Community-based conservation and recovery of native species on Monuriki Island, Fiji

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Abstract The small uninhabited island of Monuriki (40.4 ha) in western Fiji is of national and international conservation concern for its several protected species. Exotic invasive species and a Category 5 cyclone have exacerbated conservation challenges. The cooperation of local, national, and international stakeholders continues to be crucial in restoration of the island's native flora and fauna. This summary presents a timeline of restoration efforts and current status of the recovery programme for Monuriki. The critically endangered dry forest habitat of Fiji is only found in a few isolated patches on disparate islands. The Fijian crested iguana (*Brachylophus* cf. *vitiensis*) is a critically endangered species restricted to a few small islands in this dry forest zone of western Fiji. The population of crested iguanas on Monuriki Island is the third largest remaining population. Even before iguanas were first documented on the island in the early 1980s, individuals had been removed by local resorts for display purposes, a practice that was previously unregulated. In the late 1990s, the first efforts to conserve and restore Monuriki Island were discussed, but conservation initiatives were not implemented until the development of the Crested Iguana Recovery Plan in 2008. In 2011, domestic goats (*Capra hircus*) and non-native rats (*Rattus exulans*) were removed from the island, and 10 pairs of iguanas were brought into captive breeding facilities within Fiji. In 2015, the first 32 captive-bred crested iguanas were released back on Monuriki Island. More than half of these iguanas (N=26) were radio-tracked for 56 days post-release in order to assess survivorship and help provide insights into their short-term movement patterns. Of the 26 iguanas that were tracked, nearly 70% (N=18) were found after 56 days indicating excellent short-term survival. In February 2016, Tropical Cyclone Winston, a Category 5 storm passed through Fiji and devastated some of the tropical dry forest habitat on Monuriki. With sustained winds of up to 230 km/hr nearly all of the canopy leaves from trees on Monuriki Island were removed and large amounts of debris covered the forest floor. Following the cyclone, a brief wildlife survey revealed Monuriki's iguana and bird populations were still present. In 2017, the crested iguana captive breeding programme was brought to an end when 16 of the original 20 iguana founders, and an additional 32 captive bred offspring, were reintroduced onto Monuriki. This was accomplished, in part, due to successful breeding and reestablishment of the remaining wild iguanas on the island. Despite a major storm event, reestablishment likely resulted from reduced egg and hatchling predation by the rats, and excellent habitat recovery after goat removal. Overall these invasive species eradications have proven highly successful for the recovery of the iguanas, wedge-tailed shearwaters (*Puffinus pacificus*), and several other non-target species including the banded rail (*Gallirallus philippensis*) and endangered Fijian peregrine falcon (*Falco peregrinus*). Furthermore, eradication of non-native species has also helped the recovery of the highly threatened tropical dry forest ecosystem in which these species exist.

Keywords: *Brachylophus* cf. *vitiensis*, eradication, Fijian crested iguanas, goats, island restoration, Pacific rats, *Puffinus pacificus*, wedge-tailed shearwater

INTRODUCTION

Tropical dry forest habitats are globally rare and often contain highly endemic faunas. These forests are typically impacted by anthropogenic fires to convert them into lands for agriculture on mainland regions and degraded by multiple invasive alien species such as grazing and predatory mammals, and various invertebrates on islands. In Fiji, most of the dry forest on the two large islands of Viti Levu and Vanua Levu has been transitioned into sugar cane, cattle grazing, or invasive grasslands (Olson, et al., 2010). Dry forest persists only on some of the smaller islands, or in very limited patches on larger islands. Of the smaller islands Monuriki and Monu have been identified as Key Biodiversity Areas (KBA's) by Conservation International because of their significance as critical refugia for the Fijian crested iguana (*Brachylophus* cf. *vitiensis*) and tropical dry forest (Conservation International, 2005; Olson, et al., 2010). These islands, and particularly Monuriki, also support the largest wedge-tailed shearwater (*Puffinus pacificus*) population in Fiji. This paper outlines progress made with the restoration of Monuriki Island by working with the traditional land owners through an innovative and inclusive conservation partnership.

