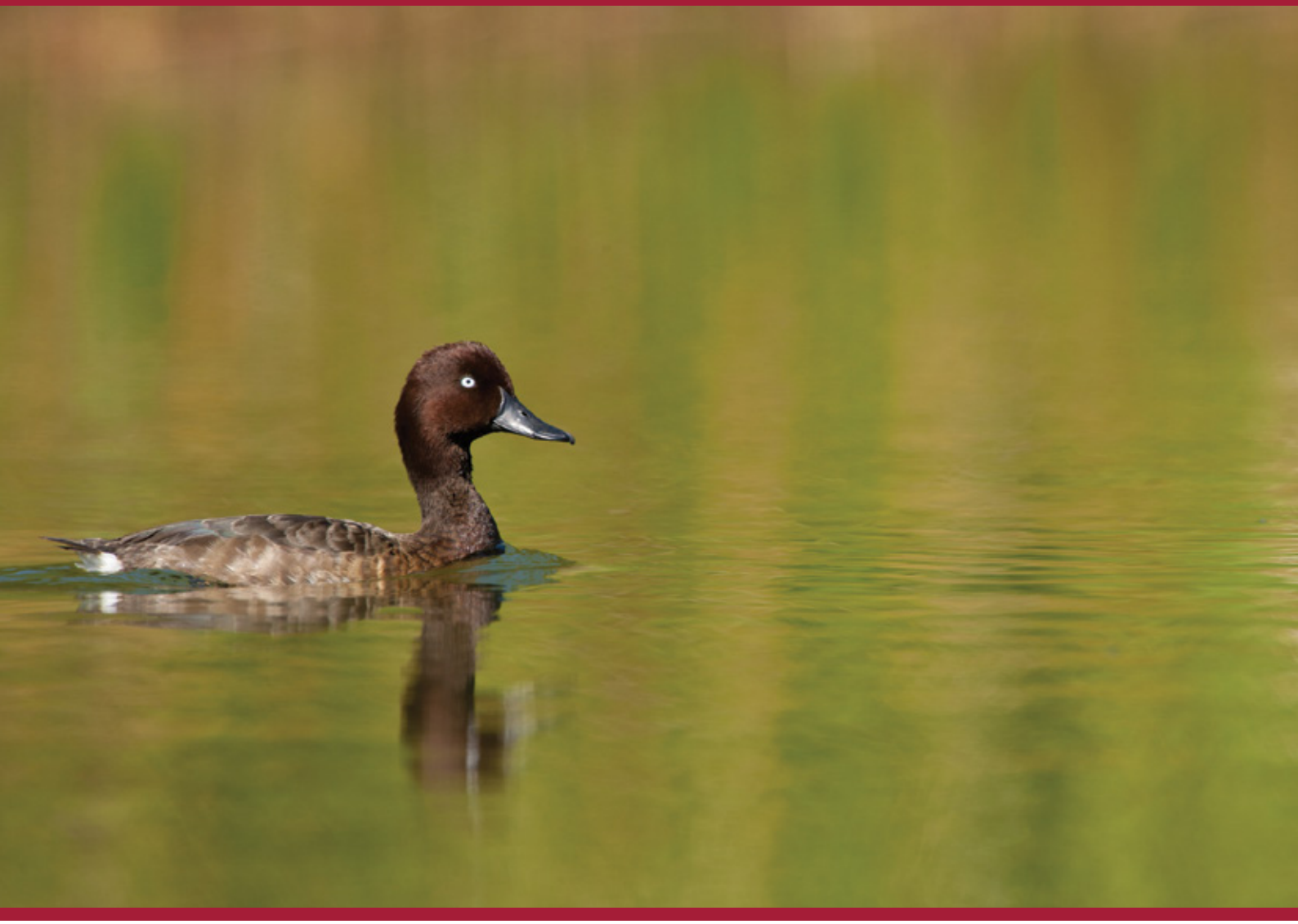
MIARO NY FOTSIMASO
SAUVONS LE FULIGULE DE MADAGASCAR
SAVING THE MADAGASCAR POCHARD

Species Action Plan 2014-2024

For the conservation of the critically endangered Madagascar pochard



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Milestones in the production of this plan

A Species Action Planning Workshop was held between the partners and key stakeholders from 3–6 December 2013 in Antananarivo, Madagascar.

The workshop was the first of its kind in Madagascar, following IUCN guidelines, with the full participation of representatives from the local community level to national government and international partners. Stakeholders included representatives from local communities near the remaining wild population in Bemanevika and the potential release site at Lac Sofia.

The workshop was opened by Mr Richard Lewis (Director Durrell Wildlife Conservation Trust Madagascar Programme) and Madame Sahondra Rabesihanaka (*Chef du Service de la Gestion de la Faune et de la Flore*, DVRN/DGF/MEEF). The workshop was facilitated by Dr David Mallon (IUCN Species Conservation Planning Sub-committee) and Ms Domoina Rakotobe. Speeches were presented during the workshop by Mr Desire Randriamaro (*Directeur de Développement Régionale*, Sofia), Mr Rufin Zamany (*Direction Régionale de l'Environnement, et de l'Ecologie et des Forêts*, Sofia), Madame Voninavoko Raminoarisoa, (Director Asity Madagascar), Mr Jaomanody (Mayor of the Commune of Bemanevika), Mr Jean Nestor and Mr Eric Ferdinand Randrianantenaina (VOI Sofia Mandroso), and Mr Nestor Robert Tilahy (President Federation FBM/FIMAKA). The workshop was closed by Mr Timothy Smart (British Ambassador to Madagascar) and Mr Jean Claude Rabemanantsoa (Directeur General, MEEF).

The workshop identified priority conservation actions for the next 10 years (2014-2024). Full minutes were taken during the meeting and circulated to all participants during 2014.The record of the Vision, Goals and Objectives and the Project and Activity tables produced during the workshop was agreed and this Action Plan is considered to be a faithful report of the workshop outcomes which are presented in the languages used during the workshop (English and Malagasy) to ensure that the exact meaning and intent is not lost or transformed during translation.

Figure 1. Participants of the Action Planning workshop in Antananarivo, December 2013.

Donors

The workshop and Action Plan were funded by the Darwin Initiative the IUCN Species Survival Commission's Species Conservation Planning Sub-Committee, and supporters and members of WWT and Durrell.

New Information

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Cover photo: Male Madagascar pochard at Lake Matsaborimena. Iñaki Relanzón/www.photosfera.com.

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Acronyms and abbreviations

AM	Asity Madagascar
CEEF	Cantonnement de l'Environnement, et de l'Ecologie et des Forêts, Madagascar
CI	Conservation International
CITES	Convention on International Trade in Endangered Species
COBA	Communauté de base (Local community)
DCBSAP	Direction de Conservation de la Biodiversité et du Système des Aires Protégées, Ministère de l'Environnement, de l'Ecologie et des Forêts, Madagascar
DDR	Directeur de Développement Régionale
DGF	Direction Générale des Forêts, Ministère de l'Environnement, de l'Ecologie et des Forêts, Madagascar
DREEF	Direction Régionale de l'Environnement, et de l'Ecologie et des Forêts, Madagascar
Durrell	Durrell Wildlife Conservation Trust
DVRN	Direction de la Valorisation des Ressources Naturelles, Ministère de l'Environnement, de l'Ecologie et des Forêts, Madagascar
FBM	Fikambanan'i Bemanevika Miray (Association of People Unified for Bemanevika)
FIMAKA	Fikambanana Mitantana Ala Ketsan'Amberivery (Association of People for Protecting the Forests of Amberivery)
GELOSE	Gestion Locale Sécurisée
IUCN	International Union for the Conservation of Nature
MEEF	Ministère de l'Environnement, de l'Ecologie et des Forêts, Madagascar
NPA	New Protected Area
NGO	Non-Governmental Organisation
ODA	Organismes des developpement appui
ONE	Office National pour l'Environnement
PBZT	Parc Botanique et Zoologique de Tsimbazaza
VOI	Vondron'Olona Ifotony (Local Committee representing the Community)
TPF	The Peregrine Fund
UNIV TAN	University of Antananarivo
WWF	World Wide Fund for Nature
WWT	Wildfowl & Wetlands Trust

Avant-propos
Plan d'Action Fotsimaso

Depuis la prise de conscience mondiale sur la nécessité de s'adonner à la conservation, Madagascar tient une place toute particulière de par le grand taux d'endémicité des espèces qu'on y trouve. Malheureusement, le pays se classe également parmi ceux en situation d'urgence par rapport au nombre d'espèces menacées d'extinction. Voilà maintenant plusieurs décennies que le gouvernement malgache a mis en œuvre des programmes environnementaux avec l'aide des divers partenaires locaux, nationaux et internationaux à travers différentes approches. L'adhésion aux conventions internationales, la création de nouvelles aires protégées, les tentatives de conjuguer ensemble conservation et développement, tout cela a été fait pour tenter de conserver au mieux ces richesses naturelles.

Même si le pays est encore loin d'être tiré d'affaires, le Ministère de L'Environnement, de l'Ecologie, de la Mer et des Forêts avec ses partenaires techniques et financiers ont pris de nombreuses initiatives pour tenter de sauvegarder des espèces en danger critique. C'est le cas avec le « fotsimaso » *Aythya innotata* ou fuligule de Madagascar, une espèce de canard sauvage que personne n'avait plus vue pendant presque quinze ans et qui avait été redécouverte avec une population de moins d'une vingtaine d'individus en 2006. Une mobilisation a alors été faite autour de l'espèce et des études ont déjà été menées pour avoir les premières idées de stratégie à adopter pour sa sauvegarde. Aujourd'hui, le consortium d'institutions pour la conservation du Fotsimaso en est à établir ensemble le plan d'actions, et le fait est assez rare pour le mentionner, c'est l'une des premières fois où toutes les parties prenantes sont impliquées pour ce faire, y compris les communautés à la base.

Le Ministère est tout à fait confiant et disponible en ce qui concerne le projet fotsimaso. En tant que tel, ce projet œuvrera sans aucun doute à essayer d'assurer la survie de cette espèce menacée mais il se distinguera des autres grâce à la collaboration entre des parties de différentes nationalités, de différentes catégories, de différents domaines d'intervention et de différents niveaux d'influence.

C'est l'existence de tel projet qui ravive encore notre espoir d'un avenir meilleur pour la merveilleuse biodiversité de Madagascar et le Ministère enjoint tout un chacun à en être conscient et à agir en conséquence.

Foreword
Action Plan Madagascar pochard

Madagascar holds a special place within the natural world due to our high level of endemic biodiversity. Unfortunately, the country is also facing serious environmental pressures and therefore has an alarmingly high number of species facing extinction. For this reason, over the last several decades the government of Madagascar has been implementing a wide range of environmental programmes in collaboration with a range of local, national and international partners. By adhering to international conventions, creating New Protected Areas, and combining conservation with rural development, we have done everything within our ability to conserve the country's rich natural resources.

Although Madagascar is still a long way from fully succeeding in its conservation goals, the Ministry of Environment, Ecology, Sea and Forests has established many programmes to save critically endangered species with our technical and financial partners. This is the case for the *fotsimaso* or Madagascar pochard *Aythya innotata*, a species that had not been seen for nearly fifteen years until it was rediscovered in 2006 with a population of less than twenty individuals. After the rediscovery, the government of Madagascar, conservation organisations, and local communities worked together to begin a recovery programme and detailed studies were undertaken to inform the development of a strategy to save the species from extinction. One of the results has been the creation of this species action plan for the Madagascar pochard which has been possible due to the strong partnership between many institutions and organisations. It is worth noting that this action plan is one of the first of its kind for Madagascar, involving stakeholders at all levels from international, national, regional and local communities.

The Ministry has complete confidence in, and will continue to provide full support for this project. The inclusivity of the collaboration between stakeholders of different nationalities, different disciplines and different levels of influence distinguishes it from many other conservation programmes.

The Madagascar pochard project revives our hope for a better future for the unique and marvellous biodiversity of Madagascar. The Ministry urges every partner involved with the conservation of the *fotsimaso* to actively follow this action plan and to recognise the responsibility of each in ensuring that this project is a success.

Summary

The Madagascar pochard *Aythya innotata* is a globally threatened species. It is classified as Critically Endangered on the IUCN Red List.

The species is endemic to Madagascar and is believed to have once been relatively widespread across the country. Widescale and severe environmental degradation in Madagascar has caused extensive loss and degradation of wetland habitats and declines in waterbirds. Major threats include sedimentation from the increased erosion following extensive deforestation, conversion of wetlands to agricultural land, hunting, by-catch from fishing practices, and introduced species.

A population of just 25 pochards remains, restricted to four small lakes near Bemanevika in the north west of the country. A captive population was established in 2009 to prevent imminent extinction and with the intention of releasing captive-bred birds in the future. The captive population numbered 78 birds in 2015. Some research on the wild birds has been undertaken, but knowledge of the species' ecology and threats remains limited. Lake Sofia, *c.* 50 km from Bemanevika, has been identified as a potential release site. This action plan identifies the key actions required to improve the conservation status of Madagascar pochard. A range of stakeholders – including researchers, conservationists, authorities and local communities around the lakes at Bemanevika and Sofia – have identified the threats to the species and determined a series of actions to remove the threats or mitigate their effects.

The plan's **Vision** is that populations of Madagascar pochards are increasing and restored and thrive in healthy, well-managed ecosystems, involving local communities and other stakeholders, contributing to sustainable development and being a source of pride as a flagship species for Madagascar.

The plan identifies two **Goals**:

1. Increase population numbers and expand the distribution of Madagascar pochards in the wild
2. Ensure that each stakeholder benefits from the conservation of the Madagascar pochard and the sustainable management of its habitats

To meet these goals, the plan sets out a series of **Objectives**:

1. The wild population at Bemanevika is protected through improved management by stakeholders
2. The wild population at Bemanevika is effectively managed through improved knowledge of limiting factors
3. The habitat around the Bemanevika lake-complex is restored and protected
4. The captive-breeding population is maintained and further developed to provide assurance colonies and birds for reintroduction
5. The number of wild sites and the global population size of Madagascar pochard is increased through habitat restoration and reintroduction
6. Bush fires are controlled and effectively managed in habitats around wild pochard populations (Bemanevika and release site)
7. Collaboration between all stakeholders is improved and maintained
8. Living conditions of local people that share wetlands with pochards are improved through wise resource use and development of alternative livelihoods
9. Awareness of the pochard and wetland conservation is increased among local and regional communities and decision-makers
10. The implementation of the recovery programme is supported through adequate funding
11. Effective implementation of the strategy is ensured through consistent review.

A series of actions for the period 2015–2024 are identified to deliver each of the objectives. Authorities and stakeholders are encouraged to work collaboratively to implement the actions.

Progress towards both delivery of the actions and achievement of the results should be reviewed on a regular basis. Barriers to implementation should be identified and overcome to ensure that the plan is successful. A review of the plan should be undertaken midway through the plan period, given the improved understanding of the species' requirements and of the impact of threats upon the species and wetlands that will have been developed at that point.

1 Introduction

The Madagascar pochard *Aythya innotata* is the rarest Anatid, and one of the most threatened species on the planet. In the wild, it is restricted to a single volcanic lake complex near the village of Bemanevika in north-western Madagascar. The pochard is only known to breed on a single lake, Matsaborimena, 36ha in surface area. The species, therefore, has an extremely limited distribution and is on the brink of extinction.

The Madagascar pochard was known historically from a handful of sites in eastern Madagascar, including Lake Alaotra in the 1930s-50s but was probably more widespread throughout an extensive network of central plateau wetlands, which unfortunately no longer exist. Its decline was largely unnoticed: the last reliable report of a group of pochards was from Lake Alaotra in 1960. Thirty-one years later a single male pochard was captured by hunters at Alaotra. Extensive surveys in subsequent years failed to find any more birds and in 2004 the species was declared 'probably extinct'. Fortunately the species was 'rediscovered' by The Peregrine Fund at Matsaborimena in 2006, where the population has remained relatively stable around 20-25 adults.

The relative importance of the various anthropogenic factors leading to the pochards' decline are unknown but the massive loss of central plateau wetlands through deforestation of watersheds followed by siltation, and the conversion of remaining wetlands for rice cultivation were likely the most significant drivers behind the decline of the Madagascar pochard. Secondary factors including overexploitation by humans and the introduction of exotic fish likely played roles in the pochard's final decline.

Following rediscovery in 2006, Durrell Wildlife Conservation Trust (Durrell), the Wildfowl & Wetlands Trust (WWT), The Peregrine Fund, Asity Madagascar, and Madagascar's regional and national governments have been working in close partnership to save the pochard from extinction. The last wild population has been provided temporary protected status within the Bemanevika New Protected Area and a captive-breeding population has been established in Antsohihy. Eggs were brought into captivity in 2009 and the first captive-bred pochards hatched at the breeding facility in 2011. As of 2015, 63 pochards have been hatched and reared in captivity and the captive population consists of 42 males and 36 females. This captive population will provide pochards for reintroduction to increase the range and distribution of the species in the wild.

Ecological studies of the wild population have provided important information on the habitat suitability, nesting and feeding ecology, and lack of recruitment at Matsaborimena. Poor breeding success is attributable to a number of factors, key among which is that the lakes are too deep for ducklings and the benthic substrate is poor for invertebrates. The sites are probably atypical for pochards, and it is likely that they represent the last refuge for the species because of their relative isolation rather than because they are the only remaining suitable habitat.

An extensive survey documented the very poor condition of nearly all of the remaining major wetlands in the central plateau and the need for restoration of any release site. This survey also identified one site, Lake Sofia, as having high potential as a release site. Recent efforts have focussed on working with the local communities that have been managing Lake Sofia and the surrounding marsh, and on collecting information to develop a robust long-term plan for integrated management of the lake for the benefit of local communities and biodiversity, including the reintroduction of captive-bred pochards.

Madagascar pochard, as for other endemic wildfowl, received full legal protection in 2006 (Young *et al*. 2013).

Re-establishing a self-sustaining population in the wild means moving beyond the site where the species was rediscovered in 2006 – those lakes are far from ideal habitat for pochards and probably only have capacity to sustain the existing small population. The project will need to address the wide range of environmental problems and underlying social issues that have caused the catastrophic deterioration of Madagascar's wetlands.

2 Medium-term Recovery Strategy 2014 – 2024

2.1 Species Action Plan term and purpose

Species Action Plans are recognised as important tools in conservation as they set out a long-term vision and agenda to guide conservation efforts, improve partnerships and attract funding.

