherent in IAP management that are a result of a combination of the dynamic ecological nature of the problem and its human component, a full understanding of the decision making processes in IAP management also requires a social assessment (Cowling & Wilhelm-Rechmann 2007). Through such an assessment I have demonstrated that, while science can inform practice to (hopefully) improve effectiveness, social and organizational arrangements can limit the use of science. The hierarchical management structure in WfW, for example, renders science “the business of the people upstairs”. Human resource limitations at this high level of decision making create a bottleneck in the flow of scientific information to the operational level. I thus recommend scientific capacity building at lower levels, including at operational level. I commend the advances that have been made in the program to generate evidence internally. This approach is important in overcoming the science-practice gap, which continues to afflict the management of natural resources.

Acknowledgements

My sincere thanks go to the WfW staff who participated in the interviews, as well as members of senior management who were supportive of this study. The financial assistance of the National Research Foundation (NRF) and the Council for Scientific and Industrial Research (CSIR) towards this research is acknowledged.

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Chapter 6

Exploring a transdisciplinary path to evidence-based restoration

Abstract

Mainstreaming evidence-based practice into restoration is beset by challenges which range from disciplinary gaps, all the way through to value systems of practitioners, scientists and managers. I suggest that the root of these challenges lies in the conventional disciplinary approach to solving complex real-world problems. I therefore propose that transdisciplinarity could hold some useful lessons in exploring a way forward for evidence-based restoration. Distinguishing between weak and strong transdisciplinarity, based on a model that incorporates four hierarchical levels of knowledge management, I emphasize that strong transdisciplinarity moves beyond the empirical and pragmatic levels, which are essentially concerned with discipline-bound knowledge creation and implementation, respectively. Through an analysis of South African restoration practice, I illustrate how interactions with elements at the two higher levels of the knowledge hierarchy (i.e. incentives, legislation and policy instruments at the normative level, and shared values and ethics at the purposive level) can assist with the generation and use of evidence in restoration practice, which is currently a pragmatic inter-discipline.

Keywords: Complexity; decision-making; knowledge hierarchy; science.

Introduction

Decision makers in conservation and restoration are often faced with the challenge of having to choose *the right intervention* from among several options. Ideally, they would like to choose an intervention with a high degree of certainty in its ability to achieve the desired objective. Contemporary conservation literature suggests that the decision of which option to use is best based on scientific evidence of effectiveness. This so-called evidence-based (EB) approach is a challenge in itself. It requires that practitioners find, weigh/assess, and use research findings to support decision-making. As such, it is likely to be constrained by lack of evidence, or even limited access to the scientific evidence that exists (Roberts *et al.* 2006; Gibbons *et al.* 2008), which may, in turn, be a consequence of a lack of monitoring

(Coughlan & Oakley 2001; Legg & Nagy 2006; Field *et al.* 2007; Morton *et al.* 2009). Solutions to these challenges have been proposed, including the design of monitoring and evaluation tools (Stem *et al.* 2005) and making research findings easily accessible (Sutherland *et al.* 2009).

An even bigger challenge to EB practice is the fact that conservation and restoration activities are not all about "science" (Balmford & Cowling 2006). Decision makers may not necessarily understand the language of science, resulting in them either not wanting, or being unable, to use scientific evidence, a situation that continues to affect these applied disciplines (Cabin *et al.* 2010; Cook *et al.* 2010). Moreover, literature advocating the EB approach often uses the terms "science" and "research" in reference to the natural sciences (Pullin *et al.* 2004; Roberts *et al.* 2006), thereby implying the marginalization of information emanating from the social sciences. This focus on biophysical solutions is not adequate to address normative and complex conservation problems, which are often driven by social and economic issues (Knight *et al.* 2006). Recommendations on how to be EB should thus move beyond focusing on the "science" that is supposed to inform practice, and to equally emphasize the need for an understanding of the practitioners involved and their challenges.

Here I focus on a set of restoration projects to review how far the EB approach has been mainstreamed into practice (chapters 2 and 5). I identify the challenges (chapters 3, 4 and 5) and finally, make some recommendations for furthering this approach based on the learning gained. This chapter reports on this final stage, pulling together the lessons learnt through the study to identify a possible way forward for EB restoration in South Africa, and perhaps more broadly. In reviewing restoration programs in South Africa, through literature and practitioner interviews, my study highlighted some of the major challenges faced in making restoration EB. More details of these challenges can be found in Ntshotsho *et al.* (2011) and the three preceding chapters, but here I summarize them into three major challenges.

Challenges to evidence-based restoration

Evidence generated in practice is weak

In contrast to the stringent thought spent on designing scientific experiments, projects in practice suffer from a lack of proper design protocol (Ferraro & Patanayak 2006), often addressing a multitude of goals and lacking specific provision for proper monitoring (chapter 2 of this thesis; Ryder & Miller 2005; Ntshotsho *et al.* 2011; van Wilgen *et al.* 2012). For evidence to be usable, however, it has to answer the question of effectiveness, i.e. “to what extent is intervention *x* effective in addressing problem *y*”? Considering that problem *y* is likely to have both biophysical and socioeconomic facets, solution *x* should thus be designed to address both. Answering the question of effectiveness requires the setting of quantifiable goals and the identification of appropriate indicators to monitor progress towards their achievement (see chapter 2 and Addendum B). From a biophysical perspective, a certain level of ecological training is necessary to enable this kind of design. In practice, limited scientific capacity poses a challenge in this regard (see chapter 3). Likewise, a practitioner who is scientifically trained in the ecological sciences may not have the skills required to engage in social assessment, a process that is necessary to improve effectiveness of conservation programs (Cowling & Wilhelm-Rechmann 2007). This can then result in an “either/or” situation, where the type (biophysical or socio-economic) of evidence produced at project level depends on the skills of the people involved in its planning and execution. For example, in many restoration programs in South Africa there is a bias towards the use of indicators of input, which are easier to use than indicators of effectiveness, which would require more training in either the ecological or the social sciences.

Practical limitations to mainstreaming evidence-based practice

What does it take for practice to be evidence-based? I explored the use of science in practice in chapter 5 and demonstrated that EB practice is not only about science, but also about an enabling environment for the use thereof. For example, procedural constraints may determine the extent to which individuals have autonomy over the choice of intervention, and hence the use of scientific evidence. As demonstrated in chapter 5, with regards the WfW program in South Africa, the long process of policy formulation and implementation may delay the incorporation of scientific evidence, as and when it becomes available, into practice. This highlights the critical role of policy and institutional arrangements in mainstreaming EB practice.

Under-appreciation of the need for evidence-based restoration

In interacting with practitioners I sensed limited appreciation of the need for an EB approach to restoration. This was apparent in the way restoration projects were not designed to yield strong evidence, as demonstrated by a mismatch between baseline condition assessment, goals and monitoring, which potentially compromises the ability to determine effectiveness of a particular restoration intervention. An additional gap observed in restoration project design was in the assertion by practitioners themselves that monitoring is sometimes not in the project's terms of reference. Moreover, the failure of practitioners to perceive the weak evidence base as such (chapter 3), also points to the under-valuing of the EB approach, as does the restricted understanding, at lower management levels, of the need to use scientific evidence (chapter 5).