Location

The uninhabited Monuriki Island (12.610° S, 177.034° E) lies within the Mamanuca group in the province of Nadroga, western Fiji (Fig. 1). This 40.4 ha volcanic island reaches its peak at 177 m above sea level (Fig. 2). Monuriki is owned by the Mataqali Vunaivi, the traditional Fijian clan living on the nearby island of Yanuya. Monuriki is listed under the National Biodiversity Strategic Action Plan as a site of national significance due to its tropical dry forest and two particular species of international or national conservation concern, the Fijian crested iguana (*Brachylophus* cf. *vitiensis*) and the wedge-tailed shearwater (*Puffinus pacificus*) (Coulston, et al., 2010; Olson, et al., 2010). Monuriki is the location of the third largest population of the endemic Fijian crested iguana (IUCN, 2014). This iguana is listed on CITES Appendix I, as Critically Endangered by the IUCN Red List (IUCN, 2014), and Endangered by the US Fish and Wildlife Service; it is protected in Fiji under the Endangered and Protected Species Act (2002). Monuriki Island crested iguanas are genetically distinct from all other crested iguana populations (Keogh, et al., 2008), and the 2008 Iguana Species Recovery Plan (Harlow, et al., 2008) prioritised Monuriki as the single most important site

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for immediate conservation action for this taxon. These iguanas were discovered only in 1980. At that time there was "a high density of iguanas" on Monuriki (Gibbons, 1984); however, less than 20 years later a survey revealed fewer than 100 iguanas remained (Harlow & Biciloa, 2001). A more recent survey indicated the population had dropped precipitously further with more extensive surveys reporting only eight individuals found in 2003 (Harlow, et al., 2007). The island also hosts several nesting colonies of the wedge-tailed shearwater (*Puffinus pacificus*), a species known from seven islands in Fiji and among which Monuriki supports the most significant population. These sea birds excavate burrows, often in the fragile coastal strand substrates, to rear their chicks. It was estimated that more than a thousand pairs of wedge-tailed shearwaters annually breed on this island (Rasalato, et al., 2012). Exotic faunal and floral species have invaded many of the islands in Fiji and pose a serious environmental threat to Monuriki's native biodiversity.

Threats to native species

Fire is an anthropogenic threat to Monuriki, due to the island's small size and lack of natural ignition sources. Exacerbating this is the threat of exotic non-native species. The history of exotics on the island of Monuriki may date back more than 3000 YBP. Pacific rats (*Rattus exulans*) were the first exotic species introduced to this island, most likely as stowaways with the early human arrivals (Roberts, 1991). This adaptable species has been able to sustain itself on most islands left unchecked until eradication is implemented. Rats are known to prey on eggs and chicks of nesting birds, as well as lizards, juvenile tuatara (*Sphenodon punctatus*), and seeds (Towns, et al., 2006). Domesticated goats (*Capra hircus*) were established on Monuriki during the 1970s. Originally brought as livestock, they provided an income for the Yanuya owners of the island. As voracious grazers, goats denuded the island of its undergrowth and ate the seedlings of forest trees, and leaf litter causing serious habitat degradation and severe erosion. The dry forest habitat may recover from infrequent dry season burning in the next rainy season provided seedlings are left intact. However, when goats are present the seedlings are grazed, preventing the regeneration of these native plants and trees. This causes the endangered dry forest habitat to convert to a mostly non-native composition while any remaining mature native trees senesce and eventually die. Following this cycle with fire and goat grazing on Monuriki, the lack of native food plants posed a threat to the diminished population of iguanas. Most of the surviving vegetation was unpalatable to both goats and iguanas. The open ground left by the continual grazing created space for opportunistic invasive exotic and unpalatable plants to take hold, including the native but invasive vaō (*Neisoperma oppositifolium*). Normally found in low abundance, vaō became overabundant with disturbance and an increase in light through the canopy increasing its representation in the forest composition. Goats also threatened the ground-nesting shearwaters by trampling nests, and causing the collapse of fragile burrows containing eggs, chicks, and nesting adults. The loss of insulating vegetation (leaf litter and understorey structure), moderating water runoff and erosion during heavy rain events, also potentially reduced shearwater breeding success due to inundation of burrows and nests. Most documented extinctions and current causes of declining numbers of Pacific island birds result from the effects of invasive alien species, and particularly vertebrates such as rats and goats (McCreless, et al., 2016).