This plan specifies a series of actions to improve the conservation status of the Madagascar pochard *Aythya innotata*. Experts and stakeholders, through workshops and consultations, have identified the most important threats to the species and determined a series of actions to remove these threats or mitigate their effects. This approach enables unpublished data and expert opinion to be included in the development of the plan while retaining high scientific rigour.

The conservation of the Madagascar pochard will be dependent on the successful implementation of this plan. This will require the collaborative efforts of national and regional authorities and a range of key stakeholders. Progress towards both delivery of the actions and achievement of the results should be reviewed on a regular basis. Barriers to implementation will need to be identified and overcome to ensure the objective of the plan is met.

This plan covers the period 2014 to 2024. Given the limited body of knowledge about the Madagascar pochard, a review should be taken midway through the period (around three years after birds have been released onto a new site) given the improved understanding of the species' requirements and of the impact of threats upon the species and wetlands that will have been developed at that point.

2.2 Threats

A number of threats have caused widescale and severe environmental degradation in Madagascar, particularly to wetlands and waterbirds. Although these threats have been relatively little studied and their precise impact is poorly understood, several are likely to be a direct or indirect threat to the remaining wild pochards. It is likely that some environmental threats interact with or exacerbate one another.

Although not threats per se, the very small size of the remaining wild population and that it is restricted to just one small complex of wetlands greatly increases its vulnerability. Whilst the remote nature of the site means that some widescale threats are not currently present at the Bemanevika lakes, they may have a large impact should they occur.

The level of dispersal of birds from Bemanevika is unknown, though it is likely to be low. It is considered highly likely that any dispersing birds would succumb to the many threats widespread at most wetlands in Madagascar. Thus, while the population at Bemanevika appears stable, it is almost certainly prevented from expanding significantly and would, therefore, likely remain as Critically Endangered even if conditions at Bemanevika improved.

A key aim of this plan is, therefore, to minimise the risk of extinction by increasing the number and range of the species, through a captive population and by releasing birds at additional sites. The list of threats below, therefore, addresses those that apply to the remaining wild birds, the captive birds and those that would apply to birds when released at Lake Sofia, the intended re-introduction site.

Although research has been undertaken on the remaining wild birds in recent years to identify and understand the threats,

the small number of birds involved and the nature of the site mean the findings may be of limited value for assessing which threats would apply at a release site and how they would affect the birds. Bemanevika lakes are probably not typical habitat for pochards, and may differ from release sites, both in terms of their ecology and how they are impacted by the threats. Whilst our understanding of the threats given below represents our best current knowledge, it includes some assumptions and generalisations and it is likely that the nature of the threats, their impact and the appropriate actions to address them may change rapidly as new information comes to light, particularly once birds are released at a new site.

A summary of threats is given below. Further information is provided in Section 3 of this plan.

2.2.1 Critical and important threats

Deforestation and grass burning
Importance: high
Deforestation for fuel and to clear large areas for grazing of zebu is widespread in Madagascar. Cleared areas are regularly burned to maintain and enhance grazing. The resultant soil erosion in cleared areas has led to large amounts of sediment being introduced into lakes. Increased siltation can cause significant changes in invertebrate communities and disrupts aquatic food webs, thereby affecting food availability for pochards.

Fires in grassland also have the potential to spread to marsh vegetation, further impacting the lake ecology and reducing the area of potential breeding habitat. Although grassland burning occurs around the Bemanevika lakes (and occasionally spreads to the forests), the majority of the watershed currently remains forested. Clearance and burning is widespread in Madagascar, affecting many wetlands that could be potential release sites. The great majority of the catchment of Lake Sofia has been deforested.

Conversion of wetlands for rice cultivation
Importance: high
Rice is a staple food in Madagascar and rice cultivation is widespread. Historically, this has led to the conversion of many wetlands, making them unsuitable for wildfowl. As a diving duck, Madagascar pochards are highly unlikely to be able to feed in rice fields and will be excluded from converted wetlands.

There is no rice cultivation in the lakes at Bemanevika, as the topography of the lakes and surrounding means there is very little marsh. There is extensive rice growing in the Lake Sofia catchment.

Pollution
Importance: high
The extent of chemical pollution of wetlands has not been extensively studied in Madagascar. Diverse chemicals including DDT and Lindane have been found in Lac Alaotra. Their impacts in wetlands are unclear but are likely to be highly detrimental, particularly to benthic invertebrate abundance. Pesticides such as these, many banned in Europe or the USA, have been freely available in Madagascar for use in the rice cultivation.

Pollution at Bemanevika is considered to be negligible due to the absence of agriculture near the lakes. Pollution at Lake Sofia has not been studied, but it is considered likely that harmful chemicals are being used to a lesser or greater extent as at Alaotra.

Hunting
Importance: high
Subsistence hunting of all waterbirds is widespread in Madagascar, indiscriminate and generally uncontrolled. There is no record of Madagascar pochards being hunted (though perhaps partly because of their rarity; it presumably occurred when the species was more numerous) and hunting

no longer occurs at Bemanevika. Hunting is considered likely to be a major factor that would limit their dispersal from Bemanevika and a release site. Hunting is known to take place at Lake Sofia, but the extent to which it happens is unknown.

By-catch in gillnets
Importance: high
Monofilament gillnets used for fishing may catch diving waterbirds which then drown. This by-catch is considered to have been a major factor in population declines of freshwater diving waterbirds and has shown to be a problem in Madagascar. Fishing does not occur at Bemanevika, and fishing is regulated at Lake Sofia although bycatch may still occur. By-catch is likely to be a major factor that would limit dispersal of pochards from Bemanevika and a release site.

Disease
Importance: high
Many avian diseases (e.g. cholera, Newcastle disease, duck viral enteritis) are widespread in Madagascar and have caused mass mortalities among poultry, including ducks and geese. Outbreaks occur annually in many village communities.

Although infectious disease has not been recorded in Madagascar pochard, the proximity of poultry (including domestic mallard *Anas platyrhynchos* and Muscovy duck *Cairina moschata)* to wetlands in Madagascar, and interactions with wild waterbirds, makes the risk of disease transmission to wild waterbirds severe at wetlands with villages nearby.

There is a particular risk to the captive population in Antsohihy, where transmission from poultry could potentially occur via a number of routes (notably wild and domestic birds and animals or carried on the clothes or footwear of people working at or visiting to the breeding facility).

2.2.2 Other threats

Introduced species
Importance: medium
Exotic fish have been introduced widely in Madagascar for food (at least 24 species of freshwater fish have been deliberately introduced). They may have many potential impacts, including the extinction of native fish, competition with waterbirds for invertebrate prey, predation of ducklings, and causing increased turbidity of the water (potential affecting the lake's ecology and making it difficult for diving waterbirds to locate food).

There are no introduced fish in the Bemanevika lakes. *Tilapia* are the only exotic fish known to be present in Lake Sofia and their effect on diving ducks in unknown. Other introduced fish that are widespread in Madagascar are more directly a threat to diving ducks, and may be a factor limiting pochards becoming established at new wetlands. These include common carp *Cyprinus carpio* which can reduce invertebrate densities and increase water turbidity, and blotched snakehead (fibata) *Channa maculata* which are predatory and may prey upon ducklings.

Introduced mammals (e.g. rats *Rattus* spp., Indian civet *Viverricula indica*) are known to take eggs and perhaps young ducklings. These species occur at Bemanevika, in the extensive forest habitat around the lakes although they do not appear to impact the wild population of pochards.

Predation by native species
Importance: low
A number of native species prey upon waterbirds, e.g. crocodile *Crocodylus niloticus*. Madagascar harrier *Circus macrosceles* has been observed taking ducklings at Matsaborimena. There are, however, no specialist waterbird predators in Madagascar. Due to the rarity of both crocodiles and harriers, such predation is considered to be uncommon at Bemanevika.

Disturbance
Importance: low
Human presence may cause disturbance to the birds. Given the small size of the remaining population and the very limited area of suitable breeding habitat, it is possible that even low levels of disturbance may have an impact. Although the lakes at Bemanevika are relatively remote, the main route between Bemanevika and Antananivo-Haut passes close by, providing relatively easy access.

Threats to the existing wild population
• The entire wild population is found at only one site. • The remaining wild population is in small numbers (<30 adults).
• Lack of food for ducklings.
• Hunting and trapping. • Predation by invasive species. • Disease could affect the single small wild population. • Competition with other species.
• Low carrying capacity for breeding birds. • Inbreeding. • Unequal adult sex-ratio of wild adults. • Risk to birds during dispersal from Bemanevika. • Predation by native species (crocodile, raptors).

Threats to the habitat at Bemanevika
• Deforestation from illegal cutting around lakes. • Deforestation from traditional grass burning for zebu.
• Disturbance to ducks from people because lakes are accessible and close to main route between Bemanevika and Antananivo-Haut. • Degradation of watershed and sedimentation causing reduced habitat quality at lakes.

Threats to wetland habitats outside of Bemanevika (including potential release sites)
• Deforestation around wetlands. • Unsustainable resource use at wetlands. • Conversion of wetlands for rice cultivation. • Pollution. • Changes to wetland habitats including siltation reducing food availability and reduction in nesting habitat.

Concerns for the management of the captive population
• Disease and biosecurity.
• Unreliable electricity and water in supplies. • Lack of funding. • Support of partners and stakeholders. • Theft. • Predators.
• Difficult to find good quality construction materials. • Climate. • Access to visitors. • Inbreeding.

The most important threats identified for the species survival were the fact that pochards existed at only a single site and in small numbers.

For the existing population at Bemanevika deforestation was identified as the most important threat.

Similarly, for future reintroduction sites, deforestation and resulting degradation of wetlands was identified as the most significant threat, along with non-sustainable resource use.

The most significant threat identified for the captive population was biosecurity and the risk of infectious disease.

2.3 Vision, Goal and Objectives

2.3.1 Vision

Populations of Madagascar pochards are increasing and restored and thrive in healthy, well-managed ecosystems, involving local communities and other stakeholders, contributing to sustainable development and being a source of pride as a flagship species for Madagascar.

Mitombo tsara sy mihamaro ny Fotsimaso miaina anaty tontolo salama izay tsara tantana iarahan'ny Vondron'Olona Ifotony (VOI) sy ireo mpiara-miombon'antoka hafa rehetra; mandray anjara amin'ny fampandrosoana maharitra ary fitaratra ho reharehan'i Madagasikara.

2.3.2 Goals

Two goals were identified for the recovery of the Madagascar pochard.

Goal 1
Increase population numbers and expand the distribution of Madagascar pochards in the wild.

Hampitomboina ny isan'ireo Fotsimaso izay haparitaka amin'ireo toeram-ponenany maro voa-janahary.

Goal 2
Ensure that each stakeholder benefits from the conservation of the Madagascar pochard and the sustainable management of its habitats.

Iantohana fa ny mpiara miombon'antoka rehetra dia mahazo tombotsoa amin'ny fitantanana mahomby ny Fotsimaso sy ny fonenany.

2.3.3 Objectives

Whilst all of the objectives listed below will be needed to address the threats facing the Madagascar pochard, it was recognized during the development of this action plan that the first five objectives were of overriding importance to save the species from imminent extinction, and accordingly contain many of the highest priority actions.

Higher priority objectives

1. The wild population at Bemanevika is protected through improved management by stakeholders
Voaaro ireo Fotsimaso any Bemanevika amin'ny alalan'ny fanatsarana ny fitantanan'ny mpiaramiombon'antoka.

The wild population at Bemanevika is of utmost importance and all efforts need to be taken to ensure that this globally important site be protected, not only for Madagascar pochard but for the other unique species found there.

Key projects include the implementation of the management plan for the New Protected Area Bemanevika ensuring the highest level of collaboration between the local communities (COBA) and other stakeholders, primarily the community associations (VOI) representing the seven village groups (*fokontany*) around the NPA, and the NPA promoter (TPF).

A well-managed NPA will minimise human impacts and disturbance to the wild population. Key activities will focus on raising awareness (including signage near the lakes), of the conservation project among resource users that visit the road, forest and marshes at the Bemanevika lake-complex.

Other activities to improve site protection include continued monitoring of natural conditions at the site and managing pochard habitat (e.g. artificial islands) to increase productivity and juvenile survival and increase the overall carrying capacity of the four lakes for Madagascar pochards.

2. The wild population at Bemanevika is effectively managed through improved knowledge of limiting factors
Ireo Fotsimaso any Bemanevika dia voatantana tsara noho ny fahalalana tsara ireo olana fototra na vato misakana

Predators, both natural (raptors, small carnivores) and introduced (rats) may be having an impact on adult, juvenile or nest survival, although there is little evidence to suggest that this is having a major effect. High duckling mortality appears to be the main factor limiting recruitment. Further research is required to better understand factors affecting survival and recruitment in the wild population.

This will be achieved by continuing studies on (a) the high mortality of ducklings, and (b) the effects of predators on nest, duckling and adult survival.

3. The habitat around the Bemanevika lake-complex is restored and protected
Hatsaraina ny fonenany manodidina ny matsaborin'ny Bemanevika

Effective habitat management is required to ensure that intact forested areas exist around the lake-complex to buffer the lakes from siltation and pollution.

Reforestation with native trees of the 1km^2 of deforested watershed, followed by further restoration of the other catchment areas around the four lakes in the Bemanevika lake-complex is recommended to reduce the impact of excessive sedimentation.

Other actions will focus on the construction and maintenance of a firebreak around the forest surrounding the Bemanevika lake-complex, and a complimentary programme to raise awareness of the effects of fires and deforestation on ecosystem services.

4. The captive-breeding population is maintained and further developed to provide assurance colonies and birds for reintroduction
Ampitomboina ny fiompiana am-bala mba tsy hahalany taranaka azy ary mba hahafahana manatevina ireo any an-toeram-poneny voa-janahary

The captive breeding programme has been highly successful in creating an assurance colony to ensure the immediate survival of the species, and we are confident that pochards can be produced in sufficient numbers to support reintroductions. The captive breeding programme will remain invaluable until such time as reintroductions and habitat protection/restoration have resulted in sustainable wild populations.

The main goal of the captive breeding programme is to maintain the current facility to produce young pochards for restoration of the species in the wild. The development of captive husbandry protocols and a studbook will ensure the highest standards of health and welfare and genetic management of the captive population.

Assessment of the potential for establishing supplemental captive breeding centres for pochards, with appropriate authorization to move the ducks between facilities, will minimise risks from infectious diseases, known to be prevalent in Madagascar.

5. The number of wild sites and the global population size of Madagascar pochard are increased through habitat restoration and reintroduction
Hampitomboina ny isan'ny Fotsimaso any amin'ny natiora amin'ny alalan'ny famerenana ireo biby any ary koa amin'ny alalan'ny fanatsarana ireo fonenany

The Madagascar pochard will not be considered safe from extinction until multiple wild populations over a wide distribution throughout the historical range have been re-established. In order to ensure this we will need to assess all of the major remaining wetlands throughout the central plateau to identify potential sites for reintroduction. The next step will be to assess the feasibility of reintroduction and develop a reintroduction strategy. Given the degraded condition of Madagascar's wetlands, it is realistic to assume that we will have to restore the ecological health of any wetlands that we identify as reintroductions sites.

To achieve this we will need to quantify the resource use and identify the needs of local communities at any potential release site and develop a participatory management plan for sustainable use of the lake and watershed with all local stakeholders. An important component of this will be to support and strengthen the capacity of the site manager(s) at any future release site.

Lower priority objectives

6. Bush fires are controlled and effectively managed in habitats around wild pochard populations (Bemanevika and release site)
Fehezina ny afo manodidina ny fonenan'ny Fotsimaso

Bush fires were identified as one of the main threats affecting habitats around wetlands, resulting in degradation through excessive sedimentation.

Key projects to minimise deforestation include the establishment of operational fire-fighting structures and the prosecution of people responsible for illegal activities related to bush fires and deforestation.

Other main activities include the construction and maintenance of firebreaks in habitats around wild pochard populations and the identification and implementation of alternative pasturing systems to reduce burning around key pochard sites.

7. Collaboration between all stakeholders is improved and maintained
Hatsaraina ny fiaraha-miasa amin'ny Mpiara-Miombon'antoka (MMA) rehetra

A weakness of the existing pochard recovery project was identified as a lack of communication between the main stakeholders in the programme.
Key actions to improve collaboration

will be to organize regular meetings and clearly define the roles and responsibilities of each stakeholder by developing a protocol for collaboration between each stakeholder and the government. Ensuring effective implementation of the action plan may require increasing the capacity of local partners, through training, in good governance and management of resources. Linked to this we will need to ensure that all partners have the resources needed to achieve their goals and responsibilities as outlined within this action plan

8. Living conditions of local people that share wetlands with pochards are improved through wise resource use and development of alternative livelihoods
Hatsaraina ny fari-piainan'ny mponina eo an-toerana

Local communities in Madagascar rely heavily on natural resources to survive. If conservation recovery of the Madagascar pochard is to be successful, local communities need to see a benefit to conservation of the pochard and wetlands.

The key action identified in this action plan is the development of local capacity to diversify income generation through alternative livelihoods that reduce over-reliance of local communities on wetland resources and allow VOI to sustainably manage pochard habitats.

9. Awareness of the pochard and wetland conservation is increased among local and regional communities and decision-makers
Ampitomboina ny fahafantarana ny Fotsimaso sy ireo olana ara-tontolo iainana eo anivon'ny fokonolona sy ny manam-pahefana

Given the uniqueness of the Madagascar pochard and its need for healthy wetlands to survive, there is an opportunity for the pochard to be a flagship species for wetland conservation in Madagascar.

Promotion of the pochard as a flagship will require the development of a national Information, Communication and Education strategy. One of the main actions in this strategy will be to assist teachers to deliver curricula that include Madagascar pochard conservation and emphasise the link between healthy wetlands and ecosystem services. The creation of interpretation centre(s) for the Madagascar pochard and wetland habitats will provide opportunities for local people and school groups to visit captive population(s) site and learn about wetland conservation.

The celebration of an annual Fotsimaso Festival within the Sofia region will be a valuable forum for promoting awareness within large and diverse audiences.

10. The implementation of the recovery programme is supported through adequate funding
Mikaroka lalam-bola hafa karazany

Activities within this plan will require significant amounts of funding. A funding strategy and business plan must be developed so that funding proposals submitted by implementing agencies sit within a larger strategy for species recovery. Identifying and reporting to donors is crucial for developing long-term partnerships with donors and for protecting the reputation of the recovery programme with external funders.

