Ecological Restoration for Protected Areas

Principles, Guidelines and Best Practices

Prepared by the IUCN WCPA Ecological Restoration Taskforce
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Peter Valentine, Series Editor

Developing capacity for a protected planet

Best Practice Protected Area Guidelines Series No.18

WCPA World Commission on Protected Areas
Convention on Biological Diversity
Parks Canada Parcs Canada
SER Society for Ecological Restoration
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IUCN WCPA's BEST PRACTICE PROTECTED AREA GUIDELINES SERIES

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IUCN PROTECTED AREA DEFINITION, MANAGEMENT CATEGORIES AND GOVERNANCE TYPES

IUCN defines a protected area as:
A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

The definition is expanded by six management categories (one with a sub-division), summarized below.
Ia Strict nature reserve: Strictly protected for biodiversity and also possibly geological/ geomorphological features, where human visitation, use and impacts are controlled and limited to ensure protection of the conservation values
Ib Wilderness area: Usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, protected and managed to preserve their natural condition
II National park: Large natural or near-natural areas protecting large-scale ecological processes with characteristic species and ecosystems, which also have environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities
III Natural monument or feature: Areas set aside to protect a specific natural monument, which can be a landform, sea mount, marine cavern, geological feature such as a cave, or a living feature such as an ancient grove
IV Habitat/species management area: Areas to protect particular species or habitats, where management reflects this priority. Many will need regular, active interventions to meet the needs of particular species or habitats, but this is not a requirement of the category
V Protected landscape or seascape: Where the interaction of people and nature over time has produced a distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values
VI Protected areas with sustainable use of natural resources: Areas which conserve ecosystems, together with associated cultural values and traditional natural resource management systems. Generally large, mainly in a natural condition, with a proportion under sustainable natural resource management and where low-level non-industrial natural resource use compatible with nature conservation is seen as one of the main aims

The category should be based around the primary management objective(s), which should apply to at least three-quarters of the protected area – the 75 per cent rule.

The management categories are applied with a typology of governance types – a description of who holds authority and responsibility for the protected area. IUCN defines four governance types.
Governance by government: Federal or national ministry/agency in charge; sub-national ministry/agency in charge; government-delegated management (e.g. to NGO)
Shared governance: Collaborative management (various degrees of influence); joint management (pluralist management board; transboundary management (various levels across international borders)
Private governance: By individual owner; by non-profit organisations (NGOs, universities, cooperatives); by for-profit organsations (individuals or corporate)
Governance by indigenous peoples and local communities: Indigenous peoples' conserved areas and territories; community conserved areas – declared and run by local communities

For more information on the IUCN definition, categories and governance type see the 2008 *Guidelines for applying protected area management categories* which can be downloaded at: www.iucn.org/pa_categories

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IUCN (International Union for Conservation of Nature)
IUCN helps the world find pragmatic solutions to our most pressing environment and development challenges. IUCN works on biodiversity, climate change, energy, human livelihoods and greening the world economy by supporting scientific research, managing field projects all over the world, and bringing governments, NGOs, the UN and companies together to develop policy, laws and best practice. IUCN is the world's oldest and largest global environmental organization, with more than 1,200 government and NGO members and almost 11,000 volunteer experts in some 160 countries. IUCN's work is supported by over 1,000 staff in 45 offices and hundreds of partners in public, NGO and private sectors around the world.
www.iucn.org

Protected Planet
Protected Planet is a partnership between IUCN, IUCN-WCPA and UNEP-WCMC that envisages a world that recognizes the value of protected areas and is empowered to take positive action to maintain and improve their integrity in the face of global change. The partnership includes the development of a global platform for the acquisition, analysis, exchange and communication of data and knowledge on the status and trends of protected areas that engages the full spectrum of stakeholders, and is instrumental in the achievement of the Millennium Development Goals, the CBD Strategic Plan for Biodiversity, informed decision-making and enhanced action. The Protected Planet report, IUCN WCPA's Best Practice Guidelines and PARKS journal are all part of empowering this action.
www.protectedplanet.net

IUCN World Commission on Protected Areas (WCPA)
IUCN WCPA is the world's premier network of protected area expertise. It is administered by IUCN's Programme on Protected Areas and has over 1,400 members, spanning 140 countries. IUCN WCPA works by helping governments and others plan protected areas and integrate them into all sectors; by providing strategic advice to policy makers; by strengthening capacity and investment in protected areas; and by convening the diverse constituency of protected area stakeholders to address challenging issues. For more than 50 years, IUCN and WCPA have been at the forefront of global action on protected areas.
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Convention on Biological Diversity
The Convention on Biological Diversity (CBD), which entered into force in December 1993, is an international treaty for the conservation of biodiversity, the sustainable use of the components of biodiversity and the equitable sharing of the benefits derived from the use of genetic resources. With 193 Parties, the Convention has near universal participation among countries. The Convention seeks to address all threats to biodiversity and ecosystem services through scientific assessments, the development of tools, incentives and processes, the transfer of technologies and good practices, and the full and active involvement of relevant stakeholders including indigenous and local communities, youth, NGOs, women and the business community. The tenth meeting of the Conference of the Parties to the CBD, held in 2010, adopted a revised and updated Strategic Plan for Biodiversity for 2011-2020, comprising five strategic goals and 20 Aichi Biodiversity Targets. The Plan is the overarching framework on biodiversity, not only for the biodiversity-related conventions, but for the entire United Nations system.
www.cbd.int

Parks Canada Parcs Canada

Equilibrium RESEARCH

Parks Canada Agency

The Parks Canada Agency protects and presents nationally significant examples of Canada's natural and cultural heritage, and fosters public understanding, appreciation and enjoyment in ways that ensure the ecological and commemorative integrity of these places for present and future generations. National parks, national historic sites and national marine conservation areas, of which Parks Canada is the proud steward, offer to Canadians and international visitors the opportunity to live meaningful experiences and to personally connect with these heritage places. In carrying out its responsibilities, Parks Canada works in collaboration with Aboriginal peoples, stakeholders and neighbouring communities.

www.pc.gc.ca

Equilibrium Research

Equilibrium Research promotes positive environmental and social change by linking targeted research to field application. Sue Stolton and Nigel Dudley established Equilibrium in 1991. Equilibrium work with groups ranging from local communities to United Nations agencies. Major issues include protected areas and broadscale approaches to conservation. Equilibrium offers a consultancy service and also runs its own portfolio of projects. Sue and Nigel are members of IUCN's World Commission on Protected Areas (WCPA) and its Commission on Environmental, Economic and Social Policy (CEESP). Nigel chairs the WCPA theme on capacity development.

www.EquilibriumResearch.com

SER SOCIETY FOR ECOLOGICAL RESTORATION

Wrangellia Consulting

Society for Ecological Restoration (SER)

SER is an international NGO representing a network of restoration experts that include researchers, practitioners, decision-makers, and community leaders from Africa, Asia, Australia/New Zealand, Europe, and the Americas. SER's mission is "to promote ecological restoration as a means of sustaining the diversity of life on Earth and re-establishing an ecologically healthy relationship between nature and culture." SER works at the international, regional, and national levels partnering with government agencies, intergovernmental organizations, NGOs, the private sector, and local communities to advance the science and practice of ecological restoration for the benefit of biodiversity, ecosystems, and humans. SER facilitates the sharing of restoration science and knowledge through its peer-reviewed journal, Restoration Ecology, Island Press book series, and international conferences and workshops.

www.ser.org

Wrangellia Consulting

Specializing in protected areas management, climate policy, and carbon pricing, Wrangellia Consulting helps policy makers distill expert advice, synthesize emerging best practices, and plan new initiatives. It is based in Victoria, Canada. Stephanie Cairns and Carol Hall led Wrangellia's contribution to this publication.

www.wrangellia.ca

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The text of this book is printed on Flo Dull 80lb paper made from wood fibre from well-managed forests certified in accordance with the rules of the Forest Stewardship Council (FSC).

Foreword

"The difference between what we do and what we are capable of doing would suffice to solve most of the world's problem.[1]" Mahatma Gandhi

Now more than ever, it is clear that achieving our shared vision for a world in which nature is valued and conserved requires enhanced action, not only to protect what remains, but also to recover what has been lost. We have collectively done much to expand the global network of protected areas and to improve the management of these treasured places and the lands and waters between them as a fundamental contribution to meeting our global conservation challenges. But we are capable of doing more! In some places, natural, cultural, or other associated values of protected areas have been compromised or lost. We know that in many cases, we can restore these values. By taking action, through ecological restoration both within and outside protected areas, we can re-establish species, re-connect habitats, re-instate natural processes and recover cultural traditions and practices; and in doing so, we can restore the values and benefits of protected areas for all. The promise of ecological restoration is thus the hope that, through action, our shared vision can be realized.

This publication offers a guidance framework for ecological restoration that is intended to support managers of, and stakeholders in, protected areas of all categories and all governance types in their efforts to restore natural and associated values of protected areas. More broadly, it will also contribute to the achievement of global goals and targets for biodiversity conservation. As we increase our efforts to restore protected area values, however, we must also act with caution and humility, recognizing that ecological restoration is a complex and challenging process and that our interventions can have unforeseen consequences. This guidance framework thus has at its foundation a clear set of principles which, rather than defining rigid processes, underpin an approach that encourages a holistic perspective, broad collaboration, careful planning, and thoughtful implementation to achieve results. The text is replete with short examples and detailed case studies that enrich the reader's understanding of the potential for ecological restoration to help us overcome some of our most daunting challenges.

To the best of our knowledge, this publication is the most comprehensive compilation of guidance and related examples of ecological restoration for protected areas produced to date. It is with great pleasure that we encourage you to explore the ideas, guidance, and examples it contains. More importantly, however, in the tradition of Mahatma Gandhi, one of the 20th century's visionary people of action, we encourage you to test these ideas through 21st century action.

Nik Lopoukhine,
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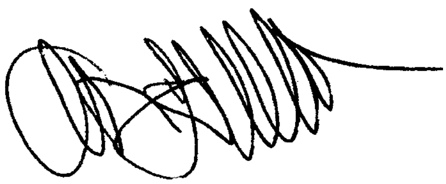

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Braulio Ferreira de Souza Dias,
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1 From: Dalton, Dennis. 2012. *Mahatma Gandhi: Nonviolent power in action. Columbia University Press. New York, pp 336*

Preface: Document Development

This document is intended to guide the efforts of protected area managers and partner organizations aimed at restoring natural, cultural and other important values of protected areas. Restoration in and around protected areas is a key priority of IUCN and the Convention on Biological Diversity (CBD)'s Programme of Work on Protected Areas (PoWPA). The CBD PoWPA encourages States to: 'Establish and implement measures for the rehabilitation and restoration of the ecological integrity of protected areas' (Section 1.5.3 of the Programme of Work on Protected Areas). The need for guidance on implementing these measures was recognized at the 4th IUCN World Conservation Congress (October 2008, Barcelona, Spain), where IUCN members voted in favour of a resolution (4.036) calling on the IUCN Director General to produce a best practice protected area guideline for ecological restoration. This call was reinforced at the 10th Conference of Parties of the CBD (October 2010, Nagoya, Japan) where IUCN's World Commission on Protected Areas (WCPA) was invited to work with other relevant organizations to: 'develop technical guidance on ecological restoration' (Decision X/31, Paragraph 3.8[2]). IUCN also committed to 'working with Parks Canada and the Society for Ecological Restoration to provide technical guidance on restoration within protected areas', aiming to publish restoration guidelines at the World Conservation Congress in 2012 (IUCN WCPA, 2010).

IUCN WCPA consequently established a Task Force on Ecological Restoration, the primary focus of which is to respond to these calls for guidance. Parks Canada leads this Task Force, in collaboration with the Society for Ecological Restoration (SER). The Task Force has 25 members representing over a dozen countries worldwide. The best practice approach agreed to in Barcelona was modelled on Canadian guidelines (*Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas*) developed by Parks Canada and the Canadian Parks Council (2008) which were also prepared in collaboration with numerous partners, including members of the SER and SER's Indigenous Peoples' Restoration Network, and built on SER's *Primer on Ecological Restoration* (2004).

This document has been shaped by many people. In August 2009, approximately 30 protected area managers and other ecological restoration professionals from around the world convened in Perth, Western Australia, for a one-day workshop in order to offer initial ideas and input on the content and structure of the current document. In October 2010, the IUCN WCPA Ecological Restoration Task Force was established. Members have provided detailed advice, based on experience in protected areas worldwide, regarding the underlying principles and technical aspects of ecological restoration best practice. In August 2011, many Task Force members were able to meet in Merida, Mexico, to review a full pre-consultation text. The meeting, held just after SER's 4th World Conference on Ecological Restoration, also offered the opportunity to involve other experts from SER as well as staff of the Secretariat of the CBD. In May 2011, an informal meeting of international experts was held in Victoria, Canada, on ecological restoration and resilience under conditions of rapid, unprecedented change. The specific mandate was to discuss best practices for setting restoration objectives in the context of rapidly changing ecological conditions, and best practice guidelines to support resilience in the face of multiple ecological shifts, most notably climate change.

Drawing on this body of work, this publication has been developed by Karen Keenleyside (Parks Canada), Chair of the IUCN WCPA Task Force on Ecological Restoration, and consultants Stephanie Cairns (Wrangellia Consulting, Canada), Carol Hall (Canada), and Nigel Dudley and Sue Stolton (Equilibrium Research, UK).

2 http://www.cbd.int/decision/cop/?id=12297

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A wide range of experts contributed their extensive knowledge and substantial time to guide the development of this document, and about 100 reviewers in addition to the Task Force and IUCN WCPA Steering Committee were invited to provide advice and input. The authors are deeply grateful for their help (apologies to anyone who has been left out of the extensive list below).

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Victoria 2011 expert consultation on restoration under rapid change

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Contents

Chapter 1
How to Use this Guide

This publication provides guidance for terrestrial, marine, and freshwater protected area managers at both system and site levels on the restoration of natural and associated values of protected areas. As this sometimes necessitates restoration beyond protected area borders (e.g., to address ecosystem fragmentation and maintain well-connected protected area systems), this guide uses the term 'restoration for protected areas' for activities within protected areas and for activities in connecting or surrounding lands and waters that influence protected area values. It provides information on principles and best practice, with examples, and advice on the process of restoration, but is not a comprehensive restoration manual and does not give detailed methodologies and techniques. Some manuals are listed in the bibliography.

The guide starts by introducing key concepts relating to restoration and protected area management and provides a brief explanation of when and where restoration might be the best option (Chapter 2). It then summarizes principles and guidelines for restoration (Chapter 3), to help in setting restoration policies, goals, and objectives, and in implementation. The aim is to encourage consistency with underlying principles, while allowing for biome-, site- or issue-specific variation in implementation. The document draws on global experience to identify best practice methods and techniques for restoration projects (Chapter 4). Finally, a seven-phase framework recommends decision-making processes for carrying out ecological restoration for protected areas (Chapter 5) (see Figure 1).

A set of case studies (Chapter 6) illustrate real-life applications in and around protected areas. While learning from experience is encouraged, practice is seldom transferable in any simple way. Methods are specific to particular locations and conditions, so that any approach must be confirmed on a site-specific basis. The guide includes a glossary of key terms. Readers are referred to more detailed technical guidance and manuals, particularly when information is readily accessible on the internet in the reference list and bibliography. While the guide assumes some technical knowledge, it is aimed principally at practitioners.

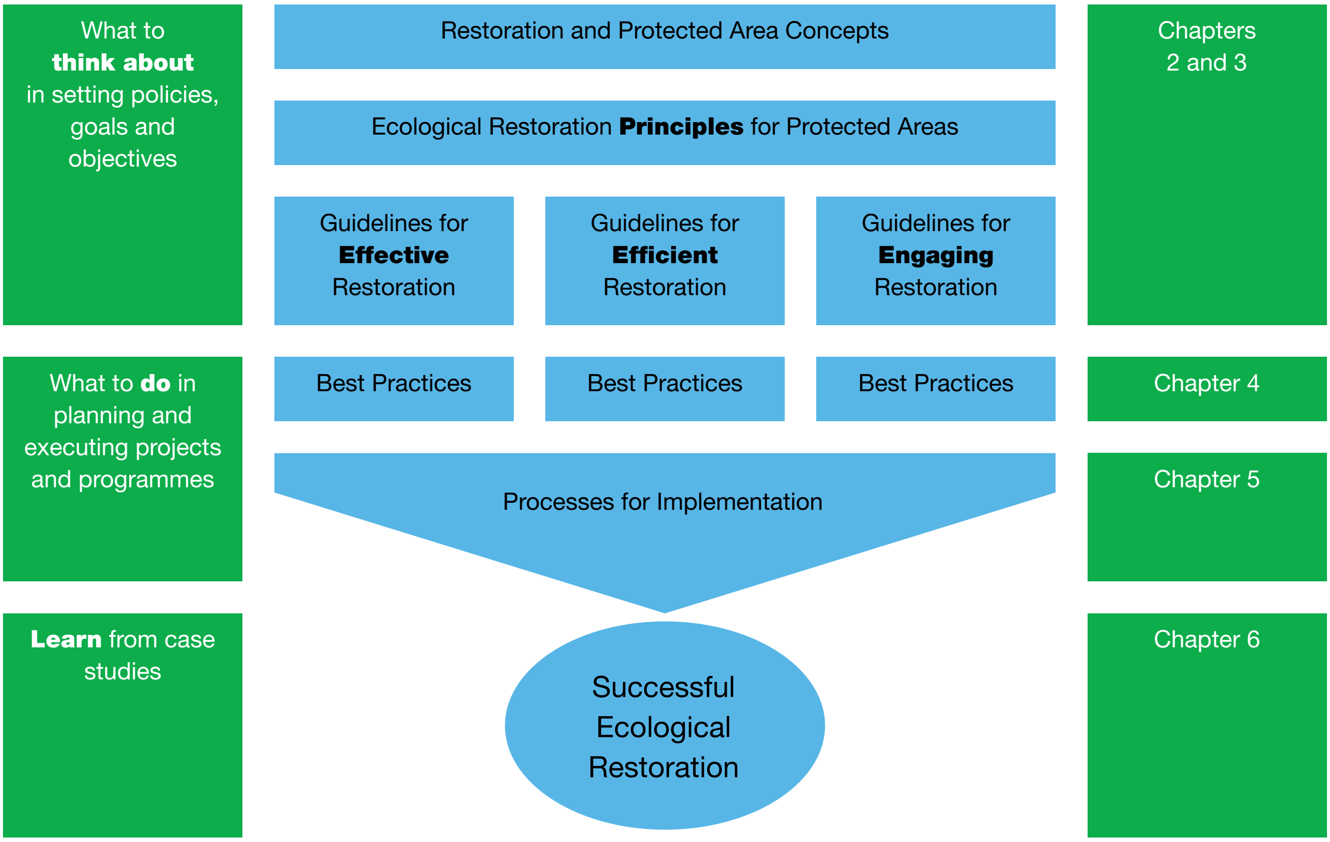


Figure 1: Underpinning framework for this document

Case studies (Chapter 6) provide detailed examples of ecological restoration around the world, such as the Oyster Reef Restoration Project in Canaveral National Seashore, USA. (Case study 12) © Anne P. Birch, The Nature Conservancy

Chapter 2
Restoration and Protected Area Concepts

This chapter introduces some of the basic definitions and concepts used in the guide.

Definitions

- Ecological restoration: ‘the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed’ (SER, 2004)
- Protected area: ‘A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values’ (Dudley, 2008)

Key Concepts

- Restoration in and around protected areas contributes to many societal goals and objectives associated with biodiversity conservation and human well-being
- Reasons for implementing restoration projects vary and may include, for example, recovery of individual species, the strengthening of landscape- or seascape-scale ecosystem function or connectivity, improvement of visitor experience opportunities, or the re-establishment or enhancement of various ecosystem services
- Restoration can contribute to climate change adaptation by strengthening resilience to change and providing ecosystem services. It can contribute to climate change mitigation by capturing carbon in ecosystems
- Rapid climate change and other global changes create additional challenges for restoration and underscore the need for adaptive management
- Protected area managers need to work with stakeholders and partners inside and outside protected area boundaries to ensure successful restoration within and between protected areas

Chapter 2: Restoration and Protected Area Concepts

Fandriana Marolambo Forest Landscape Restoration Project, Madagascar: The project is making special efforts to expand knowledge on indigenous species through setting up community nurseries to propagate native plants. (Case study 3) © Daniel Vallauri (WWF)

Protected areas are a positive response to many significant conservation challenges of the 21st century. Habitat loss and degradation, overexploitation of resources, climate change, invasive species and pollution all contribute to loss of species and ecosystem services (SCBD, 2010a). The Millennium Ecosystem Assessment found 60 per cent of the world's ecosystem services were degraded. Humanity directly affects 83 per cent of the land surface (Sanderson et al., 2002) and 100 per cent of the ocean, with 41 per cent strongly affected (Halpern et al., 2008). The greatest cause of species extinction is habitat loss (SCBD, 2010a). Protected areas protect habitat. Recent global commitments to conserve biodiversity and ecosystem services through effectively and equitably managed, ecologically representative and well-connected systems of protected areas (SCBD, 2010b) underscore their value.

At the same time, increasing attention is being given to restoration of terrestrial, marine and inland water ecosystems to re-establish ecosystem functioning and ecosystem services (ten Brink, 2011). Ecological restoration is an important management approach that can, if successful, contribute to broad societal objectives for sustaining a healthy planet and delivering essential benefits to people (SCBD, 2010b). It offers hope of repairing ecological damage, renewing economic opportunities, rejuvenating traditional cultural practices, and enhancing ecological and social resilience to environmental change.

Over time, protected areas have moved from being places where management was frequently hands-off or *laissez-faire* to places where active management and restoration are done to conserve biodiversity and other key protected area values. Although protected area management aims first at protecting existing ecosystems, a combination of previous degradation and continuing external pressures mean that restoration is

Box 1

RESTORATION CONCEPT

Slow and steady wins the race

Much of the guidance presented in this document relates to the careful planning of ecological restoration activities. Rather than seeing attention to planning as a barrier to action, protected area managers should think of the time and effort spent on preparatory phases of a project as an investment in an increased likelihood of success. Similarly, while not all of the concepts and details presented here will be relevant to every ecological restoration project, they offer a rich variety of ideas and examples that can inform thinking about ecological restoration for protected areas generally while also guiding implementation and decision-making locally. Readers are thus encouraged to take the time to explore the guidance, case studies, and other examples contained in this volume with a view to thoughtfully and carefully restoring some of the world's most treasured places.

2.1 Ecological restoration and protected area concepts

Palmyra Atoll, North Pacific: Undertaking preparations for the eradication of black rats © Island Conservation

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

often needed. There are thousands of successful examples worldwide of ecosystem recovery, species re-introductions, removal of exotic species and many other active restoration processes in protected areas. Ecological restoration is thus an increasingly important aspect of protected areas management. In many cases, the time, resources, and effort invested in ecological restoration can restore not only biodiversity, but also broad additional material and non-material values and benefits of protected areas ecosystems.

Carefully planned and managed ecological restoration of protected areas will become more necessary with increasing environmental pressure and climate change. But it is a challenging and complex process that involves decisions to manipulate features of some of the most valued ecosystems intentionally to achieve specific conservation goals. Techniques and approaches are still developing and at the same time, unprecedented levels of uncertainty (e.g., associated with changing climate, invasive species and habitat degradation) mean that despite even the best efforts some restoration will not be successful. Global uncertainty, and uncertainty about the degree to which ecological restoration efforts will succeed, impose special responsibilities on those engaged in protected area restoration to act intelligently, resolutely and with humility (Higgs & Hobbs, 2010).

What is ecological restoration?

Ecological restoration is 'the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed' (SER, 2004). It is an intentional intervention that initiates or accelerates recovery of an ecosystem with respect to its structure (e.g., species composition, soil and water properties) and functional properties (e.g., productivity, energy flow, nutrient cycling), including exchanges with surrounding landscapes and seascapes (SER, 2004; Parks Canada and the Canadian Parks Council, 2008; SCBD, 2011). Collectively, these make up general attributes of 'ecological integrity' (Woodley, 2010), and ecological restoration thus aims to recover or re-instate ecological integrity, and accompanying resilience, of the ecosystem. The term 'ecological restoration' can generally be taken as synonymous with 'ecosystem restoration' (SER, 2010), although some restoration projects within protected areas may have narrower aims, such as recovery of a single rare species. Ecological restoration can be confined to reducing pressures and allowing natural recovery, or involve significant interventions, such as planting vegetation, re-establishment of locally extinct species or the deliberate removal of invasive alien species.

In this document, the term 'degraded' refers to any harmful alteration to protected areas (i.e., degradation, damage and destruction, as defined by SER, 2004), such as the introduction and spread of an invasive species; the loss of important species interactions; the loss of biophysical attributes such as soil structure and chemistry or hydrological processes; and the decline in its potential to sustain livelihoods.

Ecological restoration will often include or build upon efforts to 'remediate' ecosystems (e.g., remove chemical contamination), or 'rehabilitate' ecosystems (e.g., recover

Australia: The critically endangered Gilbert's potoroo (*Potorous gilbertii*) is being introduced to an offshore island to establish an insurance population. The only known population (35 individuals) is vulnerable to extinction by a single wildfire event. © Western Australia Department of Environment and Conservation

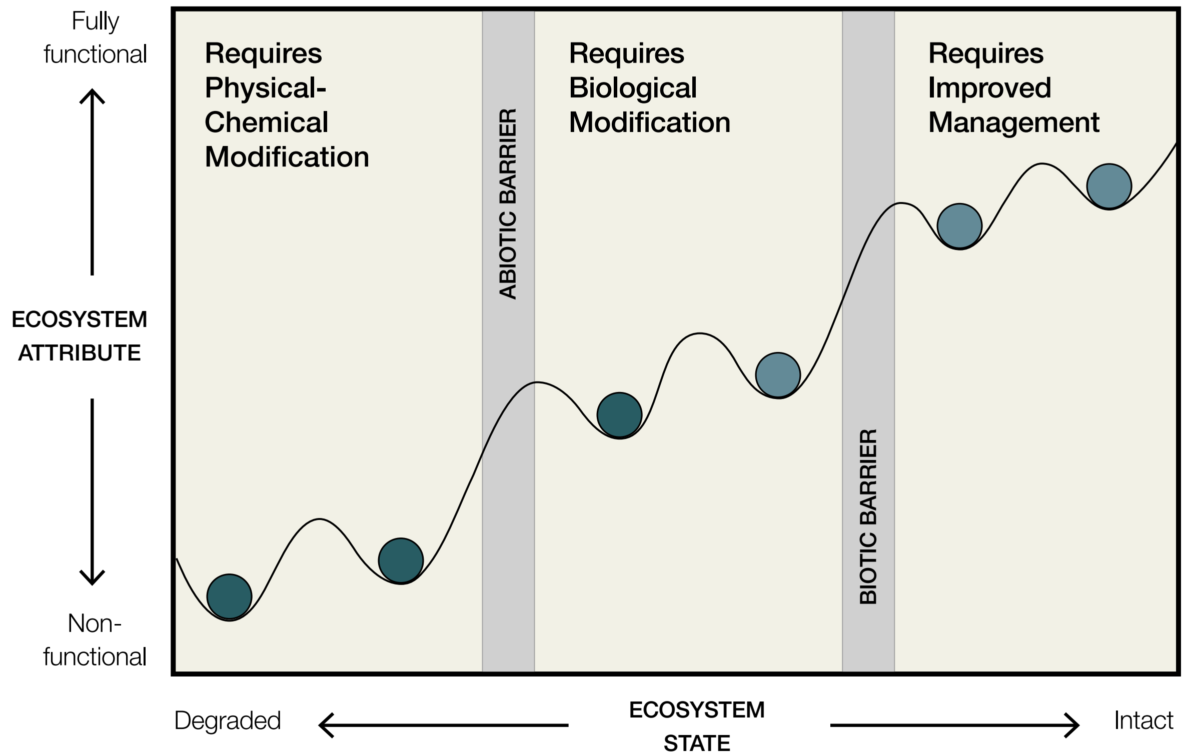


Figure 2: Simplified conceptual model for ecosystem degradation and restoration (Parks Canada and the Canadian Parks Council, 2008; adapted from Whisenant, 1999 and Hobbs & Harris, 2001). The numbered balls represent alternative ecosystem states, with the resilience of the system being represented by the width and depth of the 'cup'. Disturbance and stress cause transitions towards increasingly degraded states, with 6 being the most degraded. Barriers, or thresholds may also exist between some ecosystem states (e.g., between states 2 and 3) that prevent the system from returning to a less degraded state without management intervention. Restoration attempts to move the ecosystem back towards a more structurally 'intact', well functioning state, (i.e., towards state 1). *See* Parks Canada and The Canadian Parks Council (2008) for additional details.

Box 2

A CLOSER LOOK Indigenous traditional resource management

The value of Indigenous traditional resource management (TRM) has only recently received attention from conservation and restoration science. It is still poorly understood. The recent interest by scientists in TEK and TRM is driven by the need for local data and eco-historical baselines—before irreversible thresholds are crossed—in an increasingly unpredictable world.

TRM—and collaborative, collegial Indigenous partnerships—are important to ecosystems. Traditional ecological knowledge (TEK) is complementary to Western science and resource management in protected areas, particularly in this age of rapid environmental change. This is acknowledged by ecologists in the Ecological Society of America (ESA)'s journal *Frontiers in Ecology:* 'Spatially explicit local knowledge is particularly important for identification of thresholds or tipping points…native peoples have intimate knowledge of spatial and temporal variabilities as observable indicators, which when combined with a scientific understanding…can be used to develop reliable descriptions of reference conditions for [environmental] assessments…' (Herrick et al., 2010).

TEK is an oral intergenerationally transmitted knowledge-practice-belief complex (Berkes, 2008), capturing a strong cultural environmental memory and sensitivity to change, and is dependent on the survival of living cultures in their aboriginal homelands. Ecosystem-based adaptation was essential to Indigenous peoples' proven resilience to change. Survival required *knowledge*-based stewardship. Consequently, TEK was [and is] innovative and adaptable. Its long-term local qualitative observations can 'ground-truth' Western science's more generalized experimental and remote technological approaches. As climate disruption continues to affect ecosystems, observational data on sites that are not easily manipulated experimentally are becoming critically important. TEK is in a position to supply such data.

Traditional cultural practices have, for the most part, been ecologically sustainable. Parks Canada and the Canadian Parks Council (2008) recognize 'longstanding, tested, ecologically appropriate practices as *ecological* values to be restored or maintained.' Indigenous land ethics are based on a spiritual obligation to give back to animal and plant relations that sustain humans or suffer the consequences. Many ecosystems have evolved for millennia with Indigenous sustainable cultural practices that have shaped ecosystem structure and composition. These Indigenous cultural landscapes can be a reference model as a source of context and constraint in shaping restoration goals. Indigenous peoples can be valuable partners in collaborative research, and are able to intervene periodically to achieve, monitor, and maintain restoration objectives intergenerationally. Incorporating Indigenous cultural practices in protected areas strengthens Indigenous cultures and, reciprocally, their sustainable cultural practices are a necessary part of maintaining ecosystem health. Indigenous peoples are a keystone biotic component of many ecosystems, and their removal can lead to unintended cascading negative ecological events that could cross irreversible thresholds. Their continued presence in—or their return to—homelands that are now protected areas is a win-win solution for Western managers and Indigenous stewards alike and abides by the rights set out in the UN Declaration on the Rights of Indigenous Peoples.

Dennis Martinez: Indigenous Peoples' Restoration Network

functions and services). However, ecological restoration is generally broader in its purpose than either of these activities, as it takes an 'ecosystem approach' to management (SER, 2008) and can have multiple goals that encompass the simultaneous recovery of ecological, cultural and socio-economic values of the system. The twelve principles of the ecosystem approach from the CBD[3] provide guidance on ecosystem management that supports biodiversity, sustainable use and fair and equitable benefit sharing. In addition, the IUCN's Commission on Ecosystem Management and the SER (Gann & Lamb, 2006) have identified fourteen principles for restoration that support this broader ecosystem approach[4].

The method of restoration, its timescale, costs and chances of success depend on the threat to be addressed, surrounding biological and social conditions and how far degradation has advanced. For example, overcoming abiotic (non-living) barriers to recovery such as soil contamination or hydrological function can be a critical first step in recovery of biological attributes such as species composition (SER, 2010). Conversely, in some situations simply removing a stress factor (for instance, reducing uncharacteristic grazing intensity from livestock in a protected landscape) can be enough to allow an ecosystem to recover. Sometimes a variety of approaches is needed. For example, although deforestation has been the dominant process in tropical forest during the last 20 years there has been a substantial increase in tropical secondary forest due to primarily passive restoration (i.e., natural regeneration), along with active restoration (Holl & Aide, 2011).

3 http://www.cbd.int/ecosystem/principles.shtml
4 http://www.ser.org/content/Globalrationale.asp

Pacific Rim National Park Reserve, Canada: Visitors on the West Coast Trail with a First Nations interpreter © Parks Canada

Figure 2 provides a simplified conceptual diagram of the relationship between the degree of degradation and approaches to restoration. While not shown in Figure 2, social and cultural issues such as the absence of support from local communities or unhelpful laws and policies may be barriers to restoration. In landscapes that have evolved with human interventions (often by indigenous people) over millennia, the removal of these interventions (e.g., intentional burning) may itself be a stressor. Addressing improved management, socio-economic and cultural needs, motivation and governance in restoration are all vital for achieving success (Hobbs et al., 2011).

Ecological restoration is a knowledge and practice-based undertaking. It uses natural, physical and social science, other forms of knowledge including traditional ecological knowledge (TEK), and lessons learned from practical experience to guide the design, implementation, monitoring and communication of restoration. It needs to be an inclusive process that embraces interrelationships between nature and culture, and engages all sectors of society including indigenous, local, and disenfranchised communities (Block et al., 2001, SER, 2011). In some cases cultural restoration is a necessary precursor to ecological restoration. For example, the re-establishment of taboos on tree cutting in sacred groves in Kenya was necessary for their restoration (Wild & McLeod, 2008; Verschuuren et al., 2010).

The relative ease and speed of ecological restoration differs between ecosystems and with the type and extent of degradation. It also depends on what is considered an 'end point' of restoration. For example, recovery of a mature ecosystem with a full complement of expected species can be extremely slow, if possible at all. However, an ecosystem that functions well but does not necessarily have a full complement of native species can sometimes be restored relatively quickly. Although generalizations are difficult, restoration of wetlands and mangroves is often a relatively quick process; and tropical forests recover more quickly than temperate and boreal forests. Much remains to be learned about restoration of peatlands and corals. The ease with which grassland ecosystems recover depends largely on vegetation history and climate, with restoration in arid areas being more challenging.

What are protected areas?

Protected areas, as discussed in this document, refer to any areas (e.g., national parks, nature reserves, wilderness areas, indigenous and community conserved areas) that meet the IUCN definition of a protected area (Dudley, 2008): 'A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values'. They can include a range of different management approaches and governance types (*see inside front cover*). The IUCN protected area management category provides information on the overall focus of management for the protected area and can guide the approach to ecological restoration, particularly in the absence of formal, written management objectives.

Under this definition, IUCN recognizes six protected area management categories, varying from strict protection to protected landscapes and/or seascapes, and protected areas with sustainable use. These categories broadly reflect the natural and cultural values for which protected areas are established. As impairment of these values can be a trigger for management intervention, ecological restoration may thus be appropriate in any category of protected area. However, the degree and type of intervention will be highly dependent upon the management goals of the particular protected area. For example, loss of ecological integrity may be a trigger for restoration in a protected area managed according to category II objectives (ecosystem protection) whereas threats to interactions between culture and nature (e.g., survival of traditional, nature-friendly management systems) or to sustainable uses (e.g., fisheries) would identify the need to restore protected areas managed for values related to natural landscapes or seascapes or to the sustainable flow of products and services (categories V and VI). An area requiring *indefinite* active management interventions would not generally be categorized as a wilderness area (category Ib).

Similarly, protected area governance types—which include governance by governments; non-profit or for-profit private organizations; indigenous peoples and local communities; and various forms of shared governance—are the means by which decisions are made about management. They are therefore, in their institutional and social setting, a crucial factor in the overall restoration process for any category of protected area. As mentioned previously, incorporating the power of diverse

Box 3

A CLOSER LOOK Ecological restoration for protected areas and the Convention on Biological Diversity (CBD)

In October 2010 in Nagoya Japan, the tenth meeting of the Conference of the Parties (CoP) to the CBD set the stage for an increased global focus on ecological restoration through the adoption of a new Strategic Plan for Biodiversity 2011-2020 and 20 headline targets (known as the Aichi Biodiversity Targets), as well as through decisions related to protected areas, plant conservation and the third Biodiversity Outlook report.

Strategic Plan 2011-20 and the Aichi Biodiversity Targets

The restoration of protected areas and surrounding and connecting lands and waters will contribute to achievement of the goals of this Strategic Plan and the Aichi Biodiversity Targets, in particular Targets 11, 14, and 15:

Target 11: By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes**.**

Target 14: By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

Target 15: By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

Protected Areas

Ecological restoration for protected areas is an important element of the CBD Programme of Work on Protected Areas, which was adopted by CoP VII in 2004. In Nagoya, under paragraph 26 of the Protected Areas Decision (Decision X/31), section 'Restoration of ecosystems and habitats of protected areas', the CoP urged Parties to:
(a) Increase the effectiveness of protected area systems in biodiversity conservation and enhance their resilience to climate change and other stressors, through increased efforts in restoration of ecosystems and habitats and including, as appropriate, connectivity tools such as ecological corridors and/or conservation measures in and between protected areas and adjacent landscapes and seascapes; and (b) include restoration activities in the action plans of the programme of work on protected areas and national biodiversity strategies.

Plant Conservation

In decision X/17, the CoP adopted the consolidated update of the Global Strategy for Plant Conservation wherein target 4 calls for securing at least 15 per cent of each ecological region or vegetation type through effective management and/or restoration. Target 8 of this consolidated update calls for availability of at least 20 per cent of threatened plant species for recovery and restoration programmes.

Biodiversity Outlook

In paragraph 6 of decision X/4 on the third edition of the Global Biodiversity Outlook, the CoP noted the need to place greater emphasis on the restoration of degraded terrestrial, inland water and marine ecosystems with a view to re-establishing ecosystem functioning and the provision of valuable services taking into account existing guidance.

Table 1: Reasons for restoring protected areas

Reason	Examples
To restore ecological integrity in and around protected areas by re-instating key ecological processes	Reinstatement of fire in Finnish protected areas has increased populations of red-listed or rare insect species in boreal forests in Finland (Hyvärinen et al., 2006).
To restore ecological integrity in and around protected areas by reducing the influence of invasive species	The coypu (*Myocastor coypus*) was eliminated from protected areas and linking habitat in eastern England (Baker, 2006) and actions have been taken to control the matandrea or butterfly ginger (*Hedychium coronarium*) in the Flora and Fauna Sanctuary of Otún Quimbaya in Colombia (Ramirez et al., 2008).
To restore ecological integrity in and around protected areas by maintaining or recovering species and habitat degraded or lost	On Santa Barbara Island, California, invasive rabbits were eliminated to maintain viable populations of the endangered plant, *Dudleya traskiae*, endemic to the island (Rolston, 1995).
To restore ecological integrity in and around protected areas by reintroducing species to former habitats	Black rhinoceros (*Diceros bicornis*) and white rhinoceros (*Ceratotherium simum*) have been widely re-established across southern and eastern Africa following the decimation of populations by hunting in the 19th century and more recently poaching (Emslie et al., 2009).
To restore ecological integrity in and around protected areas by re-establishing natural hydrology, or other physical and chemical conditions that support ecosystem structure and function	WWF Indonesia has been helping restore the peat wetlands in Sebangau National Park, Indonesia by blocking canals built to facilitate logging operations which took place in the area before designation (Wetlands International, 2007; WWF, 2009).
To create new protected areas on reclaimed or previously damaged lands	New reserves in Kuwait are being established on areas that have been damaged by heavy oil pollution following the first Gulf War (Omar et al., 1999).
To expand an existing protected area or buffer zone to a protected area	In Queensland, Australia, the Government acquired additional land to expand the Springbrook National Park and World Heritage area by 28 per cent. Restoration of cleared areas by volunteers is restoring critical habitat and landscape connectivity to increase viability and resilience to climate change and other threats to this refugial area (see Case Study 11). Degraded and largely abandoned farmland in Khao Phaeng Ma, an area adjoining Khao Yai National Park in central Thailand and managed by the Wildlife Foundation of Thailand, has been restored through the planting of seedlings. It is now being colonized by a variety of species from the national park (Lamb, 2011).
To connect existing protected areas, or habitat patches within a protected area	Restoration within and between remaining patches of Atlantic forest reserve in Brazil (Rodrigues et al., 2009).
To maintain or create suitable habitats along migration pathways	The Western Hemisphere Shorebird Reserve Network maintains and restores essential feeding and resting places for migratory species in the Americas (Haig et al., 1998).
To enhance the resilience of ecosystems and help nature and people adapt to climate change	The Climate Change Adaptation Programmes for Natural Protected Areas in Mexico defines strategies designed by managers and other stakeholders; restoration increases ecosystem resilience and reduces vulnerability to climate change (CONANP, 2011a).
To help mitigate climate change by storing and sequestering carbon	UNDP is working with local communities in Belarus to restore degraded peat areas in protected areas (Tanneberger, 2010).
To protect and/or augment ecosystem services such as clean water	In Ecuador, Quito's population drinks water from two protected areas; local communities are paid by the water company to restore forest to ensure a pure supply (Troya & Curtis, 1998).
To support societal goals such as poverty alleviation, sustainable livelihoods, human health etc.	Poverty can lead to environmental degradation, so restoration projects like the Fandriana Marolambo Forest Landscape Restoration Project in Madagascar need to support poverty alleviation along with other ecological goals (see Case Study 3).
To restore culturally important nature	The Tsurui village in Japan has restored wetland wintering grounds of red-crowned cranes (*Grus japonensis*), which are considered sacred (Matthiesen, 2001).
To improve or provide high quality visitor experiences of the protected area	The 'From Log to Canoe' project in La Mauricie National Park of Canada restored water levels, riparian habitats, and a natural hydrological regime (variations in the water cycle) to aquatic ecosystems affected by past forestry. Removal of logs and other debris enhanced visitor experience by improving recreational canoeing opportunities in the park (Parks Canada, 2011a).
To protect, reinforce, and/or augment local, traditional and indigenous cultures and communities	Restoration in Gwaii Haanas, Canada (see Case Study 9) has simultaneously helped support traditional cultures and ecological integrity of forest ecosystems.

governance and traditional knowledge within protected area restoration can inspire effective approaches to restoration (Borrini-Feyerabend et al., 2012).