Searching for solutions

The challenges outlined above, like many in the environmental domain, are complex and comprised of several sub-problems that fall into the domains of different disciplines (Klein 2004), ranging from the empirical disciplines of ecology, economics and social science, through to the often neglected purposive disciplines of ethics and philosophy (Jantsch 1972). I suggest that the challenges are rooted in the traditional way of viewing and solving environmental problems from (mostly empirical) disciplinary comfort zones. For example, a typical approach to addressing degradation caused by mining would include soliciting input from engineers, ecologists, hydrologists and perhaps an economist. Individual reports from these various experts would then be used to find a solution. This sort of approach has been termed multidisciplinarity (Max-Neef 2005) and in fact results in a low level of coordination between the disciplines and does little to solve complex problems. Lengwiler (2006) suggests that there are several kinds of cross-disciplinary interaction which differ in terms of the level of cooperation between the disciplines, and therefore their ability to solve complex problems. He therefore emphasizes the need to move from multidisciplinarity, with its low level of cooperation, to interdisciplinarity where there is a higher level of interaction between the disciplines, often resulting in new knowledge and solutions not possible in the individual disciplines. Max-Neef (2005) cites medicine as a good example of an interdiscipline which arose from an interaction between physics, chemistry and biology and now exists as its own pragmatic interdiscipline giving purpose to and coordinating the underlying empirical disciplines.

In my view, this is what restoration currently is (or has the potential to become): a pragmatic interdiscipline, informed by many underlying empirical disciplines (e.g. ecology, economics, hydrology) while at the same time directing these disciplines in their data and knowledge generation. However, it appears that being interdisciplinary alone is not enough to address complex socio-ecological problems (Klein 2004; Max-Neef 2005; Miller *et al.* 2008).

Instead, there is a need to go beyond the integration of empirical disciplines to an approach that not only spans various research disciplines; but also includes non-research knowledge spheres; communities and governments (Apgar *et al.* 2009). This type of approach has been termed transdisciplinarity (Max-Neef 2005; Apgar 2009) and here I explore how such an approach could address the challenges associated with production and use of evidence in restoration practice.

Using transdisciplinarity to mainstream evidence-based practice

For transdisciplinarity to be a reality, the different elements in each of the four hierarchical levels of knowledge proposed by Max-Neef (2005) have to interact both horizontally and vertically (Fig. 6.1). My proposition of using transdisciplinarity to facilitate evidence-based restoration is based on this model, specifically because it incorporates two higher levels of knowledge management (*viz:* the normative and purposive levels), and thus distinguishes between weak and strong transdisciplinarity. The former is often a result of the accumulation of different brains, which happens when teams of people with different expertise interact to solve a problem (Max-Neef 2005). Weak transdisciplinarity, therefore, is characterized by strong interaction between and among components of the empirical and pragmatic levels, a situation which is developing in conservation practice in South Africa (Reyers *et al.* 2010). Strong transdisciplinarity, on the other hand as illustrated in Figure 6.1, is made possible by shared values and ethics, and governed by informed legislation and policies. Below I illustrate what a strong transdisciplinary approach might look like and the solutions it might offer EB restoration. Because the relationship between restoration (as a pragmatic interdiscipline) and the empirical disciplines supporting it is fairly well-understood, the following discussion gives a brief account of the two lower levels of the knowledge hierarchy, but only to provide context for the stronger focus on the normative and purposive levels, which form the bulk of this chapter .

Transcending disciplinary confines at the empirical and pragmatic levels

Several disciplines contribute to the motivations for restoration and how it is conducted (Fig. 6.1). Because of the interdisciplinary nature of restoration, the evidence base feeding into practice should come from various disciplines. Disturbingly, Klein (2004) has noted that even when integration of disciplines occurs, the use of social science knowledge is often accompanied by a tendency to sideline concepts and approaches that are incompatible with ‘‘hard’’ knowledge (e.g. empirical knowledge derived from natural sciences). This then highlights the critical influence of the empirical level on the pragmatic level. Strong transdisciplinarity at the lower empirical level could translate into the production of transdisciplinary knowledge that could be more easily assimilated into practice. Equally, the needs of the pragmatic level for holistic knowledge would exert pressure for those working at the empirical level to respond accordingly.

Max-Neef (2005) states that the pragmatic level is about asking the question “What are we capable of doing with that which we have learned from the empirical level?” One possible answer is “We can design and implement robust monitoring and evaluation protocols within restoration programs”. In this vein, the importance of the pragmatic level in evidence-based practice goes beyond the mere use of evidence. This is also the level where evidence production needs to take place. To a large extent, restoration is currently an activity-centered practice, with limited attention being paid to monitoring of outcomes (Bash & Ryan 2002; Levendal *et al.* 2008; Ntshotsho *et al.* 2011). As alluded to previously, restoration project design (including the design of monitoring and evaluation tools) needs to take cognizance of the complex nature of degradation and restoration, with their multiple and interacting social and ecological drivers, and hence the need to tap into various sources of information to integrate the biophysical and social considerations.

The legal and policy framework for restoration

The next level of the hierarchy, termed the normative level, is concerned with laws and policies, and signals a transition from weak to strong transdisciplinarity. This level should be influenced by, and in turn, influence the preceding pragmatic level. For example, a restoration project that implements adaptive management, whose ultimate goal is to adapt and learn to improve an ongoing project or intervention (Stem *et al.* 2005), can update its policies as new evidence becomes available. Relevant evidence generated outside of the specific project can also be used to improve policy. This influence on policy can go beyond project boundaries to ultimately influence environmental policy and legislation (Lovett *et al.* 2007). A practical example of this is the Working for Water (WfW) program, which is using scientific information to not only improve its own operations (chapter 5), but has also influenced the drafting of laws concerned with the management of invasive alien plants.