11. Effective implementation of the strategy is ensured through consistent review
Iantohana ny fampiharana mahomby ny paikady

In order for this action plan to be effective it will require regular evaluation and monitoring. This will be achieved by ensuring that the plan has been endorsed by the government of Madagascar and all implementing partners. A national Madagascar pochard recovery steering committee, led by MEEF, will be responsible for overseeing implementation of the plan and carrying out annual monitoring and evaluation of the plan.

2.4 Factors affecting plan implementation

Obstacles to overcome in order to effectively implement Action Plan
• Lack of collaboration. • Lack of financial resources.
• Lack of alternative livelihoods for local communities to reduce need to unsustainably use wetlands. • Lack of ecological knowledge for Madagascar pochard. • Lack of knowledge of critical habitat required by Madagascar pochard.
• Poor communication among partners. • Lack of personnel. • Lack of resources to carry out further research. • Local communities are not invested in conservation and management of natural resources.

Constraints to consider in order to effectively implement Action Plan
• Weak belief (conviction) of local communities in the value of conservation. • Illiteracy of people relying on wetlands for subsistence. • Lack of confidence and trust of local communities regarding the conservation project. • Bandits pose a risk to local communities and to conservation projects. • Political power is not always used in the best interests of the environment. • Conflict between local people (Fokontany) and the community associations (VOI).
• Political belief that the Madagascar pochard is the property of the Sofia Region. • Difficult site access and lack of infrastructure at Bemanevika to promote ecotourism.
• Potential loss of financial partners.

A lack of collaboration among partners and stakeholders was identified as the primary obstacle that needed to be resolved in order for the recovery plan to be successful. A lack of resources (financial and staffing) was also identified as a major obstacle to successful implementation of a recovery strategy.

Constraints that need to be addressed in order for the Action Plan to be successfully implemented focussed around local communities, specifically a lack of conviction and capacity for local communities to be able to prioritise conservation when faced with more serious issues (low quality of life, insecurity, illiteracy) and around political issues (lack of political will to prioritise conservation issues and conflict and distrust between local communities, village associations, politicians and conservation organisations).

2.5 Project and Activity Tables

VISION	**Populations of Madagascar pochards are increasing and restored and thrive in healthy, well-managed ecosystems, involving local communities and other stakeholders, contributing to sustainable development and being a source of pride as a flagship species for Madagascar.** ***Mitombo tsara sy mihamaro ny Fotsimaso miaina anaty tontolo salama izay tsara tantana iarahan'ny Vondron'Olona Ifotony (VOI) sy ireo mpiara-miombon'antoka hafa rehetra; mandray anjara amin'ny fampandrosoana maharitra ary fitaratra ho reharehan'i Madagasikara.***
GOALS	**Increase population numbers and expand the distribution of Madagascar pochard in the wild.** ***Ampitomboina ny isan'ireo Fotsimaso ary alehibiazina ny fanaparitahana ny fianakaviany eny amin'ny natiora.*** **Ensure that each stakeholder benefits from the conservation of the Madagascar pochard and the sustainable management of its habitats.** ***Iantohana fa ny mpiara miombon'antoka rehetra dia mahazo tombotsoa amin'ny fitantanana mahomby ny Fotsimaso sy ny fonenany***

Objective 1. The wild population at Bemanevika is protected through improved management by stakeholders. ***Hamafisina ny fiarovana ny toeram-ponenany ankehitriny***

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
1.1	Complete the process of the establishment of Bemanevika NPA *Tohizana ny fametrahana ho Faritra Arovana vaovao an'i Bemanevika*	Critical	**TPF**, MEEF, DCBSAP,VOI	10k	T1 (2014-2016)	Permanent Protected Status granted. PAG implemented.	Lack of funding.
1.2	Manage the wild population to increase productivity and carrying capacity of lake-complex *Tantanana ireo fotsimaso voa-janahary mba hampitombo ny isany sy ny fetra fahazakan'ny toeram-ponenany*	Moderate	**Durrell, WWT**, TPF, VOI	2-5k	T1 (2014-2016)	Fledging success improves from current and breeding is regular at one other lake.	Need to respect ecological integrity of site. Sufficient experience exists worldwide in improving wetlands for biodiversity.
1.3	Continue research on natural conditions at the site *Tohizana ny fikarohana momba ny toetran'ny toerana*	Moderate	**WWT, Durrell**, UNIV TAN	1-5k	T1 (2014-2016)	Regular surveys completed and data analysed.	Trained local staff in place on site.
1.4	Strengthen local collaboration between COBA and other stakeholders *Hamafisina ny fiaraha-miasa amin'ny VOI sy ny mpiara miombon'antoka*	Critical	**TPF**, VOI	5-10k	T1-T4 (Ongoing 2014-2024)	Permanent presence of field teams and regular surveys of lake and surrounding habitats	
1.5	Minimise human disturbance to Madagascar pochard habitat *Hahena ny kotaba sy fanimbana ataon'ny olona eo amin'ny fonenan'ny Fotsimaso*	Critical	**TPF**, VOI	10-15k	T1-T4 (Ongoing 2014-2024)	Permanent presence of field teams and regular surveys of lake and surrounding habitats	Trained local staff in place on site.

1.6	Provide signage near the lakes to indicate the uniqueness of site *Ametrahana Takela-by famantarana manodidina ny matsabory mba hampahafantarana ny mampiavaka azy*	High	**VOI, MEEF**, TPF	1-5k	T1 (2014-2016)	Signs placed along main roads and trails and around lakes.	
1.7	Improve road access to the site *Hatsaraina ny fahafahana mankeny an-toerana*	Moderate	**VOI, MEEF**, DRDR	10-15k	T1-T4 (Ongoing 2014-2024)	Gov'ts lobbied to improve road. Road improved.	Lack of funding. Lack of political will.
1.8	Raise awareness of conservation program with users of the road, forest and marshes at the lake-complex *Ampahafantarina ireo mpampiasa ny lalana sy ny ala manodidina ireo matsabory mikasika ny fiarovana atao ny*	High	**VOI, MEEF**, TPF	5-10k	T1-T4 (Ongoing 2014-2024)	Regular meetings between COBAs, VOI, MEEF and NGOs.	

Objective 2. The wild population at Bemanevika is effectively managed through improved knowledge of limiting factors. *Hamafisina ny fiarovana ny biby any amin'ny natiora*

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
2.1	Study the effects of predation: (birds of prey, rodents, carnivores) *Manao fikarohana momba ireo mpihinana ny fotsimaso : (voromahery, voalavo, bibyhafa)*	Critical	**TPF, WWT, Durrell**, UNIV TAN	1-5k	T1 (2014-2016)	Quantified evidence of effects of predators on pochards survival and recruitment.	Trained local staff in place on site
2.2	Conduct studies on the high mortality of ducklings *Jerena ireo antony mahafaty betsaka ireo zana-gana*	High	**WWT, Durrell**, UNIV TANA	1-5k	T1 (2014-2016)	Quantified evidence of causes of high mortality.	Trained local staff in place on site

Objective 3. The habitat around the Bemanevika lake-complex is restored and protected. ***Hamafisina ny fiarovana ny biby any amin'ny natiora***

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
3.1	Reduce impact of sedimentation at Lake Matsaborimena *Ahena ny fidinan'ny fasika na atsangy ao anatin'i Matsaborimena*	Moderate	**VOI, MEEF**, TPF	1-10k	T1-T4 (Ongoing 2014-2024)	Evidence of improved substrate quality and invertebrate abundance.	Methods need to be defined.
3.2	Restore catchment areas at lake-complex *Averina amin'ny laoniny ny sahandriaka*	Moderate	**VOI, MEEF**, TPF	1-10k	T1-T4 (Ongoing 2014-2024)	Catchment areas identified and original habitats restored.	Methods need to be defined.
3.3	Reforest with native trees the 1km^2 of watershed that has been cleared to date *Hambolena hazo zanatany amin'ny sahandriaka eo amin'ny 1km^2 izay efa may*	High	**VOI, MEEF**, TPF	1-5k	T1-T2 (2014-2018)	Survival of planted seedlings within 1km^2 watershed.	Reforestation efforts have significant impact on social cohesion.
3.4	Construct and maintain firebreaks in habitats around wild pochard sites *Hametrahana aro afo ireo faritra manodidina ny toeram-ponenan'ny fotsimaso*	High	**VOI, MEEF**, TPF	1-5k	T1-T4 (Ongoing 2014-2024)	Firebreaks created and maintained annually.	
3.5	Raise awareness on effects of fires and deforestation on ecosystem services *Hampahafantarina ny olona ny fiantraikan'ny afo na motro sy ny fanimbana ireo ala izay manimba ny rohi-piainana misy*	Moderate	**VOI, MEEF**, TPF	1-10k	T1-T4 (Ongoing 2014-2024)	Regular awareness workshops held around NPA Bemanevika following an established awareness strategy. Reduction in harmful fires observed in NPA.	

Objective 4. The captive-breeding population is maintained and further developed to provide assurance colonies and birds for reintroduction. ***Ampitomboina ny fiompiana***

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
4.1	Maintain the existing breeding centre *Tohizana ny fiompiana am-bala ankehitriny*	Critical	**Durrell, WWT**, MEEF	150k	T1-T4 (Ongoing 2014-2024)	Breeding centre maintained to high standards. Captive-bred young produced.	Disease risks if only a single captive population. Local capacity has been developed to run facility.

4.2	Develop a studbook for the species (captive breeding) *Anamboarana boky mirakitra momba ny biby (fitantanana ny fiompiana azy)*	High	**Durrell**	0-1k	T1 (2014-2016)	Studbook up to date and used for management	
4.3	Assess potential for establishing supplemental captive breeding centres for pochard with appropriate authorization to move the ducks *Jerena ny fahafahana mampitombo ny toeram-mpiompiana miaraka amin'ny fahazoan-dalana amin'ny famindrana ny biby*	High	**MEEF, VOI, Durrell**, WWT	0-1k	T1 (2014-2016)	Feasibility study report	Lack of funding for annual running costs of a captive facility.

Objective 5. The number of wild sites and the global population size of Madagascar pochard is increased through habitat restoration and reintroduction. ***Ampitomboina ny isan'ny Fotsimaso sy ny fonenany any amin'ny natiora***

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
5.1	Carry out research on wetlands in different ecoregions in the central plateau to identify potential sites for reintroduction *Tohizana ny fikarohana momba ny toetran'ny fonenany aty afovoan-tany mba hahitana toerana azon'ny fostimaso iainana ka hanaterana azy amin'ny afara*	High	**WWT, Durrell**, MEEF	5-10k	T1 (2014-2016)	Site evaluations completed with recommendation report written and distributed to stakeholders.	Valuable research on status of Madagascar's central wetlands.
5.2	Assess the feasibility of reintroducing captive-bred pochard *Jerena ny fahafahana mampiverina ireo biby nompiana any amin'ny natiora*	High	**Durrell, WWT**, MEEF	0-1k	T1 (2014-2016)	Feasibility study report and reintroduction strategy written and distributed to stakeholders.	

5.3	Restore wetlands that have been identified as potential reintroduction sites *Hatsaraina ireo toeram-ponenana izay hita sy fantatra fa mety ho afaka mandray fotsimaso*	High	**WWT,** Durrell, VOI, MEEF, *fokonolona*	100-150k	T1-T4 (Ongoing 2014-2024)	Restoration strategy developed and implemented.	Long-term process that may take 10-20+ years. Model for other wetland restoration projects in Madagascar.
5.4	Identify resource use and needs of local communities at release site *Fantarina ny fampiasana zava-boahary sy ny filan'ny VOI eo amin'ilay toerana handefasana ny biby*	Critical	**VOI, *fokonolona***, Durrell, WWT, MEEF	5-10k	T1 (2014-2016)	Resource use and needs assessment written and distributed to stakeholders.	Consultative process with local communities.
5.5	Develop a participatory management plan for sustainable use of lake and watershed with all local stakeholders *Volavolaina ny drafi-panajariana iombonana mba hisy fampiasana maharitra ny matsabory sy ny sahandriaka amin'ny alalan'ny fiarahamiasan'ireo MMA rehetra*	Critical	**VOI, *fokonolona*, Durrell**, WWT, MEEF	5-10k	T1 (2014-2016)	Robust management plan developed and implemented by local communities.	Consultative process supported by NGOs and gov't.
5.6	Strengthen the capacity of the new site manager *Hamafisina ny fahaiza-manaon'ny mpitantana ny toerana*	Critical	**VOI, *fokonolona*, Durrell**, WWT, MEEF	5-10k	T1-T4 (Ongoing 2014-2024)	Number of annual training workshops to develop capacity of site manager. Evidence of autonomy.	Durrell's experience with training in good governance for community associations. VOI Sofia Mandrozo has already exhibited strong initiative, capably managing Lake Sofia and resources prior to project.

Objective 6. Bush fires are controlled and effectively managed in habitats around wild pochard populations (Bemanevika and release site). *Fehezina ny afo*

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
6.1	Establish operational fire-fighting structures *Apetraka ny rafitra afaka miasa iadiana amin'ny afo*	High	**VOI, CEEF**, Forces d'Ordre, ODA	5k	T1 (2014-2016)	Firefighting structure defined with all stakeholders. Firefighting strategy written and distributed. Annual evaluation meeting held to refine strategy.	Requires a realistic and feasible strategy that does not demand too much from local impoverished communities
6.2	Prosecute offences relating to fires and bush clearance *Enjehina ireo tsy manara-dalàna amin'ny fanaovana afo sy tavy*	Moderate	**Forces d'Ordre, DREEF**, CEEF, Justice	5-10k	T1-T4 (Ongoing 2014-2024)	High percentage of illegal activities going to prosecution. Increase in conviction rates.	Corruption within justice system

6.3	Construct and maintain firebreaks in habitats around wild pochard sites at future release sites *Asiana aro afo mandavan-taona manodidina ireo toeram-ponenana mety hanaterana fotsimaso any aoriana*	High	**VOI, CEEF,** Forces d'Ordre, ODA	5-10k	T1-T4 (Ongoing 2014-2024)	Firebreaks maintained by local communities and gov't services over 10 year period.	
6.4	Identify and implement alternative pasturing systems to burning in habitats around key pochard sites *Hitady tekinika vaovao mba hanatsara ny fiompiana omby sy mba tsy handorana ireo kijana manodidina ny fonenan'ny Fotsimaso*	Moderate	**Détenteur des droits coutumiers, VOI, DRDR**, Commune, CEEF, ODA	5-10k	T1-T4 (Ongoing 2014-2024)	Alternative pasturing systems identified. Training workshops held with local farmers. Change in methods observed.	Lack of funding to support long-term buy-in from local communities of changes to alternative methods.

Objective 7. Collaboration between all stakeholders is improved and maintained. ***Hatsaraina ny fiaraha-miasa amin'ny Mpiara-Miombon'antoka (MMA) rehetra***

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
7.1	Organize stakeholder meetings *Asiana fivoriana matetika eo amin'ny MMA*	High	**MEEF, Durrell**, VOI, WWT, TPF, Asity, DRDR	5-10k	T1-T4 (Ongoing 2014-2024)	Stakeholder meetings held 2x per annum. Minutes of meetings written and distributed.	
7.2	Clearly define the roles and responsibilities of each stakeholder *Zaraina mazava tsara ny andraikitra sahanin'ny MMA*	Critical	**MEEF**, Durrell, VOI, TPF, Asity, DRDR	0-1k	T1 (2014-2016)	Roles defined and distributed among stakeholders.	
7.3	Develop a protocol for collaboration between each stakeholder *Apetraka ny fifanaharam-piaraha-miasa amin'ireo MMA*	High	**MEEF,** Durrell, VOI, TPF, Asity, DRDR	0-1k	T1 (2014-2016)	Protocols signed and evaluated annually if necessary.	

7.4	Train stakeholders, especially local partners, in governance of resources *Hofanina ireo MMA, indrindra ireo eo an-toerana, momba ny fitantanana ny zava-boahary*	High	**Durrell, MEEF, VOI**	5k	T1-T2 (2014-2018)	Training needs identified and workshops held.	Durrell's experience with training in good governance for community associations
7.5	Ensure stakeholders have resources needed to carry out responsibilities *Omena fitaovana hoentina miasa ireo MMA*	High	**VOI, MEEF, Durrell, TPF**, Asity, WWT	5-10k	T1-T4 (Ongoing 2014-2024)	Resource needs identified and met.	

Objective 8. Living conditions of local people that share wetlands with pochard are improved through wise resource use and development of alternative livelihoods.
Atsaraina ny fari-piainan'ny mponina eo an-toerana

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
8.1	Develop and diversify ways of alternative income generation for the VOI/communities managing habitats for pochard conservation *Ampiroboroboina sy hamaroana ny asa ho fidiram-bola ho an'ny mponina miaro ny fotsimaso sy mitantana ny toeram-ponenany*	High	**ODA, VOI**, Commune, Région	40-60k??	T1-T4 (Ongoing 2014-2024)	Improved rice yields, shorter lean seasons, improved methods of raising livestock. Alternative livelihood projects (coffee, vanilla) implemented	Lack of funding. Population densities and level of poverty make this a challenge. Successful solutions based on wetland management can be modelled elsewhere
8.2	Develop local capacity (technical, operational and market research) to improve livelihoods *Ampiroboroboana ny fahaiza-manaon'ny VOI (Teknikasyara-pitatanana ary fitadiavana lalam-barotra)*	Moderate	**ODA, DRDR**, Commune, VOI	10-20k??	T1-T4 (Ongoing 2014-2024)	Approaches to enhance existing local livelihoods (livestock, fishery, rice production) and establish additional livelihood options (coffee, vanilla) developed and demonstrated.	Lack of funding. Population densities and level of poverty make this a challenge. Successful solutions based on wetland management can be modelled elsewhere

Objective 9. Awareness of the pochard and wetland conservation is increased among local and regional communities and decision makers.
Ampitomboina ny fahafantarana ny Fotsimaso syireo olana ara-tontolo iainana eo anivon'ny fokonolona sy ny manam-pahefana

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
9.1	Develop a national Information, Communication and Education strategy for Madagascar pochard and wetland conservation *Volavolaina ny paikady nasionaly amin'ny fampahafantarana, fifandraisana sy fampianarana momba ny Fotsimaso sy ny faritra mando*	High	**MEEF, Durrell**, Asity, WWT	0-1k	T1 (2014-2016)	Strategy written and distributed.	

