Australian Government
Director of National Parks

Pulu Keeling National Park
Climate Change Strategy
2011–2016

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1. Background

The *Intergovernmental Panel on Climate Change Fourth Assessment Report* concluded that human induced climate change is expected to have a discernible influence on many physical and biological systems. The resilience of many ecosystems is likely to be exceeded over the course of the twenty-first century and about a quarter of all plant and animal species are likely to be at increased risk of extinction if increases in global average temperature continue to match current projections (IPCC 2007).

Pulu Keeling National Park is located in the Indian Ocean about 2,900 kilometres north-west of Perth, 975 kilometres west-south-west of Christmas Island and 1,000 kilometres south-west of Java Head (Figure 1). The park is the northern-most atoll of the Cocos (Keeling) Islands and is located 24 kilometres from the southern group of islands. The park is the smallest Commonwealth national park and includes the 1.2 square kilometres land area of North Keeling Island, the central lagoon, and the waters around the island extending out to 1.5 kilometres from the high water mark (Director of National Parks 2004).

North Keeling Island is a remote oceanic island that has been colonised by flora and fauna via wind, pelagic drift, flight or animal carriage. This isolation has resulted in a unique assemblage of species and ecology which is of great scientific interest to biologists. The park's most outstanding feature is its intact coral atoll habitat, considered one of the last areas of pristine reef systems in the world. With the rapid decline of similar coral island environments, the conservation and protection of this habitat is of international importance (Director of National Parks 2004).

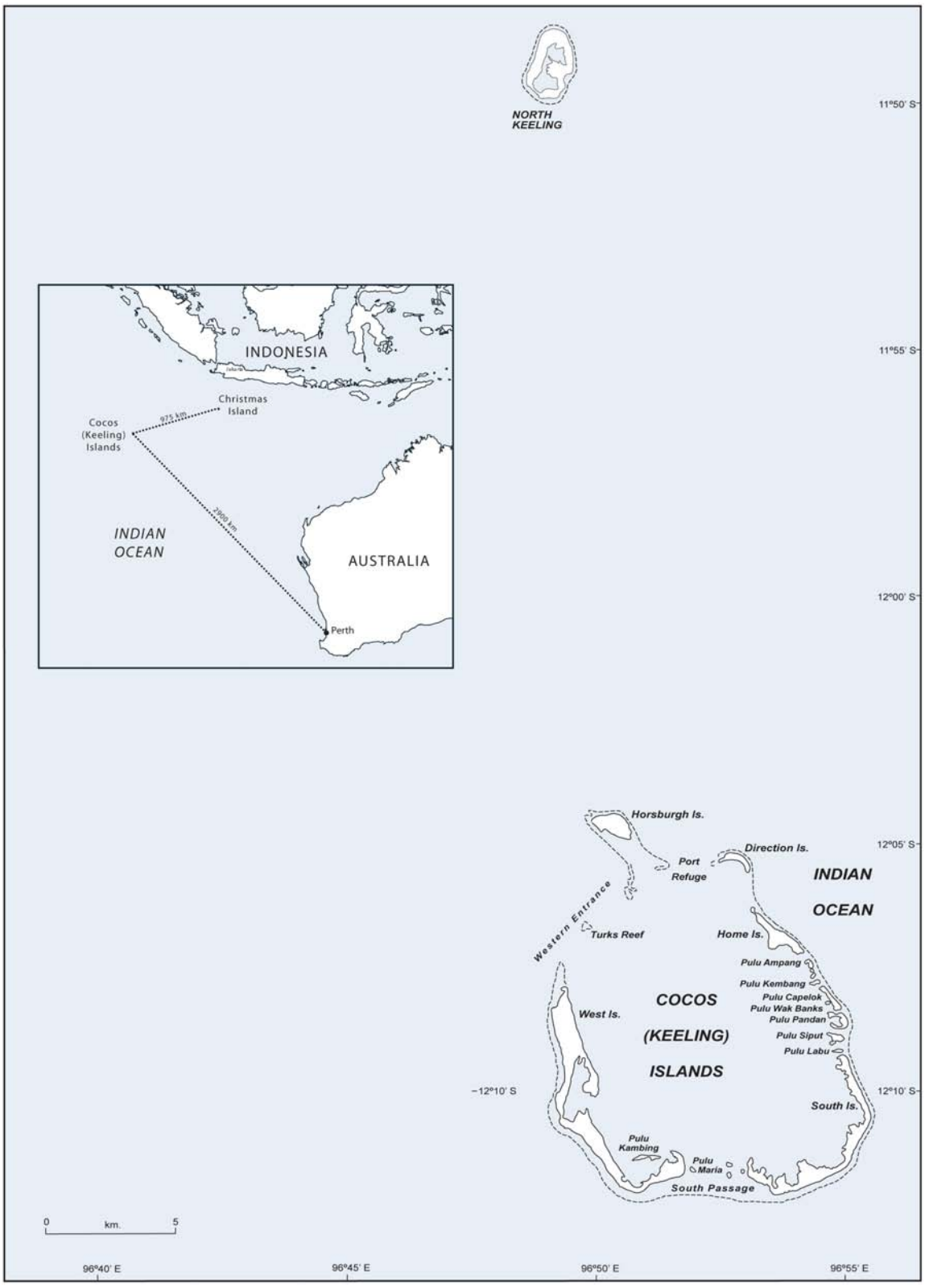
Pulu Keeling National Park is an internationally recognised seabird rookery and is listed as a wetland of international importance under the Ramsar Convention. It supports one of the world's largest remaining populations of the red-footed booby (*Sula sula*) and is also home to the endemic and endangered Cocos buff-banded rail (*Gallirallus philippensis andrewsi)* and the endemic Cocos angelfish (*Centropyge joculator*) (Director of National Parks 2004).