All protected area management needs to be flexible enough to adapt if circumstances change: if new information emerges or management interventions do not have the expected results. Restoration projects need to be more flexible than most, as knowledge remains incomplete about how restoration influences ecosystems, how their components interact, and how human interventions can influence restoration. Additional guidance regarding the establishment of ecological restoration goals in and around protected areas is discussed in Chapter 5.

2.2 Why restore protected areas?

Despite a large global conservation effort, biodiversity decline is increasing (Butchart et al., 2010) and losses are also recorded in protected areas (Craigie et al., 2010). Previous degradation, climate change, invasive alien species and wider landscape or seascape changes affect even well-managed protected areas, while illegal encroachment of people into the protected area, poaching and weak management may result in serious degradation. While the potential for restoration must not be seen as an excuse or a compensation tool for activities that damage protected area values, it can help to reverse losses that have already occurred.

Restoration of protected areas is fundamental to addressing a number of societal goals related to biodiversity conservation such as those associated with species conservation or human well-being. Protected areas are often the only remaining habitats for vulnerable or specialized species, and restoration may be needed to maintain or recover threatened populations. At a larger scale, protected areas are often the best opportunity to maintain valuable ecosystems within large-scale terrestrial and aquatic networks, which involve both protected and non-protected areas (Worboys et al., 2010a), and ecosystem restoration that also enhances connectivity can help to regain these values. Increasingly, restoration of protected areas is applied to regain lost or degraded ecosystem services, including carbon storage and sequestration and to address issues relating to disaster risk reduction, food security and water supply to both local and more distant communities (Cairns, 1997).

Governments have an obligation to restore protected areas as a result of their commitments under international treaties as well as under domestic policy and legislation. For example, restoration is explicitly referenced in the strategic plan of the United Nations Convention on Biological Diversity—in Aichi Biodiversity Target 14 on ecosystem services and Target 15 on ecosystem resilience and carbon stocks (see Box 3). Meeting obligations associated with commitments under the United Nations Framework Convention on Climate Change, particularly those related to Reducing (carbon dioxide) Emissions from Deforestation and Forest Degradation, including conservation, sustainable management, and enhancement of carbon stocks (i.e., REDD-plus) will also require restoration activities both inside and outside protected areas.

Restoration of protected areas can have other benefits also, apart from its purpose in achieving the recovery of degraded ecosystems. Protected areas facilitate and provide controlled environments for research, learning and teaching about restoration and provide reference ecosystems for monitoring. Improved opportunities for visitors to enjoy protected areas through experiencing healthy restored ecosystems can be an additional important ecological restoration goal and well-designed ecological restoration projects can be a tourism attraction and illustrate how management is responding to pressures or previous ecosystem degradation. Restoration can serve as a means of building public support for protected areas through hands-on participation of visitors and volunteers in restoration projects. Table 1 provides an overview of specific reasons for ecological restoration in and around protected areas.

2.3 When and where to restore

Decisions about when and where to restore have to strike a balance between *need* and *feasibility*. Chapter 5 highlights phases in the restoration processes to undertake this assessment (see for example **Phases 2 and 5.2**).

'Need' can be identified as when (for example):

- One or more protected area values have fallen below a certain threshold and intervention (or a change in approach) is required to recover them;
- Restoration would help recover a species/habitat/ecosystem of regional or national importance;
- Legal requirements are imposed; or
- Benefits to communities or co-benefits for climate change adaptation, mitigation, or other ecosystem services can be restored without compromising protected area values.

'Feasibility' is driven by decisions such as when:

- Success is relatively likely;
- There is sufficient support from partners and stakeholders to assure long-term success;
- Sufficient funding, resources and capacity are available; or
- Restoration activities are fairly cheap and easy.

Sulaybia Experimental Station, Kuwait: Irrigated shrub restoration © Nigel Dudley

Sebangau National Park, Central Kalimantan, Indonesia: View of ex-Sanitra Sebangau Indah's peat canal. The canal was built to drain the peat land area, Central Kalimantan, Indonesia. © WWF-Indonesia/Tira Maya Maisesa

Sebangau National Park, Central Kalimantan, Indonesia: WWF built a canal dam to increase the water level and soil humidity in peat areas. © WWF-Indonesia/Hendry

2.4 Protected area restoration in the context of climate change

Protected areas are an essential part of the response to climate change through their role in enhancing resilience to change (*adaptation*) and protecting and augmenting carbon stores (*mitigation*) (Dudley et al., 2010).

Helping nature adapt to climate change

As the climate changes, factors such as disturbance, extreme events, variations in weather patterns and changes in natural processes such as fires and pest outbreaks are expected to lead to habitat change and shifts in species' ranges. Protected areas provide safe havens (refugia) for species under climate change, and can also allow their dispersal to suitable habitats as conditions change. Protected areas with high ecological integrity and connectivity will be relatively resilient to change: i.e., they may be more resistant to change in the first place and/or better able to tolerate and adapt to new climatic conditions without completely transforming to a new type of system. Restoration that maintains or increases genetic diversity and the tolerance of ecological communities to change can help to build resilience to climate change (Maestre et al., 2012).

Helping people adapt to climate change

Restoration of protected areas can also enhance the capacity of human communities to adapt to climate change (Dudley et al., 2010). Protected areas maintain intact ecosystems to buffer local climate; reduce impacts of extreme weather events; and provide other ecosystem services such as food and medicines, air quality regulation, water purification, aquifer recharge and erosion control (Stolton & Dudley, 2010). By restoring ecosystems and the services they provide, ecological restoration of protected areas can build social and economic resilience and increase community adaptive capacity (Hobbs et al., 2010). Additional

Box 4

RESTORATION CONCEPT The role of historical information in setting restoration goals under conditions of rapid change

Restoration often uses historical information as an important guide for setting goals based on conditions prior to degradation (see identifying reference ecosystem(s) in Phase 2.2 of Chapter 5). The extent to which historical information is useful in determining specific goals depends on many factors, including site constraints, availability of historical information, type of damage, and restoration goals. Furthermore, restoration of historical ecosystem conditions is increasingly challenged by rapid environmental (climate), ecological (species invasions) and cultural (shifting values) changes.

There are cases where historically-determined references may be insufficient to help develop realistic goals for ecological restoration projects (Seabrook et al., 2011; Thorpe & Stanley, 2011; Hobbs et al., 2011; SER, 2010). For example, where conditions have shifted significantly and novel ecosystems resist any practical efforts at achieving historically-determined goals, the objectives of ecological interventions are more focused on ensuring maintenance or recovery of biodiversity and ecosystem services, and resisting further degradation (Hobbs et al., 2011).

Such developments represent emerging approaches to environmental management under conditions of rapid change. However, this is not to suggest that novel ecosystems should be embraced as restoration targets for protected areas. Several important points should be borne in mind. In particular, the effects of environmental and ecological change are not distributed evenly across the landscape or seascape, and may vary tremendously at local and regional scales. As a result, some protected areas may be relatively resistant to change and restoration with a focus on historically-determined goals will still make sense. Even when novel ecosystems involving new species assemblages are considered necessary or desirable, the use of historical information may become more significant as a source of context and constraint in shaping goals of restoration projects.

Understood in all of its myriad forms, historical knowledge will play a key role in restoration—for example in improving understanding of range shifts, species interactions and adaptive capacity, regardless of the extent to which it is used as the basis of goal-setting.

benefits for climate change adaptation and mitigation can be realized through engagement of protected area communities and visitors in ecological restoration and stewardship activities as well as through enhanced visitor experiences associated with the restored protected area. Engagement can lead to increased understanding of nature-based solutions to climate change and inspire wider action in people's daily lives (NAWPA, 2012).

Climate change mitigation

Ecosystem loss and degradation are major causes of the greenhouse gas emissions that cause climate change. Protected areas help to *secure* carbon stored in terrestrial, marine, and freshwater vegetation, soil and sediments and also protect the natural ecosystems that will continue to sequester additional carbon. Data from the UNEP-World Conservation Monitoring Centre (UNEP-WCMC, 2008) indicates that at least 15 per cent of the world's terrestrial forest carbon is stored in protected areas. Restoration can help to maintain and enhance these stores. For example, peat is a major carbon store, but can release carbon if it dries out or catches fire (Ramsar, 2007): this can be prevented through careful restoration of the hydrologic processes that keep it damp. The restoration of degraded protected areas can also sequester carbon by enhancing relevant ecosystem functions (e.g., photosynthesis, microbial processes, soil building), through, for example, planting vegetation. These opportunities are not confined to land: oceans are the largest long-term carbon sink on Earth and mangroves, salt marshes and some seagrass species rank among the most intense carbon sinks (Laffoley & Grimsditch, 2009). Yet loss of these ecosystems is very high—sometimes four times that of rainforests (Nellemann et al., 2009)—and restoration is urgently needed.

How to restore under conditions of rapid climate change?

Restoration needs to focus *first* on maintaining biodiversity in the face of climate change and *then* consider mitigation and adaptation. While restoration offers solutions to climate change, it (and other rapid changes) also creates additional challenges for protected area managers, who must set realistic, achievable restoration goals and objectives. Protected area system managers need to take strategic decisions about whether they need to intervene and, if so, where and how to intervene in protected area ecosystems. Such decisions need to take account of projections about climate and climate-related extreme events (Hobbs et al., 2009) while recognizing the uncertainty of those projections (see Box 4). In some cases relatively less degraded protected areas might be targeted for restoration because they provide the best opportunity to maintain ecosystems that are resilient in the face of climate change (Hobbs et al., 2011). In other situations, critical climate-related threats to particular species will necessitate working in highly degraded or threatened protected areas to restore habitats and enhance resilience. Restoration of ecological connectivity is particularly important (Beaumont et al., 2007). This document provides advice on these issues, particularly in the discussion of goal and objective setting in Chapter 5.

Banff National Park, Canada: A grizzly bear using a highway overpass © Parks Canada

Uncertainty and adaptive management

Climate change leads to increased uncertainty about how ecosystems will respond to restoration. While restoration goals may be enduring, operational objectives may need to be more flexible, as what appears to be realistic at planning stages may prove unrealistic in practice (Hobbs et al., 2010). At the same time, new or unexpected options may materialize. Protected area managers will need to be adaptable, regularly re-visiting objectives and management decisions, and changing them as knowledge advances. Although the concept of adaptive management is central to all ecological restoration (see Chapter 5) it is particularly important in the context of rapid change.

2.5 Restoring connectivity

Restoration beyond the borders of a protected area may be needed to foster links between isolated protected areas: an application of *connectivity conservation* (Worboys et al., 2010a). This is regularly achieved through large corridors. Connectivity conservation in large corridors recognizes landscape connectivity (the spatial interconnectedness of vegetation), habitat connectivity (connectivity which focuses on the habitat needs of certain species), ecological connectivity (which focuses on connectivity that facilitates ecosystem function) and evolutionary process connectivity (which emphasizes the retention of opportunities for the retention of species) (Worboys et al., 2010a). Corridors need to be actively managed to ensure that their integrity is maintained, threats are managed and essential links are restored. Prioritization would normally be guided by a strategic plan for the corridor, and that plan (ideally) would have been strongly guided by scientific inputs such as from experts in species biology and regional ecology (Aune et al., 2011). Within a broader landscape or seascape, restoration may be particularly important to restore connectivity in the following circumstances, recognizing the 'blurring' of these in real world situations (Soulé & Terbourgh, 1999) (see Figure 3).

a. **Buffer zones adjacent to or around protected areas**: to embed a protected area in a landscape or seascape that will support conservation: e.g., liaising with forestry companies to block roads in old logging concessions around protected areas, or negotiating with farmers to switch to shade-based coffee to provide forage opportunities for woodland birds (Ricketts et al., 2004).

b. **Corridor linkages between protected areas**: to allow movement of species and thus genetic interchange and migration of ranges as species adapt to a changing climate: e.g., working with service providers, real-estate developers, forest managers or farmers to ensure the restoration of linking corridors of trees or other suitable vegetation. Most corridor analyses are based on current habitat, but restoration scientists can sometimes identify the effort required to restore degraded areas, thus increasing opportunities for connectivity in such analyses.

c. **Ecological stepping stone linkages between protected areas (often these are parts of corridors)**: to ensure that migratory mammals, birds and insects have resting and feeding locations spaced so as to ensure their safe passage. Actions might include restoration (or creation) of wetland or reed habitat for migrating water birds or restoration of food sources and roosting places in deforested landscapes.

d. **Landscape/seascape mosaic**: to link various habitats into a viable and more functional ecosystem. This involves planning at a larger scale to make sure that there are no important elements missing from the ecosystem and restoring them when necessary. The role of matrix condition is emerging as increasingly important for connectivity.

Connectivity conservation goals inspire additional challenges for restoration, and external partnerships are usually needed such as protected area managers working with other managers, communities and landowners, and particularly with those authorities that govern land/water-use planning and decision-making. In practice, success or failure usually rests on the extent to which communities and stakeholders are actively engaged. Support is often built gradually, through stakeholder engagement, honest explanation of the costs and benefits, and the personal relationships that grow up over time (Bennett & Mulongoy, 2006). Working outside protected areas and with a wider range of partners may also require using simpler indicators of restoration, such as vegetation structure instead of detailed indicators of ecological integrity. In general, efforts to restore the structure, function, and composition of reference habitats, and to remove or overcome barriers to movement such as dams, highways and high density development will contribute to landscape and seascape connectivity. Restoration performance outcomes may also be assessed as part of a larger corridor management effectiveness assessment.

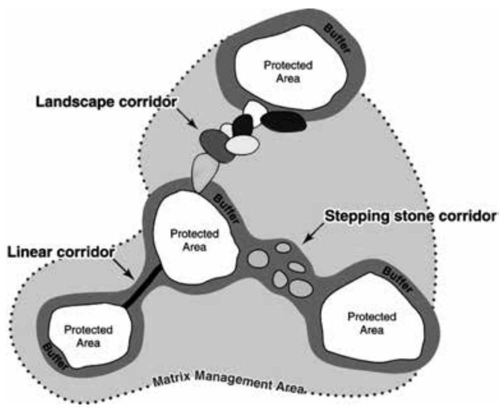


Figure 3: Options for linking terrestrial ecosystems
(from Worboys et al., 2010a and sourced from Bennett, 2004)

Chapter 3
Principles and Guidelines of Restoration for Protected Areas

This chapter describes underpinning principles and guidelines of ecological restoration for protected areas.

***Effective* ecological restoration for protected areas is restoration that re-establishes and maintains the values of a protected area**

- ‘Do no harm’ by first identifying when restoration is the best option
- Re-establish ecosystem structure, function and composition
- Maximize the contribution of restoration actions to enhancing resilience (e.g., to climate change)
- Restore connectivity within and beyond the boundaries of protected areas
- Encourage and re-establish traditional cultural values and practices that contribute to the ecological, social and cultural sustainability of the protected area and its surroundings
- Use research and monitoring, including from traditional ecological knowledge, to maximize restoration success

***Efficient* ecological restoration for protected areas is restoration that maximizes beneficial outcomes while minimizing costs in time, resources and effort**

- Consider restoration goals and objectives from system-wide to local scales
- Ensure long-term capacity and support for maintenance and monitoring of restoration
- Enhance natural capital and ecosystem services from protected areas while contributing to nature conservation goals
- Contribute to sustainable livelihoods for indigenous peoples and local communities dependent on the protected areas
- Integrate and coordinate with international development policies and programming

***Engaging* ecological restoration for protected areas is restoration that collaborates with partners and stakeholders, promotes participation and enhances visitor experience**

- Collaborate with indigenous and local communities, neighbouring landowners, corporations, scientists and other partners and stakeholders in planning, implementation, and evaluation
- Learn collaboratively and build capacity in support of continued engagement in ecological restoration initiatives
- Communicate effectively to support the overall ecological restoration process
- Provide rich experiential opportunities, through ecological restoration and as a result of restoration, that encourage a sense of connection with and stewardship of protected areas

Chapter 3: Principles and Guidelines of Restoration for Protected Areas

This chapter identifies three underlying **principles** and fourteen **guidelines** for ecological restoration in protected areas. They are supplemented by more technical **best practice methods and techniques** (Chapter 4) and **recommended implementation processes** (Chapter 5) that draw on knowledge and experiences in restoration for protected areas around the world (see **case studies** in Chapter 6).

Principles of Ecological Restoration for Protected Areas: Effective, Efficient, Engaging

To be successful, ecological restoration should adhere to the following three underlying principles.

a. It should be effective

Effective ecological restoration for protected areas is restoration that re-establishes and maintains protected area values.

Ecological restoration for protected areas will be motivated primarily by the desire or need to restore natural and any associated cultural values of the protected area (Higgs & Hobbs, 2010) related to ecosystem structure and function (i.e., the essential elements of ecological integrity). The objectives of restoration draw on the original purposes of a protected area and objectives for management, which are often described in management plans, or embedded in traditional knowledge in the case of community conserved areas, and reflected in the protected area management category. Associated cultural values (e.g., cultural heritage values, recreational, aesthetic, visitor experience, or spiritual values) or practices may be restored simultaneously. Achievement of ecological restoration goals also requires attention to the underlying causes of degradation, opportunities for restoration associated with human knowledge and cultural practices, and careful monitoring to learn from experience and facilitate adaptive management.

b. It should be efficient

Efficient ecological restoration for protected areas is restoration that maximizes beneficial outcomes while minimizing costs in time, resources and effort.

Ecological restoration can be complex and costly, and early action to prevent, halt or reverse degradation is more efficient than waiting to act until the degree of degradation is more severe. However, ecological restoration can also achieve significant benefits in addition to its immediate conservation goals. Such benefits may be related to, for example, climate change adaptation and mitigation, cultural renewal and survival, and socio-economic well-being, some of which also provide direct economic benefits. Evidence suggests that if these benefits are taken into account, well-planned, appropriate restoration can have high benefit:cost ratios in terms of return on investment (Neßhöver et al., 2011). Efficient ecological restoration for protected areas thus aims to maximize beneficial ecological, social-economic and cultural outcomes and minimize costs, while not losing sight of conservation goals. This may involve prioritizing restoration efforts according to locally-determined criteria.

c. It should be engaging

Engaging ecological restoration for protected areas is restoration that collaborates with partners and stakeholders, promotes participation and enhances visitor experience.

Collaboration and support among partners and stakeholders is a long-term foundation for restoration success (Egan et al., 2011), particularly when protected areas have resident or local indigenous peoples and communities. Some countries have a legal obligation to consult (e.g., SCBD, 2004) and free, prior and informed consent should always be obtained from traditional and indigenous peoples for projects on their territory. Engaging and involving partners and stakeholders in planning, implementation and reciprocal learning can build a sense of ownership and generate trust, thereby creating a constituency of support (Hill et al., 2010) for restoration. Traditional ecological knowledge can bring valuable practice and information (Berkes et al., 2000). Careful listening and a willingness to act on what is heard can help maximize community benefits, identify potential problems and engage people in restoration and monitoring, thus reconnecting them with nature (Gann & Lamb, 2006). By inspiring people, including protected area visitors, restoration can build partnerships to reduce degradation and contribute to the achievement of broader protected area and biodiversity conservation objectives.

These principles are supported by a set of guidelines and examples that provide details on how the principles are interpreted in practice.

PRINCIPLE 1: Effective in re-establishing and maintaining protected area values

To be effective, ecological restoration for protected areas should:

Guideline 1.1: 'Do no harm' by first identifying when active restoration is the best option

Decisions about whether, when and how to restore need to be made with caution; ecological restoration projects have high failure rates and sometimes the best choice is not to intervene. Issues to consider include: (a) whether active restoration is needed (e.g., whether simply removing pressure would result in natural recovery; *see* Holl & Aide, 2011); (b) whether it is feasible, from a practical, cost and social perspective; and (c) if there are serious risks of harmful side effects, which implies the need for a careful impact analysis. Ill-conceived interventions can have unintended indirect or long-term consequences (Suding et al., 2004). For example, cane toads (*Bufo marinus*) were deliberately introduced to Australia in 1935 in a futile attempt to stop cane beetles from destroying sugar cane crops in North Queensland. Since then cane toads have spread rapidly, as they have no natural predator, and are thought to be responsible for the decline in quoll (a native carnivorous marsupial) and native frogs (CSIRO, 2003).

Guideline 1.2: Re-establish ecosystem structure, function and composition

The need to restore will often be identified because a measure of ecosystem structure or function falls below a pre-determined threshold (see Chapter 5). Ecological restoration will generally aim to re-establish an ecosystem capable, as far as possible, of continuing to function, with species diversity and interactions typical of its geographic, geological and climatic situation. The restored ecosystem may reflect historical conditions or may be a culturally-defined mosaic or a novel ecosystem evolving due to climate change. The degree of intervention, timescale and approach will depend on how far degradation has advanced (see Chapter 2). Changes in management, such as the frequency of removal of invasive species, may be all that is required to meet restoration objectives. Other cases require dedicated projects, such as habitat recreation or species re-introduction. Where degradation is advanced, abiotic properties (e.g., soil quality) may need to be restored before biological components can be manipulated. The extent to which restoration seeks to return to an historical ecosystem or reflects current and predicted changes must be decided on a case by case basis (see Chapter 5).

West Lake Park, USA: Time series pictures of mangrove restoration project from 1989, 1991 and 1996. Mangroves recolonized the area naturally following restoration of the hydrology. © Robin Lewis

Thumama Nature Park, Saudi Arabia: Vegetation was restored through a mixture of planting and irrigation. © Nigel Dudley

Guideline 1.3: Maximize the contribution of restoration actions to enhancing resilience

Restoration for protected areas will increasingly address the need to re-establish resilient ecosystems that are capable of absorbing and adapting to rapid environmental change, including climate-driven changes; or to reinforce the resilience of ecosystems to prevent them from crossing key biotic or abiotic thresholds—i.e., transitioning to states from which recovery is difficult or impossible—and thus risking collapse. Objectives may vary from restoring and securing climate change refugia (Ashcroft, 2010), where resistance to change may be higher, to assisting sites that are transforming to new types of ecosystems. In many cases climate change is taking place alongside other more immediate pressures, such as land conversion, unsustainable resources use and invasive species, which also need to be addressed. A resilience strategy may influence the prioritization of restoration projects at a protected area system scale. For example, historically, a severely degraded system might have been a priority candidate for restoration. However, under conditions of rapid change a more effective use of time, effort, and resources may be to focus on increasing the resilience of less damaged ecosystems.

Box 5

RESTORATION CONCEPT Resilience

Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al., 2004). The resistance of an ecosystem to change is an important component of its resilience. Restoration actions such as re-establishing natural water flows (Dyson et al., 2003), removing invasive species, and providing migration/dispersal corridors between protected areas help to enhance resilience by maintaining diverse and evolving gene pools over the long-term (Walker et al., 2004; Elmqvist et al., 2003). Factors such as ecologically effective population sizes, genetic and functional diversity, densities of highly interactive species, the tolerance of ecological communities to extreme events, and microtopographic diversity are also important considerations in restoration strategies that aim to maintain or restore resilience (Meretsky et al., 2006; Gilman et al., 2010).

Guideline 1.4: Restore connectivity within and beyond the boundaries of protected areas

Connectivity is important to increase the functional size of the ecosystem conserved, allow genetic interchange, permit species to migrate to suitable habitats if their surrounding ecosystems change, allow opportunities for species to interact and for evolutionary processes to occur. To enhance connectivity, protected areas should be planned and managed within a matrix of ecosystem-based, environmentally sensitive land and water management strategies. Restoration projects can both enhance the value of core protected areas and also increase connectivity conservation between protected areas by: establishing buffers and easements; reducing habitat fragmentation inside and outside protected areas; re-establishing migration corridors; conserving sources of plant material for propagation and colonists; conserving refugia for sedentary species; reducing edge effects; and increasing opportunities for adaptation to disturbances (Worboys et al., 2010a).

Guideline 1.5: Encourage and re-establish traditional cultural values and practices that contribute to the ecological, social and cultural sustainability of the protected area and its surroundings

Ecological restoration needs to consider cultural values and practices that influence protected areas along with the natural values of these places. These values and practices are often intertwined. Traditional, ecologically sustainable human activities have shaped some ecosystems to the extent that cultural practice and ecological integrity are mutually reinforcing. In such cases, effective ecological restoration may require the recovery of traditional, ecologically sustainable cultural practices. In other cases, conflict may exist between cultural values (including cultural heritage values) and practices and natural values, or even among different cultural values and practices themselves. New pressures such as climate change may result in changes in the demand for, and nature of, natural resource use, placing novel pressures on fragile ecosystems. Where such conflict exists—for example where ecosystem degradation is being caused or amplified by the subsistence livelihood needs of dependent communities—an understanding of root causes will contribute to conflict resolution and ultimately to the effectiveness of restoration efforts.

Guideline 1.6: Use research and monitoring, including from traditional ecological knowledge, to maximize restoration success

Experience suggests a strong correlation between effective research and monitoring and effective, adaptive management. Accurate monitoring data, collected over time, provides the information needed to measure progress towards achieving objectives and to make necessary changes during the lifetime of the project. Well-documented monitoring data may also help in planning future projects. Climate change makes a strong knowledge base even more important. Monitoring is essential: to detect long-term ecosystem change; help identify potential ecological consequences of change; and help decision makers select management practices. It may be used to define baseline conditions, understand the range of current variability and detect desirable and undesirable changes over time.

PRINCIPLE 2: Efficient in maximizing beneficial outcomes while minimizing costs in time, resources and effort

To be efficient, ecological restoration for protected areas should:

Guideline 2.1: Consider restoration goals and objectives from system-wide to local scales in prioritizing restoration activities

Faced with multiple pressures and the need to accommodate the diverse interests and concerns of multiple partners and stakeholders, protected area managers need a clear vision for prioritizing restoration activities. Prioritization frameworks can include a combination of factors, including: broad scale conservation goals; the need for large scale processes (fire, flooding); whether resources are at imminent risk of permanent loss; determining which actions will save significant effort in future (i.e., avoiding a cascade of negative effects); the need to assess risk from restoration activities at several scales; and opportunities to contribute to social or cultural objectives (e.g., opportunities simultaneously to improve biodiversity and enhance human well-being). Options range from managing to resist deleterious change to managing for change.

Guideline 2.2: Ensure long-term capacity and support for maintenance and monitoring of restoration

Restoration for protected areas will take time, money and commitment; abandoning the process part of the way through can result in much work being wasted and can even exacerbate some problems, such as invasive species. This risk can be minimized by implementing a robust long-term planning process that includes a rigorous assessment of the capacity and support for restoration activities and is also supported by having effective long-term monitoring processes in place (see Chapter 5).

Niumi National Park, The Gambia: Local communities are growing seedlings to restore dune areas that have eroded. © Colleen Corrigan

Guideline 2.3: Maximize the contribution of restoration actions to enhancing natural capital and ecosystem services from protected areas

Major studies such as the Millennium Ecosystem Assessment (2005) and The Economics of Ecosystems and Biodiversity (TEEB)[5] have identified the multiple benefits and ecosystem services, of well-managed protected areas. Emphasizing these values can help raise awareness about the benefits of ecological restoration actions and mobilize additional funding for protected area restoration activities. For example, under climate change mitigation programmes such as Reducing Emissions from Deforest and Forest Degradation plus (REDD+), it is possible that new funds for carbon-focused restoration, afforestation or reforestation efforts could emerge, which could be accessible within protected areas (Angelsen, 2009; Nellemann & Corcoran, 2010; Alexander et al., 2011). Including issues related to measurement and valuation of ecosystem services in restoration projects may involve developing markets or other approaches to capture the benefits of ecosystem goods and services products (ITTO, 2002; Aronson et al., 2007). Related business training and skills development may also be required to foster entrepreneurship (Murali, 2006). However, although they are important, *restoration objectives related to ecosystem services remain secondary to the overall nature conservation aims of protected areas and care must be taken that a focus on provisioning of ecosystem services does not inadvertently undermine conservation*. Well-designed projects can achieve both.

5 http://www.teebweb.org/

Guideline 2.4: Contribute to sustainable livelihoods for indigenous peoples and local communities dependent on the protected areas

Well-planned and implemented ecological restoration can contribute to livelihood security (Fisher et al., 2008) by recovering ecosystem services such as a sustainable harvest of natural resources that can be traded or sold, or by providing employment in restoration activities (Calmon et al., 2011). Ecological restoration projects that support new livelihood opportunities for local communities can reduce pressure on protected areas (Brandon & Wells, 2009). Involving communities in restoration activities can increase their own adaptive capacity and skill in determining future options. The traditional resource management practices known to local and indigenous communities can also be very cost-effective.

Guideline 2.5: Integrate and coordinate with international development policies and programming

Ecological restoration in protected areas can yield many social and developmental co-benefits in addition to ecological benefits. Development agencies and NGOs might therefore integrate ecological restoration within and beyond protected areas into projects as a policy option to address a range of development issues including health, waste management, water supply, disaster mitigation and food security. Restoration projects can build in cross-sectoral collaboration to address poverty and other human problems, thereby helping to build support for restoration and for protected areas more broadly.

PRINCIPLE 3: Engaging by collaborating with partners and stakeholders, promoting participation and enhancing visitor experience

To be engaging, ecological restoration for protected areas should:

Guideline 3.1: Collaborate with indigenous and local communities, landowners, corporations, scientists and other partners and stakeholders in planning, implementation, and evaluation

Restoration represents an indefinite, long-term commitment of land/water and resources, and often requires an intentional shift away from activities that have caused the initial degradation. It therefore benefits from collaborative decisions arising from thoughtful deliberations, which are more likely to be honoured, implemented and sustained over long time horizons and across political changes than are unilateral decisions. Collaboration between various interested parties

Community reserve, near Hue Viet Nam: Local commmunity forests restored for multiple functions © Nigel Dudley

Point Pelee National Park, Canada: Planting seedlings for restoration of endangered sand spit savannah © Parks Canada

needs to start early on in the planning and decision making of how the process will be implemented. Engagement of partners and stakeholders needs to be legitimate, authentic, and on an equal basis, and fitted to the spatial scale affecting or affected by the restoration. Monitoring programmes should include evaluation of the effectiveness and efficiency of programmes related to partner and stakeholder participation.

Guideline 3.2: Learn collaboratively and build capacity in support of continued engagement in ecological restoration initiatives

A commitment to continuous and reciprocal learning should animate the collaboration between protected area managers, restoration practitioners, partners, and stakeholders. Local communities, partners, and stakeholders may need to learn new knowledge or skills in order to contribute to an ecological restoration initiative. For some communities, an acquisition of transferable knowledge and skills will strengthen commitment to the stewardship of the protected area. Protected area managers and restoration practitioners will also gain new information and understandings through active listening to the perspectives, priorities, and local and traditional knowledge held in these communities. This expanded experience, knowledge and skills will be most valuable if it remains available to the protected area and local community into the future to contribute, facilitate and deliver local insight to similar processes.

Guideline 3.3: Communicate effectively to support the overall ecological restoration process

Building and maintaining support for restoration can be helped by regular and accurate communication and outreach activities to visitors, local communities and other constituencies interested in the protected area. Communication is strengthened if planned and monitored in conjunction with collaborative engagement (Guideline 3.1) and with direct learning experiences during and following ecological restoration activities (Guideline 3.2).

Guideline 3.4: Provide rich experiential opportunities that encourage a sense of connection with and stewardship of protected areas

Successful ecological restoration activities are based on meaningful public engagement and visitor experiences that connect people more deeply to their protected areas. Ecological restoration initiatives also offer rich opportunities for individuals to explore and experience the potential to reverse ecological degradation, and be inspired. This social learning contributes substantially to social well-being and ecological sustainability through behavioural change (Reed et al., 2010), and contributes to improved stewardship of protected areas. Similarly, enhanced opportunities for visitors to discover and experience healthy, restored protected area ecosystems can improve attachment to, and support for protected areas over the long term.

Canaveral National Seashore, USA: Mosquito Lagoon Oyster Reef Restoration project partners counting the number of live oysters on a restored oyster reef as one metric of restoration success (Case study 12) © Anne P. Birch, The Nature Conservancy

Chapter 4
Best Practices

In this chapter the principles and guidelines are augmented by best practices. Each best practice is illustrated with an example. Specific best practices to apply in any particular project should be selected during the project planning and design phases discussed in Chapter 5.

Key messages

- Identify major factors causing degradation—undertaking restoration without tackling underlying causes is likely to be fruitless
- Set clear restoration objectives—it may not be appropriate to aim for a 'pristine' or 'pre-disturbance' state, particularly under conditions of rapid environmental (e.g., climate) change
- Ensure a participatory process involving all relevant stakeholders and partners in planning and implementation, facilitating participation and shared learning, contributing to acquisition of transferable knowledge, improving visitor experiences, and celebrating successes
- Recognize that some objectives or motivations for restoration may conflict and work collaboratively to prioritize among them
- Ensure that the time frames for the objectives are clear
- Assess the possible impacts of climate change and other large-scale changes on the feasibility and durability of restoration and try to build resilience
- Ensure that monitoring addresses the full range of restoration objectives and the intermediate stages needed to reach them
- Use monitoring results and other feedback in adaptive management
- Restore, where possible, ecosystem functioning along with physico-chemical conditions and hydrology
- Consider natural capital, ecosystem services, disaster risk reduction and climate change mitigation and adaptation
- Identify potential negative impacts of the restoration programme and take action to limit or mitigate them as much as possible
- Identify and where possible control external factors such as pollution that may compromise restoration efforts

Chapter 4: Best Practices

The detailed best practices below provide guidance for managers and others directly involved in implementing restoration in protected areas on how the principles and guidelines can be applied in practice. In each case, the best practice is clarified by a short example and linked where appropriate to the more detailed case studies (Chapter 6) or to phases of the restoration process (Chapter 5).

PRINCIPLE 1: Effective in re-establishing and maintaining protected area values

Guideline 1.1: 'Do no harm' by first identifying when active restoration is the best option

Best Practice 1.1.1: Restoration that 'does no harm'

Restoration is an expensive and time-consuming process that can itself cause further damaging changes if not managed correctly. The first focus of good protected area management is to avoid degradation by removing existing pressures; in many cases this is all that is needed and further interventions are unnecessary. Best practices can ensure that resources are not wasted on unfeasible or unnecessary restoration and that restoration efforts do not have unintended, detrimental side effects.

a. **Make any decision to restore based on clear evidence that there is real ecological degradation and that the values of the protected area will not be regained through natural processes.**
In Bayerischer Wald National Park in Germany, after storm damage and subsequent bark beetle attack, it was decided not to intervene and let 'nature take its course' resulting in a regenerated forest with a greater diversity of species and variation in forest structure (see Box 12). In Diawling National Park, however, annual flooding to the lower Senegal River Delta had been disrupted by dams and restoration activities were supported by data collection, modelling and monitoring. **See Case Study 6** and **Phases 1.1 and 2.1**.

b. **Adopt precautionary approaches to avoid restoration processes causing inadvertent damage.**
An Environmental Assessment (EA) was carried out before restoring hydrological functions and fish habitat in Lyall Creek, Gulf Islands National Park Reserve of Canada. The EA process helped identify work practices and mitigation measures so that work involving heavy equipment could be undertaken in sensitive stream habitats without causing adverse environmental effects (Parks Canada, 2011b). **See Phase 2.2**.

Guideline 1.2: Re-establish ecosystem structure, function and composition

Best Practice 1.2.1: Restoration through improved ecosystem management

In protected areas with relatively undisturbed systems, improvements in management (e.g., restoring ecologically important natural disturbance regimes such as fires and floods; removing harmful invasive species; and changing patterns of visitor use) may be sufficient to recover structure, function and composition of the ecosystem (e.g., before the biotic barrier shown in Figure 2 of Chapter 2 is crossed). The best practices are suitable for broadly healthy, natural systems where some changes in functioning are needed to regain ecological integrity or where imbalances in species (due to invasive species or hyper-abundant native species) are causing problems.

1.2.1.1 Restoration after degradation

a. **Allow the protected area to recover naturally where further degradation from other factors (e.g., pest introductions) is unlikely; or introduce management to prevent other factors that are present (e.g., over-grazing) from limiting recovery.**
In Coromandel Forest Park, New Zealand, remnant kauri (*Agathis australis*) forests are undergoing natural regeneration after a 99.5 per cent reduction (Taylor & Smith, 1997). The forests will take centuries to reach old-growth status, but the restoration process is low cost.

b. **Restore, where possible, disturbances such as fires and floods to approximate natural severity/frequency e.g., reduce impacts of fire suppression.**

Bayerischer Wald National Park, Germany: Visitors are invited to see how storm damage and insects determine the evolution of the mountain spruce forests as 'ecosystem engineers'. © Hans Kiener/Bayerischer Wald NP

In Kootenay National Park of Canada, prescribed fire mimics traditional burning by Aboriginal people, helping to restore open forest winter habitat for bighorn sheep and reducing potentially dangerous use by sheep of roadsides in the neighbouring community (Dibb & Quinn, 2006).
In the UK, ponies have been introduced to maintain grassland habitat in the absence of natural herbivores, for example in Snape Warren, Suffolk, rare lowland heath, the UK's rarest habitat, has been recreated with the help of sheep and Exmoor ponies[6].

c. **Adapt restoration interventions to recognize and take advantage of the timing and influence of natural disturbances such as saltwater inundations, weather events, insect outbreaks, etc.**
In Springbrook National Park, Australia, timing of some restoration activities is linked to El Nino Southern Oscillation Cycles. **See Case Study 11**.

d. **Where populations of ecologically or commercially important species are reduced by exploitation in or outside the protected area, consider use of 'no take' zones to help populations recover; this can ensure sustainable harvest beyond the protected area boundaries.**
Staff of Cu Lao Cham National Park, an island MPA in Viet Nam, work with local communities to agree to no-take zones, to address serious declines in commercially important fish species. Fish populations are now increasing. MPA managers hope to use evidence to persuade the community to agree to an increase in the size of the no-take zone.

1.2.1.2 Restoration after natural disturbances and perturbations

a. **Allow and assist natural regenerative processes to occur after disturbances such as fire, wind, flood, earth movements and tidal surges.**
Retaining standing and lying dead wood in forests can recover micro-habitats for birds, insects and fungi (Cavalli & Mason, 2003) and re-establish nutrient cycling. The impact of large storms in French protected areas has allowed development of more natural forest ecosystems, with e.g., a higher proportion of dead wood, more snags and uneven age structure (Vallauri, 2005).

b. **Only intervene in natural recovery processes if they pose serious threats to: (i) particularly important species and habitats; (ii) local communities; (iii) protected area staff or visitor safet**y.
After a storm in New York state, USA, damaged 35,000 ha of the Adirondack Park Forest Preserve, salvage logging was not carried out and clean-up operations confined to roads, trails and camping facilities, reinforcing the 'forever wild' policy (Vallauri, 2005).

c. **Inform the public/stakeholders as appropriate and temporarily limit public access when a natural disturbance makes the ecosystem more vulnerable to human impact.**
In SW Australia, vegetation loss linked to fire causes both changes in surface hydrology and easier access for hikers, increasing infection risk (e.g., *Phytophthora cinnamomi*) and introduction of invasive species from walking boots (J. Watson, pers. comm., 2010).

1.2.1.3 Control of invasive alien species (IAS)

a. **Aim first to prevent the introduction of IAS by: (i) using outreach to influence visitor behaviour to avoid spread of IAS; (ii) minimizing disturbances that can help IAS spread; (iii) avoiding introduction and spread of IAS during restoration; (iv) implementing strategies to ensure that increasing connectivity within and between protected areas does not create pathways for IAS.**
The 'Weedbusters Campaign' in Palau has run annual 'Invasive Weed Cleanup' days to control and inform about invasive alien species such as mile-a-minute weed (*Mikania micrantha*) and a booklet describing 11 species targeted for management was produced (Shine et al., 2002). The spread of the alien black locust (*Robinia pseudoacacia*) outside urban areas in South Korea is closely linked to human disturbance patterns (Lee et al., 1994) although in undisturbed conditions it will be shaded out and replaced by native species (Aronson et al., 1993).

b. **Recognize that large-scale global changes are resulting in the spread of IAS into protected areas and that while this may be a focus of restoration, not all alien species can be either prevented or eradicated.**
In New Zealand, invasion by introduced mammals like possum, stoats and rats is so pervasive that eradication is impossible even in national parks; instead rangers and volunteers use trapping to establish safe areas within parks, where threatened endemic ground-nesting birds can raise young (Parkes & Murphy, 2003).

c. **Focus efforts on managing harmful alien species (e.g., those competing with ecologically important native species or altering ecological processes).**
There are over 100 alien plant species in Snowdonia National Park, Wales, but control focuses on the highly invasive *Rhododendron ponticum* and Japanese knotweed (*Fallopia japonica*). For most island states and particularly in Australia a key consideration is the critical role of IAS in suppressing

Springbrook Rainforest Project, Australia: *Aristea ecklonii* (Blue Stars) from South Africa and Madagascar belongs to an emerging and insidious new class of shade-tolerant weeds invading undisturbed habitats. Its densely clumping, light-blocking habit, vigorous rhizomatous growth and rapid spread over large areas is difficult to control and can eventually lead to displacement of entire forests. (Case study 11) © Keith Scott

6 http://www.rspb.org.uk/reserves/guide/s/snape/about.aspx

ecological structures and functions. It has been found that fencing to exclude predatory species may be an essential part of ecological restoration. For example in the Peron Peninsula in Shark Bay World Heritage area in Western Australia, a fence was constructed across the base of the peninsula to exclude feral species responsible for extinctions. Project Eden, as the work is called, is a work in progress[7].

d. **Prioritize management of IAS by: (i) wherever possible eradicating new IAS; (ii) eradicating or controlling existing IAS; (iii) ignoring alien species that do not significantly affect protected area values; (iv) recognizing potential *negative* effects of removing alien species.**
Mosquito ditching on Little Pine Island, Charlotte Harbor Preserve State Park, Florida, USA, destroyed freshwater, brackish and saltwater habitats consisting of exotic plants displacing native vegetation. Infestations of the following exotic tree species were removed from over 800 ha: melaleuca (*M. quinquenervia*), Australian pine (*Casuarina equisetifolia*) and Brazilian pepper (*Schinus terebinthifolius*). Filling canals restored freshwater systems and tidal flows. Dormant native seeds have sprouted to produce well-balanced ecosystems replete with wildlife[8] (Erwin, undated).

e. **Consider using restoration of non-invasive native species (e.g., those with similar seral and life history characteristics to compete with aliens) as a means of replacing or controlling IAS**.
The Mauritian Wildlife Foundation has worked in the island of Rodrigues to restore 13 ha of native forest in Grande Montagne reserve and 8 ha in Anse Quitor reserve, now the largest contiguous native forests on the island, to help block the spread of invasive plant species (Payendee, 2003).

f. **If control is needed, where possible use methods that replicate natural processes, e.g., managing total grazing pressure, shading out invasive species, or protecting natural predators by considering multi species interactions.**
In southern Brazil, invasive *Brachiaria* grass species from Africa were controlled by shading through the appropriate choice and planting of native species with rapid growth and dense crown (Ferretti & de Britez, 2006).

g. **More active controls can be mechanical (physically removing the invasive species), chemical or biological. If chemical or biological controls are considered to be essential, ensure best practices for human health and to avoid environmental side effects on non-target species.**

Box 6

A CLOSER LOOK Invasive species on offshore islands

Offshore islands represent about 3 per cent of the earth's surface, yet support around 20 per cent of global biodiversity. Since 1600, about 64 per cent of known species extinctions have occurred on islands, and today almost 40 per cent of IUCN threatened species depend on island ecosystems. IAS (in this case, animals) have been a primary cause of insular extinctions and are recognized as a key risk to today's threatened species. IAS also damage the social and economic livelihoods of island communities by acting as disease vectors and consuming agricultural crops.