9.2	Promote Madagascar pochard as a unique species and a flagship for Madagascar's wetlands *Ankalazaina ny Fotsimaso ho biby tokana sy rehareha ho an'ny faritra mando eto Madagasikara*	High	**MEEF, Asity**, Durrell, WWT	10k	T1-T4 (Ongoing 2014-2024)	Number of media events and reports. Number of events under the pochard banner. Madagascar pochard accepted in Madagascar as flagship species for wetlands.	Pochard is an ideal iconic flagship species for wetland conservation in Madagascar.
9.3	Assist teachers to include conservation of Madagascar pochard and wetlands within school curricula *Ampiana ny mpampianatra hampiditra ny fotsimaso sy ny fiarovana ny faritra mando anatin'ny programa-mpampianarana an-tsekoly*	Moderate	**MEEF, CISCO, Asity,** Durrell	1-10k	T1 (2014-2016)	Modules developed and implemented in schools in Sofia region.	
9.4	Create interpretation centre(s) for Madagascar pochard and wetland habitats *Hanamboarana toerana iray na maromaro hampisehoana na hampahafantarana ny mikasika ny fotsimaso sy ny toeram-ponenany*	Moderate	**MEEF, WWT, Durrell**, MEEF	20-40k	T1 (2014-2016)	Interpretation centre(s) built and receiving visitors.	
9.5	Provide opportunities for local people and school groups to visit the captive breeding site and learn about wetland conservation *Hamoraina ny fahafahan'ny mponina sy ireo sekoly hijery ireo biby ompiana sy hianatra ny fiarovana ny faritra mando*	Moderate	**MEEF, Durrell, WWT**, CISCO	1-10k	T1 (2014-2016)	Number of visits by different age groups. School visits linked to modules being implemented in Sofia region.	Biosecurity risk if only a single centre. High impact activity with school groups.
9.6	Organise an annual Fotsimaso Festival for Sofia region *Asiana fetin'ny Fotsimaso isan-taona eo amin'ny faritra Sofia*	Moderate	**DREEF, Durrell**, TPF	1-10k	T1 (2014-2016)	Annual festival held. Participation by target groups (students, local and regional authorities, VOI, general public).	

Objective 10. The implementation of the recovery programme is supported through adequate funding.
Mikaroka lalam-bola hafa karazany

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
10.1	Develop a business plan for the Madagascar pochard conservation strategy *Fanamboarana drafi-pitadiavam-bola hofiarovana ny Fotsimaso*	High	**MEEF, VOI, Durrell, TPF, WWT**	0-5k	T1 (2014-2016)	Business plan developed and distributed among stakeholders.	
10.2	Submit the business plan to funders *Alefa amin'ny mpamatsy vola ny drafi-pitadiavam-bola*	High	**MEEF, VOI, Durrell, TPF WWT**	0-1k	T1 (2014-2016)	Proposals submitted to funders. Funding secured for activity implementation.	
10.3	Source funding and communicate between donors and government *Mitady sy mifandray amin'ny mpamatsy vola sy ny fanjakana*	High	**MEEF, VOI, Durrell, TPF WWT**	0-5k	T1-T4 (Ongoing 2014-2024)	Reports submitted on time to funders. Funding and gov't approval secured for activity implementation.	

Objective 11. Effective implementation of the strategy is ensured through consistent overseeing
Iantohana ny fampiarana mahomby ny paikady

Action	Project and Activities	Priority	Agencies responsible	Cost (£)	Timescale	Indicators	Risks and opportunities
11.1	Obtain government endorsement of the strategy *Azo ny faneken'ny fanjakana (governemanta) ny paikady*	High	Project partners, **MEEF**	0-1k	T1 (2014-2016)	Strategy endorsed by gov't and all stakeholders.	
11.2	Create a national Madagascar pochard steering committee *Foronina ny komity nasionaly manara-maso ny paikady Fotsimaso*	High	**MEEF,** Project partners	0-1k	T1 (2014-2016)	Steering committee defined and functional. Annual meetings of steering committee to review results and set annual priorities/targets.	
11.3	Develop a monitoring and evaluation plan for the strategy *Amboarina ny drafi-panahara maso sy tombana ny paikady*	High	**MEEF,** Project partners	0-1k	T1 (2014-2016)	Monitoring and evaluation plan written and distributed to partners. Annual meetings of steering committee to review results and set annual priorities/targets.	

3. Background information

3.1 Overview of species

3.1.1 Taxonomic background

The Madagascar pochard *Aythya innotata* (Salvadori 1894) nestles in a four species clade of the white-eyed pochards that includes the Eurasian / African ferruginous duck *A. nyroca*, Baer's pochard *A. baeri* from Asia, and the Australian endemic hardhead *A. australis* (Young & Kear 2006). Analysis of morphological and genetic material has revealed that the Madagascar pochard is most closely related to *A. australis* (Livezey 1996; Sorenson & Fleischer 1996).

Aythya innotata is the only pochard (*Aythya*) species recorded from Madagascar (Young 2013). Subfossil remains of an *Aythya* in Réunion have been tentatively linked to *A. innotata but* may be a distinct taxon (Mourer-Chauviré *et al.* 1999).

The Madagascar pochard has two Malagasy names, being called *onjy* around Lake Alaotra in the Alaotra-Mangoro Region of Madagascar and *fotsimaso* in the Sofia Region where the remaining wild population is found. The species is also referred to as *fuligule de Madagascar* in French.

3.1.2 General description and biology

The Madagascar pochard is sexually dimorphic with males being heavier (526-780g in captivity) than females (476-740g). Males also have a distinct white iris, which they begin to develop during their first winter.

The adult breeding plumage differs with males having a dark mahogany-brown head and neck, which turns to a more rufous-mahogany on the upper breast and sides of breast. Adult males have a whitish lower breast, which blends into a sepia-brown belly. The female by contrast has a dark brown head, neck and upper breast that is slightly paler on the chin and throat, and sepia-brown underparts with diffuse buffy white barring (Figure 2). Adult female eyes are dark brown. Bills in both sexes are lead-grey with black nails and legs and feet are grey. Both sexes have white secondary wing feathers creating clearly visible wing-bars when in flight. Immature birds are similar to the adult female but are a lighter and duller brown on the head and body with little rufous (Young 2013).

The Madagascar pochard is generally very quiet with the female typically louder than

Figure 2. Adult male and female Madagascar pochard in water (in captivity; photos: G Garcia/Durrell) and, overleaf, in flight (in wild; photos: I Relanzon and W Osterman).

the male. Male calls are mostly associated with displays, including high, wheezy *whirrs* during 'Kinked-neck' displays, and higher, polysyllabic *whistles* during 'Head-throw' displays. Females are quite vocal with soft, clucking *gek-gek* and louder rasping *gak-gak-gak* calls, often between separated or aggressive individuals. The female may also "Kink-neck" when calling (Young 2013).

The Madagascar pochard is not known to flock or associate with other ducks (Young 2005) but pairs and trios have been commonly observed to fly the length of Lake Matsaborimena (*c.*750m) and to congregate on open water in small groups of 3-5 birds (HG Young and others pers. obs.), and groups of 3-20 birds were observed on Lake Alaotra in 1960 (Dee 1986).

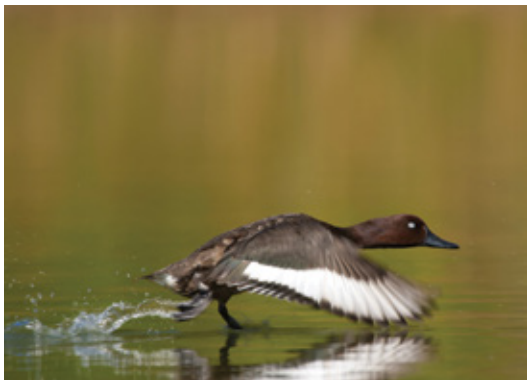
The Madagascar pochard is active throughout the day with bouts of activity during the hours following dawn and preceding dusk. Nocturnal activity patterns have not yet been studied. The species feeds primarily by diving, with adult wild pochards at Matsaborimena spending 38% of daylight hours feeding, and remaining submerged on average for 24.5 ± 3.5 seconds per dive (Bamford *et al.* 2015).

The white iris of the male, white wing-bars in both sexes, and the need to run across water to take off distinguish the Madagascar pochard from all other resident ducks in Madagascar.

3.1.3 Breeding behaviour and ecology

Breeding displays for the Madagascar pochard have not been studied in nature but some components have been observed in the captive population. Males use 'Bill-flicks' and 'Raised shakes', in addition to a 'Kinked-neck' display that is used by male(s) in the presence of female(s). During the latter the male's head and neck are raised or with the bill close to the water. A male 'Head-throw' is very visible with the head thrown onto the back and accompanied by a *whistle*. Female displays are less obvious with a 'Kinked-neck' display associated with vocalisation (see 2.1.2 above).

There does not appear to be a definite breeding season in wild Madagascar pochard, or it is at least quite extended. Breeding activity takes place in nine months of the year with nest-building observed as early as mid-May and broods being observed from early July until February.



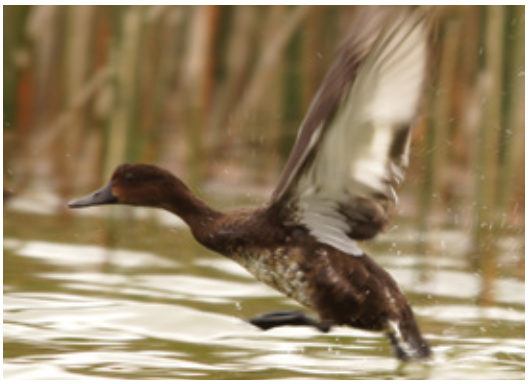


Figure 3. Wild Madagascar pochard nests and eggs (photos: H G Young/M Roberts and M Brown/L Woolaver).

Figure 4. Madagascar pochard ducklings at two days old, 14 days old and 40 days old (photos: R Digby).

Multiple nesting attempts after nest failure or loss of ducklings is not uncommon.

In the wild, the nest is a shallow circular bowl 22.5 ± 8.7 cm in diameter on the ground, made from available aquatic or marsh vegetation, dead ferns and grasses, and constructed in the emergent vegetation of dense papyrus *Cyperus* (Figure 3). The nest is lined with down feathers by the female at the onset of incubation (Young 2013). Nests, supported by the dense papyrus stems, were built 111 ± 98 cm from open water and with the top of the nest 20-40 cm above water level (Bamford *et al.* 2015). Mean distance recorded between concurrently active nests was 5-25 m (Bamford *et al.* 2015).

Clutch sizes in wild Madagascar pochard have ranged from 7-11 eggs with a mean of 8.8 ± 1.1. Eggs are buffish white and ovate. Only females incubate and incubation periods have been 24-28 days in captivity and 25-27 days in the wild. The fledging period in captivity is eight weeks and duckling development in captivity follows normal developmental stages (Figure 4) observed in other *Aythya* species (Young 2013; Bamford *et al.* 2015; HG Young pers. obs.).

Nest success in the wild population appears high with 76.2% success at Matsaborimena in 2007-2008 (n = 21 nests). Unsuccessful nests were either presumed destroyed by rats, as evidenced by faeces found in the nest (n = 2), or abandoned (n = 3). Egg fertility and hatch success have not been a problem in captivity and hatch success in the wild was 86.7% in 2007-2008 (Bamford *et al.* 2015). However, fledging success has been extremely low in the wild at 1.8 % in 2011 and 6 % in 2012. Twelve broods totalling 57 chicks were seen in 2011 and 20 broods totalling 100 chicks in 2012. Only seven of these chicks fledged. Fledging success has been very high in the captive population.

3.1.4 Diet and ecological role

Madagascar pochards are predominantly diving ducks. Ducklings feed at the surface until approximately 14 days old after which they begin diving to feed (Bamford *et al.* 2015).

Faecal samples and stable isotope analysis (Bamford *et al.* 2015) suggest that adult Madagascar pochards at Matsaborimena have a diet consisting almost entirely of invertebrates. Midge larvae (Chironomids) are the most abundant group of

Figure 5. Female Madagascar pochard with ducklings at Lake Matsaborimena in 2010 (photo: I Relanzón).

invertebrates in the lake's sediment (Figure 6) but were not as common in faecal samples, and pochards appear to prefer less abundant caddis-fly (Trichoptera) and other larger aquatic insects (Hemiptera).

Other *Aythya* species consume plants (seeds and vegetative parts of submerged aquatic vegetation) and invertebrates (insects and molluscs), with many species' diets biased more to plants (Kear 2005), so an entirely insectivorous member of this genus is unusual.

The invertebrate density in Matsaborimena is apparently enough to maintain adults in good condition as evidenced by multiple nest attempts and high productivity, although the time spent feeding on Matsaborimena is significantly higher than for other *Aythya* species (Hamilton *et al*. 2002; Houhamdi & Samraoui 2008). The preference for non-breeding adults to spend time on Andriakanala (see 3.2.2 Current distribution) may be due to higher invertebrate densities on macrophytes, but this needs further study.

However, it appears that invertebrate densities in the limited areas of shallow water are not sufficient to support duckling development and survival (see 2.2.3 below). Water depth, which is directly related to the energy required for diving, may be the most important limiting factor for the remaining wild population of Madagascar pochards at Bemanevika. Ducklings cannot dive as deep as adults, and are, therefore, even more restricted to the small areas of the relatively steep sided lakes at Bemanevika, in order to find food.

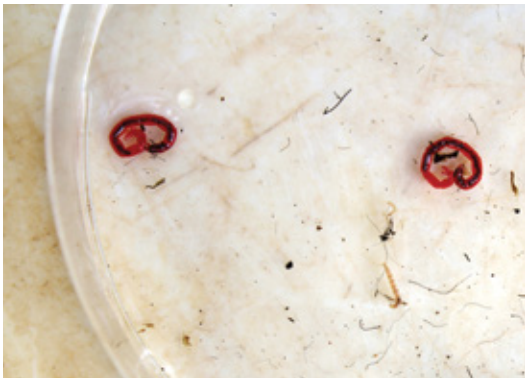


Figure 6. Chironomid larvae from sediment samples. Lake Sofia 2013 (photo: L Woolaver).

3.1.5 Habitat requirements and resource assessment

Habitat choice is difficult to determine as the entire remaining world population is at one small site and the Madagascar pochard was little studied at Lake Alaotra when locally common in the 1930s-50s (Young 2013).

Critical habitat for a diving duck like the Madagascar pochard will consist of areas where pochards can nest, forage and seek refuge from predators. Historical sites such as Lake Itasy and Alaotra are very large lakes (3200-18500ha) with surrounding marshlands that likely provided a range of nesting, feeding, and refugia sites, prior to being transformed by human activity. The few historical observations of Madagascar

Figure 7. Nesting habitat of *Cyperus* and ferns used by Madagascar pochard at Lake Matsaborimena. Kassidi is holding a Madagascar pochard egg (photo: L Woolaver/M Brown).

pochards suggest they were found in well-vegetated areas, particularly quiet pools with extensive emergent vegetation and water lilies *Nymphaea* spp. within the marsh at Lake Alaotra's southern end. By contrast the largest of the four lakes at Bemanevika, Andriakanala, is only 70ha. The four lakes at Bemanevika do not appear to provide ideal habitat for a diving duck. All four lakes are steep sided and deep (Bamford *et al.* 2015) providing very little shallow areas for a diving duck to feed. Only Matsaborimena has emergent fringing vegetation suitable for nesting (Figure 7).

The lakes in their current condition at Bemanevika appear to be at carrying capacity. A large number of ducklings are produced at Matsaborimena each year but are then unable to survive, and nesting only occurs at one of the four lakes. This could be improved by modifying the lakes in order to either provide more habitat for nesting and/or feeding at the three other lakes (see 3.6.2 below). Matsaborimena itself is likely already at carrying capacity in terms of breeding pairs but improvement of feeding habitat for ducklings would boost production significantly.

3.2 Distribution, abundance and population trends

3.2.1 Historical distribution

The Madagascar pochard is endemic to Madagascar and occurs nowhere else in the world. The species was first described by Salvadori from "Betsileo country" in 1894; however, the exact location has never been identified (Salvadori 1894; Wilmé 1994).

All records for the Madagascar pochard are from the central plateau (Figure 8) *c.*1200m above mean sea level (AMSL). Historical records are primarily from Lake Alaotra, with a few records and specimens from Lake Itasy, the Sahabe River 25km east of Alaotra, and the Didy region 45km south-east of Alaotra (Delacour 1932; Rand 1936; Webb 1936; Lavauden 1937; Dee 1986; Wilmé 1994).

Three specimens collected in 1915 from Ambatomainty in the Maevatanana district were attributed to a site 200km west of Lake Alaotra (Benson *et al.* 1976) but this may have been a site misidentification as there are localities with these common place names closer to Lake Alaotra. This requires further investigation. Subfossil records from other sites on the central highlands of Madagascar, and an apparent *Aythya* on Réunion, may have been *Aythya innotata* or a related endemic species (Mourer-Chauviré *et al.* 1999).

In 2006, the Madagascar pochard was rediscovered in the north-west in Sofia at three small forested volcanic lakes around the village of Bemanevika (René de Roland *et al.* 2007). The Bemanevika wetlands are 350km north of Alaotra.

Birds fly between the three lakes at Bemanevika but the frequency of longer movements within Madagascar are unknown. Unconfirmed reports away from Bemanevika (Salvan 1970), as well as a lone male captured at Lake Alaotra in 1991 (Wilmé 1993) (see 3.2.3 below) may indicate that the Madagascar pochard can occasionally disperse long distances from Bemanevika.

An extensive and interconnected system of wetlands would have at one time extended throughout the central plateau of Madagascar and would have linked the lakes and marshes around Alaotra to an extensive area of wetlands in the Bealanana watershed. Evidence of these once extensive wetlands can still be seen as large areas that have been converted to rice fields in between Bealanana and Alaotra. It is probable that the historical distribution of the Madagascar pochard was once more extensive throughout the central highlands beyond the limited number of historical site records we have for this species.

3.2.2 Current distribution at Bemanevika

Bemanevika consists of a wetland complex of four small lakes (total surface area of 150ha) and areas of marsh near the village of Bemanevika (14° 20.5' S, 48° 35.4' E) in the Sofia Region in the north-west (Figures 9-10). The lakes are approximately 1,600m AMSL and have a correspondingly cool climate (Bamford *et al.* 2015). Temperatures are generally between 10-30 °C, but during the coldest month (July) night-time temperatures can be as low as 0°C. Annual precipitation ranges from 1,600-2,700mm (Bamford *et al.* 2015). The rainy season extends from November to May, with most rain falling in January-March.