Tourism and poaching are additional disturbances to this island which greatly impact iguanas, and increased foot traffic during the breeding season might impact wedge-tailed shearwaters, and other natives such as the banded rail (*Gallirallus phillippensis*), and peregrine falcon (*Falco peregrinus*). Monuriki is the site where the award-winning 1999 Dreamworks movie "Castaway" was filmed, and subsequently the island has become popular as a tourist stop with the remaining movie set maintained as a primary attraction. Ecotourism is the major contributor to Fiji's economy in this region. An estimated 70–100 tourists visit the island daily although the number could be much larger some days. Local resorts are still removing iguanas for display on other nearby islands as an "ecotourism" prop to draw in customers, and for tourist activities such as staged photos.

Restoration plans and community conservation

In the late 1990s, the first efforts to conserve and restore Monuriki were discussed. In 1998, 2000, and 2003, surveys of Monuriki detected a rapid decline in the iguana population as a result of continued major habitat degradation by goats, with only adult iguanas being detected and no evidence of recent recruitment (Harlow, et al., 2007). The landowners were approached on at least three occasions to remove goats from Monuriki, but declined to participate each time. In 2004 the IUCN Iguana Specialist Group (ISG) met in Fiji to discuss the current impacts on Monuriki, as part of identifying potential conservation actions possible for the species, including captive breeding. Through the development of the IUCN Crested Iguana Recovery Plan in 2008, conservation action steps for Monuriki were fully-developed and finally implemented. In 2009, BirdLife International undertook surveys that documented rats and goats to be major threats to nesting seabirds on Monuriki and nearby Monu and Kodomo islands (NTF, 2012). It was concluded that, if left unchecked, the persistence of rats and goats would lead to the loss of the dry forest and nesting seabirds on Monuriki. With the endorsement of the Yanuya

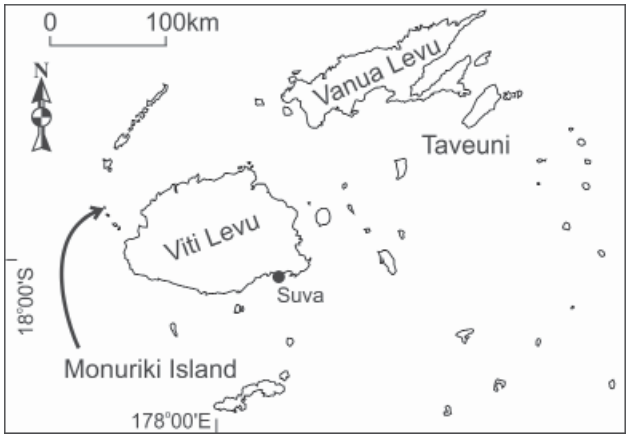

Fig. 1 Map of Fiji with arrow showing the location of Monuriki Island.

Fig. 2 View of Monuriki Island from 2017, looking to the south-west.

Village Chief and chief landowner, Sitiveni Drigi, an eradication programme was therefore implemented during 2010–2011, specifically targeting invasive rats and feral goats remaining on Monuriki (NTF, 2012). The goal of this programme was to restore an ecosystem suitable for the wedge-tailed shearwater, birds native to Fiji's tropical dry forest, and the critically endangered crested iguana. Regular post-eradication monitoring, along with environmental education campaigns specifically targeting biosecurity among island users including tourists and fishermen, were critical components to sustaining the eradication results and restoration outcomes (Donlan & Keitt, 1999). The eradications were designed in collaboration with eradication experts (i.e., Pacific Invasives Initiative), local land owners, the Provincial and National government, and consultants. Two years of monitoring on Monuriki (and Kodomo) did not detect rats and goats and by the end of 2013 their eradication was confirmed.

METHODS

Consultation

Many stakeholders were included in discussions regarding the invasive species eradication plan. The plan was launched as a community-based effort to successfully restore and protect the natural state of Monuriki. The involvement of the landowning unit in the village of Yanuya (the Mataqali Vunaivi) and their chief, the late Taukei Yanuya (Ratu Sitiveni Drigi) played a pivotal role in ensuring the restoration and protection of Monuriki was supported by the Yanuya community.