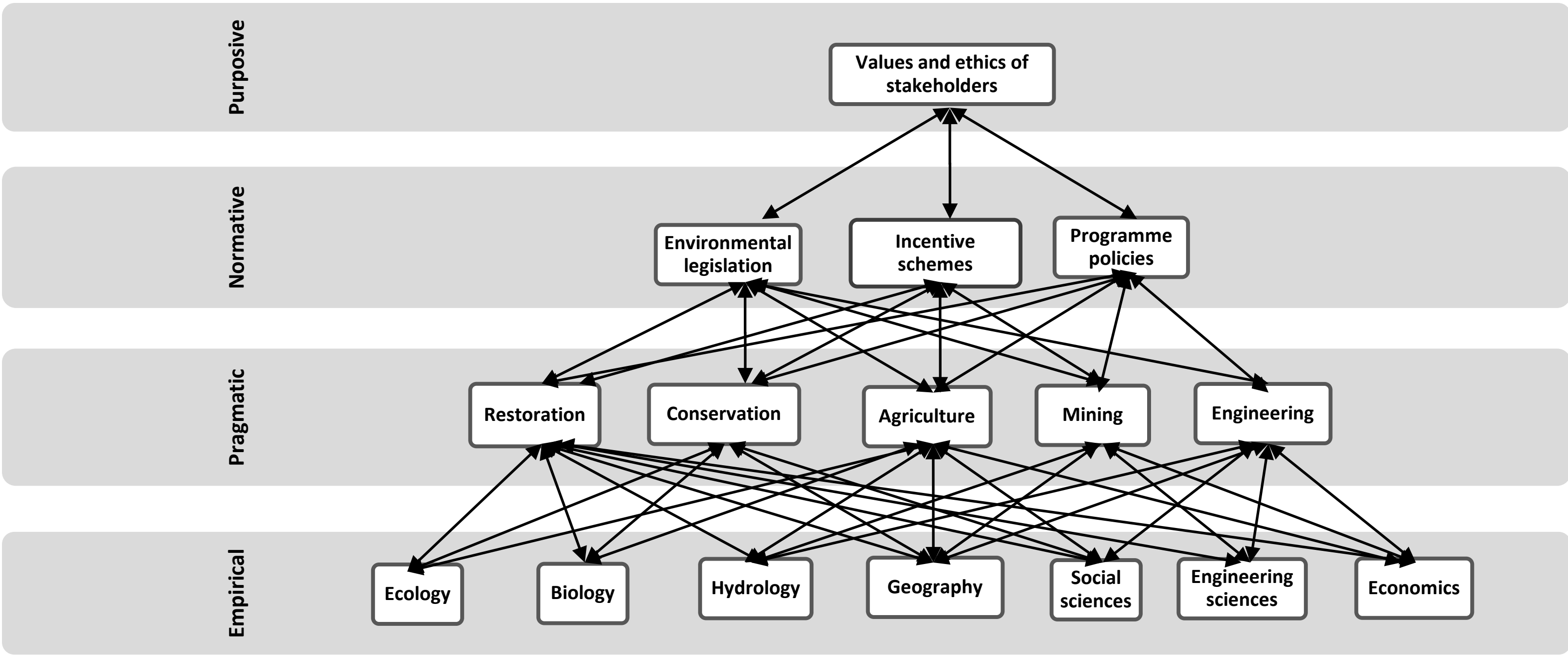


Fig. 6.1. An illustration of restoration as a transdisciplinary process, showing interactions between the four hierarchical levels (modified from Max-Neef 2005).

At least two pieces of legislation, *viz:* the Conservation of Agricultural Resources Act No. 43 of 1983 (CARA) and the National Environmental Management: Biodiversity Act No. 10 of 2004 (NEMBA), and their draft Regulations have directly benefited from scientific input from the WfW program. This example illustrates the upward influence of the two lower rungs of the transdisciplinarity pyramid on the third level (Fig. 1.6).

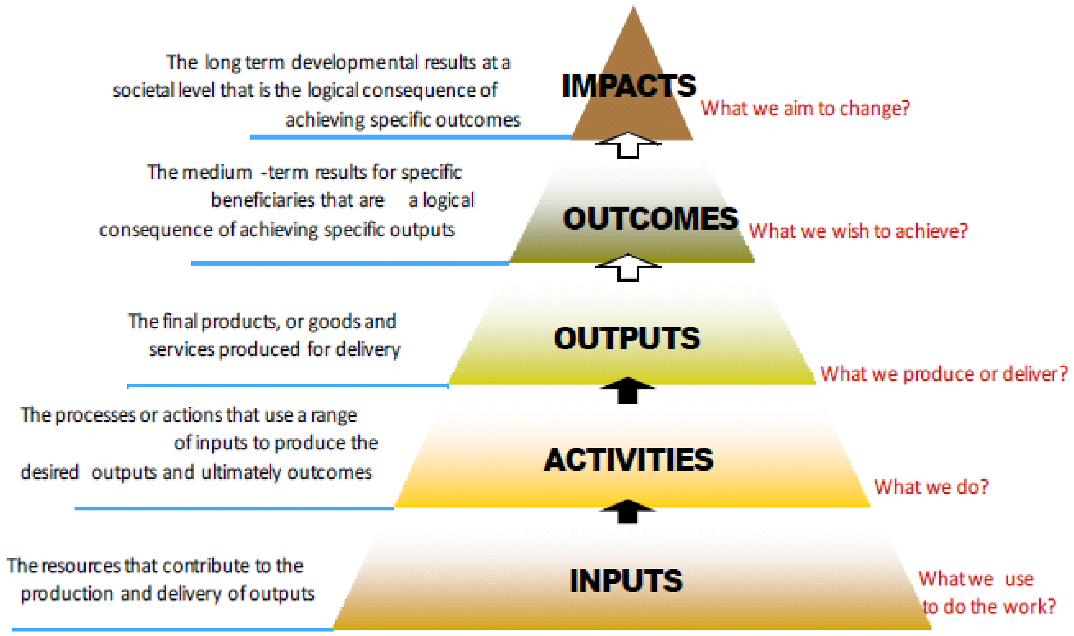
Despite this typical portrayal of science as advisor of policy in natural resource management, more recent insights describe knowledge creation and decision making processes as highly interrelated and intermingled (Luks & Siebenhüner 2007). As such, we should see reciprocal influence between the two lower levels of the transdisciplinarity hierarchy and this level. Indeed, clearly defined regulations and policies should guide responsible environmental behavior.

The South African constitution (section 24) enshrines the right of every individual to have the environment protected, for the benefit of present and future generations. Implicit in this is the need for the minimization or elimination of factors that may have a detrimental impact on the environment (that is, sources of environmental degradation). In line with this provision, there is environmental legislation that specifically addresses restoration (Wassenaar & Ntshotsho 2006). The most stringent and enforceable of these laws are aimed at the mining sector, probably because of its ecological footprint which is larger than that of other land uses. The top-down influence of legislation on the production of evidence is most apparent in this sector, where companies are legally bound to demonstrate that they have restored to a certain, pre-determined state, as provided for in Environmental Management Plans. Other legislation that addresses restoration includes CARA (Act No. 43 of 1983); the National Environmental Management Act (NEMA) Act No. 107 of 1998; and NEMBA (Act No. 10 of 2004). Additionally, the recent Presidential Outcome 10 (see Box 6.1.) sets out clear targets for the valuing, protection and enhancement of the natural environment as well as actions and indicators required to meet the targets. The performance agreements signed with cabinet ministers of responsible departments have great potential to drive a greater focus on the need to develop indicators to monitor and assess progress at national and sub-national levels. Indeed, the National Department of Environmental Affairs (DEA), which is responsible for the implementation and monitoring of Outcome 10, has begun the task of developing the required indicators (see The Presidency, no date). These examples highlight the contribution of compliance monitoring to the mainstreaming of EB practice.

Box 6.1. (Text and figure courtesy of the South African Presidency, see www.thepresidency.gov.za/dpme/docs/outcome10.pdf)

The Presidential Outcomes

The presidential outcomes are an expression of the South African government's need to go beyond the work it does and interrogate the impacts thereof. The approach involves management using a logic model which links inputs, activities, outputs, outcomes and impacts, as demonstrated in the figure below. A set of twelve outcomes was developed, together with performance agreements signed with responsible government ministers to improve accountability for the outcomes.



Outcome 10: Protected and enhanced environmental assets and natural resources, specifically refers to the natural environment, with outputs 1, 3 and 4 explicitly listing restoration and rehabilitation of degraded ecosystems, as well as valuing of ecosystem services as sub-outputs and indicators.

List of outputs under Presidential Outcome 10, that specifically address restoration and ecosystem services.