Large areas of moderately fragmented forest remain in the landscape. The four lakes are crater lakes with small watersheds, although Matsaborimena has two small, seasonal rivers feeding into it and thus a slightly larger watershed (Bamford *et al.* 2015). Matsaborimena has a narrow fringe of marsh and emergent aquatic vegetation, consisting mainly of *Cyperus madagascarensis* and *Eleocharis*

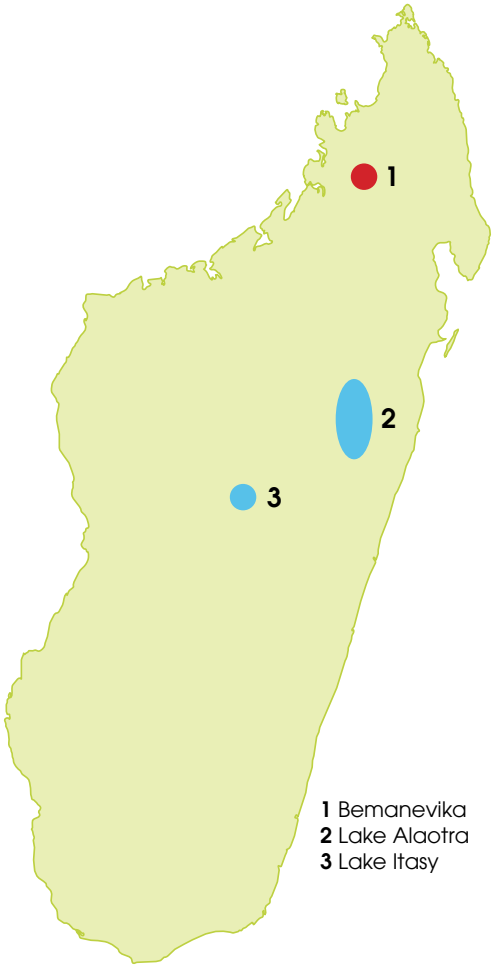


Figure 8. Potential historical distribution of Madagascar pochard in grey (central highlands>750m AMSL. with current locality at (1) Bemanevika and historical known sites at (2) Lake Alaotra and surrounding wetlands of Sahabe and Ididy and (3) Lake Itasy. Map by H Andrianandrasana and L Woolaver.

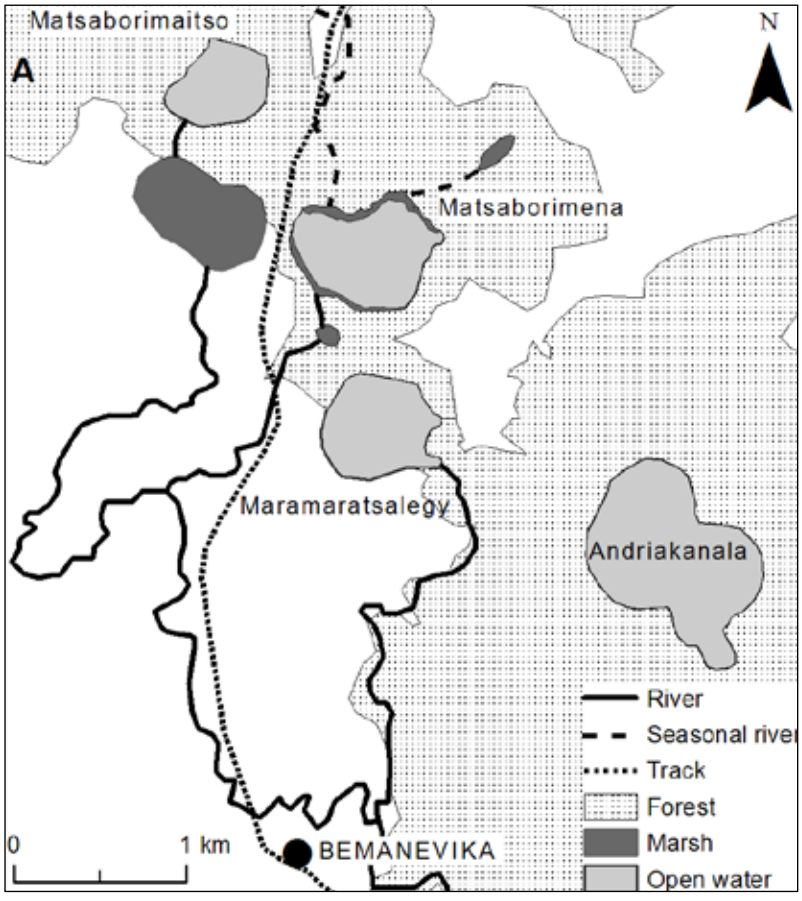


Figure 9. Map of the four lakes at the Madagascar pochard site near Bemanevika (Bamford *et al.* 2015).

spp. plus other sedges and ferns. At the other lakes there is forest to the water's edge.

Although Madagascar pochards have been observed throughout the year on three of the four lakes; Lakes Matsaborimena, Andriakanala, and Matsaborimaitso, there is a marked difference in the seasonal use of the three lakes. Pochards are observed year round at Matsaborimena (Figure 11) and this is the only lake where nests and ducklings have been recorded. Pochards have been observed at Andriakanala in all months apart from August, but numbers are noticeably lower from June-November when most birds are at Matsaborimena. They have also been recorded at Matsaborimaitso from December-May, with highest use appearing to be during the months of March-May. Moulting, flightless pochards have only been observed on Matsaborimena and Andriakanala.

Figure 10. Google Earth map of the crater lake complex at Bemanevika showing extent of forest.

All four lakes are steep-sided with very little areas of shallow water. Maximum measured depths have been 2.8m at Matsaborimena; 14m at Matsaborimaitso and 83m at Andriakanala (Rabearivony *et al.* 2010; Sam 2011; Bamford *et al.* 2015). Matsaborimena has a total surface area of 36ha, of which *c.*35.5ha is >1m deep. Andriakanala is mostly >80m, except a bay in the south of the lake that slopes smoothly from shore to 40m deep. This bay contains an area (*c.* 0.5ha.) of submerged macrophytes at a depth ranging from 1 to 5m. Andriakanala was the only lake with submerged macrophytes. The benthic substrate is uniform across all lakes: deep, fine silt (Bamford *et al.* 2015).

Figure 11.Lake Matsaborimena (photo: P Cranswick).

3.2.3 Abundance and population trends

The Madagascar pochard was considered common at Lake Alaotra in 1929 and 1935 (Delacour 1932; Webb 1936) and was still present in 1960 when groups of 3-20 pochards were observed between May-July (Dee 1986). Surveys at Lake Alaotra by Durrell, WWT and WWF in 1989 and the early 1990s failed to find Madagascar pochards (Young & Smith 1989; Young & Smith1990; Wilmé 1994).

The Madagascar pochard was not seen again until a single adult male was captured in 1991 at Lake Alaotra by local waterbird hunters (Wilmé 1993). This male was kept in captivity and died in 1992. Extensive surveys of Alaotra and the adjacent wetlands on the central plateau failed to locate any more pochards (Wilmé 1994; Pidgeon 1996) and with no further sightings, by 2006 the Madagascar pochard was considered to have gone extinct (Young & Kear 2006).

The rediscovery of the single population of Madagascar pochard at Bemanevika in 2006 (René de Roland *et al.* 2007) significantly expanded the previously known distribution for the species. Monthly counts at the Bemanevika lakes have shown that birds move seasonally between three of the four lakes (see 3.2.2 above) and there are seasonal fluctuations in total adult population size with highest counts of 21-29 adults in the months of April-June. Despite monthly fluctuations, which are due to the variable visibility of birds during nesting and moulting seasons, the overall population size has remained stable since rediscovery in 2006 (Figure 12) with a total population ranging from 20-29 adults. Highest annual counts of adult females have ranged from nine in June of 2014 to 14 in June of 2011.

Subsequent surveys of nearby wetlands in the Bealanana region and other areas in the central plateau have failed to locate any other populations (Razafindrajao 2007; Razafindrajao *et al.* 2008; Bamford & Razafindrajao 2012).

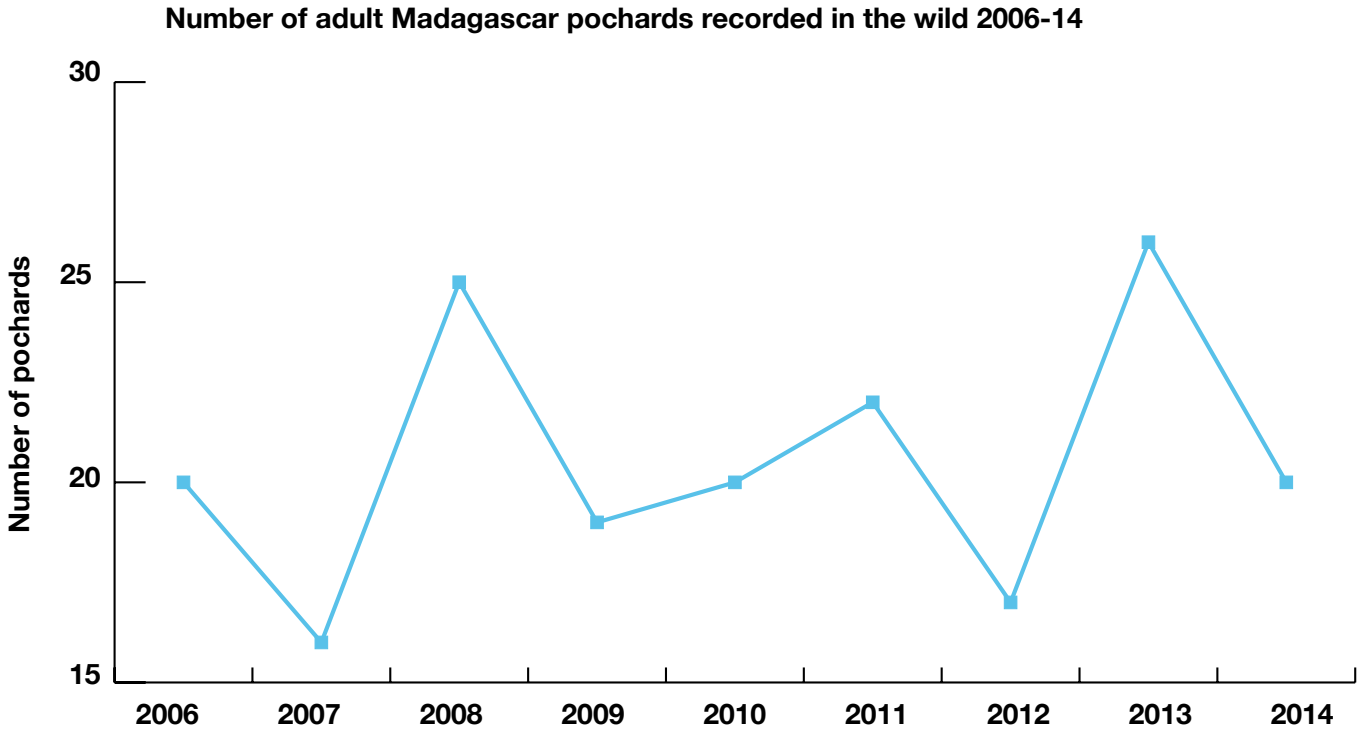


Figure 12. The population trend of adult Madagascar pochard at Bemanevika 2006-2014. Numbers from 2010-2014 are of adults recorded during simultaneous monthly counts at all three lakes in September. The numbers for 2006, 2007, 2008 and 2009 are single counts at Matsaborimena in December, January, December and July respectively.

3.3 Threats, potential threats and limiting factors

3.3.1 Potential causes of historical decline

3.3.1.1 Habitat loss

The decline of the Madagascar pochard went almost unnoticed making it difficult to determine the exact combination of factor(s) which nearly led to the species' extinction. However, the ultimate causes of decline are undoubtedly the extensive degradation and loss of wetlands throughout the Alaotra and Bealanana watersheds. The Alaotra watershed encompasses 7,225,000ha but has been all but converted into ricefields and pasture with less than 20,000ha of open water and 14,000ha of marsh remaining at Lake Alaotra, and the lake itself had been reduced to 20% of its original size by the year 2000 (Andrianandrasana *et al.* 2005; Bakoariniaina *et al.* 2006). Even less remains of the Bealanana watershed.

Although there is very little in the way of accessible records or publications on wetland decline in Madagascar, there has been considerable documentation of the loss of Madagascar's forest cover with 40% of Madagascar's rainforest cover being lost from 1950-2000 (Harper *et al.* 2007) and continuing at a rate of 102,000 hectares, or 1.6%, per year (Dufils 2003). Although most of the central highland forests had already been cleared by the 1700s, significant areas of fragmented forest remained on the highland massifs until the 20th century (Gade 1996) that could have protected wetlands from the effects of deforestation and erosion. However, even most of these remnant massif forests have been cleared from the 1930s onward (Gade 1996).

Rice is extremely important in Madagascar, the country ranks 5th in the world in terms of per capita consumption (136kg/year, or 0.375kg per person per day) (De Laulanié 2011). Cultivation is widespread (Figure 13) and has led to the conversion of many existing wetlands making them unsuitable for wildfowl and diving waterbirds. Those waterbirds that can utilise the new habitat are typically highly persecuted. Madagascar pochards are unlikely to be able to feed in rice fields and will have been forced out of converted wetlands. Increasing siltation and subsequent shallowing of many wetlands following deforestation has increased areas suitable for conversion to rice cultivation.

3.3.1.2 Habitat degradation

Deforestation has direct effects on wetland ecosystems, including increased sedimentation, higher water temperatures, increased nutrient loads, and changes in the relative availability of basal food resources. Of all these changes, increased sedimentation caused by accelerated erosion has had the most devastating

Figure 13. Rice cultivation in former central plateau wetland (photo L Woolaver 2015).

effect on Madagascar's highland wetlands (Benstead *et al.* 2003a). Heavy siltation and the loss or riparian vegetation can both cause significant changes in invertebrate communities and disrupt aquatic food webs. For example, a significant difference was found in invertebrate richness and diversity between streams in deforested versus forested areas around Ranomafana National Park (Benstead *et al.* 2003b). Food web changes could have significantly altered wetland habitats making them unable to support higher-level taxa like an invertebrate reliant diving duck such as the Madagascar pochard.

Benthic invertebrate abundance appears to be extremely low in Madagascar's wetlands (Razafindrajao & Bamford unpubl. data) and may be a serious limiting factor in distribution and abundance of many waterbirds including Madagascar pochard. The causes of this problem are unclear but are potentially related to several of the factors described above including annual and long-term siltation following deforestation, annual burning of adjacent grasslands, pollution and the high densities of exotic fishes.

While undoubtedly linked to conversion of marshlands to riziculture, the extent of chemical pollution of wetlands has not been extensively studied in Madagascar. Pidgeon (1996) found presence of diverse chemicals including DDT (dichlorodiphenyltrichloroethane) and Lindane (*gamma*-hexachlorocyclohexane) in samples from Alaotra. The impacts of these pesticides in the wetland are unclear, but likely to be highly detrimental. Pesticides such as these, many banned in Europe or the USA, have been freely available in many parts of Madagascar for use in the rice fields.

3.3.1.3 Overhunting and by-catch in gillnets

A combination of proximate causes may have contributed to the final disappearance of Madagascar pochard throughout their former range, including direct overhunting and trapping of wildfowl by local waterbird hunters (Wilmé 1994), and by-catch of diving birds in monofilament gill fishing-nets (Hawkins *et al.* 2000).

Wilmé (1994) describes a number of highly effective hunting methods used by waterbird hunters and suggests that an unsustainable level of hunting for commercial sale linked to an exponential rise in the number of fishermen on the lake in the 1980s was the most likely reason for the final disappearance of Madagascar pochards from Lake Alaotra.

Figure 14. Deforestation and siltation. (photo: H G Young 2004).

Hawkins *et al.* (2000) cite the intensive use of monofilament gill nets in the 1980s as one of the major reasons for the final decline of grebes in Lake Alaotra and are able to show counterfactual evidence from nearby Lake Antsomangana where grebes were still found and gillnets were not being used. By-catch in monofilament gillnets has also been cited as a major factor in population declines of other diving bird species including freshwater species like the Titicaca flightless grebe *Rollandia microptera* (Martinez *et al.* 2006).

There are no records of Madagascar pochards being hunted. However, subsistence hunting of all aquatic birds is widespread in Madagascar (Figure 15), indiscriminate and generally uncontrolled (Young 1996). Locally made traps are typically used but birds may also be hunted with slingshots, spears and dogs. Eggs are collected whenever possible. Hunting with firearms is uncommon, mostly through expense, and 'sport' hunting may no longer be a major problem although 'sportsmen' from major cities and overseas do regularly hunt ducks. Madagascar pochard, and other endemic wildfowl, received full legal protection in 2006 (Young *et al.* 2013).

Mono-filament gillnets are in widespread use by fishermen in Madagascar particularly at larger lakes like Alaotra. Diving birds like white-backed duck *Thalassornis l. leuconotus*, grebes, and crested coot *Fulica cristata* have been accidentally caught and drowned in nets and these species' disappearance from

many wetlands may be a direct result of this fishing method (Young 1996). There are no records of pochards being caught in nets, which have only been in use at Alaotra since the duck disappeared from this wetland, but, as with introduced carnivorous fish, their use may prevent any recolonisation by pochards at any lake where gillnets are used.

Figure 15. White-backed duck for sale near Lake Alaotra (Photo DWCT).

Figure 16. Asian blotched snakehead Channa maculata from Lake Alaotra (photo: J Copsey).

3.3.1.4 Disease

Infectious disease has not been recorded in Madagascar pochards. In Madagascar, epidemics of avian cholera (fowl cholera, Pasteurellosis), Newcastle disease (a paramyxovirus), avianpox (Avipoxvirus) and duck plague (duck viral enteritis) occur regularly amongst domestic poultry including ducks and geese causing mass mortalities (Lopez 2010; Maminiaina *et al.* 2010; Cappelle *et al.* 2015).

A pilot, questionnaire-based survey in April 2010 (Lopez 2010) assessed local disease risks in waterbirds and poultry at Ampijoroa, Ankarafantsika National Park. Results showed yearly outbreaks of diseases compatible with avian cholera, Newcastle disease, avian pox and duck plague causing severe mortality in domestic ducks and chickens. The disease outbreaks appeared to begin in August and peak in October-November each year, at which time diseased and dead wild birds such as egrets (*Bubulcus* and *Egretta*) from a large colony at Lake Ravelobe were observed.

Proximity of poultry, including domestic mallard *Anas platyrhynchos* and Muscovy duck *Cairina moschata* to wetlands in Madagascar and interactions with wild waterbirds such as cattle egret *Bubulcus ibis* makes the risk of disease transmission to wild waterbirds including Madagascar pochard severe.

