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Review

# A review of the impacts of nature based recreation on birds

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ABSTRACT

Nature based recreation such as wildlife viewing, hiking, running, cycling, canoeing, horse riding and dog walking can have negative environmental effects. A review of the recreation ecology literature published in English language academic journals identified 69 papers from 1978 to 2010 that examined the effect of these activities on birds. Sixty-one of the papers (88%) found negative impacts, including changes in bird physiology (all 11 papers), immediate behaviour (37 out of 41 papers), as well as changes in abundance (28 out of 33 papers) and reproductive success (28 out of 33 papers). Previous studies are concentrated in a few countries (United States, England, Argentina and New Zealand), mostly in cool temperate or temperate climatic zones, often in shoreline or wetland habitats, and mostly on insectivore, carnivore and crustaceovore/molluscivore foraging guilds. There is limited research in some regions with both high bird diversity and nature based recreation such as mainland Australia, Central America, Asia, and Africa, and for popular activities such as mountain bike riding and horse riding. It is clear, however, that non-motorised nature based recreation has negative impacts on a diversity of birds from a range of habitats in different climatic zones and regions of the world.



## 1. Introduction

Nature based tourism and recreation, such as the viewing of wildlife, is popular and often occurs in protected areas (Newsome et al., 2002; Higginbottom, 2004). However, these activities have a range of negative environmental effects on fauna, including birds (Liddle, 1997; Newsome et al., 2002; Buckley, 2004; Jones and Nealson, 2005). Nature based tourism and recreation activities have been found to alter the physiology and immediate behaviour of birds (Liddle, 1997; Beale and Monaghan, 2004; Walker et al., 2006; Lindsay et al., 2008). Physiological responses include changes in temperature, heart rate or stress hormone secretion (Müllner et al., 2004; Thiel et al., 2008). Immediate behavioural responses include changes in foraging, vigilance and evasion (Regel and Putz, 1997; Buckley, 2004). Within bird populations responses can include changes in reproductive success and/or the number or density of birds (Liddle, 1997; Buckley, 2004; Banks and Bryant, 2007; Cardoni et al., 2008). For example, many studies have found a reduction in the number of nests built, eggs laid, and chicks hatched or fledged as a result of nature based tourism (Liddle, 1997; Buckley, 2004; Müllner et al., 2004; Liley and Sutherland, 2007).

Quantifying the effects of nature based tourism and recreation on birds is a growing area of research in recreation ecology (Liddle, 1997; Buckley, 2004). A review of the impacts of tourism on birds (Buckley, 2004) found much of the research had focused on motorised recreational activities such as off-road vehicles, use of personal water craft and a range of aircraft. In contrast there was limited research on the impacts of many popular non-motorised activities such as wildlife viewing, hiking, mountain biking, dog walking and horse riding (Buckley, 2004).

This study assesses the current recreation ecology literature on the effect of non-motorised nature based recreation on birds. A database of English language papers published in academic journals on this topic was compiled to determine; 1) what methods have been used to detect effects on birds; 2) which species/families of birds have been assessed; 3) what are the responses of birds; 4) where has the research been conducted; and 5) conversely, which locations, habitats and bird taxa are missing from the literature.

## 2. Methods

Research papers published in English language journals on the impacts of non-motorised nature based recreation on birds were obtained by searching electronic databases of scientific and tourism journals including; Web of Science, Google Scholar, and Science Direct from July to September 2010. Keywords used for the searches were 'bird' and a combination of the following terms; 'trail', 'track',

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'walking', 'hiking', 'impact', 'disturbance', 'mountain bike', 'effect', 'dog walking', 'horse riding', 'ecotourism', 'tourism' and 'recreation'. This study did not look at other non-motorised nature based tourism and recreation activities that involve people deliberately altering bird behaviour such as bird feeding. There is separate literature on bird feeding, including studies examining impacts on birds (Orams, 2002; Green and Giese, 2004).

Only papers describing the results of original research on the impact of these types of non-motorised nature based recreation activities that had been peer reviewed and published in academic journals were included. Review papers along with reports and other types of grey literature were not included in the database. The first articles to appear in the searches on many of these databases tend to be the most recently published. Therefore, the reference lists of articles were also used to find additional academic papers along with the reference lists in books on ecotourism and recreation ecology and review papers, as well as personal communication with other researchers.

From each paper examining the effects of non-motorised nature based recreation or tourism on birds, the following information was recorded in a database; author, year of publication, country where research was conducted, journal published in, methods used in the paper, individual and population level responses of birds examined, type of habitat and information about the bird(s) studied (Tables 1,2, Appendix 1). Methods were classified as observational or experimental, if they compared disturbed and undisturbed areas, or had control sites for experimental studies. Activities were recorded as standing/observing wildlife, walking/hiking, running, mountain biking, canoeing, dog walking and horse riding. The size of the group engaged in the activity was recorded (one person or two or more). Details of the location of the research were recorded (country and ecozone) including if it was undertaken in a protected area, the broad climatic region of the location (e.g. Polar, Subantarctic, Cool Temperate, Dry, Warm Temperate and Tropical) (Miller, 2007) and habitat type(s) (e.g. shoreline, wetlands, grassland, savanna, desert or arid shrublands, coniferous forest, deciduous forest, broad-leaved evergreen forest, rainforest, heathland or shrublands, montane, or assorted, as stated in each paper reviewed). The number and name (common and scientific) of all the bird species examined was recorded. The conservation status of the birds was classified as threatened if the study examined a species that is listed on the IUCN threatened species list, or if it stated the species was threatened in the paper. Birds were assigned to a foraging guild (Carnivore, Frugivore, Granivore, Insectivore, Scavenger, Folivore, Crustaceovore/molluscivores, Nectarivore, Omnivore) based on information in the paper or from the general bird literature.

