RECOVERY ASSESSMENT: THE PROCESS NEEDED AFTER IMPACTS HAVE EXCEEDED SUSTAINABILITY LIMITS

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ABSTRACT

Recovery assessment is the process needed after impacts of development exceed sustainability limits. This contrasts with impact assessment whose purpose is to avoid, minimise or mitigate adverse effects of development. Despite decades of impact assessments, state-of-environment reports indicate deteriorating environmental quality. One solution emerging to reverse this trend is "recovery assessment" – the process of developing management interventions to address environmental damage and degradation. The paper places impact assessment and recovery assessment in the context of managing socio-ecological systems based on four phases of the adaptive cycle: exploitation (use of resources), accumulation (build-up of effects of resource use), disturbance/release (when effects exceed sustainability limits), and reorganisation (restructuring of the system after disturbance). Restructuring leads to either a degraded system (i.e. unsustainable) or recovery of the system (i.e. sustainable). Impact assessment addresses the exploitation and accumulation phases to keep development within sustainability limits, while recovery assessment addresses the reorganisation phase after sustainability limits are exceeded. Four case studies are presented to illustrate the recovery assessment concept and new environmental management techniques associated with the concept. The first is the Exxon Valdez oil spill. Interventions to address spill damage and natural recovery processes have been extensively monitored. The technique of "net-environmental-benefit" evolved from this work. The second is the Fundão tailings-dam failure. Restoration investigations used the technique of "equivalency-analysis". The third is the Great Barrier Reef which is degrading not only because of impacts of cyclone damage, land-based contamination and rise in sea-temperature, but also because reef ecosystem recovery processes have been compromised. Enhanced natural recovery techniques are being developed to address ecological deterioration. The fourth is fire management at Uluru. The European approach of fire suppression reduced fire frequency but led to major fires causing ecological and development damage. Indigenous fire management techniques have led to ecological recovery and reduced damage.

Keywords: Recovery assessment, Sustainability limits, Oil spill recovery, Tailings dam failure, Reef ecosystem recovery, Fire management, Adaptive cycle, Managing socioecological systems.

1 INTRODUCTION

1.1 Impact and Recovery Assessment

The concept of environmental impact assessment was introduced in the 1970s requiring proponents of development to assess the adverse effects of proposed developments and to change the development to avoid or mitigate significant adverse effects. The intent was to ensure that the incremental impact of the proposed development above the current environment baseline was within environmental limits (Fig. 1).

However, when the existing environmental condition exceeds environmental limits, then allowing further development with incremental impacts will further exacerbate environmental degradation. To achieve sustainable development there is a need for "recovery assessment" which is the process of developing management interventions to address the environmental damage and degradation that has already occurred (Fig. 2).

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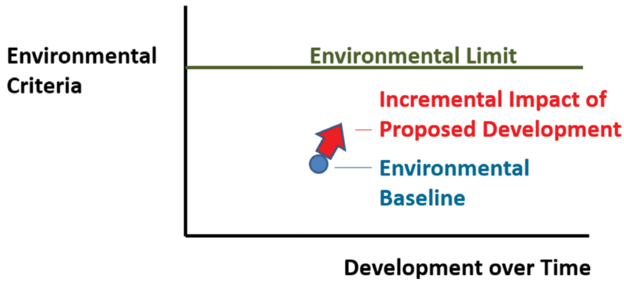

Figure 1: Impact assessment: Incremental impacts within environmental limits.

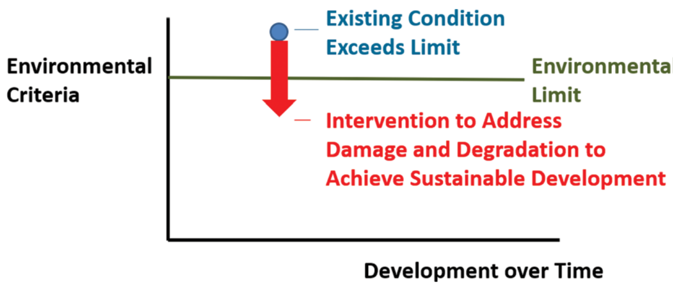

Figure 2: Recovery assessment: Intervention when environmental limits exceeded.