Parasites such as Coccidia (a protozoan) and nematodes like *Syngamus trachea* are widespread in Madagascan poultry and their transmission to wild waterbirds is highly likely (Lopez 2010).

3.3.1.5 Introduced fish species

Hawkins *et al.* (2000) cite the near simultaneous introduction of Asian blotched snakehead (locally *fibata*) and the increase in use of monofilament gill nets as being the ultimate causes of the decline of grebes from Lake Alaotra, and suggests that these two effects may have also led to the final disappearance of the Madagascar pochard.

The introduction of exotic fish species has caused widespread extinctions of native fish species throughout Madagascar (Reinthal & Stiassny 1991; Canonico *et al.* 2005). At least 24 species of freshwater fish have been deliberately introduced to Madagascar (Benstead *et al.* 2003a). While exotic cichlids (*Oreochromis* and *Tilapia* spp.) may have hastened the decline of Madagascar pochard by competing with them for invertebrate prey (Wilmé 1994; Hawkins *et al.* 2000; Bamford *et al.* 2015), predatory species such as black bass *Micropterus salmoides* (introduced to Alaotra in 1961) and the snakehead (introduced to Madagascar in 1978) (Raminosoa 1987), may have also been directly responsible for waterbird declines. Whether or not this is true, snakehead in particular is certainly not a species that would be able to coexist with Madagascar pochards at small isolated wetlands such as the lakes at Bemanevika.

Carp (introduced to Alaotra between 1900 and 1926) and cichlids (introduced between

1955 and 1960) have altered the floral structures of Alaotra and competed with waterbirds for food resources (Young 1996). Carp may have increased lake turbidity making it difficult for diving waterbirds to find food (Zambrano & Hinojosa 1999; Miller & Crowl 2006).

Carnivorous fish (*Micropterus* and *Channa*) are implicated in the extinction of grebes and possibly competed with pochards for food and predated ducklings (Young 1996). Asian snakehead (Figure 16) was introduced into Alaotra in 1980 after the pochard's presumed extinction at Alaotra but may have prevented any recolonisation by pochards at any lake where snakehead were present (Young & Kear 2006).

3.3.2 Threats facing remaining wild population at Bemanevika

The factors mentioned in the previous section as having contributed to the global decline of the Madagascar pochard (wetland conversion to ricefields, overhunting, by-catch and introduced species) do not currently impact the last remaining wild population or at least have not yet reached levels (deforestation, heavy siltation) that have caused the species to disappear from the last wild site. They do, however, remain concerns and could lead to the extinction of the species in the wild if measures are not taken to mitigate them.

3.3.2.1 Deforestation and siltation

The upper watershed of Matsaborimena is deforested (*c.* 30% of the watershed area) and is burnt in some years, but the remainder of the watershed is covered in pristine forest. Lakes Matsaborimaitso and Andriakanala are completely forested and there is forest to the water's edge. Maramaratsalegy is approximately 60% forested with deforested grassland on the western edge. Grassland fires remain a threat to the forest particularly at Matsaborimena where fire almost reaches areas of marsh and may impact on the sparser forest at the western end of the lake. Timber extraction is not extensive and has been reduced since the presence of The Peregrine Fund and development of the New Protected Area.

Siltation at the four lakes is limited as only Matsaborimena has any stream inflow. Soil washed off the grassland during annual rains does not appear to be the same problem at the four lakes as it is throughout most of Madagascar.

The water at Matsaborimena has a fairly high phosphate (PO_4) and nitrate (NO_3) content and may be extremely turbid (Secchi distance of 0.4m in August 2011, although in July 2012 the water was clear for the first 1.0m depth) (Bamford & Razafindrajao 2012).

3.3.2.2 Potential predators

Mammalian and avian predators are responsible for most duckling predation worldwide (Baldasarre & Bolen 2006). Only Madagascar harrier has been recorded, on two occasions, predating the young of Madagascar pochards (Donald *et al.* 2010; Bamford *et al.* 2015). The only mammalian carnivore known to occur at Bemanevika, is the ring-tailed vontsira *Galidia elegans*, but this is forest dwelling and a diurnal predator (most duckling disappearances recorded occurred overnight) (Bamford et al. 2015). Another carnivore, Durrell's vontsira *Salanoia durrelli*, is known from the marshes of Alaotra but its diet has not been studied.

Few predators are capable of catching adult wildfowl; however, two bird species, peregrine *Falco peregrinus* and Henst's goshawk *Accipiter henstii* are potential threats (Young 2013).

Another potential predator is Nile crocodile, which must have been sympatric with Madagascar pochards in the past. One small crocodile is occasionally sighted in Matsaborimena. The absence of fish in the lake suggests that waterbirds may form a substantial part of its diet, but infrequent sightings suggest it is not always present and unlikely to be a major threat (Bamford *et al.* 2015).

Exotic rats (*Rattus rattus* and *R. norvegicus*) are widespread in Madagascar (Garbutt 1999) and, often present in marsh. These may be a threat to nesting Madagascar pochards and some unsuccessful nests at Matsaborimena have been presumed destroyed by rats (n = 2), as evidenced by faeces found in the nest (Bamford *et al.* 2015).

3.3.2.3 Low breeding productivity at Bemanevika

Juvenile survival a key factor preventing the remaining wild population from growing. Only 4% of young fledge successfully suggesting that the habitat at Bemanevika is not optimal for Madagascar pochards. Observations suggest the main factor is lack of food for the ducklings, which are left to feed themselves. While adults can dive to find food at depth, ducklings are

confined to feeding in shallow water. As the crater lakes are steeply shelved there is not much area that is accessible to the ducklings and the vast majority do not survive.

Twelve broods totalling 57 chicks were seen in 2011 and 20 broods totalling 100 chicks in 2012. Mean brood size at first sighting, generally in the first week after hatching but in the second week for four broods, was 4.9 chicks. Overall fledging success was 4.5% over the two years, or 3% when the Mayfield corrector is used. The seven fledged chicks were from four broods and were aged between 9-10 weeks, by which time their plumage was similar to adult females.

The majority of ducklings did not live beyond about three weeks (Figure 17). Mortality varied by age, peaking between two and three weeks. One dead chick was found (in August 2011) and, in over 600 hours of observation, one chick was observed being taken by a predator (in October 2012). Losses occurred gradually, with usually one or two chicks per brood disappearing in a 24 hour period (maximum of four out of seven). The dead chick was examined and found to be starved: aged approximately four weeks, it weighed 107g (compared to 203g at 25 days for 23 captive chicks) and the stomach and intestines were empty. Four chicks, other than the seven that fledged, survived until six weeks of age, by which age captive chicks are well feathered. However, two of these four chicks showed no visible signs of juvenile feather growth.

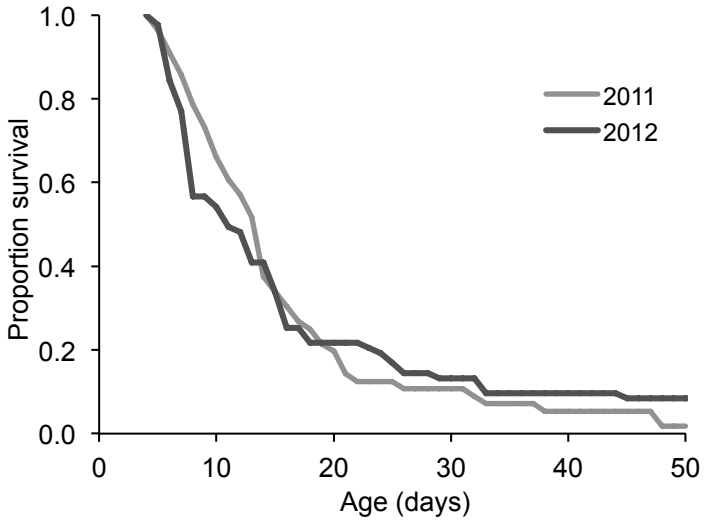


Figure 17. Survival of Madagascar pochard ducklings at Bemanevika in 2011 and 2012. From Bamford *et al.* 2015.

The Bemanevika wetlands are probably not ideal habitat for pochards, or at least not ideal breeding habitat. The habitat at Matsaborimena may be problematic: it is too deep for ducklings to dive and feed, with a low density of invertebrates. Young of a close relative, tufted duck *A. fuligula*, feed in water 0.75m deep and could not meet their energetic requirements at chironomid densities of 2,000m² (Giles 1990) – four times the mean invertebrate density recorded in Matsaborimena and half the depth. Water depth, which is directly related to the energy required for diving, may be the most important limiting factor in foraging by diving ducks (Lovvorn & Gillingham 1996). Another relative, common pochard *A. ferina* preferred low density food at 1m depth over higher density food at 2-3m (Carbone & Houston 1994). Ducklings cannot dive as deep as adults, reflected in shorter dive times, and even adult pochards stayed in the shallower parts of Matsaborimena when foraging. Ducklings were generally not observed diving until two weeks old, before which they fed at the surface. This switch in foraging method has been observed in other *Aythya* species and may occur because surface feeding no longer meets the growing ducklings' energetic requirements (Hill & Ellis 1984). The depth of Matsaborimena may mean that two-week old chicks cannot meet energy requirements by diving either – perhaps explaining the peak in mortality.

Ducklings require brooding from their mother to maintain body temperature until they can regulate their own. This typically takes 14-21 days with the female brooding her young for the equivalent of 10-15 minutes in any hour during the day and the majority of the night-time. Unlike some waterbirds (e.g. grebes) the mother duck needs to rest on a solid or floating object in order to cover the young with her body feathers and wings. Roosting like this makes the female duck and her young very vulnerable to predators and they must choose their site carefully. Brooding pochards have not been recorded anywhere and it is assumed that they do this essential behaviour within the small area of marsh or under other lake-side vegetation. There are no islands or large fallen tree perches available to the ducks to brood on and limited sites may further stress both mother ducks and their young. Poorly brooded young may not be kept sufficiently warm as they grow and, coupled with inadequate food resources, may be a further cause for chick mortality

in the early stages of growth and poor development of those that live beyond their second week.

Temperatures at Bemanevika typically range from 10-30°C but may go down almost as low as 0°C at night (Bamford *et al.* 2015) which is very cold by Madagascan standards e.g. minimum temperatures over the highlands average at 11°C in winter (July) and 16°C in summer (January) (Jury 2003). Such cold temperatures at night make adequate brooding of young by their mother essential for survival.

3.3.2.4 Human activity

1. Hunting and fishing
The Bemanevika lakes do not contain any fish, native or exotic. There is evidence of hunting in the forest, typically for mammals but snares, including those for waterbirds, have been used close to the lake edge. Brown lemur *Eulemur fulvus* and tailless tenrec *Tenrec ecaudatus* are the most commonly hunted animals but birds have been trapped and occasionally shot but are not hunted systematically. Nests of waterbirds may have been sought at the lakes for eggs. Feral pigs *Sus scrofa* are hunted in the forest. The majority of hunting in the forest or at the lakes has been much reduced or has disappeared since 2006 (Système des Aires Protégées de Madagascar 2014).

2. Extraction of plants and timber
Bark of bilahy (*Melicope fatraina*) and kotofy (red stinkwood *Prunus africana* or African cherry *Pygeum africanum*) is collected in the forest for commercial purposes and women collect certain species of emergent aquatic plants at lake edges, marshes and swamps. They have traditionally collected two main species: *Juncus* sp. and *Cyperus* sp. These have been collected for local handicrafts such as mat and basket weaving. Timber has been extracted directly from the forest but the forest, where present, is in very good condition.

3. Agriculture
The four existing lakes in the complex are too deep for rice cultivation. Deforestation has come close to Matsaborimena (Figure 18) and has removed forest cover from *c.* 30% of the watershed area. Anthropogenic grassland adjacent to this lake is burnt in most years for pasture: the remainder of the watershed is, however, covered in pristine forest. Andriakanala and Matsaborimaitso are almost completely untouched by human disturbance. The grassland fires have impacted onto the edge of the forest and come close to the water at Matsaborimena. Despite being part of the Bemanevika New Protected Area, burning of the grassland continues to slowly but steadily destroy areas of the primary forest around Matsaborimena each year.

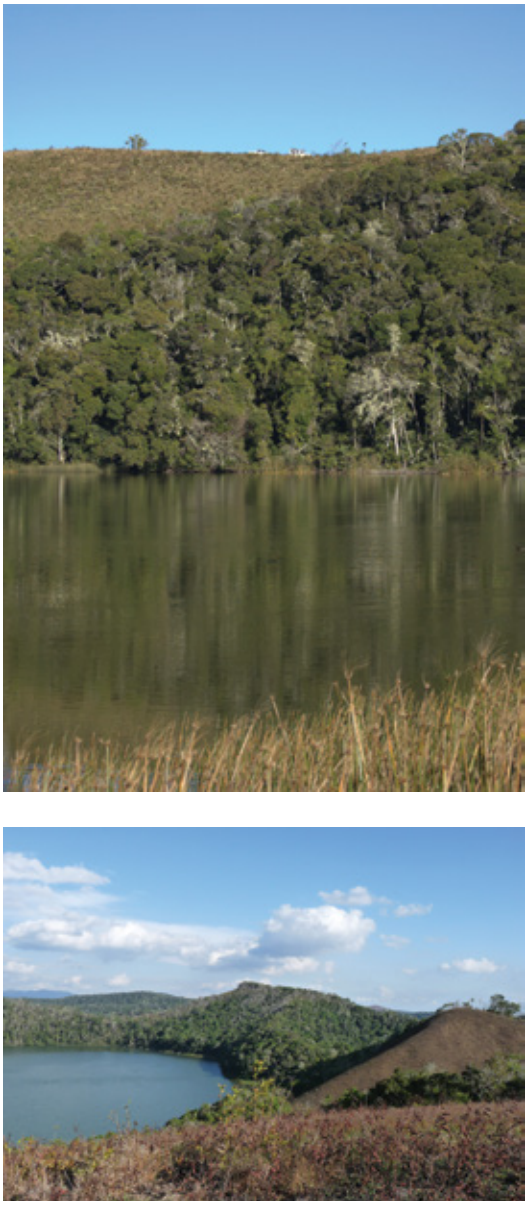


Figure 18. Proximity of anthropogenic grassland to Lake Matsaborimena in 2009 (photo: N Jarrett (top) and P Cranswick (below)).

The forest, marshes and swamps, however, provide important grazing area for zebu (Système des Aires Protégées de Madagascar 2014). Herdsmen leave their herds, which trample aquatic vegetation, a practice that can destroy nests as well as disturb waterbirds. Forest grazing has in places led to significant damage including the disappearance of the herbaceous layer and reduced natural regeneration.

4. Proximity of road to Antananivo-Haut.
The road from Bealanana to the village of Antananivo-Haut (Chef Lieu de Commune Antananivo) passes by Bemanevika, and within <100m of Lake Matsaborimena.

Although in very poor condition, the road is accessible by 4 x 4 during the dry season (May-November) and by motorcycle and oxcart year-round. The road beyond the village of Bemanevika is a historical track that runs to the coast, passing along the ridge just above (west of) Lake Matsaborimena. People are able to easily access the site throughout the year and drive vehicles close to the lake during the dry season.

5. Permanent presence of TPF and Durrell-WWT staff.
Since 2006 there has been a permanent presence at the site with a camp in the forest, close to the north shore of Matsaborimena. The camp was moved in 2010 to avoid risks of pollution of the lake via an inflow stream. Full time field personnel now stay closer to the village of Bemanevika but still within a 30 minute walk of Matsaborimena. The permanent presence of TPF and Durrell-WWT staff at the site has undoubtedly aided protection of the habitat and animal and plant species.

6. Ecotourism
Small numbers of birding tourists have visited Bemanevika since 2007. Visits may be principally to see Madagascar pochard but other rare birds such as Madagascar serpent-eagle *Eutriorchis astur* and red owl *Tyto soumagnei* attract tourists (Mills & Rogerson 2013). Visitors stay at the research camp through arrangement with The Peregrine Fund but must bring tents, bedding and utensils etc. Visitors are expected to pay a fee for the privilege of visiting, directly to the local community association. These fees have been used mainly to support biodiversity conservation, develop alternatives to subsistence farming methods and to create activities for generating some further income for the local community (Mills & Rogerson 2013).

3.4 Red List Status

During the first assessment of the species in 1988, the Madagascar pochard was listed in the IUCN Red List of Threatened Species as Threatened (Birdlife International 2013). However, during several revisions since 1994 *Aythya innotata* has been listed as Critically Endangered because there has been "an observed, estimated, inferred, projected or suspected population size reduction of ≥ 80% over any 10 year or three generation period, whichever is longer …and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible" and because "it is currently known from a single location where 29 mature individuals were seen in 2011."

3.5 Policies and legislation relevant for management

The Madagascar pochard is not specifically protected by any international (e.g. CITES) or national legislation. The pochard just missed inclusion in national legislation when the list of protected species was revised by the government of Madagascar in 2006, due to the species rediscovery after this revision. The pochard is also not protected by any local traditional laws or *Dinas*. There is a *Dina* for the forest at Bemanevika which was created in 2003 during a *Transfert de Gestion* which has been incorporated with the *Plan de Gestion* for the New Protected Area but this *Dina* does not specify protection for the Bemanevika lakes complex, nor does it specify protection of the pochard or the other threatened endemics at Bemanevika. The Peregrine Fund is working with the local communities to renew the Dina, which would include better protection for these habitats and species.

The pochard is a conservation priority or "*cible de conservation*" for the Bemanevika New Protected Area and the four lakes and surrounding forest are included within the "*noyau dur*" or strict conservation zone (Système des Aires Protégées de Madagascar 2014).

Management of the species in captivity or in the wild requires agreements from the government Ministry of Environment, Ecology and Forests (MEEF), as well as regional and local authorities, local associations and federations, and community representatives.

Research on the species in the wild and transportation of biological samples out of the country require permits from MEEF.

Any management or restoration of wetlands requires collaboration with the Ministry of Water and Sanitation and any community projects involved with improved resource use in and around wetlands would require collaboration with the government Ministry of Fisheries and Freshwater Resources as well as the Ministry of Agriculture and Rural Development.