Output	Sub-outputs	Associated indicator
1. Enhanced quality and quantity of water resources	• Water resource protection	• Number of wetlands rehabilitated per year
3. Sustainable environment	• Restoration & rehabilitation of degraded ecosystems	• Number of hectares of degraded ecosystems rehabilitated • Number of derelict mines rehabilitated
4. Protected biodiversity	• Valuing the ecosystem services (ES)	• Better measurement, understanding and communication of ES • Appropriate incentive schemes implemented

At project level, policies and agreements may be formulated to guide the use and production of evidence. Depending on project priorities and other pressures, the extent to which the normative level influences the generation (and type) of evidence at the lower pragmatic level varies. For example, WfW's draft policy on working on private land (which is guided by the CARA and NEMBA Acts, together with their associated regulations) provides for the signing of clearing agreements between the program and private landowners, with the *proviso* that after clearing, the landowner will take responsibility for the management of invasive plants on her/his land. Compliance to this stipulation is supposed to be enforced by the Department of Agriculture. Interestingly, I observed that whereas WfW is under obligation from its funders to gather data and report on its socio-economic effectiveness (under a separate agreement), the private landowners (who are supposed to be partners in the effective management of invasive alien plants, as per the policy mentioned above) are not yet held to account for lack of compliance. In a way, this renders the source legislation (CARA and NEMBA) ineffective in encouraging monitoring of the long-term biophysical and social impacts of the program. This illustrates the need for good governance and policies that are synergistic, resulting in the incorporation of various considerations in the overarching policy framework.

In addition to punitive measures such as enforcement of legislation and policies, evidence use and production could be encouraged through the use of suitable incentive schemes. To this end, the incorporation of ecosystem services in restoration planning and practice (Rey-Benayas *et al.* 2009; Reyers *et al.* 2009; Trabucchi *et al.* 2012) has a role to play in the use and generation of evidence in restoration. The inherent need for mapping, quantification and valuation of services (Bohensky *et al.* 2006; Egoh *et al.* 2007), encourages engagement with, and use of tools from disciplines such as economics and geography. Indeed, the Subtropical Thicket Restoration Project (Mills *et al.* 2007) is one example of how the payments for ecosystem services (PES) model has necessitated good monitoring and evaluation.

Entrenching the value of evidence-based restoration

The highest level of the knowledge hierarchy is the value level, concerned with ethics and philosophy (Max-Neef's 2005). As such, the fundamental question "why do we even do restoration?" can be answered at this level. Clewell and Aronson (2007) discuss a range of motivations for restoration, including the biocentric and anthropocentric perspectives.

Assuming that restoration is largely based on the anthropocentric view (Cairns 1998; Hobbs & Harris 2001; Aronson *et al.* 2007), and thus driven by the question "What benefits will it bring us?", it then follows that evidence of effectiveness will be in the benefits gained. This has the potential to promote EB restoration because the need to increase (and document) benefits could arguably (1) drive the use of the most effective methods, as demonstrated by available evidence and (2) encourage the monitoring of indicators of benefits accrued. The potential, however, depends on the types of benefits valued. For example, the valuing of socio-economic benefits is likely to drive the demonstration of accrual of these benefits through the use of socio-economic indicators.

While there is global recognition of the potential of restoration to benefit human wellbeing through the restoration of ecosystems' capacity to provide essential services, my own assessment of government-run restoration programs showed a strong focus on socioeconomic indicators, which were more about inputs than impact, and had no link to the ecosystem services benefits of restoration, as evidenced by limited monitoring of biophysical indicators (Ntshotsho *et al.* 2011; chapters 3 and 4). As a result, good statistics of job-creation are often interpreted as an indication of overall program success. This is then the kind of evidence used to lobby for further funding from National Treasury (Magadlela 2001). This is to be expected in South Africa, where the reduction of widespread poverty remains government's top priority (NPC 2011). That being said, there is still a need for managers in restoration to emphasize that restoration has a greater, ecosystem service-based, socioeconomic value that goes beyond the often short-lived benefit of employment creation. This is particularly relevant in the local context where employment in the government-funded programs sometimes fosters a sense of dependency on the employer (Hope 2006), and indigent communities have been known to lack a sense of ownership of restoration projects (personal observation). Awareness raising, specifically focusing on the longer-term human well-being benefits of restoration, could be used to remedy the situation. Alternatively, restoration could adopt the community based natural resource management (CBNRM) approach, which has been shown to be effective in not only engendering a sense of ownership (Everson *et al.* 2007), but also in ensuring better management of natural resources (Armitage 2005). Community members could be trained to monitor the biophysical impacts of restoration, thereby contributing to the production of evidence, instead of only being involved in the execution of restoration activities.

How else can we ensure the valuing of evidence-based restoration? The mining sector presents a learning opportunity. In contrast to restoration conducted in the public sector, a higher value is placed on scientific evidence of a biophysical nature in post-mining restoration. It is not uncommon in South Africa for mines to fund research programs to gather this evidence (e.g. van Aarde *et al.* 1996; Carrick & Kruger 2007; Blood 2008). The prevalent use of scientific evidence in this sector is related to the legislation that makes monitoring compulsory. But it could also be related to the importance of the financial bottom line, which translates to a need for efficiency and return on investment. Currently, public funds are being spent on restoration and there are no instruments or incentives for the demonstration of benefit accrual to society. I suggest that tapping into the payments for ecosystem services market, which relies on the demonstration of accrual of traded ecosystem services (Jack *et al.* 2008), is likely to encourage monitoring of effectiveness of restoration interventions conducted using public funds. Additionally, evidence of effectiveness will allow practitioners to answer questions such as "what happened to all the money?" and "what good did it do?" (Field *et al.* 2007), which are likely to come up eventually.

Conclusion

Transdisciplinarity is inherently about the production and management of knowledge to solve complex real-world problems. The recommendation that restoration practice be regarded as a contributor to knowledge production, coupled with its being rooted in complex socio-ecological systems, already places it within the framework of transdisciplinarity, albeit a weak transdisciplinarity. Embedding the evidence-based approach in restoration, however, requires strong transdisciplinarity. An exploration of the two higher levels of the knowledge hierarchy proposed by Max-Neef (2005) reveals opportunities and challenges to realizing this ideal. Positive advances have been made at the normative level, with legislative and policy measures that are, to some extent, rooted in science. I argue that better enforcement of these measures could further encourage the production and documentation of evidence of effectiveness, mainly through compliance monitoring. Additionally, positive incentives could influence evidence generation at the pragmatic level while also inspiring a higher appreciation of evidence-based restoration at the purposive level. Ultimately, the swaying of values and attitudes is dependent on the three preceding levels, particularly the empirical level, where institutions of higher learning have a critical role to play in producing a new generation of restoration researchers, practitioners and policy-makers.

Acknowledgements

The logistic support of the Council for Scientific and Industrial Research (CSIR) and Stellenbosch University is gratefully acknowledged. Financial assistance for this work was provided by the National Research Foundation (NRF).

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Chapter 7

Synthesis

"Science is as much an inner path of spiritual development as it is a discipline aimed at accumulating knowledge of the physical world. It involves not only a rigorous training of our faculties of observation and thinking, but also of other human faculties which can attune us to the spiritual dimension that underlies and interpenetrates the physical". Goethe 1749-1832.

I spent the past few years undergoing scientific training as described above. At the start of my journey I set out to investigate the plausibility of an evidence-based (EB) approach to ecological restoration. I specifically endeavored to examine the potential contribution of restoration practice to the production of information to enable EB practice. Additionally, I wanted to explore the extent to which scientific evidence is used to make decisions in practice. A common thread throughout the five core chapters of this thesis is a challenge to the traditional view of EB practice as being solely possible through the use of scientific evidence, which invariably implicitly refers to *research* evidence. In other words, I argue with the implied unidirectional flow of information from science to practice (Bosch *et al.* 2003; Roux *et al.* 2006; van Wyk *et al.* 2008; Bayliss *et al.*2012), which inherently evokes a dependency relationship between science and practice in terms of information. In this synthesis I discuss the main findings of the core chapters and how the work as a whole contributes to the advancement of EB restoration and my personal learning. A summary of this contribution is provided in table 7.1, at the end of this synthesis.