Green turtles (*Chelonia mydas)* nest on North Keeling Island and hawksbill turtles (*Eretmochelys imbricata*) are resident in the waters of the park. Three of the world's six other marine turtle species visit the park from time to time. Two species of dolphin are regularly seen in the park, which also has healthy populations of butterfly fish and sharks (Director of National Parks 2004).

The Pulu Keeling National Park Climate Change Strategy 2011–2016 recommends the preliminary adaptation, mitigation and communication actions that are required to manage the consequences of climate change and reduce the carbon footprint of park management activities. The strategy is consistent with the Parks Australia Climate Change Strategic Overview 2009–2014 and the policies and actions of the Pulu Keeling National Park Draft Management Plan which is currently being drafted.

Climate change is a long–term issue and this strategy is a 'first step' to what must be a long–term and enduring response. This strategy is an adaptive tool subject to ongoing review, and management responses will be amended to take account of improvements in the understanding of the implications of climate change for the park.

Figure 1: Location of Pulu Keeling National Park



2. Regional Climate Change Projections

The projected effects of climate change in the Indian Ocean Territories region include sea level rise, an increase in air and sea temperatures, increase in ocean acidity and changes in the frequency and intensity of extreme weather events. A summary of these effects are provided in Table 1. These projections are based on high range or worst case global warming scenarios (uncertainties shown in brackets).

Table 1: Climate change scenarios for Indian Ocean Territories region

Climate change factor	Current average	2030 scenarios	2070 scenarios
Sea level rise	0	+17cm [a] +14cm [b]	+50cm [a] +40cm [b]
Annual average air temperature	Max 29° [c] Min 24.5° [c]	+0.7° C [b]	+1.8°C [c]
Annual average sea temperature		+0.6°C [b]	1.8° C [b]
Annual average rainfall	1,974mm [c]	Rainfall projections are associated with very high level of uncertainty. However, it is likely that the driest seasons may become drier and wettest season may become wetter. [b]	
Annual average potential evaporation	-	+1% (±8%)	+2% (±24%)
Extreme weather events	-	Increasing periods of drought and increasing frequency and intensity of storm activity.	
Ocean acidity	pH 8.06[b]	-	pH value is projected to decrease to 7.92 [b]
CO_2 concentration [b]	353ppm	+165ppm	+365ppm

a Hyder 2008
b AECOM 2010
c Bureau of Meteorology

The endemic and endangered Cocos buff-banded rail (*Gallirallus philippensis andrewsi)*

