Disturbance effects of boat-based tourism on waterbirds at the Ramsar-designated De Hoop Vlei, Western Cape, South Africa

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Plagiarism Declaration

I hereby declare that all of the work presented in this thesis, titled "Disturbance effects of boat-based tourism on waterbirds at the Ramsar-designated De Hoop Vlei, Western Cape, South Africa", is my own, except where otherwise stated in the text. This thesis has not been submitted in whole or part for a degree at any other university.

Signed in Cape Town in March 2017

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Abstract

Recreation and ecotourism activities are growing in demand worldwide, especially in biodiversity hotspots. Protected area managers may seek to introduce novel activities in order to generate revenue. However, disturbance effects brought about through encounters between humans and wildlife can have negative consequences, which conflict with conservation goals. De Hoop Vlei is a large coastal lake within the De Hoop Nature Reserve. It is a Ramsar site as well as a key feature of a BirdLife Important Bird Area (IBA). Proposals for motorized boat tours and kayak tours on the vlei have been made, for which this study provides an impact assessment. Repeated counts were performed in order to characterize the waterbirds present during the high water level conditions required for boating. Birds were concentrated in areas with aquatic vegetation and shallow water, mainly along the vlei's western shoreline and southern and northern ends. Two routes were designed for boat tours that would minimize disturbance by avoiding these areas as well as breeding sites. Count data were also used to revise the Ramsar and IBA assessments, which underestimated the site's conservation value. Boat tours were monitored to estimate the number of birds disturbed, and to measure agitation distances (ADs) and flight initiation distances (FIDs) in response to the boat as well as a kayak. Post-disturbance recovery was investigated, as was the likelihood of habituation using a space-for-time substitution at a site with regular boat traffic. Boat tours did not typically disturb more than 10% of birds present at the vlei, and largely avoided disturbing species of conservation concern. Responses to the kayak were more severe than to the boat, which is most likely due to the similar speeds of the two boats are similar and the kayak is more easily perceived as a threat due to its shape and stealth, the presence of a paddler, and the consistent paddling motion. Post-disturbance recovery of species was slow and incomplete after an hour, meaning that there are likely costs for foraging opportunities and breeding if important areas are disturbed. Most species did allow a closer approach at the site with regular boating, but AD did not differ between them for most species. From these results it would be dangerous to assume that habituation will mitigate against disturbance impacts. Recommendations made included that kayak tours should not be permitted. Boat tours, with correct management, can be conducted in a manner that will not be too disruptive to birds. This study is the first to document such a large difference in responses of birds to two differing boat types, and is a rare example of disturbance of birds being studied in an African context.

Chapter 1

The difficult relationship between ecotourism and conservation, and its bearing on boat-based tourism at De Hoop Vlei

General Introduction

The costs and benefits of ecotourism in protected areas

Nature-based tourism or 'ecotourism' (Buckley 2009) is projected to grow in many regions worldwide (Cordell et al. 2005). This is especially true for global biodiversity hotspots (Christ et al. 2003), which hold a disproportional amount of the world's endemic and threatened taxa (Myers et al. 2000, Mittermeier et al. 2011). Protected areas have already been established in many of these hotspots, and the persistence of effective networks of protected areas are considered key to the preservation of biodiversity (Rodrigues et al. 2004, Chape et al. 2005). The most biodiverse 12% of the Earth's terrestrial surface also supports 20% of the world's human population, and the rate of population growth in biodiversity hotspots is substantially higher than the global average (Cincotta et al. 2000). Therefore, human-induced environmental changes by local people and tourists are likely to be an increasingly important factor for biological conservation, even within protected areas.

Protected areas provide various natural and cultural resources. Opportunities for people to enjoy these resources form the foundation of the ecotourism industry. Benefits from protected areas and the associated access to nature can take many forms, including educational, cultural, spiritual, and recreational opportunities (Frumkin 2001). Tourist visits to protected areas often contribute heavily to the financial security of these areas and the conservation activity taking place within them (Buckley et al. 2012). It is important, therefore, for managers to take advantage of opportunities for sustainable tourism in order to promote the longevity and effectiveness of successful protected areas (McCool 2006).

While providing diverse, high-quality experiences for tourists is one priority for protected areas, it is important that these activities are not detrimental to the resources that the protected areas are mandated to protect. Negative effects of tourist activity are often difficult or impossible to avoid (e.g. Müllner et al. 2004), and there is a need for compromise between tourism opportunities and conservation. Managers need to weigh up the potential benefits to be gained through tourism (e.g. financial gain) against the potential impacts thereof on the area (e.g. disturbance of biota). Tourist activities need to be planned and managed to minimize their impacts to make them environmentally sustainable.

South Africa contains impressive biodiversity and an array of different landscapes, including three biodiversity hotspots: the Cape Floristic Region, Succulent Karoo, and the Maputaland-Pondoland-Albany Hotspot (Myers et al. 2000). The country has an existing network of national parks and provincial reserves, as well as private reserves, which provide a broad spectrum of ecotourism experiences. Tourism is a large component of South Africa's economy, supporting large numbers of local jobs and in some areas alleviating socio-economic issues (Binns and Nel 2002). With growing tourist demand, these parks and reserves provide an opportunity for economic growth and increased funding for conservation (Lindsey et al. 2007). One way for protected areas to attract more tourists is to initiate novel ecotourism and recreational opportunities. These activities should be appropriate to the local landscape and resources available in each area. However, managers need to take into account the possible effects that such activities might have on the natural resources and environment that they protect. Balancing these opportunities and costs can be difficult for protected area managers.

Recreation and ecotourism inevitably have some negative effect on the environments in which they occur. Simply allowing visitors into a protected area requires the establishment of infrastructure. Roads, for instance, have a vast array of documented negative environmental effects, ranging from the facilitation of alien species introductions to lethal collisions with wildlife (Coffin 2007). Recreation has been shown to be associated with decreases in species abundance and activity (Garber and Burger 1995), alteration of species composition and behaviour (Ikuta and Blumstein 2003), and the partial or full avoidance by wild animals of otherwise suitable habitat or sites (Papouchis et al. 2001, Taylor and Knight 2003). Recreation was cited as the second greatest threat to wildlife on U.S. Federal land (Losos et al. 1995) and the fourth greatest factor contributing to threatened species declines (Czech et al. 2000). Even quiet and non-consumptive activities (e.g. wildlife viewing) can have serious ecological effects (Boyle and Samson 1985, Knight and Gutzwiller 1995). In the USA, protected areas that include recreation as an activity for visitors have consistently lower diversity and numbers of native predators and higher densities of non-native predators than protected areas that do not offer recreational opportunities (Reed and Merenlender 2008). These negative effects must be managed for when implementing activities in protected areas.

Anthropogenic disturbance and its possible effects on birds

Recreation and ecotourism bring people into close proximity to wild animals, which can result in 'disturbance'. A disturbance in this sense is defined as an event that evokes a reaction from an animal (Van der Zande and Verstrael 1985, Fox and Madsen 1997). Short- and long-term consequences of disturbance are termed ‘disturbance effects’ and ‘disturbance impacts’, respectively. Disturbances can be natural (e.g. the approach of a predator) or anthropogenic (e.g. the approach of a person on foot or in a vehicle). Both natural and anthropogenic disturbances result from a perception of a threat or danger, which initiates a response from the animal.

There is a large body of evidence documenting the negative effects of human disturbance on birds (reviewed in Buckley 2004, Steven et al. 2011), even from seemingly benign activities such as birdwatching (Şekercioğlu 2002). Increased pressure on protected areas to allow recreation and ecotourism activities can lead to adverse consequences for bird populations, especially threatened species (Buckley 2003, Kerbiriou et al. 2009). Consequences of disturbance can range from minimal (e.g. short-term distraction) to intense (e.g. breeding failure). Steven et al. (2011) laid this out as a hierarchical relationship showing increasing impact with increasing disturbance (Figure 1.1). The ecological significance of a disturbance impact depends on many factors, including the type, severity, duration, and frequency of the disturbance.

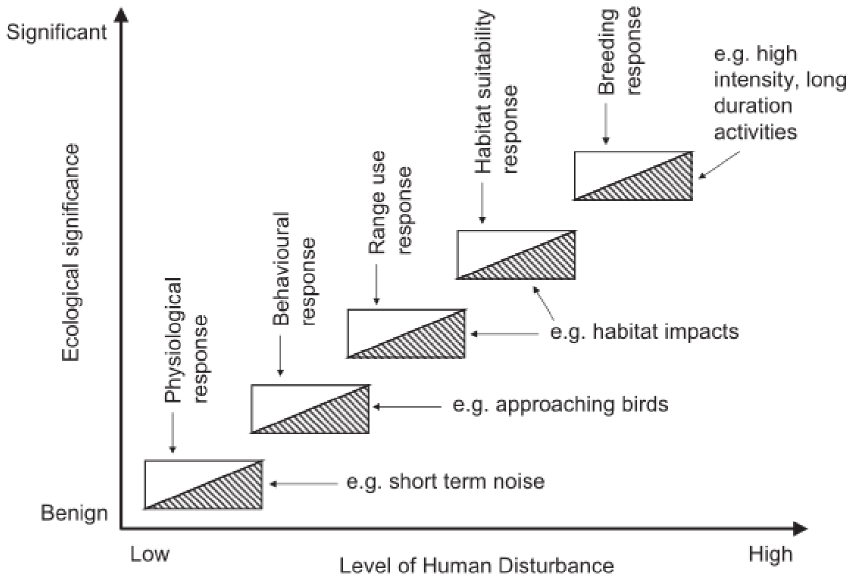

Figure 1.1: The conceptual relationship between human disturbance events and their ecological impacts (from Steven et al. 2011).

The immediate reaction to a disturbance can be physiological and/or behavioural, which result in different disturbance impacts. Physiological responses typically are brought about by increased stress. This manifests through the production of glucocorticoids, which spike adrenalin production, increasing heart rates and metabolic rates (Weimerskirch et al., 2002, Müllner et al. 2004, Holmes et al., 2005, Walker et al. 2006, Wikelski and Cooke 2006, Thiel et al. 2008). In some instances, a physiological response may occur, along with the negative consequences thereof, without an observable change in behaviour (e.g. Holmes et al. 2005). They are therefore difficult to detect without invasive methods, which is why physiological responses are generally understudied and underappreciated.

Behavioural responses to disturbance are easier and less intrusive to study than physiological responses (Gill 2007, Steven et al. 2011). Typical responses to an approach include orienting the head or body to monitor the oncoming threat, cessation of the current activity to engage in vigilance, and movement away from the source of the disturbance. Responses to disturbance can be energetically expensive for birds, especially when they interrupt important activities such as feeding, nest care, or social interactions (Lord et al. 2001, Pearce-Higgins et al. 2007).

There are immediate costs of disturbance to a bird, but the impact of a disturbance may continue for much longer than the event. Regular disturbance may cause sensitive birds to avoid certain areas, either on a short- or longer-term basis (Végvári et al. 2011). This can be particularly detrimental if these are important feeding, staging or breeding areas (e.g. Bélanger and Bédard 1990). Disturbance can also displace birds into less productive areas, or areas where other birds are resident, increasing ecological pressures on the habitat and increasing competition between birds. Increased competition for resources such as food or nesting/roosting sites and territorial disputes can cause a decrease in bird condition (Kitaysky et al. 1999, Brown and Sherry 2006), compromise reproductive ability (Martin 1987), or decrease survival (Brittingham and Temple 1988, Oro and Furness 2002). Birds may also try to avoid competition by leaving the site completely, which reduces the number of birds that a site can sustain.

In addition to the immediate responses of birds, disturbance events can have significant ecological effects over long time-scales (Liddle 1997, Buckley 2004, Cardoni et al. 2008). The extent of these effects depends on the intensity, duration and periodicity of the disturbance regime (Steidl and Powell 2006). Possible impacts include the avoidance of certain areas within an individual’s home range, rendering an entire habitat unsuitable for an intolerant species, and affecting breeding performance by causing nest abandonment, increased nest predation, or disrupting courting, incubating, or feeding behaviours (Steven et al. 2011). The severity of the impacts also depends on the species concerned, their age, sex, size, body condition, and breeding status, and the state of the habitat and/or site being sampled, time of day, the availability of similar habitats nearby, and the level of previous exposure to similar disturbances (Gill et al. 2001, Beale and Monaghan 2004a, 2004b, Beale 2007, Beauchamp and Ruxton 2008, Bejder et al. 2009). Considering the wide range of possible disturbance effects arising from recreation and ecotourism, it is advisable for managers of protected areas to undergo some form of impact assessment before implementing new plans (Glasson et al. 2013). This allows for identification of possible impacts at an early stage, thereby allowing avoidance or mitigation actions to be taken.

De Hoop Vlei is a large coastal lake situated along the southern coast of the Western Cape, South Africa, and falls within De Hoop Nature Reserve (see site description below). The wetland is recognized as a globally important site for waterbird conservation through its designation as a Ramsar site (Ramsar 1971) and its inclusion within the greater De Hoop Nature Reserve Important Bird Area (IBA; Marnewick et al. 2015, BirdLife International 2016). Proposals have been made to begin conducting motorized boat and kayak tours on the vlei. Considering the site's importance for waterbirds, it is crucial that the potential impacts are investigated in order to address or mitigate possible threats to local birdlife.

Introduction to my thesis

Site Description

De Hoop Vlei (34° 27' S, 27° 23' E) is a large, dynamic waterbody which forms the western boundary of the 340 000 ha De Hoop Nature Reserve with the Cape Floristic Region biodiversity hotspot (Myers et al. 2000). It is a Ramsar site (Ramsar 1971) and a major component of a BirdLife Important Bird Area (IBA; Marnewick et al. 2015, BirdLife International 2016). The vlei is a large coastal brackish lake situated on the eastern Agulhas Plain approximately 50 km east of Cape Agulhas It was formed when the Sout and Potteberg Rivers were cut off from the sea by the formation of a broad system of dunes. In addition to the two rivers, a number of freshwater springs feed the vlei. The vlei is narrow in width (< 0.5 km) but runs for 17 km north to south (Figure 1.2) and is up to 8 m deep. Water levels and salinity are highly variable, with inter-annual variation exceeding seasonal cycles (Figure 1.3), altering the area, shape and character of the vlei (Uys and Macleod 1967, Lanz 1997). Large numbers of waterbirds feed, breed, roost and/or moult at De Hoop Vlei, but their numbers fluctuate dramatically (Harebottle 2012), largely due to the dynamic nature of the vlei. The western edge of the vlei abuts onto the Overberg Missile Testing Range. The air space above the vlei is designated a no-fly zone, but this restriction is not always adhered to by military planes. Private planes also occasionally land on the runway recently constructed adjacent to the main accommodation area in the reserve, Die Opstal.

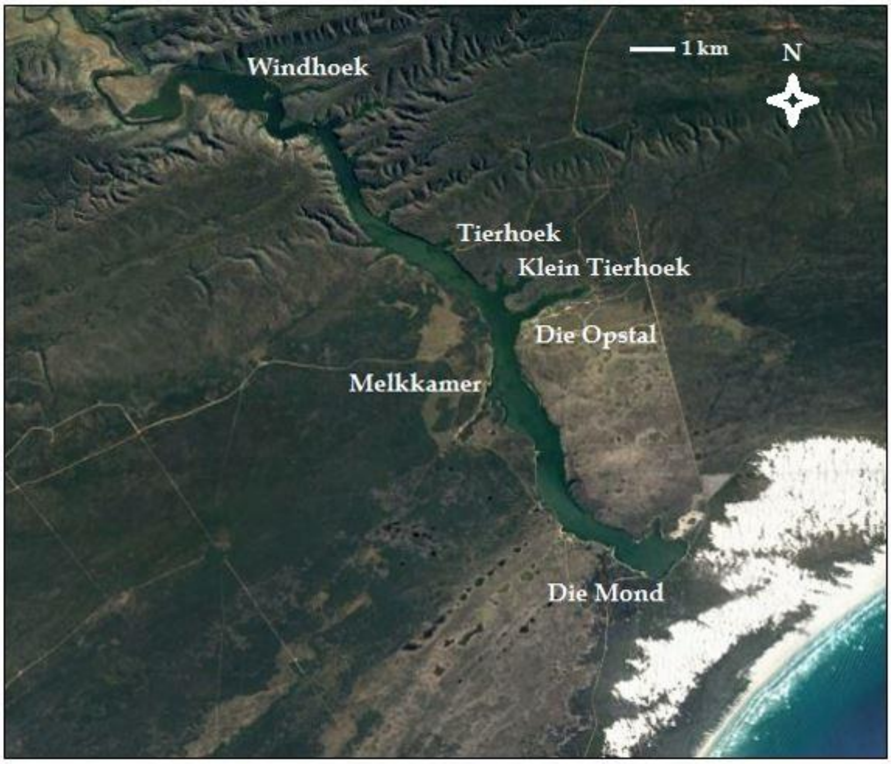

Figure 1.2: Satellite image of De Hoop Vlei showing the main areas of the vlei (Image: Google Earth).

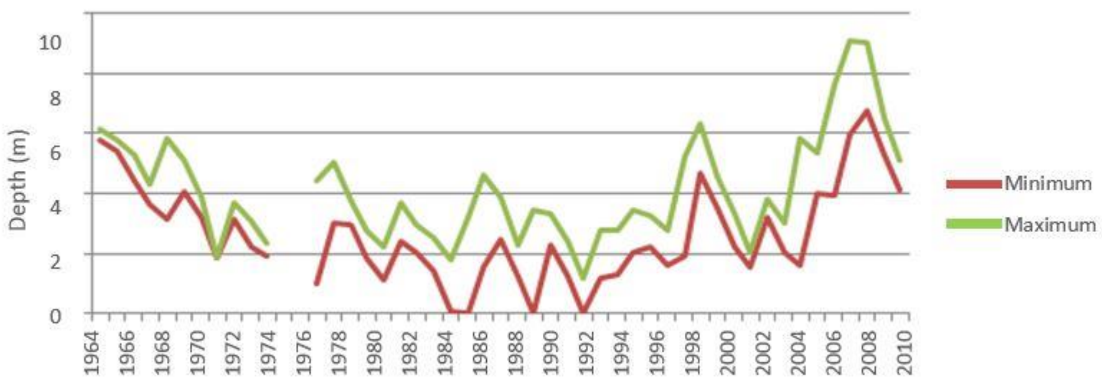

Figure 1.3: Mean monthly maximum (green) and minimum (red) water levels for De Hoop Vlei from 1962-2010 (courtesy Kevin Shaw, Cape Nature).

The bathymetry of the vlei has not been mapped in detail. However, the vlei is steep-sided and deep along the eastern edge, which is characterized by imposing sandstone cliffs and White Milkwood *Sideroxylon inerme* forests, whereas the western shore is characterized by gentler slopes and sandier habitat with the shallow water supporting dense stands of Fennel-leafed Pondweed *Potamogeton pectinatus,* an important nesting and foraging plant for many waterbirds (Stewart and Bally 1985).

Waterbirds tend to prefer the western edge of the vlei because of its gentler slope and more productive habitats (Uys 1983, pers. obs.).

Three bays occur in the eastern edge of the vlei near Die Opstal. Tierhoek is accessible to tourists via a 4x4 track, whereas Klein Tierhoek, closer to Die Opstal, is not accessible by road. The bay immediately north of Die Opstal supports relatively large numbers of waterbirds, despite being utilized intensively by hikers on the Vlei Route, and by motorists/quadbikers that visit the head of the inlet on the road to Tierhoek. During periods of high water levels, the western side of the vlei floods an inlet south of Melkkamer that supports large numbers of waterbirds attracted to its shallow water and aquatic vegetation (Uys and Macleod 1967). At mid-water levels, an island emerges in the middle of the vlei between Die Opstal and Melkkamer, where large numbers of birds roost and occasionally breed (P. Chadwick. pers. comm.). At low water levels, the vlei dries up between Die Opstal and Melkkamer, apart from a few pools. Towards the north end of the vlei, past the Tierhoek lookout, pockets of *Phragmites australis* reedbeds provide nesting and refuge sites for birds. These reedbeds are typically found in small inlets formed in gorges along the vlei edge. The extreme northern end of the vlei, named Windhoek, lies outside the De Hoop Nature Reserve and abuts a cattle farm. Access to this part of the vlei is challenging and is limited to Cape Nature staff who have an agreement with the farmer. The Sout River joins the vlei at this point, and the water here is much shallower. The southern end of the vlei, called Die Mond ('The Mouth') despite the absence of any outlet to the sea, is less dramatic on its eastern shore than the rest of the vlei, with gently-sloping sandy shores typical of the western shore.

Historically, boating has been strongly discouraged given concerns about disturbance to the vlei's birds. Despite this protection, the number of birds using De Hoop Vlei has decreased by 43% from 1979 to 2009 (Harebottle 2012). A few species have increased in numbers (e.g. Egyptian Geese *Alopochen aegyptiaca* and Great White Pelicans *Pelecanus onocrotalus*, reflecting trends across the Western Cape), but almost all other species have decreased. In some instances these changes probably reflect regional changes in abundance, especially among Palearctic migrant birds (Harebottle 2012, Ryan 2013).

In 2009, the tourism operator in De Hoop Nature Reserve, De Hoop Collections (hereafter DHC), developed an old farmhouse at Melkkamer on the western shores of the lake opposite Die Opstal as a luxury retreat, and a request was made to use a small boat to ferry guests across the vlei between Die Opstal and Melkamer. Experimental boat trips across the vlei showed a short-term decrease in the waterbird numbers in the core area where boat traffic occurred (Marks 2009). However, permission was granted for tourist trips to commence because high water levels at the time complicated road access to the site. Boat access has continued despite changes in road access routes and lower water levels. Due to the guests' enjoyment of the short boat trips, the tourism operators perceived an opportunity for longer, guided tours around the vlei. Proposals were put forward to reserve management to begin conducting boat-based tours as well as guided kayak tours at De Hoop Vlei. The Percy FitzPatrick Institute of African Ornithology at the University of Cape Town was contacted in order to undertake a scientific impact assessment of these activities, and to deliver recommendations on how best to conduct them with least impact. This was developed and advertised as a Master's thesis, for which I was the successful applicant.

Overview of the thesis purpose and structure

I investigated waterbirds' reactions to boat-based disturbance, comparing how these differed to birds elsewhere, and outlined what the consequences could be if boat-based tours went ahead. Recommendations on how to prevent or limit possible disturbance impacts were given to reserve management based on data collected at De Hoop Vlei as well as findings from other literature.

Chapter 1 (pp 5-13) has introduced the theoretical background to the conservation problems inherent with growing ecotourism, as well as the role that disturbance effects can play within these negative consequences. The Ramsar Convention and Birdlife Important Bird Areas (IBAs) are also introduced as global bird conservation schemes relevant to this site.