What is "science" anyway?

"Science" means different things to different people in different situations (Wynne 1991). For one person, science is that which helped mankind land on the moon. For yet another, it's the technological and/or medical advances that make life comfortable. For a social scientist, it is the study of society and human behavior. I prefer the Wikipedia definition, which depicts science as a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe. Despite its obvious inadequacy in relation to the natural world and its complexity and unpredictability (see Funtowicz & Ravetz 1991;

Francis & Goodman 2010), this definition does not limit *science* to specific disciplines. If *science* is about *building and organizing knowledge*, then whether this happens in a research setting or in practice is of little consequence. In the case of EB practice, what matters is the functionality and validity of said knowledge. A central principle of EB practice is "evidence of effectiveness", which then means that for knowledge to be usable as evidence, it must be in the form verifiable data. How then, does restoration practice fulfill the requirement of producing evidence? I addressed this subject in chapter 2.

Doing science in practice

In order to generate evidence restoration projects should be designed in such a way that they provide an answer to the fundamental question "is intervention *x* effective in solving problem *y*?" This requires the diagnosis of ecosystem damage (i.e. quantification of the baseline condition); setting of specific and realistic goals (Ryder & Miller 2005; Hobbs 2007) and proper monitoring protocols over long enough time-frames to detect impact (Havstad & Herrick2003; Herrick *et al.* 2006; Ntshotsho *et al.* 2011). Such rigorous design would make restoration practice akin to research. The resource and management challenges faced by practitioners in realizing this ideal are not insurmountable, as discussed in chapter 3.

In addition to robust project design, EB practice requires that evidence be made accessible. I explored this requirement in chapters 3 and 4 and found practice wanting in this regard. For example, a lot of information remains undocumented and thus unavailable to inform decisions. I recommend a mind-shift in restoration practice, towards a culture of deliberate knowledge dissemination, something similar to the publish-or-perish culture of research. Publishing need not necessarily be limited to peer-reviewed journal articles, as is the norm in research. Indeed, practitioners mentioned that they do use several tools to communicate (or publish) their work, with conference presentations being the commonest mode of communication. This finding is similar to Seavy and Howell's survey (2009) which found that conservation managers in California rated in-person interaction highly as a source of information. As a matter of fact, I would also rate direct interaction with stakeholders highly, based on my experience while doing this research. The work of Seavy and Howell, however, specifically considered one-on-one interaction between scientists and decision makers, with the former being providers of information and the latter mere recipients. This familiar portrayal of a one-way exchange between scientists and managers/practitioners (Stewart *et al.* 2005; van Wyk *et al.* 2008; Bayliss *et al.*2012) could change with the production of authoritative information in practice. Practitioners could then exchange verifiable information (i) among themselves to improve the implementation of effective interventions, and (ii) with other stakeholders to contribute to the advancement of science. In this way, restoration practice could merge with science to become a means to achieve *learning*, not by mere theoretical speculation on the one hand, nor by the accumulation of practical facts on the other, but rather by a motivated iteration between theory and practice (Box 1976).

I am by no means suggesting that research be considered redundant. On the contrary, the theoretical contribution of research will remain indispensable, owing to our insufficient level of understanding of ecosystem level ecology, which is a consequence of ecosystems being highly dynamic, complex and unpredictable (Kay *et al.* 1999).When dealing with restoration, this complexity is compounded by socio-economic factors and their accompanying difficulties, which are an integral element of the management of natural resources.

Holistic evidence-based restoration

The importance of taking social factors into consideration when exploring any branch of natural resource management is often emphasized (Balmford & Cowling 2006; Knight *et al.* 2006; Temperton 2007; Chapin *et al.* 2010). To do justice to my investigation of EB restoration I thus had to delve into the social aspect thereof, which I did in chapter 5. Through the process of engaging managers I became familiar with the practical limitations to the use of science in decision making. Adopting an evidence-based approach in practice is not a simple matter of individuals finding and using science to help make up their minds. There are procedures and institutional arrangements to consider, in addition to other motivations and/or priorities which are likely to influence decisions. Moreover, the mere discomfort and frustration of operating with unfamiliar information (which may be true for a manager with no scientific training, who now has to make sense of scientific information) is enough to stop any aspiration to become evidence-based dead in its tracks. Being faced with this science-practice gap, which seemed to be rooted in disciplinary divisions, prompted me to probe transdisciplinarity as a possible vehicle to becoming evidence-based. With its focus on understanding the actual world holistically, transdisciplinarity seemed like a suitable solution. So I pursued this possibility in chapter 6.

A close look at the four levels of the knowledge hierarchy revealed challenges at all levels, from discipline-specific research at the empirical level, through slack legal instruments at the normative level, all the way to values and attitudes driven by factors at preceding levels. The biggest challenge to realizing the ideal of being evidence-based in restoration practice is at the empirical level because this is where the training of minds happens. This level can then exert influence on the higher levels, as illustrated in the preceding chapter. Indeed, it has been emphasized that transdisciplinary approaches can only be effective if there is a significant shift in disciplinary thinking (Lawrence & Despres 2004; Max-Neef 2005). As such, in order for stakeholders in restoration to be competent producers and users of information that transcends disciplinary confines, institutions of higher learning need to make a concerted effort in the training of future stakeholders in transdisciplinarity. This is not an improbable feat. I started this PhD journey from an ecology ivory tower and I am completing it with a different, wider outlook on how the real world functions, having been stretched beyond my disciplinary comfort zone.

Concluding remarks

Practitioners need to realize the important role they must play in building a strong body of evidence to help them, and indeed other stakeholders in restoration, make informed decisions. Because restoration practice is inherently complex, by virtue of incorporating a combination of biophysical and social factors, there is a necessity for all stakeholders to think beyond disciplinary confines, taking cognizance of the need for multiple sources of information to tackle complexity and thus minimizing the marginalization of some sources of evidence. Consequently, it is imperative that the trainers of potential practitioners, researchers and decision makers step up to this challenge.

Table 7.1. A summary of the contribution of the current PhD study to the field of restoration and the personal journey of a budding restoration stakeholder.

Contribution of this thesis to…		
Restoration science and practice	**Personal learning**	**Thesis chapters**
Perception of evidence-based practice		
Literature on EB practice directs disproportionate focus on the **use** of **research-**produced information to support decision making in practice. The potential of restoration practice to **produce** quality evidence should be optimized by	Research need not be superior to practice in terms of knowledge production.	2 & 3

applying scientific rigor in project design.

The information gap in restoration		
Fundamental changes in practice need to occur to improve access to the wealth of information produced in practice.	Science journals are not the only relevant source of information in my field.	3 & 4
Disciplinary limitations		
Restoration ecology alone is not an adequate empirical foundation for restoration practice. Training of restorationists needs to include the social sciences.	As an ecology student I had always regarded social science as "soft science". Now I know better.	5 & 6

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Addendum A

Short descriptions of the ten programs used in the assessment

The file was supplied as online supplementary material (Supplementary file S1) to the publication: Ntshotsho, P., B. Reyers, and K. J. Esler. 2011. Assessing the evidence base for restoration in South Africa. *Restoration Ecology* **19(5):** 578-586.