1.2 Managing Socio-ecological Systems

Managing for sustainability can be considered in the context of the adaptive cycle for socio-ecological systems. Gunderson and Holling [1] describe four phases of the adaptive cycle: (1) the exploitation phase which relates to the use of resources; (2) the accumulation phase which relates to the build-up of effects of resource use; (3) the disturbance/release phase when effects of resource use reach sustainability limits threatening the viability of the socio-ecological system, and, (4) the reorganisation phase where the system recovers from the disturbance (i.e. sustainable), or, shifts to a degraded state (i.e. unsustainable). A key property of a socioecological system for sustainability is resilience – the capacity of the system to absorb disturbance and still retain its basic function and structure.

Impact assessment and recovery assessment can be considered in the context of the adaptive cycle. Impact assessment is focussed on the exploitation phase with the intent of ensuring impacts of resource use do not exceed environmental limits. Whereas recovery assessment is related to the reorganisation phase after environmental limits have been exceeded with the intent of achieving recovery of a sustainable system. This is depicted in Fig. 3 with impact assessment shown as targeting the exploitation phase and recovery assessment targeting system recovery to maintain system sustainability.

1.3 Recovery Assessment Case Studies

Four case studies are presented to demonstrate the application of recovery assessment. The first is the assessment of the extent of recovery after the *Exxon Valdez* oil spill. This is a well-documented case where environmental limits had been exceeded and significant clean-up

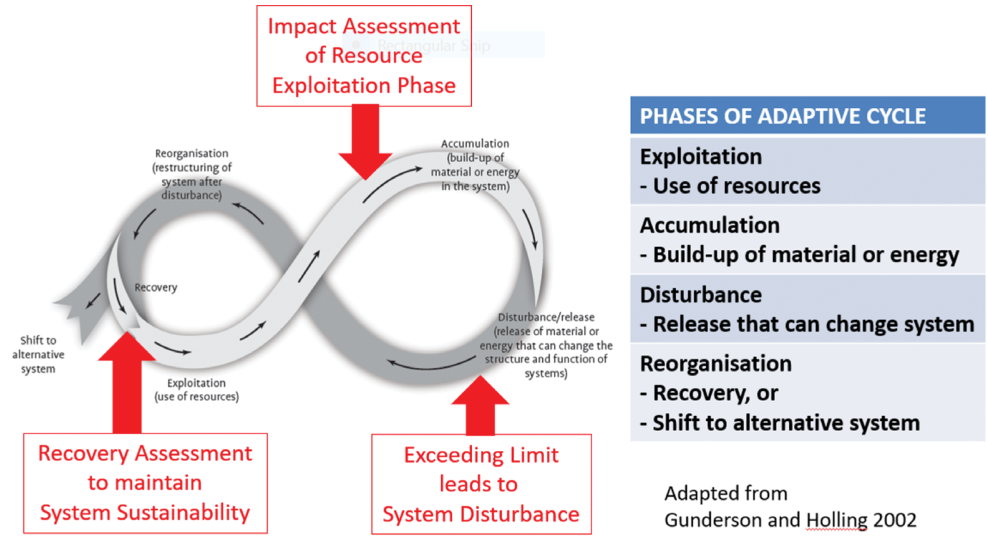

Figure 3: Impact and recovery assessment in the context of the adaptive cycle.

operations were undertaken to remediate the damage from the oil spill. Monitoring of the outcomes of clean-up operations and natural recovery provide a basis for recovery assessment.

The second case study is the collapse of the Fundão tailings dam in Brazil causing extensive environmental and socio-economic damage downstream of the dam. The mining companies responsible for the dam and the government authorities reached an agreement on the approach to restoration involving resource and habitat equivalency analysis as the basis for recovery assessment.

The third example is the management of the Great Barrier Reef on Australia's north-eastern coast. Large areas of the reef have suffered two significant coral bleaching events in two years as well as damage from a tropical cyclone. The increased frequency of these disturbances is threatening its recovery processes putting the reef's sustainability at risk. A program to enhance the reef's recovery from disturbance is being developed.