3. Impacts of Climate Change on Pulu Keeling National Park

Keeling National Park contains both marine and terrestrial environments that will face impacts from climate change. The key threats of climate change to the park include sea level rise and inundation, and increases in sea surface temperature. These threats may then lead to impacts such as vulnerable ecosystems and biodiversity loss (AECOM 2010). There is a degree of uncertainty regarding how some of these projections of climate change will specifically affect the natural, cultural and economic values of Pulu Keeling National Park. However, based on regional climate change predictions the following impacts are likely.

Sea level rise and increased storm intensity and frequency

Pulu Keeling National Park is located on a low lying, flat island with an elevation of 3-5 metres (Director of National Parks 2004). The sea level surrounding North Keeling Island is expected to rise due to increases in global average sea level. Any change in mean sea level, combined with the effects of storm surge associated with large storms or cyclones, is likely to have dramatic consequences and will have a significant impact on a range of species living on the island. Any increase in sea level will result in a substantial loss of nesting beaches used by green turtles. Rises in sea levels also impact low lying areas through enhanced coastal erosion and increased vulnerability to storm surges (Maunsell 2009).

Current predictions for cyclone activity in the area of Cocos (Keeling) Islands suggest that the number of tropical cyclones occurring within a 500km radius of the islands will decrease by 25 per cent, but the frequency of high intensity cyclones (category 4 or 5) is projected to double (Maunsell 2009). Any increase in tropical cyclone activity has the potential to threaten species and subspecies with small population sizes and restricted distributions, such as the Cocos buff-banded rail. An increased number of intense tropical cyclones will have the potential to repeat the defoliation and partial destruction of Pisonia forest at North Keeling Island that occurred in 1989 and 2001. Seabird populations declined after the 1989 cyclone, for example 40% of chicks and 2% of adult red-footed booby birds were killed by the cyclone and the nest numbers decreased by 60% the following year. Red-footed booby numbers recovered after four years. The numbers of sea birds have been increasing over the past 20 years but future intense storm events have the potential to again have an impact on these species.

Increased numbers of intense cyclones may lead to an increase in storm surge events on the island. Hyder (2008) suggests that, in the short term, increased damage from cyclones is likely to be the most threatening impact of climate change on the park.

Seabirds are regularly and illegally hunted on the southern atoll of Cocos (Keeling) Islands and are unable to establish nesting colonies. Cooperation and education of local residents and reintroduction of native vegetation such as Pisonia grandis has the potential to create additional habitat in the long term for migratory species, and refuge during localised storm events.

Impacts of adjacent oceanic ecosystems

A projected rise in sea surface temperature (SST), coupled with doldrum conditions, has the potential to cause mass fish kill events and coral bleaching. A coral bleaching event occurred in 1997 at parts of the outer reef (before the world wide bleaching event of 1998) because of doldrums conditions and higher than normal SST. Plate corals died and did not return, recovery was via growth of soft corals. Rises in SST will impact species breeding cycles (e.g. robber crab, green turtle) and food availability (e.g. sea birds dependent on ocean food). Predicted increases in SST are also directly linked to cyclone proneness and changes to oceanic currents (AECOM 2010).

Rises in sea level, ocean acidification and SST may adversely affect marine food chains. Temperature and current changes at lower trophic levels may alter the abundance and distribution of small pelagic fish, which form the staple food source of many native seabird species. Seabirds are entirely dependent on the ocean for food. Breeding success has been positively correlated to incidence of cold water upswelling, which results in rich food resources. Any significant changes to currents and SST from projected climate changes may alter seabird breeding success.

The main ocean currents in the vicinity of Cocos (Keeling) Islands are the Indonesian Throughflow, which flows in a westerly direction to the south of the islands, and the South Java Current. Observations over the last 50 years indicate a reduction in the strength of the Indonesian Throughflow. Results from climate models indicate that this trend should continue in the future.