Other stakeholders since 2009 include (but are not limited to):

- BirdLife International
- Commissioner Western's office of the Fiji Government
- Community members and village groups
- Critical Ecosystem Partnership Fund
- David & Lucile Packard Foundation
- Department of Heritage and Arts
- Disney Conservation Fund
- School of Geography at the University of the South Pacific
- Iguana Specialist Group (IUCN)
- International Iguana Foundation
- Kula Wild Adventure Park
- Mamanuca Environment Society
- Ministry of Agriculture (Fiji)
- Ministry of Local Government, Housing & Environment (Fiji)
- Nadroga/Navosa Provincial Office
- National Trust of Fiji Islands
- NatureFiji-MareqetiViti
- New Zealand Department of Conservation
- Pacific Invasives Initiative
- San Diego Zoo Global
- South Sea Cruises
- Survivor Entertainment Group
- Taronga Conservation Society Australia
- US Embassy Suva, Fiji, Regional Environmental Affairs Office
- US Geological Survey, Western Ecological Research Center
- Yanuya Rugby Team.

Consultations with landowners were (and will continue to be) conducted before, during and after each activity or site visit. Transparency of all information and intentions of any actions are disclosed to stakeholders (BirdLife, 2011b).

From 2009–2010, discussions that addressed goat grazing on the island were held with landowners. Although the BirdLife surveys in 2009 confirmed goats to be a significant factor in the decline of the native species, goats were also a contributor to the village of Yanuya's financial income through market sale or occasional harvest for meat. Therefore, compensation for the village of Yanuya to halt goat grazing was agreed upon by the community and supported by various stakeholders. In 2010 a Memorandum of Understanding (MOU) was signed with the Mataqali Vunaivi, National Trust, and Kula Eco Park (now Kula Wild Adventure Park) for rat and goat removal, and iguana harvest for the captive breeding programme. The National Trust of Fiji and BirdLife International jointly carried out operations to eradicate rats in August of 2011 and goats between June 2010 and November 2011. At the same time, it was decided the best way to conserve the crested Fijian iguana was to harvest 10 sexually mature adult pairs (N = 20) from the remaining iguanas on the island for captive breeding and subsequent reintroduction. From April 2010 to February 2012 Monuriki iguanas were collected and brought to captive breeding facilities located at Kula Eco Park as part of the MOU.

Goat removal and eradication

The local Yanuya Rugby Team was employed to muster and catch goats on the island utilising mustering routes and techniques established by the local communities from decades of catching goats on Monuriki. From June to November 2010, 151 goats were mustered from the island over 12 days, and as of January 2011 an estimated 20 goats remained (BirdLife, 2011a). Captured goats were taken to the Viti Levu mainland for sale. Two professional hunters from New Zealand using trained dogs eliminated more than 50 additional goats over an 11-day period in September 2011. A final four day follow up hunting effort in November 2011 detected no additional goats (BirdLife, 2011a). To compensate for expected revenue loss of these animals, the owners received FJ$100 per goat. Post-eradication monitoring of the forest vegetation using fixed photo points and of the wedge-tailed shearwater population was conducted to assess the response to the goat eradication (Rasalato, et al., 2012).

Rat eradication

Eradication of Pacific rats (*Rattus exulans*) was carried out by delivering specially formulated rodenticide (brodifacoum at 20 ppm) baits (PestOff 20R) from a helicopter using standard procedures and equipment including a specifically designed spreader bucket calibrated to the required application rate (20 kg/ha) and GPS (Seniloli, et al., 2011). To determine the success of the rat eradication, a series of transects with rat-trap (Victor Professional) and rat-detection stations were created in two to three main locations across the island for each monitoring event in 2012, 2013, 2015, 2016, and 2017. The transects were set up in areas of the eastern, northern, and south-western beaches with between 10 and 20 stations for each transect (Rasalato, et al., 2012; Fig. 3). Each station comprised at least one snap trap, but the first assessments also included a peanut butter wax tag, a tracking tunnel and a second snap trap. The peanut butter wax tags were nailed to trees at random heights so as to reduce hermit crab access. Ink pads were placed in tracking tunnels with roasted coconut placed on the pads to act as baits. Snap traps were also baited with roasted coconuts and positioned to minimise non-target interference (e.g. hermit crabs).