The final case is fire management at Uluru in central Australia where fire is a natural part of the landscape. Biodiversity loss has occurred with the shift from traditional Aboriginal fire management practices with the introduction of pastoralism by Europeans who did not use fire as a management tool but tried to suppress fires. The reintroduction of Aboriginal fire management practices which have been designed to regenerate vegetation is improving biodiversity recovery after fires.

2 RECOVERY FROM THE EXXON VALDEZ OIL SPILL

2.1 The Oil Spill and Clean-Up

On 24 March 1989, the *Exxon Valdez* struck Bligh Reef in Prince William Sound, Alaska. While 43 million gallons of oil was directed to other vessels, 11 million gallons of oil was spilled into the Sound. This created a 750-mile oil slick, covering 3,000 square miles and contaminated 350 miles of beaches. It was estimated that 250,000 seabirds, 2,800 sea otters, 250 bald eagles and 22 killer whales were killed as well as billions of salmon and herring eggs. The response to the oil spill was hampered by poor preparedness. A number of techniques were tried to reduce the impact of the spill. Six applications of dispersant were made but with inconclusive or unsatisfactory results. A trial of in situ burning was encouraging but a storm system dispersed what was a fairly contiguous slick and the oil could not be ignited [2].

A significant clean-up operation was attempted at an estimated cost of $US2.1 billion. Oil skimming from the water surface was undertaken and high-pressure hoses were used in an aggressive shoreline clean up. However, it was estimated that a little more than 10% of the spilled oil was removed from the environment. This means that about 10 million gallons of oil from the *Exxon Valdez* spill remained in the environment [2].

2.2 Environmental Recovery

The National Oceanic and Atmospheric Administration (NOAA) was involved in the response, operational monitoring, and research in relation to the effects of the oil spill and the degree of recovery of the environment over time. In a review 25 years after the spill NOAA evaluated the ecological response and recovery. Although substantially reduced since the time of the spill, there is still residual oil along the shoreline of Prince William Sound. The ecological response has been variable. While some components have recovered, the overall ecology has not recovered [2].

Pigeon guillemots have undergone long-term decline and failed to recover. They are nearshore foraging birds feeding on fish and benthic invertebrates. Biomarkers indicated exposure of adult guillemots to lingering oil through at least 1999. Furthermore, pigeon guillemot populations in parts of Prince William Sound have also been affected by predation from the American mink. In the year of the spill, bald eagles experienced about 5% acute mortality and significantly reduced reproductive performance in oiled areas. However, no differences in survival and reproduction were observed in subsequent years and recovery to pre-spill numbers was considered to have occurred by 1995. During breeding bald eagles are highly linked to shoreline habitats but are at low risk of exposure to oil within beach sediment [3].

Two population trends in two major groups of orcas suggest simultaneous reductions in whale numbers associated with the oil spill and clean-up, but one group is showing slow recovery while the other continues to decline. Harlequin ducks and sea otters that were affected by the oil spill appeared to have recovered by 2013. The herring fishery, that has both ecological and commercial importance, collapsed four years after the spill and is yet to recover. This collapse cannot be conclusively linked to the oil spill but cannot be rejected as the cause. Long-term monitoring has shown a high degree of interannual variability unrelated to the oil spill, for example, community composition and abundance of key taxa in the rocky intertidal habitat in Kasitsna Bay appear to be associated with the Pacific Decadal Oscillation [2].

2.3 Net Environmental Benefit Analysis

A significant development in the oil spill recovery work was the design of a new form of analysis to assess remedial actions. This is called Net Environmental Benefits Analysis (NEBA). NEBA is assessing the gains in services of resources and processes inherently supplied by natural ecosystems or attained by remedial actions, minus the environmental injuries caused by those remedial actions. This differs from traditional environmental impact assessment which focusses on the identification of remedial actions. NEBA includes the assessment of effects of the remedial actions and involves evaluating the clean-up or remediation to determine if the proposed remediation is warranted or sufficient.

In the oil spill recovery work the analysis was developed to assess whether the use of shoreline excavation and washing with high-pressure hot water to remove oil from beaches was environmentally beneficial. The analysis concluded that there was no net benefit gained by shoreline excavation and washing. Despite the analysis, the decision was taken to proceed with oil removal remediation through excavating shoreline gravels and washing them with high pressure hot water [2].