The solution to the problem of IAS on islands is relatively straightforward compared with mainland areas, i.e., eradication: the complete, 100 per cent removal of introduced animals using techniques that have been used on over 1,000 islands worldwide over the last 150 years. Ongoing monitoring has proven that once IAS are eliminated, island ecosystems, economies, and native plants, animals and the ecosystems on which they depend, recover. Invasive animals should not get back to the island, unless intentionally or accidentally transported by people. Thus, investment into ongoing biosecurity may be necessary for frequently visited or islands that are close to source populations.

Eradications utilize techniques and tools that that are already in use for controlling IAS; however, there is a fundamental difference: eradication projects are designed to remove the last invasive animal, while control projects are designed to reduce the invasive population. Thus, eradications require a unique approach to the design, implementation and investment by island communities, landowners, and stakeholders. The more than 1,000 eradications worldwide have established global guidelines and principles, regardless of biomes in which they have been applied. These principles (edited for context) are (*see* Cromarty et al., 2002):

- All animals can be put at risk by the eradication technique (so care should be taken when using IAS removal techniques);
- All animals (i.e., IAS) must be killed (faster than they can replace themselves); and
- Immigration must be zero.

Strategic application of these principles following a feasibility assessment and project design; comprehensive operational planning; regulatory compliance and permitting; effective project management; and skilled use of many common tools available to the global community (rodenticides and other toxicants, live traps, kill traps, hunting) will lead to successful removal of IAS from islands. This will facilitate the recovery of whole island ecosystems, improve the livelihoods of people and communities, and prevent the extinction of endangered species worldwide.

7 http://www.sharkbay.org/PE_future.aspx
8 http://environment.com/index.php/featured-projects/florida/little-pine-island-regional-wetland-mitigation-bank/

Palmyra Atoll, North Pacific: Aerial view of Palmyra Atoll showing the series of lagoons, islets and bays which presented challenges during the black rat eradication. The bait station is composed of PVC tubing to prevent land crabs from accessing the bait. © IslandConservation

Box 7

RESTORATION CONCEPT
Hyperabundant species/populations

The term hyperabundant species refers to populations of native species that, as a result of human-induced changes, have increased to unnaturally high population levels and thus play a similar damaging role in the ecosystem to alien invasive species. For example, loss of natural predators, or provision of artificial water or food sources has led to hyperabundant populations of herbivores (e.g., kangaroos, deer, elephants) in many protected areas. Hyperabundance can also occur due to additions to the ecosystem; e.g., rapid algal growth in water as a result of artificial nutrient enrichment from sewage or fertilizers (eutrophication). When the algae die the resulting decomposition processes can use up available oxygen, killing other freshwater species. Programmes to reduce populations of native species can create ethical concerns for protected area managers and their partners and stakeholders. A solid scientific rational (e.g., Hebert et al., 2005; Parks Canada, 2008b) and strategic, sensitive communication with visitors and other interested groups can help to ensure that management decisions are supported (*see* Chapter 5, Section 1.3).

A global survey, reported in 2007, found that there had been 284 successful rodent eradications on islands around the world, which are now mainly protected areas. All but two used poisons (Howald et al., 2007).

1.2.1.4 Management of hyperabundant populations (See Box 7)

h. **First identify and address the root causes of population hyper-abundance such as nutrient enrichment (e.g., algae blooms), altered food-web interactions or habitat limitations or game management policies.**
Artificial water sources, loss of predators and reduction in Aboriginal hunting has caused hyperabundance of some kangaroo species in Australia: integrated control methods look beyond culling to recovery of natural predators and ecosystems. Artificial water sources are now being closed off in places such as Idalia National Park (D. Lamb, pers. comm., 2012).

i. **Employ humane methods for control of wildlife, referring to existing legislative or policy tools as required.**
On Sidney Island reserve in Canada, government agencies and private land owners re-designed a deer cull with animal care as a priority. The first federally approved mobile abattoir processed deer for the commercial restaurant market to offset capital costs and meat, hides, antlers and hooves were provided to indigenous groups. Over 3,000 deer were successfully removed in three years (T. Golumbia, pers. comm., 2012).

Lintulahdet Life Project, Finland: Clearing of reed beds to restore coastal meadows using a special crushing machine attached to a tractor (Case study 1) © Ilpo Huolman

Best Practice 1.2.2: Restoration through improved species interactions

In relatively disturbed ecosystems (often experiencing reduced biological diversity and productivity), manipulation of multiple ecosystem components may be required (e.g., after the biotic barrier shown in Figure 2 of Chapter 2 is crossed). Interventions might include, for example, re-establishment of native communities or species re-introductions. In some systems (e.g., those experiencing climate change) acceptance of new biotic assemblages or novel ecosystems may be necessary and restoration efforts may focus on achieving functionality, resilience, diversity or other agreed-upon objectives of the new ecosystem. See Best Practice 1.3.1.

1.2.2.1. Re-establishment of native plant and animal communities or habitat

a. **Increase the viability of depleted or fragmented populations by habitat expansion and reconnection, and help dispersal of species by increasing connectivity, vegetation buffers and mosaic habitats.**
Replanting native tree species in selected areas inside and between protected areas along the Kinabatangan River in Sabah, Malaysia, is reconnecting habitat for a population of forest elephant living in the area, by allowing movement along the river.

b. **Restore natural vegetation patterns at an appropriate spatial scale, e.g., replanting native grassland species mixes to recreate traditional habitats for invertebrates such as butterflies.**
The Lintulahdet Life Project in Finland, for example, created small bog habitat for rare dragonfly and re-created open meadows at 12 wetland sites for migrating birds. **See Case Study 1 and** also **Case Studies 4** and **7**.

c. **Consider planting 'framework' or 'foundation' species that play a particularly important role in helping to restore an ecosystem.**
In Doi Suthep-Pui National Park, northern Thailand, native fruit trees are being re-introduced in degraded dipterocarp forest to attract fruit eating birds and primates (Blakesley & Elliott, 2003).

d. **Choose a mix of species and genotypes that will facilitate the establishment of other native species and provide habitat for species that are: (i) already present in the protected area; (ii) are expected to migrate into the protected area; or (iii) will be re-established.**
'Tree islands' made up of two native species were planted on abandoned tropical pasture in Pico Bonito National Park, Honduras, to provide seed and canopy protection to speed up natural recovery (Zahawi, 2005).

e. **Focus effort on restoring strongly interactive species that are important for the functioning of many forest ecosystems and play a disproportionate role in maintaining ecosystem function such as predators, bird pollinators, mycophagous mammals (i.e., animals that eat fungi), or rodents.**
Prior to the re-introduction of bison into Grasslands National Park of Canada, all grazing had been excluded, and the associated benefits to the mixed-grass prairie ecosystem had been lost. Restoring the function of grazing through the re-establishment of a bison population, along with the re-introduction of cattle grazing in parts of the park, was essential to restoring a healthy prairie ecosystem and its diversity of species (Parks Canada, 2011d).

f. **Wherever possible use genetic material native to the protected area or adjacent areas. (Exceptions to this may occur during periods of rapid change, when greater genetic variation provides greater evolutionary potential and thus resilience).**
Magnolia sharpii and *Oreopanax xalapensis* are tree species of the cloud forests of the central highlands of Chiapas, Mexico. *M. sharpii* is very rare, narrowly endemic and severely reduced by land-use change (Newton et al., 2008; González-Espinosa et al., 2011). *O. xalapensis* is a near threatened widespread tree from Mexico and Central America (Ruiz-Montoya et al., 2011). Both can easily be propagated in nurseries allowing for active restoration (Ramírez-Marcial et al., 2010).

g. **In some ecosystems, consider planting short-lived 'nurse' species, if they are non-invasive, to hold soil temporarily and encourage native species regeneration.**
In Guanacaste National Park in northern Costa Rica the 'nurse' species approach was used in large-scale forest restoration (Calvo-Alvarado et al., 2009).

Grasslands National Park, Canada: Re-introduced bison grazing © Parks Canada

Jirisan National Park, Korea: Re-introduced Asiatic black bear (Case study 2) © Species Restoration Center (SRC), Korea National Park Service

h. **Consider using artificial habitats if key natural habitats are absent or will take a long time to restore; for example artificial nesting sites or boxes, artificial reefs, salmon runs and tunnels and bridges to help migration across roads or obstacles.**
WWF-Philippines has been working with multiple partners to install ceramic corals (EcoReefs®) near Tres Marias, a group of islets in Bacuit Bay, El Nido-Taytay Managed Resource Protected Area, Philippines. The EcoReefs® are made of ceramic stoneware that is ideal for the settlement of corals and other invertebrates in a relatively short period (around 7-15 years)[9].

1.2.2.2. Plant and animal species re-introductions

See also IUCN/SSC Guidelines for Re-introductions (IUCN, 1998) and species-specific guidelines for Galliformes, African and Asian rhinoceros, great apes (World Pheasant Association and IUCN/SSC Re-introduction Specialist Group 2009; Emslie et al., 2009 and Beck et al., 2007 respectively).

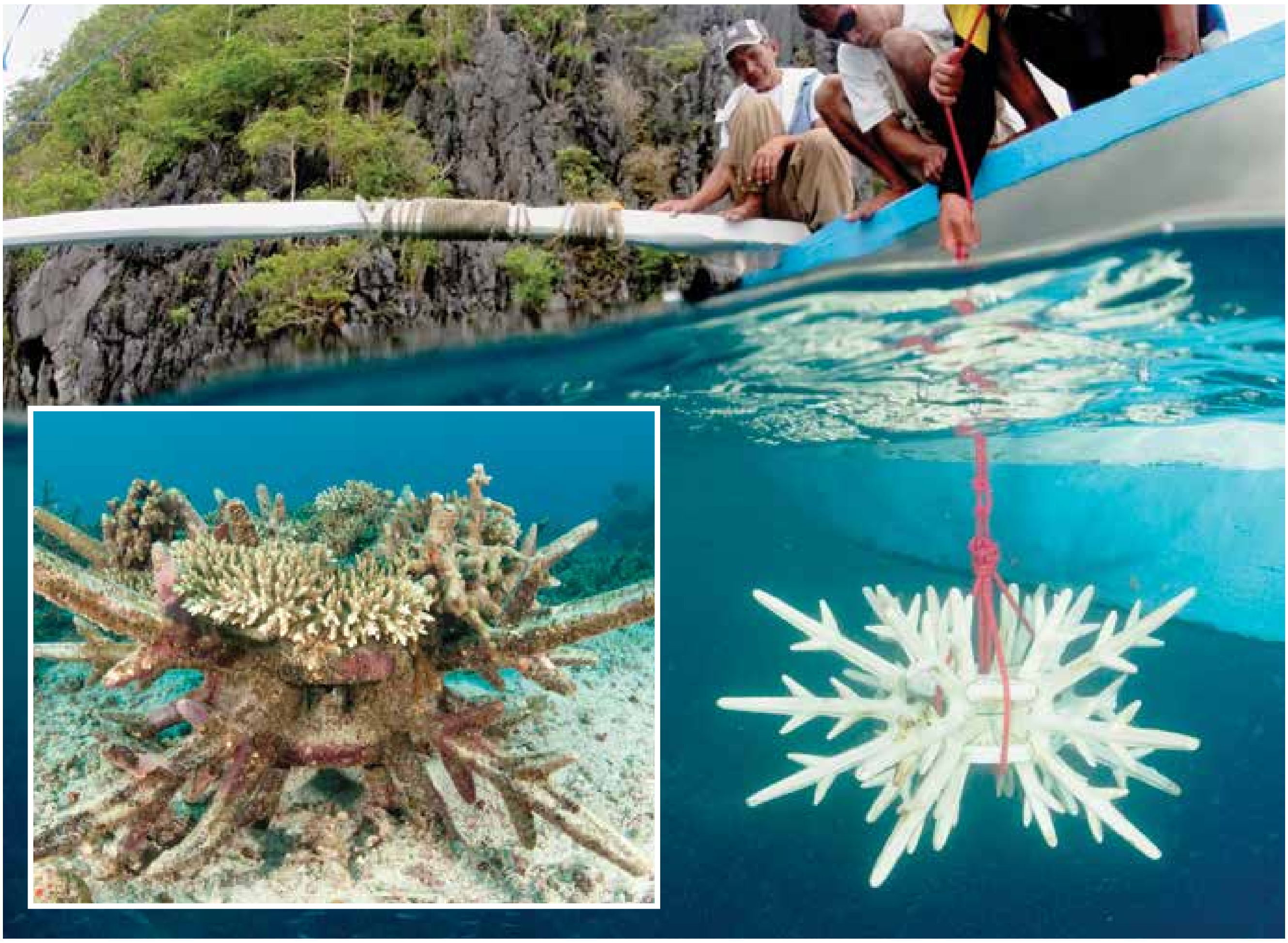
a. **Ensure stakeholders inside and outside the protected area who might be affected by species introductions are appropriately informed and engaged so that they support reintroduction efforts.**
A multi-disciplinary team of biologists, ecologists, veterinarians and local communities has managed the re-introduction of a self-sustaining population of the Asiatic black bear (*Ursus thibetanus*) in Jirisan National Park, South Korea. **See Case Study 2**.

b. **Develop individual species recovery plans in the context of broader goals for the restoration of protected areas.**
It is increasingly recognized that tiger recovery plans need to focus on many aspects of protected area management, including overall habitat quality, population of prey species and general ecosystem health (World Bank, 2011).

c. **Consider habitat and ecological requirements of target species including co-occurring and symbiotic species (such as microbial, fungal, floral and faunal organisms) that make up the ecological community.**
Koalas feed almost exclusively on species of eucalypts but not all species are equally favoured. Degraded areas near Brisbane in southern Queensland are being reforested with preferred species to encourage koalas to recolonize these areas (Boyes, 1999).

d. **Evaluate possible negative interactions with other species that could occur following re-introduction, including risks of disease and parasite transmission, and the potential for introduction of invasive species when transplanting and introducing wild populations.**
Human disturbance, logging and alien species have degraded the island of Ile Aux Aigrettes Nature Reserve, Mauritius. Restoration aims to conserve and re-establish native plant and animal species. However reintroductions are progressing cautiously and a habitat requirement study will be carried out before endangered native passerine populations, including the Mauritius fody (*Foudia rubra*),

9 http://www.wwf.org.ph/newsfacts.php?pg=det&id=10



Tres Marias, El Nido, Palawan, Philippines: Artificial coral modules used in the Coral Reef Restoration Project © J. Freund / WWF-Canon

are released as success relies on eradication of shrews (Varnham et al., 2002).

e. **Aim at sufficient genetic diversity (and/or sufficiently large founding populations) to sustain viable, resilient populations into the future.**
Research on reintroducing capercaillie (*Tetrao urogallus*) to protected areas in Scotland estimated that at least 60 individuals would be required across 5,000 ha of habitat for the population to have a high probability of surviving 50 years. But supplementing populations with two unrelated individuals every five years reduced the minimum viable population to ten individuals (World Pheasant Association and IUCN/SSC Re-introduction Specialist Group, 2009).

f. **Restore natural trophic cascades (e.g., predators suppressing prey species so that their prey or food plants can expand), particularly in freshwater and marine ecosystems.**
Sea-otters along Canada's Pacific shoreline are a red-listed species. Their food includes sea urchins, which graze on seaweed. The re-introduction of sea-otters in Checleset Bay Ecological Reserve has led to a drop in urchin populations, and the consequent return of the kelp seaweed forests that provide food and habitat for many fish and invertebrate species (COSEWIC, 2007).

g. **In the case of restoration of species or communities that require sourcing from elsewhere, e.g., seeding from donor coral communities, minimize stress on donor ecosystem by excising only sustainable percentages of the donor populations, and by using nurseries.**
The Millennium Forest in St Helena occupies part of the site of the Great Wood, the island's last remaining tract of native forest, which was completely cleared in the 18th Century. Several endemic tree species have been rediscovered over the past 50 years with populations numbering between 1-5 individuals. A careful ex-situ conservation programme has allowed the planting of the forest, which not only is recovering degraded land, with a strong community component but now contains the largest existing populations of several endemic tree species (St Helena National Trust, undated).

h. **Where suitable habitat no longer exists in the original range of the species and is impossible to restore, consider restoration through introduction under strictly controlled conditions elsewhere: e.g., on an offshore island.**
In New Zealand, remaining individuals of the kakapo parrot (*Strigops habroptila*) have been moved to remote offshore islands, previously cleared of invasive mammals, so that viable populations can survive in relatively natural conditions that are unavailable on the mainland due to introduced predators (Clout, 2001).

Box 8

A CLOSER LOOK Restoring drylands in the Middle East

Global drylands—as arid and semi-arid lands are often called—support a third of the world's population yet are undergoing widespread degradation resulting in desertification (Dregne, 1983; UNEP, 2005). Dryland biomes are one of the most fragile of ecosystems with changes in grazing behaviour, land use, fire, recreational impacts and climate change leading to the rapid and potentially irreversible loss of biodiversity, ecological resilience, and human livelihoods. Yet great strides have been made in science and technology that addresses land degradation and furthers the potential for dryland ecosystem restoration (Whisenant, 1999; Bainbridge, 2007; Cortina et al., 2011).

The need to recover ecological integrity in drylands through ecological restoration is a major priority in Saudi Arabia. The Wadi Hanifah Restoration Project, led by the Arriyadh Development Authority (ADA), is attempting to transform problems into opportunities, leading to a sustainable and productive setting, a continuous ribbon of naturalized parklands that interconnects Riyadh and the Wadi, in which residential development, farming, recreation, cultural activities and tourism exist in harmony within an oasis that extends the full length of the City, and into the surrounding rural areas. The region includes three protected areas; Al Hair, Al Laban, and Al Hasiyah. The first large scale trial involving 50,000 plants is underway to determine how to reinstate plant cover and develop appropriate technologies to scale up restoration efforts. This project is critical in halting the incidence of choking dust-storms that have increased in frequency and intensity over the past 20 years resulting in serious health and economic impacts. The challenges are significant in rolling-out restoration and will eventually require tens of millions of native plants, well-suited to the desert environment, to be established across vast areas of degraded land (Salih et al., 2008).

Thumama Nature Park, Saudi Arabia: Irrigated restoration of land degraded by overgrazing © Nigel Dudley

Best Practice 1.2.3: Re-establishment of appropriate physical-chemical conditions that are conducive to ecological restoration

In some situations, the physical or chemical environment has become so impaired (e.g., after the abiotic barrier shown in Figure 2 of Chapter 2 has been crossed) that there is no longer an intact, functioning ecosystem even with respect to its physical components (e.g., soil composition, hydrology or water and soil chemistry). In extremely degraded ecosystems, improvements in basic physical and chemical conditions are needed before biotic manipulations are worthwhile. In such cases, restoration aims at restoring terrestrial and aquatic habitats, geomorphic structures, hydrologic regimes, and water, soil and air quality.

1.2.3.1: Landforms and soil

a. **Restore healthy and stable soil composition and landforms to marine and freshwater banks and shorelines, through restoration of natural processes, and/or by using natural materials (Poff et al., 1997).**

Restoration of mangroves in the eroding coastal areas of the Mekong Delta region of southern Viet Nam is being supported by Ho Chi Minh City to reduce flooding risks, for example at Can Gio biosphere reserve (Hong, 1996).

b. **Build up soil with natural organic material from within the protected area (e.g., by retaining materials excavated during developments in the protected area for this purpose) or sterile organic material from outside. Bring only weed-free, contaminant-free and invasive species-free soils into the protected area.** Local compost, lake sediment, biosolids, and sawdust are being used to build up soils in former gravel pits in Jasper National Park of Canada. Sites are then being revegetated using mixtures of native seeds and transplants (A. Westhaver, pers. comm., 2008).

1.2.3.2: Hydrology

a. **Restore natural topographic gradients, hydrological conditions and flow regimes, along with associated microhabitats (e.g., remove dams that alter river**

Diawling National Park, Mauritania: The Lemur sluicegate allows flooding of the Bell basin by the Senegal River and was installed as part of a project to restore seasonal flooding to the delta. (Case study 6) © Diawling National Park, Mauritania

systems and trenches in drylands that intercept seasonal water flow, or block drainage channels).
Lakenheath Fen nature reserve in England restored a former carrot field to marsh by bringing back natural hydrology; after 11 years cranes (*Grus grus*) were found breeding in the Fens for the first time in 400 years[10]. **See also Case Study 1** (Finland) where artificial drainage ditches were removed and vegetation cleared to restore wetland meadows.

b. **Work on the scale of drainage basins/watersheds where possible, considering both surface and groundwater conditions. This includes considering and addressing the impacts of land/water use outside protected area boundaries, particularly for wetlands and cave systems in protected areas.**
A multi-stakeholder restoration project based in and around Diawling National Park in Mauritania is working to restore the ecosystem function of the lower of the Senegal River Delta and support development of community livelihoods. Following disruption of flood regimes caused by dam construction, flooding has been reintroduced gradually to affect progressively larger areas and longer periods of time. **See Case Study 6**.

c. **Restore habitat features such as floodplains, riparian systems, coarse woody debris accumulations, terraces, gravel bars, riffles, and pools, using local natural materials wherever possible.**
Removal of riverside dykes in protected areas in the Netherlands has allowed flood events to occur. The restored dynamics of the rivers has attracted plant and animal species, including numerous bird species and beavers (Stuip et al., 2002).

d. **Reduce sedimentation by improving hydrological regimes in protected areas rather than through dredging, wherever possible.**
Subtropical thicket restoration in the Baviaanskloof World Heritage Area and surrounding landscape in South Africa aims to reduce soil erosion, increase infiltration and reduce sedimentation of the Kouga Dam. The reduction in sedimentation may reduce the need to dredge the dam at some stage in the future (M. Powell, pers. comm., 2010 and 2011).

e. **Control water flow artificially (via pumping etc.) as a last resort to mimic natural regimes where natural mechanisms are no longer available, if this practice is consistent with broader restoration objectives.**
The restoration of the pre-dam ecological integrity of the Delta of the Senegal River Delta in and around Diawling National Park in Mauritania has been achieved through constructing hydraulic infrastructure (embankments and sluice gates) to manage flood releases. **See Case Study 6**.

f. **Monitor the impact of any artificial changes in hydrology to ensure that these do not have unintended side effects.**
In Kruger National Park, South Africa, many artificial water holes are being closed because the provision of water in areas normally dry during winter, led to over-abundance of some mammals, which in turn necessitated culling[11].

1.2.3.3: Water, Soil and Air Quality

a. **Identify water, air and soil quality issues likely to affect protected area values, distinguishing those that can be addressed directly in or around the protected area from those beyond a manager's control (e.g., long range air pollution, ocean acidification).**
New Forest National Park in the UK has lost many lichen species because of air pollution. For instance, loss of Cladonia stellaris at this location means that it has been extirpated from the UK (Rose & James, 1974), but these issues are recognized as being beyond the immediate control of managers.

b. **Promote healthy nutrient cycles by ensuring that living, dead and decomposing plant and animal materials are all present.**
Retention of leaf litter and dead wood in protected areas in Poland, particularly Białowie a National Park (Bobiec, 2002), have helped to regain old-growth characteristics and build populations of saprophytic fungi and invertebrates. Artificial creation of dead wood stumps in Nuuksio National Park, Finland has ensured species were retained while forest regained old-growth characteristics (Gilligan et al., 2005).

c. **Work with neighbours of the protected area to reduce chemical and biological contamination of oceans and coastal waters, inland surface waters, groundwater, aquatic sediment and soil.**
The Danube Biosphere Reserve is at the end of the catchment for 19 European countries; pollution control is a major problem. WWF have calculated that, if restored, the wetlands could provide almost 1 million litres of clean water per second[12]. Completion of the first basin-wide management plan in 2009 includes proposals for collaborative efforts to reduce the pollution load (Sommerwerk et al., 2010).

d. **For pressures coming from far outside the protected area, identify possible remedial actions (e.g., liming of freshwaters to reduce impacts of acid deposition).**
Selected lakes in Sweden and Norway were limed to counteract acidification (Henriksen et al., 1992) from long range air pollution (Henrikson & Brodin, 1995), e.g., in Tyresta National Park, Sweden (Edberg et al., 2001). Many species re-colonized (Degerman et al., 1995). A study of 112 limed lakes in Sweden found fish diversity increased after 5-9 years (Degerman & Nyberg, 1989).

10 http://news.bbc.co.uk/1/hi/england/6659827.stm

11 http://www.bwa.co.za/Articles/Borehole%20Closures%20in%20the%20Kruger%20National%20Park.pdf

12 http://danube.panda.org/wwf/web/static/wetland.jsp

Box 9

A CLOSER LOOK Mangrove forest restoration

As noted in the hierarchy of likely wetland restoration success in Lewis (2011), mangrove forests are technically easy to restore since they have predictable hydrology and produce large numbers of floating seeds and seedlings. However, in the real world, successful restoration is rare due to the misapplication of the known requirements for successful restoration (Lewis, 2005). The most common error is the attempt to plant mangrove propagules on mudflats that never supported mangroves in the first place (Samson & Rollon, 2008). These efforts rarely are successful, and even those few that produce some survival of plantings result in monoculture plantations with little ecological resemblance to natural mangrove forests. Planting of mangroves is in fact rarely required for successful restoration as exemplified by the West Lake Park Mangrove Restoration Project in Hollywood, Florida, USA, where 500 ha of mangroves were successfully restored through both removal of dredged materials deposits and hydrologic restoration (Lewis, undated). However, planting may be required in severely degraded situation. The lack of training of practitioners of wetland restoration in the common pitfalls and solutions to these is cited by Lewis (2011) as one of the key factors is the high failure rates of this type of restoration.

Joal-Faljouth National Park, Senegal: Mangrove restoration project undertaken by the local community association © Colleen Corrigan

Guideline 1.3: Maximize the contribution of restoration to enhancing resilience

Best Practice 1.3.1: Restoration practices that contribute to maintaining or enhancing resilience under conditions of rapid environmental change

Most of the best practices outlined in this guide should contribute to maintaining or enhancing ecological, social and economic resilience to environmental change. Resilience-related benefits of restoration can be maximized by including consideration of resilience explicitly in planning. Efforts aimed at restoring ecosystem structure and function, and at enhancing large landscape- and seascape-scale connectivity, will generally help maintain or restore the ecosystem's resilience (Walker et al., 2004; Elmqvist et al., 2003)—i.e., its capacity to tolerate and adapt to change—thus enhancing the likelihood of long-term restoration success. A key strategy is to enhance the diversity of functional types that are present so that the new communities are able to withstand environmental stresses and changes. Similarly, attention to economic and social benefits of restoration will contribute to the resilience of communities (Ervin et al., 2010, Clewell & Aronson, 2006). The following best practices should be considered in maintaining or enhancing resilience to rapid environmental change within restoration projects.

a. **Consider how restoration can facilitate large-scale (i.e., regional, national) resilience to rapid environmental change by prioritizing restoration in protected areas that offer the best chance for conserving biodiversity (e.g., that have not yet begun to change or that offer microclimatic, rainfall, and temperature refugia).**
Mexico's National Commission for Natural Protected Areas developed an adaptation programme for its Caribbean protected areas, which identifies restoration of coral reefs and sea grasses as an adaptation strategy to reduce vulnerability to climate change. Activities will include the use of fragments of coral, broken from healthy reefs as the result of impacts from ships, to restore sites where natural coral populations are affected by bleaching. The goal is to enhance the resilience of these corals and the human communities that depend on coral reef systems to climate change (CONANP, 2011b).

b. **Establish and communicate realistic restoration goals and objectives, recognizing that under climate change, some changes in ecosystem structure and function are forecast and will likely be inevitable.**
In Somerset, England, a series of wetland reserves have been recreated on abandoned peat-digging areas in what was historically a seasonally-flooded area. Sea level rise is likely to increase floods once again. Government plans are to not invest in defences in some areas, allowing seasonal floods to occur. While this will alter the structure and function of the reserve ecosystems, it will also provide additional valuable habitat for wintering wading bird populations and reconnect the reserves (Somerset Biodiversity Partnership, 2008). **See Phases 2 and 3**.

Sian Ka'an Biosphere Reserve, Mexico: Monitoring nursery of the coral *Acropora palmata* for use in ecological restoration projects © Oceanus A.C.

c. **As a last resort, where the ecosystem is no longer resilient enough to cope with change, and where the survival of one or more species or populations of species is deemed to be critical, cautiously consider strategies for moving to new locations (i.e., translocating) species with specialized needs whose habitats have shifted dramatically or have disappeared locally due to rapid environmental change.**

See best practices 1.2.2.2, as well as Dawson et al., 2011. No translocations from or to protected areas are known to have yet taken place in response to predicted climate-driven changes, although the issue is being discussed (e.g., Hunter, 2007). No best practices for such anticipatory strategies can be recommended at this time.

d. **Use restoration projects in protected areas to help build local community capacity to adapt to the effects of rapid environmental change by conducting**

Box 10

A CLOSER LOOK Restoration in karst and cave systems

Karst and cave landscapes are highly sensitive ecosystems. Careful management of the flow and condition of water and air through cave systems is commonly critical to successful management, as is safeguarding fundamental natural processes through careful management of the vegetation and soils of the entire catchment. Thus karsts and caves require special management considerations often extending beyond the formal boundaries of protected areas in which the more obvious features occur. In addition, appropriate management expertise frequently lies with cave and karst scientists and explorers. Karst systems are effectively delineated by the total watershed area, of which the karst may be only a part. The effective subterranean divide which bounds such a watershed is often quite different from the surface divide. The boundary of these extended catchments can fluctuate dramatically according to weather conditions, and relict cave passages can be reactivated following heavy rain. This further distorts the boundary of any existing protected areas. Protected area managers need to be aware that best practices include:

a. identifying the total catchment area of any karst system, and being sensitive to the potential impact of any restoration activities within the catchment, even if not located on the karst itself;
b. defining the whole karst drainage network using planned water tracing experiments and cave mapping; and
c. where appropriate, developing caves for tourism through restoration of damaged caves rather than opening new caves (Watson et al., 1997; Vermeulen & Whitten, 1999).

scenario planning and by building knowledge and understanding of anticipated changes and potential responses.
The El Triunfo Biosphere Reserve, Chiapas, Mexico, developed a capacity building programme with coffee producers as an adaptation strategy. In 2011, a workshop gathering 300 people was held, in order to enhance better decisions on climate change mitigation and adaptation, where actions of soil conservation and restoration were identified as a strategy to increase resilience of socioeconomic systems (CONANP, 2011c).

e. **Integrate knowledge about current and predicted changes (e.g., in extreme weather events, average temperature, sea level, ocean circulation patterns, etc.) into restoration decision-making, using an adaptive management approach that recognizes and adjusts for uncertainties associated with measurements and predictions.**
The Australian Alps catchment is directly threatened by climate change with, for example, drier conditions, increased fire frequency and severity, and the spread of invasive species. A systematic assessment of the 11 Alps national parks to forecast impacts of climate change is informing actions for restoration and adaptation (Worboys et al., 2010c). **See also Case Study 11**.

Box 11

A CLOSER LOOK Seagrass meadow restoration

Seagrass meadows are submerged flowering plant communities of great importance to coastal marine ecology. Often out of sight and thus lacking real protection and management, they are rapidly declining worldwide (Waycott et al., 2009). Fonseca et al. (1998) provides a good summary of seagrass meadow restoration options for the USA and adjacent waters. More recently Paling et al. (2009) provides an international summary of similar efforts. Both authors caution that seagrass meadow restoration is difficult and expensive, with typical costs of US$1 million per successful ha of restoration. IUCN has also produced a detailed manual on managing seagrasses for resilience to climate change (Björk et al., 2008).

Lewis (2011) lists seagrasses as the most difficult of all wetland types to successfully restore. Seagrass restoration as mitigation for impacts has been done successfully but is rare (Treat & Lewis, 2003). Large scale ecological restoration of seagrasses for management purposes is even less common, but see Lewis ***et al.*** (1998) and Greening ***et al.*** (2011) for the successful Tampa Bay, Florida, USA, restoration of approximately 4,000 ha of seagrass through natural recruitment after significant water quality improvements.

The simple planting or transplanting to areas devoid of seagrass is rarely successful at establishing significant new seagrass cover. Unless the original cause of the loss of seagrass cover is known and is ameliorated, prior to any planting or transplanting attempts, successful restoration is not likely. Such efforts may come through water quality improvements or removal of stress such as routine boat groundings or propeller damage as is becoming more common with increased boating activities in seagrass dominated shallow waters.

Guideline 1.4: Restore connectivity within and beyond the boundaries of protected areas

Best Practice 1.4.1: Restoration that facilitates connectivity conservation within and between protected areas

Connectivity conservation is addressed both by actions *within* protected areas, such as ensuring healthy populations that can move or 'spill over' into surrounding environments, and management *outside* protected areas that ensures suitable conditions for movement through connectivity conservation corridors including stepping stones for migratory species. Both these approaches can benefit from restoration.

a. **Identify the relevant ecosystem boundary (e.g., watershed, species' ranges) and potential conservation corridors when planning restoration at a landscape or seascape scale.**
Cross-boundary conservation initiatives such as ecoregional plans help to put restoration into a wider context. For example the ecoregional plan for the northern Great Plains in the USA includes extensive restoration of habitat and re-introduction of species covering both protected areas and the wider landscape (Forrest et al., 2004).

b. **Restore connectivity within protected areas when necessary by addressing anthropogenic barriers to species movements such as roads and fences. Connectivity is more important to some species than others, and specific requirements will vary according to species.**
Highway over-passes have been introduced to encourage natural wildlife movement in Banff National Park of Canada[13] (White & Fisher, 2007).

c. **Remove unnecessary roads within protected areas.**
In Mount Athos, Greece, the monks who manage the peninsula as a nature reserve have progressively removed roads wherever possible to retain large forest areas (Kakouros, 2009; Philippou & Kontos, 2009).

d. **When planning restoration in a protected area, also consider opportunities for movement beyond the boundaries to support both regular genetic interchange and species migration in response to climate change (e.g., linking to connectivity corridors leading out of the protected area, or facilitating spillover of species important for subsistence or commerce, such as fish from MPAs).**

13 http://www.pc.gc.ca/pn-np/ab/banff/plan/gestion-management/IE-EI.aspx

Repeated research projects show that marine protected areas not only rebuild fish populations within the areas but also result in spillover beyond its borders that can supply local fishing communities with sustainable sources of protein. Examples include Columbretes Islands Marine Reserve, Spain (Stobart et al., 2009) and Nabq Managed Resource Protected Area, Egypt (Ashworth & Ormond, 2005). Replanting forest fragments along the Kinabatangang River in Sabah, on the island of Borneo, helps to reconnect protected habitat and allow twice-yearly elephant migration (Vaz, undated).

e. **Consult and collaborate with all relevant partners and stakeholders and the public and make sure any necessary governance mechanisms (such as contractual parks, landowner agreements, stewardship areas) are established and maintained and stakeholders and partners are committed to the process.**
The Habitat 141° project in Australia provides an example of restoring functional connectivity within and beyond the boundaries of protected areas by mobilizing rural and regional communities through partnerships and collaboration between private and public landowners, land managers, investors, special interest groups and volunteers. **See Case Study 8**.

f. **Incorporate considerations of timescale into restoration of connectivity, for instance by managing an ecosystem through a period of change so that other components of the system can catch up.**
Provisions to Queensland's Nature Conservation Act ensure the long-term sustainability of restoration efforts in Springbrook National Park, Australia, which allow a 20-year time frame for a showcase ecological restoration project. **See Case Study 11**.

Guideline 1.5: Encourage and re-establish traditional cultural values and practices that contribute to the ecological, social and cultural sustainability of the protected area and its surroundings

Best Practice 1.5.1: Restoration that incorporates cultural management

Traditional cultural practices can in some cases maintain or restore natural values that are otherwise declining or missing; maintaining or reintroducing these management systems can play a major role in restoration in some circumstances.

a. **Encourage broad-based participation in restoration and management planning.**
Ashton Lagoon, the largest lagoon in the Grenadines, suffered significant damage after a failed development project in the conservation area. A participatory planning workshop determined the community's vision for the sustainable use of the lagoon, including a plan to address the many conservation needs, such as removal of impediments to the natural hydrologic flow, restoration of marine and coastal habitats and re-establishment of aquatic and coastal flora and fauna (Sorenson, 2008).

Springbrook Rainforest Project, Australia: Monitoring includes a state-of-the art, continuously operating wireless sensor network with 175 sensor nodes and 700 individual sensors providing long-term, catchment-wide micrometeorological, edaphic, and plant productivity data. A battery-powered wireless multi-media network monitors animal movements. (Case study 11) © Keith Scott

b. **Integrate cultural knowledge and objectives into project goals (e.g., through publicity campaigns, public celebrations of restoration, community participation in restoration and monitoring, and other actions that ensure cultural intimacy with ecosystem recovery).**
Parks Canada is using prescribed burns in its actions to restore the Lake Erie Sand Spit Savannah in Point Pelee National Park. The Caldwell First Nation conducted a traditional fire ceremony to celebrate the re-introduction of fire into the ecosystems protected in the park and the pubic was invited to attend (Parks Canada, 2012a). **See also Case Study 5**.

c. **Encourage restoration of ecologically sustainable cultural practices, particularly those with which the protected area ecosystem has co-evolved, by supporting the cultural survival, languages and traditional knowledge of indigenous peoples associated with the area.**
In Gwaii Haanas, Canada, the salmon is a symbol of the strong connection between the Haida people with their land and the sea. The restoration of suitable spawning and rearing habitat for several species of salmon is helping reconnect people with their land. **See Case Study 9** for more details.

Guideline 1.6: Use research and monitoring, including from traditional ecological knowledge, to maximize restoration success

Best Practice 1.6.1: Adaptive management, monitoring and evaluation of ecological, social and economic aspects of restoration

Effective monitoring and evaluation increases success in restoration projects by facilitating adaptive management. Monitoring can be used to identify when restoration might be required in a protected area and subsequently to measure progress towards agreed-upon objectives. Most monitoring systems should include both ecological and social indicators for measuring progress. Monitoring needs first to identify indicators and monitoring protocols to measure progress on the main objective and then to consider other costs and benefits. Those involved in monitoring will often include both conventionally qualified restoration experts and those with an intimate knowledge built from local experience. Monitoring and associated adaptive management needs to start at the very beginning of the planning of restoration and not be added on at the end as an afterthought.

a. **In the case of ecological restoration that aims to achieve both ecological and livelihood objectives, continually monitor and evaluate the impacts of all restoration activities (Fisher et al., 2008) against: (i) conservation aims; (ii) social and equity impacts; (iii) economic goals.**
When Doi Suthep-Pui National Park was established in northern Thailand a number of villagers were already living in the area. An agreement has been reached for people in the village of Ban Mai Sa Mai to restore part of the land they have been using for agriculture in return for continued occupancy of the area (Blakesley & Elliott, 2003).

Grasslands National Park, Canada: Monitoring plot © Parks Canada

b. **Choose indicators and methods that can be monitored cost-effectively for the long time period required for many restoration programmes**. **See Phase 5.3**.

c. **Develop clear protocols for monitoring, so that monitoring can remain constant through changes of responsible staff.**
Monitoring has been a particularly strong feature of the Lintulahdet Life Project in Finland. **See Case Study 1**.

d. **Plan monitoring protocols with involvement of specialists. The effects of restoration cannot be separated from natural fluctuations without clearly stating questions, collecting data and conducting well-planned analyses.**
In Cockayne Reserve, New Zealand, an Index of Wetland Conditions allowed changes to be measured from 1982 to 2000 after a restoration project. Monitoring showed general improvements due to planting native species but also remaining problems from weeds and sedimentation (Clarkson et al., 2004).

e. **Plan restoration projects so that the restoration actions can be adapted according to the feedback from monitoring.**
Continual monitoring and assessment of an area degraded over 100 years ago has informed the Springbrook rainforest restoration project in Australia. **See Case Study 11**.