Chapter 2 (pp 14-35) looks at the current waterbird community at De Hoop Vlei. I completed different counts in order to characterize the waterbird community, paying special attention to threatened species (Taylor et al. 2015) and birds that congregate in regionally significant numbers (Wetlands International 2016). This was especially important to catalogue at the outset because of the dynamic nature of the vlei and its bird community (Harebottle 2012). I also look at which areas and habitats at the large wetland are used the most by birds, including breeding areas and again looking especially at threatened species and large congregations, in order to prioritize these for protection. The results of the counts were compared to the data supplied in the qualification documents provided for De Hoop Vlei's Ramsar status (Shaw 1998) and the greater De Hoop Nature Reserve IBA (Marnewick et al. 2015).

Chapter 3 (pp 36-59) deals with the responses of waterbirds to boat-based tourism. This includes disturbances by both a motorized tour boat and a kayak. Boat tours along two set routes were monitored for the number of birds agitated or displaced per trip. The distance at which birds were agitated and displaced by the boat was also measured to investigate whether certain species were more/less tolerant of the boat than others. The responses of birds to the boat was then compared to responses to a kayak using the same methods. Lastly, I tested the time taken for birds to recover after a disturbance, as well as the likelihood of their habituation to boat disturbance.

Lastly, Chapter 4 (pp 60-65) highlights the major findings of Chapters 2 and 3, and briefly outlines the recommendations provided to management at De Hoop Nature Reserve on boat-based tourism in the form of boat tours and kayak trips. Each recommendation is motivated either by data collected as part of this study, or in other relevant literature. This should provide a scientific basis on which reserve management can make decisions and move forward.

Chapter 2

Characterizing the birdlife of De Hoop Vlei at persistent near-flood levels with special attention to its Ramsar and Important Bird Area (IBA) status

Abstract

Wetlands are a disproportionately important habitat type for ecosystem service provision and support of biological diversity. Conservation of wetlands is therefore critical. It is important for managers of wetlands to have accurate and up-to-date information on which to base their decisions. De Hoop Vlei in the Western Cape of South Africa has been designated as a Ramsar wetland of global importance, and is a key feature of a BirdLife Important Bird Area (IBA). Both these classifications rely on the presence of threatened species and large congregations of birds as criteria for inclusion. However, waterbird counts carried out over 12 months in 2015/16 revealed that previous assessments of the site for both of these schemes have underestimated its conservation value. Five additional qualifying species are suggested due to large congregations of each at the vlei. Updates to the latest regional threat statuses suggest that only two species qualify through that criterion. Important habitats and areas for birds are discussed, as well as observations of breeding and moulting birds that increase the conservation value of the site. This information is useful for understanding the spatial and temporal distribution of waterbirds, which can feed into management actions and policy.

Introduction

The importance of wetlands and their conservation

Wetlands account for only 6% of the world's surface (Junk et al. 2013), but are disproportionately important habitats. Wetlands contribute to global-scale processes such as biogeochemical and hydrological cycles (Galloway et al. 2003, Ringeval et al. 2010, Bridgham et al. 2013), are highly biodiverse (Gibbs 1995, Gopal et al. 2000, 2001, Dudgeon et al. 2006), and supply key ecosystem services such as flood control, shoreline stabilization, nutrient retention, food chain support, water provision and purification, as well as cultural and spiritual significance (MEA 2005). Wetlands outrank even the most productive terrestrial habitats in terms of their ecosystem service value per unit area (Costanza et al. 1997, 2014). Loss and degradation of wetlands is currently taking place due to urban encroachment, climate change, water abstraction and land use changes (Gibbs 2000, Junk et al. 2013).

Other threats to wetlands include diversion and damming, eutrophication, pollution and contamination, alien invasion, human activity, and agriculture (Brinson and Malvárez 2002).

Conservation of wetlands has become of critical importance not only because of their inherently fragile nature and their worrying declines, but also for the health of their associated biodiversity and their contribution to many critical ecological services. Up-to-date and relevant information is necessary for the effective conservation of wetland sites. Prioritization of species-specific conservation should be informed by the latest threat status allocations, and knowledge of the birds' spatial and temporal patterns at a site can aid managers to limit disturbance to areas that have the least consequence for the conservation of the site.

The Convention on Wetlands of International Importance especially as Waterfowl Habitat, more commonly known as (and hereafter referred to as) the Ramsar Convention (after the city in Iran where the Convention was drafted), seeks to bring focus and multi-national effort to wetland conservation. It was adopted in 1971 by 18 countries, and first came into effect in 1975 (Ramsar 1971). By 2017 the Ramsar Convention had 169 signatories (called 'contracting parties'), each with at least one wetland designated as a 'Ramsar site'. The total number of Ramsar wetlands currently exceeds 2200. The Ramsar Convention's principal objective is "to stem the progressive encroachment on and loss of wetlands now and in the future", while its mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (Ramsar, Iran, 1971). The inclusion of the "wise use" of wetlands went against the protectionist/preservationist attitudes of the time. As such, the Ramsar Convention is considered to have been ahead of its time in advocating for the sustainable use of natural resources and its recognition that multiple stakeholders, including the public, were important to the future of conservation (Finlayson et al. 2011). The designation of wetlands as Ramsar sites has led to the formalization and standardization of wetlands on a near-global scale, with the added benefit that parties are obliged to adhere to an agreed set of standards within a clear framework. Parties are required to implement a formal national conservation plan, including the wardening of the wetland as a nature reserve, and are encouraged to open the site for research to inform its management. The continual addition of new sites onto the List of Wetlands of International Importance facilitates the monitoring of wetland conservation on a global scale. Contracting parties meet at a triennial Convention of the Parties (COP) to discuss progress, provide feedback, revise targets, and draft resolutions. The most recent event, COP12, was held in Uruguay in 2015.

The Convention heavily emphasizes the value of a site as "waterfowl habitat" as a starting point for designation. Waterfowl (hereafter referred to as waterbirds) are defined in Article 1.2 of the

Convention text as "birds ecologically dependent on wetlands" (Ramsar 1971). However Wetlands International, the organization that supplies the waterbird population estimates that inform Ramsar qualification, further delimit waterbirds to include the following groups of birds: Gaviiformes (divers), Podicipediformes (grebes), Pelicaniformes (pelicans, cormorants, darters), Ciconiiformes (herons, bitterns, storks, ibises, flamingos), Anseriformes (screamers, swans, geese, ducks), Gruiformes (cranes), Ralliformes (coots, rails), Charadriformes (waders, gulls, terns)" (Wetlands International 2006). While this is not a comprehensive list, and some species within these groups may not, in fact, be ecologically dependent on wetlands, it does provide a useful point of reference. These waterbird groups are used as the basis for much of the initial designation of a Ramsar site, and their populations are used to monitor a site's success. The criteria used for waterbirds to be used as justification for Ramsar status are based around i) the conservation status of a species, and ii) the numbers of birds regularly congregating at a site. Sites that support species that have been deemed by the IUCN to be at risk of extinction (by the assignment of a threat status of Vulnerable or worse) immediately classify as trigger species (www.iucnredlist.org). Species that regularly congregate in numbers exceeding one percent of the relevant biogeographical population estimate (supplied online by Wetlands International 2016 at www.wpe.wetlands.org) are also considered as trigger species for a site. These simple criteria make it easy for contracting parties to set up and monitor their wetland sites.

Contracting Parties are encouraged to report back periodically on the progress of their listed sites. In the instance of a site's ecological character being under threat, the contracting party is obliged to notify the Ramsar Bureau, which reviews the situation and makes recommendations for appropriate actions. Regular assessments of Ramsar wetlands may also reveal an underestimation of a site's perceived conservation value, such as the presence of more trigger species. This would not affect its designation as a Ramsar wetland, but such information may have ramifications for local management and the site's priority within wider structures. The more that is known about a site, the easier it is for management to make appropriate and informed decisions for its conservation.

De Hoop Vlei and the Ramsar Convention

South Africa was one of the first countries to ratify the Ramsar Convention in 1975, with De Hoop Vlei (see Site Description in Chapter 1) and Barberspan designated as the country's first Ramsar sites. South Africa has since added a further 20 sites to its list, while both original sites have maintained their status. As a Contracting Party, South Africa is committed, through Cape Nature, to "work towards the wise use of all their wetlands… and ensure their effective management" (Ramsar Convention Secretariat 2010a). De Hoop Vlei was designated primarily on the basis of the waterbird populations hosted on the vlei. The two criteria applicable in this case pertain to the total waterbird population and the portion of species-specific populations supported at De Hoop Vlei. The first of these, criterion 5, stipulates that "a wetland is considered internationally important if it regularly supports 20000 or more waterbirds" (Ramsar Convention Secretariat 2010b). Criterion 6 is relevant to "a wetland regularly supporting 1% of the individuals in a population of one species or subspecies of waterbird" (Ramsar Secretariat 2010b). These populations are split either by subspecies or biogeographical location, with De Hoop Nature Reserve falling either under the Sub-Saharan or southern African regions, depending on the species (Wetlands International, 2016).

The last published update on De Hoop Vlei's status as a Ramsar site was published in 1998 (Shaw 1998), and an update is therefore overdue. Harebottle (2012) analyzed long-term count data of waterbird populations at the site that were pertinent to the Ramsar status of the vlei, yet this does not reflect on the website (www.ramsar.org; last accessed 5 March 2017). The site faces possible threat from the introduction of boat tours on the vlei, which makes an update on the status of the birdlife even more pertinent and urgent. Shaw (1998) listed seven species as being trigger species due to their presence in the South African Red Data Book (Brooke 1984): Great White Pelican *Pelecanus onocrotalus*, Little Bittern *Ixobrychus minutus*, Black Stork *Ciconia nigra*, Greater Flamingo *Phoenicopterus roseus*, Lesser Flamingo *Phoeniconaias minor*, Caspian Tern *Hydroprogne caspia*, and Chestnut-banded Plover *Charadrius pallidus*. Six species were considered to congregate in large numbers at De Hoop Vlei: Yellow-billed Duck *Anas undulata,* Cape Shoveler *Anas smithii*, Great White Pelican, Red-knobbed Coot *Fulica cristata*, Greater Flamingo, and Lesser Flamingo. The report mentions that 75 wetland-dependent species occur at the site, and that De Hoop Vlei is "of special regional importance as one of a "chain" of wetlands along the southern Cape coast".

De Hoop Vlei is also a major feature of the Important Bird Area encompassing the entire De Hoop Nature Reserve (Marnewick et al. 2015, BirdLife International 2016). BirdLife International, an avian conservation NGO, embarked on a project to identify areas that were particularly prolific for birds, especially endemic and threatened species. These sites, called Important Bird Areas (IBAs), are intended to provide a framework for effective avian conservation (Marnewick et al. 2015). The 1% threshold congregatory criterion of the Ramsar sites were adopted by the scheme as sufficient for a site to be regarded as important for a particular species. IBA criteria also include the presence of locally endemic and threatened species. De Hoop Nature Reserve, which encloses De Hoop Vlei, was declared as a BirdLife IBA with a large emphasis on the waterbirds present. In the latest site summary (Marnewick et al. 2015), Yellow-billed Duck, Cape Shoveler, Great Crested Grebe *Podiceps cristatus*, Greater Flamingo, and Red-knobbed Coot were all deemed to be in sufficient abundance to qualify under the congregatory criterion. The total number of waterbirds congregating at the site (estimated between 20 000 and 50 000; following Shaw 1998 and not Harebottle 2012) was also a factor in the declaration. Marnewick et al. (2015) did not differentiate between threatened and Near-threatened species, but of the waterbirds they list as being of regional concern only Caspian Tern and Great White Pelican are threatened regionally (both Vulnerable; Taylor et al. 2015).

Summary of historical data on the waterbirds of De Hoop Vlei and possible population drivers

Harebottle (2012) was able to pick up significant trends in waterbird populations using the long-term count data collected, despite a high variability in water levels and conditions at De Hoop Vlei. Between 1979 and 2009, all species at the vlei decreased significantly, with the exceptions of Egyptian Goose which increased (however this may be because of a general increase in the Overberg area rather than conditions at the vlei; Magnall and Crowe 2001), Great White Pelican which had an insignificant and weak positive trend, and Great Crested Grebe for which there was no trend. The overwhelming negative trend may reflect regional declines, especially for migrants (Ryan 2013). Red-knobbed Coot, Yellow-billed Duck and Cape Shoveler experienced the most severe declines, but were previously abundant and were three of the six species designated as congregatory triggers in line with the Ramsar Convention criterion (Shaw 1998). However, Harebottle (2012) notes that despite large declines, Yellow-billed Duck and Cape Shoveler remained in excess of their 1% thresholds. Red-knobbed Coot last exceeded their threshold in 1983. Two other congregatory species, Greater and Lesser Flamingos, which are also species of conservation concern (regionally near-threatened; Taylor et al. 2015), were abundant at the vlei pre-1985, but were largely absent or erratic thereafter. The last trigger species, Great White Pelican, moves in and out of the vlei, peaking irregularly, not showing any significant trend. Overall, Harebottle (2012) noted a shift in the bird community away from being dominated by species within the Anatidae and flamingos in the 1980s to a community dominated by fewer species, with strong declines in coots, ducks, teal, and shovelers, and increases in the number of Egyptian Goose, Great White Pelican, and cormorant species. A lack of data for ecological variables such as water depth, salinity, pH, and dissolved solids restricted the conclusions Harebottle could make about the links between the environment and waterbird populations, however it is generally agreed that water level plays a dominant role (Uys and Macleod 1967, Harebottle 2012).

The purpose and aims of this chapter

Proposals have been made to run boat tours at the vlei. For boating to take place the water level must be high. It is especially important, then, to have a good understanding of which waterbirds utilize the vlei at high water levels as well as their spatio-temporal patterns of site use. By identifying important habitats and areas for waterbirds these can be incorporated into planning for any future activities.

This chapter provides an updated report on waterbird populations at De Hoop Vlei, with special regard to those birds listed as trigger species pertinent to the Ramsar and IBA status of the wetland. My counts were performed at a finer scale than the quarterly counts performed by reserve management, which lends a different perspective. To aid local management, the spatial and temporal usage patterns as well as habitat preference of the waterbird species is documented. This finer-level detail of the interaction between birds and the wetland should help to inform management decisions about the possible sustainable 'wise use' of the wetland through boat tours, especially at high water levels.

Methods

The first part of the study aimed to assess the latest Ramsar and IBA reports by comparing the threat status and abundance estimates of the listed trigger species against current levels at De Hoop Vlei. If species differed significantly in either their threat status or abundance then additions/removals from the list of trigger species were recommended. To assess the threat status criterion, it was necessary to ascertain the waterbirds presently occurring at De Hoop Vlei. A list was compiled of all waterbird species encountered at De Hoop during the study period April 2015 to April 2016 using my records as well as those of other reputable observers. The loose definition supplied by the Ramsar Convention of "birds ecologically dependent on waterbirds" was used to judge whether a species could be considered a waterbird. Two South African Red Data Books for birds (Barnes 2000, Taylor et al. 2015) have been published since Shaw's (1998) report which used Brooke (1984) to evaluate threatened status. I therefore looked at how threat status has changed since Brooke (1984). The regional and global threat status was sourced from Taylor et al. (2015) and compared to the available Ramsar and IBA assessments to assess whether there are any suggested additions and/or removals from the respective lists of trigger species.

Semi-regular counts of the whole wetland were performed to ascertain the abundance of waterbirds at De Hoop Vlei. The route and protocols for the counts were copied from the Co-ordinated Water Avifaunal Counts (CWACs) that have been conducted at De Hoop Vlei since 1979 (analysed by Harebottle 2012).

I counted all waterbirds visible from seven viewpoints (Figure 2.1). Using a 30x magnification Kowa spotting scope and 10x magnification binoculars, I systematically tallied the birds by species in the count area before moving to the next. Upon arrival at a new point a period of one minute was allowed for birds to acclimatize to the counter's presence. During this time measurements were taken of the wind speed, direction, and temperature using an anemometer (Kestrel 2000, USA). Cloud cover was estimated in integers from zero (no clouds) to eight (no open sky). Other weather conditions that were deemed to have a possible effect on the count such as mist or precipitation also were recorded. Birds flying over were treated as being in the count area if they were flying in the opposite direction to the next point. Therefore, all birds flying south were included in count areas one and two, while only birds flying north were included in points three, four, and five. This was done to limit the risk of double counting birds moving into and settling in the remaining count areas. Birds such as gulls and terns that flew continuously between count areas (e.g. for foraging) were only counted in the first area in which they were seen. On some occasions an assistant was available to record the counts as they were dictated to by the counter. When the counter was alone a cell phone was used to record voice files which were transcribed after the count was completed. Counts typically began around 7:00 in summer and 8:00 in winter to ensure good light, and depending on the abundance of birds the counts took a full day to complete.

I carried out these counts on a semi-regular basis between April 2015 and March 2016. An attempt was made to perform counts as close to a month apart as possible, notwithstanding the logistics of sometimes irregular site visits. The counts provided a much finer time scale than the quarterly counts carried out be Cape Nature. The only differences between the counts performed by Cape Nature and this study is that Cape Nature use a 20x magnification spotting scope and do not record contextual data, including weather.

The large size of the vlei and the limited road access to large portions of the wetland, coupled with the natural movements of birds over the hours of counting, make it impossible to conduct very accurate counts of the entire system. However, consistent counts repeated regularly can reveal significant trends, meaning that this is still a valuable exercise.

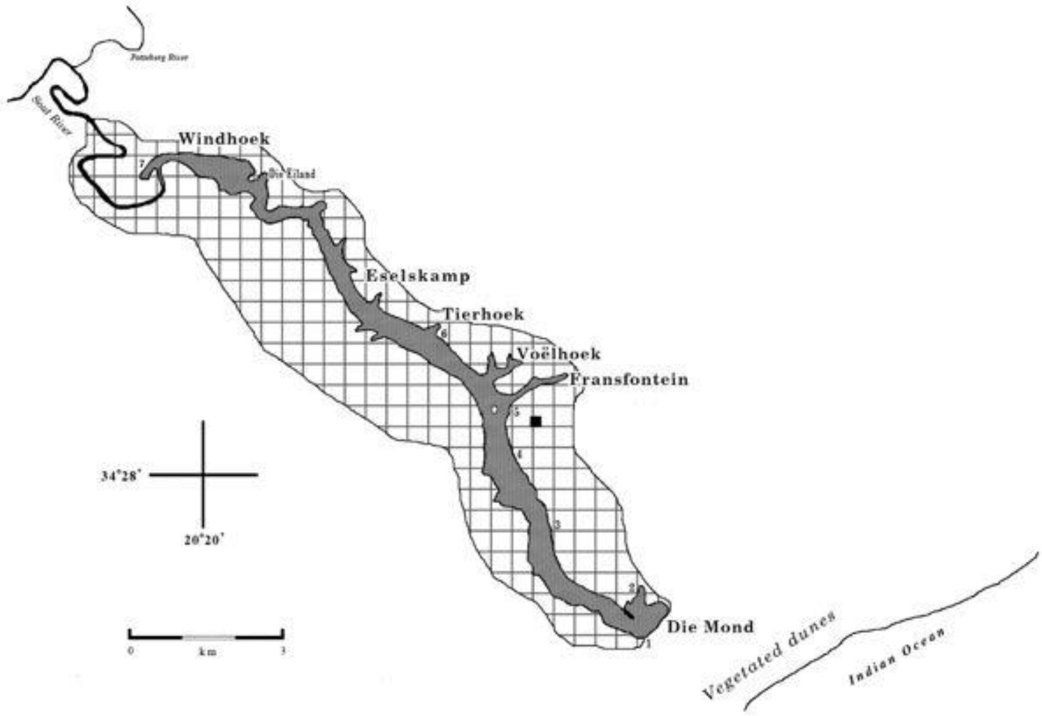

Figure 2.1: Map of De Hoop Vlei with the Co-ordinated Water Avifaunal Count (CWAC) counting points numbered 1 to 7 (from Harebottle 2012). Dark grey indicates surface of the Vlei; hatched area is milkwood-dominated matrix surrounding the Vlei.

The second part of the study entailed documenting the changes in bird abundance over the course of a day, as well as the birds' habitat preferences. By repeating counts of the same areas at different times of day I could investigate how the waterbird community changed over the course of a day.

The second count method focused around the area most likely to be affected by boat-based tours, the area centred on Die Opstal, where the boat is housed and launched. These counts were performed between 27 April and 23 May 2015 to establish a baseline before boat tours commenced. Fortunately, this area was easily accessible on foot via the public hiking trail along the eastern edge of the vlei. Five set points along the edge of the vlei were chosen for these counts to maximize the count area on both the near and far shores (Figure 2.2). Each point was assigned a specific count area, the boundaries of which were approximately 30 m apart from the neighbouring area in order to minimize birds being double counted as they moved between count areas. Count area boundaries were defined by landmarks such as large trees, bays, and old stone walls. The northern and southern limits were determined by the distance at which all birds could be identified. Counts always took place in the same order from points one to five.

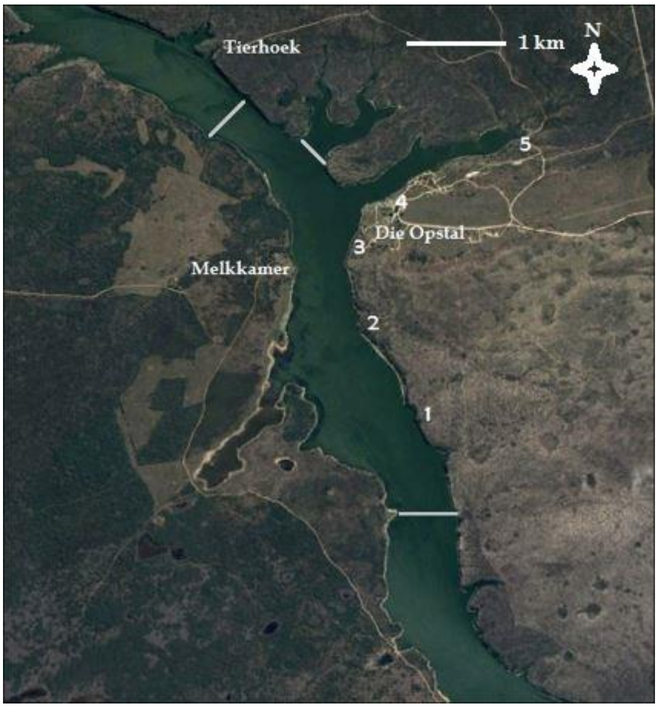

Figure 2.2: Map of the five set points used for the pre-boating survey with the total count area delineated by white lines (Image: Google Earth).