Monitoring of the outcomes indicated that the use of high-pressure hot water resulted in 50–100 per cent mortality of exposed organisms while intertidal plants and animals survived three–four months of exposure to heavy oil. Furthermore, longer term monitoring showed that differences rapidly diminished over time (1–2 years) and that intertidal impacts whether by spill or treatment were not evident within 3 to 4 years [2].

NEBA has become a methodology for comparing the net environmental benefits of alternative management options for contaminated sites. It typically involves the comparison of (1) leaving contamination in place and relying on natural attenuation, (2) removing contamination through physical or chemical methods, (3) improving ecological value through onsite or offsite restoration that does not involve removing contamination, or, (4) a combination of approaches [4]. NEBA focusses on the recovery of ecosystem services compared to EIA which focusses on mitigation of adverse effects.

3 RESTORATION AFTER COLLAPSE OF THE FUNDÃO TAILINGS DAM

3.1 Collapse of the Fundão Tailings Dam

On 5 November 2015, 39 million m^3 of mine tailings from the Fundão Dam spilled into the Rio Dôce River in Brazil. The communities of Bento Rodrigues, Gesteira and Paracatu were flooded and other downstream communities were affected. Nineteen people were killed: five community members and fourteen workers. An area of 1,469 ha of river floodplain was damaged with 500 homes affected. There was sediment deposition in the reservoir of Candonga Dam with a 140 MW hydroelectric power plant that was forced to close for 2 years. Fine sediment passed over the dam and 650 km of the river to the Atlantic Ocean was contaminated resulting in an estimated 11 tons of dead fish and affecting water supply systems. A plume was visible 750 km out to sea. Seven bridges and community infrastructure were destroyed and access roads damaged [5], [6], [7].

3.2 Restoration Agreement

In March 2016, a Framework Agreement was reached between the mining companies (Samarco, Vale and BHP Billiton) and the Brazilian authorities for the restoration of the environment and communities affected by the dam failure. There were 41 environmental and socio-economic programs under five dimensions: (i) natural capital, such as aquatic and terrestrial ecosystems; (ii) human and social capital, such as community relocation and resettlement; (iii) physical infrastructure, including village reconstruction; (iv) economic and financial, such as compensation and economic recovery; and (v) governance of recovery program management. A private foundation (Fundação Renova) was established to develop and execute the environmental and socio-economic programs [5], [6]. Note that while the program is comprehensive, there have been complaints that the implementation of tailings removal, and, environmental and social remediation has been slow [8].

3.3 Resource and Habitat Equivalency Analysis

To design the programs, use was made of resource and habitat equivalency analysis [9]. Resource and habitat equivalency analysis is a methodology to determine restoration and compensation for damage to habitat and resources. Indicators are developed to reflect the resource and habitat services provided and damage incurred [10]. For the Fundão Dam collapse one indicator for natural capital was the percentage of riparian areas recovered, while one of the indicators for social and human capital was resumption of fishing activities [6]. Equivalency analysis is based on the cost of restoring the damaged resources to the baseline condition prior to the disaster, compensation for the interim loss of resources from the time the damage occurred to the recovery of baseline condition, as well as the costs of undertaking the damage assessment [10].

Environmental damages are primarily based on ecosystem services. Determining the scale of restoration to compensate for losses involves (i) estimating the extent and duration of loss of ecosystem services, (ii) estimating the ecosystem services that can be provided by restoration projects, (iii) calculating the size of restoration project to provide services equal to the lost services, and (iv) calculating the project cost (for compensation) or performance standards (for implementation). Consideration is given to the difference in services under natural recovery and under active restoration. In relation to habitat, the area of vegetation lost immediately after the incident was 1318 ha, with a further 186 ha lost due to remediation and restoration activities, and, indirect habitat losses due to chronic effects on vegetation estimated to be 26 ha, i.e. a total area of lost habitat of 1530 ha. The restoration requirement to match the ecosystem services at pre-incident baseline levels was assessed to comprise 766 ha of equivalent replacement of restoration of affected areas; 1528 ha of replacement or restoration of affected areas that provided 50% equivalency to compensate for 764 ha lost; 546 ha to compensate for initial losses; 72 ha to compensate for areas affected by restoration activities; and, 10 ha to compensate for chronic effects on vegetation, i.e. a total area of 2922 ha [9].