Best Practice 1.6.2: Ensure that monitoring processes are participatory and results are transparent

Agreeing on what indicators to monitor can be an important part of participatory processes, when broader restoration values can be identified and assessed. Direct involvement of visitors, neighbouring communities, the public, and other partners and stakeholders in monitoring can help build confidence in the process and will also often increase the accuracy of the results.

a. **Choose indicators and undertake monitoring on a collaborative basis with partners, affected communities, and other stakeholders, particularly when projects have a social component (e.g., providing ecosystem services) or livelihood implications.**
As part of developing national environment indicators for wetlands in New Zealand, which include aspects of restoration, a participatory approach was used to agree a generic set of indicators selected by the Maori to monitor wetland condition and trends (Harmsworth, 2002). **See Phase 5.3**.

PRINCIPLE 2: Efficient in maximizing beneficial outcomes while minimizing costs in time, resources, and effort

Guideline 2.1: Consider restoration goals and objectives from system-wide to local scales in prioritizing restoration activities

Best Practice 2.1.1: Restoration that focuses on the most urgent and important interventions for reaching system-wide, landscape-/seascape-level or protected area goals

Maximizing beneficial outcomes while minimizing costs will require prioritization and may include trade-offs among competing objectives and consideration of wider factors such as climate change (e.g., Holl & Aide, 2011).

a. **At the protected areas system level, prioritize the most important protected areas on which to focus restoration efforts. Consider/analyze risks, costs and benefits of restoration versus other management strategies and factors such as likelihood of support from key stakeholders.**
Priority sites could include World Heritage sites, UNESCO biosphere reserves, Ramsar sites, sites in biodiversity prioritization schemes and those containing many Red List species. IUCN is also formulating a Red List for Threatened Ecosystems using quantitative criteria for assigning levels of threats to ecosystems at local, regional, and global levels, reflecting degree and rate of change in an ecosystem's extent, composition, structure, and function (Rodriguez et al., 2010).

b. **At the landscape and/or seascape level, assess the relative contribution of different site level restoration interventions to biodiversity conservation, and the provision of ecosystem services in order to prioritize resource allocations across the protected area network.**
In New Caledonia, 19 sites were selected across the whole island, amounting to over 1,000 ha, to serve as critical sites for protection and restoration of critically endangered dry forests; with high population pressure and extreme threats to the habitat such focused efforts were considered essential (Gunther, 2004).

c. **At the species or biological community level, identify criteria to prioritize ecological restoration needs for species, including factors associated with the conservation of rare, threatened and endangered species.**
These are likely to include information from the Alliance for Zero Extinction (relating to endangerment, irreplaceability and discreteness) (AZE, 2011), and reference to national and international Red Lists[14] of endangered species, and national species action plans.

d. **At the site level, identify and prioritize situations where prompt restoration will save significant effort in the future. For example: (i) where failure to restore will result in permanent loss of endemic or rare species, habitats and ecosystems; (ii) biologically important degraded areas that need minimal intervention to begin natural regeneration; (iii) abating urgent threats including causal agents of degradation, bad management practices and sources of invasive species; (iv) stabilizing sites that pose a threat to public health, such as an avalanche; (v) containing biological and chemical contaminants that may move off-site.**
At Halstead Meadow in Sequoia National Park, California, the US National Park Service is restoring a 10 ha montane wet meadow that had developed deep gullies in response to past overgrazing and culvert construction for roads. Left untreated, the gullies would continue to deepen and migrate further up the valley, draining more and more ecologically important wet meadow habitat and increasing the difficulty and cost of future restoration. Eroded channels were backfilled and planted with native, sod-forming wetland species, biodegradable erosion control fabric was installed, and a new highway bridge is being constructed to replace the culverts and restore natural sheetflow hydrology (Wagner et al., 2007).

Best Practice 2.1.2: Development of an implementation plan

Good planning is critical to success and is a key part of the restoration process described in Chapter 5.

a. **Develop an implementation plan in collaboration with stakeholders and partners that: (i) identifies the rationale for restoration priorities; (ii) lists intended outcomes; (iii) lays out steps needed for restoration; and (iv) explains the intended monitoring system.**
The Endangered Species Act obligates the US Fish and Wildlife Service to develop restoration plans for species designated as Endangered. For example, the Northern Rocky Mountain Wolf Recovery Plan, a co-operation between the National Park Service, Fish and Wildlife Service, academia, state wildlife agencies and environmental groups (US Fish and Wildlife Service, 1987), led the reintroduction of wolves in Yellowstone National Park. **See Phase 5.2.**

Guideline 2.2: Ensure long-term capacity and support for maintenance and monitoring of restoration

Best Practice 2.2.1: Restoration that supports establishment of long-term capacity, commitment and vision for restoration

As most forms of ecological restoration take a long time to complete (if in fact 'completion' is ever possible), it is important

14 http://www.iucnredlist.org/

Diawling National Park, Mauritania: The restoration project has provided support for local livelihoods. This support has included training and provision of capital for women's groups to reestablish artisanal matmaking using local materials as a source of income. (Case study 6) © Diawling National Park

to be sure that there is a good chance that the restoration process will be able to continue long enough to succeed.

a. **Ensure effective protected area governance mechanisms are in place to protect the initial ecological restoration investment (e.g., secure budget, strong commitment from partners and appropriate laws and policies).**
In Gwaii Haanas, Canada, the cooperative management model and institutionalized structures of decision-making have supported stakeholders in developing restoration project goals that are appropriately grounded in the ecological, cultural and community context, and that are meaningful to both the Haida Nation and Parks Canada. **See Case Study 9**.

b. **Work closely with local communities to ensure that they understand and support restoration, and receive a fair share of the benefits where these accrue.**
Support for the development of local livelihoods was central to the restoration project in Diawling National Park, Mauritania. The project provided support for new and traditional economic activities which have resulted in an estimated benefit of at least US$780,000 annually for local communities. **See Case Study 6**.

c. **Invest in restoration efforts in protected areas with secure tenure or, in the case of contractual arrangements on private lands and waters, try to ensure that these agreements preclude future changes in use that would eradicate the restoration investment**.
In Springbrook, Australia, governance mechanisms to secure long-term restoration investments involving not-for-profit partnerships use clauses in Queensland's Nature Conservation Act and covenants on private lands. **See Case Study 11**.

d. **Maintain monitoring and adaptive management frameworks over the long-term to maximize the chances of success and also to have clear evidence that restoration is delivering benefits.**
In Brazil, systematic collection of data using GIS has been critical in informing and adapting project design. A research programme has been developed with universities to evaluate the restoration process and training needs. **See Case Study 7**.

Guideline 2.3: Maximize the contribution of restoration actions to enhancing natural capital and ecosystem services from protected areas

Best Practice 2.3.1: Restoration that contributes to climate change mitigation

Ecological restoration in protected areas can sequester carbon in living biomass and thus mitigate climate change. The carbon market has the potential to provide finance for restoration, but it is unclear if this will be available to protected areas. There is also a risk that the market price for carbon will govern the quality and type of restoration and unless co-benefits are an explicit factor in project eligibility, the emphasis on carbon could constrain the scope of restoration (Galatowitsch, 2009; Alexander et al., 2011). Navigating the carbon market requires up-front investment and willingness to take on risk. The potential benefits need to be weighed against the challenges.

Atlantic Forest, Brazil: Photographic monitoring of the restoration planting area over time (Case study 7) © Ricardo Miranda de Britez – SPVS

a. **Consider carbon sequestration opportunities and their potential contribution to national and global climate change strategies in all suitable restoration projects in protected areas, even where carbon credit funding is not being pursued**.
Efforts to restore the degraded Nariva Wetlands protected area in Trinidad are boosted by recognition of the wetland's role as a carbon sink. Reforesting parts of the area with native trees is being funded by The BioCarbon Fund, which intends to purchase about 193,000 t CO_2 equivalent up to 2017 (Anon, 2009).

b. **Ensure goals for restoration remain appropriately focused on protected area values: i.e., avoid changing the ecosystem for carbon sequestration purposes such as creating a forest where the degraded ecosystem is grassland.**
The recent emergence of carbon storage as a potential role for protected areas means that this has not happened to a large extent yet, but this will become an increasingly important issue to watch in the future. **See Phases 3.1 and 4.1**.

c. **Design restoration projects with a carbon component to the highest standards consistent with (i) restoration best practices and (ii) carbon offset standards, covering technical requirements for eligibility to offset schemes, and ecological and social impacts.**
The Climate, Community, and Biodiversity Project Design Standards (CCBA, 2008) identify criteria for land-based climate change mitigation projects that can simultaneously deliver compelling climate, biodiversity and community benefits.

d. **Include carbon storage and sequestration in monitoring programmes established to measure progress in restoration.**
Many restoration projects have a carbon sequestration objective (Miles, 2010), for example, **see Case Study 4** and **Phase 7.1.**

e. **Integrate learning into ecological restoration carbon offset projects.**
The Mantadia forest corridor restoration project in Madagascar is restoring 3,020 ha of forest linking the Antasibe and Mantidia protected areas. Habitat restoration is expected to sequester 113,000 t CO_2 equivalent by 2012 and 1.2 million t CO_2 equivalent over 30 years. The project includes a major capacity building component that aims to reduce slash and burn agriculture, provide alternative income through carbon credits and offers five sustainable livelihood activities: forest gardens, saroka gardens, fruit gardens, mixed endemic species plantations and fuelwood plantations (Pollini, 2009). **See Phase 7.2**.

Best Practice 2.3.2: Restoration that contributes to mitigating the effects of natural disasters

Coral reefs, mangroves, wetlands, forests, marshes and natural riparian vegetation help block or absorb the impacts of natural disasters from coastal and river flooding; tidal surges and tsunamis; typhoons and hurricanes; landslips and avalanches; dust storms; desertification and drought. Many protected areas play a role in alleviating disasters and restoration can sometimes significantly improve these services (Stolton et al., 2008).

a. **Consider co-benefits of: (i) restoring forests in protected areas, particularly on steep slopes, in mitigating erosion, flooding, avalanches, landslides and rockfall, including after earth tremors; (ii) restoring inland and coastal wetland and salt marsh reserves to provide spill-over sites for flooding and tidal surge; (iii) restoring mangroves and coral reefs in marine protected areas as protection against storms, tsunamis and ocean surges; (iv) re-opening river channels to allow floodwater to disperse naturally rather than causing floods downstream; (v) protecting arid lands to eliminate over-grazing, trampling and four-wheel drive vehicles, to restore vegetation and reduce erosion and dust storms.**
Malaga in Spain has ended 500 years of regular flooding by restoration and protection of forests in the watershed (Dudley & Aldrich, 2007). An investment of US$1.1 million for mangrove restoration by local communities in Viet Nam has saved an estimated US$7.3 million/year in sea dyke maintenance (Brown et al., 2006). In Europe, floodplains of the Rhine and Danube have been restored in response to past flooding. Since 2000, the Netherlands government has run a 'Space for the River' flood management programme; the 600 ha Millingerwaard protected area is a test site (Bekhuis et al., 2005).

Best Practice 2.3.3: Restoration that supports ecosystem provisioning services (food and water security, health and materials)

Natural ecosystems contribute enormously to human wellbeing through the provision of ecosystem services, including clean and in some cases sufficient water, food supply, genetic materials used for medicines and other resources. While these are not the major objective of protected areas, they are often critically important bonus values of such places and when consistent with nature conservation objectives, restoration of such values can be important. Analysis shows restoration of ecosystem services can improve ecosystem services by 25 per cent on average (Benayas et al., 2009).

a. **Work with protected area managers, local communities, indigenous peoples and other partners and stakeholders to identify critical biodiversity components and ecosystem services supplied by the protected area that can be restored for livelihood benefits in a manner consistent with conservation aims, even when restoration aims primarily at restoring natural values.**
The restoration of the floodplain, mangroves and dune systems of the lower Senegal River Delta in and around Diawling National Park has also restored the ecosystem goods and services, such as fisheries, that local people depend on far beyond the park's boundaries. **See Case Study 6**.

b. **Use restoration in protected areas to improve food supply by: (i) reducing infestations of invasive species, pests and diseases; (ii) establishing host-plants for, or otherwise restoring natural predators of, pests; (iii) restoring plants that support pollinators; and (iv) providing subsistence foods, when compatible with protected area objectives.**
Guanacaste National Park in Costa Rica receives Payment for Ecosystem Service contributions from adjacent fruit plantations for services that include water, pollination and pest control (Janzen, 2000).

c. **Collaboratively plan and communicate resource uses and species management and restoration strategies with affected communities such that negative influences on livelihoods are minimized and benefits are maximized (e.g., management strategies such as 'no take zones' aimed at restoring fish populations to support subsistence and small-scale commercial fishing communities to the extent practicable).**
The Fandriana Marolambo Forest Landscape Restoration project in Madagascar, has consulted extensively with local communities to elaborate a common vision of land use, identify their needs and wants and develop opportunities for alternative livelihoods to alleviate poverty and reduce pressures on the area. **See Case Study 3**.

Guideline 2.4: Contribute to sustainable livelihoods for indigenous peoples and dependent and local communities

Best Practice 2.4.1: Restoration that respects traditional, cultural and spiritual values

Along with provisioning values, many protected areas also contain cultural heritage sites or resources and more intangible values, such as sacred natural sites and pilgrimage routes, which have enormous value to local and indigenous people and sometimes also to the wider population. Restoring these values has intrinsic worth, can help build support for the protected area, and sometimes also has direct nature conservation values (e.g., many sacred natural sites have high associated biodiversity). Respecting these values, and the traditional knowledge associated with a protected area, can help to build successful partnerships with the broader community.

a. **Maintain respect for all cultural values and the individuals who hold those values throughout all phases of the project referring to existing guidance where appropriate. Resolve conflicts or agree to any trade-offs between cultural values (including identified cultural heritage values of the protected area) and natural values, before the planning process proceeds.**
See rehabilitation of the lower delta of the Senegal River (**Case Study 6**), restoration of connectivity in Australia (**Case Study 8**), and restoration of cultural values associated with land and water use in Canada (**Case Study 9**).

b. **Maintain, restore, or modify cultural practices so as to contribute to ecological restoration.**
When fire is suppressed in the grasslands of Riding Mountain National Park, Canada, aspen forests have been shown to encroach at rates as high as 1.1 per cent total area/year. Park ecologists have developed a fire restoration programme mimicking the 5-10 year fire cycle prevalent when Aboriginal people were actively lighting fires. Since then, encroachment has slowed-to-stopped in managed areas, and forests are slowly being pushed back towards pre-suppression sizes, successfully increasing landscape diversity (P. Sinkins, pers. comm., 2012).

Riding Mountain National Park, Canada: Fire restoration programme © Parks Canada

Lacandon forest, Mexico: Working with farmers in the Lacandon community has led to more effective tools for management of invasive species and forest restoration. (Case study 5) © Antonio Sánchez Gómez

c. **Take account of all forms of historical and current information, including indigenous and local TEK, alongside best available scientific knowledge. Use appropriate techniques for accessing TEK and take care to avoid inequitable exploitation of TEK.**
Understanding the traditional ecological techniques of Lacandon Maya farmers in Southern Chiapas, Mexico, has helped researchers develop effective tools for the management of invasive species and forest restoration in the UNESCO Montes Azules Biosphere Reserve. Accessing TEK requires particular techniques, including semi-directed interviews, questionnaires, facilitated workshops and collaborative field projects (Huntington, 2000). See Case Study 5 and in particular the section on lessons learned accessing TEK.

d. **Consider cultural values associated with spiritual, educational, recreational, or historical aspects of the ecosystem in setting goals and building societal support for restoration actions.**
Prescribed burns are being re-introduced into Point Pelee National Park, Canada, to restore endangered sand spit savannah by clearing invasive species and promoting growth of native plants. To celebrate the change in management, the Caldwell First Nation conducted a traditional fire ceremony open to anyone who wished to take part. See also Case Study 9.

e. **Work with faith groups to restore sacred natural sites, shrines and pilgrimage routes in protected areas such that both spiritual and ecological values are enhanced.**
In Catalonia, Spain, the lands around the Cistercian Monastery of Poblet have been declared a protected area and monks are working with the government to manage and improve the ecosystem, including through restoration of riparian white poplar woods (Mallarach & Torcal, 2009).

Best Practice 2.4.2: Restoration activities that consider social impacts and equity

Restoration often implies costs, both direct investment costs and wider societal costs in terms of restrictions to access, potential side effects and even unintended consequences such as an increase in human-wildlife conflicts. Ensuring that potential social impacts, including impacts on equity, are considered up-front will help to minimize risks.

a. **Consider peoples' views and their use and dependence on the ecosystem, now and in the future, during restoration. This includes the socio-economic and cultural links between people, species and landscape or seascape priority areas and the use of resources from these areas.**
The Meso-American Biological Corridor covers seven countries and is a mixture of protected areas and connectivity areas with sustainable management. Restoration plays a major role in some parts of the Corridor. The mix of state, community and private lands makes it particularly important to agree actions and ensure that benefits accrue to local people (Álvarez-Icaza, 2010).

b. **Where indigenous peoples and other local communities have a connection to the land, embedding their values and perspectives in the restoration team's work is important whether or not representatives participate in the design of the restoration plan. Suggested approaches need to be in line with historical, cultural and political realities.**
Lyell Island, Canada, part of the archipelago protected as Gwaii Haanas National Park Reserve and Haida Heritage Site, is a place of great significance to the Haida Nation. Restoration activities on the Island have sought to reinforce cultural values associated with land and water use. See Case Studies 9 and 10 .

Best Practice 2.4.3: Restoration that contributes to social benefits, economic opportunities and equity

Improved social benefits and income opportunities from ecosystem services, and directly from work on restoration, can provide an incentive for local stakeholders to participate in restoration (ITTO, 2002). Education, training, and learning opportunities about alternative livelihoods can encourage sustainable economic activities compatible with restoration goals. Efforts can help ensure that benefits reach all community members, focusing on those who are disenfranchised, less influential or less powerful.

a. **Strive to ensure that restoration projects do not make the poor worse off, maintaining, if not expanding, development options. Ecological restoration needs to take impacts on local livelihoods into account; gender-specific issues and opportunities for labour are important determinants of the local acceptability of restoration activities.**
Employ social impact assessment methodologies that directly assess impacts of the ecological restoration project in terms of costs and benefits to the poor. The Working for

Gwaii Haanas, Canada: Haida Dancing at Athlii Gwaii Celebration (Case study 9) © Parks Canada

Woodlands project in South Africa (**see Case Study 4**) is under the umbrella of a poverty alleviation programme and focused on the poorest rural areas; and the Asiatic black bear restoration project in South Korea (**see Case Study 2**) took into account livelihood of beekeepers affected by bear reintroduction.

b. **Where possible, ensure a flow of economic and social benefits as a result of the restoration project to low-income populations whose livelihoods depend on the restored lands.**
Restoration activities in the Mountain Pine Ridge Forest Reserve, Belize, have generated employment for 800 people, the single biggest source of employment in the region (Walden, undated).

c. **Learn from rural communities about their livelihood interests and demonstrate that there is a commitment to developing alternative livelihoods through restoration.**
Restoration in and around Fadriana Marolambo National Park, Madagascar, includes strategies for developing alternative livelihoods to alleviate poverty and reduce pressures on the area. **See Case Study 3**.

Guideline 2.5: Integrate and coordinate with international development policies and programming

Best Practice 2.5.1: Restoration that is coordinated with national and international development policies and programming

Many protected areas are already recipients of, or are adjacent to areas that are involved in, international development projects covering both social and environmental issues. Engaging with these partners can strengthen restoration projects and increase their chances of success.

a. **Work with development banks and agencies and/or NGOs to co-ordinate policies and programming focused on ecological restoration.**
Restoration of mangrove in the Red River Delta biosphere reserve in Viet Nam has been undertaken by the Red Cross to address both conservation and livelihood issues. The World Bank has also supported mangrove restoration projects in the Mekong Delta region, such as a Can Gio biosphere reserve. **See also Case Study 10** for challenges in coordinating multiple agencies and NGOs in restoring Iraq's southern marshlands.

Fandriana Marolambo Forest Landscape Restoration project, Madagascar: Establishment of community nurseries and engagement with local people have helped develop knowledge of indigenous species and built long-term support for restoration activities (Case study 3) © Appolinaire Razafimahatratra (WWF)

Subtropical Thicket Restoration Programme (STRP), South Africa: Restoration workers in the programme, which provides support for livelihoods through employment in rural areas (Case study 4) © M. Powell

PRINCIPLE 3: Engaging through collaboration with partners and stakeholders, promoting participation and enhancing visitor experience

Guideline 3.1: Collaborate with indigenous people, local communities, landowners, corporations, scientists and other partners and stakeholders in planning, implementation, and evaluation

Best Practice 3.1.1: Restoration processes that promote stakeholder consent, participation, inclusion and collaboration

Restoration represents an indefinite, long-term commitment of land/water and resources, and often requires an intentional shift away from activities that caused the initial degradation. It therefore benefits from collective decisions arising from thoughtful deliberations, which are more likely to be honoured, implemented and sustained over long time horizons and across political changes than are unilateral decisions. Spending time at the start of the restoration project to build relationships and understand partner and stakeholder perceptions and priorities will help ensure effective partnerships. Knowing the worldview, opinions and priorities of stakeholders can inform planning and communication. During the relationship building process, care is needed to ensure realistic promises, timescales and expectations and avoid exaggerating potential benefits. Engagement takes time for everybody involved and it may therefore be sensible to vary the time, spatial scale and regularity of engagement depending on the values/attributes being restored, and of the area under restoration.

a. **Identify and engage the full range of partners and stakeholders with an interest in the restoration, including all who will be affected, even if geographically distant from the project.**
The British Virgin Islands (BVI) National Parks Trust 'Moorings Programme', has installed 160 moorings at 65 popular snorkel and dive sites throughout the BVI, to prevent anchor damage and allow the natural regeneration of the corals. The Trust has worked closely with private dive operators from the start, and the industry has implemented the programme and has a representative on the Trust board. The programme requires ongoing monitoring, surveillance and enforcement; six Marine Wardens are responsible for the maintenance and patrol of moorings (N W. Pascoe, pers. comm., 2011). **See Phase 1.2**.
b. **Build relationships with stakeholders based on trust, openness and shared benefit.**
About 20 per cent of Jirisan National Park, in South Korea, is privately owned. The project to reintroduce the Asiatic black bear (*Ursus thibetanus*) has had to address this overlap of human use and bear habitat by partnering with local government and communities, establishing a compensation programme for damage by bears, monitoring bear activity and promoting education and awareness materials. **See Case Study 2**.
c. **Ensure the ecological rationale for species management is fully understood and supported by the public and other stakeholders, that they are encouraged to participate as appropriate, and that effective communication continues throughout.**

Research in Sweden shows that attitudes towards the recovery of wolf populations in the country improve as people learn more (Ericsson & Heberlein, 2003). The Duncan Down community conservation project in England has produced a simple attractive leaflet for the local community which explains the habitats on the Down and why and how they have been restored and are being managed (Friends of Duncan Down, undated).

d. **Determine the needs, constraints and behaviours that led to the degradation and develop strategies to engage people making changes that will safeguard the existing protected area and promote restoration.**
Helping local communities understand the benefits of adopting alternatives to traditional shifting agriculture was vital for the success of restoration activities in and around Fadriana Marolambo National Park, Madagascar. **See Case Study 3**.

Best Practice 3.1.2: Restoration that is collaborative within existing protected areas

Involving communities in restoration can help them to connect with their protected areas and share or acquire knowledge that supports restoration efforts.

a. **Explore options for involving those people who live in or near protected areas in restoration projects, including through reintroduction of traditional practices.**
The invasive plant *Amorpha fruticosa* is destroying wetland habitat in Lonjsko Polje Nature Park in Croatia. Cutting does not control the spread, but cutting followed by grazing by Slavonian symrian podolian cattle, grazed by farmers within the reserve, has proven successful. It also provides pasture and has created a market for the high quality, traditional beef produced (G. Gugić, pers. comm. 2012).

Best Practice 3.1.3: Restoration that involves collaboration in community-conserved protected areas

Successful restoration efforts are often those in which communities have undertaken the restoration efforts of their protected areas themselves, often based on cultural values.

a. **Expand ecosystem restoration beyond the state protected area system through collaborative projects in indigenous and community conserved areas and other lands and waters being managed sustainably by indigenous peoples and local communities. Here the focus will often be on restoration that provides benefits simultaneously to people and nature, such as recovery of ecosystem services.**
A project led by an indigenous people's organization in the Puerto Princessa Subterranean River National Park in Palawan, Philippines, has restored degraded forest in two ancestral claim areas, including action by community members in monitoring and protection (Brown et al., undated). Villages around Chakrashila wildlife sanctuary in Assam, India helped declare and restore the surrounding forests as a sanctuary to revive the dwindling population of the endemic golden langur (*Trachypithecus geei*) and to provide social development through eco-development projects (Pathak, 2009).

Guideline 3.2: Learn collaboratively and build capacity in support of continued engagement in ecological restoration initiatives

Best Practice 3.2.1 Restoration that develops a commitment to continuous and reciprocal learning

Learning opportunities facilitate the development of deeper understanding and appreciation of natural systems and can lead to broad-based commitment to restoration goals (Schneider, 2005).

a. **Include support to allow indigenous people to engage in the restoration process and/or develop their TEK; particularly if communities have lost TEK; or where immediate subsistence pressures may hamper restoration initiatives.**
Members of the Mohawk community of Akwesasne are working in partnership with St. Lawrence Islands National Park of Canada to reduce the local deer populations. Providing an opportunity for involvement in the deer herd reduction allows the Mohawk people an opportunity to reconnect with a place of spiritual and traditional importance to them. As well, it offers opportunities for youth in the community to learn harvesting techniques that have been

St. Lawrence Islands National Park, Canada: Members of the Mohawk community of Akwesasne assisting with deer herd reduction © Parks Canada passed down from generation to generation (Parks Canada, 2008a). See also Case Studies 5 and 10.

b. **Include stakeholders in action-oriented research (e.g., citizen science) to assist in creating collective understanding of the system and related issues.**
In China, the Guangdong Forestry Institute ran a stakeholder workshop on lessons learned from forest rehabilitation, identifying key challenges, main lessons and outputs required from different stakeholders (Chokkalingam et al., 2006).

c. **Share experiences and lessons learned.**
The Society for Ecological Restoration's *Global Restoration Network* (GRN) provides a diverse range of information on ecological restoration including in-depth case studies and proven restoration methods and techniques. The overriding mission of the GRN is to link research, projects, and practitioners in order to foster an innovative exchange of experience, vision, and expertise[15].

Best Practice 3.2.2. Restoration that is empowering through the acquisition of transferable knowledge and skills

When people gain skills and knowledge through engagement with protected area restoration, they are empowered to facilitate and deliver local insight to similar processes elsewhere.

Protected area in Victoria, Australia: Planting to stabilize steep slopes in a coastal reserve © Nigel Dudley

a. **Build local capacity of stakeholders, protected area managers and staff to support the expansion and improvement of restoration. Maintain such expertise and make it available in the future.**
The reintroduction of the Asian Black Bear into Jirisan National Park, South Korea, has also sought to build public awareness of the impacts of poaching and has designated local people as 'honorary rangers' to help remove illegal snares. More than 270 illegal snares have been removed to date. See Case Studies 2 and 4 in which training in business skills and restoration is empowering the rural poor in South Africa.

Guideline 3.3: Communicate effectively to support the overall ecological restoration process

Best Practice 3.3.1: Restoration that includes communication at all stages of the process

Communicating before, during, and after implementation is important for building understanding and support for restoration goals, particularly when restoration strategies such as such as herbicide use, culling of live animals, or closure of areas to visitation may be perceived negatively by the public or other stakeholders.

a. **Decide what type and level of communication is needed before starting any restoration. This might range from a temporary sign explaining why an activity (like weed cutting) is taking place to a set of leaflets, signs and displays explaining a major restoration project.**
Temporary explanatory signs about spraying invasive weeds in the Cornwall and West Devon Mining Landscape World Heritage Site, UK, both explain why vegetation appears to be dead and warn hikers to beware of potential contamination[16]. See Phase 1.3.

b. **Implement a communication and outreach strategy in all ecological restoration projects including where possible opportunities to learn through meaningful visitor experience.**
The development of educational and communication materials were a particularly important part of the design of the Lintulahdet Life Project in Finland. See Case Study 1 and Phase 6.2.

c. **Identify the purpose of each communication mechanism as well as the target audience and frequency of communication.**
Developing the public's understanding of ecological processes has been a vital communication tool in Bayerischer Wald National Park in Germany. A boardwalk, called the Seelensteig ('Path of the Soul') enables local people and tourists to learn about the natural processes in forest regeneration. See Box 12.

d. **Address the underlying and immediate causes and effects of degradation and the anticipated benefits of restoration in communication and learning, and experience opportunities accompanying restoration. Anticipate the potential and real public perceptions, concerns and issues and address these.**

15 http://www.globalrestorationnetwork.org/

16 http://www.telegraph.co.uk/earth/earthnews/5362289/Japanese-knot-weed-purge-by-National-Trust.html

Cornwall and West Devon Mining Landscape World Heritage Site, UK: Explanatory sign about spraying invasive weeds on coastal footpaths © Sue Stolton

U Minh Thuong National Park is a freshwater wetland in the Mekong Delta of southern Viet Nam. Drainage canals in the area caused the site to become more fire prone in the dry season so park managers blocked these. This prevented wildfires but also caused the seasonal floods to last longer resulting in widespread tree deaths. Attempts are now being made to re-establish the original hydrological regime and early findings are that tree regeneration is improving (D. Lamb pers. comm., 2012).

e. **Report successes and failures, and any changes made to the initial restoration plan, including why these changes have been made.**
The Channel Islands National Park in California produced a five-year progress report that covered both successes and failures of the marine protected area (Airamé & Ugoretz, 2008). **See Phase 7.3**.

f. **Consider values, behaviours and likely reactions within a local social context while developing social marketing and communication strategies.**
See Phase 1.3.

g. **Communicate regularly, informally and inclusively with stakeholders, even if intermediate results are not final or 'ground-breaking'. Prepare scientific research results to be available without delay and in easy to understand terms.**
The project to restore area of Atlantic Forest in Brazil has emphasized research and rapid dissemination of findings for others to replicate their successes and avoid failures. **See Case Study 7** and **Phases 6.2 and 7.4**.

h. **Highlight the contribution of the various partners, stakeholders, and local communities in the actions undertaken to support the success of the project.**
Web stories on the Nature Conservancy's Oyster Reef Restoration in Canaveral National Seashore, USA (**see Case Study 12**) acknowledge the project's many partners[17] and emphasizes the public involvement in the project.

Best Practice 3.3.2: Restoration that uses multiple communication approaches to ensure inclusivity

Communication and learning are more effective when efforts are made to reach diverse audiences through a variety of tools and approaches.

a **Design a wide variety of communication and learning options (e.g., local meetings, guided tours, lectures, exhibitions, use of a range of media); presented in a range of facilities (e.g., information points, educational trails) and targeting diverse audiences (e.g., locals, tourists, children).**
The restoration project in Guaraqueçaba Environmental Protection Area in Brazil developed environmental education programmes designed for a range of audiences (e.g., employees and families, school children, community groups) to increase the appreciation and understanding of nature and the value of conservation. **See also Case Studies 1, 4 and 7**.

17 http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/florida/explore/floridas-oyster-reef-restoration-program.xml

Bayerischer Wald National Park, Germany: The "Path of the Soul" boardwalk has been a successful way for visitors to learn about natural forest regeneration. © Maria Hußlein/Bavarian Forest NP

Guideline 3.4: Provide rich experiential opportunities that encourage a sense of connection and stewardship of protected areas

Best Practice 3.4.1: Restoration that facilitates place-based and experiential learning for protected area visitors

Ecological restoration activities can wherever possible create opportunities for visitor experiences and other learning opportunities that connect people more deeply to protected areas, either through direct participation in restoration or in the chance to understand more about a restored ecosystem. Potential adverse impacts of restoration projects on visitor experience also need to be considered.

a. **Provide visitors, stakeholders and partners with opportunities to engage directly with restoration initiatives in a manner that enables them to learn about basic restoration concepts and the rationale behind the restoration project. Ensure their experience is positive, hopeful and creates a deeper and more meaningful connection with nature, leading to broader societal support and engagement for protected areas.**
In Canada, Waterton Lakes National Park's non-native plant management programme aims to eradicate, control and prevent seed production by non-native plants that threaten park vegetation communities and the economic interests of park neighbours. Visitors and local communities are engaged in the removal of non-native plants on the Blakiston Fan (Parks Canada, 2012b). Support from partner agencies, organizations and corporations, coupled with community involvement, are integral to the successful restoration of oyster reefs in Canaveral National Sea Shore, USA. **See Case Study 12**.

b. **Include monitoring of visitor experience and learning outcomes in monitoring of the ecological restoration project.**
At the Prisoners Harbor wetland-riparian restoration site on Santa Cruz Island, Channel Islands National Park (California, USA), visitors arriving by boat from the mainland encounter an interpretive display for the project as they step onto the island. The display describes the causes of site degradation, the goals of the restoration, the planned sequence of restoration activities, and the expected benefits. (J. Wagner, pers. comm., 2012). **See Phase 5**.

Best Practice 3.4.2: Restoration that facilitates memorable visitor experience

Restoration projects can enhance people's enjoyment and use of the outdoors by improving natural, aesthetic, recreational and other values of protected areas. Participation of visitors in restoration efforts can itself lead to meaningful, memorable experiences of the protected area. Research suggests that restoration volunteers experience high levels of satisfaction in what is often their first experience of ecological management (Miles et al., 1998).

a. **Promote responsible volunteer, exploration and learning activities in restoration projects, through, for example, emphasizing cultural issues (e.g., social rituals and performance, recreation and spiritual renewal).**
The Lintulahdet Life wetland restoration project in Finland used volunteers to undertake restoration activities as part of volunteer camps led by WWF. **See Case Study 1**.

b. **Consider potential positive and negative impacts of restoration projects on visitor experience during project planning.**
In Khao Yai National Park in central Thailand, restoration has reached the stage where tourists pay for the privilege of planting a seedling or sowing a seed (D. Lamb, pers. comm., 2012). In restoring Gatineau Park's Pink Lake, the goal of Canada's National Capital Commission was to enlist the public's respect and support by permitting controlled access to the lake's surroundings, while offering an interesting and educational interpretation experience (Parks Canada, 2011c).

c. **Consider how the personal efforts of visitors and other volunteers can inspire and engage people while enhancing the efficiency and effectiveness or restoration.**
At Badrinath shrine in the Indian Himalayas, pilgrims are expected to carry up and plant a tree to restore a sacred forest (Bernbaum, 2010). **See also Case Study 12**.

d. **If planning measures to limit access to ecologically sensitive areas as part of a restoration project, direct visitors in a way that also enhances their enjoyment of the restoration site.**
The Finnish Lintulahdet Life Project design incorporated measures to minimize the impacts of visitors on sensitive ecological areas whilst enhancing visitor experience

through improved nature viewing (e.g., bird towers, viewing platforms, interpretive nature trails and other visitor education materials). **See Case Study 1**.

Best Practice 3.4.3: Restoration that inspires action within and beyond protected areas

Recognizing benefits from restoration in protected areas can mobilize people to become better stewards of their protected areas and to engage in ecological restoration elsewhere.

a. **Use protected areas that have run successful restoration programmes to act as reference sites for learning about and inspiring action towards restoration in the broader landscape and seascape.** In Finnish conservation areas, successful forest and peatland restoration sites are frequently used for educating the practitioners working with restoration outside protected areas as well as students and other people visiting the parks. Similarly, less successful restoration sites are often visited by practitioners and students with a view of learning from earlier mistakes[18].The restoration of the oyster reefs in Canaveral National Seashore in the USA have been informing other estuarine restoration projects. In North Carolina the mat methodology is being adapted to address sea level rise and erosion issues and the methodology is being used to demonstrate natural alternatives to hard shoreline stabilization to neighbouring property owners. **See Case Study 12**.

Canaveral National Seashore, USA: Volunteers measure the height of oyster growth on a natural reef. This serves as a reference for determining success of restored reefs. (Case study 12) © Anne P. Birch, The Nature Conservancy

Canaveral National Seashore, USA: Conservation agencies and volunteers collaborate in making and deploying oyster mats to restore an intertidal oyster reef. (Case study 12) © Anne P. Birch, The Nature Conservancy

18 http://www.metsa.fi/sivustot/metsa/en/Projects/LifeNatureProjects/BorealPeatlandLife/communication/Sivut/Communication.aspx

Waterton Lakes National Park, Canada: A volunteer helps control the invasive spotted knapweed *Centaurea stoebe.* © Parks Canada

Box 12

A CLOSER LOOK Recovering natural forest through assisted natural regeneration in Bayerischer Wald National Park, Germany

A non-intervention policy challenged traditional approaches to forest restoration in Germany (Bayerischer Wald National Park, 2010) and highlights the importance of good communication of restoration initiatives.

In the early 1980s, after two storms left more than 170 ha of the Bayerischer Wald National Park's forest uprooted, the head of the Bavarian Ministry for Agriculture and Forestry decided not to clear the damaged trees but to allow the forest to recover naturally (Bavarian Forest National Park, 2012) and leave the 50,000 m^3 or so of timber untouched (Kiener, 1997). In the years immediately following the storms, the weakened trees on the edge of the windfall areas attracted large populations of bark beetle. As the bark beetle population grew, the Park administration again decided not to intervene and let 'nature take its course' within the park boundary (although buffer areas prevented the spread of bark beetle outside the Park). Eventually the bark beetle populations declined but not before causing destruction of more than 6,000 ha of old spruce forest.

This non-intervention policy led to problems with local communities who wanted the Park administration to remove the dead wood and prevent the spread of the bark beetle. Local resistance was based largely on concerns about the economic impact of allowing valuable timber to rot, as well as objections to the aesthetics of an untended forest (von Ruschkowski & Mayer, 2011). To improve the public's understanding of ecological processes and natural regeneration, the Park used a wide variety of educational and public relations tools, such as brochures, interpretive exhibitions, press releases and community and school programmes. Hans Kiener, head of the Park's Department of Conservation, notes that one of the most important and successful ways to convey 'the idea of non-intervention to the people and their hearts' has been the construction of a 1.3km boardwalk, called the ***Seelensteig*** ('Path of the Soul'). This enables people to visit a windfall area and learn about natural forest regeneration. Wooden panels with poems are placed along the boardwalk as a way to affect the emotions as well as the minds of visitors. Visitors can see that in place of the former spruce forest that had been managed largely as a monoculture for centuries, within a relatively short time the forest has regenerated with a greater diversity of species and variation in structure (H. Kiener, pers. comm., 2011).

Bayerischer Wald National Park, Germany: Guided tours give visitors the opportunity to experience and learn about wilderness. © Maria Hußlein/Bayerischer Wald NP

Chapter 5
Restoration Processes for Protected Areas

This chapter describes a recommended seven-phase process for undertaking ecological restoration in protected areas. The phases are not strictly sequential, and some elements—such as addressing adaptive management—need to be present throughout the project. The process is put into context by a series of diagrams and more conceptual boxes that provide supplementary details.

Chapter 5: Restoration Processes for Protected Areas

The principles, guidelines and best practices provide an overview of appropriate approaches and methods for protected area managers and their partners to use in implementing ecological restoration projects and programmes. This chapter summarizes how those approaches and methods can be brought together in a planning and implementation framework that will improve chances of success, and outlines seven phases that can help restoration managers to plan, implement and monitor successful projects.

Ecological restoration, like any management action, is best carried out within the context of the overall management of the protected area, the protected area network, and the surrounding landscape or seascape. A number of factors can influence decisions such as whether restoration is an appropriate intervention; whether it is a high or low priority (see Box 13); who needs to be involved; and what appropriate goals might be. An evaluation of information such as management objectives for the site and relevant local or national policies and legislation is an obvious starting point. A review of any regional and international conservation strategies, goals, programmes and policies can help define or impact the project. For example, national, regional or global action plans associated with invasive species or climate change adaptation and mitigation may influence restoration goals.

Key natural and associated values of a protected area are generally listed in planning documents (ideally management plans) or information from the time of designation or establishment. The values listed will tend to be the management *priorities* rather than all natural values; but in many cases restoring for a specific management priority such as an endangered species will in itself require wider ecological restoration. Many protected areas also have cultural heritage values such as sacred natural sites or historical remains which need to be respected. In some cases, natural and cultural values of the protected area may be intertwined and can benefit simultaneously from restoration.

Regardless of the management priorities of the protected area, evaluation of preliminary information about the site or nearby sites can determine whether restoration is feasible and appropriate including, for example, results of similar restoration efforts elsewhere, the attitudes of local communities, the degree of interest and support of potential partners, and resources for restoration.

Planning and implementing an ecological restoration project is an iterative process. The framework presented here puts considerable emphasis on the planning and design elements of developing effective, efficient and engaging ecological restoration. This emphasis is particularly important for projects in protected areas where restoration has not been previously carried out or where previous restoration has not

Box 13

A CLOSER LOOK Prioritizing conservation actions in Victoria, Australia's protected areas

An example of an existing prioritization approach is the *Levels of Protection Framework* used by Australia's Parks Victoria (Parks Victoria, undated). It conducts protected area planning and management in a bioregional context with the value, and hence priority, of biodiversity attributes assessed on the basis of:

a. conserving the range of ecosystems and existing biotic diversity;
b. the occurrence of attributes that depend on a particular park for their security;
c. conserving ecosystem structure and function through addressing high risk threats; and
d. higher ecological viability and integrity of populations.

The assessment criteria use available network-wide data for biodiversity measures including:

a. representation and status of rare or depleted attributes at ecological vegetation class and species levels;
b. diversity at the ecological vegetation class and species levels;
c. likelihood of sustaining natural processes derived from measures of internal fragmentation and exposure to non-native vegetation;
d. level of susceptibility to single and multiple threats; and
e. extent of threat (efficiency and likelihood of successful threat management).

been successful. Above all, however, this chapter stresses that adaptive management is a vital component of ecological restoration.