One of the effects of increased CO_2 in the atmosphere is an increase in ocean acidification which will impact the ability of marine organisms to develop their calcium carbonate shell. Specifically for Pulu Keeling National Park, the surrounding coral reefs may not be able to maintain their structural integrity and therefore their ability to provide habitat for other marine species e.g. Cocos angelfish (AECOM 2010).

Biodiversity impacts and arrival of new species

Climate change will impact on the ecology of individual organisms that will ultimately lead to changes in populations. Dunlop and Brown (2008) identified four main outcomes that might be expected from populations in response to the effects of climate change. These outcomes are not mutually exclusive as a number of the factors may occur together within a population. They are:

- survival within the current distribution (although there may be changes in abundance, behaviour or habitat)
- evolutionary adaptation to enable survival (this may be at a genetic, species or population level)
- changes in population distribution
- extinction.

The park is the home to the green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricate*) turtles which are listed as vulnerable under the EPBC Act. Before the natural closure of the lagoon mouth, both turtle species were known to forage on the seagrass beds located in the southern lagoon of the island. The lagoon closed and became shallower between the early 2000s and 2007 due to natural deposition of sediment in the lagoon entrance. The deoxygenation of water in the southern lagoon, increasing water temperature and changes to the health of seagrass beds is likely to reduce the number of foraging turtles, coral and fish species in the island lagoon. Increased sand temperatures may also impact on green turtle populations, and influence the sex of turtle offspring in favour of females.

The closure of the lagoon and deposition of sediment in the lagoon entrance has provided new opportunities for native and introduced vegetation to colonise, creating new flora and fauna communities and new nesting habitat for the masked booby (*Sula dactylatra)*. It remains unclear whether the closure of the lagoon is directly related to climate change or is a natural stage in the evolution of the atoll. While ecosystems dependant upon saltwater being regularly refreshed in the lagoon are likely to suffer, terrestrial dependant species are beginning to benefit.

Climate change is likely to change the species composition of communities and ecosystems. Invasive species such as pawpaw (*Carica papaya*) and the yellow crazy ant (*Anoplolepis gracilipes)* may be favoured by changed conditions in temperature and rainfall, especially if coupled with human disturbance or further introduction of non-native species. While none of the introduced plant species present in Pulu Keeling National Park are currently considered severe threats (Director of National Parks 2004), climate change has the potential to alter this.

Increased levels of atmospheric CO_2 may lead to increased photosynthesis in plants which can impact the level of plants water efficiency and the amount of biomass produced. Differences in individual species responses to increased CO_2 have the potential to alter species interactions and ecosystem structures (Hyder 2008).

Buildings and infrastructure

The terrestrial and marine environments of the park are potentially exposed to a number of impacts associated with climate change. Parks Australia buildings and infrastructure located on both Home Island and West Island (which are both outside the park) are subject to potential climate change impacts such as increased frequency of intense cyclones, storm surges, rising sea levels, increased erosion and more extreme climatic conditions which are expected to place additional pressure on the resilience and suitability of park infrastructure. This is likely to have flow-on implications for maintenance costs and there may be a need to relocate existing assets from high risk areas. In addition to this, no buildings on Cocos (Keeling) Islands are designed to cyclone ratings (AECOM 2010) which leaves them further prone to the adverse impacts of increased storm activity. Higher temperatures are likely to increase the demand for energy and water for cooling systems.