3.4 Restoration for Sustainability

In the consideration of the pre-incident baseline it was found that were pre-existing impacts in the Rio Dôce Basin that were not sustainable, such as water quality impacts from inadequate sewage treatment and erosion from deforestation. In terms of Fig. 2, the existing condition exceeded environmental limits. To achieve sustainability further remediation and restoration activities are needed to lead to self-sustaining solutions to achieve environmental and community outcomes [7]. These actions are likely to be beyond the scope of the recovery agreement between the mining companies and government authorities. However, a sustainability recovery program would need a collaborative approach to coordinate the actions of multiple stakeholders across the Rio Dôce Basin.

4 GREAT BARRIER REEF CORAL RECOVERY

4.1 Coral Bleaching

Climate-driven mass coral bleaching occurred in the Great Barrier Reef in 2016 and 2017. Other recent disturbances to reef ecology have been Tropical Cyclone Debbie in 2017 and a crown-of thorns outbreak since 2010. Eighty per cent of the coral reef area has been affected. Fifty per cent of the reef's shallow water coral died in bleaching events [11]. While these types of disturbance have occurred in the past and the reef has recovered, the frequency of events is challenging the capacity of the reef ecosystems to recover and thereby threatening the sustainability of the reef. The amount of larval recruitment in 2018 declined by 89% compared to historical levels [12]. The IPCC have predicted a 70–90% decline in corals worldwide with a 1.5°C increase in temperature and a greater than 99% decline with a 2°C increase in temperature [13].

4.2 Adaptive Cycle for Coral Bleaching

The recovery process for coral [14] can be described as an adaptive cycle with an exploitation, accumulation, disturbance/release and recovery phases. In the exploitation (use of resources phase), reef productivity is dependent on the symbiotic relationship between coral polyps and zooanthellae – dinoflagellate algae which live within the coral's tissues. In the accumulation phase, coral species store energy surpluses to their metabolic requirements as lipid and these lipid deposits could be considered as energy reserves [15]. While there are many types of disturbance that can cause corals to bleach, e.g. storms, diseases, sedimentation, the main cause of mass coral bleaching is increased sea temperatures. Under conditions of increased temperature, the algae release harmful oxygen radicals. The corals expel zooanthellae to avoid tissue damage leaving white coral skeletons. In the reorganisation phase, recovery can occur when the temperature reduces and zooanthellae can repopulate the coral re-establishing a food source for corals. However, with prolonged temperature stress, repopulation of zooanthellae does not occur, which means corals are deprived of their food source and die [14].

4.3 Management Interventions for Reef Manager

The loss of zooanthellae, the primary food sources of corals, is due to mass coral bleaching which is primarily caused by prolonged exposure to thermal stress. Greenhouse gases reduce the radiation of heat back into space. The oceans are a heat sink and absorb more than 90% of the additional heat trapped by additional greenhouse gases. Average global ocean mean surface temperature is now 0.9ºC above its preindustrial average. Sustained elevated sea temperatures result in coral bleaching and may be followed by mortality. Managing seawater temperatures requires global action on greenhouse gas emissions. However, with the long residence times of greenhouse gas emissions in the atmosphere and ongoing greenhouse gas emissions, seawater temperatures are expected to increase. Furthermore, mitigation is beyond the capacity of the reef manager. This means reef sustainability requires adaptation to increased seawater temperature [16].

One management intervention is the protection of coral reefs that are resistant to temperature-induced bleaching. The establishment and protection of refugia of resilient corals is important in order to maintain a seed source for reef ecosystem recovery. This requires management measures to reduce localised threats to these areas such as water quality degradation. Furthermore, recovery of reef ecosystems can be enhanced if there is a network of refugia with connectivity to reefs more susceptible to bleaching, to facilitate reseeding [17].