These monitoring stations were set-up for three trap nights and were maintained and checked daily for any signs of rat activity (Rasalato, et al., 2012).

Biosecurity control

There is on-going training and outreach to the local tour companies about the conservation activities on Monuriki Island. Furthermore, biosecurity protocols were established to help reduce the potential negative impacts of the tours and other visitations to the island. A biosecurity plan prepared in 2013 (Thaman & Niukula, 2013) is reviewed and updated every two years (Seniloli, et al., 2015). The plan includes three main biosecurity procedures: preventing the entry of invasive alien species, systematic checking for such species, and rapid response procedures if any are found. Measures include the establishment of a community-based ranger programme to train local rangers on invasive species surveys, response methods and the prevention of wildlife poaching.

Kula Eco Park captive breeding programme

Concurrently with the rat and goat eradication efforts (2010–2011), 20 Monuriki iguanas were harvested and brought to Kula Eco Park, on the main Fijian island of Viti Levu, to develop a captive breeding colony. Pairs were successfully bred in managed care with the intention of re-introducing the offspring to their home island once the forest vegetation had recovered from grazing.

Species recovery

Monitoring for native species recovery has taken place so comparisons to pre-eradication surveys can be conducted. This includes using standard protocols for the iguanas and shearwaters, and recording other incidental species recoveries (Harlow, et al., 2007; Rasalato, et al., 2012). Vegetation surveys were conducted in fixed plots prior to the mammal eradications, and these plots were resurveyed in 2016, after the eradications, following the same survey protocols (Harlow, et al., 2007).

RESULTS

Goat removal and eradication

Since the goat removal and eradication was undertaken, there have been no detections of goats on the island during the last five years (through to 2017), confirming this action to be a success.

Rat eradication

In March 2012, five months after the helicopter spread of rodenticide, no rats were trapped nor were there any obvious signs of rat presence such as droppings, gnawed fruits or sightings (Rasalato, et al., 2012). Similarly, no indications of rat presence were found during subsequent assessments to date (2013, 2015, 2016, 2017), confirming eradication of Pacific rats from Monuriki Island and an ongoing rat free status generally.

Fig. 3 Monuriki Island showing the transects with the rat sampling stations on the west and east beaches.

Biosecurity control

Ships/vessels, commercial and private, are required to abide by the biosecurity measures detailed in the most recent version of the biosecurity plan (Seniloli, et al., 2015). These measures include setting up and maintaining bait and trap stations near wharfs and landing sites, regular checks of vessels for alien species stowaways, proper storage of food and regular decontamination of equipment including footwear; detection of any alien species on the island requires immediate reporting to a designated regional support centre. Although outlined, implementation of all of these actions has been slow, due to lack of resources. Camera stations to detect and assess risk of reinvasion, especially by rodents, were set up to monitor tourist visitations at designated areas of Monuriki. Some cameras are obvious and others are hidden; this programme helped identify what items are being brought ashore. Community awareness and involvement in implementing and enforcing biosecurity measures has been important in preventing additional invasive species from establishing on the island. This includes the cooperation of tour boats and yachts that must now follow biosecurity guidelines by having to report to local landowners or designated personnel and crew for a biosecurity briefing before anchoring near the island, although this is still to be fully enforced (NTF, 2012).

Kula Eco Park captive breeding programme

After four wet seasons following goat removal, the vegetation of Monuriki showed significant recovery, so we initiated the reintroduction of iguanas from Kula Eco Park. In mid-May 2015, 32 captive-bred crested iguanas, all implanted with unique PIT tags, were released into four different areas on Monuriki Island (Chand, et al., 2016) after a major community ceremony highlighting this milestone in the programme. Community members participated in the release of the iguanas and the event has been recorded in a video documenting the story (<https://vimeo.com/163325268>). In February 2017, 32 additional captive bred juveniles along with 16 of the original wild caught adults were released; 10 of each group were tracked for five months to measure post-release survivorship. Because this event signalled the end of the captive breeding programme and to thank the community for their permission and participation, a second major community event involving many levels of the Government was planned around the release. Only a few young iguanas remain in captivity for release in 2018 or 2019.