Although discussed here as a linear list of actions, Figure 4 suggests the far more flexible and adaptive process that projects will inevitably need to take to be successful. This iterative approach (literally a process of repeating steps to achieve a desired goal) will be needed to respond to new research, monitoring data, or other new information. As noted above, phases outlined in Table 2 place a strong emphasis on detailed and participatory assessment and planning before a restoration project is considered, but even these phases are not static, but rather a set of processes. As Figure 4 illustrates, projects need to be constantly monitoring, evaluating, adjusting and communicating activities, which may well require managers to review objectives and restoration approaches several times during the project's duration.

The framework phases serve as a reminder of the need for a logical, transparent process. It has many similarities to other frameworks commonly used in conservation and development projects, such as ecological risk assessments, demonstrating how restoration might be incorporated into environmental quality programmes or broad scale NGO sustainable development projects.

Table 2 outlines these phases in greater detail and the remainder of the chapter provides additional discussion, advice and information sources for their implementation. This process represents an ideal and needs to be applied with common sense. Not every tiny restoration initiative within a nature reserve needs a full stakeholder consultation process or an environmental impact assessment, for instance, and this would also risk stakeholder fatigue. But it is suggested that every restoration project needs to consider all the steps outlined and that most will benefit from implementing all of them to some degree.

Although these phases are presented in a list, as Figure 4 suggests, many take place simultaneously; for instance stakeholder engagement and adaptive management both infuse the whole process of restoration rather than existing as distinct and separate steps.

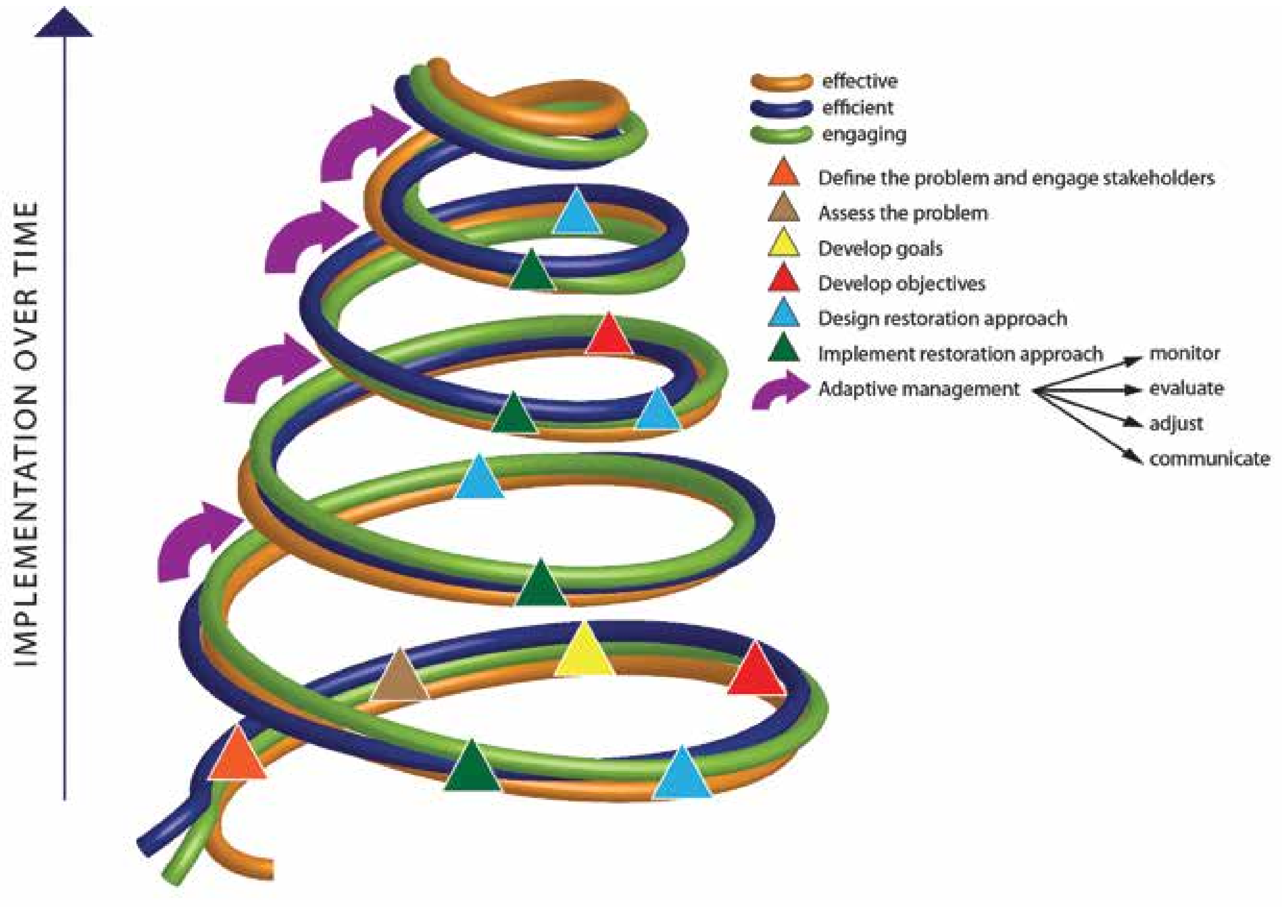


Figure 4: Conceptual illustration of the implementation of effective, efficient, engaging ecological restoration as an adaptive process. The seven key phases in any ecological restoration project (see Table 2) are sequenced along the first loop of the spiral and represent the first full adaptive management cycle. The three core principles of restoration are tied together to show the importance of an integrated approach. Subsequent loops illustrate the regular review of design and implementation phases through monitoring and evaluation, with adjustment as necessary, and communication of findings (i.e., adaptive management) to ensure original goals are met. In time, the loops in the helix become smaller to represent a decreasing level of intensity of the effort required to achieve or sustain a restored ecosystem.

Table 2: Ecological restoration planning and implementation framework

	Phase 1: Define the problem and engage stakeholders
Phase 1.1:	Define the restoration problem that needs to be addressed including likely costs
Phase 1.2:	Ensure initial stakeholder engagement
Phase 1.3:	Develop a communication strategy
	Phase 2: Assess the problem
Phase 2.1:	Assess condition
Phase 2.2:	Identify reference ecosystem(s) and departure of current conditions from desired conditions
Phase 2.3:	Carry out an environmental and social impact assessment if necessary
Phase 2.4:	Ensure an information management system is in place
	Phase 3: Develop Ecological Restoration Goals
Phase 3.1:	Develop restoration goals and outcomes
	Phase 4: Develop Ecological Restoration Objectives
Phase 4.1:	Identify measurable objectives and consider preliminary monitoring design
	Phase 5: Design Ecological Restoration Approach
Phase 5.1:	Define scope, consider a range of options and select the most suitable
Phase 5.2:	Develop an implementation plan
Phase 5.3:	Develop monitoring plans, including criteria and indicators for process and outcomes
	Phase 6: Implement Ecological Restoration Approach
Phase 6.1:	Carry out restoration
Phase 6.2:	Communicate progress as per the communication strategy (see Phase 1.3)
	Phase 7: Implement Adaptive Management
Phase 7.1:	Use appropriate adaptive management tools approach (active or passive)
Phase 7.2:	Monitor and evaluate results of restoration
Phase 7.3:	Adjust, as necessary, Phases 5 and 6, and occasionally Phase 4 based on evaluation results
Phase 7.4:	Communicate results and continue, as appropriate, with stakeholder engagement (see Phases 1.2, 1.3 and 6.2)

Phase 1: Define the problem and engage stakeholders

Action	Process and guidelines
1. Define the restoration problem that needs to be addressed	See Phase 1.1 and Guidelines 1.1 and 1.2
2. Identify stakeholders to engage, inform and consult etc.	See Phase 1.2 for further advice and Guidelines 3.1 and 3.2
3. Develop a communication strategy	See Phase 1.3 and Guidelines 1.5, 2.4 and 3.3

Phase 1.1: Define the restoration challenge, including likely costs, and find out if there are examples of similar restoration projects that have been successful and can provide advice.

Building on the information available, a problem statement (see Box 14) should be developed in collaboration with relevant partners and stakeholders as the starting point for identifying why restoration is an appropriate and effective response to an issue. If possible, read about or talk to participants in other restoration projects that have tackled similar issues and find out what did and did not work, and how much the restoration cost. Where routine monitoring is in place, a restoration problem may be identified when a particular measure of the natural or other identified value of the system falls below a pre-determined threshold. In other cases, anecdotal information may clearly indicate that protected area values are, or are becoming, degraded and that restoration would help to reverse this. Regardless of the information base available, the problem statement considers:

1. **The problem**: a description of the problem (e.g., decline in target wildlife, emergence of invasive species, loss of key habitat, loss of cultural landscape), including where possible quantitative data on the scale of the problem, timescale and rate of change.
2. **The causes**: where known, a description of the immediate and any underlying causes of the problem (e.g., immediate cause of wildlife decline might be illegal poaching, underlying causes might be poverty, lack of support for the protected area management or a thriving bushmeat trade). These, in turn, help identify a preliminary list of potential remedies.
3. **Why restoration**: a justification of why restoration is appropriate and likely to be successful. This provides evidence that the restored habitat or species will not succumb to the pressures that caused the original problems. There is, for instance, little point in spending resources to increase wildlife numbers if poaching remains unchecked.

The problem statement is an important component of adaptive management, as discussed in later steps. If defined precisely enough, the problem statement will also help to define the necessary responses and the monitoring requirements needed to assess progress.

Box 14

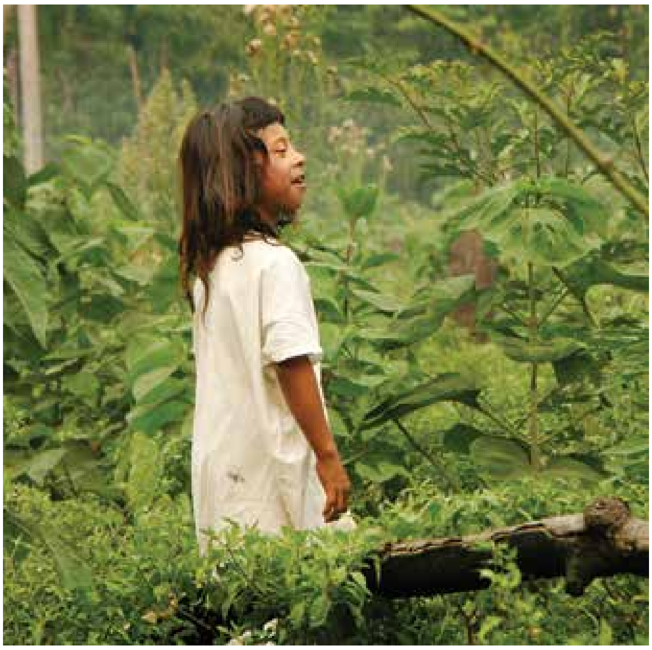
A CLOSER LOOK
Example problem statement

A problem statement for the Diawling National Park (see Case Study 6) could be defined as follows:

The problem: The lower Senegal River Delta's rich floodplain, mangroves and dune systems, which were once an internationally important site for wintering and breeding water birds, had become a 'saline desert', with devastating impacts on biodiversity as well as on the livelihoods of local communities.

The cause: Years of drought and dam construction, designed to provide water for agriculture and hydropower, had effectively eliminated annual flooding to the lower Delta.

Why restoration: Restoration of ecosystem function to the wider lower Delta through the reintroduction of flooding would help natural values of the delta recover and support development of community livelihoods.



Lacandon forest, Mexico: Portada, son of Vicente Paniagua, a traditional farmerwho has participated in the restoration project of the Lacandon forest. (Case study 5) © Maria Luisa Montes de Oca

Box 15

A CLOSER LOOK Identifying and working with key stakeholders and partners

Communication about the project's aims and impacts to a wider audiences and the participation of partners and stakeholders in all phases of the process has a crucial role in contributing to success of a project (e.g., Getzner et al., 2010).

In the early phases (e.g., Phases 1 and 2) of a restoration project it is essential to share an idea for restoration of the area, which is usually developed within a limited group of people, with all relevant stakeholders. In this phase efforts should be made to identify the key stakeholders for the project and to develop a joint vision for the area to be restored. Stakeholders to be included are all those individuals and organizations who use and value the area concerned and who are likely to be affected by the restoration initiative. At this stage it is important to note their relationships with the area, their roles and responsibilities and the current impact(s) of their activities on the area. Several interest groups could be identified in this process: primary stakeholders are those who are directly affected (might benefit or suffer losses) in the restoration project and those whose permission, approval or (financial) support is required and with whom more formal partnerships may be developed (indigenous groups, land-owners, farmers, governmental agencies etc.); secondary stakeholders include those who are indirectly affected (e.g., residents) and tertiary and other stakeholders include those who are not directly concerned but have influence or political power (politicians, opinion leaders etc.) and those with specific interest (such as visitors, NGOs, scientists, and the general public) (Alexander, 2008).

In mid phases (e.g., Phases 3 and 4) communication and participation involve efforts to understand potential resistance against the restoration project. Key players are invited to participate in the planning process which contributes to better acceptance of ecological restoration in the area.

Communication with and involvement of stakeholders in the design (Phase 5), implementation (Phase 6) and management (Phase 7) of the restoration project are focused on participation in management activities, with different types of technical information being communicated to stakeholders, formal partners, decision-makers, visitors, and the public.

Phase 1.2: Ensure initial collaboration with partners and stakeholder engagement

The identification and engagement of relevant stakeholders and partners (e.g., local communities and indigenous peoples, government agencies, universities, researchers, landowners, businesses and corporations, conservation groups, tourism bodies, recreation specialists, local experts, visitors, and the general public) is critical to successful restoration. The third principle of ecological restoration and associated best practices provide guidance on engaging partners and stakeholders in restoration projects. Meaningful engagement may range from simply informing partners, local communities, and/or those with commercial, livelihood, or recreational interests in the restoration project to involving or consulting with them, through to seeking consent and developing truly collaborative relationships that are essential for project success. Here the social complexity of the project escalates and a more extensive social learning and adaptive management approach may be applied (e.g., see Box 16).

Early engagement is generally the best practice for successful ecological restoration projects, not only in conducting project planning but also in building an understanding and appreciation of the role of restoration in broader conservation goals. Engagement starts with involvement in the development of the problem statement (Phase 1.1) and may also involve development and implementation of communication strategies (Phase 1.3). It is important to identify the full range of partners and stakeholders who should be engaged, while recognizing that the degree of engagement will vary. Particular attention is needed for those with knowledge of local ecosystems and the reasons for degradation, and also for disenfranchised resource users (e.g., women and the elderly), the displaced and the powerless (Ramsar Convention on Wetlands, 2003; Colfer et al., 1999).

Stakeholders and partners are engaged in helping to define and affirm the natural and cultural values of the ecosystem within the context of the protected area. In particular, projects need to ensure the free and prior informed consent from owners and stewards of land and water proposed for restoration. Engagement in later stages of the project involves sharing information about the ecosystem (Phase 2), setting project goals (Phase 3), defining objectives (Phase 4), gaining permission for the proposed work, and contributing skills, knowledge, financial, and human resources to the development, implementation, and monitoring of the project (Phases 5 through 7).

An important starting place in stakeholder engagement is to ensure that there is information and knowledge of the social and cultural contexts where restoration takes place. This includes history, conflicts and resolutions, organizational networks, stakeholder relationships, institutional priorities and what has (and has not) worked in the past for conservation and restoration.

Projects need to consider a broad range of tools to engage partners and tailor these to the experience of the stakeholders and complexity of issues (e.g., workshops, village meetings, open houses, visitor-focused events, modelling and

Box 16

RESTORATION CONCEPT Food for thought – blending the adaptive management approach and social learning

As is discussed by Reed et al. (2010), the concept of social learning is an evolving one in which effective social learning processes can be seen as those that: (a) demonstrate that a change in understanding has taken place in the individuals involved; (b) demonstrate that this change goes beyond the individual and becomes situated within wider social units or communities of practice; and (c) occur through social interactions and processes between actors within a social network. Some protected area managers may wish to explore the concept further through consideration of the ideas below.

1. **Co-initiating and defining the scope and context**: *Build common intent; stop and listen to others and to their needs and challenges*
   During the co-initiating phase the main objective is to create a working group which is committed to pulling the project together. This group must represent all the voices and key people who can create change. It is of great importance to build trust and a sense of ownership and create an understanding of what their needs are. During this phase the scope (see Phase 5.1) and context of the restoration project can be better defined to not only reach the objectives of the protected area, but also those of the stakeholders living in and around the area. This process can also catalyse extra resources and funding for the restoration efforts outside the protected area.

   The following activities may be part of this process: *individual meetings with key people, individual stakeholder interviews, collecting and analyzing existing data and consulting of experts, inception meeting, establishment of a working group (by signing a letter of intent).*

2. **Co-sensing (observe, observe, observe):** *Collect data and insights from all perspectives and 'unpack' current realities*
   It is of great importance during this phase that learning is carried out in a collective and participatory manner. It is about creating collective awareness and understanding between all stakeholders (everybody has to walk in each other's shoes) around the challenges and constraints of degraded areas, the opportunities and benefits of restoration and their role and responsibility. It is important in this phase that there is an emphasis on creating an awareness and understanding with all stakeholders that they are part of the problem and can be part of the solution. This process is about creating empathy and compassion for each other.

   The following activities may be part of this process: *workgroup meetings, stakeholder workshops, stakeholder learning journeys, applied research, volunteer opportunities, newsletters, popular articles*.

3. **'Presencing' and planning:** *Stop, reflect and remind one another why this matters*
   During this phase there will be an opportunity to reflect on what has been learned and to look at the changes in stakeholder perceptions and objectives. The collective awareness and understanding created during the previous phase will enable a collective intelligence to create a strategy and plan to move the project into implementation. This will result in a better ownership of the project with stakeholders.

   The following activities may be part of this process: *information booklet and maps distributed, stakeholder group meetings, strategy document developed.*

4. **Co-creating, implementing and analysing:** *Prototyping to explore the future by doing*
   In this phase the working group can commit itself to the innovations and actions identified in the previous phase. Their commitment creates an environment conducive to attracting more people, opportunities and resources that enable the action and interventions to happen.

5. **Co-evolving and sharing and learning**
   The focus during this phase is to create or strengthen infrastructures for the integration of learning, actions and project design.

The following activities may be part of this process: *participatory monitoring, dialogue platform, learning networks* (Adapted from Scharmer, 2009).

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scenario workshops, temporary programme office, advisory committees, use of local or regional planning processes, study exchanges). The cultural environment of a country will determine the appropriateness of engagement tools (e.g., Borrini-Feyerabend, 1996; Jackson & Ingles, 1998).

Relationships can be delicate and sensitive and some skill in facilitation and negotiation may be needed. Transparent and interactive conflict resolution processes should be established among the parties involved in the restoration process. For example, agreement should be reached at the start of the project on a conflict resolution processes and either a person should be nominated who will mediate a way through any conflict or there should be an agreement on the way in which a mediator would be selected (Australian Heritage Commission, 2003).

Finally, effective engagement needs to be efficient as the resources of the project and the stakeholders themselves can easily be over-stretched if engagement processes are not well planned and executed. A key step is therefore the communication plan (see Phase 1.3). Stakeholder fatigue through unplanned or over-ambitious engagement programmes can risk losing interest and engagement on really important issues in the future.

Phase 1.3: Develop a communication strategy

Communication involves giving practical management information (e.g., asking the public to keep off certain restoration areas), explaining what is happening and deeper forms of communication to develop shared objectives and strategies. Communication efforts typically focus in particular on local communities and stakeholders, visitors, and also the protected area's employees, who have contact with the public.

Early and strategic discussion about sensitive issues such as the reduction of hyperabundant populations of species can be particularly important in gaining public support for subsequent actions. Ecological restoration interventions can be supported by active communication and outreach programmes (**see Guideline 3.3** and associated best practices) focused on the initial causes and pressures leading to the degradation, the effects of degradation, and the benefits of restoration (Ramsar, 2003; Nellemann & Corcoran, 2010).

Communication strategies identify type of information to be shared, how often and with whom, including the various purposes of communication (e.g., engaging the public, visitors, and neighbours, information sharing, routine reporting); communication methods (e.g., the media, interpretative signs, community-based special events, web sites and publications, refereed literature, and presentations at conferences and meetings); the target audiences and the frequency of communication (Hesselink et al., 2007).

Box 17

A CLOSER LOOK Restoring mixed-grass prairie in Grasslands National Park, Canada[19]

Ecological restoration has enabled the vision for Grasslands National Park, Canada to be fulfilled, as visitors now pause to watch bison (*B. bison*) interact with prairie dogs and pronghorns (*Antilocapra americana*) (Parks Canada, 2011d). The park is one of the finest intact mixed-grass prairies in Canada, and evolved with natural disturbances from fire and grazing, especially by bison. While bison have been absent for over 100 years, cattle largely replaced the bison's ecological role until the 1980s when grazing was excluded from the park. In 2002, a management plan developed with extensive community and stakeholder engagement identified restoration as a priority, focused on grazing, fire and plant succession (Parks Canada, 2002).

To restore ecosystem function, the park decided to re-introduce bison. Early on, stakeholders were consulted on issues such as fencing, bison health, release location, the grazing tendering process and grazing location. A Park Advisory Committee provided a formal structure to engage stakeholders and experiments tested the effects of different levels of grazing intensity on native vegetation and wildlife.

In 2006, the Park reintroduced bison to 18,100 ha during a ceremony including neighbours, local communities and Aboriginal partners. Cattle were brought in elsewhere for grazing, with a fence erected to allow animals such as deer, pronghorns and cougars (*Puma concolor*) to pass, while restricting the movements of bison, cattle and horses. Prescribed fire has been reintroduced to influence grazer distribution, reduce invasive species and promote native species. Previously cultivated fields have been re-vegetated with native grasses and wildflowers.

'I see the buffalo coming back as a seed that's going to grow and is going to create better understanding amongst our societies, our communities'. Lyndon Tootoosis, Poundmaker First Nation. [20]

19 This box is adapted from Parks Canada Restoration Case Studies: Grasslands Ecosystem Restoration (Grasslands National Park): http:// www.pc.gc.ca/eng/progs/np-pn/re-er/ec-cs/ec-cs01.aspx

20 Ecological Restoration in Canada video, Parks Canada http://www.pc.gc.ca/eng/progs/np-pn/re-er/index/video.aspx

Phase 2: Assess the problem

Action	Process and guidelines
1. Assess the status and condition of the species or habitat etc. that is the focus of the restoration discussion	See Phase 2.1 for advice on assessment, which should include projected climate trends and impacts, as well as critical social, cultural, economic and political information
2. Identify a reference ecosystem	See Phase 2.2 for advice
3. Carry out social and environmental impacts assessments as necessary	See Phases 2.3 and 1.5
4. Develop data management systems	See Phase 2.4 to ensure the restoration project information is archived

To develop clear goals, objectives and action for ecological restoration it is first necessary to carry out a more detailed assessment of the problem; by reviewing site conditions, developing an understanding of what the site condition could or should ideally be, and assessing the potential environmental and social impacts of restoration. Phase 2 includes a series of steps to help develop this understanding:

Phase 2.1: Assess condition

Once the problem statement (Phase 1.1) has been developed, but before detailed planning can proceed, preliminary information about the state of the ecosystem is collected to assess its condition (e.g., Table 3). The condition of the system (i.e., its degree of degradation) can serve as a useful guide to selecting restoration actions as is shown in Figure 2 of Chapter 2. Additional information may include current values of the site, projected climate trends and impacts and relevant social, cultural, economic and political data, e.g., traditional ecological knowledge (see Box 18 and **Case Study 5**); relationships between local communities and the protected area; visitor trends; predicted demographic changes; economic importance of the site; political support and related governance issues). Analysis should include potential negative impacts of restoration, particularly on biodiversity (**see Guideline 1.1** and associated best practices in Chapter 4). Ideally, there should be enough information to understand the extent to which pressures are changing the ecosystem; that is to determine the degree to which natural values or other important values of the system differ from those of a suitable reference ecosystem (see Phase 2.2).

In some cases, existing monitoring and assessment frameworks may have been in place for a long enough time to detect damage to ecosystem structure and function or to other natural or cultural values of the protected area. In other protected areas, little will be known and managers and other stakeholders may have to start by identifying what is most important.

Many protected areas will already have enough information to at least start this process. For example Table 3 identifies ecological integrity indicators (modified from Parks Canada and the Canadian Parks Council, 2008) which represent what might be considered an *ideal* information base. In practice many protected areas will have to make decisions based on far less data than are shown here. Additional information about the protected area ecosystem and its regional and landscape and/or seascape context may be drawn from a variety of sources including data from similar ecosystems (see Box 19 on reference ecosystems).

Information ideally needs to be evaluated for both the protected area and the surrounding landscape and/or seascape. The latter can help identify off-site influences, which in some cases may need to be reduced or eliminated before restoration can be successful. It may also clarify priorities for establishing partnerships and/or outreach programmes.

Phase 2.2: Identify reference ecosystem(s)

A key step in assessing and defining the problem, particularly in heavily degraded or altered ecosystems, is finding and agreeing on a reference ecosystem (see Box 19) to act as a

Box 18

RESTORATION CONCEPT
Traditional ecological knowledge (TEK)

For TEK (see Box 2) to survive in protected areas there needs to be support and acknowledgement for the continuation of the social, cultural, economic and political contexts within which such knowledge thrives.

Imaginative protected area management approaches draw on TEK, with the approval of the knowledge holders and, where appropriate, with suitable reparation for the information received. TEK can benefit management in multiple ways, including in understanding: the biological and cultural values of the site; likely extreme weather events and their effects; potential ecosystem benefits and useful genetic materials; and, critically, traditional cultural practices that can help to maintain a healthy ecosystem. In terms of restoration, this can include knowledge about effective restoration approaches, seed sources, remnant animal populations and viable policy frameworks for effective restoration. TEK is neither perfect not universal: in particular communities that have been recently displaced or undermined may have either lost much of their TEK or not yet had time to develop it completely in new conditions.

Table 3: Indicators for assessing ecological integrity in protected areas

Assessing Ecological Integrity		
Biodiversity	**Ecosystem Functions**	**Stressors**
Species richness • change in species richness • numbers and extent of exotics	Succession/retrogression • disturbance frequencies and size (fire, insects, flooding) • vegetation age class distributions	Human land-use patterns • land use maps, road densities, population densities • poaching incidence, number of traps/ poachers recorded • presence of invasive species
Population dynamics • mortality/natality rates of indicator species • immigration/emigration of indicator species • population viability of indicator species • population density of individuals or species	Productivity • remote or by site • biomass • growth rates	Habitat fragmentation • patch size, inter-patch distance, forest interior • evidence of incursions etc. • pressures surrounding the protected area
Trophic structure • faunal size class distribution • predation levels • plant/animal relationships (e.g., pollination, propagules dispersal)	Decomposition • decomposition rates by site	Pollutants • sewage, petrochemicals, etc. • long-range transport of toxics
	Nutrient retention • calcium, nitrogen by site	Climate • weather data and trends • frequency of extreme events
		Other • park tourism pressure • hydrologic and sediment processes

comparison and 'ideal' against which to restore (White & Walker, 1997; Egan & Howell, 2001). These will often be undisturbed sites in similar ecosystems, descriptions of such sites, or documentation describing the target state of the restored ecosystem. For example, in the case of restoration of Gwaii Haanas National Park Reserve of Canada (**see Case Study 9**) an old-growth forest where no logging has occurred serves as the reference ecosystem. If restoration aims to bring back a cultural landscape or seascape, the reference may be a cultural ecosystem similar to the one the project is aiming to restore.

Gwaii Haanas, Canada: Monitoring of stumps during riparian forest restoration. These stumps can be sites for the persistence and growth of understory species that are important in restoration. (Case study 9) © Parks Canada

Outside of large, homogeneous ecosystems, reference ecosystems are seldom if ever exact replicas of what restoration might achieve, but rather provide a broad picture of likely ecosystems and inform the identification of key attributes and target ranges of desired outcomes. Given this complexity, project managers might consider identifying and describing multiple reference ecosystems. In such cases, objectives (Phase 4) would be described with a range of possible outcomes in mind, recognizing the inherent variability of natural systems and that unforeseen or uncontrollable disturbance may have an impact on the outcome (SER, 2004, pp. 8-9). Reference ecosystems can also be used in terms of identifying more precisely the conditions needed by particular plant or animal species that are targets for restoration, which in turn can supply ways of measuring progress in restoration.

Many managers have used historical conditions as a reference condition. This decision must be made within the context of natural or large-scale ecological changes as well as land or water use legacies. Many degraded ecosystems can no longer feasibly be restored to an historical condition, particularly under climate change. As discussed previously, a more realistic and desirable aim here may be to use an understanding of the historical ecosystem as a guide to recovering a resilient ecosystem with structural and functional properties that will enable it to persist into the future. The degree to which historical, present or future conditions are described in reference ecosystems will depend on the management objectives for the protected area and the goals and objectives of the restoration project. It will also depend on the degree to which the protected area is experiencing, or is predicted to experience, rapid change related to climate change and/or other stressors.

Box 19

RESTORATION CONCEPT **Defining reference ecosystems**

The reference ecosystem can be a site or sites representing the integrity (or aspects of integrity) that are aimed for in the planned restoration. Reference ecosystems can be near or far in terms of space and time (e.g., in the latter case historical ecosystems, where records exist which are detailed enough to understand past ecosystem interactions) (White & Walker, 1997). They are used in much the same way as references are in an article or book. In some circumstances, close attention is paid to detailed compositional features that help to set exact goals (e.g., setting the goal for heterogeneity of a mixed severity fire-dependent forested ecosystem). In other cases, where the reference is more distant or obscure (e.g., where historical accounts are slim and there are few, if any, appropriate reference sites), there is a greater need for interpretation and flexibility in setting goals. References are often helpful to ascertain a range of possible trajectories for an ecosystem, as well as the composition and function of a mature version of the restored ecosystem.

A mature ecosystem is normally selected as a reference; but a restoration site is likely to exhibit earlier ecological stages, therefore if possible several potential reference ecosystems should be identified at different stages of development, to aid planning, monitoring and evaluation. Ecosystems are complex and unique; a restored ecosystem will never be identical to any single reference ecosystem.

Where no actual reference ecosystem is available, written descriptions should be assembled from multiple sources. Such reference ecosystems can describe various levels of recovery. Sources that can help to compile information about reference ecosystems include:

a. ecological descriptions, species lists, and maps of the project site prior to damage
b. recent or historical aerial and ground-level photographs and satellite imagery
c. ecological descriptions and species lists of similar intact ecosystems
d. historical or visual accounts of the protected area, including drawings and paintings (although note that these may distorted by aesthetic values)
e. modelled predictions of ecosystem structural and functional properties under realistic climate change scenarios
f. ecological descriptions and species lists of intact ecosystems currently experiencing climatic conditions realistically predicted for the protected area
g. records of resource use (e.g., historical hunting records, details of fish catches, water flows etc.)
h. models of predicted resource needs and uses under realistic climate change scenarios local and traditional ecological knowledge and use of the protected and surrounding area (see Box 18)
i. paleoecological evidence, e.g., pollen records, charcoal, tree ring history, middens etc., including evidence of past climate-driven changes

The reference ecosystem(s) need to be referred to actively during restoration to allow adaptive management strategies and monitoring systems to be developed in ways that reflect understanding of the reference ecosystem(s). The combination of multiple lines of evidence helps in restoration design, planning, implementation, management and monitoring. During post-implementation, reference ecosystems and associated information are used to manage adaptively to unexpected developments (e.g., the arrival of a new invasive species). Generally, the more that is known about the history of an ecosystem, the better served restoration practitioners are in addressing ecosystems experiencing rapid environmental change and continuing threats from invasive species.

For example: in the mountainous regions of Western Canada, an extraordinary collection of systematic historical survey photographs yields rich information about diverse ecosystems. Photographs from the late 19th and early 20th centuries routinely show substantial change as a consequence of climate change, human activities and ecological processes. Taken by themselves, the photographs are at best a partial historical record that may or may not be directly useful in determining restoration goals. However, combined with other lines of evidence, including reference ecosystems, and set in the context of a continuously changing landscape they become important guides in shaping restoration design, implementation and evaluation (Higgs & Roush 2011; Higgs & Hobbs, 2010).

Phase 2.3: Carry out an environmental and social impact assessment, if necessary

The planning of an ecological restoration project must consider the potential for adverse effects, for example from alteration of ecosystem structure or function, introduction of infrastructure, or human presence during the restoration.

An environmental and social impact assessment will aim to identify all the potential consequences of a project, unintended as well as intended. This is an element of good planning, regardless of whether or not it is required by legislation or policy, although if there is a legal obligation the assessment can serve the needs of that process. In general, a good environmental impact assessment is one that supplies useful information to all constituencies. It need not be lengthy: checklists are available and may be suitable. Advice from an assessment specialist early in concept development can explain how and when to conduct an efficient and useful impact assessment and who to involve.

It is important to recognize that restoration also has potential social and cultural impacts, including gender related impacts, both positive and negative, that need to be identified and addressed early in the planning process. Ideally, ecological restoration projects contribute to sustainable development (**see Guideline 2.4** and associated best practices). Restoration can bring back ecosystem services, sustainable supplies of natural resources, aesthetic qualities, visitor experience values, and increased benefits from ecotourism. But it may bring costs, such as unwanted controls on natural resource use, or inadvertent damage to socially and culturally important sites. Identifying potential costs and benefits early in the process can avoid problems later. In addition, the environmental and social impact assessment process can provide an effective means of informing and engaging the public, visitors, and other stakeholders about the proposal.

Particularly in protected areas that contain indigenous populations that are resident or regular users, it is necessary to consult and follow applicable national constitutional, legislative and international obligations to determine the duties and principles for engaging indigenous communities and their governments (e.g., SCBD, 2004). When assessing the restoration problem it is crucial to understand all people's views and take into account their degree of dependence on the ecosystem, including socio-economic, livelihood and cultural issues. One of the ultimate goals of restoration can be the re-establishment of traditional cultural values and practices that contribute to the sustainability of the protected area and its surroundings (**see Guideline 1.5** and associated best practices) but this will only be effective if the cultural and social dynamics of the site are understood; this entails engaging indigenous peoples and their knowledge.

Phase 2.4: Ensure an information management system is in place and use it

The steps suggested above will include the gathering of considerable background information (e.g., research papers, policy documents). Information management and archiving, whether digital or analogue, is essential to good ecological restoration projects, particularly because many last for a long time, and good information can also help to ensure the success of future projects. Plans for managing data should be included early. Ideally sites will already have effective archiving systems. If not, important factors to consider include:

a. Use of accepted metadata standards and a records management (archival) system to identify data/records locations and ensure their effective retrieval;
b. Ensuring data/records are secure regarding access restrictions, intellectual property rights, and use of data sharing agreements where applicable (note this is of particular relevance where TEK is shared and employed);
c. Use of clearly defined and rationalized data analyses that are specific about biases in collection and analysis and limitations;
d. Developing reference collections where digital photographs are taken and identification of taxa are peer reviewed;
e. Developing data management plans that address data integrity, digital file maintenance, and data migration and include plans for efficient data and information sharing within and among protected areas management authorities;
f. Use of protocols for standardization of data collected in the field, including training for data collectors; and
g. Use of GIS systems.

Phase 3: Develop goals

Action	Process and guidelines
1. Develop restoration goals	**See Phase 3.1 and consider Guidelines 1.3, 1.4, 1.5, 1.6, 2.1, 2.3. 2.5, and 3.4**

Phase 3.1: Develop restoration goals and outcomes

Setting effective restoration goals will guide project planning and implementation (Hobbs, 2007). Protected area managers need to work closely with stakeholders to develop goals that are clearly stated, realistic and achievable based on a shared vision of the future of the ecosystem. Goals are typically presented as statements of intent, and can be developed further as clear and measurable *outcomes*, i.e., descriptions of the restored system, to inform the types and priorities of objectives.

The steps outlined above can help project managers develop realistic goals. For example, the principle of effectiveness will help to guide the selection of goals related to the recovery of specific values of the protected area. The principle of efficiency will help define the constraints within which the project needs

Sea Otter, Canada
© Parks Canada

to operate, and hence which goals are realistic. The principle of engagement reminds managers that for restoration to be successful over the long-term, goals related to community and visitor understanding, appreciation, experience, and support of the protected area may be equally important as those associated with the recovery of specific natural values of the system.

Project goals should be realistic and achievable in the context of off-site influences, broader ecosystem functioning and global change. For example, because of the often significant mobility of many marine, large mammal and bird species, their restoration may be beyond the ability of protected area managers alone, and require collaboration and coordination with other resource managers. Similar issues affect projects aimed at assisting the recovery of migratory species or restoring freshwater ecosystems within a larger watershed. Where collaboration is fundamental to success, it can be identified as part of the project's goal. For example, Habitat 141° in southern Australia (**see Case Study 8**) aims to work collaboratively to restore and connect the wider landscape and enhance the values of existing protected areas in southern Australia.

Goals for individual restoration projects should be consistent with national, regional and local policy and also reflect global goals and policies. For example, by restoring forest and implementing carbon sequestration projects to mitigate climate change, restoration of protected areas in the Atlantic Forest of Brazil (**see Case Study 7**) is contributing to local, regional and international biodiversity conservation as well as climate change-related policies and goals.

While one community or organization may initiate a project, it may serve the needs of multiple communities/organizations (*see* the example in Box 20). Understanding the linkages between different users' needs is particularly important where there are complexes of natural areas and other types of green or open space, held under different ownerships, that all contribute to the ecological integrity of a larger landscape (e.g., biosphere reserves or transboundary protected areas). Establishing linkages early will create efficiencies and ensure the project is compatible with large-scale plans and processes. In many cases, multiple competing goals for the restoration of protected areas ecosystems may exist. For example, goals for the recovery of sea otter populations may conflict with goals for the sustainable harvest of shellfish in marine protected areas (Blood, 1993). Potential conflicts need to be considered and trade-offs negotiated and resolved as goals are established.

Box 20

A CLOSER LOOK Example of multiple project goals

The vision of the Working for Woodlands Programme (see Case Study 4) is to create a new rural economy in the Eastern Cape of South Africa based on restoration of the degraded thicket (Mills et al., 2010) and to address climate adaptation by creating both more resilient ecosystems and local communities. Project goals can include a set of anticipated benefits such as (Mills et al., 2010):

Environmental:
a. improved carrying capacity of the landscape for wildlife (and possibly for well-managed livestock);
b. conserved topsoils resulting in less silt deposition in rivers;
c. greater water infiltration into soils and aquifers to replenish ground water supplies;
d. carbon sequestration; and
e. increased biodiversity.

Socio-economic:
a. job creation for rural poor (large-scale restoration proposes creating thousands of jobs);
b. ecotourism opportunities;
c. better awareness of restoration processes;
d. improved livelihoods through the generation of alternative income activities;
e. training of the rural poor in business skills and restoration; and
f. financial returns on investments in restoration.

Phase 4: Develop ecological restoration objectives

Action	Process and guidelines
1. Develop restoration objectives	See Phase 4.1 and consider Guidelines 1.3, 1.4, 1.5, 1.6, 2.1, 2.3. 2.5, and 3.4

Phase 4.1: Identify measurable objectives informed by restoration principles and guidelines and consider preliminary monitoring design

The development of *goals* outlined in Phase 3 provide an overall picture of what restoration is trying to achieve; the *objectives* then provide the details about individual actions needed to achieve the goals. Objectives where appropriate consider both ecological and cultural outcomes. They need to be specific enough to be measurable through monitoring (**see Guideline 1.6**). For example, objectives may be that: primary productivity meets a specified level; a specific percentage of an invasive species is removed; species population size is within 95 per cent confidence limits of reference conditions. They also need to be achievable within an acceptable range of variation, and consistent with other relevant protected area plans, policies and legislation. If it proves impossible to develop objectives that meet these criteria, it may be necessary to think again about the problem definition (Phase 2) and project goals (Phase 3). Identifying objectives becomes more difficult at times when there is rapid environmental change and as far as possible these issues should be addressed. Box 21 considers some of the questions that need to be considered.

Box 21

A CLOSER LOOK Are my restoration objectives reasonable under climate change or other rapid environmental changes?

Some questions to consider:

a. Is there a realistic chance of reducing the pressures that caused degradation in the first place?
b. Is the ecosystem being restored likely to be viable in the location for the medium term?
c. Will substantial investment in maintenance of the restoration be required over the long term?
d. Will new climatic patterns (e.g., extremes) mean that parts of the restoration process are unlikely to succeed?
e. Will new species entering the ecosystem upset the balance of the restored ecosystem?
f. Are new pressures likely to emerge in the foreseeable future?

In many cases, objectives may principally relate to the restoration of natural ecosystems. For example, the Lintulahdet Life Project in Finland (**see Case Study 1**) aimed to re-establish open water areas, create insect habitats and remove invasive species, including non-native mammals to improve the breeding success of wetland birds. Similarly the objectives for the restoration of Asiatic Black Bear in national parks in the Republic of Korea (**see Case Study 2**) were primarily ecological. In contrast, the Fandriana Marolambo Forest Landscape Restoration project in Madagascar (**see Case Study 3**) was set up to restore and protect degraded forest and its unique biodiversity, and address community pressures that were leading to degradation, by restoring forest goods and ecological services, thus improving the well-being of local people.

The development of objectives is best if based on a sound understanding of the condition of the area being restored (see Phase 2.1) and actions based on best practice for the specific restoration goal.

The complexity of a project will affect the number and type of objectives required. A complex project is more likely to require specific objectives for societal engagement. For example, the Lintulahdet Life Project (**see Case Study 1**) included objectives related to enhancing experiences for protected area visitors through ecological restoration. Relatively simple projects may have only a single goal and a few objectives. If there are multiple linked objectives, their relationship should be described along with the order in which they are to be pursued, and whether or not they can be pursued concurrently. The development of a conceptual model (see Box 22) may help to organize and focus the planning process and assist in the development of specific objectives and testable hypotheses (Margoluis et al., 2009). Such models use the information collected in Phase 2 above (*see also* Hobbs & Norton, 1996).