The counting methods and equipment used were identical to those described above for the CWACs. However, these counts were repeated three times daily in order to assess changes in abundance during the day. The observation points were visited once each during the early morning (7:00–10:00), at midday (11:00–14:00), and in the late afternoon (15:00–18:00). In addition to counting all birds, I also recorded their habitat use. Five habitats were recognised:

- Open water – deeper water (typically >5 m from the shoreline) lacking aquatic vegetation;
- Shallows – typically the first 5 m of water, but extending farther offshore in areas where shallow water were known to be more extensive;
- Aquatic vegetation – visible stands of Fennel-leafed Pondweed *Potamogeton pectinata*;
- Shoreline – any rocky, sandy, or grassy open shoreline;
- Vegetation – either emergent or shore vegetation (e.g. Common Reed *Phragmites australis* or White Milkwood *Sideroxylon inerme*).

The habitat data were used to assess habitat preferences for each species, and were reported as an index of the proportion of total birds inhabiting each habitat type. This was analysed using a chi-square test by comparing this index value to the proportional extent of each habitat type in the count area. Habitat extent was calculated using the most recent satellite image from Google Earth (Google, USA) and the free-to-download software ImageJ (Schneider et al. 2012). Each habitat was delineated using the ‘free-hand selection’ tool, then the area represented by each habitat was ascertained using the ‘measure’ tool and divided by the total count area to reflect proportional representation. Only species that appeared in five counts or more were included in the analysis of habitat preference. Wherever numbers are followed by ± it denotes standard deviation.

Results

Waterbird diversity and abundance

From observations during field visits and reports from reputable birders, a list of 221 bird species was amassed for 2015/2016, 35 of which are migratory (see Appendices for a full list). Of these 221 species, 66 are waterbirds that depend on freshwater habitats for feeding, roosting or breeding. Of these 66 species, 60 were observed utilizing the vlei, and the remaining 6 (Mallard *Anas platyrhynchos*, Red-chested Flufftail *Sarothrura rufa*, African Rail *Rallus caerulescens*, Baillon’s Crake *Porzana pusilla*, African Snipe *Gallinago nigripennis*, and African Reed Warbler *Acrocephalus baeticatus*) were seen at smaller wetlands in the reserve. Migrants composed a very small number of the birds at De Hoop Vlei, with only six species recorded utilizing the vlei (Little Stint *Calidris minuta*, Ruff *Philomachus pugnax*, Common Sandpiper *Actitis hypoleucos*, Grey Plover *Pluvialis squatarola,* and White-winged *Chlidonias leucopterus* and Whiskered Terns *C. hybrida*). Little Stints were the most common migrants with a maximum of 61 birds recorded in one count. The other five species had maxima < 10.

Twelve full vlei counts (CWACs) were completed between April 2015 and March 2016, on a semi-regular basis (median = 21 days, minimum interval = 11 days, maximum = 54 days). The mean count total was 5903 ± 1376 birds (95% confidence interval; but note the temporal variation, Figure 2.3). The counts revealed a large decline in bird numbers from August to November 2015 to little more than 3000 birds, with a subsequent increase to over 10 000 from late January to March 2016 (Figure 2.3).

The comparison of project counts and Cape Nature quarterly counts shows generally good agreement, although there was a discrepancy in April-May 2015 (Figure 2.3). This suggests that there was a short-term decline not picked up in the quarterly counts. Some of this discrepancy may be due to differences in count efficiency, as it was the first of the independent counts. However, it was clear at the time that waterbird numbers decreased between the two counts.

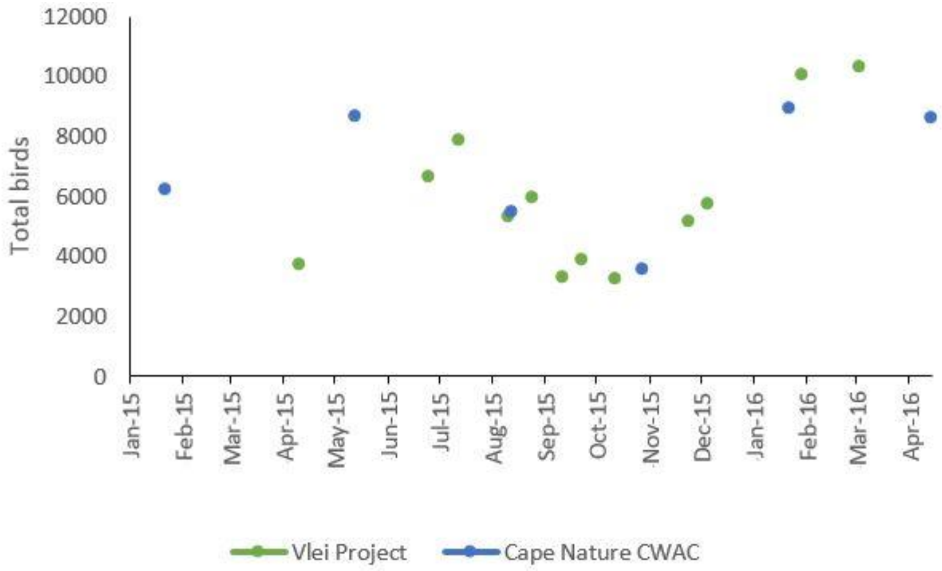

Figure 2.3: Total numbers of waterbirds counted at De Hoop Vlei from January 2015 to April 2016.

Despite the diversity of waterbird species, 90% of the total waterbirds on the vlei comprise only 12 species (Table 2.1), based on the CWACs during 2015 and 2016. Other species are either very uncommon, in areas that are inaccessible for the CWACs, or are not residents at the vlei. The waterbird community at De Hoop Vlei during this study was dominated by Red-knobbed Coot, with up to 5500 birds present. Other common species at the vlei included Egyptian Goose, Reed Cormorant, Great Crested Grebe, White-breasted Cormorant *Phalacrocorax lucidus*, and Cape Shoveler.

Table 2.1: The most common waterbirds (≥ 1% of mean count total) counted in regular counts of De Hoop Vlei from April 2015 to March 2016, listed in descending abundance. Species marked with an asterisk are regionally threatened (Taylor et al. 2015).

Species+	Mean	SD	Maximum	Mean % of total
Red-knobbed Coot	1844	1472	5574	31
Egyptian Goose	892	785	2843	15
Reed Cormorant	710	441	1651	12
Great Crested Grebe	438	173	837	7
White-breasted Cormorant	354	129	560	6
Cape Shoveler	285	219	758	5
South African Shelduck	206	447	1412	3
Black-necked Grebe	176	114	373	3
Little Grebe	157	171	493	3
Greater Flamingo*	138	132	379	2
African Darter	99	73	218	2
Cape Teal	72	100	315	1
Great White Pelican*	71	91	328	1
Kelp Gull	54	34	112	1
Grey Heron	50	29	118	1

+scientific names are listed in Appendices

Birds of conservation concern

Only two waterbirds at De Hoop are regionally threatened: Great White Pelican and Caspian Tern (both Vulnerable; Taylor et al. 2015). Four species are near-threatened: Maccoa Duck *Oxyura maccoa*, Lesser Flamingo, Greater Flamingo and Great Crested Grebe (Taylor et al. 2015), with the first two also near-threatened globally (www.iucn.org). These six species are a conservation priority at De Hoop Vlei as they underpin its status as an important wetland for waterbirds.

Population sizes of the species of conservation concern were highly variable. Great Crested Grebes were resident at the vlei, with a mean population of 438 ± 98 birds (n = 12 counts; range 191 - 837). Greater Flamingoes and Great White Pelicans moved in and out of the vlei, being abundant during some counts, and absent in others. There were on average 138 ± 75 Greater Flamingoes (2 - 379) and 71 ± 51 Great White Pelicans (0 - 328). Both flamingo species were absent for long periods, with occasional flocks present south of Melkkamer or at Windhoek. Lesser Flamingoes were only present at De Hoop Vlei for one CWAC count, when 53 birds were recorded, but during the pre-boating survey there was a flock of 337 birds present. Maccoa Duck were present during every count, with an average of 48 ± 27 birds (1 - 152 birds). Caspian Terns commonly foraged at De Hoop Vlei, with an average of 17 ± 9 birds (1 – 55, but a maximum of 65 during the pre-boating survey).

Spatial and temporal distributions of waterbirds

CWAC data revealed that waterbirds at De Hoop are concentrated at either end of the vlei, at Die Mond and Windhoek, as well as in the flooded area south of Melkkamer (points 1, 7 and 4, respectively in Figure 2.4). Point 3 abuts onto the southern end of the Melkkamer bay, and often contained some of the 'spillover' from the bay. Points 1 and 7 are some of the bigger count areas, but still supported a disproportionately large number of birds.

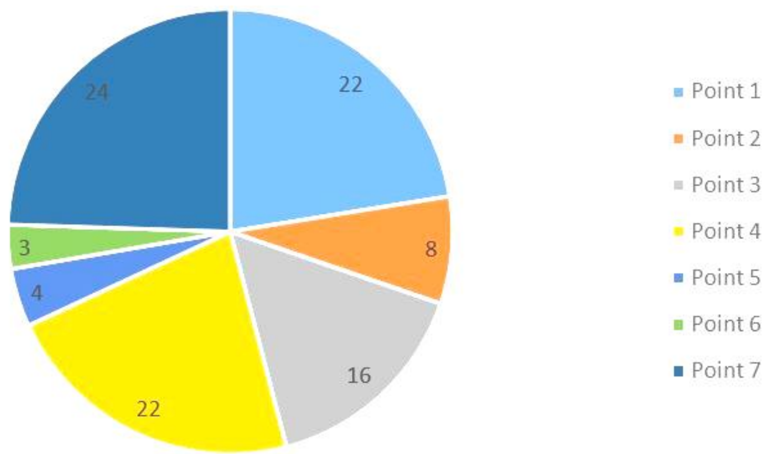

Figure 2.4: Mean percentage of total birds counted during CWACs at De Hoop Vlei per count point. Numbers indicate the percentage of the total birds represented at each point. Points 1-7 run clockwise on the chart, and south to north on the ground.

Birds were concentrated along the western shore. The eastern edge of the vlei is characterized by steep, rocky cliffs, ascending to heights of up to 10 m. This is mostly inhospitable habitat for waterbirds, with the only species seeming to favour this habitat being Grey Herons *Ardea cinerea* and Reed Cormorants *Microcarbo africanus*; the cormorants using the rocks for sunning and resting and the herons for still-hunting. Due to both the western and eastern sides of the vlei being included in the same count point this pattern was not evident from the count data.

The intensive counts performed nearer Die Opstal were carried out for 19 single day repetitions over a 27-day period. Eight days were lost to rain or fog that prevented accurate counting on the far shore. There was a weak tendency for bird numbers to decrease over the day (Figure 2.5). The change in the overall composition of the bird community was similarly weak. Most noticeably, there was a decrease in Great Crested Grebes at midday. It is unlikely that this reflects real movement of birds away from the vlei; more likely the grebes move out of open water habitats where they are more visible into emergent vegetation where they are not as easily seen.

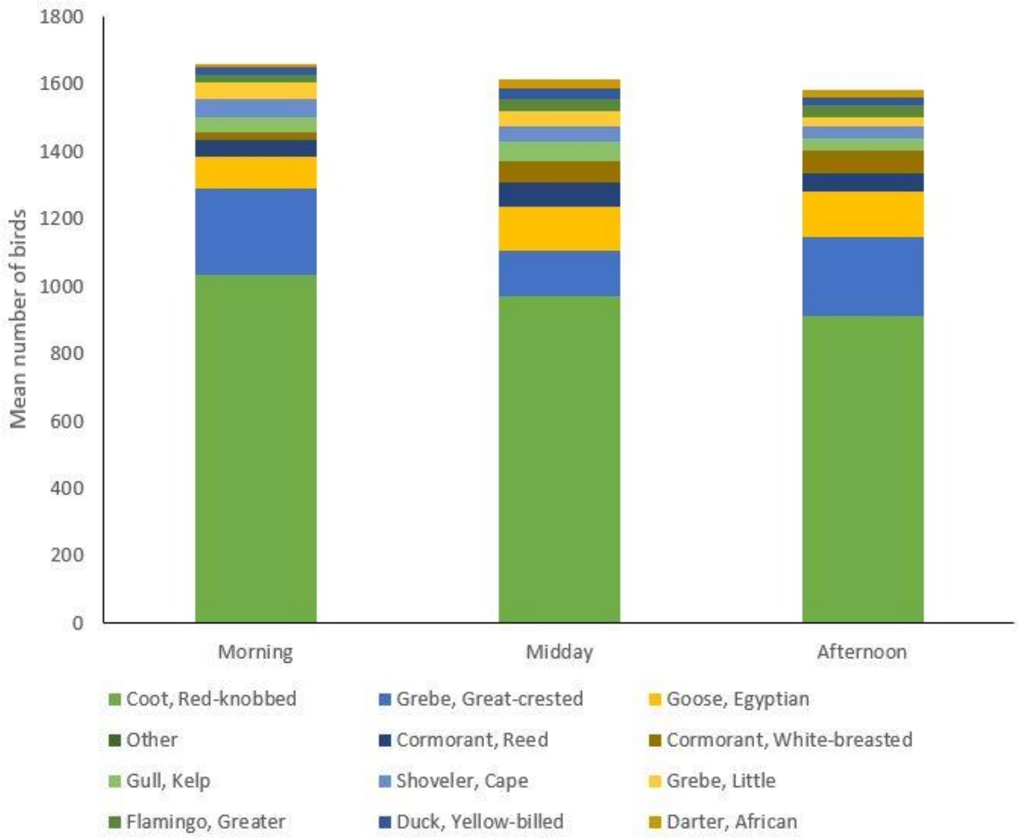

Figure 2.5: Mean number of birds per species seen in each time slot. Species with a mean of <50 individuals were lumped into 'other birds'. Species are ordered left to right in key in descending order of mean abundance across the three time periods.

Only seven of the 48 species for which there was sufficient data showed a significant degree of habitat selection (Table 2.2); five favoured shoreline vegetation (Reed Cormorant, African Darter *Anhinga rufa*, African Fish Eagle *Haliaetus vocifer*, African Marsh Harrier *Circus ranivorus* and Black-crowned Night Heron *Nycticorax nycticorax*) and two favoured aquatic vegetation (White-backed Duck *Thalassornis leuconotus* and Lesser Flamingo). Waterbirds as a group did not show significantly specific habitat selection when compared with the availability of the different habitat types. However, they tended to be proportionally more abundant in the aquatic vegetation habitat, and less abundant in open water. Data for habitat selection was used from all three time periods (see Figure 2.5).

Table 2.2: Waterbird species showing habitat selection specificity at De Hoop Vlei. χ2 < 0.05 indicates a significant deviation from the expected values. Results for all 48 species are reported in Appendix 6.

Species	Water	Shore	Shallows	Aq Veg	Veg	χ2
Cormorant, Reed	0.05	0.11	0.02	0.02	0.79	< 0.01
Darter, African	0.02	0.03	0.00	0.00	0.94	< 0.01
Duck, White-backed	0.02	0.00	0.04	0.94	0.00	< 0.01
Eagle, African Fish	0.00	0.10	0.00	0.00	0.90	< 0.01
Flamingo, Lesser	0.02	0.00	0.18	0.80	0.00	< 0.01
Harrier, African Marsh	0.00	0.00	0.00	0.00	1.00	< 0.01
Heron, Black-crowned Night	0.00	0.10	0.00	0.00	0.90	< 0.01
All species	0.23	0.15	0.16	0.29	0.16	0.68
Expected values	**0.63**	**0.1**	**0.2**	**0.04**	**0.04**	**-**

Great White Pelican, Black Stork, and Caspian Tern are the only waterbirds currently at De Hoop Vlei currently threatened at a regional level (Table 2.3; Taylor et al. 2015), however Black Stork was not seen within the reserve boundaries and only once in the surrounding farmland during the study period. The two flamingo species and Chestnut-banded Plover were listed as Near-threatened at a regional level, although Chestnut-banded Plover was never seen during the study period. The species was only present at De Hoop Vlei during the inundation event in the 1960s (Uys and Mcleod 1967). Little Bittern was down-listed to Least Concern, but none was seen at De Hoop Vlei during 2015/16. At a global level, the status of all the above-mentioned species is Least Concern, with the exception of Lesser Flamingo and Chestnut-banded Plover which are both Near-threatened.

Table 2.3: The threat status of the species included as trigger species by the Ramsar report on de Hoop Vlei (Shaw 1998). 1984 status is supplied by Brooke (1984), 2000 by Barnes (2000), 2015 regional and global by Taylor et al. (2015). R = Rare, I = Indeterminate (Brooke 1984). LC = Least Concern, NT = Near-threatened, V = Vulnerable (in order of severity; Barnes 2000, Taylor et al. 2015).

Species	Common Name	1984	2000	2015 Regional	2015 Global
Pelecanus onocrotalus	Great White Pelican	R	NT	V	LC
Ixobrychus minutus	Little Bittern	R	LC	LC	LC
Ciconia nigra	Black Stork	I	NT	V	LC
Pheonicopterus ruber	Greater Flamingo	I	NT	NT	LC
Phoeniconaias minor	Lesser Flamingo	I	NT	NT	NT
Hydroprogne caspia	Caspian Tern	R	NT	V	LC
Charadrius pallidus	Chestnut-banded Plover	R	NT	NT	NT

The maximum population for each species recorded in the CWACs was compared to the 1% threshold to qualify as a congregatory trigger species for Ramsar and IBA status (www.wpe.wetlands.org; Table 2.4). These data upheld the designation of Great Crested Grebe and Cape Shoveler as trigger species, but did not support Greater Flamingo, Yellow-billed Duck, or Red-knobbed Coot. Six new species exceeded the 1% threshold: Black-necked Grebe *Podiceps nigricollis*, Great White Pelican, White-breasted Cormorant, South African Shelduck *Tadorna cana*, Maccoa Duck *Oxyura maccoa*, and Caspian Tern (Table 2.4).

Table 2.4: Current Birdlife Important Bird Area (IBA) designations for the waterbirds of De Hoop Vlei contrasted with the results of 2015/16. Mean and maximum population values were taken from the 12 Co-ordinated Water Avifaunal Counts (CWACs). 1% thresholds of regional populations were sourced from Wetlands International's online database (www.wpe.wetlands.org).

Common name	Current trigger?	1% Threshold	Mean population	Max population	>1%
Great Crested Grebe	Yes	100	438	837	Yes
Black-necked Grebe	No	240	176	373	Yes
Great White Pelican	No	300	71	328	Yes
White-breasted Cormorant	No	130	354	560	Yes
Greater Flamingo	Yes	760	138	379	No
South African Shelduck	No	500	206	1412	Yes
Yellow-billed Duck	Yes	10000	34	103	No
Cape Shoveler	Yes	350	285	758	Yes
Maccoa Duck	No	80	48	152	Yes
Red-knobbed Coot	Yes	10000	1844	5574	No
Caspian Tern	No	20	17	55	Yes

Discussion

Update to Ramsar and Birdlife IBA characterization

This project has direct bearing on some of the criteria used by both the Ramsar Convention and Birdlife International for their classification schemes. Only two waterbird species, Great White Pelican and Caspian Tern (both Vulnerable), retain their trigger status due to being regionally threatened (Taylor et al. 2015). Others have been relegated either to Near-threatened or Least Concern status. However, count data show that several species have been overlooked for the criterion of congregations of birds > 1% of the regional population. Eight species were present during the study period in numbers in excess of their thresholds, five of which were not originally listed by either Shaw (1998) or Marnewick et al. (2015). This indicates that the conservation value of the site was underestimated by both assessments. Great White Pelican and Caspian Tern are the only two species to qualify under both the threat and congregatory criteria. Three species that were listed by Shaw (1998) as qualifying congregatory species were found to be in numbers lower than their threshold during this period. However, De Hoop Vlei is characterized by irregular, difficult-to-predict, and large fluctuations in the vlei's character and the associated waterbird populations (Harebottle 2012). Shaw (1998) used previous count data to designate trigger species, which indicates the potential of the wetland to support similar numbers of those species again if conditions change. Therefore, I do not suggest that if Shaw's trigger species did not meet the 1% threshold during the study period that they should be excluded as conservation priorities. With a waterbody such as De Hoop Vlei that is characterized by such dramatic changes it is paramount to take historical data into account when planning for an uncertain future, and long-term count data provides a valuable perspective on future potential for the site.

General characterization of waterbirds at the site

Red-knobbed Coot dominated the waterbird community in terms of numbers, with up to 5500 being recorded. Egyptian Goose and Reed Cormorant were also abundant. Great Crested Grebes were in consistently high numbers, which is encouraging as they are considered near-threatened (Taylor et al. 2015). Numbers of Greater Flamingo (138 ± 75; 95% confidence interval) and Great White Pelican (71 ± 52), both regionally Vulnerable (Taylor et al. 2015), were also high. As noted by Harebottle (2012), the bird community is dominated by fewer species than 30 years ago. However, the numbers of Greater Flamingo, and on the infrequent occasion, Lesser Flamingo, were much higher than for the period of 1985-2009. This may reflect a return of flamingos to the site, or it may be as a result of conducting monthly as opposed to quarterly counts. Quarterly counts may capture the overall trends in waterbird abundance, but large gaps in between counts may cause periodic or short-lived large fluctuations in waterbird populations to be missed. An influx of over 1400 moulting South African Shelduck in late 2015 was one case in point. Quarterly counts were performed late in the moulting window, missing a majority of the birds and therefore under-recording South African Shelduck use of the vlei. This may lead to underestimates of the vlei's importance as a moulting refuge, for example. Quarterly counts are useful in tracking long-term trends, but monthly counts offer greater insight into the true value of the vlei for waterbirds.

The role of water level and other possible drivers in determining waterbird population

De Hoop Vlei is a variable but important site for waterbirds. There were large fluctuations of birds at De Hoop Vlei across the 12 months of counts. Dynamic waterbird populations are a feature of De Hoop Vlei over long temporal scales (Harebottle 2012), however quarterly counts have not been able to document these changes taking place at such a fine time scale. While it is impossible to prove the drivers thereof with the data available, there were a few possible factors at play. Seasonal fluctuation at De Hoop is weak relative to longer-term changes in water level in the vlei (Harebottle 2012), and considering the aseasonal timing of large fluctuations over this period this was clearly not a primary driver over the study period. Very few Palearctic migrant species use the site, and local migration of birds in and out does not seem to follow a typical seasonal pattern. Other factors apparently determine waterbird abundance, with water level being the most obvious contributor.

The vlei experiences irregular drought and flood cycles, which largely determine the quality and availability of waterbird habitat. High water levels have persisted at the vlei since 2012 up until 2017, with flooding events occurring at irregular intervals. High water levels reduce the amount of shoreline available to waterbirds, and deepen the water column used for feeding, which deters benthic feeders. Aquatic vegetation, which is an important resource for waterbirds' feeding and also breeding (Stewart and Bally 1985), is covered when water levels get too high. However, when the vlei experiences a flooding event, there is creation of new habitat through inundation of new areas and the extension of the vlei.