Released iguanas were monitored in 2017 and any wild captured individuals or recaptures from the 2015 release were measured and weighed to document post-release growth and general health. Transmitters used to help track released iguanas were removed before final re-release after the five-month period. Currently, the crested iguana population on Monuriki is recovering with the release of captive breeding programme animals, and naturally with existing wild animals (see below). Due to this success the captive breeding programme was ended on 24 February 2017, after the final release of the remaining 16 wild founder iguanas. Overall, between 2015 and 2017, a total of 80 iguanas, including the founders, were released into the wild.

Species recovery

Between February and June 2017, 35 wild iguanas (not passing through captivity) were caught and marked. Many

of these were young animals that would have hatched after the rat eradication was completed. This sample of iguanas revealed that, within five years, the small remaining population of iguanas is reproducing and recruiting back into the recovering habitat.

A monitoring survey was conducted for wedge-tailed shearwater nests post-eradication. Out of the 159 burrows searched, 110 (69%) were occupied by chicks and one had an egg. Pre-eradication wedge-tailed shearwater nest site occupancy was 41% whereas post-eradication this had risen to 69% occupancy (Rasalato, et al., 2012). The size of the wedge-tailed shearwater population on the south-western beach colony during the 2011–2012 seasons was estimated to be 1383 breeding pairs (Rasalato, et al., 2012). As an additional positive outcome, banded rails (*Gallirallus philippensis*) and peregrine falcons (*Falco peregrinus*; critically endangered in Fiji) are more frequently encountered on Monuriki following rat and goat eradications.

Habitat monitoring to document terrestrial dry forest habitat recovery following goat removal was conducted in 10 previously established 100 m^2 plots in the lowlands behind Rogua Beach. Vaō trees dominated the forests on Monuriki before the eradications. This species is unpalatable to both goats and iguanas. However due to goats' removal of the edible understory and lower branches of the taller edible trees, the goats were now starting to chew on the stems of the vaō. During the presence of goats and rats, vaō comprised 91.3% of the seedlings per plot, but only 58.7% of the seedlings per plot after goats and rats were removed. Individual vaō trees (> 2 m in height) had decreased from 155 to 78 individuals across the plots after mammal removal. Although this plant is native, it spreads like an invasive with disturbance. There is no plan to control it, but the recovery of the other native forest diversity will reduce its cover over time. For example, only three other tree species seedlings were documented when goats were present; now there are about 11 species of seedlings present per plot including *Hibiscus*, *Diospyros*, and *Pongomia*. Ground cover of vine (some invasive but edible such as *Passiflora foetida*) increased from 0% with goats to 30.2% after goats were removed. Habitat recovery was determined to be successful through these habitat surveys, although no similar repeated surveys have been done on the higher slopes where a greater diversity of dry forest trees are present.

Table 1 Timeline of impacts and recovery actions on Monuriki Island.

Rattus exulans introduced to Fiji	ca. 3,000 years ago
Goats introduced to Monuriki	1970s
Iguanas discovered on Monuriki	1980
Iguanas captured for resort displays	1980s–2000s
Castaway was filmed	1999
IUCN Iguana Specialist Group Suva, Fiji	2004
Crested Iguana Species Recovery Plan	2008
Discussions with landowners over goats	2009–2010
Goat eradication operation	2010–2011
20 Monuriki iguanas harvested for captive colony	2010–2012
Rat eradication operation	2011
Goat and rat eradication confirmed	2013
32 captive-bred iguanas released	2015
Cyclone Winston (Category 5)	2016
Reality TV Show now being filmed on Monuriki	2016–2017
32 captive-bred iguanas released	2017
16 remaining original founder iguanas released	2017

DISCUSSION

Overall, the Monuriki Island restoration programme has been a great success and a model for Fiji and other nations in the region. Table 1 is a timeline that reviews the overall impacts to the island and the major milestones relevant to the plan. Monitoring will continue over the next decade as the tree canopy expands and invasive plants continue to be removed from the island. On the two main beaches, invasive plants are being removed manually and dry-forest trees are being planted within the coconut groves that persist. Over time these areas will recover to dry forest also. Most of the obvious habitat damage from cyclone Winston was on these coconut groves, breaking them in half, and the native trees on the ridges that were damaged seem to be recovering well from the event.