Box 22

RESTORATION CONCEPT Conceptual models

Conceptual models should synthesize the socio-cultural and ecological characteristics of the system, including linkages across ecosystems and interconnections amongst cultural practices, environmental stressors, ecosystem attributes, and restoration activities. As syntheses of the state of understanding of the system, conceptual models can provide a basis for examining the potential risks and consequences of various restoration options and related actions (as is discussed further in Phase 5). Modelled attributes of the restored ecosystem can also be used as benchmarks for evaluating the success of various stages of the project and determining the need to change restoration actions or policies through an adaptive approach, as discussed in Phase 5. Descriptions of the abiotic and biotic attributes of one or more sets of reference ecosystems are important contributors to conceptual models for ecological restoration projects (*see* Hobbs & Suding, 2009).

The large-scale ecosystem restoration work in and around protected areas in South Florida, USA, which is being conducted as part of the Comprehensive Everglades Restoration Plan, is guided in part by conceptual models. These models identify the major anthropogenic drivers and stressors on natural systems, the ecological effects of these stressors, and the best biological attributes or indicators of these ecological responses (Ogden et al., 2005).

The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) Nearshore Science Team (NST) has developed a Conceptual Model framework (see Figure 5) to aid in assessing restoration and preservation measures for nearshore ecosystems in Puget Sound, Washington, USA (Simenstad et al., 2006). The model illustrates the breaching of a dyke in an estuarine delta wetland to restore inundation in support of juvenile salmon residence, growth and refuge. The example maps the interactions among the restored processes, the structural changes, the associated functional response, and the restoration action itself. Potential constraints are also identified as well as the associated uncertainty in the strength of interactions and in the accuracy of predictions.

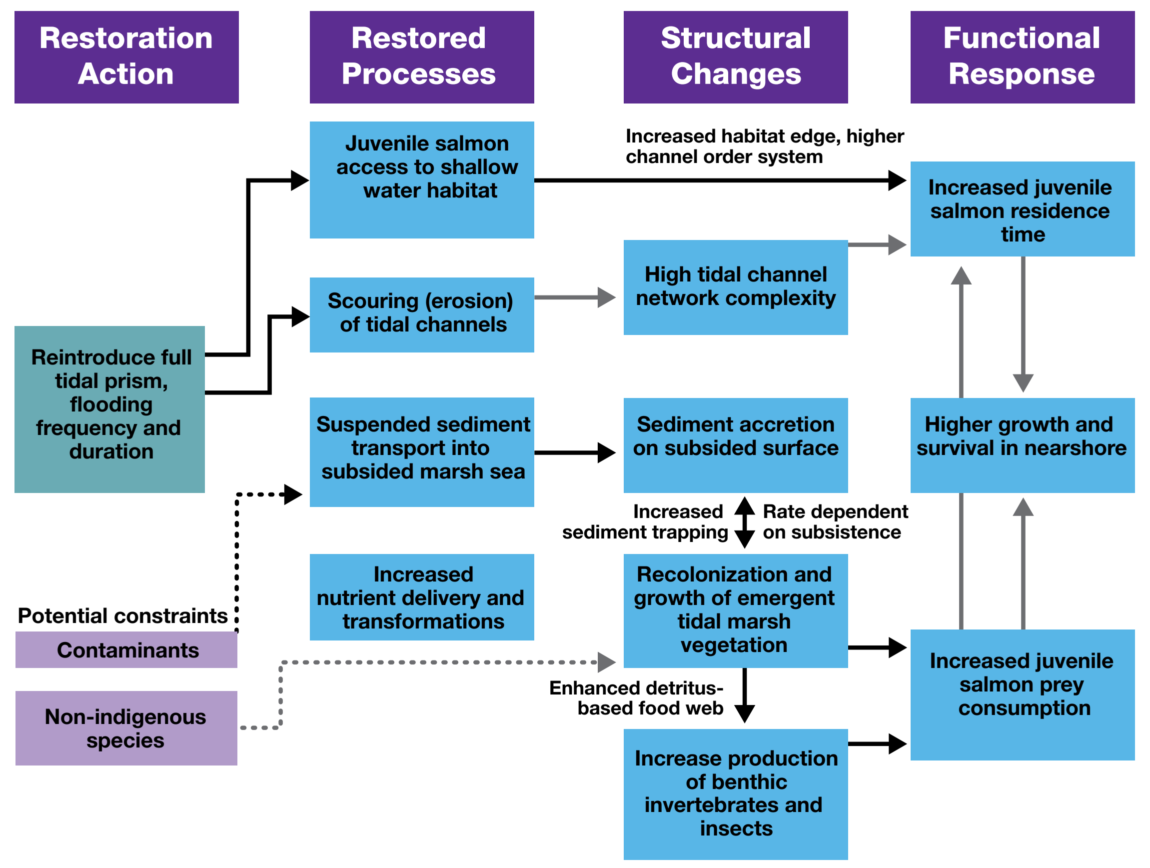


Figure 5: The PSNERP–NST Conceptual Model of the estuarine delta wetland. The arrows represent degrees of uncertainty, with the black arrows representing relatively certain relationships and the light grey arrow representing greater uncertainty (Simenstad et al., 2006).

Phase 5: Design restoration approach

Action	Process and guidelines
1. Define the scope of the project	See Phase 5.1 and consider all guidelines under Principle 1 and Guidelines 2.1 and 2.2
2. Develop a conceptual and practical project design	See Phase 5.2
3. Develop a detailed implementation plan	See Phase 5.2 and Guidelines 3.1 and 3.2
4. Develop a monitoring plan	See Phase 5.3 and Guidelines 1.6 and 2.2

Specific actions or management interventions (i.e., restoration activities) to achieve individual objectives are developed in Phase 5 and implemented in Phase 6 in the restoration process.

Phase 5.1: Define scope, consider a range of options and select the most suitable

The scope of the project is defined in terms of both the geographic area involved and the timescale, in consultation with stakeholders and partners. In many cases, restoration projects conducted primarily inside a protected area (e.g., invasive species removal) will also be dependent on actions outside the protected area (e.g., transportation of invasive species into the region). The scope of such projects, particularly as they pertain to engagement, thus extends beyond protected area boundaries.

Some objectives (e.g., species reintroduction) may be quickly attainable whereas others (e.g., reforestation) may take decades. Most restoration efforts are necessarily long-term: e.g., it is still possible to distinguish forests regenerated a thousand years ago after abandonment by the Maya in Central America from older forests nearby (Terborgh, 1992). But the period of active intervention in restoration differs markedly between biomes. Fast-growing, tropical vegetation and fast-breeding animal species like cats are generally easier to re-establish than slow growing vegetation such as boreal forest or animals that breed slowly, such as some birds of prey. Objectives included in the project scope need to be attainable with the resources available. Timescale is important in the context of community engagement and plans may need to consider how to ensure engagement is of the right intensity and duration over the long-term.

Goals and objectives from Phases 3 and 4 are used to define the interventions required. There are usually several options available. These should be considered along with relative costs and likelihood of success. For example, a project could be designed to achieve the maximum potential restoration as quickly as possible or to achieve restoration more slowly but at lower cost. A short-term intervention, such as stabilization of a rapidly eroding site, may be needed while longer term plans are developed. Decisions may be helped by a risk assessment approach. Potential risks (e.g., of failure, permanent loss of a resource, cascading effects, off-site impacts, reduced visitor experience, or losing support of partners) need to be evaluated and gaps in knowledge identified which may impact the project.

Phase 5.2: Develop an implementation plan

The development of an implementation plan can vary from simple to complex, depending on the aims of the project. For projects with an emphasis on research and lesson-learning, a conceptual model may be developed with associated hypotheses against which to test and measure progress (see Box 22, as discussed under Phase 4) in which, ideally, restoration projects are implemented as deliberately conceived experiments (see Box 23). For projects with a more practical focus, this stage just involves identifying the broad steps needed to undertake the restoration and the associated best practices.

The responses of ecosystems to restoration cannot be predicted with certainty therefore restoration embraces the concept of adaptive management. This is an approach to implementation that encourages periodic changes in restoration protocols and objectives in response to monitoring data and other new information, thus creating a feedback loop of continuous learning and modification.

Effective adaptive management requires:

a. the setting of time-bound targets for interim and final outcomes (objectives, as in Phase 4);
b. monitoring of performance measures to track progress (see Phase 5.3);
c. evaluation of this monitoring data; and
d. the setting of intermediate thresholds for consideration of success or the need to change actions or policies.

Decisions regarding appropriate management strategies, or changes to such strategies, are made on the basis of measured results. Reference ecosystems (see Phase 2.2) and conceptual models (King and Hobbs, 2006; see Box 22) can be useful in establishing targets, measures, and thresholds. The extent to which individual projects have the time or energy to adopt such a research-orientated approach will vary, but the concept of learning by doing is important to retain.

Many restoration projects will need to draw up a plan, because it is a legal or policy requirement for donors, or simply to ensure that the project is as efficient and successful as possible. (Many restoration projects will also need/benefit from a separate communications plan; see Phase 1.3).

Drawing as appropriate on elements of conceptual and practical design, detailed restoration plans identify and list the actions needed to achieve restoration, covering both the selection of specific restoration treatments and the approaches and technologies used to implement them. Restoration plans should detail roles and responsibilities, decision-making authority, onsite supervision and workforce, logistics, permits and safety concerns. Locations of the work are specified along with the timing and costs of each activity; detailed maps of the areas to be restored and their environmental characteristics are often useful. Plans and budgets have to consider contingencies (e.g., weather, availability of nursery plants) wherever possible. Plans are needed for implementation monitoring (i.e., monitoring whether the restoration was carried out according to plan) (see Phase 5.3). In addition, many ecological restoration projects will require ongoing maintenance in the future (e.g., periodic removal of invasive alien species). Details of planned maintenance activities should be included along with details of how they will be monitored.

Development of the plan should involve all concerned stakeholders. While requirements will differ between protected areas and projects, a typical template for a restoration plan is outlined in Table 4 (adapted from Cairnes, 2002; Douglas, 2001). Such a plan assumes that restoration is conducted with fixed aims and targets. In conditions of rapid environmental change, or where relatively little is known about what type of ecosystem might emerge from restoration, a more open-ended, adaptable approach might be suitable (Hughes et al., 2012). Restoration plans should be an aid to effectiveness rather than a straitjacket.

Box 23

RESTORATION CONCEPT
Designing an experimental approach to adaptive management

In implementing an experimental methodology for the adaptive management approach, restoration strategies are tested using a scientifically and statistically rigorous process that allows for evaluation of their effectiveness through monitoring (e.g., Schreiber et al., 2004). The hypothesis or hypotheses to be tested are specified and a detailed experimental design developed. Ecological models may be used to predict specific outcomes of proposed treatments. Supplementary smaller scale laboratory and/or field experiments may also be conducted to reduce model uncertainties and help refine the design.

In some cases (e.g., when the ecosystem is extensive enough and science capacity is great enough), multiple restoration hypotheses may be tested in parallel as controls and replicates. Where actual reference ecosystems can be identified and monitored, comparisons amongst control (untreated but impaired) sites, reference (unimpaired) sites and the treated (restored) sites before, during and after restoration increases the certainty of statistical analysis as well as the level of generalization of results.

In smaller sites with a limited degree of intervention it may only be possible to test one restoration hypothesis. However, comparisons between treated and untreated conditions should still be made before and after treatment wherever possible. In such cases, the generality of inferences that can be made from results will be more limited.

Table 4: Template for a restoration plan

Section	Details
Introduction	Including an overview and (if needed) a funding proposal
Problem statement	Explanation of what is needed and why, ideally with reference to similar projects carried out elsewhere, with lessons learned being elaborated at this stage (see Phase 1.1)
Site description	Information on context, condition, status and importance, including photographs and maps as appropriate (see Phase 2.1) and reference ecosystems (see Phase 2.2)
Site history and related disturbances	Both historical changes and current disturbance (the reason for the restoration), including explanation of how past degrading factors are to be controlled (see Box 19 on reference ecosystems)
Project scope, goals and objectives	This should be explicit, achievable and measurable, with target dates for achievement included (see Phase 3.1, 4.1 and 5.1)
Details of restoration activities	See Phase 5.1, these should include identification of: a) responsibilities b) work to be carried out c) location d) timing e) budget f) materials required g) supervision and safety issues
Maintenance	Details of long term maintenance required
Monitoring and adaptive management	Identification of performance indicators, how these are to be measured, how often (include detailed protocols for monitoring to ensure continuity if monitoring staff change), how the information gathered is going to be managed and how the project may be adapted to monitoring results (see Phases 2.4, 5.3 and all of Phase 7)

Phase 5.3: Develop criteria and indicators for processes and outcomes

Monitoring of restoration will often be linked to other monitoring in protected areas, and should consider other work in the protected area or surroundings to identify possible overlaps, optimize monitoring programme design and resource expenditures, and contribute to reporting (Hockings et al., 2006). Co-operation with researchers and research organizations can be very helpful. Existing monitoring may provide information on whether or not restoration is working: for instance monitoring water birds can tell a lot about success of wetland restoration. Ideally, monitoring, evaluation and adaptive management are conducted at a scale that is appropriate to capture ecosystem-level characteristics (e.g., Dudley & Parrish, 2006). Local stakeholders, including indigenous peoples, can sometimes be the most effective collectors of monitoring data, either as part of collaborative agreements or for a fee (Danielsen et al., 2007). However, the focus is on measures and strategies that are specific to restoration. **Guideline 6.1** and associated best practices provide additional guidance.

It is important to agree and record precise details on when and how monitoring is carried out. Given the long time period of restoration projects it is highly likely that different staff members will be involved in monitoring; it is therefore very important to ensure monitoring protocols are consistent over time, otherwise results are likely to differ with recorders (*see* e.g., Hockings et al., 2008).

Monitoring should be directly integrated into the design of the restoration project, ensuring that all stakeholders understand and agree with indicators, which reflect their concerns (Estrella & Gaventa, 1998). Indicators/measures need to be:

a. related to objectives (see Phase 4)
b. accurately measurable
c. appropriate to the temporal and spatial scale of the ecosystem
d. cost-effective (even photographic monitoring from fixed points can provide useful evidence over time and is inexpensive).

For effective adaptive management it is important to evaluate progress towards interim targets, to help decide whether to continue with the current approach or if it needs to be adapted. Interim reports may also be important to retain community, political or financial support and monitoring results can be included in communication plans (see Phase 1.5). The strategies for monitoring apply equally to ecological and socio-cultural objectives. Predicted expenditures should also be monitored and budgets re-evaluated during the project. The restoration design needs to consider how and when monitoring should be phased out or incorporated with other on-going monitoring.

Although monitoring is whenever possible constant over time, it is important to review indicators on a regular basis to ensure that they are up to date. Ideally all research methodologies and data should be freely available. Existing monitoring protocols and manuals should be consulted in selecting performance measures, determining monitoring frequency, level of detail and duration, and evaluating relative costs.

Phase 6: Implement ecological restoration approach

Phase 6.1: Carry out restoration

In Phase 6, the restoration plan is implemented. Monitoring of measures identified in Phase 5 is conducted to assess restoration success using an adaptive management approach (see Phase 7) and modifications to the plan are made as necessary.

Phase 6.2: Communicate progress as per the communication strategy

Communication with stakeholders and partners continues throughout the project duration, using strategies developed in Phase 1. Both successes and failures need to be reported, to encourage learning and refinement of restoration techniques and processes. The need to communicate results underscores the value of using an adaptive management approach in which progress towards meeting objectives is evaluated at intermediate stages. Communicating the achievement of short-term objectives and goals rather than waiting until longer-term objectives are met, is important to maintaining enthusiasm and ensuring ongoing engagement of partners and stakeholders.

Communication to visitors and the public contributes to a broader understanding of the concept of ecological restoration and builds public support. Communication amongst restoration practitioners helps build up the larger body of knowledge that leads to advances in this field and the development of evidence-based conservation. Communicating results to policy-makers and decision-makers helps build ongoing support and funding and is particularly important in ensuring the long-term funding of complex projects that may require ongoing maintenance and intervention.

Phase 7: Implement adaptive management

As Figure 4 illustrates at the beginning of this chapter, successful restoration projects are not going to be made up of a series of static steps with no feedback, adaption or revision. This integral part of the process is really therefore a series of steps which should be present throughout a restoration project. Restoration planning and implementation specify monitoring mechanisms that ensure results will inform subsequent management decisions, by using an applied research approach with adaptive management, based on identifying and solving problems, starting small and building on early successes (Brandon & Wells, 2009). Considerable effort is required to design and execute monitoring programmes, to collect, evaluate, analyze, interpret, and synthesize data, and to report results. This reaffirmation of the many steps given is thus only briefly discussed here.

Phase 7.1: Monitor

Apply the monitoring system developed in Phase 5 and use the data to evaluate whether or not the restoration process is running according to plan. Monitoring is not a mechanical process; along with collecting information on agreed indicators managers need to be more generally aware of other changes that may be taking place because of restoration.

Phase 7.2: Evaluate monitoring results

Monitoring needs to feed directly into management, be embedded into organizational structures and be designed in such a way that there are clear protocols for when particular monitoring data triggers action. Project staff and other relevant or concerned stakeholders need to meet to consider monitoring results, evaluate them relative to pre-determined thresholds or objectives for success, discuss the implications and, if necessary, agree on changes to increase success or address unforeseen side-effects.

Phase 7.3: Adjust, as necessary, phases 5 and 6 based on the evaluation results

Assess results of monitoring regularly and apply these through adaptive management, ensuring that people involved in the monitoring know this is being done. Adaptive management includes many formal and informal interactions, discussions and modifications to project design. In some cases, it may require a re-evaluation and reformulation of project objectives or goals. While such readjustments can be discouraging, they are not failures but a necessary part of a successful strategy.

Large-scale restoration projects that affect the wider environment beyond the borders of a protected area need to include a wider stakeholder group. For instance, success in restoring a particular species will be compromised in the long-term if it leads to increased human-wildlife conflicts that remain unresolved.

Jirisan National Park, South Korea: Radio tracking after releasing Asiatic black bear (Case study 2) © Species Restoration Center (SRC), Korea National Park Service

Box 24

RESTORATION CONCEPT When has restoration succeeded?

Restoration has succeeded when the goals/objectives set out at the beginning of the process (and adapted as necessary throughout) have been met. However, because restoration is often a long-term process, deciding when a project has 'succeeded' is challenging. In the case of relatively narrow objectives, such as re-introduction of a species, or elimination of an invasive species, targets may be set, but this is harder for more general ecosystem-scale restoration.

Efforts have been made to address the question of restoration 'success' in a standardized way. For example, SER states that: *An ecosystem has recovered—and is restored—when it contains sufficient biotic and abiotic resources to continue its development without further assistance or subsidy.* To illustrate this more precisely, nine generic attributes, listed below, have been developed to help determine whether recovery is on-going and thus ecological restoration is being accomplished (slightly amended from SER, 2004). It should be noted, however, that these attributes do not cover the whole range of restoration objectives (e.g., governance, social or cultural objectives). They also do not fully recognize evolving understanding of the key ecological role of traditional resource management in Indigenous cultural landscapes. It is further important to note that attributes 8 and 9 in particular do not account for the likelihood that many ecosystems will be undergoing rapid climate-driven social and ecological changes and thus may not only need to be resilient to 'normal periodic stress events' but also to extreme events and/or rapidly changing climatic conditions.

1. The restored ecosystem contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate ecological community structure.
2. The restored ecosystem consists of indigenous species to the greatest practicable extent.
3. All functional groups necessary for the continued development and/or stability of the restored ecosystem are represented or, if they are not, the missing groups have the potential to colonize by natural means.
4. The physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued resilience or development along the desired trajectory.
5. The restored ecosystem apparently functions normally for its ecological stage of development, and signs of dysfunction are absent.
6. The restored ecosystem is suitably integrated into a larger ecological matrix or landscape/seascape, with which it interacts through abiotic and biotic flows and exchanges.
7. Potential threats to the health and integrity of the restored ecosystem from the surrounding landscape or seascape have been eliminated or reduced as much as possible.
8. The restored ecosystem is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity or natural evolution of the ecosystem.
9. The restored ecosystem is self-sustaining to the same degree as its reference ecosystem, and has the potential to persist indefinitely under existing environmental conditions. Nevertheless, aspects of its biodiversity, structure and functioning may change as part of normal ecosystem development, and may fluctuate in response to normal periodic stress and occasional disturbance events of greater consequence. As in any intact ecosystem, the species composition and other attributes of a restored ecosystem may evolve as environmental conditions change.

Phase 7.4: Communicate results and continue, as appropriate, with stakeholder engagement

Communication of results of the restoration project is often critical to its success, as discussed under Phase 6. Effective reporting of ongoing monitoring results is also important. Regardless of the specific reporting mechanism, reporting on results is an integral component of the protected area's management cycle. Ensuring that information is freely available, in a form accessible to all concerned, with efforts at pro-active information sharing is an important factor in restoration success (Posey et al., 1995).

Conclusions

The restoration process detailed above is a generic list of actions, not all of which may be appropriate for every project. But along with the principles, guidelines and best practices presented in earlier chapters it should help all those undertaking restoration to be well prepared and to develop clear goals, objectives and activities necessary to implement the restoration process. In the following chapter a series of case studies of ecological restoration projects around the world highlights some of the real examples which have contributed to the guidance summarized here.

Chapter 6
Case Studies

This chapter includes a series of case studies from around the world that illustrate practical experience with implementing ecological restoration for protected areas that is consistent with the principles and guidelines outlined in this document. Case studies include:

1. The Lintulahdet Life Project: Restoring wetlands in Finland
2. Asiatic black bear restoration in South Korea
3. The Fandriana Marolambo Forest Landscape Restoration Project in Madagascar
4. Subtropical Thicket Restoration Programme, Working for Woodlands, South Africa: Poverty, carbon and restoration
5. Applying traditional ecological knowledge to forest restoration in Lacandon forest, Mexico
6. Rehabilitation of the lower delta of the Senegal River in Mauritania
7. Restoration in protected areas of the Atlantic Forest in Brazil
8. Habitat 141°: Restoring habitats and linking protected areas in southern Australia
9. Restoring the land and honouring the history of Lyell Island in Gwaii Haanas, Canada
10. Restoring the marshlands of Iraq
11. The Springbrook Rainforest Project: Restoring World Heritage rainforests in Australia
12. Oyster reef restoration in Canaveral National Seashore, USA

Case Study world map

Restoring the land and honouring the history of Lyell Island in Gwaii Haanas, Canada

Oyster reef restoration in Canaveral National Seashore, USA

Applying traditional ecological knowledge to forest restoration in Lacandon forest, Mexico

Restoration in protected areas of the Atlantic Forest in Brazil

See main case studies for photo credits


The Lintulahdet Life Project: Restoring wetlands in Finland
Rehabilitation of the lower delta of the Senegal River in Mauritania
Restoring the marshlands of Iraq
Asiatic black bear restoration in South Korea
The Fandriana Marolambo Forest Landscape Restoration Project in Madagascar
Habitat 141°: Restoring habitats and linking protected areas in southern Australia
Subtropical Thicket Restoration Programme, Working for Woodlands, South Africa: Poverty, carbon and restoration
The Springbrook Rainforest Project: Restoring World Heritage rainforests in Australia

6.1: The Lintulahdet Life Project: Restoring wetlands in Finland

Thanks to Ilpo Huolman, Project Manager of the Lintulahdet Life Project, for helping in the development of this case study.

Allowing for cattle grazing through agreements with local farmers ensures long term maintenance of the restored meadows. © Ilpo Huolman

The Lintulahdet project is restoring a network of wetlands that are important migratory pathways (**Guideline 1.4**) including control of invasive species (**Guideline 1.2**) and incorporating extensive monitoring (**Guideline 1.6**). The project also has an extensive outreach and education project with local schools to build understanding of ecological restoration and natural systems (**Guideline 3.2**). The project design incorporated elements to enhance visitor experience (**Guideline 3.4**) including participation in restoration activities.

The Northern Coastal Gulf of Finland is one of the main bird migration routes across northern Europe and an important flyway for waterfowl and waders that winter in the southern Baltic Sea and along the coasts of the North Sea. The area is an important resting and breeding habitat for 35 bird species listed under Appendix 1 of the European Union (EU) Birds Directive, including the swans *Cygnus cygnus* and *C. columbianus*, smew (*Mergus albellus*), corncrake (*Crex crex*) and great bittern (*Botaurus stellaris*). It has been threatened by increased nutrient levels, overgrowth of wetlands and meadows, spread of invasive species, hyperabundance of small predators and uncontrolled visitor access (Uusimaa Regional Environment Centre and Southeast Finland Regional Environment Centre, 2008).

Bird towers are a central element in managing recreational access and visitor experiance in restored wetlands. © Viliina Evokari

The Lintulahdet Life Project, which ran from 2003 to 2007, restored 12 wetlands sites covering a total of 3,353 ha along the migratory flyway. The main goals of the project were to restore the natural ecology of the coastal wetlands and meadows, establish a functional network of wetland areas along the northern coast of the Gulf of Finland flyway and secure favourable conservation status for wetland species (Uusimaa Regional Environment Centre and Southeast Finland Regional Environment Centre, 2008).

Management plans for each of the sites set out goals for restoration and management specific to the habitat, species and factors leading to degradation. Project staff consulted with local residents and the broader public to gain input on the plans and address land use conflicts that were contributing to degradation. Agreements with local farmers for grazing have secured the long-term management of the area to maintain restored coastal meadows beyond the project's life.

The project restored the ecological integrity of the wetlands through re-establishment of open water areas, removal of invasive species, creation of insect habitats and removal of small non-native mammals to improve the breeding success of wetland birds (1,310 common raccoon and 391 minks were trapped during the project). Trees and bushes were cleared from coastal meadows and marshy shores, and cattle grazing was promoted in specified areas to keep the meadow vegetation open. A total of about 185 ha of coastal meadows were restored and the removal of invasive aquatic vegetation created new mosaic-like wetland habitats over almost 78 ha. Open-water bog lakes were dug in shore areas to provide habitat for insects such as the rare yellow-spotted whiteface dragonfly (*Leucorrhinia pectoralis*), and natural marshy areas (of about 76 ha) were restored by blocking or redistributing artificial drainage ditches to allow water to flow into the meadows. In some areas nesting patches were left for birds. An old dumpsite was restored to benefit insects preferring dry sandy slopes (Uusimaa Regional Environment Centre and Southeast Finland Regional Environment Centre, 2008).

The project conducted extensive baseline and regular monitoring of bird-life, habitat and insects. Baseline and follow-up bird counts were conducted to monitor the effects of the restoration on bird populations of interest. The methods used included point counts and circling and territory mapping. Special attention was given to species listed in the EU Bird Directive Appendix 1 as well as those on Finland's endangered species list (Uusimaa Regional Environment Centre, 2007). Information was also collected on nesting and nestling production for water and wetland birds. Aerial photos were used for some sites to monitor the effect of activities on vegetation and habitat. The aerial photos showed extensive changes in the open flood meadows (categorized as transition mires and coastal swamps). Pattern-based vegetation monitoring was carried out in areas of the coastal meadows to monitor the effect of mowing and grazing on the vegetation (Uusimaa Regional Environment Centre and Southeast Finland Regional Environment Centre, 2008). Monitoring was also undertaken to determine the short-term effects of management processes on the nutrition network and biological values in these areas, as well as insect species living in the wetlands (Uusimaa Regional Environment Centre, 2007).

The project design incorporated measures to minimize the impacts of visitors on sensitive ecological areas and at the same time enhance visitor experience through improved nature viewing. The latter was achieved through the construction of 14 bird towers plus viewing platforms, interpretive nature trails and other visitor education materials. The project manager, Ilpo Huolman, reports that reaction to the towers has been very positive, as visitors have been able to watch the actual restoration work as it has developed and enjoy viewing increasing numbers of birds as a result. The towers receive thousands of visitors annually. The restoration activities themselves also created a 'visitor' experience by using volunteers to undertake restoration activities as part of volunteer camps led by WWF. Such camps have a long history in supporting restoration and management of nature reserves in Finland; they are normally made up of 15-20 volunteers, and must be properly planned, organized and managed to be successful.

Education was another important element of this project. A guidebook, *Retkelle kosteikkoon,* was produced to help elementary and primary school teachers plan their excursions. It includes activities for various age groups, articles on wetland management and descriptions of the wildlife of wetlands. Other educational materials include wetland cards for use on field trips, a video of a school field trip and a poster of wetland birds (Uusimaa Regional Environment Centre and Southeast Finland Regional Environment Centre, 2008).

This project supported Finland's implementation of EU commitments under the Birds and Habitats Directives through the Natura 2000 network of conservation sites, which aims to protect the most seriously threatened habitats and species across Europe. The overall budget for the project was close to €3.3 million (euros), with the European Commission's LIFE Programme providing half the funding and 16 financiers contributing to national funding. The project was managed by the Uusimaa Regional Environment Centre in cooperation with the Southeast Finland Regional Environment Centre and 11 other partners.

Project areas:
1. Saltfjärden, Kirkkonummi.
2 Medvastö-Stormossen, Kirkkonummi.
3 Laajalahti Bay, Espoo.
4 Lake Tuusula, Tuusula and Järvenpää.
5 Viikki-Vanhankaupunginlahti Bay, Helsinki.
6 Porvoonjoki estuary-Stensböle, Porvoo.
7 Pernajanlahti Bay, Pernaja.
8 Pyhäjärvi, Iitti, Jaala and Valkeala.
9 Salminlahti Bay, Kotka and Hamina.
10 Lake Kirkkojärvi, Hamina.
11 Pappilansaari-Lupinlahti Bay, Hamina.
12. Kirkon-Vilkkiläntura, Virolahti.

Special equipment that can operate in soft and flooded terrain was used for restoring coastal meadows. © Ilpo Huolman

Lessons Learned

- ✓ The results of the restoration and management actions are cited as 'outstanding, in particular on wetland birds' (European Commission LIFE Programme, 2008). Monitoring was crucially important in being able to confirm the project's success, by showing a significantly higher number of water bird and waders resting in the area, both in number of species and individuals (Uusimaa Regional Environment Centre, 2007).
- ✓ Control of recreational use has reduced disturbance of bird resting and nesting areas. At the same time, the use of information boards, nature paths and bird towers have proved effective in improving the accessibility of recreational facilities and enhancing visitor educational experience, and understanding of the restoration project.
- ✓ Planning for long-term maintenance of the area beyond the life of the project was essential. During the project, management agreements for the restored coastal habitats were secured by involving local farmers in project activities and encouraging them to apply for agri-environmental support for management. Since the project has been completed, partners are continuing to graze and mow areas to maintain habitat for bird species. In many sites, activities are ongoing such as trapping of small alien predators (raccoon, dog and American mink) and maintaining recreational structures such as bird towers, nature trails and main map guides.

According to Ilpo Huolman, accurate planning of the project was a key factor in its success:

'All the projects should have clear and realistic objectives. Also the measures should be chosen so that objectives can be achieved in a limited time, because projects are usually periodical. After-project planning is also important, otherwise good results may go surprisingly fast down the drain.'

6.2: Asiatic black bear restoration in the Republic of Korea

Thanks to Dr. Hag Young Heo, Korea National Park Service/IUCN Asia Biodiversity Conservation Programme, for his substantial contribution to the development of this case study.

Re-introduction of the Asian Black Bear into Jirisan National Park (**Guideline 1.2**) involves extensive stakeholder engagement and communication to ensure public support and minimize human–wildlife conflict (**Guideline 3.1, Guideline 3.3**). It also involves consideration of potential socio-economic impacts on local communities (**Guideline 2.4**) and ongoing post-release monitoring (**Guideline 1.6, Guideline 2.2**).

Veterinarians conducting black bear health screening and exchanging a radio transmitter © Species Restoration Center (SRC), Korea National Park Service

Over the past ten years, a multi-disciplinary team of biologists, ecologists, veterinarians and local communities has managed the re-introduction of a self-sustaining population of the Asiatic black bear (*Ursus thibetanus*) in Jirisan National Park—the largest mountainous national park in the Republic of Korea (South Korea), covering 471 km^2. Following a historic government policy to 'eliminate harmful animals' under the Joseon Dynasty (1392–1910) and heavy poaching during the Japanese occupation period (1910–1945), and from the 1960s to 1970s, it was estimated in 2001 that only between five and eight bears existed in the park (Jeong et al., 2010). The Asiatic black bear is listed as an endangered species in South Korea and classified as Vulnerable (IUCN) and listed in CITES App. 1.

The decision to undertake the re-introduction programme was based on extensive studies and surveys to assess the probability of survival under different re-introduction scenarios. The programme, which is managed by the Korean National Park Service (KNPS), has three main goals (IUCN and KNPS, 2009):

a. Restoration of Asiatic black bears in suitable habitat through developing public tolerance and political support;
b. Establishment of self-sustainable populations in Backdudaegan (ecological axis of Korean peninsula) area as well as Jirisan National Park; and
c. Recovery of a healthy eco-system through the re-introduction of Asiatic black bears.

Releasing Asiatic black bear into Jirisan National Park © Species Restoration Center (SRC), Korea National Park Service

After initial experimental releases in 2001, 30 wild bear cubs of a similar sub-species (*U.t. ussuricus*) obtained from Russia and North Korea were introduced into Jirisan between 2004 and 2010. Before release, all bears were quarantined and submitted to health screening to reduce the risk of introducing disease to the wild population. All the bears are monitored daily using a transmitter or GPS collar. As of March 2010, half of the released bears were alive and two bears had reproduced (Jeong et al., 2010); in 2011 it was estimated five had reproduced. KNPS has established a Species Recovery Centre (SRC) to promote expertise and research on endangered species. SRC has implemented a continuous black bear post-release monitoring programme, which collects and reviews extensive data on bear home ranges, health, habitats, behaviour, food resources and adjustments to the natural environment to inform future re-introduction approaches.

About 20 per cent of Jirisan National Park is privately owned land used by local communities for tree sapping and beekeeping. KNPS has sought to address this overlap of human use and bear habitat by partnering with local government and communities, establishing a compensation programme for damage by bears, monitoring bear activity and promoting education and awareness through materials about the programme and impacts of poaching. SRC has monitored bear movements to help anticipate where damage might occur, and erected electric fences to reduce damage; as a result in 2007 damage to beehives decreased by 85 per cent compared with 2006 (Lee, 2009). This has helped build public and political support for the project. The project has also sought to build public awareness of the impacts of poaching and has designated local people as 'honorary rangers' to help remove illegal snares. More than 270 illegal snares have been removed to date.

Lessons Learned

- ✓ With an overlap in habitat used by local communities and bears, it has been challenging to gain public tolerance of the restoration. Communication and education about the significance of species re-introduction, as well as intensive monitoring and management of the released bears, has been necessary to build public and political support for the project (Jeong et al., 2010).
- ✓ The SRC as a special organization dedicated to re-introduction of endangered species has brought expertise and financial resources that contribute to the long-term success of the project (Jeong et al., 2010).
- ✓ To provide for a larger habitat area to support the bear population, the 'Asiatic Black Bear Broad Protected Area' was designated. It expands the total area to 965 km2 including Jirisan National Park.
- ✓ Continuous post-release monitoring has been vital for the success of the programme (H.-Y. Heo, pers. comm., 2011).

'In the 10 years since the restoration programme was launched there have been many difficulties and errors, but this trial and error has led to accumulated knowledge, and a better understanding of both bears and the people who live near them' (H.-Y. Heo, pers. comm., 2011).

6.3: The Fandriana Marolambo Forest Landscape Restoration Project in Madagascar

Thanks to Daniel Vallauri, WWF, for helping in the development of this case study.

Protection, management and restoration of forest landscapes are all priority tools to achieve lasting conservation of Madagascar's unique biodiversity. © Daniel Vallauri (WWF)

Restoration in the crowded country of Madagascar is using long-term community engagement to understand stakeholder perceptions and priorities and to shape and inform project activities (**Guideline 3.1**) that restore both biodiversity and ecosystem services (**Guideline 2.3**). A commitment to learning collaboratively and building the capacity of local stakeholders (**Guideline 3.2**) and developing alternative livelihood opportunities (**Guideline 2.4**) has led to greater support for restoration activities and the creation of a new national park.

Madagascar is a country of great contrasts: it is a biodiversity hotspot but also a place that has suffered major deforestation. It is a country that has made one of the most ambitious pledges to create protected areas globally, but endures more than its share of political upheaval and social unrest.

Instability and poverty have been major underlying causes of environmental degradation. The practice of shifting cultivation (*Tavy*), uncontrolled fires, collection of wood and non-timber forest products, and illegal commercial logging has led to an estimated forest loss of 40,000 ha/year between 1990 and 2005 (Roelens et al., 2010). But as some 90 per cent of Madagascar's endemic species live in forest ecosystems, these forest remnants are of great importance to biodiversity (Gorenflo et al., 2011).

WWF's Fandriana Marolambo Forest Landscape Restoration project was set up to restore and protect degraded forest and address community pressures that were leading to degradation. Fandriana Marolambo is an area of exceptional biodiversity and endemism covering about 200,000 ha of cultivated fields, fallows, grasslands, savannahs, exotic forests (pine and eucalyptus) and native forests (Lehman, et al., 2006). WWF's project, set up in 2004, aims to:

a. conserve the unique biodiversity and functional integrity of the forest;
b. restore forest goods and ecological services; and
c. improve the well-being of the people living in the area (Roelens et al., 2010).

The high biodiversity of the area is due to fragments of both degraded and relatively pristine forests which form a 80,000 ha largely intact forest corridor with a width of 5 to 20 km. Ecological restoration, considering historical reference conditions where this knowledge was available, has been vital to prevent fragmentation or restore connectivity of the corridor. The project used passive and active restoration approaches to restore ecological integrity by promoting natural regeneration and acceleration of forest succession in some 5,000 ha through the removal of invasive plants and creation of firebreaks to protect against brush fires (Roelens et al., 2010). Passive restoration sites were reinforced by traditional law or '*Dina*' established by the communities, which helps make their engagement more official and protects sites against encroachment. In addition the project has actively restored 500 ha of forest, setting up 58 nurseries to produce and propagate 100 or so native plant species.

The project team consulted extensively with local communities to elaborate a common vision of land use, identify their needs and wants, and develop opportunities for alternative livelihoods to alleviate poverty and reduce pressures on the area. The project has sought to convince local communities to adopt alternatives to traditional shifting agriculture through demonstration rather than just teaching. Activities include training in agroforestry, beekeeping, composting, cropping systems and other activities for representatives from 70 community associations (Roelens et al., 2010). Trainees are then encouraged to implement the new techniques in their villages, which in turn become the focus of dissemination tours where the benefits of the new activity are demonstrated. To date 40 pilot projects have been established on sites held by community associations.

There has been a long history of conflict over traditional rights to the land and local mistrust of government (Roelens et al., 2010). Community engagement, built on existing local traditions, has been critical to the project's success. One important goal has been to build the capacity of grassroots communities to manage their own resources through *Communautés de base* (COBA). This voluntary process starts with the development of appropriate structures within the COBA, followed by socioeconomic studies and forest surveys of communities' habits and needs, which allow for the identification of thresholds for sustainable use of natural resources. Management plans are developed which indicate strictly protected zones and areas where use of natural resources is allowed. Currently, eight COBAs—approximately 900 households or 5,000 people—have volunteered for these natural resource management transfers (WWF, undated).

The Fandriana Marolambo project has made significant progress in a short time given the many challenges it has faced. These have included difficulties in hiring staff and consultants with the required expertise to address illegal production of sugarcane for rum, one of the main factors causing degradation to part of the forest corridor and not identified early on as a problem (Roelens et al., 2010). Managing expectations has been particularly difficult. WWF was the only outside organization working in some communities, and there was pressure to accommodate community requests not directly related to project objectives such as reproductive health advice and transportation needs.

Lessons Learned

- ✓ Given the extensive poverty within the project area, the restoration project required a comprehensive approach that has led to widespread support by communities and more lasting results. This integrated and innovative approach, however, made the project much more complex to implement and harder to sell to potential lenders and funders (Roelens et al., 2010).
- ✓ Forest restoration at a landscape level needs to be a long-term initiative. Five years is not sufficient, both from an ecological perspective and one of changing social and economic practices. Yet funders generally provide funding on a 1- to 5-year time horizon and long-term financing is a challenge (Roelens et al., 2010).
- ✓ The state is weak. Providing ongoing support for local coordinators as part of the project team has meant the project could progress even during political crisis at the national level (Roelens et al., 2010).
- ✓ Overall the high investment in local engagement has contributed to buy-in from the community. If the local communities are not convinced of its benefits, the restoration project will not succeed (D. Vallauri pers. comm., 2010). Also working with pre-existing community associations meant there were already structures in place for training and supporting locals in adopting new approaches (Roelens et al., 2010).
- ✓ All the steps of the restoration project (e.g., defining the problem, engaging stakeholders, designing the project, developing goals and objectives, monitoring, etc.) are critical but not as linear as they seem. They often need to be undertaken in concert and revised as more is learned. Some activities such as beekeeping or demonstration visits were not anticipated at the beginning of the project, but were developed later in response to community interests (Roelens et al., 2010).

In 2010, the Government established the 80,000 ha Fadriana Marolambo National Park, managed by Madagascar National Parks. Though many challenges remain to sustain and expand on the success to date, the comprehensive approach of integrating restoration at the landscape level was vital to building public support for the creation of the new national park.