3.6 Conservation and management

3.6.1 Protection status (Bemanevika New Protected Area)

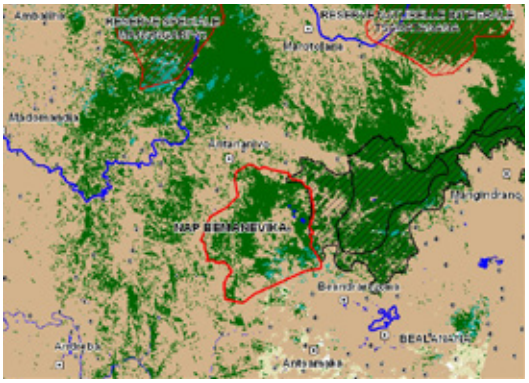
The NPA Bemanevika is a Category V protected area established to "*intégrant la conservation de la biodiversité et les intérêts culturels et sociaux traditionnels*". This means that it is a protected area managed in partnership with local communities. As such the NPA requires a promoter (The Peregrine Fund) and a co-manager representing the local communities, in this case the federation consisting of two associations *Fikambanan'i Bemanevika Miray* (FBM) and *Fikambanana Mitantana Ala Ketsan' Amberivery* (FIMAKA).

The NPA Bemanevika received Temporary Protected Status in November 2009 and was submitted with all final documentation for consideration for Permanent Protected Status in June 2014 (Système des Aires Protégées de Madagascar 2014). This will be granted by May 2015.

The NPA Bemanevika covers an area of 35,605ha protecting 20,353 ha of primary forest, 14,489 ha of savannah and 601ha of marshland. All four lakes at Bemanevika and their surrounding forests are included within the strict conservation zone or "*noyau dur*" which is defined as "*une zone sanctuaire d'intérêt biologique, culturel ou cultuel, historique, esthétique, morphologique et archéologique, qui représente le périmètre de préservation intégrale. Toute activité y est strictement réglementée. Aucune exploitation ni extraction de ressources naturelles n'est premise dans le noyau dur*" (Figure 19).

The lake-forest complex at Bemanevika (Lakes Matsaborimena, Matsaborimaitso, Maramaratsalegy and Andriakanala and their surrounding forest) and the nearby marsh of Marotaolana has been identified as critical habitat for the Madagascar pochard, Meller's duck *Anas melleri*, Madagascar serpent-eagle, red owl, northern shrew tenrec *Microgale jobihely*, and bizarre-nosed chameleon *Calumma hafahafa*.

The Madagascar pochard has been identified within the *Plan de Gestion* (Management Plan) for the NPA as a flagship species for conservation of the biodiversity at Bemanevika (Système des Aires Protégées de Madagascar 2014).



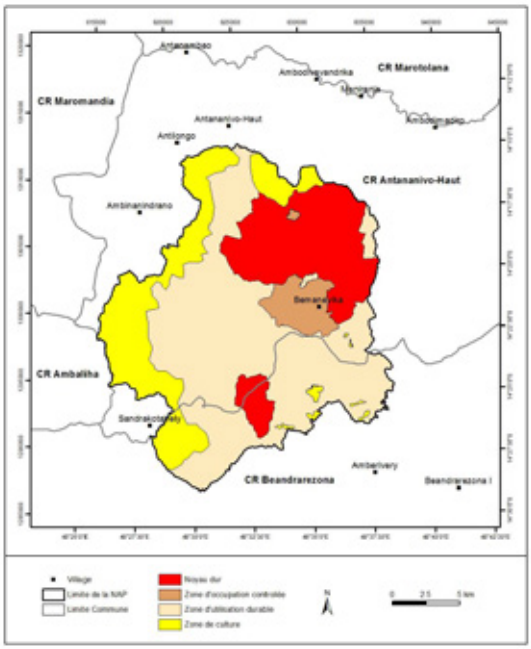


Figure 19. Maps showing the boundary (in red) of the NPA Bemanevika and the zonation with the strict conservation area (in red). From *Système des Aires Protégées de Madagascar* 2014.

Seven *Fokontany* (village groups) within the commune of Antananivo-Haut and five *Fokontany* from the commune of Beandrarezona are responsible for the co-management of the NPA, as represented by the two associations (FBM and FIMAKA) and other local authorities including the *Chefs Fokontany* and traditional leaders such as the *Rayamandreny, Sojabe, Chef Religieux*, and the *Fédération de la Femme*. These 12 *Fokontany* represent a population of *c*.17,290 people that are affected by the NPA and rely on the natural resources (forest products, pasture land) within the protected area (*Système des Aires Protégées de Madagascar* 2014).

3.6.2 Management of wild population

The Peregrine Fund has managed a permanent field team based at Bemanevika since 2006. WWT, Durrell and The Peregrine Fund staff have been carrying out monthly lake counts since 2010. The presence of these field staff and the stewardship of the lakes and pochard by the people of the village of Bemanevika have provided protection for the wild birds. The local associations FIMAKA and FBM have played important roles in the protection of the

lake-complex through their responsibility as co-managers of the NPA.

There have been no direct management interventions with the wild population. There have been proposals to improve the nesting and feeding habitat at each of the four lakes in order to increase the carrying capacity and productivity. These would involve the creation of artificial islands but this requires a more detailed assessment study and discussion among stakeholders and managers of the NPA Bemanevika.

3.6.3 Relationship between stakeholders, actions and strategies

A stakeholder table identifying main stakeholders, current and potential, for the recovery of the Madagascar pochard was developed during the Action Plan development workshop in December 2013 and is presented below.

	Project and Activities	Potential
Government	• Ministry of Environment, Ecology and Forests (MEEF) • *Direction Générale des Forêts* (DGF) • *Direction de Valorisation des Ressources Naturelles* (DVRN) • *Direction de la Conservation de la Biodiversité et la Système des Aires Protégées* (DCBSAP) • *Directeur Régionale Environnement, Ecologie et Forêts* (DREEF), Sofia. • *Chef de Région*, Sofia. • *Directeur de Développement Régionale* (DDR) Sofia. • *Cantonnement*	• Ministry of Tourism • Ministry of Education • Circonscription Scolaire • Zone Administrative Pédagogique • Ministry of Land Planning • *Gendarmes*
Local communities	• Community Associations Bemanevika Association *Fikambanan'ny Bemanevika Miray* (FBM), Association *Fikambanana Mitantana ny Ala Ketsany Amberivery* (FIKAMA) • Community Federations Sofia *Federation Sofia Mandroso, Federation Santatra Sofia* • *Fokonolona* • Traditional authorities	• Women's Associations
NGOs	• The Peregrine Fund • Durrell Wildlife Conservation Trust • Asity Madagascar • Wildfowl & Wetlands Trust	• Conservation International • World Wildlife Fund • Aga Khan Foundation • *Projet d'Urgence pour la Préservation des Infrastructures et la Réduction de la Vulnérabilité* • USAID Mahefa • Regional Office of Tourism Sofia • IUCN Species Survival Commission Specialist Groups
Research	• University of Antananarivo • Bangor University	• University of Mahajanga • Madagascar Biodiversity Partnership (MBP) • Vahatra
Decentralised governments	• *Fokontany* • Commune • Region • District	
Private sector	• Tour Operators - Bird watching	• Collectors - selective tree harvesting • Entreprise Robert - infrastructure
Other	• Primary public schools • Clubs *Vintsy* • Scout Clubs	

The main stakeholders in the conservation of the Madagascar pochard at the national level are the government departments of the Ministry of Environment, Ecology and Forests (MEEF), specifically the *Direction Générale des Forêts* (DGF), the *Direction de Valorisation des Ressources Naturelles* (DVRN) and the *Direction de la Conservation de la Biodiversité et la Système des Aires Protégées* (DCBSAP),conservation organizations (Durrell, The Peregrine Fund, WWT and Asity Madagascar).

At the site level, the Bemanevika New Protected Area is promoted by The Peregrine Fund with oversight by DCBSAP and the Comité d'Orientation et de Suivi des Aires Protégées (COSAP). The NPA is co-managed by The Peregrine Fund and the local communities for 12 Fokontany, represented by the community associations FBM and FIMAKA.

The captive-breeding programme has been a partnership between the *Directeur de Développement Régionale* (DDR) for Sofia, the *Directeur Régionale Environnement, Ecologie et Forêts*, *Cantonnement,* Durrell and WWT.

Partnerships are developing between the conservation organisations (Durrell, WWT, Asity Madagascar) development organisations (OSDRM/AK), regional authorities (DREEF, DDR) and the *Fokonolona* and community federations and at Lake Sofia (*Sofia Mandroso, Fikambana Fitantanana Matsabory Sofia* and *Santatra Sofia*), in preparation for a future release of Madagascar pochards at Lake Sofia.

Durrell, The Peregrine Fund and Asity Madagascar all have *Accords du Siege* with the government of Madagascar to carry out conservation activities.

A Memorandum of Understanding (MoU) was signed between the Ministry of Environment and Forests (MEF), Durrell, WWT and The Peregrine Fund in Antananarivo in 2009 as a partnership to work together to ensure the recovery of the Madagascar pochard.

3.6.4 Conservation breeding programme

3.6.4.1 Historical captive populations

Live Madagascar pochards were exported from Alaotra to Europe in 1929 and 1935 (Webb 1953) and subsequently bred in several European collections between the two World Wars (Delacour 1959). No ducks are known to have survived in captivity after 1946 (Scott 1947) and there are few details of their husbandry (Delacour 1959).

3.6.4.2 Collection of founder birds in 2009

The decision to collect eggs from the wild pochard population at Matsaborimena to form an *ex situ* captive population was made during a site visit by Durrell, WWT, The Peregrine Fund and MEEF in July 2009. Establishing a captive-breeding strategy would avert the potential threat of immediate extinction of the wild birds through disease, hunting or changes to the habitat such as loss of nesting areas or food sources.

Conditions at the lake were less than ideal for establishing a breeding facility (poor access, lack of electricity and running water) and logistics were difficult for transporting fragile eggs to a hatching and rearing facility at another site. A plan was established to locate active pochard nests and to monitor these closely before the clutch was collected 1-2 days before hatching. The eggs were hatched at the lakeside in battery-operated incubators and the day-old ducklings transported to a temporary rearing facility in Antsohihy (Hotel Anais). Ducklings are far more robust than eggs, and very young ducklings survive without food and water for the first 1-2 days of life by metabolising the egg-yolk, which they absorb just before hatching. Ducklings were, therefore, considered safer to transport shortly after hatching than incubating eggs would be.

Clutch no.	**1**	**2**	**3**
Date collected 2009	24th October	7th November	11th November
No. eggs	9	9	7
Date hatched 2009	25th October	10th/11th November	18th November
No. hatched	8	9	7
Sexes of young	3 male: 5 female	2 male: 6 female (1 unknown)	2 male: 5 female

The first clutch was collected on 24th October 2009 and hatched in a tent at the lakeside on 25th October. The eight ducklings were transported to Antsohihy on the 26th (Figure 20), receiving their first food (duckling crumb) and water in their transport box en route.

A second clutch of eggs (9) was collected on 7th November, hatched in the tent on 10th and 11th (Figures 21-22) and the young transported to Antsohihy on 11th November. A third partially-incubated clutch (seven eggs) was collected on 11th November and, as deteriorating weather made further visits to Matsaborimena unlikely, was transported to Antsohihy in a travel incubator on the 11th. This third clutch was transported without problem and hatched successfully on 18th November.

3.6.4.3 Rearing founder birds 2009-2010

One duckling hatched at Matsaborimena on 10th November died in Antsohihy on 23rd December 2009. The remaining 23 ducklings were reared in temporary facilities (Figure 23) at the Hotel Anais until they were transported to the Chelonian Breeding Centre at Ampijoroa Station, Ankarafantsika National Park on 15th December 2009.

The young pochards were temporarily housed in concrete ponds designed for holding and rearing Madagascar side-necked turtles *Erymnochelys madagascariensis* (Figure 24) until dedicated captive facilities could be constructed in Antsohihy. The founder pochards fledged at Ampijoroa in early 2010 and attained adult plumage. Husbandry guidelines and veterinary protocols were developed and Malagasy staff received avicultural training while the pochards were in Ampijoroa.
Two birds died at Ampijoroa at 10 and 12 months old respectively. Both bodies were preserved in formalin.

3.6.4.4 Pochard Captive Breeding Centre (PCBC) in Antsohihy

Work started on a new, purpose-built Pochard Conservation Breeding Centre (PCBC) in June 2011 and the 21 pochards at Ampijoroa were transferred on 1st September 2011. The centre was officially

Anti clockwise from top left

Figure 20. Madagascar pochard ducklings being transported to Antsohihy, October 2009. (photo: H G Young).

Figure 21. Madagascar pochard eggs in temporary accommodation at lakeside Matsaborimena in November 2009. (photo: L Woolaver / M Brown).

Figure 22. Madagascar pochard ducklings hatching at Matsaborimena in November 2009. (photo: N Jarrett).

Figure 23. Madagascar pochard weighed to assess development at Antsohihy, December 2009. (photo: M Brown).

Figure 24. Young Madagascar pochards at Ampijoroa, January 2010. (photo: O Joiner).

opened on 26th November 2011 (Figure 25).

The purpose of the PCBC is to breed Madagascar pochards for release into the wild (re-introduction) and to maintain a viable captive population as an assurance colony. Breeding pairs are maintained separately from larger groups so that the parents of all young can be identified for genetic management.

The first Madagascar pochards to be bred in captivity in Madagascar hatched at the PCBC on 2nd September 2011 (the egg had been laid at Ampijoroa and transported with the adults). A further 18 ducklings were hatched in 2011/12, 20 in 2013 and 25 in 2015.

The PCBC has four enclosures with four ponds in each (Figures 26-27). Each enclosure is entirely covered to prevent movement of the captive birds between and outside the enclosures and to prevent entry to potential mammal and bird predators. The water in each pond is changed every five days and kept clean with electric filters.

There is an additional block of 12 smaller enclosures with 2.35 x 2.20 x 0.60m ponds. These Mid-stage Rearing Units (MSRUs) are for rearing ducklings after they have left the indoor Duckery brooders (see below) and before they are placed in the full size enclosures.

The captive breeding facility is staffed by three full-time aviculturalists and two site guards. Durrell Madagascar's veterinarian is responsible for all parasite prophylaxis and control, medical treatment and *post mortem* examination of the captive birds. The project has a dedicated 4 x 4 vehicle and full-time driver.

A strict bio-security regimen is maintained at the PCBC. All personnel, including avicultural staff, must adhere to all policies including disinfection of hands and all footwear. Only special clothing kept at the facility and equipment used for each enclosure can be used. All foodstuffs and foot dishes are kept clean at all times. Full guidelines have been produced and supplied to all personnel; all visitors to the facility are expected to follow these guidelines at all times.

The PCBC has a dedicated Incubation Room where all stages of handling eggs after collection are conducted. Eggs are typically incubated in electronic incubators (Figure 28) although some may be incubated

From top to bottom

Figure 25. Opening ceremony at the PCBC attended by the DREF and Chef de Région for Sofia, November 2011. (photo: C Stevenson).

Figure 26. Pochard Conservation Breeding Centre (PCBC), Antsohihy, November 2013. (photo: H G Young).

Figure 27. Pochard Conservation Breeding Centre (PCBC), Antsohihy, November 2013. (photo: L Woolaver).

Figure 28. A Hemel 400© forced-air cabinet incubator at the PCBC. (photo: R Digby).

Figure 29. The Duckery at the PCBC. (photo: H G Young 2011).

and hatched by the parents.

After hatching, all ducklings are reared in the specialised Duckery (Figure 29) at the PCBC for up to 14 days before being transferred to outside enclosures, typically the MSRUs. Ducklings fledge in the enclosures and are moved into larger flocks until old enough for release into the wild or for breeding in the facility.

Each pochard has been given individually numbered, metal rings, coloured plastic rings and a reference number. Daily reports (Figure 30) are e-mailed by PCBC staff to Durrell's Animal Registrar in Jersey where they are entered into ARKS and stored on a computerised database. All Madagascar pochards are entered into a computerised International Studbook (Figure 31) maintained by Durrell in Jersey. This studbook is used to record all birds, for genetic management during breeding and in selection of birds for reintroduction.

Figure 30. Madagascar pochard daily report sheet from PCBC (28/09/2014).

DARWIN INITIATIVE

durrell

WWT

1

MADAGASCAR POCHARD PROJECT

DAILY REPORT

Day**: Sunday** Date: **28/09/14** Aviculturists present: FT, JZ

ID No.	Sex	Species	Identifiers (Verified)	Current Enclosure	Weight / Length	Comment Code	Initials

Fed birds
No rat caught this morning
Collected feathers from F1, F2, F3, F4, and L3
Cleaned and refilled L1
Water plants

MADAGASCAR POCHARD Studbook

(Aythya innotata)

Stud #	Sex	Hatch Date	Sire	Dam	Location	Date	Local ID	Event	Rearing	Tag/Band
MP0001	M	25 Oct 2009	WILD1	WILD2	BEMENAVIK	25 Oct 2009	UNK	Hatch	Hand	WT:BB0853
					MEF	25 Oct 2009	UNK	Transfer		
					JERSEY	25 Oct 2009	MP0001	Loan to		
					HOTEL ANA	26 Oct 2009	MP0001	Transfer		
					AMPIJOROA	15 Dec 2009	MP0001	Transfer		
					ANTSOHIHY	1 Sep 2011	MP0001	Transfer		
MP0002	F	25 Oct 2009	WILD1	WILD2	BEMENAVIK	25 Oct 2009	UNK	Hatch	Hand	BB0858:DG
					MEF	25 Oct 2009	UNK	Transfer		
					JERSEY	25 Oct 2009	MP0002	Loan to		
					HOTEL ANA	26 Oct 2009	MP0002	Transfer		
					AMPIJOROA	15 Dec 2009	MP0002	Transfer		
					ANTSOHIHY	1 Sep 2011	MP0002	Transfer		
MP0003	F	25 Oct 2009	WILD1	WILD2	BEMENAVIK	25 Oct 2009	UNK	Hatch	Hand	BB0852:PK
					MEF	25 Oct 2009	UNK	Transfer		
					JERSEY	25 Oct 2009	MP0003	Loan to		
					HOTEL ANA	26 Oct 2009	MP0003	Transfer		
					AMPIJOROA	15 Dec 2009	MP0003	Transfer		
						30 Aug 2010		**Death**		
	[Death by: Self-inflicted injuries □ Mounted or Preserved: ANTSOHIHY]									
MP0004	M	25 Oct 2009	WILD1	WILD2	BEMENAVIK	25 Oct 2009	UNK	Hatch	Hand	BK:BB0857
					MEF	25 Oct 2009	UNK	Transfer		
					JERSEY	25 Oct 2009	MP0004	Loan to		
					HOTEL ANA	26 Oct 2009	MP0004	Transfer		
					AMPIJOROA	15 Dec 2009	MP0004	Transfer		
					ANTSOHIHY	1 Sep 2011	MP0004	Transfer		
MP0005	F	25 Oct 2009	WILD1	WILD2	BEMENAVIK	25 Oct 2009	UNK	Hatch	Hand	BB0856:OR
					MEF	25 Oct 2009	UNK	Transfer		
					JERSEY	25 Oct 2009	MP0005	Loan to		
					HOTEL ANA	26 Oct 2009	MP0005	Transfer		
					AMPIJOROA	15 Dec 2009	MP0005	Transfer		
					ANTSOHIHY	1 Sep 2011	MP0005	Transfer		
						7 Jan 2012		**Death**		
	[Death by: Infection associated □ Mounted or Preserved: ANTSOHIHY]									
MP0006	F	25 Oct 2009	WILD1	WILD2	BEMENAVIK	25 Oct 2009	UNK	Hatch	Hand	BB0855:CS
					MEF	25 Oct 2009	UNK	Transfer		
					JERSEY	25 Oct 2009	MP0006	Loan to		
					HOTEL ANA	26 Oct 2009	MP0006	Transfer		
					AMPIJOROA	15 Dec 2009	MP0006	Transfer		
					ANTSOHIHY	1 Sep 2011	MP0006	Transfer		
						24 Mar 2013		**Death**		
	[Death by: Infection associated □ Mounted or Preserved: ANTSOHIHY]									

Figure 31. Page from Madagascar pochard International Studbook.