Community engagement

This programme has continued with renewed investment in the local community through the development of a regional Ranger Programme for Fiji iguana conservation. Various stakeholders have supported the development and training of local residents to act as regional iguana experts and habitat managers. This programme includes capacity building by training local rangers in field survey techniques, habitat management methods, reforestation efforts, guest experience training for tourist interactions, and anti-poaching. Support for the Rangers and other local level science educators to attend conferences and workshops (such as the IUCN Iguana Specialists Group) geared toward engagement in conservation initiatives for threatened species has continued to provide valuable training and resources for long-term capacity building within Fiji. Education and outreach materials have been developed with the goal of reaching the regional children through programmes for the classrooms. Visits to the local communities to conduct outreach programmes have provided additional opportunities to reach the local communities and encourage their continued support in the conservation of the native threatened species.

To protect the regenerating forest, the community Rangers also established tourist hiking paths with the intent of educating visitors about tropical dry forest habitat while keeping their impacts on the island to a minimum. Interpretive kiosks are being developed and will be installed at the tourist beach.

Additional threats

In February of 2016, Tropical Cyclone Winston passed through Fiji with a peak intensity of ten-minute sustained winds of 230 km/hr that removed a significant proportion of the canopy leaves from trees on Monuriki Island (Fig. 4). Terrestrial surveys conducted in March 2016, indicated that the iguanas and birds were still present and increasing, but that long-term studies after this storm event would be critical for helping to understand species resiliency and recovery in the wake of massive tropical storms. BirdLife continues to monitor the wedge-tailed shearwater population and, while no assessment was made following cyclone Winston (which occurred during the

chick feeding phase), population measures assessed will inform recruitment trends. The final 16 original founding iguanas, along with their 32 offspring produced as part of the captive breeding programme, were released after this extreme weather event (Table 1). Robust population monitoring for the iguanas will take place during 2018 to assess the longer-term survivorship of the released iguanas and track recovery of the remaining wild individuals.

2016–2017 Reality TV show, Survivor, now being filmed on Monuriki

Regional conservation efforts for Fijian iguanas have continued and grown to include additional partners. One such collaborator, Survivor Entertainment Group, has been strongly supportive of the programme since their arrival to the region. Although this partner may not be conventional when considering species conservation and habitat restoration, they have embraced and supported our efforts to save the Fijian iguanas from extinction and have assisted in efforts to continue local level engagement. There might be impacts of the filming activities on the shearwaters, but these are hard to measure, and are being minimised by marking active nest sites and putting in avoidance trails to move film crews and contestants around these sensitive sites. By providing significant local employment opportunities and incorporating and investing in biosecurity training methods and native species conservation as part of their local strategic plan they have become an advocate for these restoration and recovery efforts in the region.

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Fig. 4 Rogua Beach on Monuriki in March of 2016 after Cyclone Winston. Broken and denuded trees are seen along the beach and up the hillslope.

REFERENCES

BirdLife International. (2011a). *Monuriki and Kadomo Goat Eradication Operation Report*. Unpublished report. Suva, Fiji: BirdLife International, Pacific Secretariat.

BirdLife International, National Trust of Fiji, Pacific Invasives Initiative. (2011b). *Operational Plan for the Eradication of Feral Goats in the Mamanuca Islands, Republic of Fiji.* Unpublished report. Suva, Fiji: BirdLife International, Pacific Secretariat.

Chand, R., Niukula, J., Vadada, J., Fisher, R., Lovich, K., Pasachnik, S., Rasalato, S., Thaman, B., Seniloli, E., Tuamoto, T., Yanuya, T. and Harlow, P. (2016). 'Captive Breeding and Re-introduction of the Monoriki Island Crested Iguana in Fiji'. In: P.S. Soorae (ed.) *Global Re-introduction Perspectives: 2016. Case-studies from Around the Globe.* Gland, Switzerland: IUCN/SSC Reintroduction Specialist Group and Abu Dhabi, UAE: Environment Agency-Abu Dhabi.

Conservation International. (2005). *Conservation Outcomes: Polynesia and Micronesia, Fiji Inset, Draft Map, 1:3,200,000*. Washington, DC, USA: Conservation International and The Critical Ecosystem Partnership Fund.

Coulston, G., Ratu, M. and Nagle, B. (2010). *Monuriki Island Goat Removal; Report of a Feasibility Study Visit*. Unpublished report. Auckland, New Zealand: Pacific Invasives Initiative.