Restoration category	Short description	Source(s) of more information
Community-based restoration	A rehabilitation project in Okhombe, KwaZulu-Natal, was used as a case study of community based restoration. The project was initiated under the auspices of the National LandCare Program in 1999, focused on the rehabilitation of degraded areas in the Drakensberg catchment area. Later, a community based monitoring system was developed to determine the effect of rehabilitation on reducing soil erosion and run-off and increasing water quantity and vegetation cover in the previously degraded areas.	- Everson, T. M., C. S. Everson, and K. D. Zuma. 2007. Community based research on the influence of rehabilitation techniques on the management of degraded catchments. Research report number 1316/1/07, Water Research Commission, Pretoria.
LandCare South Africa	The National LandCare Program started in 1998/1999 and is a sustainable resource utilization program based in the community and driven by both the public and private sectors through partnerships and co-operation. Initiated by the National Department of Agriculture (now the National Department of Agriculture, Forestry and Fisheries), the program is mainly aimed at rural poverty alleviation and job creation through the launching of various natural resource rehabilitation, improvement and conservation projects. The program has various projects throughout the country, not all of which have a restoration component. Resource conservation works, which include restoration/rehabilitation activities, account for 60% of the annual budget, which ranges at approximately $US 7.2 million.	- http://www.nda.agric.za/docs/landcarepage/landcare.htm
Post-mining restoration	In South Africa mines have a legal obligation to carry out restoration and rehabilitation on areas that have been mined. The South African Chamber of Mines, in collaboration with Coaltech Research Association, loosely defines rehabilitation and restoration as activities aimed at putting the land impacted by mining activities back to a sustainable usable condition (Chamber of Mines of South Africa/Coaltech, 2007). It is up to the individual mines to refine this definition and name their specific restoration goals. Three mines, whose names cannot be divulged for confidentiality reasons, were used as case studies in this assessment. These mines’ restoration programs share the specific common goal of	- Mineral and Petroleum Resources Development Act (MPRDA) Act No 28 of 2002, section 39. - Chamber of Mines of South Africa/Coaltech. November 2007. Guidelines for the rehabilitation of mined land. URL: http://www.bullion.org.za/Departments/Environment/Environment.htm

	recovering biodiversity on mined areas.	
Restoration in protected areas	Protected areas serve the purpose of protecting and conserving biodiversity. Invasion by alien species is currently regarded as the single biggest threat to South Africa's biodiversity. Alien plant invasion constitutes degradation, and the removal of the degrading agent constitutes restoration. It is in this vein that I included restoration in protected areas in this assessment. I used Kruger National Park and Table Mountain National Park (previously known as the Cape Peninsula National Park) as case studies. Both conservation areas have a long history (over six decades each) of alien plant control operations.	- http://www.sanparks.org - Foxcroft, L. C., and D. M. Richardson. 2003. Managing alien plant invasions in the Kruger National Park, South Africa. Pages 385-403 in L. E. Child, J. H. Brock, G. Brundu, K. Prach, P. Pyšek, P. M. Wade and M. Williamson, editors. Plant Invasions: Ecological Threats and Management Solutions. Backhuys Publishers, Leiden, The Netherlands.
Restoration on commercial farming land	Information on restoration activities on commercial farming land was obtained from a computerised decision support system (DSS) developed by van der Merwe (1997) and later upgraded by Barac (2003). The DSS, named EcoRestore – Grass Expert, combines scientific and indigenous knowledge into a single, interactive computer program that users can access directly to support their decisions, based on results of land users' management practices. At the time of consultation, the database contained information from 171 case studies scattered throughout the country. Though not falling under a formal umbrella program, the individual case studies were treated as smaller projects of a larger program for the purposes of this assessment. Several other small-scale projects, conducted by various researchers, were included in the assessment.	http://www.puk.ac.za/fakulteite/natuur/soo/EcoRestore/grassexpert.html - Van Der Merwe, J. P. A. 1997. The development of a data base and expert system for rangeland reinforcement practices in southern Africa. M.Sc. Thesis, Potchefstroom University for Christian Higher Education, Potchefstroom. - Barac, A. S. 2003. EcoRestore – a Decision Support System for the restoration of degraded rangelands in southern Africa. M Sc. Thesis, Potchefstroom University for Christian Higher Education, Potchefstroom.
Working for Water (WfW)	Working for Water (WfW) is a government program that was initiated in 1995 to simultaneously control the alien invasive species problem to provide water benefits, while creating employment. It has been touted as the single biggest conservation project in South Africa in terms of manpower and impact (Hosking *et al.*, 2002). The program is under the management of the Department of Water Affairs and Forestry (DWAF) and has an annual budget of about $US 50 million that funds the	- http://www.dwaf.gov.za/wfw

	numerous projects scattered throughout the country.	
Working for Wetlands (WfWet)	Working for Wetlands (WfWet) was born out of the WfW program and commenced in 2000. It is a joint initiative of the departments of Environmental Affairs and Tourism (DEAT), Water Affairs and Forestry (DWAF) and Agriculture (DoA) that is managed by the South African Biodiversity Institute (SANBI). It has the following objectives: water resource protection; poverty reduction and capacity building; and conservation of biodiversity. Numerous projects have been implemented nationwide under this program. The annual budget is in the range of $US 9 million.	- http://wetlands.sanbi.org/wfwet
Working for Woodlands (WfWood)	Working for Woodlands is also a sister program to the Working for Water program. It is administered by the Natural Resource Management Programmes (NRMP) of the Department of the Water (DWA) (formerly the Department of Water Affairs and Forestry - DWAF) and the Department of Environmental Affairs (DEA). The key objectives of the program are to restore the composition, structure and function of indigenous woodlands and to thereby enhance ecosystem functioning, such as carbon sequestration and water regulation and purification. There are currently six sub-programs or projects falling under the umbrella program. In this assessment I disaggregated WfWood into its six component sub-programs but only assessed three, namely (i) the Subtropical Thicket Restoration Project (STRP), (ii) the African Rural Initiatives for Sustainable Environments (ARISE) project and (iii) the Matiwane forest restoration project. Short descriptions of these sub-programmes follow: (i) The STRP is a restoration programme that focuses on the restoration of degraded thicket ecosystems, using cost-effective methods and ensuring social upliftment through employment and skills training. So far the sub-programme has been implemented at three sites, *viz:* the Baviaanskloof Nature Reserve, Addo Elephant National Park and the Fish River Reserve. The implementing agent for this sub-	- Marais, C., R. M. Cowling, M. Powell, and A. Mills. 2009. Establishing the platform for a carbon sequestration market in South Africa: The Working for Woodlands Subtropical Thicket Restoration Programme. XIII World Forestry Congress, Buenos Aires, Argentina, 18 – 23 October 2009. - Mills, A. J., J. Turpie, R. M. Cowling, C. Marais, G. I. H. Kerley, R. G. Lechmere-Oertel, A. M. Sigwela, and M. Powell. 2007. Assessing, costs and benefits of subtropical thicket restoration in the Eastern Cape, South Africa. Pages 179 - 187 in J. Aronson, S. Milton and J. Blignaut, editors. Restoring Natural Capital: Science, Business and Practice. Island Press, Washington, D. C. - Mills *et al.* 2009. Investing in Sustainability: Restoring degraded thicket, creating jobs, capturing carbon and earning green credit - http://eoi.co.za/project.html

programme is the Gamtoos Irrigation Board.

(ii) The two projects falling under the ARISE initiative are based in Giyani and Port St. Johns. The two projects are aimed at the restoration of riparian thicket and coastal forests, respectively. The implementing agent is Environmental Offset Investments. These are the only two projects funded by DEA in the WfWood programme.

(iii) The Matiwane project is also concerned with the restoration of coastal forests but is funded by DWEA and implemented by a different agency.