Two key areas for this are at the southern end of the vlei at Die Mond and the area immediately south of Melkkamer (Figure 2.4). At Die Mond there is a large floodplain to the south of the regular vlei boundary. When water levels break the wall constructed here the floodplain becomes a rare resource of shallow water habitat. This occurred once during the study period, and was a major attractant for species such as Greater Flamingo, and various gulls, terns, ducks and teals. At Melkkamer the vlei floods an area west of the vlei, again creating rare habitat when water levels are high. This area is regularly populated with thousands of birds, including many herons, egrets, pelicans, shovelers, teals, ducks, cormorants, darters, and terns. On one visit to the western side of the vlei I found that cormorants and egrets were nesting in this area, away from their regular breeding areas north of Melkkamer. My estimate would be that close to 500 of these birds had built nests in this colony. A few weeks later when water levels had receded this colony had been abandoned. Waterbirds are clearly opportunistic and respond quickly to changes at the vlei. Notably, the rare record of Greater and Lesser Flamingos breeding at De Hoop Vlei between 1960 and 1962 was in the area south-west of Melkkamer during an extreme flooding event that lasted three years (Uys and Macleod 1967).

Lower water levels also create new habitat at De Hoop vlei. When water levels recede, an island surfaces between Die Opstal and Melkkamer, which has been a prolific feature for birds and occasionally hosted breeding birds (Peter Chadwick. pers. comm.). The vlei's salinity and geochemical makeup fluctuates alongside the water level, driven by evaporative effects and differential inputs from the catchment and local springs (Lanz 1997). When water levels are low, the vlei becomes more like a swamp, which attracts a different suite of birds. The record high of 30 000 birds was during a period with intermediate to low water levels, which offered a diversity of habitat.

Another clear factor influencing waterbirds was water quality. A pervasive algal bloom (species unknown) caused birds to depart the vlei towards the end of 2015. The algal bloom began in August

2015, and persisted for four months, finally dissipating by mid-December. At its worst the algae dominated the first 30 cm of water (Figure 2.6). Reserve staff reported that such events have occurred previously. The bloom stretched along the entire length of the vlei in varying degrees of severity and decreased waterbird abundance, particularly among piscivores. From late September 2015 the few piscivores remaining on the vlei mainly targeted frogs, especially Common Platannas *Xenopus laevis* (pers. obs.). The onset of the algal bloom appeared to coincide with a rise in water levels, and it is possible that eutrophic flood-water triggered the event (c.f. Lanz 1997). Once the bloom had dissipated the bird numbers recovered.

Figure 2.6: Algal bloom at De Hoop Vlei. From left: Tierhoek, Vlei Walk, and Die Mond.

There are also factors extraneous to De Hoop Vlei that may influence the number of birds at the site at any given time. For instance, the quality and availability of wetland habitat elsewhere may cause movement of birds in and out. De Hoop Vlei is the only waterbody of such a large size in the immediate area, but waterbirds are highly mobile and may be traveling to far-removed wetlands. Birds such as Egyptian Goose, Cape Shoveler, South African Shelduck, and Red-billed Teal that were ringed as far away as Barberspan (approximately 1000 km straight line distance) have been re-sighted in the Agulhas region. In the opposite direction, Cape Shovelers ringed in Bredasdorp have been seen at wetlands in the north-east of South Africa at distances > 1000 km (Underhill et al. 1999). These extreme and unpredictable movements may decouple to some extent the relationship between the total number of birds at De Hoop Vlei and the habitat quality and/or quantity (Weller 1998).

Spatial variation in waterbird populations

Although not all habitat preferences of waterbirds were statistically different from the proportion of habitat availability, some clear trends emerged. Open water habitat did not sustain many birds, despite it constituting the vast majority of available habitat (Table 2.2). It was dominated for the most part by Red-knobbed Coot and Great Crested Grebes, both of which are common residents. It may be that the vlei is currently too deep for many birds to successfully forage too far from the shoreline, which is evidenced by the large number of birds to be found in the shallow water habitat, which is much less abundant. When the water level was low enough to allow aquatic vegetation to reach the surface, this habitat was well used by a range of species. Red-knobbed Coots and Great-crested Grebes were observed breeding during a short period in February 2016 before the water again flooded the vegetation. Numbers of Red-knobbed Coot are tied to the availability of aquatic vegetation for food and breeding (Stewart and Bally 1985). Many other waterbirds used the aquatic vegetation in the flooded area south of Melkkamer to shelter from high winds, and Great Crested Grebes were commonly seen displaying here too.

Birds were largely concentrated in three areas (Figure 2.4). These were at Die Mond in the south, Windhoek in the north, and the inundated area south of Melkkamer. In addition, although this was not possible to pick up from count data because of the way the count areas are structured, birds tend to aggregate on the western sandy shore as opposed to the steep-sided and rocky eastern shore, as noted by Uys and Macleod (1967). The likely driver of this distribution was the availability of shallow water and open shoreline. This promotes shorebirds and shallow water feeders. Other areas were either densely vegetated on the water edge, steep-sided cliffs, or contained deep water, which are not conducive habitats for most birds (except loafing Great Crested Grebes and Great White Pelicans).

Temporal variation in waterbird populations

The use of the vlei by waterbirds changed little over the course of a day. The weak decline in numbers does not hold any significance when the variations in specific species are taken into account. Such variation is not unexpected when the area being counted only covers a portion of the vlei area, because birds move in and out of the count area. However, it is interesting that the area most likely to be disturbed by boat-based tours has a fairly constant number of birds. This means that boat tours are likely to encounter the same number of birds regardless of their departure time, and thus the disturbance footprint will be similar throughout the day.

Conclusions

The counts from this study over the course of just one year have showed that both Shaw (1998) and Marnewick et al. (2015) have underestimated the potential of De Hoop Vlei to support large numbers of certain species. It follows then that ongoing monitoring at the site is crucial as it reveals the potential for the site to support different species across different conditions. This will give managers a better grasp of the value of the site, and it can be afforded the conservation priority it deserves. If the extra costs incurred by performing monthly as opposed to quarterly counts can be covered, then this is recommended as it is more useful and revealing data.

The updates to the information in the Ramsar and IBA reports presented here in combination with the exploration of the spatio-temporal use of the vlei by waterbirds and the characterization of the bird community at near-flood to flood levels will assist managers at De Hoop Nature Reserve to make informed and appropriate decisions about the conservation of the site. Because of the highly dynamic nature of the site and the interrelation between waterbird populations and water level and quality, conservation assessments and policy should take water level into account, rather than just tracking populations over time.

Chapter 3

Disturbance of waterbirds by boats and kayaks: assessing the effects of boat-based tourism at a Ramsar-designated wetland

Abstract

Boat-based recreation and ecotourism provide attractive options for protected area managers wishing to generate revenue. However, these activities may come with associated negative ecological and environmental consequences through disturbance impacts. Impact assessments are an effective and important method in identifying and mitigating these impacts. Boat cruises and kayak tours were being considered as possible ecotourism opportunities at the Ramsar-designated De Hoop Vlei in the Western Cape of South Africa. This study assesses the disturbance to waterbirds by these two forms of boats. Flight initiation and agitation responses of waterbirds to both boat types showed intolerance at great distances, which was high when compared to cases documented in the literature. Overall, for most species both agitation and flight initiation responses to the kayak were more severe compared to the boat. Recovery of bird communities post-disturbance was slow, with only 70% of birds returning to the site of displacement within one hour. A space-for-time comparison using a site that has regular boat disturbance (Rietvlei, Cape Town) was performed to evaluate the likelihood of waterbird species habituating to boat traffic. Evidence for habituation of birds in the disturbed site was limited as birds were still agitated at similar distances to conspecifics at De Hoop Vlei, although most species did flush at significantly shorter distances. This suggests that birds most likely still suffer the physiological effects of an approach, but benefit from not being displaced as often. The sensitivity of species of conservation concern (e.g. Great White Pelican *Pelicanus onocrotalus* and Great Crested Grebe) to both types of disturbance was alarming. These species also showed lower rates of recovery and more limited habituation than more common species. Boat and kayak tours at De Hoop Vlei are likely to come at costs to the bird community, and need to be managed in such a way as to minimize the possible negative impacts.

Introduction

The proximity of humans and wildlife in protected areas increases the possibility of harmful disturbance impacts. Birds have been shown to be susceptible to these in a number of ways. Anthropogenic disturbance has been implicated in the decline of bird populations (Møller 2008a), alterations in species composition (Ikuta and Blumstein 2003), decreases in breeding success (Müllner et al. 2004, Lindsay et al. 2008), upsetting activity and time budgets (Galicia and Baldassarre 1997), influencing habitat and site choice (Cardoni et al. 2008), and increases in stress levels (Weimerskirch et al., 2002, Müllner et al. 2004, Holmes et al., 2005, Thiel et al. 2008, Walker et al. 2006). When possible, disturbance impacts should be avoided or mitigated against, especially within protected areas where conservation of biodiversity is the primary mandate.

Protected areas with access to rivers, lakes, or marine areas may benefit from allowing boats for recreation or organized activities by generating much-needed revenue (McCool 2006). However, the impacts of anthropogenic disturbance listed above may be incurred by boat-based activities, and the introduction of boat tours exposes novel ecosystems and species to disturbance. Boats can also have negative ecological and environmental effects, including noise pollution, destruction of habitat, increased turbidity, introduction of toxicants, spread of alien species, and displacement of animals (Asplund 2000, Burgin and Hardiman 2011). Since no boat-based activity is likely to occur without some adverse effect, it is necessary to weigh up potential gains from such activities against their possible effects on waterbirds.

Physiological responses to disturbance are brought about through stress, and there are a range of associated effects on the biology of the disturbed bird (see Chapter 1). These processes have significant consequences for a bird's short- to medium-term energy budget, and can require compensatory feeding time, or increased rest time (Madsen 1988). Physiological responses typically persist longer than the duration of the disturbance itself. In some instances, a physiological change may occur without a noticeable change in behaviour (e.g. Holmes et al. 2005, Nimon et al. 2006). It is important to consider that the impacts of disturbances on birds may be more severe and costly than they appear based on visual observations alone.

A popular way to study disturbance of waterbirds is to record the distances at which they change their behaviour in response to a disturbance, for example, when a bird flees from the perceived threat, either by flying, swimming, or diving. This is known as the Flight Initiation Distance (FID) associated with a given type of disturbance. Flight initiation provides a measure of how risk-averse or risk-tolerant a bird is, and is most often reported as an average value of a number of observations for a species. Another pertinent measure of disturbance is the Alert or Agitation Distance (AD). This is the distance between the bird and the disturbance vector when the bird first reacts, indicating that it is alert to its presence (Weston et al. 2012). AD gives an idea of how perceptive birds are of possible threats, and provides a crude proxy for Physiological Response Distance (PRD) – the distance at which the first physiological responses to disturbance begin (Weston et al. 2012). However, physiological responses often occur before any alert behaviour is exhibited, so AD typically underestimates PRD (Weston et al. 2012).

Flight initiation in birds is often considered a species-specific trait (Blumstein et al. 2003), however intraspecific variation in responses can still be high because of the number of factors influencing decision making (Steven et al. 2011). Body size (Blumstein 2006) and flock size (Batten 1977, Burger 1986) both correlate positively with FID, and are considered strong predictors of flightiness. Other factors such as age (Stalmaster and Newman 1978), previous experience (Burger and Gochfeld 1999), basal metabolic rate (Møller 2009), breeding condition and strategy (Culik and Wilson 1995, Ghalambor and Martin 2001, Blumstein 2006), eye size (Møller and Erritzøe 2010), individual character (Beale 2007), parasite load (Møller 2008b) and body condition (Beale and Monaghan 2004a) can influence the decision when to react to a disturbance. Despite the associated noise from numerous contributing factors, Møller (2008a) was able to predict (from 56 European species) which birds were undergoing continent-wide declines as a result of human expansion based on species-specific flight initiation distances (FIDs; the distance at which an animal flees from a disturbance). This suggests that FIDs can provide reliable information on the susceptibility of birds to disturbance if sufficient data are collected to combat noise and variation.

ADs and FIDs are often applied as a basis for the development of various practical conservation measures, including buffer areas, set-back distances, and no-go zones (e.g. Fernández-Juricic et al. 2005, Burger et al. 2010). Such measures aim to prevent possible disturbance vectors approaching close enough to agitate or displace birds. The advantages of using response distances as a basis to set minimum approach distances are that they tailored to priority species or an overall community, and they are based on actual observations of stress rather than estimates (Weston et al. 2012).

Contrasting the disturbance effects of motorized and non-motorized boats

Since disturbance effects are specific to the disturbance type, the reactions of birds to motorized and non-motorized boats are expected to differ. More studies have focused on the disturbance impacts of motorized boats than non-motorized types, possibly because motorized boats are assumed to be more disturbing and in greater need of impact assessment. Motorized boats are usually larger, faster and more noisy, which are all factors associated with greater disturbance (Bellefleur et al. 2009, Chan et al. 2010). Impacts of motorized disturbance include reduced body condition, survival rate, and breeding performance (Anderson and Keith 1980, Bélanger and Bédard 1989, Burger 1994, Beale and Monaghan 2004a, McClung et al. 2004, Medeiros et al. 2007, Zuberogoitia et al. 2008, Merkel et al. 2009, Velando and Munilla 2011). The disturbance effects of non-motorized vessels are comparatively understudied (Glover et al. 2015). Non-motorized boats (e.g. canoes, kayaks, and sailing boats) tend to be slower, quieter, and smaller, which by conventional wisdom means less disturbance. However, these characteristics may in fact exacerbate disturbance under certain conditions. The ability for smaller, non-motorized boats to access areas not navigable in a larger boat means they can get closer to birds and cause greater disturbance (Glover et al. 2015). The low profile of small, non-motorized boats in combination with their quiet, slow movement may also make them a seemingly more viable threat to birds than larger motorized boats. Birds perched alongside freeways frequently react in such a fashion, paying no attention to vehicles driving at great speed, but flushing when in response to vehicles traveling slowly or slowing in their approach (pers. obs.). Slower motion can also result in a prolonged disturbance duration, which can exacerbate the impact in certain circumstances (Grubb and King 1991). Only rarely have the reactions of a test population of birds to motorized and non-motorized vessels been compared directly, and with conflicting results. For example, Rodgers and Schwikert (2002) found that one species reacted worse to an approach by canoe, four reacted worse to a motorized boat, and eleven reacted similarly to both. The contrasting effects of motorized and non-motorized boats on birds are yet to be strongly documented, despite there being reason to suspect that there are differences.

The importance of measuring post-disturbance response

Birds experience natural disturbance daily, and are adapted to withstand limited short-term disturbances (Romero 2004). However, frequent displacement by anthropogenic disturbances may cause lost opportunity costs for feeding, breeding, or socializing. The length of time spent away from a disturbed site may dictate the severity of the disturbance impact. This is particularly true if the vacated site is uniquely important or contains scarce resources (e.g. isolated feeding grounds; Stillman et al. 2000). Similarly, breeding birds may suffer more the longer they spend away from a nest site. For instance, interrupting incubation may induce heat/cold stress (e.g. Ardia et al. 2010), or may subject the nest to elevated predation risk (Lenington 1979). Despite the clear link between time spent away from the site of disturbance and the severity of disturbance impacts, very few studies have addressed the temporal aspect of disturbance responses of birds (but see England et al. 2015).

Assessments that ignore post-disturbance responses run the risk of grossly under- or overestimating the possible disturbance impacts.

Habituation as a possible mitigator of disturbance effects in the long term

When assessing the possible impacts of disturbance in the longer term it is important to assess the likelihood of habituation. Habituation is a process of familiarization to a disturbance stimulus, which over time is expected to temper the flight response (Hinde 1970, Immelman and Beer 1989). Habituation in waterbirds has been demonstrated (e.g. Burger and Gochfeld 1999, Carney and Sydeman 1999, Baudains and Lloyd 2007), but how much it actually mitigates disturbance impacts is debatable (Bejder et al. 2009), and some dispute the validity of such studies (Nisbet 2000). Certain species seem to habituate more readily than others, even within closely related groups (Weston et al. 2012, Pease et al. 2015), indicating that this is likely a species-specific trait (Blumstein et al. 2003, Blumstein et al. 2005). Habituation is difficult to measure when one cannot recognize individual birds (e.g. through colour banding; Nisbet 2000). Habituation is also influenced by the specific disturbance type, and any proof of habituation should not be used to justify activities other than the one under investigation (Bejder et al. 2009). A major challenge for habituation of waterbirds is the frequent movement of individuals typical of many waterbird species, which have evolved to exploit temporally ephemeral habitats. If individuals are not regularly present at a site they risk not being exposed to a disturbance stimulus on a regular basis, which undermines the potential for successful habituation to mitigate against disturbance impacts.

To measure true habituation would take years of continuous measuring at the same site, and preferably the same individuals, which is not achievable for a graduate study. However, there are options using proxies for time that can achieve a similar goal. Space-for-time substitution tests are useful in instances where the time taken for a process is inhibitive for a study, but two comparable sites exist where the conditions at one mimic the expected condition of the other (Pickett 1989). It is also an effective way of testing habituation in situations where individuals are not identifiable and habituation can only be tested at the species-level or higher. Assuming that responses to disturbance are species-specific (Blumstein et al. 2003), then birds at sites with a history of exposure to a given disturbance (e.g. boat activity) may have become habituated and have a lesser response to the disturbance than naïve birds of the same species at a site without a history of exposure. Therefore, by comparing the reactions of birds at a site with a long history of boating with the same species at De Hoop Vlei, it may be possible to infer the likelihood of habituation without having to perform a long-term study.

The purpose and aims of this study

De Hoop Vlei is a large coastal lake that forms the western boundary of De Hoop Nature Reserve, a provincial reserve in the Western Cape of South Africa (see site description in Chapter 1 for more details). Proposals have been made by tourism operators to the reserve management to run boat and kayak tours on the vlei, which is recognized through the Ramsar Convention as a globally important wetland for various waterbird species (Ramsar 1971, Shaw 1998, Chapter 2). This study was initiated as an impact assessment of these activities. I sought to assess the waterbirds' sensitivity to disturbance in order to provide a scientific basis for local decision making. I designed two routes for boat tours taking into account waterbird prevalence in different areas and the distribution of species of conservation concern (see Chapter 2), aiming to minimize waterbird disturbance. These two routes were monitored for their disturbance footprint in the hope that the routes effectively limited disturbance. I tested species-specific sensitivity to both boats and kayak using flight initiation distance responses (FIDs), with the expectation that there would be differences between species-specific responses to the two disturbance types. I also investigated the birds' post-disturbance recovery in order to add a temporal aspect to my impact assessment. Lastly, I looked at the potential for the species of waterbird at De Hoop Vlei to habituate, using a space-for-time comparison with a site with regular boat traffic (Rietvlei). The expectation was that birds at Rietvlei should allow a closer approach before responding to the kayak than the naïve conspecifics at De Hoop Vlei.

Methods

Descriptions of the motorized boat and kayak

A flat-bottomed pontoon boat with a shade canopy is used for boat tours on the vlei and trips to Melkkamer (Figure 3.1). The boat can take a maximum of 12 passengers, has a shallow draft and since tours are run at less than 10 $km.h^{-1}$ the wake produced is minimal. The potential for the boat to disturb and erode shoreline habitats is therefore minimal, relative to the wind-induced waves that frequently occur on the vlei. The open construction of the boat is ideal for wildlife and bird viewing, but does expose the passengers to the elements. During windy days, waves can splash over the sides, the wind can blow over tables and chairs, and there is little protection from rain on windy days. The 50 horsepower four-stroke motor is relatively quiet, and is cleaner than a two-stroke motor with less risk of fuel leakage.

Figure 3.1: The pontoon boat to be used for boat tours at De Hoop Vlei.

A kayak was purchased for the purpose of this study, as there were previously no kayaks at De Hoop. I used a medium blue, two-man kayak (Legend Kayaks, Figure 3.2). The paddle had a black shaft with white heads on either side. A bright orange life vest was carried onboard at all times but not worn. The same kayak was used for all disturbance trials at both De Hoop Vlei and Rietvlei.

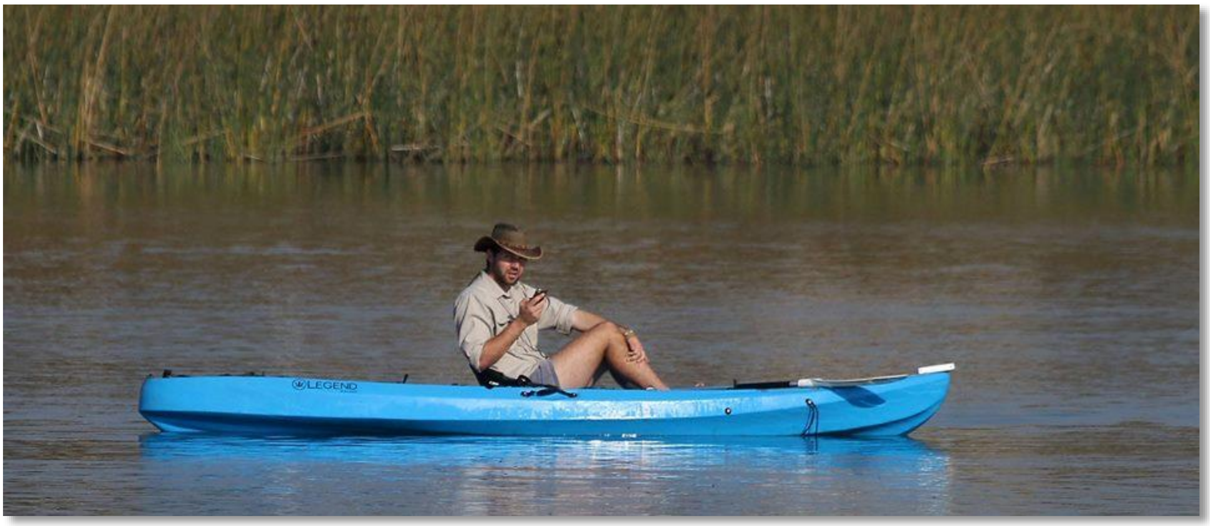

Figure 3.2: The kayak used for the duration of the study. Image credit: Frieda Prinsloo.