Donlan, C.J. and Keitt, B.S. (1999). 'Using research and education to prevent extinction'. *California Coast and Ocean* 15: 20–23.

Gibbons, J. (1984). 'Iguanas of the South Pacific'. *Oryx* 18 (2): 82–91.

Harlow, P.S. and Biciloa, P.N. (2001). 'Abundance of the Fijian crested iguana (*Brachylophus vitiensis*) on two islands'. *Biological Conservation* 98: 223–231.

Harlow, P.S., Fisher, M., Tuiwawa, M., Biciloa, P.N., Palmeirim, J.M., Mersai, C., Naidu, S., Naikatini, A., Thaman, B., Niukula, J. and Strand, E. (2007). 'The decline of the endemic Fijian crested iguana *Brachylophus vitiensis* in the Yasawa and Mamanuca archipelagos, western Fiji'. *Oryx* 41: 44–50.

Harlow, P.S., Hudson, R. and Alberts, A. (2008). 'Fijian Crested Iguana *Brachylophus vitiensis* Species Recovery Plan 2008–2012'. IUCN Species Survival Commission, Iguana Specialist Group. < http://www.iucn-isg.org/publications/actionsplans/>.

Keogh, J.S., Edwards, D.L., Fisher, R.N. and Harlow, P.S. (2008). 'Molecular and morphological analysis of the critically endangered Fijian iguanas reveals cryptic diversity and a complex biogeographic history'. *Philosophical Transactions of the Royal Society*, Series B. Vol. 363 (1508): 3413–3426.

McCreless, E.E., Huff, D.D., Croll, D.A., Tershy, B.R., Spatz, D.R., Holmes, N.D., Butchart, S.H.M. and Wilcox, C. (2016.) 'Past and estimated future impact of invasive alien mammals on insular threatened vertebrate populations'. *Nature Communications* 7: 12488.

NTF. (2012). *Restoring the Native Vegetation of Monuriki Island, Fiji. Final Report Submitted to Critical Ecosystems Partnership Fund*. Suva, Fiji: National Trust of Fiji Islands.

Olson, D., Farley, L., Patrick, A., Watling, D., Tuiwawa, M., Masibalavu, V., Lenoa, L., Bogiva, A., Qauqau, I., Atherton, J., Caginitoba, A., Tokota'a, M., Prasad, S., Naisilisili, W., Raikabula, A., Mailautoka, K., Morley, C. and Allnutt, T. (2010). 'Priority forests for conservation in Fiji: landscapes, hotspots and ecological processes'. *Oryx* 44: 57–70.

Rasalato, S., Niukula, J., Thaman, B., Mateiwai, M. and Vadada, J. (2012). *Post-eradication Monitoring Survey on Monuriki Island, Mamanuca group*. Unpublished field report. Suva, Fiji: BirdLife International, Pacific Secretariat.

Roberts, M. (1991). 'Origin, dispersal routes, and geographic distribution of *Rattus exulans*, with special reference to New Zealand'. *Pacific Science* 45: 123–130.

Seniloli, E. Rasalato, S. Tuamoto, T. and Cranwell, S. (2011). *Feasibility of Rat and Goat Eradication in the Mamanuca group Fiji*. Unpublished report. Suva, Fiji: BirdLife International, Pacific Secretariat.

Seniloli, E., Rasalato, S. and Tuamoto T. (2015). *Draft Biosecurity Action Plan for Monuriki and Kadomo Islands, Mamanuca Group, Fiji.* Suva, Fiji: Nadroga/Navosa Provincial Council, BirdLife International, National Trust of Fiji Islands, NatureFiji-MarqetiViti.

Thaman, B. and Niukula J. (2013). *Draft Biosecurity Action Plan for Monoriki and Kadomo Islands, Mamanuca Group, Fiji.* Suva, Fiji: Nadroga/Navosa Provincial Council, BirdLife International, National Trust of Fiji Islands, NatureFiji-MarqetiViti,

Towns, D.R., Atkinson, I.A.E. and Daugherty, C.H. (2006). 'Have the harmful effects of introduced rats on islands been exaggerated?' *Biological Invasions* 8: 863–891.