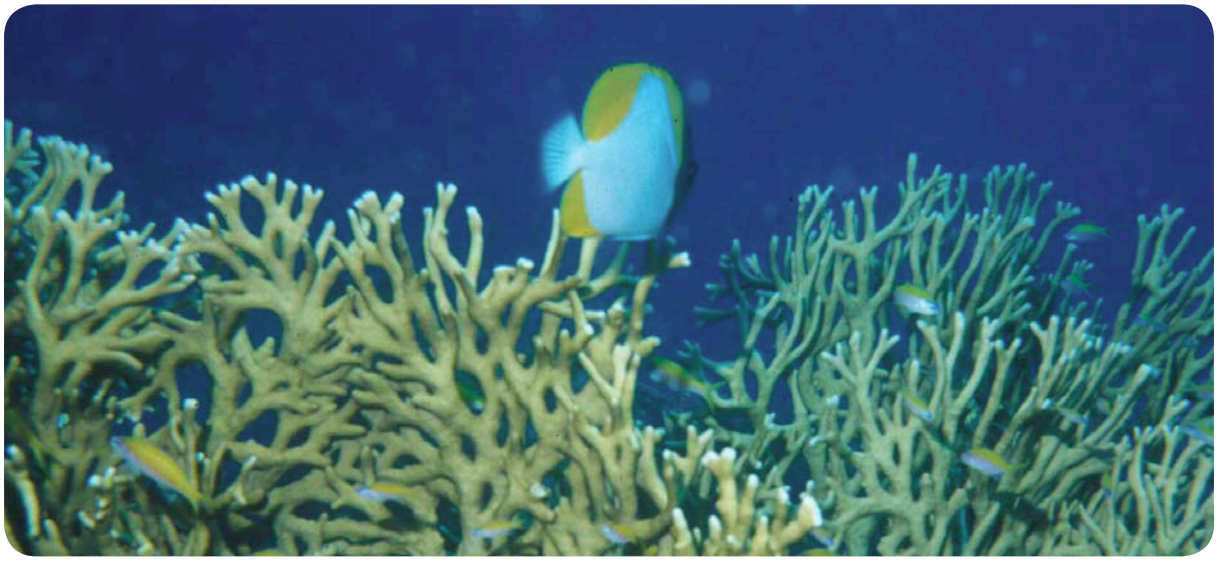
4. Recommended management actions

The recommended management actions align with the five objectives of the *Parks Australia Climate Change Strategic Overview 2009-2014* outlined below.

1. To understand the implications of climate change
2. To implement adaptation measures to maximise the resilience of our reserves.
3. To reduce the carbon footprint of our reserves.
4. To work with communities, industries and stakeholders to mitigate and adapt to climate change.
5. To communicate the implications of, and our management response to, climate change.

4.1 Understand the implications of climate change

A good knowledge of the implications of climate change is necessary to enable us to prepare and implement an effective response. Given the uncertainties of climate change at a local scale, and our current knowledge gaps, the task of improving our understanding will be an on-going effort. Understanding how various natural and cultural elements of the landscape may respond to changing conditions, and designing long term research and monitoring programs that inform management responses is a priority.



The fragile coral reefs of Pulu Keeling are vulnerable to increases in sea surface temperature

	Recommended Management Actions	Timeframe
4.1.1	Identify critical knowledge gaps in baseline data and identify priorities for further research or integrated monitoring programs to study the causes and effects of landscape and ecosystem change.	By 2012
4.1.2	Continue to partner with research institutions on projects that target identified knowledge gaps and improve understanding of the resilience of species and communities in the park.	Ongoing
4.1.3	Work with partners to develop spatial information systems that assist in predictive modelling of climate change impacts on the distribution and abundance of vulnerable species and communities (including invasive species) under different scenarios.	By 2016
4.1.4	Continue existing long term monitoring programs for significant fauna species expected to be impacted by climate change (e.g. red-footed booby, Cocos buff-banded rail), marine habitat monitoring (including marine turtles and coral reef checks), significant flora species (e.g. *Cordia subcordata*) and vegetation communities (e.g. *Pisonia grandis* forest).	Ongoing
4.1.5	Once priority research and monitoring has commenced (Action 4.1.1), identify a set of baseline parameters (climatic, geomorphological, hydrological, and ecological) to effectively monitor the effects of climate change.	By 2012
4.1.6	Establish and implement a monitoring program for parameters identified in Action 4.1.5 that are not already targeted in existing long term monitoring programs. Methods used to monitor the effects of climate change must have appropriate sensitivity to detect changes. The monitoring program should have explicit measures for communicating outcomes between land managers, researchers and the general community.	By 2013
4.1.7	Undertake a risk assessment, in partnership with Cocos (Keeling) Islands residents, of the likely impacts of climate change on significant cultural sites and identify the mitigation measures that may be required.	By 2015
4.1.8	Continue to improve the technical capacity of park staff to adapt and respond to climate change (e.g. GIS, remote-sensing and field monitoring skills).	Ongoing
4.1.9	Investigate the feasibility of making seeds and/or propagules from North Keeling Island available to the Australian National Botanic Gardens through the Centre for Australian National Biodiversity Research, or similar organisation, to support climate change research.	Ongoing
4.1.10	Monitor changes in the physical environment, such as changes to the elevation of the island as compared to the sea level rising, to determine the impact on the island ecosystem from changes in the sea level.	Ongoing
4.1.11	Liaise with the Department of Regional Australia, Regional Development and Local Government as appropriate to increase the understanding of the impacts of climate change on the Cocos (Keeling) Islands residents and the flow on impacts this may have for the park and park management.	Ongoing