Monitoring the disturbance footprint of boat tours

Boat tours at De Hoop Vlei were conducted along two set routes (Figure 3.3). These were designed to avoid areas where birds aggregated in large numbers, where species of conservation priority were commonly encountered, and breeding areas. These areas were previously determined in the two months before boat tours commenced. Co-ordinated Water Avifaunal Counts (CWACs) and repeated counts of the area surrounding the boating area revealed the areas that supported high numbers of birds generally as well as those of conservation concern (see Chapter 2 for detailed explanation of specific methods and results). Breeding areas were noted ad-hoc during field visits. The two routes both originated at Die Opstal, the main accommodation area of the reserve. Both routes avoided the western half of the vlei as waterbirds tend to congregate in large numbers along the gently sloping western shoreline (Chapter 2; Uys 1983). The northern route followed the rocky eastern shore up to Tierhoek, where the boat was parked for a short while for a refreshment stop. The boat then continued back to Die Opstal down the middle of the vlei, not within approximately 150 m of the western shoreline. The southern route hugged the eastern shore until drawing parallel with the South Point, a large sand spit that stretched out into the main body of water, where it stopped for refreshments before likewise returning down the middle of the vlei. On occasions of strong wind the option was given to the skipper to begin the tour by exploring the inlet along Die Opstal. On these occasions the time spent on the set routes was shortened to reduce the time exposed to the elements as well as keep the tours the same length. Each tour lasted approximately 1.5 hours.

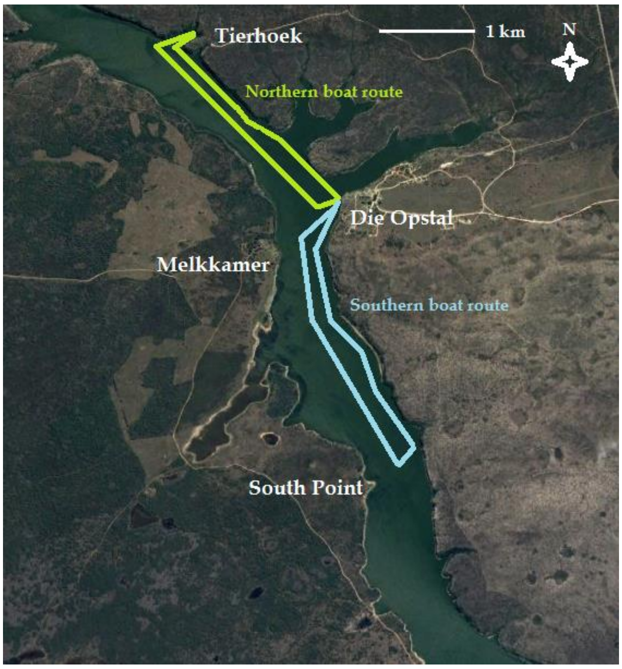

Figure 3.3: The track of the northern and southern trial boat routes adopted for boat-based tours at De Hoop Vlei (Image: Google Earth).

Boat tours and data collection began in June 2015, with data collection running until March 2016. Two trips a day departing at 11:00 and 15:00 were permitted. I joined as many tours as possible from June 2015 to March 2016 to observe and record the reactions of the waterbirds encountered. Several boat trips were cancelled due to poor weather, usually due to strong winds, but also due to rain and thunderstorms. The route for each trip was generally chosen by the skipper, although in order to maintain even sample sizes I did dictate on occasion which direction to navigate. Before departure the wind speed, wind direction and temperature at the jetty were measured using an anemometer (Kestrel 2000, U.S.A). The roughness of the water surface, or 'chop', was scored on a scale from 0-5, and cloud cover on a scale of 0-8.

During each tour I tallied how many birds were 'agitated' and/or 'displaced' by the boat's presence. A bird was considered to be agitated if its attention was diverted to the approaching boat and it ceased its previous behaviour. For birds that swam a short distance away from the boat I also recorded them as agitated. Displaced birds either flew away, dove underwater for an extended period, or swam energetically away from the boat, as opposed to agitated birds that were adjudged to have remained in the same vicinity as they were pre-disturbance. To avoid double counting, once a bird progressed from being agitated to fleeing it was deleted from the agitation tally and reclassified as displaced.

Making tallies of these disturbance responses for each trip allowed a direct comparison of the disturbance impacts of the two routes in terms of the number of birds disturbed and what species were encountered. The disturbance impact was calculated as the total number of birds agitated and displaced, which could also be compared between routes at the species level.

Agitation and flight initiation responses to the boat and kayak

The species-specific flightiness of the waterbirds at De Hoop Vlei in response to boat tours was explored by measuring their Agitation Distances (ADs) and Flight Initiation Distances (FIDs). These measurements were made on an ad-hoc basis during the same boat trips as the disturbance impact monitoring (above). Recording the number of birds disturbed by the boat was prioritized over AD and FID measurements.

For each measurement a focal individual was picked, and every observation was completed before another focal individual was chosen. The species of the focal bird was recorded, as well as how many birds were within approximately 20 m of it. Care was taken not to measure the same bird twice on one trip, but it was not possible to know if the same bird was sampled on different trips. However, the constant movement of individuals in and out of De Hoop Vlei (see Chapter 2) may help to limit this. In addition, Runyan and Blumstein (2004) showed that sampling the FID of the same individual multiple times does not necessarily bias the data, so this should not be problematic. AD was recorded as the distance at which a bird changed its behaviour in response to the approach of the boat. FID was recorded as the distance at which a bird fled from the boat and was consequently displaced. This varied between taking flight, swimming frantically, diving underwater, or for moulting birds attempting to flap their way across the water surface. AD and FID were measured using a handheld rangefinder (Nikon Prostaff, Japan). At large distances (> 100 m) the rangefinder struggled to pick up birds on the water's surface. When this happened an estimate of the distance was made to the nearest 10 m, where possible taking a comparative reading off of a nearby solid object (e.g. a rock). Estimating distances over water can be difficult as there is little frame of reference, but it was possible to practice estimating long distances on the six trial boat trips before starting data collection. This skill was refined further throughout the project by estimating distances of responses before confirming the distance with the rangefinder.

Data collection took place for kayak disturbances between October 2015 and March 2016. Four trial kayak trips were made before collecting data. I assessed the disturbance of waterbirds by kayaks using the same methodology for AD and FID measurements as for boat tours (described above), which made it possible to directly compare the disturbance caused by the boat and kayak. Kayak trips followed a similar path to the boat tours, and maintained an approach speed similar to the motorized boat. All trips were carried out between 06:15 and 10:45 to avoid often windy conditions after mid-morning. The north-south running steep cliffs along the eastern edge of the vlei tend to channel the wind into either a northerly or southerly direction, meaning that any excursions are likely to experience strong headwinds either on the out- or inbound leg.

Post-disturbance recovery of bird communities

To assess how birds at De Hoop Vlei reacted and then resettled after a disturbance, I recorded the reactions of birds to a kayak being paddled past a section of shoreline. The paddler maintained a distance of approximately 10–20 m from the shoreline. I recorded the number of birds present just before the kayak passed (pre-disturbance), and then immediately again after the kayak had passed (post-disturbance). Further counts of the affected area were then repeated every ten minutes for one hour to record the number of birds that resettled in the disturbed area. Data collection took place in March 2016. Counts were conducted using a 30x magnification spotting scope and 10x binoculars. I positioned myself at an elevated lookout spot with plenty bush cover to avoid influencing the reactions of the birds. This was repeated over a number of days across three different sites (Figure

3.4). Each of the sites offered similar habitats with open water, open shoreline, shallow water, and shoreline vegetation all present.

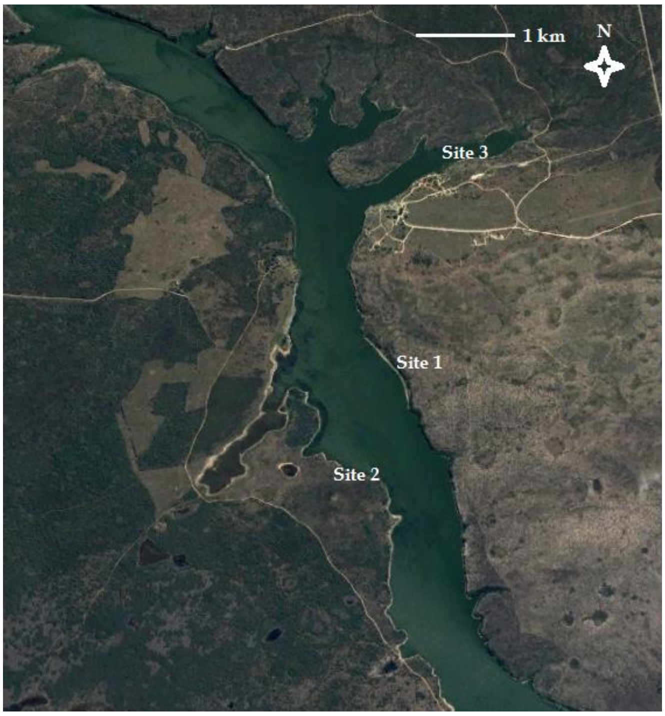

Figure 3.4: Locations of the three sites used for recovery tests (Image: Google Earth).

Evaluating habituation potential using a space-for-time substitution comparison

The space-for-time comparison was conducted at Rietvlei Nature Reserve (33° 50′ S, 18° 30′ E), a large waterbody in Milnerton on the outskirts of Cape Town (Figure 3.5). Rietvlei, like the De Hoop Vlei, is a coastal lake. It is a popular destination for boat-based recreation, especially wind-surfing as the area often experiences heavy winds. There is a high level of boat traffic of other varieties too, including motorized boats and kayaks. The water body consists of two areas that are joined by a narrow channel. Boats are only permitted in the larger, northern area; the southern area is a sanctuary for birds and other wildlife. The two areas differ structurally; the northern area is deeper and more homogenous, and is surrounded by grass lawn for much of its circumference, while the southern sanctuary is shallower, has limited sandy shoreline, and is otherwise dominated by reeds at its edges. Because of the low numbers of birds within the northern area it was necessary to collect data from both areas, which is a possible complicating factor since birds in the southern portion are not exposed to boats as regularly. Some birds sampled may therefore be more exposed to boats than others, and levels of habituation may therefore be different among individuals.

I used the same kayak as I used at De Hoop Vlei to ensure the disturbance type presented to the birds was the same. The methodology and equipment used to assess the responses of birds to the kayak were also kept the same. This ensured that any differences in the data were on account of the conditions at the different sites. Measurements of AD and FID were made from the kayak of different focal individuals of different species and compared to the results from the waterbirds at De Hoop Vlei.

Figure 3.5: Satellite photograph of Rietvlei wetland. The northern portion is where boating is allowed, while the south section is kept as a bird sanctuary (Image: Google Earth).

Results

Monitoring the disturbance footprint of boat tours

Data on waterbird disturbance was collected on 46 boat trips at De Hoop Vlei, split equally between the northern and southern routes. The mean number of birds disturbed along the southern route (461 ± 147) was three times higher than the northern route (158 ± 42) (Figure 3.6). The southern route agitated and displaced similar numbers of birds, while the birds encountered along the northern route were more likely to flush than to tolerate the boat passing.

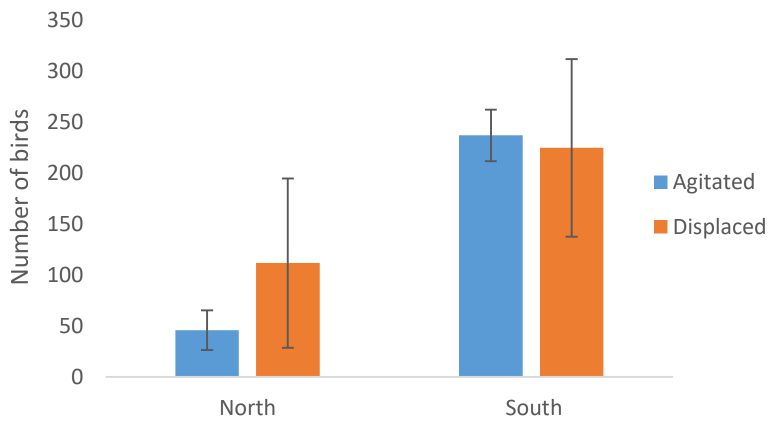

Figure 3.6: Mean number of birds agitated and displaced on the northern and southern boat routes. Error bars indicate 95% confidence intervals.

The waterbirds disturbed by the boat were dominated by four species (Red-knobbed Coot, Reed Cormorant, Great Crested Grebe, and White-breasted Cormorant), with only four other species having a mean of > 10 individuals disturbed per trip (Figure 3.7). Neither route disturbed any flamingoes or Maccoa Duck. Great Crested Grebes, which are regionally Vulnerable (Taylor et al. 2015) were disturbed in fairly high numbers, however most appear to be agitated rather than displaced by the boat, and the mean number of birds displaced equates to only ~ 10% of the regular population (see Table 2.1). Great White Pelicans, also regionally Vulnerable (Taylor et al. 2015), appear to be disturbed in low numbers, however this is misleading. Pelicans were irregular at De Hoop Vlei, but when they were present at the vlei they were regularly disturbed by the boat, and sometimes in large numbers. For example, during June to October 2015, when pelicans were consistently present, the mean number of birds disturbed on the southern route was 37 ± 65 birds (n = 12 boat trips, range 2-231 birds) and 7 ± 9 birds (n = 10 trips, range 0-26 birds) on the northern route. Their absence from November onwards decreased the mean number of pelicans disturbed.

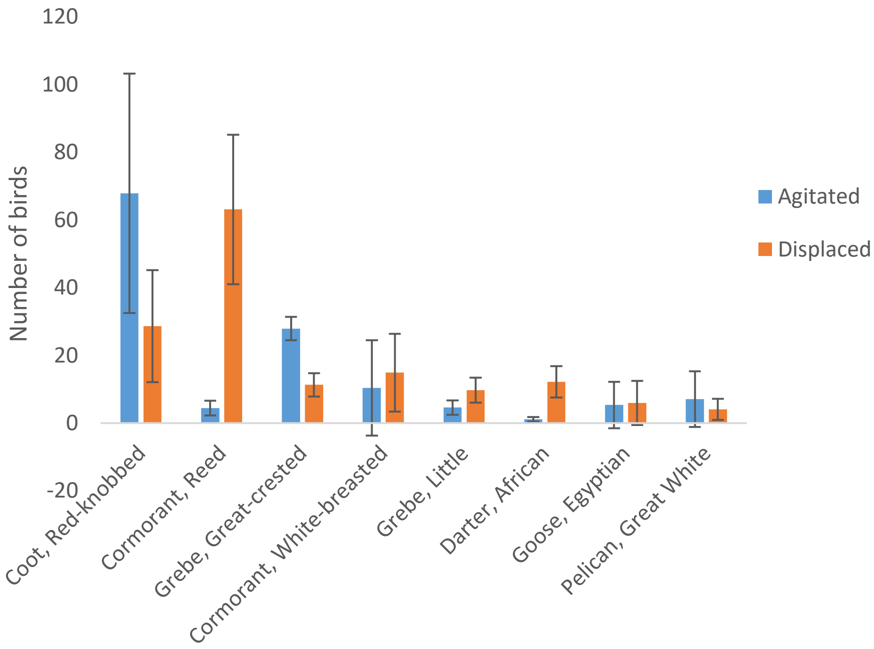

Figure 3.7: Mean number of each species agitated and displaced per boat trip. Only species with a mean of > 10 individuals disturbed (sum of agitated and displaced) per trip are included. Error bars indicate 95% confidence intervals. Species are ordered by mean number disturbed.

Agitation and flight initiation responses to the boat and kayak

A total of 323 ADs and 791 FIDs were recorded in response to the boat disturbance. More displacement (FID) responses were recorded because detecting subtle agitation responses is more difficult at large distances than displacement responses. Also, on many occasions a bird was only detected as it flushed (e.g. from thick vegetation), and thus no agitation distance for that bird could be recorded. Waterbirds were agitated at a mean distance of 110 ± 6 m (95% confidence interval) and were displaced at 62 ± 3 m, with maxima of 460 m and 370 m, respectively (both maxima were for African Fish Eagles). Most species-specific agitation responses took place at a distance of 90-110 m, and displacement between 50 and 70 m (Figure 3.8). African Fish Eagle and Great White Pelican were much flightier than the other species, reacting at greater distances from the boat.

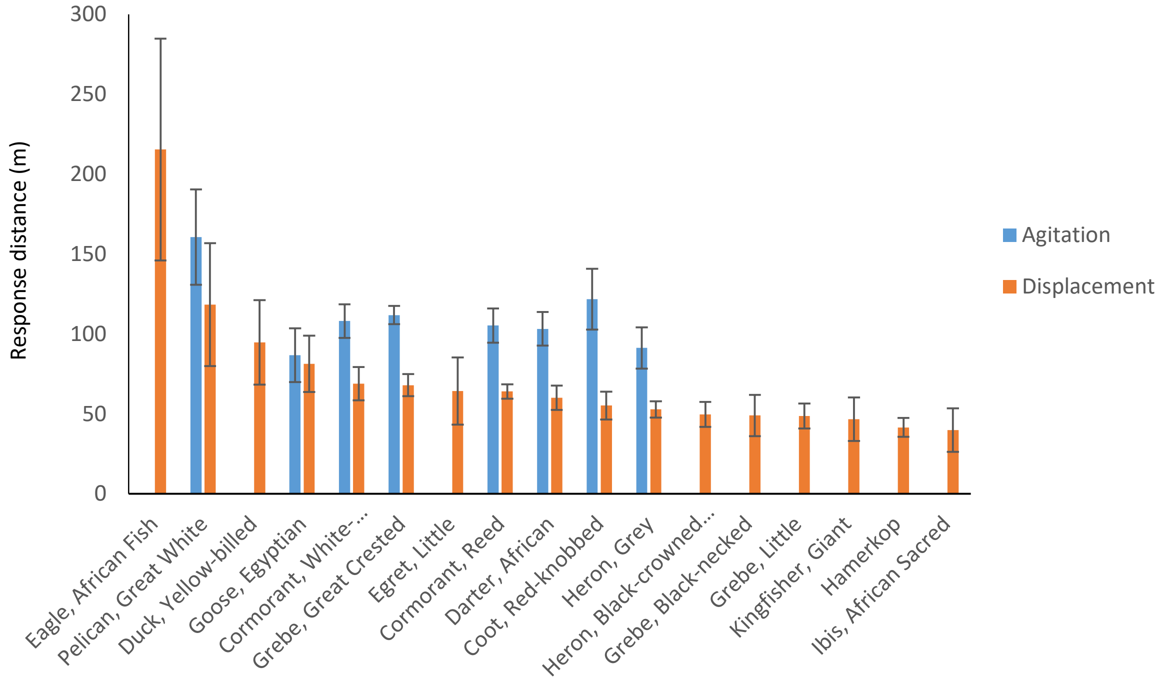

Figure 3.8: Mean response distances of waterbirds at De Hoop Vlei to an approach by boat. Species are ordered by displacement distance. All species with n < 5 observations for one or both of their responses were excluded from this graph. Error bars indicate 95% confidence intervals.

Data collection for responses to a kayak consisted of 12 trips of 2-4 hours each at De Hoop Vlei. During these trips, 156 ADs, and 454 FIDs were recorded. Birds were agitated at a mean of 123 ± 7 m, and displaced at 80 ± 4 m (Figure 3.9). The maximum displacement of 325 m was again of an African Fish Eagle, although the maximum agitation of 303 m was of Greater Flamingo (the only disturbance response recorded for a flamingo for either the boat or the kayak). African Fish Eagle maximum agitation distance was 297 m. The two species that reacted worst to the boat were also those that reacted worst to the kayak, but their sample sizes were too small to include in the figure. The mean agitation and displacement responses for the African Fish Eagle were 297 m (n = 1) and 262 m (n = 2), respectively, while for the Great White Pelican they were 140 m (n =1) and 88 m (n=2). Great Crested Grebes, a conservation priority species, proved the most sensitive to kayak disturbance for species with n ≥ 5 observations. Most species were agitated by the kayak at between 100 and 140 m, and were displaced between 60 and 100 m. African Sacred Ibis and Cape Wagtail, two species known for their ability to adapt to human-dominated landscapes (Niven 1981, Anderson 1997), exhibited much shorter FIDs (Figure 3.9).

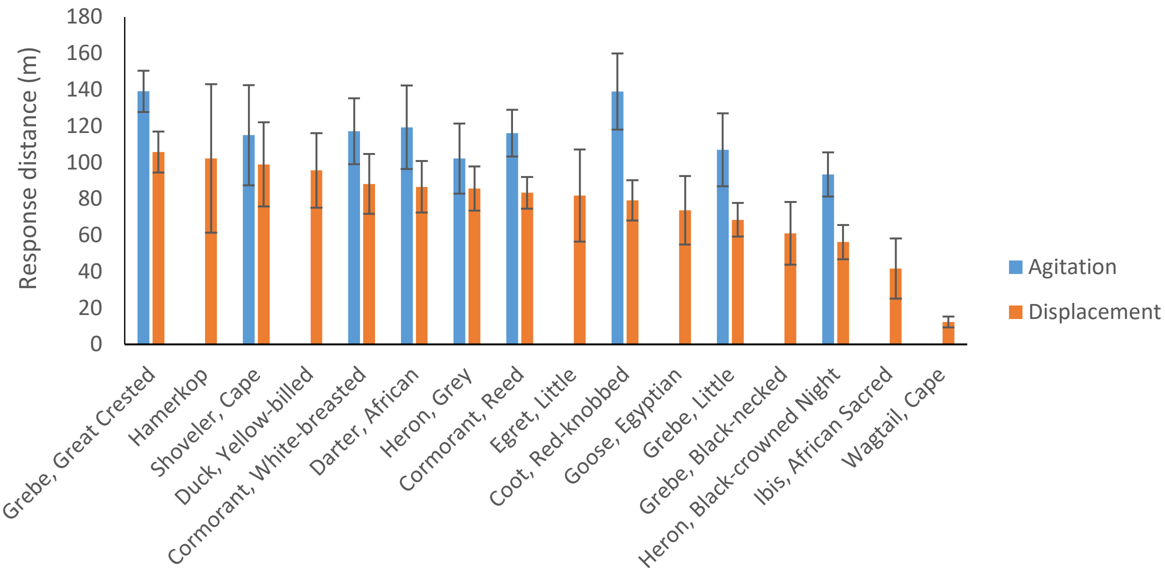

Figure 3.9: Mean response distances of waterbirds at De Hoop Vlei to an approach by kayak. Species are ordered by displacement distance. All species with fewer than five observations for one or both of their responses were excluded from this graph. Error bars indicate 95% confidence intervals.

As a community, birds exhibited significantly larger ADs for the kayak than the boat (two-tailed homoscedastic $t = 2.83$, n-boat = 323, n-kayak = 156, $p = 0.005$). For species-specific agitation responses there was a consistent trend of responses to the kayak occurring at a greater distance than responses to the boat (Figure 3.10), although only Great Crested Grebe showed a statistically significant difference ($t = -4.46$, n-boat = 65, n-kayak = 37, $p < 0.001$).