Addendum B

Survey Questionnaire

Designed by Phumza Ntshotsho

Web-based questionnaire sent to people involved in restoration in South Africa. Participation in the survey was open between December 2009 and March 2010.

Section 1: Consent to participate

The aim of this section is to get your informed consent to take part in this survey. You will not be able to continue with the survey if this box is not ticked.

1. I hereby consent to voluntarily participate in this survey

☐ Yes

Section 2: Project details

Throughout this questionnaire, the word "project" will be used to refer to both single-site projects and larger programs which may or may not have smaller sub-programs or projects falling within them.

1. What is the name of the restoration project you are involved in? If you are involved in many projects please only name one and answer the rest of the questions based on your involvement in this chosen project.

2. What is the name of the sub-project you are involved in, if applicable?

3. Please select a category that best describes your project from the list below.

- I do not know
- Erosion control
- Ecological restoration
- Restoration of natural capital
- Rehabilitation

- Reclamation
- Remediation
- Revegetation

Other (please specify)

4. Please select from the list below elements that are applicable to your project

- Ecological principles are followed
- Indigenous species are used
- Attention is paid to ecosystem structure
- Attention is paid to ecosystem function and processes
- Local ecological conditions and pre-disturbance conditions are considered and included as part of the design plan
- Due regard is given to both society and nature, and the interactions between them
- Long-term sustainability of the "restored" system is ensured
- Potential threats to the integrity of the "restored" system are minimised

5. Who funds the project?

- Government
- Private funder(s)
- Mining company
- Non-governmental organisation
- I do not know

Other (please specify)

6. What is the age of the project (age in years)?

- <2
- 2-5
- 6-10
- >10

7. What is your primary role in the project you named in question 1?

- Coordinator/facilitator
- Implementer/practitioner
- Researcher
- Other (please specify)

8. What is your other role in your chosen project?

- Coordinator/facilitator
- Implementer/practitioner
- Researcher
- No other role
- Other (please specify)

Section 3: Baseline information collection

Please answer the questions in the following sections as they apply to the restoration project you are involved in.

1. Is baseline socio-economic information collected prior to restoration?

- Yes
- No
- I do not know

2. If you answered yes above, please rate the adequacy of socio-economic baseline information collection, for those indicators applicable to your project.

	Very inadequate	Inadequate	I do not know	Adequate	Very adequate
Environmental awareness levels	●	●	●	●	●
Unemployment rate	●	●	●	●	●
People living in poverty	●	●	●	●	●
Household income	●	●	●	●	●
Literacy	●	●	●	●	●
Other 1	●	●	●	●	●
Other 2	●	●	●	●	●
Other 3	●	●	●	●	●

If other(s), please specify

3. If you chose "very inadequate" and/or "inadequate" above, what are the reasons for the inadequacy?

- I do not know
- Lack of expertise

- Lack of funds
- Lack of time
- Baseline information collection is not considered necessary
- Baseline information collection is not part of the project design and/or terms of reference
- Other (please specify)

4. Is baseline ecological information collected prior to restoration?

- Yes
- No
- I do not know

5. If you answered yes above, please rate the adequacy of ecological baseline information collection, for those indicators applicable to your project.

	Very inadequate	Inadequate	I do not know	Adequate	Very adequate
Plant species composition	●	●	●	●	●
Density/cover of indigenous species	●	●	●	●	●
Density/cover of alien species	●	●	●	●	●
Water quality	●	●	●	●	●
Water quantity	●	●	●	●	●
Aquatic diversity	●	●	●	●	●
Above-ground carbon stocks	●	●	●	●	●
Below-ground carbon stocks	●	●	●	●	●

Soil chemical quality	●	●	●	●	●
Geomorphology	●	●	●	●	●
Erosion/bare patches	●	●	●	●	●
Levels of degradation	●	●	●	●	●
Other 1	●	●	●	●	●
Other 2	●	●	●	●	●

If other(s), please specify

6. If you chose "very inadequate"and/or "inadequate" above, what are the reasons for the inadequacy?

- ☐ Lack of expertise
- ☐ Lack of funds
- ☐ Lack of time
- ☐ Baseline information collection is not considered necessary
- ☐ Baseline information collection is not part of the project design and/or terms of reference
- ☐ Other (please specify)

7. Please indicate the extent to which you agree with the following statement: a variety of incentives for collection and disincentives for the lack of collection would increase the incidence and adequacy of baseline information collection.

	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
Level of agreement	●	●	●	●	●

8. What else could be done to increase the incidence and adequacy of baseline information collection?

Section 4: Goals of restoration

1. Does your project have socio-economic goals?

- Yes
- No
- I do not know

2. If you answered yes above, what are the socio-economic goals of your chosen restoration project? Please also indicate whether they are stated in writing and/or quantified.

	Goal	Stated in writing	Quantified numerically
Job creation			
Poverty alleviation			
Livelihood improvement			
Development of a market for PES			
Capacity building			
Environmental awareness creation			
Other 1			
Other 2			

If other(s), please specify

3. If you answered no or sometimes to the question whether any of the socio-economic goals are stated in writing and/or quantified, what are the reasons?

- I do not know
- Stakeholders are vague about what they want
- It is not considered necessary to specify and quantify goals
- Not all goals can be quantified
- Goals change all the time
- Other (please specify)

4. Does your project have ecological goals?

- Yes
- No
- I do not know

5. If you answered yes above, what are the ecological goals of your chosen restoration project? Please indicate whether each goal is stated in writing and/or quantified.

	Goal	Stated in writing	Quantified numerically
I do not know			
Alien plant control			

Water resource improvement			
Biodiversity conservation			
Soil conservation			
Carbon sequestration			
Ecosystem productivity improvement			
Restoring natural capital			
Increasing resilience			
Other 1			
Other 2			

If other(s), please specify

6. If you answered no or sometimes to the question whether any of the ecological goals are stated in writing and/or quantified, what are the reasons?

- I do not know
- Stakeholders are vague about what they want
- It is not considered necessary to specify and quantify goals
- Not all goals can be quantified
- Goals change all the time
- Other (please specify)

7. Please indicate the extent to which you agree with this statement: it is better to set quantitative goals than qualitative ones, for ease of measurement.

	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
Level of agreement	●	●	●	●	●

8. Any comments pertaining to the setting of restoration goals?

Section 5: Monitoring

1. Is monitoring mandatory?

- Yes
- No
- Sometimes
- I do not know

Please elaborate

2. Is monitoring done?

- Yes
- No

- Sometimes
- I do not know

3. If you answered no or sometimes in question 2 above, what are the reasons for the lack of, or inconsistent monitoring?

- [ ] I do not know
- [ ] Lack of capacity
- [ ] Lack of knowledge
- [ ] Lack of financial resources
- [ ] It is not considered necessary to monitor
- [ ] Monitoring is not part of the project design or terms of reference
- [ ] Other (please specify)

4. If you answered yes or sometimes in question 2, what indicators are monitored, at what temporal and spatial scales, and who does the monitoring?

	Indicator monitored?	Frequency	Spatial scale	By who
I do not know				
Person hours worked				
Training provided				
Awarenes s				

campaigns held				
Number of jobs created				
Livelihood impacts				
Environmental awareness levels				
Area cleared of invasives				
Fences erected				
Solid structures built				
Area revegetated				
Water quantity				
Water quality				
Species richness				
Soil erodability				
Carbon sequestered				

Plant survival/growth				
Biomass accumulation				
Other 1				
Other 2				
Other 3				

If other(s), please specify

5. Please indicate the extent to which you agree with this statement: allocation of adequate funds and other necessary resources for monitoring should be compulsory when designing a restoration project.