4.2 Implement adaptation measures to maximise the resilience of our reserves

The condition of the natural and cultural values of the park is dependent on the rate of climate change itself and the resilience of the park to cope with this change. A focus of park management is to reduce the impact from invasive species. This will maximise the resilience of species and communities to adapt to the additional challenges brought about by climate change. The park needs to be managed using an ecosystem-based approach (rather than single species), in partnership with the Cocos (Keeling) Islands residents.

	Recommended Management Actions	Timeframe
4.2.1	Continue to implement the existing strategic weed and feral pest monitoring and control programs to maximise the resilience of species and habitats in the park.	Ongoing
4.2.2	Identify species and habitats where impacts from feral pests, weeds, and visitation rates are likely to be exacerbated by climate change and revise management programs accordingly.	By 2012
4.2.3	Continue collaboration with neighbours (e.g. Cocos (Keeling) Islands residents) to ensure coordination of data and environmental threat management including weeds and feral animals, fire, weed and feral management.	Ongoing
4.2.4	Continue collaboration with relevant land planning agencies to protect park values from external pressures from neighbouring land (e.g. the impact of developments on marine turtles migrating from the southern atoll).	Ongoing
4.2.5	Investigate the feasibility of supporting the establishment of a viable population of Cocos buff-banded rail on the southern atoll and continue to support the revegetation of Pisonia forest to provide appropriate habitat.	Ongoing
4.2.6	If parts of the landscape are changing in ways that are of concern, the Director, in consultation with relevant stakeholders, will decide on further monitoring requirements, and whether protective, rehabilitation or adaptation measures are feasible. If cost effective, appropriate actions will be implemented.	Ongoing

4.3 Reduce the carbon footprint of our reserves

The park adopts environmental best practice principles for resource use and management of waste products in the park. These principles are consistent with the need to conserve the park's natural and cultural resources, and meet broader commitments to reduce greenhouse gas emissions, reduce water use and minimise the potential impacts associated with waste management.

Park operational activities such as transport, electricity generation and use, building design, development of new infrastructure and waste management all contribute to the park's carbon footprint. Due to the isolated location of the park and difficulties in travelling to North Keeling Island, transport to and from the park is a major contributor to the carbon footprint of park management. Land management activities such as revegetation projects and pest management also have implications for the carbon cycle. It is necessary to better understand the impact of land management activities (including carbon sequestration) on the size and nature of the park's carbon footprint and the footprint of park management activities to allow performance to be holistically measured and improved over time. Careful management of these activities can help to reduce overall emissions.

Parks Australia will aim to reduce greenhouse gas emissions from park operational activities (such as energy use, transport and waste management) to 10 per cent below 2007-08 levels by mid 2015.