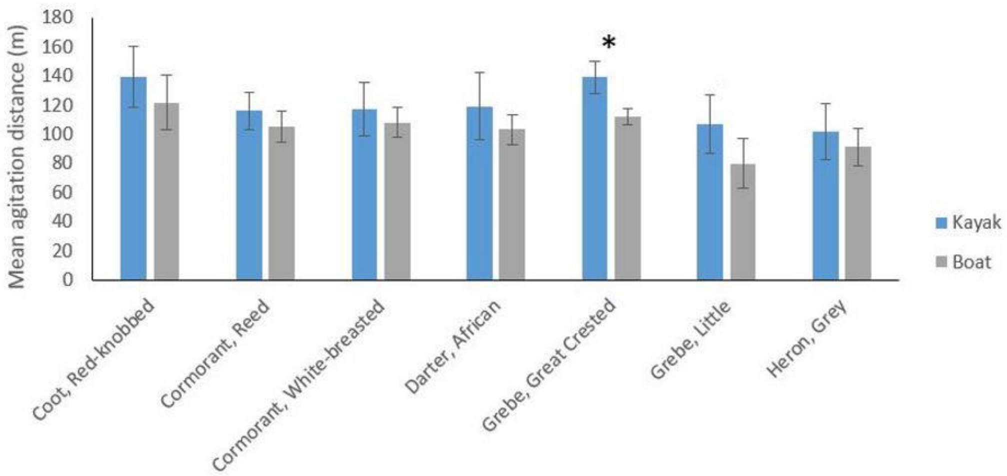

Figure 3.10: Mean agitation response distances of waterbirds in response to approaches by a kayak and a boat. Only species with >5 recordings for responses to both the kayak and the boat were included. Error bars indicate 95% confidence intervals. * denotes $p < 0.05$.

The bird community also exhibited significantly larger FIDs in response to the kayak than the boat ($t = 7.42$, n-boat = 791, n-kayak = 454, $p < 0.001$). This was also supported in the species-specific results also (Figure 3.11). The Egyptian Goose *Alopochen aegyptiaca* is the only case in which the trend is reversed, although the difference is not significant ($t = 0.62$, n-boat = 31, n-kayak = 12, $p = 0.27$). Great Crested Grebe, the only conservation priority species represented in the dataset (Near-threatened), is intolerant of both the kayak and the boat, but reacts further away to a kayak approach ($t = -5.85$, n-boat = 87, n-kayak = 42, $p < 0.001$).

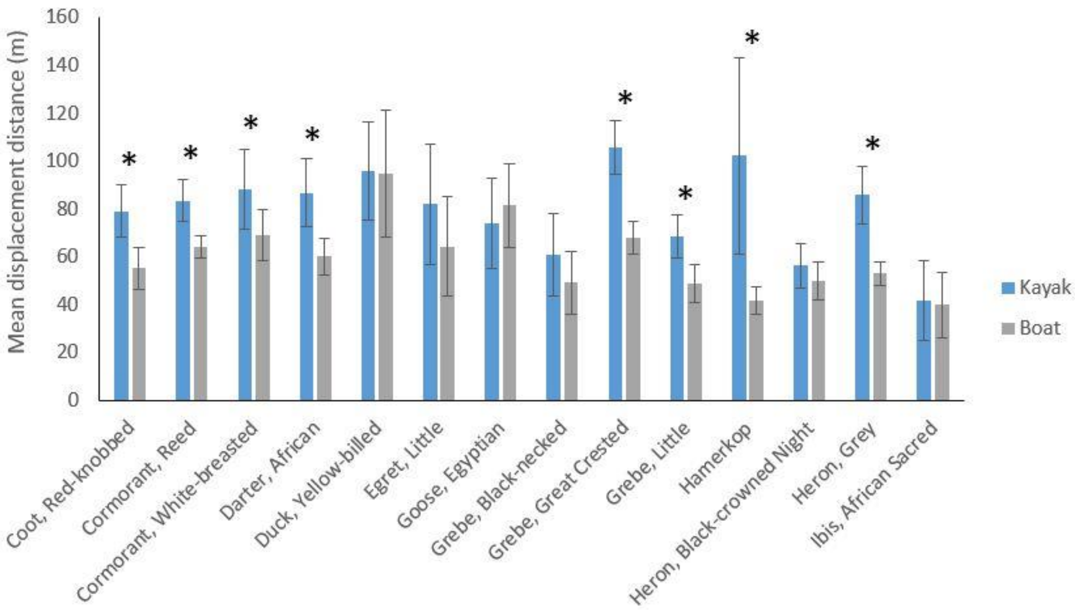

Figure 3.11: Differences between the mean displacement response distances of waterbirds in response to approaches by a kayak and a boat. Only species with >5 recordings for responses to both the kayak and the boat were included. Error bars indicate 95% confidence intervals. * indicates $p < 0.05$.

Post-disturbance recovery of bird communities

The tests of post-disturbance recovery of waterbirds consisted of four visits to each site, which included 169 instances of a single-species group being displaced. The group size for each observation ranged from 1-319 individuals. There were 66, 36, and 67 records from sites 1-3, respectively. The records covered 23 species, with 14 having more than five samples. Only these are included.

Post-disturbance community recovery plateaued at 70% after 40 minutes (Figure 3.12). However, there were very different species-specific responses (Figure 3.13; see Appendix 5 for all species responses). Around 75% of African Darters returned immediately post-disturbance, but never reached the same pre-disturbance numbers during the hour period. Very few species reached pre-disturbance levels, however Little Grebes *Tachybaptus ruficollis* were one exception where return was rapid. Egyptian Goose and White-breasted Cormorants, which were mainly using the areas for sunbathing and resting, returned to pre-disturbance levels but took nearly the full hour to achieve this. African Darters did not return to greater than 80%, but those that did return did so fairly rapidly. For some species, the returns were less impressive. Red-knobbed Coots returned to 50% quickly, but did not exceed that for the hour. Great Crested Grebes were absent for 40 minutes before returning to approximately 60%. Cape Shovelers, on the other hand, were severely affected and 70% of birds disturbed abandoned the sites for the full hour.

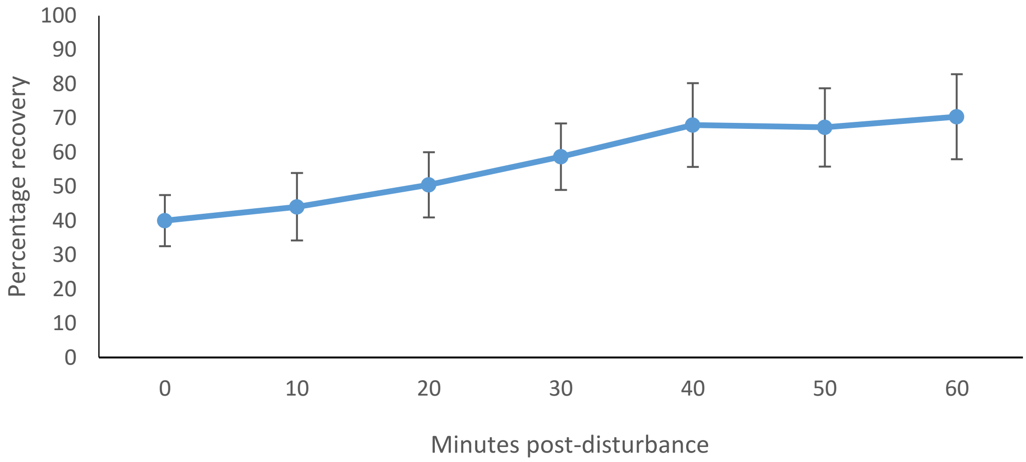

Figure 3.12: Mean recovery of waterbird communities post-disturbance by a kayak. Error bars indicate 95% confidence intervals.

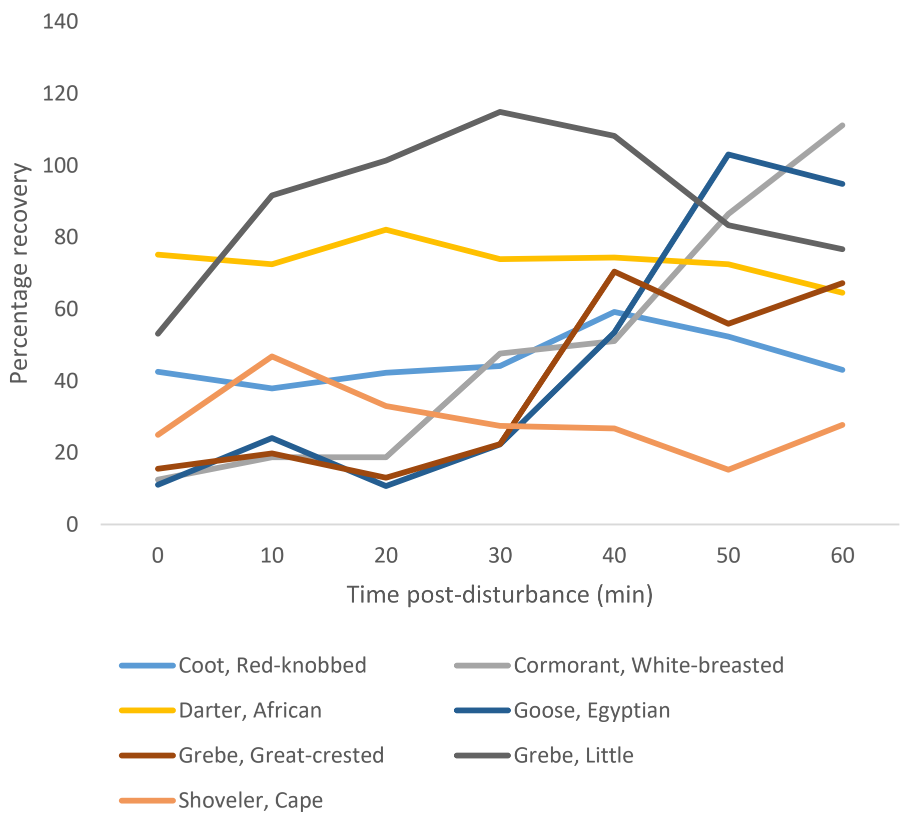

Figure 3.13: Post-disturbance recovery of 7 species showing the range of responses to disturbance by a kayak.

Evaluating habituation potential using a space-for-time substitution comparison

Four trips to Rietvlei were undertaken for the space-for-time substitution experiments, with samples of 22 species totaling 100 ADs and 190 FIDs. The mean ADs and FIDs were 112 ± 9 m and 50 ± 4 m, respectively. Across all species, AD was not significantly different between De Hoop Vlei (DHV) and Rietvlei (RV) (two-tailed homoscedastic t-test, $t = 1.85$, n-DHV = 156, n-RV = 100, $p = 0.07$). FIDs were significantly greater at De Hoop Vlei than at Rietvlei (two-tailed homoscedastic $t = 8.70$, n-DHV = 484, n-RV = 190, $p < 0.001$). In general the birds at Rietvlei allowed kayaks to approach approximately 30 m closer compared to the birds at De Hoop Vlei. However, there is a slightly different assemblage of birds at Rietvlei, and this is not taken into account in a multi-species analysis.

The ADs of Rietvlei birds were high; more than 80 m in all six species, and over 100 m in four of these. Three of the six species for which there were sufficient sample sizes at both sites ($n \geq 5$; Red-knobbed Coot, Reed Cormorant, and African Darter) exhibited lower agitation distances at Rietvlei than at De Hoop Vlei (Figure 3.14), although this was only statistically significant for Reed Cormorants ($t = 2.33$, n-DHV = 21, n-RV = 7, $p = 0.03$).

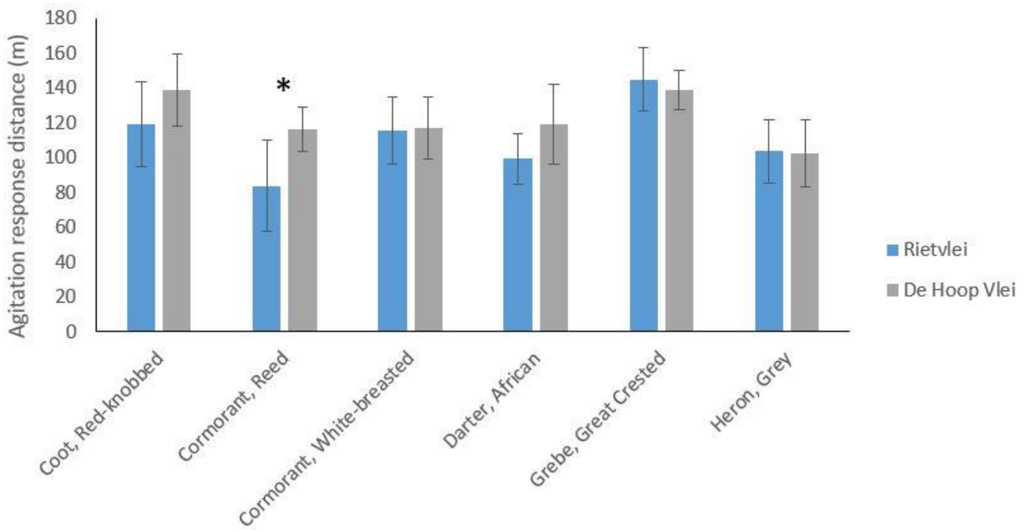

Figure 3.14: Mean distance at which waterbirds first show agitation behaviour in response to approaches by a kayak approach at two wetlands sites, Rietvlei and De Hoop Vlei. Only species with n ≥ 5 observations at both wetlands are presented. Error bars indicate 95% confidence intervals.

With the exception of Great Crested Grebes, every species with sufficient sample sizes at both sites (n ≥ 5) showed a larger displacement distance at De Hoop Vlei than at Rietvlei (Figure 3.15). The largest difference was for Reed Cormorants, which initiated flight 30 ± 10 m away at Rietvlei, but at 83 ± 4 m at De Hoop Vlei.

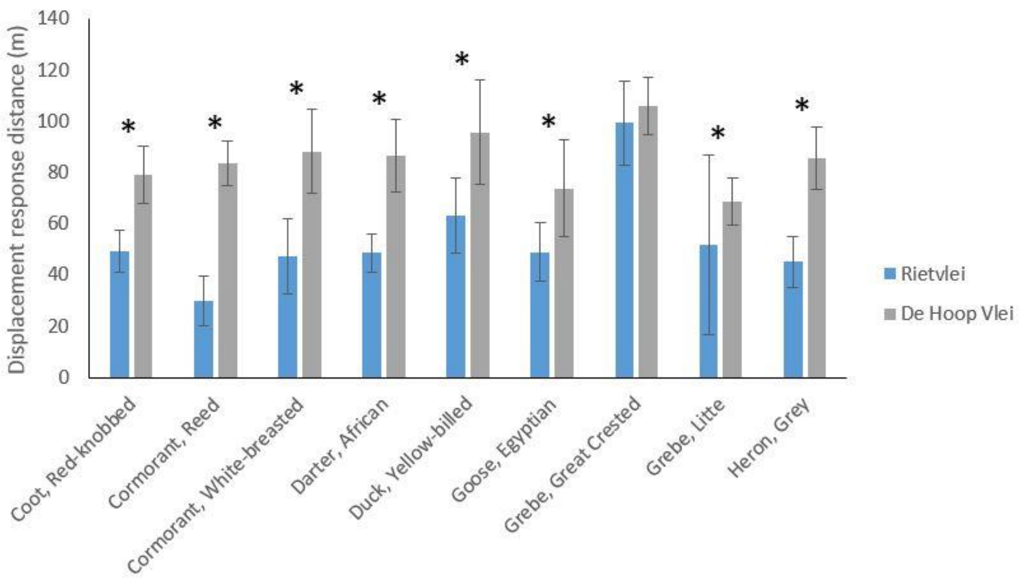

Figure 3.15: Mean distance at which waterbirds are displaced by a kayak approach at two wetlands sites, Rietvlei and De Hoop Vlei. Only species with n ≥ 5 observations at both wetlands are reported. Error bars indicate 95% confidence intervals.

Discussion

Overall sensitivity of waterbirds to boat-based disturbance

I found waterbirds at De Hoop Vlei to be sensitive to both the boat and kayak. Their responses to disturbance appear to be some of the most flighty recorded to date (e.g. Rodgers and Smith 1995, 1997, Rodgers and Schwikert 2002, Blumstein 2006, Baudains and Lloyd 2007, Møller 2008b, Chatwin et al. 2013, Guay et al. 2013, Glover et al. 2015; reviewed in Livezey et al. 2016). A review of Australian birds' flight responses to a number of stimuli including boats reported a maximum FID value across all species of 196 m (Weston et al. 2012). In comparison, at De Hoop Vlei there were 12 instances involving seven species responding to the boat and 14 instances for 10 species for the kayak where birds were flushed at distances greater than this. These results suggest that the boat has a large effect on the waterbirds at De Hoop Vlei, and that the area being impacted around the boat is large, encompassing a radius of > 150 m for more shy birds. It is important to note that physiological responses to the boat such as raised heart rate, stress, and increased metabolism likely occurs at even greater distances (Holmes et al. 2005). Approaching to within 120 m by boat is not likely to agitate most waterbird species at De Hoop Vlei, while an approach to no less than 80 m should not displace most birds, with the notable exception of the Great White Pelicans in both cases. The rural, isolated location of De Hoop Vlei and the limited numbers of visitors to the area may mean that birds are largely naïve to humans as a whole, and as such can be expected to react differently to birds in more urbanized or populated areas (Møller 2008c). Very few studies exist for African species, and conservation management on the continent would benefit from having more local benchmarks on which to make decisions when site-level data are not available.

Differences in responses to the boat and kayak

Reactions of waterbirds to the kayak were more severe than to the boat, most notably for FIDs. The consistency of the intolerance for the kayak across species was surprising and contrary to existing literature which produced mixed results (Rodgers and Schwikert 2002). While the motorized boat is capable of greater speed than a paddler might achieve on a kayak, it seldom exceeded 10 $km.h^{-1}$, which is well below regular speeds for motorized boats tested in other disturbance studies (e.g. Burger et al. 2010). The motorized boat is larger and noisier, but its speed is similar to the kayak. From other studies it is clear that approach speed is an important factor in exacerbating disturbance (Bellefleur et al. 2009, Burger et al. 2010), which means that the reaction of the birds in this study is more likely in direct relation to the appearance of each boat type. Because of its size and consistent artificial noise, the boat may appear as a more abstract object to birds than a less predictable and stealthily approaching kayak. This difference in perception of threat is demonstrated in the lesser FIDs of birds in response to buses, cars and bicycles than to a walker (McLeod et al. 2013). The more abstract vehicle forms diminish the perception of threat compared to a lone human. I propose that a paddler is viewed as a more viable threat than the metal, box-shaped boat carrying passengers. Burger et al. (2010) also found that non-motorized vessels caused greater reactions from Common Tern *Sterna hirundo* than motorized boats, which is in agreement with my findings, although the approach distances for each craft type were not recorded. My study is the first that shows such a large and consistent discrepancy in response distances of birds to different types of water transport.

Disturbance footprint of boat tours

The birds that were disturbed on the two boat routes included few species of conservation concern (Figure 3.7), with the occasional exception of Great Crested Grebes and Great White Pelicans. No flamingoes or Maccoa Ducks were disturbed along the two routes, which shows that species of conservation concern can be avoided if routes are designed correctly using knowledge of bird distributions. Boat tours avoided all actively breeding birds (judged either by being on nests or tending juveniles), which is another result of considered route design. The overall number of birds disturbed along each route was not large relative to the total number of birds on the vlei. During the study period, the vlei regularly held 4000-10000 birds (Figure 2.3). In the worst case scenario, even the northern route disturbs at most 12% of the total population of waterbirds on the vlei. More typical trips, especially when birds are abundant, disturb < 5% of the population. Similarly, for Great Crested Grebes the mean total birds disturbed per trip of 28 ± 3 birds is a small fraction of the 400-500 birds consistently present on the vlei. The number of priority species and total birds disturbed by boat tours can be reduced to manageable levels if effort is put in to identifying and avoiding the most productive and diverse areas. However, due to the variable and changing nature of wetlands, the location of such areas is likely to shift over time and adaptive management is needed to adapt boat routes to keep disturbance at acceptably low levels.

Post-disturbance recovery of waterbirds

The recovery of bird communities after disturbance was mostly slow and underwhelming, however there were distinct differences between species (Figures 3.12 and 3.13, Appendix 5). There is little literature reporting post-disturbance recovery times for waterbirds. England et al. (2015) is the only study in an African context, having studied this in shorebird flocks. Their results showed a 90%

recovery of the community within 15 minutes, but this rate of return is not expected in most waterbirds due to their generally clumsier take-off and landing (Tobalske and Dial 2000) and lack of adaptation to environments where evasive action is necessitated due to unpredictable factors such as wave action. Burger et al. (2010) reported that Black Skimmers *Rhyncops niger* return to their nests 9.5 ± 0.6 mins after disturbance by a motorized boat, however, nesting birds have a stronger incentive to return to a specific site (the nest) than foraging birds. While the results were varied, the recovery of De Hoop birds was much slower than these examples with most species requiring a full hour to achieve 70% of pre-disturbance levels. It is worth noting that having open count areas does allow birds to move outside of count areas and resettle, which would cause lower counts and appear to indicate a lower recovery. However, these specific test sites did appear to be important for birds sunbathing and sheltering from the environment (pers. obs.), and would each regularly hold major concentrations of birds which supports their importance. While a displacement of birds from a site without special importance to them may be of little consequence, this will not necessarily be true for birds that are flushed from important sites for resting, feeding or breeding (e.g. Bélanger and Bédard 1990). A recovery time of over an hour may result in an impactful loss of feeding or breeding opportunities, especially if displacement happens frequently (e.g. Galicia and Baldassarre 1997). My results, therefore, show a worryingly slow and underwhelming recovery of bird communities, though some species (e.g. Great Crested Grebe, Cape Shoveler) seem to be worse affected than others.

Habituation likelihood for De Hoop Vlei species

Evidence for the possible habituation of birds at De Hoop Vlei to boat traffic was limited, and needs to be viewed in context with other theories. Coots, cormorants, darters, geese, and herons that had previously been exposed to boat traffic flushed significantly later at the regularly-disturbed Rietvlei, but Great Crested Grebes showed no significant differences in FID between Rietvlei and De Hoop Vlei (Figure 3.15). Most species do appear to tolerate a closer approach before vacating. These birds may benefit from not being displaced from their original site as often. As discussed earlier, birds can suffer serious impacts if flushed from certain important areas (Bélanger and Bédard 1990), and this is a positive result. This is presumably because of previous experience with other watercraft, and can be seen as a form of habituation.