3.6.5 Community outreach and education

The Peregrine Fund, Durrell and Asity Madagascar have conducted initial awareness programmes in the Sofia Region in order to ensure that local communities are aware of the uniqueness and threatened status of the Madagascar pochard, and the global importance of the remaining wild population at Bemanevika.

The Peregrine Fund's message has focussed on the importance of the NPA Bemanevika in terms of the sites unique biodiversity, and the ecological services and resource benefits provided by a sustainably managed forest. The process of creating the NPA has involved extensive community consultation and discussion in order to ensure that local communities have been completely involved in the process of developing the NPA.

Durrell and Asity Madagascar carried out a community awareness and education programme from 2011-2013 that focussed on schools, scout groups, and environmental clubs in Bealanana and Antsohihy. One of the goals of this programme was to train young people from local communities that could then be involved in future awareness raising activities. An underlying theme of this outreach was to engage people through activities. For example, tree planting was used as a means of engaging entire communities in an environmentally themed activity that was then used as a forum to discuss the Madagascar pochard conservation project. The largest tree planting day in Sofia's history was carried out under the banner of the Madagascar pochard. Environmentally themed plays and radio programmes were also used to discuss the importance of wetlands and the pochard to wide audiences.

The Peregrine Fund and Durrell project staff in Bealanana and Antsohihy have been active in supporting and participating in annual regional festivals and environmental events, which has provided opportunities to spread awareness of the importance of the Madagascar pochard in Sofia. However, there is a need for a clear communication and environmental awareness strategy to be developed and implemented by partners involved in the pochard recovery programme.

3.6.6 Central plateau wetland assessments and identification of future release site(s)

Following the successful establishment of Madagascar pochard in captivity there has been a need to identify potential sites where captive-bred birds can be released to increase the population size and distribution of the species in the wild.

The historical range of the Madagascar pochard is poorly documented, although all records suggest that the species was limited to the central plateau. *Aythya* species are typically generalists with simple habitat requirements and wide diets. They are diving ducks and feed at the lake bottom, so consequently require fairly shallow water. Their diet consists of invertebrates and pondweeds, and other *Aythya* species feed from a wide range of both. Nests are constructed in marshes or on small islands, requiring dense vegetation for shelter. In Madagascar, lakes have been drained and aquatic vegetation cleared so that rice can be grown. Deforestation and resultant soil erosion have led to large amounts of sediment being introduced into lakes, increasing water turbidity and reducing the amount of aquatic vegetation, which is habitat for aquatic invertebrates. Introduced fish have also increased turbidity, compete directly with pochards for food, potentially predate on birds (especially young) and are the driving factor in mortality through gillnet entanglement. All of these factors have been implicated in the decline of the Madagascar pochard.

All major wetlands in Sofia and elsewhere in the central plateau were surveyed in 2012 in order to assess the health and biodiversity of the remaining wetlands and to identify sites which could be restored to support healthy populations of released pochards.

3.6.6.1 Extensive high plateau wetlands survey, June-August 2012

An extensive survey of 25 remaining high plateau wetlands (Figure 32) was undertaken from June to August 2012 by WWT and Durrell (Bamford & Razafindrajao 2012). The survey aimed to assess the condition of remaining wetlands on the plateau with regard to pochard habitat needs and the suitability of these sites for restoration work, and to identify a shortlist of sites to be revisited for a more detailed evaluation.

Figure 32. Map of Madagascar showing sites visited during extensive survey of high plateau wetlands (red circles).

The survey team recorded data from each of the 25 wetlands on:

- Vegetation surrounding the wetland and aquatic vegetation, including emergent (growing in the water but emerging from it forming a marsh), submergent (growing under the water) and floating;
- Water depth around the lake using a handheld depth sounder (PlastimoEchoTest II);
- Benthic invertebrates and sediment using a Petit Ponar grab sampler. A minimum of five samples of sediment from the lake bottom was taken. Invertebrates in the sample were counted and identified to family level (Figure 33). Sediment type and structure was recorded.
- Water chemistry by testing water samples for nitrates and phosphates.
- Water turbidity by recording the Secchi distance using a standard Secchi disc.

In addition to the physical assessments, interviews were conducted with local resource users and village leaders (Figure 34) to determine:

- Number of communities present near the wetland;

- Main livelihoods and resource use by those communities;
- Management structures of the wetland and who is responsible;
- Fish species present at the site and fishing practices;
- Seasonal changes in the site (water levels, resource use).

Land cover within each watershed was mapped based on Google Earth images and using GIS. The size of the lake, size of the watershed, extent of forest cover, and the area of marsh and rice cultivation were calculated.

Full methods and results of the survey are available in Bamford & Razafindrajao (2012), but from the results it is unsurprising that the Madagascar pochard is in such a critical state. All of the wetlands apart from the lakes at Bemanevika were degraded and disturbed and would be unable to support pochards in their current state. The lakes at Bemanevika were the least disturbed and healthiest remaining wetlands in the central plateau region of Madagascar.

All of the central plateau wetlands were degraded and lacked food and/or nesting habitat. By far the most common group of invertebrates recorded during the wetland assessments were chironomid midge larvae. Chironomids alone may be sufficient for pochard dietary needs if they are abundant enough, and they were abundant in a few of the lakes. Pochard species will typically graze on submergent macrophytes outside of the breeding season (Kear 2005), but only five of the 25 lakes visited had any submergent macrophytes. However, these five lakes were also low in benthic invertebrate abundance.

Although huge areas of marsh have been cleared, several of the wetlands did still have substantial areas of marsh remaining. Pochards require marshes that are dense enough to build a nest out of the water, and provide shelter. However, the marsh does need to be fairly undisturbed by people.

Wetlands are extremely important to local communities for rice farming, fishing and collection of *Cyperus* from which mats, baskets and other items are made. The population density around the wetland areas of the plateau can be very high. The extent of human traffic and disturbance to which it can be managed may be a crucial factor in the success of a release site.

Figure 33. Invertebrate sampling during wetland assessments in central plateau (photo: L Woolaver).

Figure 34. Interview process at Lake Sofia (photo: L Woolaver).

3.6.6.2 Repeat assessment of short-listed wetlands, November 2012

Four of the sites visited in June-August 2012 (Lake Sofia, Antafiandanaka, Antsomangana and Amparahinandiambavy) were revisited in November 2012 for a more detailed assessment (Shore *et al.* 2013). Further interviews were held with village leaders and elders to gather information on the environmental and socio-economic history, status and trends at the site. Efforts were made to invite elder members of the community to ensure that a historic perspective was gained, and to ensure all participants contributed to the discussions so that all responses were captured. Where opinions differed this was noted and discussions held to seek confirmation of viewpoints. Conversations were structured in order to gather basic social information (number of people, ethnic/social composition, infrastructure, organisational structure) and learn about landscape and land-use, wildlife (including common and rare/extinct species, new invasive species and any trends observed), agriculture (main crops/livestock, use of pesticides, scale of farming, outside interests, shifts/trends in practices), fisheries (fishing seasons, catch composition and size, fishing locations and methods, wild harvest vs aquaculture, important species, contribution to diet), and any other issues raised by the community.

The survey team also walked or canoed around each site to gather more information through visual observations on an *ad-hoc*

basis. This was to gather complementary biological and ecological data, particularly in relation to site suitability for pochards. Further data were collected as outlined in Bamford & Razafindrajao (2012) including notes on the vegetation at the site, depths across the site, benthic invertebrates, and sediments.

Evaluation of these four sites and results from the earlier surveys at additional sites within the historic range of Madagascar pochard demonstrated the depressing state of wetlands on the central plateau. There were no wetland sites on the plateau that were currently suitable for the establishment of a sustainable population of Madagascar pochard through reintroduction.

None of the remaining wetlands could even realistically be restored to a condition and managed in such a way that Madagascar pochards could become self-sustaining within the next 3-5 years. A more realistic target was to identify a site that would be capable of supporting an assisted population in the short-medium term and a self-sustaining population in the medium-long term. This would only be feasible if immediate restoration and management interventions were undertaken alongside efforts to support/establish sustainable livelihoods to reduce reliance on the wetland to a manageable level.

In order to assess if any of the wetlands fall into this category, a semi-quantitative site assessment matrix was developed to consider the various attributes of a candidate release site (see Shore *et al*. 2013). A series of thresholds were proposed that would identify a site that holds sufficient potential across the full range of criteria. These thresholds were as follows:

- An average overall score of at least six out of ten
- No scores lower than four out of ten
- No average section scores lower than five out of ten

The only wetland that met these thresholds was Lake Sofia, supporting views of the survey team that Lake Sofia was the only wetland where habitat restoration would be feasible.

Summary site assessment matrix from Shore *et al*. (2013).

Section	Category	Sofia	Antafiandakana	Antsomangana	Amparihina-ndrianbavy
1. GENERAL CONTEXT	*Geographic location*	8	7	7	6
	Political/administrative	8	2	4	2
	Socio-economic	7	3	5	5
	Section Average	**7.7**	**4.0**	**5.3**	**4.3**
2. POCHARD REQUIREMENTS	General	7	5	5	6
	Physical	8	5	3	6
	Chemical	6	4	8	7
	Ecological	6	5	5	4
	Section Average	**6.8**	**4.8**	**5.3**	**5.8**
3. POCHARD THREATS	Fish	5	2	3	3
	Agriculture/land-use	5	3	5	5
	Invasive species	9	6	4	9
	Hunting/ resource use	8	5	7	4
	Disturbance	7	2	6	3
	Water use	5	3	5	7
	Section Average	**6.5**	**3.5**	**5.0**	**5.2**
4. OPPORTUNITIES AND CONSTRAINTS	Community capacity	6	4	5	7
	Partners/ funders	5	4	5	7
	Additional barriers	7	5	5	6
	Logistical	4	6	5	5
	Section Average	**5.5**	**4.8**	**5.3**	**6.3**
	Overall Average	**6.5**	**4.2**	**5.1**	**5.4**

3.6.6.3 Lake Sofia

Lake Sofia is the most intact remnant of the once vast Bealanana Wetlands Complex and the most suitable high plateau wetland in the Sofia region for the release of captive-bred Madagascar pochards (Figure 35). Lake Sofia is large (surface area 2.3km^2) but shallow (maximum depth of 2m) with areas of marsh (approx.15km^2) and rice cultivation. There is extensive emergent vegetation (especially the *Cyperus*-dominated marsh) but little or no submergent vegetation. Fish catch was dominated by *Tilapia* species, which were introduced in the 1950s. The predatory snakehead has not been reported to have been introduced nor observed in fishermen's catches.

Grab samples of the sediment produced low invertebrate numbers and diversity, including few chironomids and molluscs. The sediment consisted primarily of silt and non-decomposed *Cyperus*. The water was turbid and had high phosphate levels but little nitrate. The lake is not in ideal condition for pochards, but is in better condition than all of the other wetlands, with promising potential for restoration.

The lake and entire watershed are contained within one commune and the road to access the main town of Marotolana is impassable by vehicle during the wet season. Land use around the lake is unregulated, based on customary usage with people surviving as subsistence farmers. Fishing is undertaken by a small proportion of the population – fewer than 100 people rely on fishing as their main livelihood. *Cyperus* is collected from the marsh (for weaving into mats and baskets) and areas of the marsh are burned each year.

Lake Sofia is unique in having a well-organised management structure already in place, being managed by a community association for sustainable resource use. This makes it most likely that a wetland restoration project of value to both people and wildlife, including the Madagascar pochard could be established.

Figure 35. Lake Sofia, November 2012 (photo: L Woolaver).

Monitoring of environmental conditions, wildlife populations and fish catches at the lake began in 2014. A watershed-wide questionnaire survey of socio-economic conditions was also carried out in 2014 to collect information to develop a wetland restoration programme that will address rural development in a way that is compatible with environmental management objectives and designed to be sustainable. Existing agricultural practices will be improved and new rural livelihood options across the catchment established. Longer-term work will tackle existing environmental issues to improve habitat quality for wildlife and ecosystem services for the local communities.

Lake Sofia is not quite ready for the release of Madagascar pochards. A partnership between the stakeholders in Madagascar pochard recovery and the population at Lake Sofia is being developed to create a practical, robust framework for sustainable management of the lake and its catchment, combined with practical work to improve livelihoods and environmental conditions. This will focus on the establishment of community-based structures with good governance to manage natural resources. This will involve supporting the three existing associations to finalise the process of establishing a long-term community-managed wetland within national and local policy frameworks and establishment of Lake Sofia as a co-managed community-led protected area. This will involve creating a legal basis for the associations' work and enabling continued, sustainable use of natural resources for over 6,000 people.

3.6.7 Timeline of significant events

1894 The Madagascar pochard is first described. Type location is never identified.

1929 The Madagascar pochard is reported as being "locally common" at Lake Alaotra.

1960 Last confirmed reports of Madagascar pochards at Lake Alaotra.

1970 Last reported sighting of Madagascar pochards (at Lake Ambohibao, Antananarivo).

1970-1990 Madagascar pochards not reported from Lake Alaotra or any other historical site despite extensive surveys in 1989-1990 (carried out by Durrell, WWT and WWF).

1991 A single male Madagascar pochard is captured alive at Lake Alaotra by fishermen and is presumed to be the very last of its kind.

1991-1993 Extensive survey of central plateau lasts 18 months and goes well beyond Lake Alaotra watershed to include wetland but does not find any further pochards.

2004 The Madagascar pochard is believed to have gone extinct.

2006 A small population of fewer than 25 Madagascar pochards is rediscovered by The Peregrine Fund at Matsaborimena, an isolated volcanic lake near the village of Bemanevika.

2007 Sofia wetlands searched for first time to look for other populations of pochards but no further birds found.

2009 A rescue mission is carried out by Durrell, WWT and the Malagasy government to collect eggs from wild nests to start a captive breeding safety-net population. Twenty four ducklings are hatched and raised at the Hotel Anais, Antsohihy.

2009 Bandits threaten the staff taking care of the pochards in Antsohihy and all captive birds and staff move immediately to the Chelonian Breeding Centre in Ampijoroa (managed by Durrell Madagascar).

2009 The wild population of Madagascar pochards is provided official protection within a New Protected Area for Bemanevika promoted by The Peregrine Fund in Madagascar

2010 Concerns over avian cholera, which is common in domestic birds throughout Madagascar, leads to an intensive vaccination programme for the captive pochards.

2011 A new captive facility is built and the pochards are moved back to Antsohihy. The breeding centre is officially opened by Dr Lee Durrell and government authorities in November.

2011 Eighteen ducklings hatch in captivity. The captive population is now twice that of the wild population.

2011 Research investigating reasons for the rarity of the pochard in the wild determines that widespread wetland degradation and lack of invertebrate food for a diving duck are the most probable causes of the species' decline.

2012 A large-scale survey effort of 24 wetlands throughout the historical range of Madagascar pochard is undertaken to search for potential release sites for captive-bred birds. Nearly all of the lakes surveyed are severely degraded and unsustainably used by people. Fortunately one site, Lake Sofia, is identified as a promising site for a reintroduction.

2013 Twenty more ducklings hatch in captivity and the recovery programme is confident that Madagascar pochard can be bred in captivity to provide ducks for future reintroductions.

2013 The wild population at Bemanevika remains stable but extremely vulnerable with 20-25 birds, only 8-12 of which are adult females. The captive breeding population stands at 55 birds, 25 of which are females.

2013 A Species Action Plan Workshop brings together stakeholders from the local communities, government, and conservation NGOs to develop a strategy for the long-term restoration of the Madagascar pochard.

2014 Multiple stakeholder meetings held at Lake Sofia in order to discuss a potential reintroduction of Madagascar pochard and to begin developing an ambitious wetland restoration project which can serve as a model for the rest of Madagascar

3.7 Knowledge gaps

Almost nothing is known about the natural ecology of Madagascar pochards in optimum habitat, their former distribution or the reasons for their decline. Although we can infer critical habitat based on what is known about other *Aythya* species, we cannot with all confidence define critical habitat needs for the Madagascar pochard. It is possible that these gaps in our understanding of the species may never be fully understood.

In addition, further study is required to understand movements of pochard within the four lakes complex at Bemanevika and their use of each site in order to answer the following questions:

- Do all age groups and sexes move between the different lakes and do any of the birds leave the lake-complex completely at any time? This is particularly important if there are habitats or sites that are used by these birds that are not under any current protection.
- Is movement around the lake-complex seasonal or dependent on the time of day? Where and at what time of year do adults at Bemanevika undergo annual wing moult? What is the amount of recruitment at Bemanevika and where do any surplus young birds disperse to? Again this information is important in determining how best to manage the wild population.

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Saving the Madagascar pochard is a collaborative project of Asity Madagascar, Durrell Wildlife Conservation Trust, the Madagascar Government, The Peregrine Fund and the Wildfowl & Wetlands Trust. This is an ambitious programme to address a wide range of issues. A captive population has been established, both to avert imminent extinction of the species and to be the source of birds for eventual re-introduction to sites in the species' former range. A bespoke breeding facility has been built and Malagasy staff have been employed and trained in avicultural techniques. Research of the wild birds has provided the first concrete information on the species' breeding and feeding ecology, and insights into how the deterioration of wetland habitats has impacted upon the species. Formal protection of the site supporting the remaining wild birds is largely complete, a Species Action Plan has been developed, and a programme of engagement has raised awareness among local communities.

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