Unsustainable use of natural resources, notably through slash and burn agriculture, by poor rural populations has led to the loss of an estimated 90 per cent of original forest cover in Madagascar: alternatives are required both to restore biodiversity and to sustain agricultural development. © Appolinaire Razafimahatratra (WWF)

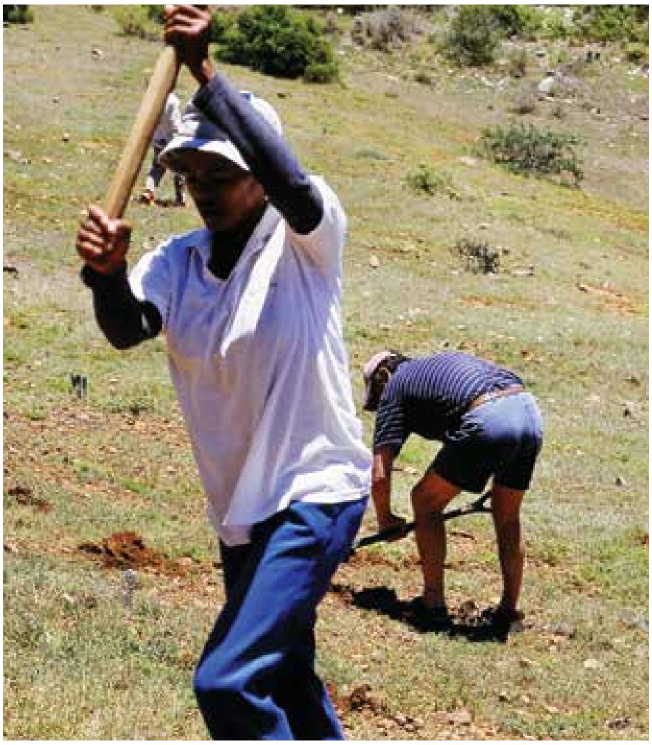
The key to success: the right species in the right site at the right time © Appolinaire Razafimahatratra (WWF)

6.4: Subtropical Thicket Restoration Programme, Working for Woodlands, South Africa: Poverty, carbon and restoration

Thanks to Mike Powell, Rhodes Restoration Research Group, Rhodes University, Ecological Restoration Capital, for his substantial contribution to the development of this case study. Thanks also to Andrew Knipe, WfWoodlands, for his input into this case study.

A government initiative to restore sub-tropical thicket provides training and capacity building for local communities (**Guideline 3.2**) to carry out planting and other restoration activities (**Guideline 1.2**). Its focus includes a range of benefits including carbon sequestration (**Guideline 2.3**) and poverty alleviation through rural employment (**Guideline 2.4**).

Some of the protected areas of the Eastern Cape in South Africa are relatively small and fragmented. A large-scale restoration effort that includes private lands is necessary to support the natural values of the protected areas, re-establish connectivity and resilience of the landscape, and achieve the goals of the Eastern Cape Biodiversity Conservation Plan (Berliner & Desmet, 2007).The South African Government started the Subtropical Thicket Restoration Programme (STRP), an initiative under the Working for Woodlands (WfWoodlands) Programme, in 2004 to create a new rural economy in the Eastern Cape through carbon sequestration and the restoration of spekboom- (*Portulacaria afra)* rich subtropical thicket. The WfWoodlands programme itself is part of a larger rural poverty alleviation initiative. The Department of Environmental Affairs, through the implementing agent Gamtoos Irrigation Board, has therefore provided training in restoration techniques and in life skills (e.g., primary health, HIV), employment for low-income rural workers, and business skills for new entrepreneurs.



The project employs low-income workers to restore degraded thicket and help alleviate rural poverty. © Mike Powell

Widespread degradation of thicket is a result of historical overgrazing and the spread of invasive species that inhibit natural regeneration of the landscape. The degradation of thicket also results in loss of ecosystem services and negatively impacts rural livelihoods, resulting in an estimated loss of R1,500 (rands) in annual potential income per household (Mills et al., 2010). Restoration of thickets can provide carbon sequestration as well as numerous benefits including restoration of biodiversity, control of soil erosion and improved water supply and quality.

Scientific studies have shown that spekboom and its associated ground layers of mulch, leaf litter and soil has a relatively high capacity for carbon storage, and that degraded thicket can be successfully restored at a low cost by planting cuttings taken from intact thicket. This research led to the decision, with support of the Eastern Cape Parks and Tourism agency, to pursue funding for the restoration through the international carbon market.

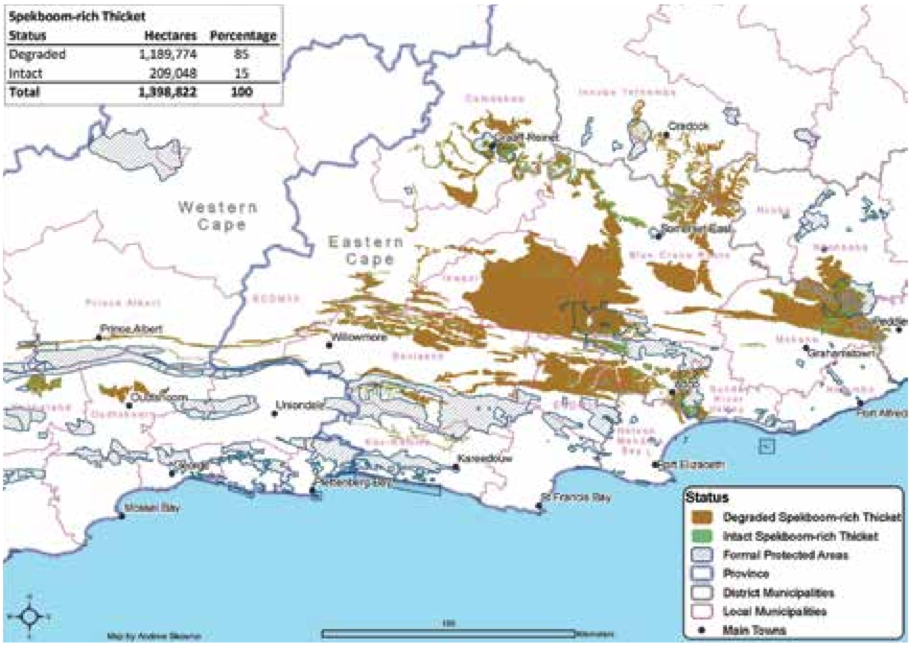
While the project has focused on carbon sequestration, it has sought to follow the Voluntary Carbon Standards and the Climate, Community and Biodiversity Project Design Standards, which require co-benefits of biodiversity and support for local livelihoods. The plantings are recent and sufficient carbon has not yet accrued, so the project has yet to be visited by a verification team. The Government is seeking to eventually sell the carbon on the voluntary market.

Natural regeneration of severely degraded thicket cannot be achieved simply by removing the stressor (goats); however, planting of cuttings has been shown to be quite effective in helping to re-establish thicket. Evidence from older restored plots (by Department of Agriculture and private landowners) suggests that within fifty years of restoration the biodiversity of vegetation may be able to re-establish (Mills et al., 2010). A major experiment (300 plots) was built into the project to gain knowledge, in part about how soils and climatic conditions affect spekboom survivorship as well as carbon accrual. Ongoing monitoring of the plots allows for continuous learning to inform project design and strategies based on, for example, the most cost-effective techniques for planting of cuttings (Mills et al., 2010).

Protocols outlined in Mills et al. (2010) for the development of suitable sites for restoration include:

a. Assessing historical coverage of spekboom-rich thicket to ensure suitable sites for restoration, and defining areas of degraded spekboom-rich thicket;
b. Assessing which sites will be suitable in the future under climate change, based on predictive modelling;

Fenceline shows degraded thicket and protected area restored under the STRP. © Mike Powell



Map showing the extent of degraded spekboom thicket and protected areas © Andrew Skowno, adapted from Mills et al (2010)

c. Considering proximity to abundant source of intact spekboom-rich thicket for harvesting of cuttings, both to minimize transport costs and to ensure the appropriate plant variety; and
d. Excluding livestock from restored sites for 3–5 years (since browsing negatively affects newly restored areas, it must be feasible to exclude them).

The project focuses its restoration efforts within protected areas where an estimated 61,000 ha are degraded. To date, it has restored 2,000 ha of degraded thicket in three protected areas in the Eastern Cape. From the outset, however, it was envisioned that the STRP would be a launching platform for private sector investment to scale up restoration activities on private lands with carbon credit funding (Mills et al., 2010, M. Powell, pers. comm., 2010 and 2011). With 1.2 million ha of degraded thicket, several companies have formed to help meet the challenge of restoring priority areas outside the protected areas. A landscape-scale initiative that includes restoration of degraded private lands enhances the natural values of the fragmented existing protected areas and re-establishes connectivity and resilience of the landscape.

One company, Ecological Restoration Capital, is pursuing several restoration projects that would combine a full suite of payment for ecosystems services (PES), including carbon, water and biodiversity. These values would be incorporated into project design and generate additional revenue to compensate local farmers for restoring their lands in areas that will enhance the conservation value of nearby protected areas.

Lessons Learned

- ✓ Given the highly fragmented and degraded landscape, restoration cannot be only a 'within-parks' strategy. Restoration in protected areas must be undertaken with a holistic view of the surrounding landscape and various actors, stressors and role players. Even in large protected areas such as the Baviaanskloof Nature Reserve, the actions of landowners in the surrounding landscape have a direct and fundamental impact on restoration activity. Current plans to restore alluvial fans will not be effective if there is no vegetation cover in the rangelands upstream to curb episodic flood events (M. Powell, pers. comm., 2010 and 2011).
- ✓ Additional tools are needed to secure investment on private lands such as contractual parks and stewardship areas. It is not feasible (in terms of cost or capacity) to continue to expand protected areas only through purchasing and management. In semi-arid landscapes, restoration is likely to take 30–50 years to achieve and requires intensive capital input. Stewardship agreements are, however, typically less than 30 years long and longer agreements are needed. In a changing socio-political environment and under severe duress landowners may not honour these agreements and switch back to sheep and goat farming which has been shown to be unsustainable (M. Powell, pers. comm., 2010 and 2011).
- ✓ Initial thicket restoration has focused on one species—spekboom—although future restoration aims to be more diverse. Research by several experts identify spekboom as an ecosystem engineer that when planted at appropriate densities will allow for autogenic succession over 30–50 years, i.e., succession driven by the biotic components of an ecosystem (Mills et al., 2010; van der Vyver, 2011). Another expert, Mike Powell, recommends employing a precautionary principle, particularly within protected areas of high biodiversity significance, by propagating additional plant species to encourage the recovery of the full biodiversity found in an intact system (M. Powell, pers. comm., 2010 and 2011).
- ✓ Restoring spekboom in degraded areas is largely still in an experimental phase. The scientific understanding of the occurrence of spekboom is still limited subject to a wide range of factors effecting their growth and restoration potential. It is no surprise therefore that restoration success is often very disappointing—or sometimes surprisingly successful (Powell et al., 2010).

6.5: Applying traditional ecological knowledge to forest restoration in Lacandon forest, Mexico

Thanks to Samuel Levy-Tacher for his substantial contribution to the development of this case study.

Lacandon community nursery producing 200,000 plants of 15 native trees © Francisco Román Dañobeytia

A fusion of traditional ecological knowledge (**Guideline 1.5, Guideline 2.4, Guideline 3.2**) from Mayan communities and western science has helped to restore forests on degraded lands in Chiapas. The Lacandon project involves extensive scientific experimentation and learning of traditional land-use systems to inform the technical aspects of restoration (**Guideline 1.2, Guideline 2.4**). It also involves engagement with farmers in research and restoration activities that provide economic benefits (**Guideline 2.4, Guideline 3.2**), training programmes in nursery management for local students (**Guideline 3.2**), and ongoing monitoring (**Guideline 1.6, Guideline 2.2**).

By learning about traditional ecological techniques from Lacandon Maya farmers in Southern Chiapas, Mexico, scientific researchers are gaining effective tools for the management of invasive species and forest restoration. Ethnobotanist Samuel Levy-Tacher and Don Manuel Castellanos Chankin (local Lacandon expert) have been working together in the Lacandon forest since 1993 to successfully adapt traditional techniques to restoration of degraded lands.

The Lacandon forest, located within the UNESCO Montes Azules Biosphere Reserve, is an area of exceptional biological diversity. The Mayan territory in southeast Mexico has long been shaped by human presence. For the Lacandon people, the traditional land-use system cycles through three stages including cultivation, a long fallow and natural forest succession. This system allows for soils to recover while providing local communities with a source of food, medicine, fuelwood and other ecosystem services during each stage and reducing pressure for conversion of tropical forest for agricultural use (Levy-Tacher et al., 2002). Migration of displaced populations in past decades, associated with social and economic change, have led to loss of traditional agricultural practices and intensification of land use and soil compaction, a reduction in species diversity, and the spread of invasive species (Levy-Tacher & Aguirre, 2005). In many cases, abandoned fields remain degraded and no longer naturally regenerate.

To recover and document traditional ecological knowledge (TEK), researchers have undertaken a range of different studies that include:

a. Identification of the most representative vegetation types and the ethnobotanical characterization of more than 400 species of native trees (Levy-Tacher et al., 2002, Levy-Tacher et al., 2006);
b. Increased knowledge of the key species and functional groups in the Lacandon agricultural productive system (Levy-Tacher, 2000; Levy-Tacher & Golicher, 2004);
c. Management of native tree species to promote restoration of soil fertility (Diemont et al., 2006);
d. Identification of successional pathways derived from different agricultural use patterns (Levy-Tacher & Aguirre, 2005);
e. Control of invasive bracken fern (*Pteridium aquilinium*) that inhibits natural forest succession (Douterlungne et al., 2010);

Trees established four years after the area was infested by Pteridium, in Selva Lacandona © Francisco Román Dañobeytia

f. Use of tropical early-, mid- or late-successional tree species for restoration of degraded pastures (Román Dañobeytia et al., 2007; Román Dañobeytia et al., 2012); and
g. A strategy to recover landscape connectivity by TEK in the Lacandon rainforest (Levy-Tacher et al., 2011).

As an example, Douterlungne et al. (2010) examined the effectiveness of traditional approaches to control an invasive bracken fern (*Pteridium aquilinium*) that inhibits natural forest succession. To control the fern, Lacandon farmers plant a fast growing balsa tree (*Ochroma pyramidale*), known locally as *Chujúm.* The balsa, found throughout Central America and northern South America, offers shade to prevent growth of the bracken fern while its leaf litter decomposes to replenish the soil and support colonization by native species. The study found that by applying Lacandon techniques of direct broadcasting of balsa seeds with weed control, lands which had been invaded and degraded by the fern for decades were quickly transformed into forest. In addition to providing good results, this approach is also cost-effective.

The 'fusion of traditional Maya knowledge with western science has begun to produce new management strategies aimed at restoring degraded lands.'[21] There are two traditional Mayan strategies that have been useful for ecological restoration: *tolches* and *fundo legal*. There was a strong tradition of leaving a strip of forest, about 20 m wide, on either side of all paths, around fields, and on the banks of rivers, ponds, and canals. These 'tree rows' prevented erosion and flooding along watercourses, and are known by the Maya people as *tolches*. On the other hand, all the local Mayan people had the custom of leaving a belt of forest about 2 km deep around the village known as *fundo legal*, a common area that could be lightly exploited for firewood and hunting, but otherwise remained intact. The villagers saw one of its additional benefits as the regulation of temperature, since the proximity of dense vegetation reduced the suffocating heat.

The application of this knowledge is illustrated with a project that began in 2005 in the community of Nueva Palestina, Lacandon rainforest, where actions were undertaken to rehabilitate degraded areas on a large scale. The project takes into account TEK and is based on the characterization and mapping of the areas of intervention and the use of *tolches* and *fundo legal* to promote landscape-level connectivity. To date a total of 320 ha is under different phases of ecological rehabilitation, with numerous experimental treatments involving the use of 20 multi-purpose native tree species that appear highly promising and complementary. These plots were established in abandoned pasture, bracken fields, low fallow and corn fields.

The project involves 100 Tzeltal farmers that own 2 ha/person on average, with an economic benefit of US$365/ha/year. Rehabilitation costs are funded by several government institutions and these fees have become an important economic source for farmers participating in the project. In 2010 the rehabilitation process areas were monitored in order to evaluate the survival and growth of trees planted in different

Restoration of pastures with native fast growing trees, Palenque, Chiapas © Samuel I. Levy Tacher

conditions. From this information, intervention strategies were improved (made more efficient) for the use of species, costs and benefits.

The project includes the participation of students and teachers from agricultural schools located in New Palestine (CECyT 25). High school students involved in seedling production comply with their social service and pre-professional practice requirements. To date they have trained 250 students and four teachers in nursery management. They receive an economic incentive and a certificate of training endorsed by El Colegio de la Frontera Sur (ECOSUR), which has had a collaborative agreement with this agricultural school since 2004.

Lessons Learned

✓ The value of TEK needs to gain more recognition by Western science, in particular by acknowledging its predictive ability and the feasibility of widely replicating traditional restoration approaches (S. Levy-Tacher, pers. comm., 2011).

✓ It is necessary to consult and involve traditional farmers as experts in the design and implementation of research. There is an urgent need to go beyond the publication of descriptive studies on the use of TEK and start understanding and using TEK through scientific experimentation (S. Levy-Tacher, pers. comm., 2011).

✓ Studies to validate TEK can inform the design of restoration strategies that are more likely to be adopted by local people (Douterlungne et al., 2010).

✓ Forestry expert Francisco Román states in Raices Mayas, a 2011 film about traditional land management in the Lacandon forest: '*I confess that before getting involved with these farmers I thought that the word 'traditional' meant a certain orthodoxy—old fashioned ways that rarely change though adaptable to contemporary situations. But now I see that these traditional farmers really have an open and innovative spirit. They are, in fact, the vanguard*.'[22] Indeed, traditional ecological techniques '*may be rooted in the distant past but turn out to be quite new to our eyes*'[23].

21 From the video Raices Mayas, 2010. 50:25.

22 From the video Raices Mayas, 2010. 53:26-54:10

23 From the video Raices Mayas, 2010. 53:06

6.6: Rehabilitation of the lower delta of the Senegal River in Mauritania

Thanks to Dr. Daf Ould Sehla Ould Daf, Director of Diawling National Park, and Olivier Hamerlynck for helping in the development of this case study, which draws heavily from Hamerlynck and Duvail (2003) and Hamerlynck and Duvail (2008).

Restoration of more natural hydrological systems (**Guideline 1.2**) in and around Diawling National Park has led to rehabilitation of the delta's mangrove ecosystems and the return of water bird populations, restoring the ecosystem services that local communities depend on for their livelihoods (**Guideline 2.3**). Support for livelihoods was central to the project to ensure benefits flow to local communities and encourage economic activities compatible with restoration goals (**Guideline 2.4**). Management of flood releases were adjusted over time based on close monitoring of the ecological, social and economic impacts (**Guideline 1.6, Guideline 2.2**) and input gained through stakeholder participation (**Guideline 3.1**).

By 1991, when Diawling National Park was established, the lower Senegal River Delta's rich floodplain, mangroves and dune systems had become a 'saline desert'. The Delta had been an internationally important site for wintering and breeding water birds, including cormorants, herons, spoonbills, pelicans, flamingos and many others. Years of drought and dam construction, designed to provide water for agriculture and hydropower, had effectively eliminated annual flooding to the lower Delta. This had a devastating impact on biodiversity as well as on the livelihoods of local communities dependent on natural resources for fishing, food gathering, livestock grazing and artisanal crafts. Furthermore, few of the positive local impacts from the dams materialized, with only about 20 per cent of the planned irrigation area cultivated because of increased soil salinity (Hamerlynck & Duvail, 2008).

Between 1991 and 1996, Diawling National Park, which covers 16,000 ha along the Mauritania side of the Senegal River, developed a management plan to restore ecosystem function to the wider lower Delta and support development of community livelihoods. This plan was part of a multi-phase collaboration between the IUCN and the Government of Mauritania, with support from the Government of the Netherlands. The establishment of the new national park was controversial, with local communities fearful that their access to natural resources would be restricted within the park (Hamerlynck & Duvail, 2008). In fact the restoration effort targeted about 50,000 ha and enhanced the provision of ecosystem goods and services that livelihoods depended on far beyond the park's boundaries.

To restore the pre-dam ecological integrity of the Delta, hydraulic infrastructure (embankments and sluice gates) were constructed to manage flood releases. Data were systemically collected on hydrological, biological, socio-economic and other effects to simulate different flood scenarios through a computer model. When flooding was reintroduced, it was done gradually to affect progressively larger areas and longer times. After each managed flood, the impact was monitored and assessed from a biodiversity and local livelihoods perspective. The flooding regime was then adjusted based on these impacts and stakeholder input (Hamerlynck & Duvail, 2003).

The project led to the rapid and spectacular rehabilitation of Diawling National Park and the lower River Delta (Hamerlynck & Duvail, 2008). The few mangrove stands that survived the drought and saline conditions are now healthy and produce large quantities of seedlings which are successfully recolonizing the estuary; annual and perennial vegetation cover increased tremendously and is visible on satellite. Floodplain fish and estuarine shrimp, mullet and shad returned to their spawning and nursery areas and crocodiles reappeared. The average number of wintering waterbirds increased from less than 6,000 in 1992–1993 to over 60,000 in 1994 (Hamerlynck & Duvail, 2008). This recovery brought enormous livelihood benefits to communities both outside the park and inside, as all traditional uses deemed compatible with biodiversity conservation were recognized and encouraged.

From the start, a participatory approach with support for development of local livelihoods was central to the project's design. The project provided support for new and traditional economic activities, such as training for women's groups to re-establish artisanal mat-making as a source of income and

Artisanal products produced by local women's groups © Diawling National Park

Restored fisheries © Diawling National Park

provision of capital through a rotational fund for purchase of equipment, e.g., fishing nets, boats, gardening tools, seeds, and sewing machines (Hamerlynck & Duvail, 2008).

One study by Moulaye Zeine (2004) estimated that communities derived an economic benefit of at least US$780,000 annually from the restoration and associated livelihood activities (Hamerlynck & Duvail, 2008). In other terms, Hamerlynck and Duvail (2008) estimated that based on the total area affected by the flooding, the investment in hydraulic infrastructure was about US$26/ha compared with the direct monetary benefit to households of at least US$1,300 annually. However, despite the successes and clear benefit of the project, widespread poverty still exists, and it remains a challenge to secure financing to maintain and replace the aging hydraulic infrastructure needed to maintain the restored flooding regime, let alone to expand the ecosystem restoration model to other parts of the Delta and Senegal River.

Lessons Learned

- ✓ The need to collect data was instrumental in creating a process that mobilized stakeholders and promoted a dialogue about optimal flood scenarios (Hamerlynck & Duvail, 2003).
- ✓ In creating the park, it was necessary to demonstrate that local communities would be able to continue to use the natural resources and that there was a commitment to developing alternative sources of income (Moulaye Zeine, 2004).
- ✓ By managing annual releases to return flooding to the Delta, ecosystem function and associated ecosystem services were relatively easy to restore. It is thought this was particularly successful because the ecosystem was very resilient: species had adapted to a highly variable system of extent and timing of flooding, so reacted immediately to favourable conditions (Hamerlynck & Duvail, 2008).
- ✓ Technical challenges remain around management of water levels and engineering, however, and require ongoing observation and refinement of approach (Hamerlynck & Duvail, 2003).

The restoration project helped produce the conditions necessary for the creation of a Transboundary Biosphere Reserve in 2005, which includes Diawling National Park and Chat Boul Reserve in Mauritania and Oiseaux de Djoudj National Park in Senegal. The challenge now is to involve all stakeholders in this much more complex and larger area in an effective, shared environmental governance arrangement with the authorities of both countries (Borrini-Feyerabend & Hamerlynck, 2011).

6.7: Restoration in protected areas of the Atlantic Forest in Brazil

Thanks to Ricardo Miranda de Britez, Society for Wildlife Research and Environmental Education, for his substantial guidance in developing this case study.

Photographic monitoring showing a planting area in one of three private natural reserves being restored © SPVS

Carbon projects (**Guideline 2.3**) have been used to finance restoration of protected areas and connectivity (**Guideline 1.4**) of critically endangered Atlantic Forest habitat in Brazil through a mixture of planting and natural regeneration (**Guideline 1.2**). Collaboration with local communities has been integral to the project (**Guideline 3.1**), including facilitation of reciprocal learning opportunities (**Guideline 3.2**) and promotion of economic benefits through local employment and alternative livelihoods (**Guideline 2.4**). Extensive monitoring and research (**Guideline 1.6, Guideline 2.2**) is ongoing, with results and lessons learned widely disseminated (**Guideline 3.3**).

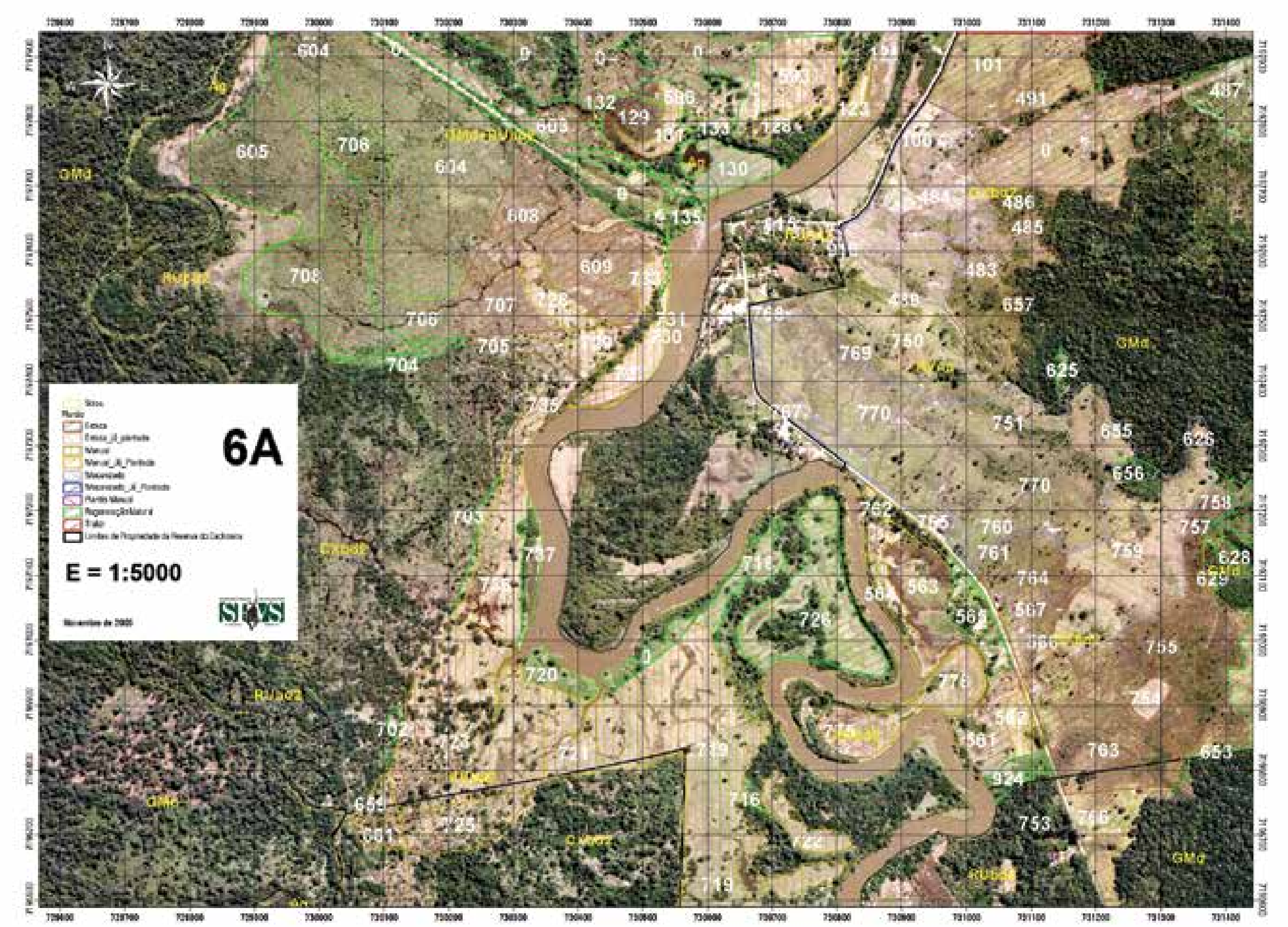
Brazil's Atlantic Forest is high in biodiversity but extremely fragmented with less than 10 per cent of its historical forest cover remaining (Metzger, 2009; Laurance, 2009). The Guaraqueçaba Environmental Protection Area (EPA), located on the coast of the southern state of Paraná, contains one of the largest forest remnants. More than half of Guaraqueçaba's forest tree species and nearly three-quarters of its other plants are endemic.

In 1999, the Society for Wildlife Research and Environmental Education (SPVS) and The Nature Conservancy (TNC) began an initiative to conserve and restore nearly 19,000 ha in Guaraqueçaba by restoring forest habitat and natural ecological processes and implementing carbon sequestration projects to mitigate climate change (SPVS, 2004). The partners established three private natural reserves (a category of the Brazilian protected area system): Serra do Itaqui, Rio Cachoeira and Morro da Mina Natural Reserves. Multiple project objectives (which encompassed the required focus, funding and partnerships) included:

a. Conservation of biodiversity through the protection of forests and restoration of degraded forest areas;
b. Implementation of projects for climate change mitigation through carbon sequestration;
c. Creation of income generating activities compatible with conservation goals;
d. Support for the empowerment of community in the Guaraquecaba EPA through the creation of organizations such as cooperatives and associations of small farmers;
e. Environmental education of protected area employees, visitors and communities;
f. Protection of water resources; and
g. Dissemination of information about these projects in order to successfully restore other areas.

In complement with the restoration work, SPVS has worked closely with local communities to draw on local knowledge and concerns in planning and implementing restoration activities. Conservation efforts have concentrated on restoring 1,500 ha of degraded pastures through reforesting 30 per cent of the area and encouraging natural regeneration by reducing grazing pressure. To improve survival of seedlings during the first years, maintenance includes weeding, mowing and organic fertilization. Over ten years, some 750,000 seedlings have been planted, sourced from two plant nurseries with the annual capacity to produce approximately 300,000 seedlings of several dozen native species (Ferretti & de Britez, 2006).

Since 1997, systematic collection of data has been critical in informing project activities. To better understand the area's ecology and contribute to of the project design, more than 70 experiments and studies were conducted in partnership with several research institutions. Research studies have examined the effectiveness of different methods of restoration, biodiversity indicators (soil fauna, butterflies, birds, etc.), natural regeneration of vegetation, and modelling of succession and ecological processes (pollination, seed dispersal, nutrient cycling, etc.) (see, for example, Bruel et al., 2010; Leitão et al., 2010; Cheung et al., 2010). Ongoing monitoring assesses plant species for growth rates, maintenance costs and performance in different soil types. All



Aerial photography scale 1:5,000, showing planting areas for use in planning, maintenance and monitoring © SPVS

data related to the restoration activities, including production of seedlings, planting, cultivation methods and monitoring have been stored in GIS and are used to assess results and costs of activities. As a consequence, substantial technical knowledge has been gained about production and planting of native species in this biome and the project approach has been adapted based on these findings.

The project was financed by three US-based private corporations[24]. Baseline measurements of carbon stock were carried out prior to the start of the project and 274 permanent plots were established in the restoration areas to measure carbon sequestration as a basis for generating carbon credits. Biomass monitoring is ongoing.

The project has also embraced a strong participatory process to empower local communities and help them develop incomes through activities more compatible with conservation alternatives, such as agro-forestry, eco-tourism and beekeeping. Emphasis has been placed on hiring local people and to date 65 locals have been hired as park rangers and for maintenance, administration and restoration jobs. Local communities have also sought support in the creation of new community associations and cooperatives, such as an eco-tourism partnership to promote responsible and equitable

Preparation of seedlings to be planted
© Ricardo Miranda de Britez, SPVS

24 American Electric Power, General Motors, and Chevron Texaco.

tourism. Technical support has helped develop agro-forestry systems for organic banana and heart of palm production, which has generated income and resulted in decreased pesticide use and fewer forest fires (which were used to create new banana plantations). SPVS and community partners have developed environmental education programmes designed for a range of audiences (e.g., employees and families, school children, community groups) to increase the appreciation and understanding of nature and the value of conservation. Information learned through the project has been widely disseminated.

This was one of the first projects to try to link climate change, biodiversity conservation and sustainable development. Although it remains a challenge to obtain additional financial resources necessary for continuity of long-term projects such as forest restoration, SPVS and TNC aim to replicate this project on a larger scale and add new initiatives. SPVS is also trying to attract new companies to invest in conservation, using Guaraqueçaba as a model and training centre aimed at raising awareness of the importance of biodiversity conservation for the maintenance of ecosystem services (R.M. de Britez, pers. comm., 2011).

Lessons Learned

- ✓ The technology developed through this project, such as strategies of planting fast-growing native species to combat invasive species of Brachiaria grasses, can be applied to restore degraded areas in similar conditions. Knowledge developed through the project has been applied to restoration of Salto Morato, another private reserve in Guaraqueçaba EPA.
- ✓ The restoration process is ongoing. About 30 per cent of areas still lack complete tree regeneration, attributed to the more humid soils found in these areas. To address this, future activities will prioritize the eradication of Brachiaria grass which prevents the flow of water in small streams and increases soil humidity, thereby impairing tree development.
- ✓ It is important to promote self-organization of the community through support for cooperatives and associations. This empowerment requires training and education, and consideration of impacts on communities over short-, medium- and long-term horizons.
- ✓ How the results will be disseminated, e.g., through meetings, lectures, papers, field visits for landowners, etc. should be carefully planned so outcomes can be communicated, replicated and improved.

The joint approach of restoration and support for local livelihoods, financed partly through the private-sector, offers a model that may be replicated in other protected areas (R. M. de Britez, pers. comm., 2011)

6.8: Habitat 141°: Restoring habitats and linking protected areas in southern Australia

Thanks to Ian Walker, Parks Victoria, for his substantial contribution to this case study.

Habitat 141° provides an example of restoring functional connectivity within and beyond the boundaries of protected areas (**Guideline 1.4**), extending restoration to a landscape scale that accounts for the diverse interests and concerns of multiple partners and stakeholders (**Guideline 2.1**), and embracing a long-term vision of stakeholder participation, planning and decision making (**Guideline 3.2**).

Habitat 141° is a long-term initiative that aims to work collaboratively to restore and connect the wider landscape and enhance the natural and cultural values of existing protected areas in southern Australia. It is one of six landscape-scale initiatives underway in Australia, collected under the Linking Landscapes collaboration, which are creating continental-scale connectivity conservation corridors to address the impacts of climate change (Worboys et al., 2010b). Although southern Australia has an extensive network of protected areas[25], they are surrounded by some of the country's most fragmented and highly modified (primarily for agriculture) ecosystems.

The project area extends over 20 million ha (slightly less than the total land area of England and Scotland) across three state jurisdictions (South Australia, New South Wales and Victoria) and is named after the longitude it follows: 141°. It encompasses a diversity of ecosystems including rangelands, heath, mallee (small, multi-stemmed Eucalypt trees), red gum (*Eucalyptus camaldulensis*) forests and floodplains, grassy woodlands and the limestone-rich coastal plain[26]. Restoration is contributing to the maintenance or recovery of 107 nationally listed threatened species, including the malleefowl (*Leipoa ocellata*), black eared miner (*Manorina melanotis*), Major Mitchell cockatoo (*Lophochroa leadbeateri*), and brush-tailed rock wallaby (*Petrogale penicillata*), as well

25 The Habitat 141° region includes two World Heritage sites, two National Heritage sites, six Ramsar sites, in excess of 2000 conservation reserves over a dozen National Parks, two Indigenous Protected Areas and a number of privately owned conservation reserves.

26 http://www.habitat141.org.au/about/

as three nationally threatened ecological communities, Buloke woodland communities, grassy woodlands and many orchid species.

An important part of the Habitat 141° vision relates to habitat 'connectedness' in terms of maintaining or increasing permeability of terrestrial and aquatic systems. In some areas this may involve restoring 'stepping stones' or corridors along rainfall gradients in ecological systems, including the River Murray floodplains, coastal strip, and lowan sand systems of the Little Desert. The project focuses on increasing the area of available habitat and restoring east-west connectivity (Koch, 2009).

Habitat 141° has four major focuses (I. Walker, pers. comm., 2010 and 2011):

a. Mobilizing rural and regional communities through partnership between private and public landowners, land managers, investors, special interest groups and volunteers (Habitat 141° has so far allied 22 member organizations, including Greening Australia, Parks Victoria, Wilderness Society and Victoria Naturally Alliance as key partners);
b. Using the strengths, skills and knowledge of members to apply resources efficiently to achieve high-yield, value-for-money outputs;
c. Embedding a lasting philosophy of environmental stewardship in communities; and
d. Focusing investment on priority areas identified through 'conservation action planning' (Habitat 141° has adopted systematic planning from regional to continental scales and is using the Nature Conservancy's Conservation Action Planning (Koch, 2009) to develop co-ordinated and targeted planning).

Map of the Habitat 141° initiative © Greening Australia, Victoria

Climate change is expected to have major impacts in Australia (Preston and Jones, 2006) and is likely to exacerbate existing threats. Conservation driven responses to this threat are based on improving the resilience of natural systems and their ability to adapt (Dudley et al., 2010). However, the scale, intensity and pace of response to many of these problems need to be substantially increased. Habitat 141° aims to help secure resilient landscapes in which genes, species, flora and fauna assemblages have the potential to survive and evolve under an adaptive management regime. By protecting and restoring degraded, fragmented lands the project hopes to improve the connectivity of protected areas and enhance the ecosystems services they provide. Restoration activities focus on increasing the viability of depleted or fragmented plant and animal populations through habitat expansion. Connectivity is a key objective, as is facilitating species dispersal by increasing structural connectivity, vegetation buffers, stepping stones and mosaic habitats (Koch, 2009).

Habitat 141° has focused its efforts on building and establishing a governance model for collaboration. It also has undertaken (or is in the process of conducting) coordinated planning for nine zones across the region. The planning process identifies and assesses focal conservation assets and priorities for protection and restoration to enhance the natural values of the area. As a result of this planning a number of projects ranging in size, aim and focus are already underway:

a. Led by Habitat 141° member 'bankmecu' (an Australian bank), three properties totalling over 600 ha of critical connectivity habitat have been acquired in Victoria. The Buloke and Desert Stringybark woodlands provide habitat for the threatened red-tailed black cockatoo (*Calyptorhynchus banksii*) and other rare species that are threatened by loss of habitat in a fragmented landscape. In partnership with the community, bankmecu is actively revegetating these areas. These projects fit within the larger framework of Habitat 141° by conserving and restoring private lands that will support species that are not adequately supported by existing protected areas and facilitate their movement and survival in a changing climate[27].
b. Trust for Nature, Greening Australia and The Grampians Little Desert Biolink have worked together to secure one of the few remaining populations of swamp she-oak (*Casuarina obesa*), also a threatened species in Victoria. The project involves 90 ha of land protected by covenant and 10 ha of Buloke woodland restoration (Habitat 141°, 2010b). Overall the project contributes to the quality and extent of native habitat between the Grampians and Little Desert National Parks and contributes to the connectivity priorities.

27 www.bankmecu.com.au/why-bank-with-us/sustainability/environmental/conservation-landbank.html

Greening Australia's Biodiverse Carbon restoration with view of Mt. Arapiles. The property was purchased and restored strategically to directly improve habitat connectivity within the Nurcoung Link, a priority corridor within the Habitat 141° vision. © Gail Weston, Wimmera Conservation Volunteers Australia

c. The Woorinen Recovery Project, developed as a result of Habitat 141°, is a collaboration of the Murray Mallee Local Action Planning Association Inc. (MMLAP), Greening Australia and government agencies to enhance and extend the understorey of the shrubby dunetops and open swales to complement the natural values of a nearby Conservation Park (Bakara) (Habitat 141°, 2010b; MMLAP, 2009). The project is restoring critical habitat for a range of rare and threatened Mallee birds that are in decline such as the purple-gaped honeyeater (*Lichenostomus cratitius*), the southern scrub-robin (*Drymodes brunneopygia*) and the white-fronted honeyeater (*Phylidonyris albifrons*) (Government of South Australia). Restoration activities are focused on 350 ha of dunetop vegetation, and include revegetation with native plant species, grazing management and weed control. The project is also helping to strengthen the collaboration of multiple organizations and, through the mobilization of volunteers, to build awareness of Habitat 141° and support for the management of protected areas (Government of South Australia, undated).

Lessons Learned

- ✓ The overriding lesson learned is the critical importance of developing a vision with many partners. Having a vision that enables and empowers people is fundamental, as it is the ability to inspire and encourage people to do something different that makes the outcomes on the ground real and tangible (I. Walker, pers. comm., 2010 and 2011).
- ✓ Getting the balance right between top down and bottom up. It is clear that people do not want to feel controlled, pressured, directed or owned by some overarching entity, just as the overarching entity is seeking improved alignment coordination and direction. One of the challenges has been the relationship between government and NGOs. The 'new role' of government organizations as a facilitator is now better recognized, as is the role of NGOs to harness resources and community passion. Any relationship between multi-sector partners takes time to build consensus and deliver on the ground. This is the first multi-sector partnership involving such a diversity of partners to occur in Australia (I. Walker, pers. comm., 2010 and 2011).
- ✓ Habitat 141° has required the development of a governance model for decision making and collaboration. (I. Walker, pers. comm., 2010 and 2011; Habitat 141°, 2010a).

The Habitat 141° vision is to work with communities to conserve, restore and connect habitats for plants and wildlife from the ocean to the outback.

Habitat 141° ocean to outback

6.9: Restoring the land and honouring the history of Lyell Island in Gwaii Haanas, Canada

Thanks to Marie-Josée Laberge and Laurie Wein for their substantial contributions to this case study.

School children during salmon fry release at Lyell Island, Gwaii Haanas © Parks Canada

An ecological restoration project on Lyell Island on Canada's west coast has linked stream and riparian forest restoration with the cultural significance of the area to the indigenous Haida people (**Guideline 1.5**). The project offers a model for collaborative decision making and management (**Guideline 3.1**) and fosters a sense of connection and long-term support for the protected area through visitor engagement (**Guideline 3.4**) and extensive involvement of younger people in restoration activities (**Guideline 3.2**).

Lyell island, part of the archipelago protected as Gwaii Haanas National Park Reserve and Haida Heritage Site, is a place of great significance to the Haida Nation. Meaning 'Islands of Beauty' in the Haida language, Gwaii Haanas embodies the essence of the beauty and rich ecology of the Pacific coast of Canada. The island is an icon in the history of Gwaii Haanas and an important symbol of the Haida struggle to protect their natural and cultural heritage.

Lyell Island is one of the largest (17,300 ha) islands in the archipelago, with well-developed and intact forest ecosystems in the unlogged watersheds. Prior to its protected area status, Lyell Island had seen extensive logging activity that led to degradation of forest ecosystem function, including damage to stream channels and the loss of suitable spawning and rearing habitat for several species of salmon. Salmon is a mainstay of the traditional Haida diet, an important symbol for the Haida Nation as illustrated by its presence in many Haida legend, and a vital economic resource for the remote Haida communities.