However, AD was not significantly different for most species across the two sites (Figure 3.14). Because AD can be a proxy for physiological response distance (Weston et al. 2012), the lack of difference in AD between the two sites suggests that birds possibly suffer the same physiological distress from disturbances whether they have experience of boats or not. Considering the persistence of physiological distress, the reduction in FID without a reduction in AD is not likely to mitigate against negative physiological consequences. Habituation is therefore unlikely to reduce disturbance effects to a neutral interaction (Bejder et al. 2009), and negative consequences will still be felt by birds that come into contact with boats. In regularly disturbed sites, such as Rietvlei, the possibility exists that intolerant individuals have simply left the site with only individuals tolerant enough to withstand the disturbance remaining (c. f. Fowler 1999). The De Hoop Vlei birds are relatively undisturbed, and it is fair to assume that a spectrum of individual personalities exist within and across species (Beale 2007). It could therefore be misleading to assume an ability for De Hoop Vlei birds to habituate by comparing them to highly tolerant individuals of the same species at another site. Therefore, when interpreting the results one needs to consider that the ability of species at De Hoop Vlei to habituate is likely overestimated to some extent. Beale (2004) also found that birds showing negligible responses to disturbance, which may be interpreted wrongly as habituation (Nisbet 2000), still suffered significant physiological stress that has been linked to nest failure in another species (Beale and Monaghan 2004b). From these results it cannot be assumed that habituation will mitigate against disturbance impacts.

Reactions of species of conservation concern to boat traffic

The fact that flamingoes and Maccoa Ducks were not disturbed by the boat is a good result in terms of limiting disturbance, but because of the lack of encounters with these species (apart from one approach to a Greater Flamingo with the kayak) it was impossible to gauge their sensitivity to disturbance. However, from other literature it is clear that other species of flamingo are particularly susceptible to disturbance from motorized tour boats (Galicia and Baldassarre 1997), and there is therefore good reason to believe that local flamingo species will be similarly affected.

The reactions of birds to disturbance at De Hoop Vlei were concerning overall, but this was especially so for the species of conservation concern. Great White Pelicans (Vulnerable) and Great Crested Grebes (Near-threatened; Taylor et al. 2015) exhibited large ADs and FIDs to both the boat and the kayak relative to both other species at the vlei. Boat routes were also not completely successful in avoiding the disturbance of these species as they commonly inhabit the contiguous open water and do not rely on easily identifiable areas that can then be avoided by design. The data from Rietvlei suggest that Great Crested Grebe show little to no habituation to disturbance, but they are more readily approached at some other wetlands in the region (e.g. Sandvlei; P. Ryan pers. comm.). I was not able to record sufficient responses of Maccoa Ducks or Caspian Terns as they are rare at the vlei, and in the case of Caspian Terns they are seldom static as they mostly use De Hoop Vlei for hunting.

Greater and Lesser Flamingos were never encountered on the two boat routes. This is a positive result as these species were deliberately avoided through careful route design, but it also meant that I could not investigate their level of sensitivity to boat-based tourism. I encountered Greater Flamingo only once during the study while kayaking, and recorded an agitation distance of 303 m. Being larger birds and clumsy at takeoff, flamingoes are likely to be sensitive to disturbance (Tobalske and Dial 2000, Laursen et al. 2005, Blumstein 2006). Galicia and Baldassarre (1997) studied the disturbance responses of the related American Flamingo *Phoenicopterus ruber* to motorized tour boats in Yucatan, Mexico, and found that birds became agitated at > 100 m, which negatively affected their foraging rate and activity budgets. This supports the idea that flamingoes at De Hoop Vlei may also be largely intolerant of boats. It is important that these species are kept in mind when making conservation decisions.

Conclusions

The sensitivity of birds at De Hoop Vlei to both boat types, limited post-disturbance recovery and low potential for habituation all indicate that ecotourism and recreational opportunities on the vlei will need to be well managed to avoid serious negative consequences. Chapter 4 makes specific recommendations to reserve management on how best to manage boat-based tourism to minimize disturbance. If activities are conducted in a careless or unstructured manner then it is likely that the waterbirds at this globally important wetland site will experience otherwise-avoidable disturbance impacts.

Chapter 4

Minimizing the disturbance impacts of boat-based tourism: providing scientifically-based recommendations for reserve management at De Hoop Vlei

Managers of protected areas may look to introduce ecotourism activities as a means of generating revenue. However, ecotourism activities can have detrimental effects on the natural resources being protected within these areas, and so need to be carefully managed. De Hoop Vlei is an important site for waterbird conservation, recognized as a Ramsar site (Ramsar 1971) and an Important Bird Area (IBA; Marnewick et al. 2015, BirdLife International 2016, Chapter 2). It hosts a number of species of conservation concern as well as large congregations of certain species. The site is highly variable in terms of water level and water quality, which drives fluctuations in waterbird abundance and distribution. Tourism operators within the De Hoop Nature Reserve proposed motorized boat and kayak tours of the vlei as possible ecotourism ventures. This study formed the impact assessment for these activities.

Summary of important findings

In Chapter 2 I characterized the waterbird community at De Hoop Vlei at high water levels and compared my data to an analysis of long-term counts at the site (Harebottle 2012). Through different count methods I identified the dominant species at the vlei, the abundance of species of conservation concern, and the species that congregate in large numbers. At high water levels, the waterbird community is dominated by relatively few species: Red-knobbed Coot, Egyptian Goose, and Reed Cormorants. Great Crested Grebes (near-threatened; Taylor et al. 2015), Maccoa Duck (near-threatened) and Caspian Tern (Vulnerable) were the only species of conservation concern consistently present. Great White Pelican (Vulnerable), Greater Flamingo (near-threatened), Lesser Flamingo (near-threatened), and Maccoa Duck (near-threatened) were irregular visitors, but occasionally were present in large numbers. Eight species were present in regionally significant numbers, judged by comparing their maxima with the 1% threshold of the regional population (Wetlands International 2016), which is the minimum threshold required to qualify as a Ramsar wetland. Of these eight species, six were not previously listed as qualifying species (Shaw 1998, Chapter 2). Particularly notable were the additions of Great White Pelican and Caspian Tern, as they can qualify through both threat status and congregatory criteria. By collecting data at a finer time scale than historical quarterly counts, I found that the site's value for waterbirds has been underestimated. Periodic influxes by species such as South African Shelduck and flamingos may be missed in quarterly counts, which is the main cause for this underestimation.

I also investigated the spatial and temporal distributions of birds at the vlei. Bird numbers did not change greatly throughout the day, but there was definite preference shown by waterbirds for specific areas of the vlei. Areas of shallow water and gently sloped shoreline are preferred by most species to deeper waters and steep-sided cliffs. Inundation played a clear role in promoting waterbird abundance at De Hoop Vlei by providing novel shallow water habitat when water levels are otherwise high. This is in agreement with historical observations by Uys and Macleod (1967) who documented a three-year inundation event in the 1960s.

Chapter 3 dealt with the disturbance of waterbirds by a motorized boat and a kayak, and investigated the effects and possible impacts thereof. Overall, birds were sensitive to disturbance from both boat types. The reaction distances of waterbirds were extreme compared to values reported in the literature from other areas. Reactions of almost all species were more severe to the kayak than to the motorized boat. I hypothesize that this is because the motorized boat moved at a slow cruising speed, and that the severity of disturbance is therefore more dependent on the appearance of the respective vessel. The boat is larger, noisier, and less easily associated with humans, while the kayak is more regularly shaped, has a low profile, is quiet, and has an obvious paddler who is using a constant circular paddling motion. The kayak may therefore appear more like a believable predator, and is more readily perceived as a threat. This study was the first to my knowledge that showed such a consistent difference in reactions to two boat types. It was also the first study that documented the distances at which birds respond to boat-based disturbance in Africa, and one of very few studies in an African context that looked at disturbance of birds in general.

I also monitored the disturbance footprint of two boat tour routes by counting the numbers of birds agitated or displaced by the boat. The two routes were designed to avoid areas where birds regularly congregate in large numbers, as well as areas favoured by conservation concern species (both from Chapter 2 data) and those used for breeding (personal observations). The number of birds disturbed along these routes was generally < 10% of the birds present at the vlei, and were typically not species of conservation concern. Great Crested Grebes were the only species regularly disturbed by the boat, but not typically in large numbers, and Great White Pelicans were occasionally disturbed when they were present at the vlei. The boat routes successfully avoided disturbing flamingoes and Maccoa

Ducks as well as most breeding birds. This proved that careful consideration of waterbird distribution can limit the disturbance by boat tours.

I also considered the temporal aspect of disturbance by observing how long it took for bird communities to recover post-disturbance. Bird communities typically recovered to only 70% of their original numbers, reaching this after a period of 40 minutes and then plateauing until one hour post-disturbance. Existing literature reporting post-disturbance recovery for birds is scant, but compared to two other studies my results showed a much slower and less complete recovery. I argue that this limited and slow recovery may in certain conditions translate into negative consequences for foraging opportunities and breeding.

Lastly, I showed through a space-for-time substitution comparison that habituation is likely limited and an ineffective mitigator of disturbance effects. I compared the responses of birds at De Hoop Vlei to conspecifics at Rietvlei – a popular site for boat-based recreation where birds are regularly disturbed. My hypothesis (that birds at Rietvlei should tolerate a much closer approach than birds at De Hoop Vlei because they have had the necessary exposure to habituate) was only partly correct. Most species did show a reduced flight initiation distance (Great Crested Grebe was the one exception), which on its own appears to show successful habituation. However, the distances at which birds were taking flight were still large, and most species (Reed Cormorant was the one exception) did not differ in the distance at which they were agitated by an approach. This means that birds are still likely to suffer the same physiological distress from disturbance, but by reducing their flight initiation distance they may benefit from not being displaced from important sites as often. Thus habituation is limited, and cannot fully mitigate against negative consequences of disturbance.

Recommendations for boat-based tourism at De Hoop Vlei

Drawing on the findings of Chapters 2 and 3 as well as other literature and personal observations, I compiled the following set of recommendations to Cape Nature, the reserve management authority, on kayak and boat tours:

Kayak tours

Kayak tours should not be implemented on De Hoop Vlei for two reasons. Firstly, because kayaking is seldom practical given the weather conditions at the vlei. The vlei is a natural wind tunnel, making kayaking extremely challenging one the wind gets up around mid-morning. Secondly, reactions of birds to the kayak were more severe than to the boat (Chapter 3), which means that the area of disturbance around the kayak is significantly larger. Kayak tours, unlike boat tours, will consist of multiple boats. This will spread the already large area of disturbance over an even wider area. Factors that were controlled in this study such as neutral clothing colour, noise level, paddling speed, and behaviour would not easily be controlled on tours, and would likely exacerbate disturbance. Also, paddlers are liable to explore areas inaccessible to the boat, which may expose hidden breeding areas and naïve birds to disturbance.

Boat tours

Most waterbirds are sensitive to boat disturbance, with species of conservation concern especially susceptible. Consequently, allowing unrestricted boat activity will have negative consequences for the waterbirds. However, with correct management, boat tours on De Hoop Vlei can be conducted in a manner that is not too disruptive to birds.

<u>Avoidance of important areas</u>

While water levels remain at current high levels, boat tours should continue to use the two routes tested in this study. These effectively minimized disturbance to most species of conservation concern, limited the total number of birds disturbed, and avoided disturbing sensitive breeding birds. When water levels drop, altering the abundance and distribution of waterbirds, an adaptive strategy will be required to redesign boat routes (or cancel them) to keep disturbance to acceptable levels. I propose a target of at most 10% of the vlei population of any given waterbird species being affected by the boat routes.

<u>Frequency</u>

I recommended that no more than three boat tours take place per day, and that each tour departs at least one hour after the previous tour has returned. These two measures will limit the number of times per day that species are disturbed, and will give them respite in between disturbance events.

<u>Noise</u>

Boat tours do not play any music or use amplified speakers, which I recommended be maintained. Loud or erratic noise can exacerbate disturbances (e.g. Chan et al. 2010). Boat skippers/guides should encourage guests to keep voice levels onboard to a reasonable level.

Speed

The current cruising speed of the boat appears to minimize the disturbance to waterbirds. I recommended that the boat adheres to a strict speed limit of 15 $km.h^{-1}$. Greater speed has been shown to induce larger disturbance in birds (Burger et al. 2010).

Timing of disturbance

Tours should not take place within two hours of sunrise or sunset. In the morning, diurnal birds need to forage after the night's fast, and in the evening birds begin to settle into roosts. Disturbance at this time can require compensatory feeding at nighttime (Bélanger and Bédard 1989), and flushing from roost sites just before dark may force birds into less suitable sites which may have consequences for rest quality and predation risk.

Avoidance of breeding birds

Considering the distances at which birds were agitated and displaced by the boat, I recommended a set-back distance of 120 m from any breeding birds along the boat routes. This should prevent disturbance effects for most species. This distance can also be used to avoid important areas (e.g. the island that surfaces between Die Opstal and Melkkamer) when redesigning routes in future.

Guest education

On each boat tour a qualified nature guide accompanied the passengers. I support this practice, as there is a benefit to educating ecotourists about the environment. If education of ecotourists encourages better attitudes towards the environment or greater financial inputs into ecotourism then this can considered as an 'offset' to disturbance impacts. Guides should be trained to identify waterbird species and stress behaviours, and use their judgment to avoid undue disturbance to birds.

Conclusions

The importance of De Hoop Vlei for waterbirds has previously been underestimated. The new information presented in my study provides strong motivation for the continuation of monitoring at the site, and if possible this should be implemented on a monthly rather than quarterly basis. The site would benefit from an updated assessment for both the Ramsar and IBA schemes.

The impact of boat tours is likely to change as the number of birds, composition of the bird community, spatial and temporal distributions of species change in response to rising and falling water levels, among other factors. Boat tours should be monitored from time to time in order to track the impact. If this exceeds an acceptable level (I propose this is when > 10% of the total population is regularly being disturbed by tours, but management may prefer to focal on individual species) then tours will need to be redesigned or canceled. I was unable to test the drivers of waterbird populations at the site because of a lack of data for environmental variables. I recommend that the tracking of variables such as water level, pH, salinity, and dissolved solids is implemented to better understand the fluctuations in populations of waterbirds at De Hoop Vlei. It would also be informative to track waterbird populations at other nearby wetlands in order to investigate the local movement of birds, but logistical constraints for this may be inhibitive.

Disclaimers

Statistical results disclaimer

Statistical advice was provided by Ms Sanet Hugo of the UCT Statistical Consultancy. Any opinion, findings and conclusions or recommendations expressed in this document are those of the author and the Statistical Consulting Service (UCT) does not accept responsibility for the statistical correctness of the research results reported.

Ethics disclaimer

This thesis was granted ethics clearance by the UCT Science Faculty Animal Ethics Committee before commencement of fieldwork (ethics number 2015/V10/PR).

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Appendices

Appendix 1: List of bird species recorded at De Hoop Nature Reserve from March 2015 to July 2016

	Common Name	Genus	Species	Waterbird	Migrant	Status
1	Common Ostrich	*Struthio*	*camelus*			
2	Helmeted Guineafowl	*Numida*	*meleagris*			
3	Grey-winged Francolin	*Scleroptila*	*africana*			
4	Cape Spurfowl	*Pternistis*	*capensis*			
5	Common Quail	*Coturnix*	*coturnix*		x	
6	White-faced Whistling Duck	*Dendrocygna*	*viduata*	x		
7	White-backed Duck	*Thalassornis*	*leuconotus*	x		
8	Spur-winged Goose	*Plectropterus*	*gambensis*	x		
9	Egyptian Goose	*Alopochen*	*aegyptiaca*	x		
10	South African Shelduck	*Tadorna*	*cana*	x		
11	Cape Teal	*Anas*	*capensis*	x		
12	Mallard	*Anas*	*platyrhynchos*	x		
13	Yellow-billed Duck	*Anas*	*undulata*	x		
14	Cape Shoveler	*Anas*	*smithii*	x		
15	Hottentot Teal	*Anas*	*hottentota*	x		
16	Southern Pochard	*Netta*	*erythrophthalma*	x		
17	Maccoa Duck	*Oxyura*	*maccoa*	x		NT
18	White-chinned Petrel	*Procellaria*	*aequinoctialis*			
19	Little Grebe	*Tachybaptus*	*ruficollis*	x		
20	Great Crested Grebe	*Podiceps*	*cristatus*	x		NT
21	Black-necked Grebe	*Podiceps*	*nigricollis*	x		
22	Greater Flamingo	*Phoenicopterus*	*roseus*	x		NT
23	Lesser Flamingo	*Phoeniconaias*	*minor*	x		NT
24	Black Stork	*Ciconia*	*nigra*			
25	African Sacred Ibis	*Threskiornis*	*aethiopicus*	x		
26	Hadeda Ibis	*Bostrychia*	*hagedash*			
27	Glossy Ibis	*Plegadis*	*falcinellus*	x		
28	African Spoonbill	*Platalea*	*alba*	x		
29	Black-crowned Night Heron	*Nycticorax*	*nycticorax*	x		
30	Western Cattle Egret	*Bubulcus*	*ibis*			
31	Grey Heron	*Ardea*	*cinerea*	x		
32	Black-headed Heron	*Ardea*	*melanocephala*			
33	Purple Heron	*Ardea*	*purpurea*	x		
34	Great Egret	*Ardea*	*alba*	x		
35	Yellow-billed Egret	*Egretta*	*intermedia*	x		
36	Little Egret	*Egretta*	*garzetta*	x		
37	Hamerkop	*Scopus*	*umbretta*	x		
38	Great White Pelican	*Pelecanus*	*onocrotalus*	x		V
39	Cape Gannet	*Morus*	*capensis*			
40	Reed Cormorant	*Microcarbo*	*africanus*	x		
41	Crowned Cormorant	*Microcarbo*	*coronatus*			
42	White-breasted Cormorant	*Phalacrocorax*	*lucidus*	x		
43	Cape Cormorant	*Phalacrocorax*	*capensis*			
44	African Darter	*Anhinga*	*rufa*	x		
45	Secretarybird	*Sagittarius*	*serpentarius*			
46	Black-shouldered Kite	*Elanus*	*caeruleus*			
47	African Harrier-Hawk	*Polyboroides*	*typus*			
48	Cape Vulture	*Gyps*	*coprotheres*			
49	Martial Eagle	*Polemaetus*	*bellicosus*			
50	Booted Eagle	*Hieraaetus*	*pennatus*			
51	Verreaux's Eagle	*Aquila*	*verreauxii*			
52	Pale Chanting Goshawk	*Melierax*	*canorus*			
53	African Goshawk	*Accipiter*	*tachiro*			
54	Black Sparrowhawk	*Accipiter*	*melanoleucus*			

55	African Marsh Harrier	*Circus*	*ranivorus*	x	
56	Black Harrier	*Circus*	*maurus*		
57	Yellow-billed Kite	*Milvus*	*aegyptius*		
58	African Fish Eagle	*Haliaeetus*	*vocifer*	x	
59	Common Buzzard	*Buteo*	*buteo*		x
60	Jackal Buzzard	*Buteo*	*rufofuscus*		
61	Lesser Kestrel	*Falco*	*naumanni*		x
62	Rock Kestrel	*Falco*	*rupicolus*		
63	Amur Falcon	*Falco*	*amurensis*		x
64	Peregrine Falcon	*Falco*	*peregrinus*		
65	Denham's Bustard	*Neotis*	*denhami*		
66	Southern Black Korhaan	*Afrotis*	*afra*		
67	Red-chested Flufftail	*Sarothrura*	*rufa*	x	
68	African Rail	*Rallus*	*caerulescens*	x	
69	Black Crake	*Amaurornis*	*flavirostra*	x	
70	Baillon's Crake	*Porzana*	*pusilla*	x	
71	Common Moorhen	*Gallinula*	*chloropus*	x	
72	Red-knobbed Coot	*Fulica*	*cristata*	x	
73	Blue Crane	*Grus*	*paradiseus*		
74	Hottentot Buttonquail	*Turnix*	*hottentottus*		
75	Water Thick-knee	*Burhinus*	*vermiculatus*	x	
76	Spotted Thick-knee	*Burhinus*	*capensis*		
77	African Black Oystercatcher	*Haematopus*	*moquini*		
78	Black-winged Stilt	*Himantopus*	*himantopus*	x	
79	Pied Avocet	*Recurvirostra*	*avosetta*	x	
80	Blacksmith Lapwing	*Vanellus*	*armatus*	x	
81	Crowned Lapwing	*Vanellus*	*coronatus*		
82	Grey Plover	*Pluvialis*	*squatarola*	x	x
83	Common Ringed Plover	*Charadrius*	*hiaticula*	x	
84	Kittlitz's Plover	*Charadrius*	*pecuarius*	x	
85	Three-banded Plover	*Charadrius*	*tricollaris*	x	
86	White-fronted Plover	*Charadrius*	*marginatus*		
87	African Snipe	*Gallinago*	*nigripennis*	x	
88	Bar-tailed Godwit	*Limosa*	*lapponica*		x
89	Whimbrel	*Numenius*	*phaeopus*		x
91	Common Sandpiper	*Actitis*	*hypoleucos*	x	x
92	Little Stint	*Calidris*	*minuta*	x	x
93	Ruff	*Philomachus*	*pugnax*	x	x
94	Grey-headed Gull	*Chroicocephalus*	*cirrocephalus*	x	
95	Hartlaub's Gull	*Chroicocephalus*	*hartlaubii*	x	
96	Kelp Gull	*Larus*	*dominicanus*	x	
97	Caspian Tern	*Hydroprogne*	*caspia*	x	
98	Swift Tern	*Thalasseus*	*bergii*		
99	Sandwich Tern	*Thalasseus*	*sandvicensis*		x
100	Common Tern	*Sterna*	*hirundo*		x
101	Whiskered Tern	*Chlidonias*	*hybrida*	x	x
102	White-winged Tern	*Chlidonias*	*leucopterus*	x	x
103	Namaqua Sandgrouse	*Pterocles*	*namaqua*		
104	Rock Dove	*Columba*	*livia*		
105	Speckled Pigeon	*Columba*	*guinea*		
106	African Olive Pigeon	*Columba*	*arquatrix*		
107	Red-eyed Dove	*Streptopelia*	*semitorquata*		
108	Cape Turtle Dove	*Streptopelia*	*capicola*		
109	Laughing Dove	*Spilopelia*	*senegalensis*		
110	Namaqua Dove	*Oena*	*capensis*		
111	Jacobin Cuckoo	*Clamator*	*jacobinus*		x
112	Diederik Cuckoo	*Chrysococcyx*	*caprius*		x
113	Klaas's Cuckoo	*Chrysococcyx*	*klaas*		x
114	Black Cuckoo	*Cuculus*	*clamosus*		x
115	Red-chested Cuckoo	*Cuculus*	*solitarius*		x