	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
Level of agreement	●	●	●	●	●

6. Please comment on what could be done to increase the incidence of long-term monitoring.

6. Information sharing

1. Is information pertaining to your project and its impacts shared with other parties?

- Yes
- No
- I do not know

2. If you answered yes above, information pertaining to your project and its impacts is shared by means of (tick all that apply):

- [ ] I do not know
- [ ] Website postings
- [ ] Periodic organisation reports and newsletters
- [ ] Presentations at conferences
- [ ] Popular articles
- [ ] Awareness campaigns
- [ ] Media releases
- [ ] Articles in refereed journals
- [ ] Other (please specify)

3. Does your project experience failures (instances where goals are not achieved)?

- Yes
- No
- I do not know

4. If you answered yes above, are the failures publicised?

- Yes
- No

- I do not know

5. How likely are you to use an information sharing platform (e.g. an electronic portal) to disseminate information about your project and to learn about other projects?

	Highly unlikely	Unlikely	I do not know	Likely	Highly likely
Likelihood	●	●	●	●	●

6. What would limit your use of such an information sharing platform?

- [ ] Organisation's privacy policy
- [ ] Lack of interest
- [ ] Time constraints
- [ ] Funding constraints
- [ ] Other (please specify)

Section 7: Correspondent contact information

1. Please provide your name and contact information. This information will not be used in any analysis and is only required for record keeping purposes.

Name:

Company/organisation:

Email Address:

Phone Number:

Addendum C[3]

No evidence-based restoration without a sound evidence base: a reply to Guldemond *et al.*

Phumza Ntshotsho, Belinda Reyers and Karen J. Esler

Abstract

Evidence-based practice is not possible without an evidence base. Guldemond and colleagues (2011) confuse our attempt at assessing the status of the evidence base of restoration programs in South Africa with attempting to assess whether restoration is evidence-based. While we fully agree with them that there is a need to assess whether practitioners use evidence in their decision-making, we assert that use of evidence is the last step in the evidence-based approach. It is preceded by the generation (and documentation) of evidence through baseline condition assessment, proper goal setting, sound monitoring of the impacts of the chosen intervention as well as effective dissemination of resulting evidence. To answer the question whether restoration is evidence-based would require the assessment of all stages from generation to use. We chose to start at the beginning, a logical place to start.

Keywords: indicators; monitoring; restoration practitioners; systematic review.

We enjoyed reading the thought provoking comments raised by Guldemond et al. (2011) on reading our paper (Ntshotsho et al. 2011). They raise some important points about the complexity of assessing evidence-based practice and provide some useful insights into ways to take this work forward. These comments have helped us to clarify our thoughts and, in the spirit of moving the restoration community forward to evidence-based practice, we appreciate this opportunity to share our responses to their criticisms.

Guldemond et al. raise two major concerns with our study – the first being that we confuse "evidence-based" with "evidence base" and fail at assessing either. Their second concern is that we confuse individual restoration goals (especially socio-economic goals) with restoration success.

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[3] Published in 2012, in Restoration Ecology 20(2): 158-159.

The first concern is an important one - assessing evidence-based practice is not a simple task and would certainly require more than just this one study. As we highlight in our paper, proper evidence-based restoration would include (a) finding, (b) appraising and (c) using evidence of restoration effectiveness – assessing this process will be no mean feat. But all of these stages require the presence of evidence. As Guldemond et al. point out, a thorough assessment would require both an assessment of the evidence base itself, as well as an assessment of whether this evidence base is used. Restoration cannot be evidence-based if either one or the other is missing. And so our study began with an assessment of the evidence base, as a first step to assessing whether restoration is evidence-based.

While we agree with Guldemond et al. on the need for a central and standard platform through which evidence can be disseminated, we do not agree with their opinion that systematic review of peer reviewed literature is the only way of assessing the evidence base. Their emphasis on systematic reviews ignores the fact that many restoration efforts never get peer reviewed or published (especially failed efforts), and what gets published in scientific journals is not necessarily read by practitioners and/or decision-makers, who have been shown to still rely on experience (Pullin et al. 2004; Cabin et al. 2010; Cook et al. 2010). We therefore decided to conduct our review of the evidence base focusing on the information the practioners themselves gather and report on, complemented with interviews of the practitioners themselves. When complemented with systematic reviews already in existence (e.g. Aronson et al. 2010) we have a much better idea of the evidence base available. Moreover, the requirements of the systematic review method (Stewart et al. 2005) are such that, in the world of application, where time and financial resource constraints are a reality, few practitioners can afford to undertake systematic reviews before making decisions on how to restore.

Guldemond and colleagues' second concern is that we confuse restoration goal achievement with successful restoration. In fact we do not even attempt to assess success – either that of goals or programs. As outlined in our study, we merely assess what types of goals are set and report on the bias towards socio-economic goals. We do not, as Guldemond et al. assert, associate the presence of these goals with restoration success. However, the authors might want to reconsider their assertion that it is only ecological goals that matter in determining success. Increasingly more research highlights that sustainable conservation programs require social, political as well as ecological success to survive in the long term (Higgs 1997; Mathevet & Mauchamp 2005; Aronson et al. 2010). And so, while we pass no judgement on the bias of goals in our paper, we do not agree that it is only ecology that matters in restoration.

We thank Guldemond et al. for taking up this challenging topic and helping us think through these issues as we continue with our work. In fact it seems there is a lot we agree on, and their closing line is in fact a summary of our long term goals: “[In] encouraging evidence based restoration in South Africa we need to first assess whether restoration is evidence based, and if not why not, and second to introduce or improve systems to evaluate the data collected in restoration programs and incorporate it into an evidence base available to and useful for decision makers”. Our study now moves on from examining the evidence base to explore these issues. And, in the interest of mainstreaming evidence-based practice into restoration, we hope to continue engaging in collegial, constructive debate.

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Addendum D

Working for Water manager interview schedule

Designed by Phumza Ntshotsho,

with help from Miss Nadia Sitas

Telephonic interviews conducted with Working for Water managers between January and March 2012.

1. What is your position in the WfW program?
    a. How long have you been in this position?
    b. What are your main roles and responsibilities?

2. Since you started working for WfW have you noticed any changes in how WfW's work is carried out?
    a. If yes what changes?
    b. What informed these changes?

3. Since you started working for WfW, have you noticed any changes in the way clearing of alien plants is planned and done?
    a. If yes, what changes have occurred?
    b. What informed these changes?

4. How is it decided where clearing should be done?

5. How is it decided which alien plants should be targeted?

6. How is it decided what methods should be used to clear a specific alien plant?

7. When working, does WfW collect information/data on the work being done?
    a. If yes, what data/information is collected?
    b. What is this information used for?

8. Is any data collected on the impacts of the clearing?
    a. If yes how and when is this done?
    b. Is this information used in any way to improve how the program operates
    c. If not, do you know the reasons?

9. Does WfW use scientific data and information in planning and conducting its work?
    a. If so what kind of data or information is used?

10. Does WfW consult with scientists in planning and conducting its work?
    a. If so how is this done?

b. If so which scientists are used?

11. When you make decisions in your job what information do you use?

12. Is there any other information that you would like to share that you feel would be relevant to this study?

13. Is there someone else that you think I should speak to?