	Recommended Management Actions	Timeframe
4.3.1	Undertake a carbon emissions audit (consistent with ISO14064-1) that considers energy use, waste, water and support infrastructure (e.g. insulation) across all buildings, vehicles and equipment.	By 2013
4.3.2	Identify actions to reduce the carbon footprint of park operations and the level of carbon emission reduction associated with each mitigation action, for example: • transitioning park buildings to renewable energy sources such as solar energy • transitioning existing electric hot water systems to more efficient systems (e.g. solar hot water, gas, efficient heat pumps) as replacement becomes necessary • installing energy efficient light fixtures and light-controlling devices (e.g. motion sensors) in all park facilities • investigate and implement ways to minimise vehicle energy use • establishing guidelines to formalise waste reduction strategies into standard park practices (e.g. reducing consumption, printing double sided).	Ongoing
4.3.3	Work with partners to improve quantification of the carbon cycle as it relates to relevant park management activities.	By 2014

4.4 Work with communities, industries and stakeholders to mitigate and adapt to climate change

A small number of Cocos (Keeling) Islands residents and businesses rely on Pulu Keeling National Park to attract tourists. Climate change may have an impact on these communities and industries and they will need to mitigate and adapt to the changes. The park will work with local communities and stakeholders to identify and support proactive measures to reduce the negative impacts of climate change and to adapt where climate change induced impacts are unavoidable. The increase in frequency and intensity of extreme weather events will necessitate the development of risk control measures to protect life, infrastructure and the natural and cultural values of the park.

	Recommended Management Actions	Timeframe
4.4.1	Continue to work with the Cocos (Keeling) Islands residents, and other park stakeholders (e.g. commercial tour operators) to promote renewable energy projects.	Ongoing
4.4.2	Identify employment opportunities for Cocos (Keeling) Islands residents, to participate in climate change monitoring and remedial activities.	Ongoing
4.4.3	Participate in emergency response planning and operations as part of the emergency management committee for Cocos (Keeling) Islands.	Ongoing

	Recommended Management Actions	Timeframe
4.4.4	Conduct an infrastructure risk assessment to identify assets at risk from climate change impacts and extreme weather events. Assessment should recommend assets requiring upgrading, relocation or those unsuitable in the future climate change environment.	By 2013
4.4.5	Conduct education programs to communicate park values with an emphasis on sustainable use of marine resources and effective management of seabird populations.	Ongoing

4.5 Communicate the implications of, and our management response to, climate change

Climate change is a global issue affecting all aspects of our community and it is vital we share our knowledge with stakeholders, government bodies and the general public. This will ensure that stakeholders and the public are informed about potential climate change impacts and the management directions that are being taken. This will help ensure that efforts between government agencies, scientific researchers and the community are well coordinated.

	Recommended Management Actions	Timeframe
4.5.1	Liaise with Parks Australia, and the Department of Regional Australia, Regional Development and Local Government to ensure that communications messages regarding climate change are consistent and that agencies work together to develop and implement climate change strategies, and climate change communications plans.	Ongoing
4.5.2	Support the maintenance of publicly available information on the Parks Australia website for climate change policies, strategies and other documents relevant to the park.	Ongoing

5. Implementation and Review

The *Pulu Keeling National Park Climate Change Strategy 2011-2016* will be implemented over a five year period. While the strategy is consistent with the *Pulu Keeling National Park Management Plan 2004*, implementation of the recommended management actions is subject to budgetary and resource constraints. The strategy will be reviewed on a rolling basis to take account of new information or changes in policy directions.

Parks Australia will maintain liaison with the Department of Regional Australia, Regional Development and Local Government to ensure this strategy and any climate change strategies and communications developed for the Indian Ocean Territories are consistent.

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Prepared by: Director of National Parks

Note: This strategy sets out the preliminary actions and tools necessary to manage the consequences of climate change at Pulu Keeling National Park. While the Australian Government is committed to acting in accordance with the strategy, the attainment of objectives is subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the strategy due to changes in knowledge and policy direction.

This plan should be cited as:

Director of National Parks 2011. *Pulu Keeling National Park Climate Change Strategy 2011-2016*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australia.

This strategy is available from the Department's web site at http://www.environment.gov.au/parks/climate.html