There are also interventions designed to assist or accelerate the natural recovery process. One is coral translocation of bleaching-resistant corals to make a greater contribution to the next generation of corals. A second is coral seeding which involves the migration of heat-tolerant genotypes to reef areas affected by bleaching. While there are ecological risks associated with these approaches, they represent options when natural recovery processes fail [17,18].

In addition to enhancing coral recovery processes, another type of management intervention is addressing the stressors that inhibit reef ecosystem recovery. Natural recovery of reefs following bleaching may be hindered by excessive growth of filamentous or fleshy algae. Overharvesting of herbivores, in particular herbivorous fish, can result in excessive algal growth. This reduces the availability of bare substrate required for settlement of coral larvae. Degraded water quality can affect the fertilisation success of corals. Furthermore, water quality can have a negative effect on recovery by encouraging algal growth which can reduce larval recruitment. Controlling crown-of-thorns outbreaks is an additional management strategy to improve the chances of coral recovery [17].

4.4 Process of Recovery Assessment

The recovery from coral bleaching is one component of the Reef 2050 Long Term Sustainability Plan which provides an overarching strategy for the management of cumulative effects that have resulted in deterioration of reef ecosystem health and world heritage values [19]. The process for the development and implementation of Reef 2050 is significantly different from undertaking an environmental impact assessment of development proposals by proponents. Rather than a proponent-driven development, Reef 2050 was prepared using a collaborative approach through a Partnership Group that was jointly chaired by the Commonwealth and Queensland Environment Ministers. It brought together government representatives, Traditional Owners, key industry organisations, scientists and interest groups.

The sustainability plan drew upon two complementary strategic assessments: one for the coastal component [20], and one for the marine component [21]. Reef 2050 sets out coordinated action for all stakeholders and is outcome-focussed. It establishes a vision for the Reef and defines “Outcomes” to be achieved by 2050 to realise the vision. It defines management interventions, termed “Actions”, to achieve “Targets” for 2020 (a five-year horizon) with reviews every five years to achieve “Objectives” by 2035 (the medium term) linking to the 2050 Outcomes. There is also an investment framework for implementation. It sets out current investments, investment priorities, and a strategy for securing further investment [22].

There are institutional arrangements that have been put in place to facilitate implementation. There is: a Ministerial Forum that oversees the Plan’s implementation with annual reports on progress; a Reef Trust to provide investment focussed on improving water quality, restoring ecosystem health and enhancing species protection in the Great Barrier Reef; an Advisory Committee to facilitate community engagement; and, an Independent Expert Panel to advise on funding priorities.

A key element for guiding future management is the Great Barrier Reef Blueprint for Resilience. Two of the defining features of the resilience-based management approach consistent with the theme of this paper are: (i) taking a systems perspective, and (ii) understanding the processes of resilience to guide management actions and adaptation responses [23].

5 FIRE MANAGEMENT AND ECOLOGY AT ULURU

Uluṟu-Kata Tjuṯa National Park covers 1,325 km² in central Australia. It has World Heritage Listing for its cultural and natural values. In the ancestral home of the Aṉangu people with numerous sites of significance, stone arrangements and rock art. The natural values are associated with the sandstone massifs of Uluṟu and Kata Tjuṯa, and, high biodiversity of the desert landscape. The most extensive land system in the region is sandplains and dunefields with areas of mulga woodland in spinifex grassland [24].

5.1 Fire History of Uluṟu

Fire is a major factor in the biodiversity of the region. Historically (for at least 30,000 years), Aṉangu people conducted "patch burning" of spinifex to create a mosaic of burnt and unburnt terrain. The fires were lit to regenerate vegetation in order to stimulate growth of bush foods and provide fresh growth for animals like kangaroo. With the introduction of European pastoralism in the 1930s, Aboriginal people were driven off their lands. Cattle were introduced, as well as feral animals. Introduced grasses (buffel, couch) for cattle, also increased the fuel load for fire. European pastoralists have not used fire as a management tool and have at times actively suppressed it. The cessation of traditional burning practices and the introduction of pastoralism is thought to have led to the increase in size and intensity of wildfire [25].