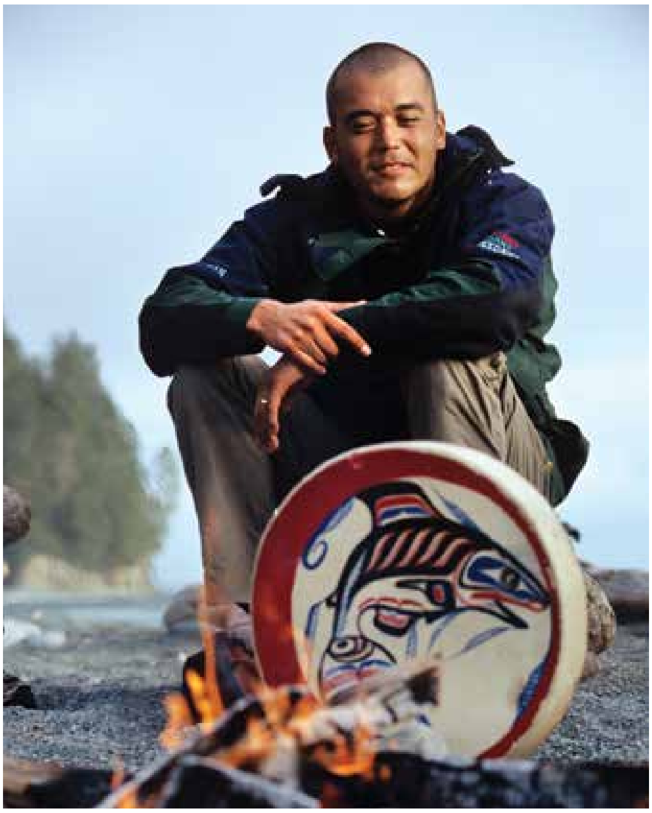
In 1985, elders of the Haida Nation led an historic political standoff on Lyell Island to protest against unsustainable logging on their traditional lands. These protests ultimately led to the 1993 designation of Gwaii Haanas National Park Reserve and Haida Heritage Site and the establishment of the cooperative management model in protected areas management—a unique development at that time in Canada. Today, management decisions about Gwaii Haanas, including those about restoration activities, are made jointly and through consensus by the Archipelago Management Board, which comprises representatives of the Government of Canada (Parks Canada) and the Haida Nation.

In 2009, the Park Reserve launched an initiative to restore degraded streams and adjacent riparian forests to support re-establishment of self-sustaining salmon populations in the islands creeks. The project is not only restoring ecological integrity of the Park Reserve ecosystem but is supporting the traditional and commercial fisheries of the region and reconnecting the Haida people with this important symbol of the Haida struggle to protect their natural and cultural heritage.

Activities focus on three creeks, Sandy, Takelly and Powrivco, covering a total of 2.5 km of stream channel and 15 ha of adjacent riparian forest. Traditional knowledge, along with quantitative data of the historical salmon runs of the area, informed the selection of creeks for restoration. An old-growth forest (Windy Creek) where no logging had occurred serves

Winching a tree into place during stream restoration at Sandy Creek on Lyell Island, Gwaii Haanas © Parks Canada

Juvenile chum salmon being released on Lyell Island, Gwaii Haanas © Parks Canada



Park interpreter with Haida drum depicting salmon, Gwaii Haanas, Canada © Parks Canada

as the reference ecosystem. The addition of large woody debris to streams and stabilization of banks aims to increase stream channel complexity, thus providing improved habitat for spawning salmon. Chum (*Oncorhynchus keta*) salmon broodstock were collected from streams in the autumn of 2010 and raised in a hatchery and released in the spring of 2011 into restored creeks (L. Wein, pers. comm., 2011).

In riparian forest areas adjacent to the creeks, secondary forest is being restored through the creation of canopy gaps to emulate old-growth characteristics and to provide a future source of woody debris for streams. Monitoring of stream health and riparian forest health is ongoing and will continue in the long-term (Muise, 2010).

Haida Fisheries (the fisheries management organization of the Haida Nation), Hecate Strait Streamkeepers and Fisheries and Oceans Canada are key partners in stream restoration and salmon enhancement work. Fieldwork activities, including the building of in-stream structures and monitoring and research, are undertaken by both Parks Canada and Haida Fisheries staff.

Project results have, and continue to be, disseminated widely through reports, journal articles, media outreach and conference presentations. In November 2010, the Council of the Haida Nation recognized the 25th anniversary of the 1985 protests by holding a celebration, including a potlatch (a west coast First Nations ceremony where witnesses are paid, commonly through gifts, to provide testimony of significant events), to commemorate their struggle to protect the area and recognize the 80 elders who 'stood the line at Lyell'. As part of the celebration, the Gwaii Haanas National Park Reserve and Haida Heritage Site showcased the restoration and salmon enhancement work.

One important aspect of the project has been to engage young people in the restoration activities. Programmes developed in partnership with Parks Canada and Fisheries and Oceans Canada aim to raise awareness about the ecological and cultural significance of salmon. School children have been actively involved in projects to learn about the salmon lifecycle, including setting up fish-tanks in classrooms to raise salmon fry from Lyell Island broodstock, and have been involved in releasing the fry into restored creeks. Haida elders and representatives also give talks to school children about the significance of Lyell Island to the Haida, from the anti-logging demonstrations to the success in gaining control over the management of traditional lands and protection of the area for the benefit of future generations.

Lessons Learned

- ✓ By engaging visitors, community members and young people in hands-on ecological restoration activities, the project fosters an increased understanding of the importance of ecological integrity and the significance of Lyell Island to the Haida people and to all Canadians (Parks Canada, 2011e).
- ✓ The Park Reserve's cooperative management body, the Archipelago Management Board, has provided an institutionalized structure of decision-making that supports consensus building and has enabled stakeholders to develop project goals and objectives that are appropriately grounded in the ecological, cultural and community context of the Haida Nation (L. Wein, pers. comm., 2011).
- ✓ The Lyell Island initiative highlights the connection of the living culture of the Haida people to the land and sea. The benefits of this project go beyond the restoration of Haida land and the return of the salmon to the creeks of Lyell Island; it rebuilds the strong connection of the Haida people with the land and the sea, the return of the salmon being one symbol of that strong connection (Parks Canada, 2011e).
- ✓ Robust and productive partnerships with other government agencies has resulted in both efficiencies in project implementation, and has maximized restoration impacts, particularly in this remote island environment where project costs can escalate if off-island expertise is sought. In particular, strong partnerships with on-island agencies (Fisheries and Oceans Canada and British Columbia's Ministry of Forests, Lands and Natural Resources Operations) have been fruitful in advancing successful project outcomes (L. Wein, pers. comm., 2011).

'Our island groups collectively ask not what our streams could do for us but what we could do to help our streams,' says Peter Katinic, Haida Fisheries Biologist. 'The Lyell Island Restoration Project is a great example of how island groups can join forces to help our fisheries resource.'

6.10: Restoring the marshlands of Iraq

Thanks to Dr. Nadia Al-Mudaffar Fawzi (Head of Research and Development Department) and Prof. Malik Hassan Ali (General Manager) Marine Science Centre, University of Basrah, for their substantial joint contribution to the development of this case study.

Remnant water and some dry reeds in Al-Safeya Reserve in late 2008 following reductions in water flows to the marshlands © Marine Science Centre, University of Basrah

Efforts to restore Iraq's unique marshlands, destroyed as part of a strategy of social suppression, have provided important benefits both in terms of recovering some unique ecosystems and also as a way of rebuilding cultural heritage (**Guideline 2.4**). One of the biggest challenges has been coordination of development policies and programming (**Guideline 2.5**) among the many national and international agencies undertaking activities in the region. Several projects at the local level have focused on building long-term relationships with the communities around planning and capacity building (**Guideline 3.1, Guideline 3.2**). Effective communication (**Guideline 3.3**), research and monitoring (**Guideline 1.6**), and the design of governance mechanisms to secure restoration investments (**Guideline 2.2**) have also been important elements of the projects.

Iraq's southern marshlands, formerly one of the greatest expanses of marshland in Eurasia, were once famous for their biodiversity and cultural richness. They provided important bird habitat and a flyway between Siberia and Africa; served as spawning grounds for fish species including *Barbus (Mesopotamichthys) sharpeyi* and *Barbus (Luciobarbus) xanthopterus* and a nursery for panaeid shrimp (*Metapenaeus affinis*). The marshes were also an important natural filter for polluted water from the Tigris and Euphrates Rivers before they entered the Arabian Gulf. Other important biodiversity included crustaceans such as *Atyaephyra desmaresti mesopotamic* and *Parhyale basrensis*; bivalves including *Pseudodontopsis euphraticus* and *Parhyale basrensis*; and plant species including *Phragmites australis* and *Typha domingensis.*

In addition to their ecological significance, the marshlands have unique heritage values. They played a vital role in the economic and social advancement of the local indigenous communities—the Marsh Arabs or '*ma'adan'*—for millennia. They are regarded as the site of the 'Garden of Eden' and are the homeland of the Abrahamic religion, containing many sites of archaeological importance.

Centred at the confluence of the Tigris and Euphrates, the marshlands are formed by permanent and seasonal shallow and deep water lakes, as well as mudflats that are regularly inundated during periods of seasonal flooding. The marshes are divided into three major units:

a. The Al-Hammar marshes on the west banks of the Euphrates and Shatt Al-Arab Rivers (when the Hammar marshes were still intact, the permanent lake in Al-Hammar was the largest water body in the lower Euphrates at 120 km-long (UNEP, 2005));
b. The Central (Al-Qurnah) marshes, bordered by the Tigris River to the east and the Euphrates River in the south, which covered an area of about 3,000 km^2 extending to well over 4,000 km^2 during flood periods; and
c. The Al-Hwaizeh marshes to the east of the Tigris River between the Iraq-Iran border.

Al-Safeya Reserve in February 2007 © Marine Science Centre, University of Basrah

Local people using the wetlands of the Al-Safeya Reserve
© Marine Science Centre, University of Basrah

The most serious threat to the marshes has been the drainage and diversion of water supplies for agriculture and oil exploration and production. This threat was exacerbated after the first Gulf War. The unsuccessful uprising of Shiite Muslims, who used the lush reeds and maze of waterways as a way to hide out, led the former regime to drain the marshes deliberately through construction of dykes to remove the threat of further insurgency. The culture of fishing and rice production was replaced with dry agriculture (Lawler, 2005). This deliberate destruction had a devastating impact on the ecosystem; endangering species and the Marsh Arabs, who were forced to abandon their culture as their environment was destroyed. The full extent of the destruction became clear when UNEP released satellite images in 2001 showing that 90 per cent of the marshlands had been lost (UNEP, 2009).

Since the fall of the regime in 2003, the high-level attention given to re-flooding and restoring the marshlands reflects their ecological and heritage significance to Iraqis and the international community. A new state ministry for the Marshes was created to coordinate the restoration and the protection of the marsh environment and its communities. Many foreign governments and international agencies have undertaken activities to support the restoration process of the marshes including UNEP, which has provided scientific and logistic support to rehabilitate the marshes and facilitate the return of the marsh Arab communities to their homeland. The Ramsar Convention on Wetlands came into force in Iraq in February 2008, and Iraq presently has one site, The Hawizeh Marshes, designated as a Wetland of International Importance.

The Iraqi Government's current goal is to restore the marshlands to 75 per cent of the 1973 area. Since 2003, levels have fluctuated. It has not been possible to sustain the quantity and quality of water to feed the marshes owing to many unforeseen conditions including frequent droughts and increasing high temperatures, as well as the continued pollution of the rivers feeding the marshes from agricultural runoff and raw sewage discharge. Dams on the Euphrates in Turkey and Syria now control the volume and timing of water coming into the marsh; as a result the total volume of incoming water has diminished and the spring flood pulse has dropped by two-thirds (Lawler, 2005). However some progress has been made: by January 2011, the Marshlands area had recovered by 45 per cent mainly owing to hydraulics projects undertaken on the Euphrates to divert water to the Al-Hammar marsh (UN, 2011). A biotic survey from 2004 to 2005 from the Al-Hammar and Suq Al-Shuyukh marshes indicated that most macrophyte, macroinvertebrate, fish and bird species were returning to the restored marshes, although densities were low compared with historical records (Richardson & Hussain, 2006).

Restoration activities are occurring throughout many areas of the marshland. In 2005, as one example, the Iraqi Ministry of Agriculture put forward a plan to establish the 'Alsafia Reserve' as a protected area in the Al-Hwaizeh Marsh on the Iraq–Iran border. The Marine Science Centre (MSC) of the University of Basrah, which has participated extensively in research activities undertaken in the marshlands, worked closely with the government to develop the Alsafia Reserve area concept. To move the concept forward, MSC has led research and training activities and is providing recommendations for developing protected area laws based on international protocols for restoration and protection, which currently do not exist in the country. An establishment plan for a restoration programme was developed and included three main stages: (a) determine the location and establishment of a small research field laboratory; (b) develop a community awareness and educational media campaign on the need for restoration and (c) develop a database to record baseline data. After two years of effort, and substantial funding spent on the restoration programme, the initiative has unfortunately faced serious setbacks including lack of coordination among provinces concerning the water budget and among donor countries and UN programmes around the restoration efforts. Capacity is also a problem as there is a lack of prior experience and knowledge of planning and managing protected areas. These problems are not an isolated case. Other recent efforts to revitalize the marshes have met with serious challenges in governance and human development. National and regional planning lack an overall vision for the sustainable development of the marshes and the well-being of its people, with requirements for water and other basic services still largely undetermined.

Local community-based projects are perhaps the way forward. The MSC is working with the community of Al-Malha village, on the edge of Al-Hammar marsh, on several projects including restoration of local marshes and reintroduction of important fish species. Engagement with the community elders (men and women), as well as wider discussions with service providers and community groups, has resulted in a number of priority actions including:

a. Securing financial contributions from oil companies for restoration as part of their social responsibility;
b. Providing support for the community to develop a restoration plan for the designated area that includes a long-term monitoring plan;
c. Using traditional practices in the restoration process (one important component of the project is to record the stories of older men and women as a resource for future generations on traditional environmental management used prior to the destruction of the marshes); and
d. Using the restored area as a model to provide the tools and knowledge to restore nearby areas, with the eventual aim of restoring neighbouring patches to reconnect the ecosystem.

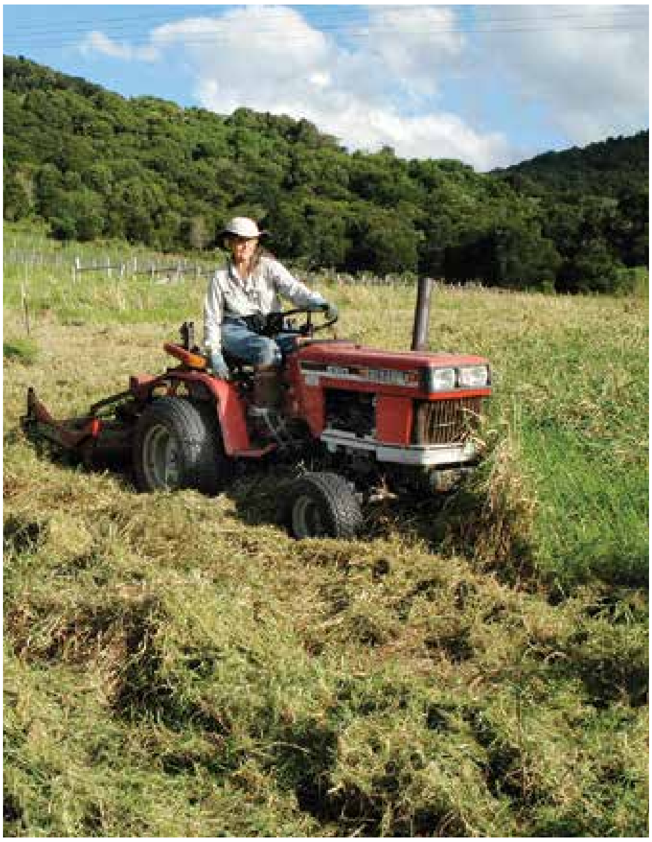
Lessons Learned

- ✓ The destruction of the marshes occurred relatively recently and local traditional practices (e.g., TEK) need to be recorded and incorporated in the restoration and future management of the marshes. In particular, donors and/or technical support staff need to consider these traditional methods when developing restoration projects.
- ✓ Marshlands management and governance regimes need to be clearly documented and respected.
- ✓ Restoration projects must include consideration of the role of civil society, the private sector and the international community in marsh development. A first step in the development of restoration projects must be dialogue and agreement with all interested partners, including the community, to plan initiatives.
- ✓ There is a need to balance environmental protection with socio-economic development (defining land-use priorities). Any future rehabilitation must acknowledge these competing sectors and strike a balance between development and restoration.
- ✓ Many community leaders see the benefits of the restoration in their locality but they feel action is beyond their capacity. International donors and the Iraqi government need to recognize the importance of partnerships with local communities and capacity building.
- ✓ For restoration programmes to achieve long-term success, legislation, in particular for protected areas, needs to be in place.
- ✓ Oil companies working in the area should be involved in restoration projects and help provide long-term, sustainable financial and technical contributions as part of their social responsibilities.
- ✓ Start small. The ultimate goal of large-scale initiative should be developed through small, relatively cheap restoration projects to build up local skills and interest in restoration.

The future protection of the marshes, through appropriate conservation and management practices, is recognized as crucial for their survival. Various protected area approaches, including Ramsar sites, nomination for World Heritage designation and National Park status, are being developed (UN, 2011). However it is clear that restoring, managing and protecting the marshes will only be possible if the indigenous Marsh Arabs are fully involved in the process and there is sufficient water to support essential ecological processes (Stevens, with Ahmed, 2011).

6.11: The Springbrook Rainforest Project: Restoring World Heritage rainforests in Australia

Thanks to Aila Keto, President, Australian Rainforest Conservation Society Inc., for developing this case study.



Flat valley floors dominated by stoloniferous, rhizomatous mat-forming South African pasture grasses require management interventions guided by ecological conceptual models, resilience theory and plot-based monitoring to assist natural regeneration. © Keith Scott

The Springbrook project is restoring critical rainforest habitat, connectivity and resilience (**Guideline 1.3, Guideline 1.4**) within a key refugium of the Gondwana Rainforests of Australia World Heritage Area. The project is based on both natural and assisted natural regeneration (**Guideline 1.2**) within an adaptive management framework relying on research and monitoring (**Guideline 1.6**), and volunteer and stakeholder engagement (**Guideline 3.1**). Project partners have implemented robust planning to establish long-term capacity and commitment that ensures secure governance arrangements and fosters financial sustainability (**Guideline 2.2**).

The Gondwana Rainforests of Australia World Heritage Area (GRAWHA) provides climate refugia for a wide range of ancient lineages of plants and animals. The high-country cloud forests of the Springbrook Plateau in the McPherson Ranges represent the wettest core of the GRAWHA. This area is the closest present-day analogue of wetter and more equable palaeo-climates under which the ancestry of the world's songbirds evolved more than 30 million years ago. Springbrook contains nearly 1,100 species of native plants, over 200 species of fungi, and more than 220 species of native animals including 31 frog, 50 reptile, 183 bird and 43 mammal species in little more than 5000 ha. However, most of the plateau area of 2000 ha had been repeatedly cleared over the past century, damaging or destroying many of the refugium's buffers responsible for its resistance to climate change. The Springbrook project, starting in 2005, is a long-term project aimed at restoring those critical habitats and buffers as well as restoring landscape-wide functional connectivity between poorly configured parts of the existing National Parks and World Heritage area.

Between 2005 and 2009, in Stage 1 of the project, the Queensland Government spent AUS$40 million purchasing land (760 ha) adjoining Springbrook National Park in the Gold Coast hinterland. The majority of this land was recently gazetted as National Park or National Park (Recovery) under the Queensland Nature Conservation Act 1992. In 2008, the Australian Rainforest Conservation Society Inc. (ARCS)[28] entered into a 20-year legal agreement with the State of Queensland to restore rainforest and associated vegetation, *pro bono*, on 268 ha of National Park. ARCS own a further 205 ha with strict covenant protection, which is also part of the project. The project is multifaceted and multidisciplinary, involving collaborative, community-based ecological restoration and scientific partnerships, and is breaking new ground on many fronts:

Engaging volunteers from local and broader communities in weeding provides rich learning and sharing experiences. © Aila Keto

28 ARCS is a not-for-profit community conservation organization, established in 1982 to conserve and restore biodiversity, especially that of rainforests and related forests.

Twin Falls in Springbrook National Park, part of the Gondwana Rainforests of Australia World Heritage Area, draws its water from the Boy-ull Creek Catchment which was extensively and repeatedly cleared in the past and now is being restored to re-establish critical habitats, connectivity and resilience. © Mark Ash

a. The project represents a paradigm shift in reserve selection from primarily 'undisturbed' remnants to including abandoned pastures for strategic reassembly of fragmented communities.
b. The restoration is science-based, using explicit conceptual models of social-ecological systems and resilience theory to direct, monitor and review on-ground practices.
c. Social, economic and ecological conceptual models are integrated across multiple scales to more comprehensively understand and address the drivers of system change.
d. Social learning is considered integral to successful outcomes and to ensuring World Heritage has a function in the life of the community; conceptual models enable better targeting and testing of effectiveness and efficiency of adopted approaches.
e. Adaptive management uses emerging monitoring technologies such as autonomous wireless sensor and multi-media networks to monitor ecological community and ecosystem processes and habitat recovery in real time, in remote locations and complex terrain, and at catchment scales that would be impossible by traditional means.
f. Long-term monitoring and regular reporting against baselines, indicators and targets allows continual review and adjustment of objectives, assumptions, risk projections and management.
g. The project is based on assisted natural regeneration and aims to generate broadly applicable generic principles based on functional attributes to achieve more cost-effective restoration at ecologically meaningful scales.
h. Work is primarily conducted *pro bono* by dedicated volunteers and retired scientists.
i. Long-term financial security of the project is provided by two ecotourism accommodation businesses run by ARCS where all profits are directed to restoration, research and monitoring.
j. Governance arrangements have statutory protection to enhance long-term sustainability.

The project provides a case study for improving knowledge, capacity, strategies and design of enabling technologies to facilitate restoration. Since most of the Springbrook plateau was cleared and burnt (often repeatedly) over the last 100 years, the present-day mosaics of vegetated and cleared areas represent excellent chronosequences for study of successional responses to a wide range of past human disturbances and compressed environmental gradients (e.g., 200–1050 m altitude, 1800 to >3500 mm annual rainfall, leached skeletal soils to deep, nutrient rich basalt-derived soils) within a relatively small area of complex terrain.

Trials are underway, in collaboration with CSIRO[29] and the Queensland government[30], using a state-of-the art wireless sensor network with 175 sensor nodes and 700 individual sensors (one of the largest continuously operating networks of its kind in the world). It provides long-term, catchment-wide micrometeorological (including cloud base and cloud immersion) and soil hydrological data for evaluating abiotic

29 CSIRO (the Commonwealth Scientific and Industrial Research Organisation) is Australia's national, government-funded science agency and leading publisher of scientific and technical research.

30 DERM: the Department of Environment and Resource Management within the Queensland government.

drivers of habitat quality and ecosystem dynamics[31]. Biotic responses are monitored, in part, by dendrometers, sap-flow sensors, wireless multimedia sensor networks, microphone arrays and camera trapping, which complement long-term demographic monitoring data from stratified plots. These are powerful technologies that can transform understanding of the life histories and complex interactions between species and their habitats, of how refugia function, and thus enhance the capacity for more efficient and effective restoration and monitoring.

Management of invasive species is an inevitable and costly part of restoration. While up to 130 invasive plant species occur on these restoration lands, initial priority is given to the most seriously invasive and damaging species in a pilot programme aimed at developing more cost-effective management strategies. An overarching social-ecological systems framework for cross-scale management is being adopted, based on alternative stable-state models, to better understand evolutionary, ecosystem and invasion processes, assess risk, and design the type and timing of management interventions (see Keto & Scott, 2009 for details). Life-history and functional traits influencing competitive dominance in species assemblages are identified including resource-use efficiencies to determine e.g., shade-tolerance and frost-tolerance rankings. These data allow a novel, more cost-effective approach to invasive species management that is integrated with facilitation of native species recruitment. This becomes critically important where year effects, most probably associated with EÑSO cycles, and seasonally adverse microclimates affect natural regeneration potential.

Since recovery of vegetation cover alone is no guarantee of species survival, the approach has been to integrate restoration of habitat quality with linkage design for habitat connectivity across landscapes. Guiding principles include meeting fundamental niche and dispersal requirements of species, providing capacity for tracking climate change and resisting impacts of invasive species and other threatening processes.

Carbon sequestration is taken into consideration, but it is unclear whether credits can be claimed from restoration within a protected area.

Lessons Learned

- ✓ The use of conceptual ecological models has been vital for helping determine if, when or where assisting natural regeneration is required. If realistic, a conceptual model can provide a powerful tool to test assumptions and cope with inevitable surprises that prescriptive approaches are less able to deal with. All interventions can be interpreted in terms of system drivers or response variables that affect complex systems dynamics or successional trajectories via feedback interactions. For example, weeding, mowing etc. are framed as controlled disturbances that remove biomass (productivity), change competitive dominance, or limit recruitment of invasive species to favour desired native species.
- ✓ A social-ecological systems model has been helpful in more broadly addressing a broader range of possible drivers of change in an integrated way.
- ✓ Facilitation is a much underrated ecosystem process in restoration projects compared with competition but it provides opportunities for more effective and efficient ecological restoration strategies. This is particularly so for tertiary relicts with phylogenetically conserved traits that constrain where they can regenerate and survive. Any species, whether invasive or native, which ameliorates harsh environmental conditions, can facilitate survival of such relicts at the vulnerable seedling stage. Timing of invasive species removal becomes all-important in order to balance facilitation benefits against competitive costs. These alien species, when properly managed, can help restore damaged soils and act as 'nurse' plants before they destructively out-compete native species.
- ✓ The business model that was adopted includes all profits from ecotourism accommodation, and is proving fundamental to the long-term sustainability of the project. Philanthropic donations or grants are unreliable and generally short-term in nature, and government priorities can change in relatively-short-term cycles.
- ✓ The importance of patience and long-term planning was graphically illustrated by mass seeding events of key 'foundation' species associated with decadal climate cycles such as the El Niño Southern Oscillation. It is too easy to resort to traditional revegetation approaches involving planting nursery stock when initially confronted with large areas of abandoned pastures.
- ✓ Without monitoring, it would have been difficult to cope adaptively with surprises that inevitably arose, nor transparently assess progress in meeting objectives. Monitoring technologies are proving vital to the learning process because they can be more affordably deployed at ecologically relevant spatial and temporal scales and reveal cryptic species and phenomena generally better than with traditional means.
- ✓ Social learning and engagement are more important issues than originally envisaged, leading to improvements as part of adaptive management.

31 http://www.sensornets.csiro.au/deployments/63

6.12: Oyster reef restoration in Canaveral National Seashore, USA

Thanks to Anne Birch, Director, Marine Conservation, The Nature Conservancy Florida Chapter, for developing this case study.

Aerial photograph of Restored Oyster Reefs in Canaveral National Seashore © Anne P. Birch, The Nature Conservancy

An oyster reef restoration project in Canaveral National Seashore on Florida's east central coast has restored oyster reefs using a novel science-based methodology of oyster mats (**Guideline 1.2**) and engaged thousands of community volunteers of all ages (**Guideline 3.4**). Annual monitoring is revealing that the technique is very successful at restoring reefs with the same attributes and function as nearby natural reefs (**Guideline 1.6, Guideline 2.2**). The technique is also being applied to stabilize shorelines along significant historical Indian middens within the Seashore (**Guideline 2.4**).

Oyster reefs are the engines of an estuary, providing ecosystem services that support a diverse assemblage of species, including humans. Like coral reefs, oyster reefs have declined by 85 per cent globally (Beck et al., 2011), including reefs within many protected areas in the USA. The Canaveral National Seashore (CANA) and Mosquito Lagoon Aquatic Preserve are marine protected areas that harbour the largest remaining expanse of oyster reefs in the Indian River Lagoon (IRL) system. CANA officials originally noticed the formation of 'dead margins' adjacent to the oyster reefs—piles of disarticulated oyster shells on the seaward edges of oyster reefs—and supported research to identify the cause and support subsequent reef restoration. Research has shown that repeated boat wakes cause extensive oyster shell movement and sediment re-suspension in the lagoon, which results in formation of the dead margins (Grizzle et al., 2002; Wall, et al., 2005).

Since 2005 The Nature Conservancy (Conservancy), University of Central Florida (UCF), Brevard Zoo, partner agencies and organizations, as well as thousands of community volunteers have been helping to restore the intertidal oyster reefs in the boundaries of CANA. The overall project goal is to increase the areal coverage of live intertidal oyster reefs in Canaveral National Seashore by manually levelling the dead margins and covering the shell material with oyster mats, a stabilized recruitment substrate for oysters. The anticipated benefit is to increase available oyster habitat and thus the number of live oysters, oyster clusters and associated oyster reef organisms. Spillover in terms of increased biodiversity in adjacent areas is also expected to be significant (Barber et al., 2010). Long-term success will be measured by the effectiveness of the restoration, i.e., formation of dead margins abated on the restored reefs, sustained increase in the number of live oysters on the restored reefs, and sustained reef structure on the restored reefs.

The oyster mats are 0.4191 m^2 aquaculture grade plastic mesh material to which 36 oyster shells, oriented upright, have been attached. The mats are placed on the levelled, dead margin shell material and secured in place using cement donut weights attached to each corner and adjoining mats,

Excavator, Mosquito Lagoon: The overall project goal is to increase the areal coverage of live intertidal oyster reefs by leveling the dead margins and covering the shell material with oyster mats, a stabilized recruitment substrate for oysters. © Anne P. Birch, The Nature Conservancy

Volunteers restoring an oyster reef and signage used to inform boaters about the oyster reef restoration project partners and work in progress © Anne P. Birch, The Nature Conservancy

laid in a tile floor-like fashion. Once in place, this 'blanket' of mats mimics a natural reef and provides a stable substrate for oyster larva settlement. Making the mats is a perfect activity for involving community volunteers of all ages and abilities. More than 23,000 volunteers have assisted in this community-based science-based restoration project, many of them school children.

Fifty reefs have been restored since 2007. Annual monitoring shows that the methodology works: restored reefs are maintaining their structure and are not being dislodged by boat wakes, and oyster mats have similar recruitment rates to the natural reference reefs. When the data collected is extrapolated to all the restored reefs (25,978 mats), it shows that this project has provided substrate for 2,062,653 live oysters. Support from partner agencies, organizations, and corporations, coupled with community involvement, is integral to the project's success. Summer monitoring in 2011 has also revealed seagrass recruitment adjacent to numerous restored reefs where seagrass was not documented pre-restoration.

Lessons Learned

- ✓ Conserving the natural and restored oyster reefs in the protected area in the long-term will require an integrated approach that includes user-based education outreach and alteration of management practices.
- ✓ The restoration technique is very successful in restoring the target habitat (oyster reefs) and is showing promise as an excellent shoreline stabilization technique to repair eroding shorelines along Indian middens in Canaveral National Seashore (L. Walters, pers. comm., 2011).
- ✓ Science-based methodologies and long-term monitoring are essential to tracking success and adapting restoration activities to meet objectives.
- ✓ The effectiveness of the technique for oyster reef restoration in other estuaries will require science-based field research.
- ✓ People are clamouring to participate in marine conservation and given the opportunity they will rise to the occasion. The high level of community engagement demonstrates that restoration of oyster reefs and coastal habitats is a worthwhile investment.
- ✓ It is important to be proactive in educating and involving the media. They, too, are clamouring for good news stories and can serve as an important partner in meeting project goals through newspaper, radio, television, and web-based media outreach.
- ✓ The technique is very time intensive and would not be successful without the thousands of citizen volunteers making and deploying the thousands of mats required for restoration of the oyster reefs.
- ✓ The project's results, together with other reef restoration projects, are helping to inform policy that improves restoration and coastal conservation. The increasing priority placed on restoring oyster reefs for a multitude of ecological benefits is an exciting example.
- ✓ Restoration is emerging as an important part of the 'green economy', providing jobs and many indirect economic benefits to communities near and far from the coast. Examples of indirect benefits are: protection of coastal lands and populations from erosion, inundation and storm impacts by natural forces, and an increase in the amount of available habitat for commercially and recreationally valuable finfish and shellfish.
- ✓ The experience and new methods developed by this project are already helping to inform efforts to restore other important estuaries such as the Albemarle Sound in north Carolina and the Gulf of Mexico.

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Glossary

Abiotic: Non-living chemical and physical factors in the environment.

Adaptive Management: An iterative approach (to management) that encourages learning (e.g., through hypothesis testing) and the periodic review and adjustment of management objectives and processes as needed, in response to new research, monitoring data, or other new information.

Adaptation: Strategies and processes to moderate, cope with and/or take advantage of the consequences of climatic events.

Climate change: Changes in global temperature and precipitation patterns that are largely attributable to increasing atmospheric concentrations of carbon dioxide and other greenhouse gases (e.g., methane, nitrous oxides) since the mid-19th century.

Connectivity: Connectivity conservation describes actions taken to conserve landscape connectivity, habitat connectivity, ecological connectivity or evolutionary process connectivity for natural and semi-natural lands that interconnect and embed established protected areas. It stresses the need to think beyond isolated protected areas to a 'whole-of-landscape' vision of many lands under various tenures and jurisdictions contributing to an integrated approach to conservation.

Degradation: The simplification or disruption of ecosystems, and the loss of biodiversity, caused by disturbances that are too frequent or severe to allow natural ecosystem recovery in a relevant or 'reasonable' period of time. Degradation resulting from various factors, including climate perturbations and extreme events, as well as human activities, generally reduces flows of ecosystem goods and services.

Ecological integrity: Refers to '…a condition ... characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes' (Canada National Parks Act, 2000).

Ecological restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER, 2004).

Ecological trajectory: Describes the projected developmental pathway of the ecological attributes, biotic and abiotic, of an ecosystem through time. In restoration, the trajectory should begin with the unrestored ecosystem and progresses towards the desired state of recovery that is expressed in the goals of a restoration project that is often based on a historical or reference ecosystem. The historical or future ecological trajectory can be predicted by ecological models (SER, 2004).

Ecosystem: A community of plants, animals and smaller organisms that live, feed, reproduce and interact in the same area or environment. Ecosystems have no fixed boundaries; a single lake, a watershed, or an entire region could be considered an ecosystem[1].

Ecosystem Services: Natural products and processes generated by ecosystems that sustain and fulfil human life. The Millennium Ecosystem Assessment (MEA, 2005) recognizes four categories of benefits to people: provisioning, regulating, supporting and cultural functions. Examples include the provisioning of clean water; regulation of flood waters; soil protection, erosion control; climate maintenance (carbon sequestration), and crop pollination; and cultural in terms of fulfilling recreational, intellectual and spiritual needs.

Fragmentation: The separation of a formerly continuous natural area into smaller natural units isolated from one another by lands that were converted for economic production or the development of infrastructure such as road building.

Hyperabundant populations: Populations whose numbers clearly exceed the upper range of natural variability that is characteristic of the ecosystem, and where there is a demonstrated impact on ecological integrity (Parks Canada and the Canadian Parks Council, 2008).

Invasive alien species: A species introduced outside its normal distribution. Its establishment and spread modify ecosystems, habitats, or species[2].

Landscape: A land–area mosaic of interacting natural ecosystems, production systems and spaces dedicated for social and economic use (Rietbergen-McCracken et al., 2007).

Nature: In this context nature *always* refers to biodiversity at genetic, species and ecosystem levels, and often *also* refers to geodiversity, landform and broader natural values.

Partnership: A formalized collaborative working relationship between organizations or individuals and a protected area or protected area organization, which sets out shared goals and objectives and is based on mutual benefit.

1 http://www.iucn.org/what/tpas/biodiversity/about/bio_glossary/
2 http://www.iucn.org/what/tpas/biodiversity/about/bio_glossary/

Perturbation: An alteration of the function of a biological system, induced by external or internal mechanisms.

Phytoremediation: The direct use of living green plants for in situ (i.e., in place) removal, degradation, or containment of contaminants in soils, sludges, sediments, surface water and groundwater[3].

Protected area: A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley, 2008).

Reclamation: The process of returning land to its former or other productive uses (Parks Canada and the Canadian Parks Council, 2008).

Reference ecosystem: A similar existing or hypothetical ecosystem that defines the ideal future state of an area of land or water after an ecological restoration project has taken place. It serves as a model for planning restoration work and later for evaluation. The restored ecosystem is eventually expected to emulate the attributes of the reference, and project goals and strategies are developed in light of that expectation (SER, 2004).

Refugia: Areas that have escaped ecological changes occurring elsewhere and so provide suitable habitat for relict species.

Rehabilitation: In the broad sense, is the improvement of ecosystem functions without necessarily achieving a return to 'predisturbance' conditions. Emphasis is generally given to restoring ecosystem processes and functions so as to increase the flow of goods and services to people (SER, 2004).

Remediation: The process of removal, reduction or neutralization of contaminants from a site to prevent or minimize any adverse effects on the environment now or in the future (Parks Canada and the Canadian Parks Council, 2008).

Resilience: The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity; that is, the capacity to change in order to retain the same identity (Walker et al., 2004).

Stakeholder: Any individual or group directly or indirectly affected by, or interested in, actions pertaining to a given resource.

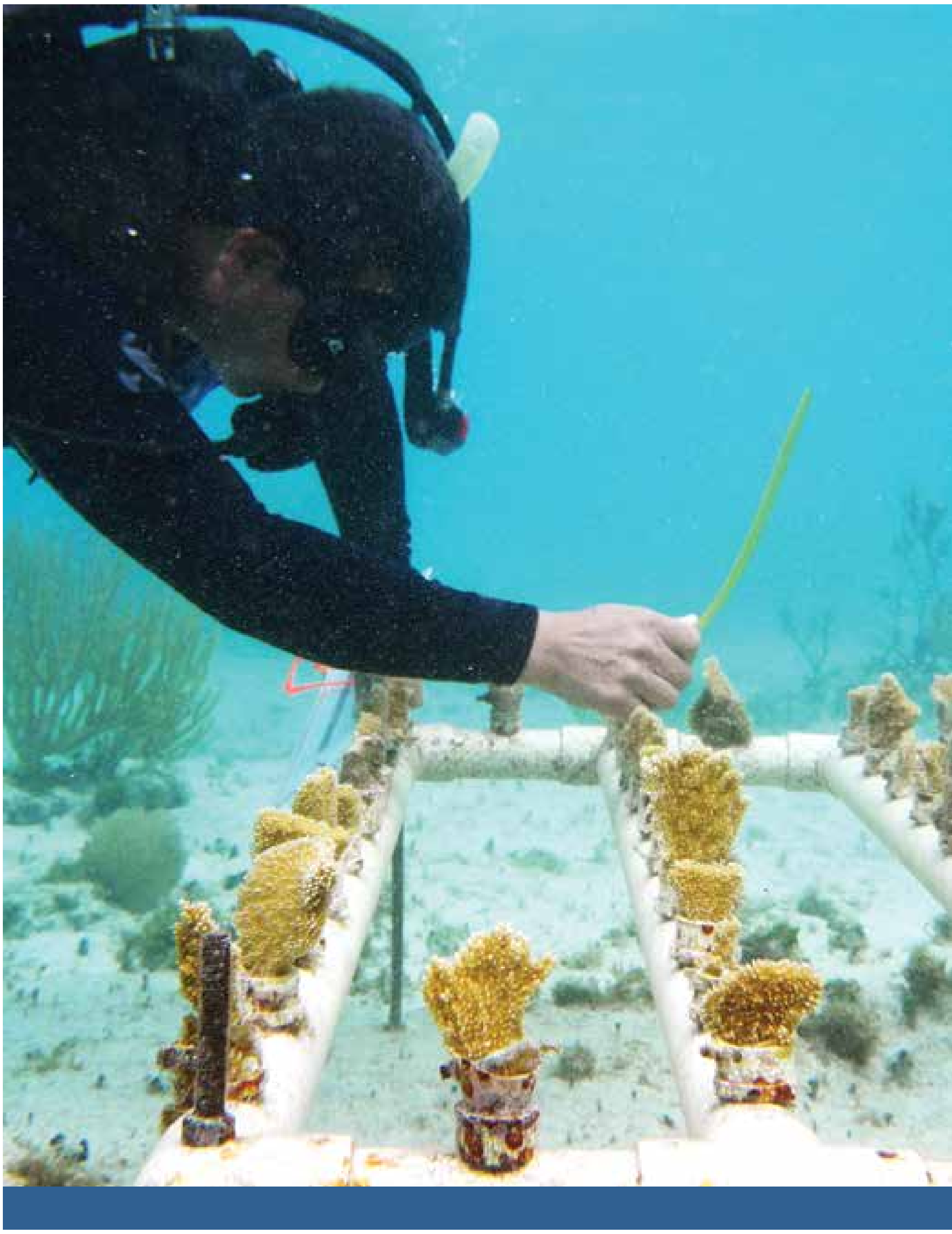
Traditional Ecological Knowledge (TEK): The knowledge, innovations and practices of indigenous and local communities developed from experience gained over time and adapted to the local culture and environment[4].

Trophic cascade: An ecological phenomenon triggered by the addition or removal of top predators and involving reciprocal changes in the relative populations of predator and prey through a food chain, which often results in dramatic changes in ecosystem structure and nutrient cycling[5].

3 http://www.unep.or.jp/ietc/publications/Freshwater/FMS2/1.asp
4 http://www.ser.org/iprn/tek.asp
5 http://www.britannica.com/EBchecked/topic/1669736/trophic-cascade

Appendix 1: Index to Best Practices

Index to Best Practices
The best practices provide guidance for managers and others directly involved in implementing restoration in protected areas on how the principles and guidelines can be applied in practice.



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