116	Western Barn Owl	*Tyto*	*alba*		
117	Spotted Eagle-Owl	*Bubo*	*africanus*		
118	Rufous-cheeked Nightjar	*Caprimulgus*	*rufigena*		x
119	Fiery-necked Nightjar	*Caprimulgus*	*pectoralis*		
120	Alpine Swift	*Tachymarptis*	*melba*		x
121	Common Swift	*Apus*	*apus*		x
122	African Black Swift	*Apus*	*barbatus*		
123	Little Swift	*Apus*	*affinis*		x
124	Horus Swift	*Apus*	*horus*		x
125	White-rumped Swift	*Apus*	*caffer*		x
126	Speckled Mousebird	*Colius*	*striatus*		
127	White-backed Mousebird	*Colius*	*colius*		
128	Red-faced Mousebird	*Urocolius*	*indicus*		
129	Malachite Kingfisher	*Corythornis*	*cristata*	x	
130	Giant Kingfisher	*Megaceryle*	*maxima*	x	
131	Pied Kingfisher	*Ceryle*	*rudis*	x	
132	African Hoopoe	*Upupa*	*africana*		
133	Acacia Pied Barbet	*Tricholaema*	*leucomelas*		
134	Lesser Honeyguide	*Indicator*	*minor*		
135	Greater Honeyguide	*Indicator*	*indicator*		
136	Knysna Woodpecker	*Campethera*	*notata*		
137	Cardinal Woodpecker	*Dendropicos*	*fuscescens*		
138	Olive Woodpecker	*Dendropicos*	*griseocephalus*		
139	Cape Batis	*Batis*	*capensis*		
140	Bokmakierie	*Telophorus*	*zeylonus*		
141	Southern Tchagra	*Tchagra*	*tchagra*		
142	Southern Boubou	*Laniarius*	*ferrugineus*		
143	Black Cuckooshrike	*Campephaga*	*flava*		
144	Southern Fiscal	*Lanius*	*collaris*		
145	Eurasian Golden Oriole	*Oriolus*	*oriolus*		x
146	Fork-tailed Drongo	*Dicrurus*	*adsimilis*		
147	African Paradise Flycatcher	*Terpsiphone*	*viridis*		x
148	Cape Crow	*Corvus*	*capensis*		
149	Pied Crow	*Corvus*	*albus*		
150	White-necked Raven	*Corvus*	*albicollis*		
151	Grey Tit	*Parus*	*afer*		
152	Cape Penduline Tit	*Anthoscopus*	*minutus*		
153	Cape Clapper Lark	*Mirafra*	*apiata*		
154	Agulhas Long-billed Lark	*Certhilauda*	*brevirostris*		
155	Red-capped Lark	*Calandrella*	*cinerea*		
156	Large-billed Lark	*Galerida*	*magnirostris*		
157	Cape Bulbul	*Pycnonotus*	*capensis*		
158	Sombre Greenbul	*Andropadus*	*importunus*		
159	Black Saw-wing	*Psalidoprocne*	*pristoptera*		x
160	Brown-throated Martin	*Riparia*	*paludicola*	x	
161	Barn Swallow	*Hirundo*	*rustica*		x
162	White-throated Swallow	*Hirundo*	*albigularis*	x	x
163	Pearl-breasted Swallow	*Hirundo*	*dimidiata*		x
164	Rock Martin	*Ptyonoprogne*	*fuligula*		
165	Common House Martin	*Delichon*	*urbicum*		x
166	Greater Striped Swallow	*Cecropis*	*cucullata*		x
167	Cape Grassbird	*Sphenoeacus*	*afer*		
168	Long-billed Crombec	*Sylvietta*	*rufescens*		
169	Willow Warbler	*Phylloscopus*	*trochilus*		x
170	Lesser Swamp Warbler	*Acrocephalus*	*gracilirostris*	x	
171	African Reed Warbler	*Acrocephalus*	*baeticatus*	x	x
172	Little Rush Warbler	*Bradypterus*	*baboecala*	x	
173	Grey-backed Cisticola	*Cisticola*	*subruficapilla*		
174	Levaillant's Cisticola	*Cisticola*	*tinniens*	x	
175	Neddicky	*Cisticola*	*fulvicapilla*		

176	Zitting Cisticola	*Cisticola*	*juncidis*
177	Cloud Cisticola	*Cisticola*	*textrix*
178	Karoo Prinia	*Prinia*	*maculosa*
179	Bar-throated Apalis	*Apalis*	*thoracica*
180	Chestnut-vented Tit-babbler	*Sylvia*	*subcaerulea*
181	Layard's Tit-babbler	*Sylvia*	*layardi*
182	Cape White-eye	*Zosterops*	*capensis*
183	Cape Sugarbird	*Promerops*	*cafer*
184	Common Starling	*Sturnus*	*vulgaris*
185	Wattled Starling	*Creatophora*	*cinerea*
186	Pied Starling	*Lamprotornis*	*bicolor*
187	Red-winged Starling	*Onychognathus*	*morio*
188	Olive Thrush	*Turdus*	*olivaceus*
189	Cape Robin-Chat	*Cossypha*	*caffra*
190	Karoo Scrub Robin	*Erythropygia*	*coryphaeus*
191	African Stonechat	*Saxicola*	*torquatus*
192	Capped Wheatear	*Oenanthe*	*pileata*
193	Familiar Chat	*Oenanthe*	*familiaris*
194	Chat Flycatcher	*Bradornis*	*infuscatus*
195	Fiscal Flycatcher	*Sigelus*	*silens*
196	African Dusky Flycatcher	*Muscicapa*	*adusta*
197	Orange-breasted Sunbird	*Anthobaphes*	*violacea*
198	Amethyst Sunbird	*Chalcomitra*	*amethystina*
199	Malachite Sunbird	*Nectarinia*	*famosa*
200	Southern Double-collared	*Cinnyris*	*chalybeus*
201	Greater Double-collared	*Cinnyris*	*afer*
202	House Sparrow	*Passer*	*domesticus*
203	Cape Sparrow	*Passer*	*melanurus*
204	Southern Grey-headed	*Passer*	*diffusus*
205	Cape Weaver	*Ploceus*	*capensis*
206	Southern Red Bishop	*Euplectes*	*orix*
207	Yellow Bishop	*Euplectes*	*capensis*
208	Swee Waxbill	*Coccopygia*	*melanotis*
209	Common Waxbill	*Estrilda*	*astrild*
210	Cape Wagtail	*Motacilla*	*capensis*
211	Cape Longclaw	*Macronyx*	*capensis*
212	African Pipit	*Anthus*	*cinnamomeus*
213	Long-billed Pipit	*Anthus*	*similis*
214	Yellow Canary	*Crithagra*	*flaviventris*
215	Brimstone Canary	*Crithagra*	*sulphurata*
216	White-throated Canary	*Crithagra*	*albogularis*
217	Streaky-headed Seedeater	*Crithagra*	*gularis*
218	Cape Siskin	*Crithagra*	*totta*
219	Cape Canary	*Serinus*	*canicollis*
220	Lark-like Bunting	*Emberiza*	*impetuani*
221	Cape Bunting	*Emberiza*	*capensis*

Appendix 2: Birdlife Important Bird Area (IBA) designations for the waterbirds of De Hoop Vlei contrasted with the results of the De Hoop Vlei Project of 2015/16. Mean population values were taken from the 12 Co-ordinated Water Avifaunal Counts (CWACs). Maximum population values were either from CWACs or from counts in the baseline survey, with the exception of Hottentot Teal and Grey Plover where only one or two individuals were ever encountered, and never on official counts.

Common name	Regional Status[1]	Global Status[2]	Trigger Species?[3]	1% Threshold[4]	Mean popn	Max popn	>1%
Little Grebe	LC	LC	No	10000	157	493	No
Great-crested Grebe	NT	LC	Yes	100	438	837	Yes
Black-necked Grebe	LC	LC	No	240	176	373	Yes
Great White Pelican	V	LC	No	300	71	328	Yes
White-breasted Cormorant	LC	LC	No	130	354	560	Yes
Reed Cormorant	LC	LC	No	10000	710	1651	No
African Darter	LC	LC	No	1000	99	218	No
Grey Heron	LC	LC	No	10000	50	118	No
Great White Egret	LC	LC	No	2200	1	3	No
Yellow-billed Egret	LC	LC	No	1000	1	8	No
Purple Heron	LC	LC	No	870	1	5	No
Cattle Egret	LC	LC	No	10000	-	-	No
Little Egret	LC	LC	No	3200	33	124	No
Black-crowned Night Heron	LC	LC	No	10000	3	25	No
Hamerkop	LC	LC	No	10000	3	8	No
African Sacred Ibis	LC	LC	No	3000	40	347	No
Hadeda Ibis	LC	LC	No	1000	4	23	No
Glossy Ibis	LC	LC	No	20000	1	4	No
African Spoonbill	LC	LC	No	1000	35	114	No
Greater Flamingo	NT	LC	Yes	760	138	379	No
Lesser Flamingo	NT	NT	No	600	4	53	No
White-faced Whistling Duck	LC	LC	No	10000	1	7	No
White-backed Duck	LC	LC	No	180	0	2	No
Egyptian Goose	LC	LC	No	3500	892	2843	No
South African Shelduck	LC	LC	No	500	206	1412	Yes
Spur-winged Goose	LC	LC	No	750	10	62	No
Cape Teal	LC	LC	No	1750	72	315	No
Yellow-billed Duck	LC	LC	Yes	10000	34	103	No
Red-billed Teal	LC	LC	No	7500	2	6	No
Hottentot Teal	LC	LC	No	1000	-	2	No
Cape Shoveler	LC	LC	Yes	350	285	758	Yes
Southern Pochard	LC	LC	No	500	39	130	No
Maccoa Duck	NT	NT	No	80	48	152	Yes
Common Moorhen	LC	LC	No	10000	0	2	No
Red-knobbed Coot	LC	LC	Yes	10000	1844	5574	No
Black-winged Stilt	LC	LC	No	10000	16	60	No
Pied Avocet	LC	LC	No	190	9	49	No
Water Thick-knee	LC	LC	No	1000	2	6	No
Spotted Thick-knee	LC	LC	No	1000	-	2	No

Blacksmith Lapwing	LC	LC	No	10000	4	11	No
Crowned Lapwing	LC	LC	No	6500	-	-	No
Grey Plover	LC	LC	No	900	-	1	No
Common Ringed Plover	LC	LC	No	1900	0	6	No
Kittlitz's Plover	LC	LC	No	2500	4	16	No
Three-banded Plover	LC	LC	No	1000	1	4	No
Common Greenshank	LC	LC	No	12300	1	4	No
Common Sandpiper	LC	LC	No	N/A	2	2	No
Little Stint	LC	LC	No	10000	9	61	No
Ruff	LC	LC	No	N/A	1	6	No
Kelp Gull	LC	LC	No	700	54	112	No
Grey-headed Gull	LC	LC	No	3000	15	51	No
Hartlaub's Gull	LC	LC	No	300	5	36	No
Caspian Tern	V	LC	No	20	17	55	Yes
Whiskered Tern	LC	LC	No	100	0	1	No
White-winged Tern	LC	LC	No	20000	0	2	No

[1]Taylor et al. 2015. *The 2015 Eskom Red Data book of birds of South Africa, Lesotho and Swaziland*. Birdlife South Africa. Johannesburg.

[2]IUCN 2016. *The IUCN Red List of Threatened Species. Version 2016-2*. <http://www.iucnredlist.org>. Downloaded on 01 November 2016.

[3]BirdLife International. 2016. Important Bird and Biodiversity Area factsheet: De Hoop Nature Reserve. Downloaded from http://www.birdlife.org on 01 November 2016.

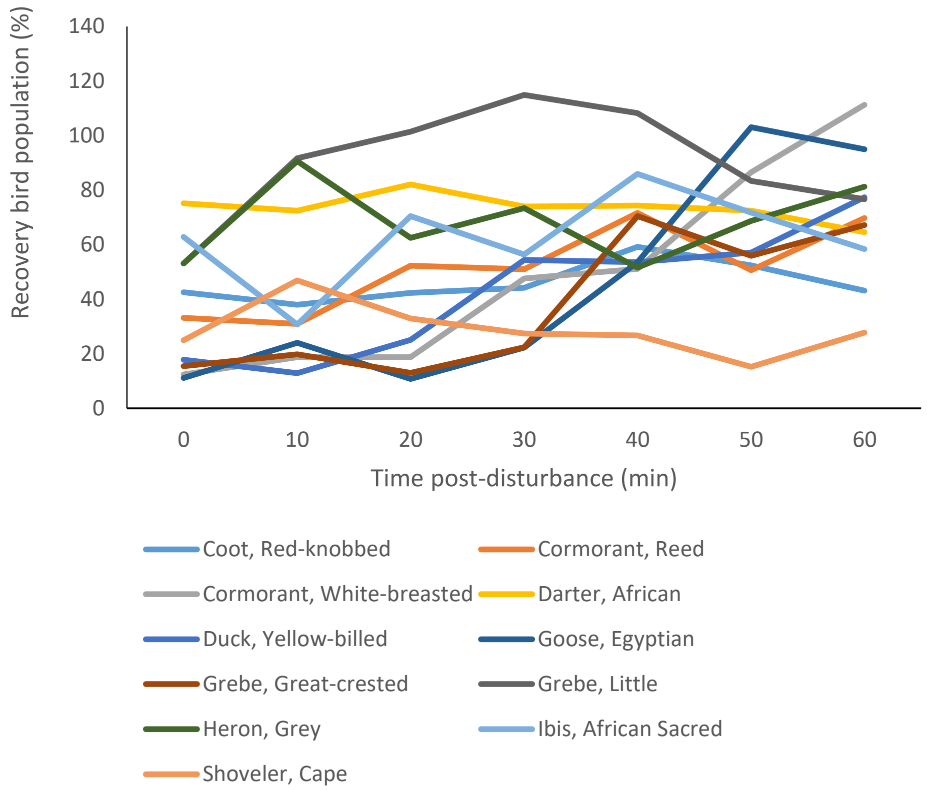
[4]Wetlands International. 2006. (eds. Delany, S., Scott, D., & Helmink, A. T. F) *Waterbird population estimates – fourth edition*. Wetlands International. Wageningen, Netherlands.

Appendix 3: Summary of data and significance of differences in agitation distance (AD) and flight initiation distance (FID) in response to a boat and a kayak, as well as between De Hoop Vlei and Rietvlei wetlands. Those with fewer than five observations are shaded grey and were not used in statistical testing. Statistical test used was a homoscedastic, two-tailed t-test.

	p value				Sample size					
	Motorized boat v Kayak		**De Hoop Vlei v Rietvlei**		**Boat**		**De Hoop Kayak**		**Rietvlei Kayak**	
Species	**AD**	**FID**	**AD**	**FID**	**AD**	**FID**	**AD**	**FID**	**AD**	**FID**
Coot, Red-knobbed	0.129	0.001	0.133	0.001	37	41	24	45	13	20
Cormorant, Reed	0.135	0.000	0.014	0.000	51	242	21	96	7	14
Cormorant, White-breasted	0.199	0.027	0.457	0.004	27	39	12	32	8	12
Darter, African	0.111	0.000	0.084	0.000	31	67	7	32	17	38
Duck, Yellow-billed	-	0.482	-	0.015	2	10	3	16	8	12
Egret, Little	-	0.160	-	-	3	16	1	12	-	-
Goose, Egyptian	-	0.267	-	-	10	31	2	12	-	-
Grebe, Black-necked	0.375	0.163	-	-	7	11	3	6	-	-
Grebe, Great-crested	0.000	0.000	0.310	0.286	65	87	37	42	12	14
Grebe, Little	0.034	0.001	-	-	11	47	10	34	-	-
Hamerkop	-	0.004	-	-	1	12	3	10	-	-
Heron, Black-crowned Night	-	0.186	-	-	4	24	5	43	-	-
Heron, Grey	0.234	0.000	0.455	0.000	29	102	7	46	8	19
Ibis, African Sacred	-	0.439	-	-	12	15	2	9	-	-
All birds	0.004	0.000	0.066	0.000	323	791	156	484	100	190

Appendix 4: Summarized results of Co-ordinated Water Avifaunal Counts (CWACs) performed between April 2015 and March 2016. 95% CI = 95% confidence intervals. n Counts = number of counts with total > 0.

Species	Mean	95% CI	Maximum	n Counts
Avocet, Pied	9	9	49	6
Coot, Red-knobbed	1844	833	5574	12
Cormorant, Reed	710	249	1651	12
Cormorant, White-breasted	354	73	560	12
Darter, African	99	41	218	12
Duck, Maccoa	48	27	152	12
Duck, White-backed	0	0	2	2
Duck, White-faced Whistling	1	1	7	1
Duck, Yellow-billed	34	18	103	12
Eagle, African Fish	2	1	7	10
Egret, Great	1	1	3	6
Egret, Little	33	21	124	12
Egret, Yellow-billed	1	2	8	3
Flamingo, Greater	138	74	379	12
Flamingo, Lesser	4	9	53	1
Goose, Egyptian	892	444	2843	12
Goose, Spur-winged	10	10	62	9
Grebe, Black-necked	176	64	373	11
Grebe, Great-crested	438	98	837	12
Grebe, Little	157	97	493	12
Greenshank, Common	1	1	4	6
Gull, Grey-headed	15	8	51	10
Gull, Hartlaub's	5	6	36	5
Gull, Kelp	54	19	112	12
Hamerkop	3	1	8	10
Heron, Black-crowned Night	3	4	25	8
Heron, Grey	50	16	118	12
Heron, Purple	1	1	5	5
Ibis, African Sacred	40	55	347	12
Ibis, Glossy	1	1	4	9
Ibis, Hadeda	4	4	23	5
Kingfisher, Giant	2	1	4	7
Kingfisher, Malachite	0	1	3	3
Kingfisher, Pied	1	1	5	2
Lapwing, Blacksmith	4	2	11	11
Moorhen, Common	0	0	2	4
Pelican, Great White	71	52	328	12
Plover, Common Ringed	6	-	6	1
Plover, Kittlitz's	4	3	16	9
Plover, Three-banded	1	1	4	8
Pochard, Southern	39	25	130	10
Ruff	1	1	6	2
Sandpiper, Common	2	-	2	1
Shelduck, South African	206	253	1412	6
Shoveler, Cape	285	124	758	12
Spoonbill, African	35	21	114	10
Stilt, Black-winged	16	9	60	12
Stint, Little	9	10	61	6
Teal, Cape	72	56	315	11
Teal, Red-billed	2	1	6	7
Tern, Caspian	16.75	9	55	12
Tern, Whiskered	1	-	1	1
Tern, White-winged	2	-	2	1
Thick-knee, Water	2	1	6	8
Wagtail, Cape	8.25	3	18	12
All species	**5913**	**1376**	**10310**	**12**



Appendix 5: Post-disturbance recovery of 11 species of waterbirds after being flushed by a kayak showing the range in recover rates for different species.

Appendix 6: Percentage habitat use by waterbird species at De Hoop Vlei, listed alphabetically by group. $\chi 2 < 0.05$ indicates a significant deviation from the expected values (highlighted in grey).

Species	**Water**	**Shore**	**Shallows**	**Aq Veg**	**Veg**	**χ2**
Avocet, Pied	0.00	0.00	0.75	0.25	0.00	0.48
Coot, Red-knobbed	0.32	0.05	0.23	0.39	0.01	0.49
Cormorant, Reed	0.05	0.11	0.02	0.02	0.79	0.00
Cormorant, White-breasted	0.06	0.60	0.03	0.00	0.31	0.28
Darter, African	0.02	0.03	0.00	0.00	0.94	0.00
Duck, Maccoa	0.34	0.01	0.08	0.46	0.11	0.29
Duck, White-backed	0.02	0.00	0.04	0.94	0.00	0.00
Duck, Yellow-billed	0.03	0.17	0.31	0.49	0.00	0.21
Eagle, African Fish	0.00	0.10	0.00	0.00	0.90	0.00
Egret, Great	0.00	0.49	0.00	0.03	0.47	0.12
Egret, Little	0.02	0.52	0.01	0.00	0.45	0.14
Egret, Yellow-billed	0.00	0.42	0.03	0.05	0.50	0.12
Flamingo, Greater	0.00	0.08	0.63	0.28	0.00	0.54
Flamingo, Lesser	0.02	0.00	0.18	0.80	0.00	0.00
Goose, Egyptian	0.08	0.57	0.07	0.28	0.00	0.36
Goose, Spur-winged	0.06	0.31	0.11	0.51	0.00	0.14
Grebe, Black-necked	0.49	0.00	0.23	0.28	0.00	0.79
Grebe, Great Crested	0.47	0.00	0.03	0.50	0.00	0.22
Grebe, Little	0.54	0.00	0.24	0.21	0.00	0.92
Gull, Grey-headed	0.01	0.94	0.01	0.03	0.02	0.10
Gull, Hartlaub's	0.00	1.00	0.00	0.00	0.00	0.06
Gull, Kelp	0.44	0.54	0.01	0.00	0.00	0.69
Hamerkop	0.00	0.76	0.00	0.00	0.24	0.18
Harrier, African Marsh	0.00	0.00	0.00	0.00	1.00	0.00
Heron, Black-crowned Night	0.00	0.10	0.00	0.00	0.90	0.00
Heron, Grey	0.00	0.73	0.05	0.05	0.17	0.27
Ibis, African Sacred	0.00	0.80	0.07	0.04	0.09	0.23
Ibis, Glossy	0.00	0.93	0.02	0.04	0.02	0.10
Kingfisher, Giant	0.00	0.80	0.00	0.00	0.20	0.17
Kingfisher, Malachite	0.00	0.50	0.00	0.00	0.50	0.09
Kingfisher, Pied	0.00	0.43	0.14	0.00	0.43	0.22
Lapwing, Blacksmith	0.00	0.99	0.00	0.01	0.00	0.06
Moorhen, Common	0.01	0.40	0.40	0.19	0.00	0.68
Pelican, Great White	0.25	0.67	0.04	0.05	0.00	0.45
Plover, Kittlitz's	0.00	0.83	0.00	0.17	0.00	0.15
Plover, Three-banded	0.00	0.97	0.03	0.00	0.00	0.08
Pochard, Southern	0.27	0.00	0.18	0.55	0.00	0.14
Ruff	0.00	1.00	0.00	0.00	0.00	0.06
Shelduck, South African	0.01	0.68	0.15	0.16	0.01	0.35
Shoveler, Cape	0.04	0.16	0.42	0.37	0.01	0.46
Spoonbill, African	0.00	0.42	0.21	0.37	0.01	0.34
Stilt, Black-winged	0.00	0.95	0.01	0.01	0.03	0.08
Teal, Cape	0.03	0.31	0.66	0.00	0.00	0.71
Teal, Hottentot	0.00	0.60	0.40	0.00	0.00	0.49
Teal, Red-billed	0.00	0.75	0.23	0.02	0.01	0.30
Tern, Caspian	0.00	0.98	0.00	0.00	0.02	0.07
Thick-knee, Water	0.00	0.75	0.00	0.00	0.25	0.18
Wagtail, Cape	0.02	0.94	0.00	0.00	0.04	0.09
All species	0.23	0.15	0.16	0.29	0.16	0.68
Expected values	**0.63**	**0.1**	**0.2**	**0.04**	**0.04**	**-**