In Uluṟu-Kata Tjuṯa National Park, large intensity wildfires occurred in 1950 (burning one third of the Park) and two fires occurred in 1976 (burning about 76% of the Park) [26]. In 1985 land title returned to the Aṉangu traditional owners with a lease back to the Australian National Parks and Wildlife Service. This led to the reintroduction of traditional Aboriginal methods of fire management in Uluṟu-Kata Tjuṯa National Park [24]. Extensive wildfires occurred in central Australia in 2002 following substantial fuel accumulation in the high rainfall years of 2000 and 2001. A high proportion of the Park (approximately 50%) burnt in these wildfires despite extensive patch burns and strategic firebreaks. However, the 2002 wildfires consisted of many separate fires with variation in intensity and patchiness compared to earlier fire events [26].

5.2 Fire Ecology in Uluru

Fire is a natural component of central Australia bringing both ecological disturbances and recovery. Traditional Aboriginal methods of fire management were designed to enhance vegetation and habitat recovery whereas European pastoralists did not use fire as a management tool other than to suppress it and introduced grasses added to the fuel load. There has been a loss of diversity in post-fire vegetation age after cessation of nomadic Aboriginal burning [26].

There is now a better understanding of wildfire risk and vegetation responses to be able to design fire management strategies to achieve sustainable development. Wildfire risk in the arid areas of central Australia is related to successive years of above average rainfall. Infrequent large rainfall events drive profuse vegetation growth. The vegetation dries leaving a large fuel load and an ecosystem prone to massive wildfire. Lightning during electrical storms is a natural source of ignition [27].

The vegetation response to fire varies. Spinifex is considered "fire-tolerant" because it re-establishes after fire and persists under fire regions characterised by relatively frequent and intense fire. However, mulga is considered "fire-sensitive" because it does not persist in areas subject to relatively frequent hot fires [26]. In intense fires mulga can be killed if its canopy is burnt. Mulga takes 5–15 years to set seed after fire. If a second intense fire occurs before mulga has time to set seed, then mulga can potentially be eliminated from an area [25].

Fire strategies for managing biodiversity values are being designed around species recovery. The main elements are (i) patch burning of spinifex to reduce fuel loads and maintain

Table 1: Comparison of recovery assessment and impact assessment.

Recovery assessment	Impact assessment
Proactive environmental improvements to achieve sustainability outcomes	Reactive analysis of actions to mitigate adverse effects
Reorganisation phase of adaptive cycle	Exploitation phase of adaptive cycle
Focus on system recovery	Focus on impact mitigation
Outcome-based approach	Effects-based approach
Managing resilience of socio-ecological systems	Managing effects of proposed actions
Enhancement of natural recovery processes as well as engineered interventions	Changes to proposals to avoid or mitigate adverse effects
Collaborative approach to coordinate actions of multiple stakeholders based on bioregions	Proponent responsibility to reduce impacts of actions on project footprint

habitats at different stages of succession; (ii) burning fire breaks around mulga to limit fire frequency and intensity; and (iii) establishing networks of strategic firebreaks to limit the spread of intense wildfires. Removal of fire-tolerant introduced species, e.g. buffel grass, may also need mechanical clearing, chemical spraying or controlled grazing.

6 CONCLUDING COMMENTS

Table 1 sets out a comparison of key differences between impact assessment and recovery assessment. Recovery assessment is a process of proactively developing environmental improvements to achieve sustainable outcomes whereas impact assessment is a process in reaction to proposed development involving the analysis of adverse effects and ways to mitigate those effects. Both processes contribute to the adaptive cycle for sustainable socio-ecological systems but focus on different phases of the adaptive cycle: recovery assessment on the reorganisation phase and impact assessment on the exploitation phase. The emphasis of recovery assessment is on system recovery while the emphasis of impact assessment is on mitigation of adverse effects. Recovery assessment is an outcome-based approach addressing the resilience of socio-ecological systems. Whereas impact assessment is an effects-based approach addressing the management of effects of proposed actions. Management interventions for recovery assessment include natural recovery processes as well as engineered interventions while impact assessment includes changes to proposals to avoid or mitigate adverse effects. Recovery assessment involves a collaborative approach to coordinate actions of multiple stakeholders based on bioregions. Whereas impact assessment is a proponent responsibility to reduce impacts of actions based on a project footprint.

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