Based on previous reviews of the impacts on birds (Liddle, 1997; Buckley, 2004), the response of birds was assigned as either an individual response (physiological or behavioural), or population level response (density/abundance) or reproductive response (number of nests, number eggs laid, number of chicks that hatched or fledged). The database was then analysed using simple descriptive methods to detect patterns in the papers reviewed.

## 3. Results

Sixty-nine journal articles were identified that examined the impacts of non-motorised nature based recreation on birds. Nearly all papers were published in conservation or ecology journals with the majority published between 2000 and 2010 (Table 2). Based on the methods sections, 50 papers were conducted in protected areas (reserves/national parks) and 26 examined threatened birds (Table 1). Over half (44 papers) used observational methods, 36 compared disturbed with undisturbed or control sites, and 31 used an experimental methodology (Table 1). Forty-three of the papers looked at effects on a single species of bird, 11 looked at several species simultaneously and 15 looked at the birds from a guild or community perspective (e.g. ducks, forest birds, frugivores) (Appendix 1). Although research has been conducted in 25 countries/locations most papers are from the United States (17 papers), England (ten papers), Argentina (five papers) and New Zealand (five papers) (Table 2). This pattern reflects a bias in studies to areas with lower species richness in general, while there was a lack of effort in avian hotspots such as the Afrotropical, Indomalayan and Australasian ecozones (Table 3).

Recreation was reported to have negative effects on birds in 61 papers (88%), with only seven papers reporting no effect on birds, and one a positive effect (Table 1). Papers assessing immediate

**Table 1**
Number of published studies (1978–2010) that examined the impacts of non-motorised nature based recreation on birds.

| Category | Total | Negative effect | No Effect /Positive |
|---|---|---|---|
| All studies | 69 | 61 | 8 |
| Protected area | 50 | 44 | 6 |
| Threatened species examined | 26 | 24 | 2 |
| Method | | | |
| Observation | 44 | 40 | 4 |
| Experimental | 31 | 27 | 4 |
| Disturbed/undisturbed or control site | 36 | 30 | 6 |
| Human activity | | | |
| Standing/observing | 15 | 14 | 1 |
| Touring/walking/hiking | 51 | 45 | 6 |
| Running | 6 | 6 | |
| Cycling/mountain bike riding | 3 | 3 | |
| Canoeing | 3 | 3 | |
| Dog walking | 11 | 11 | |
| Horse riding | | | |
| Size of group undertaking activity | | | |
| One person | 40 | 37 | 3 |
| Two or more people | 47 | 41 | 6 |
| Individual level response in birds | | | |
| Behaviour | 41 | 37 | 4 |
| Physiological | 11 | 11 | |
| Population level response in birds | | | |
| Numerical/density | 33 | 28 | 5 |
| Reproductive | 33 | 28 | 5 |
| Climatic region | | | |
| Polar | 3 | 3 | |
| Subantarctic | 4 | | |
| Cool temperate | 30 | 25 | 5 |
| Dry | 8 | 7 | 1 |
| Warm temperate | 17 | 17 | |
| Tropical | 7 | 5 | 2 |
| General habitat type | | | |
| Coniferous forest | 6 | 4 | 2 |
| Shoreline | 24 | 23 | 1 |
| Montane | 5 | 4 | 1 |
| Grassland, savanna or shrublands | 5 | 5 | |
| Wetlands | 9 | 8 | 1 |
| Desert or arid shrublands | 2 | 2 | |
| Deciduous forest | 5 | 5 | |
| Rainforest | 4 | 3 | 1 |
| Broad-leaved evergreen forest | 2 | 1 | 1 |
| Heathland | 5 | 4 | 1 |
| Assorted | 1 | 1 | |
| Foraging guild | | | |
| Carnivore | 19 | 17 | 2 |
| Frugivore | 1 | | 1 |
| Granivore | 6 | 6 | |
| Insectivore | 26 | 24 | 2 |
| Scavenger | 5 | 4 | 1 |
| Folivore | 2 | 2 | |
| Crustaceovore/molluscivores | 15 | 15 | |
| Nectarivore | 1 | | 1 |
| Omnivore | 8 | 6 | 2 |

**Table 2**
Details of the 69 studies examining the impacts of non-motorised nature based recreation on birds.

| Authors (year) | Location | Journal |
|---|---|---|
| Negative effect studies | | |
| Aben et al. (2008) | Bolivia | Bird Conservation International |
| Anderson and Keith (1980) | United States | Biological Conservation |
| Arroyo and Razin (2006) | France | Biological Conservation |
| Aubad et al. (2010) | Colombia | Acta Oecologica |
| Banks and Bryant (2007) | Australia | Biology Letters |
| Baudains and Lloyd (2007) | South Africa | Animal Conservation |
| Beale and Monaghan (2004) | Scotland | Journal of Applied Ecology |
| Burger and Gochfeld (1998) | United States | Environmental Conservation |
| Burger and Gochfeld (2007) | Antarctica | Polar Biology |
| Cardoni et al. (2008) | Argentina | Biological Conservation |
| Ellenberg et al. (2007) | New Zealand | General and Comparative Endocrinology |
| Fernández-Juricic (2000) | Spain | Condor |
| Fernández-Juricic and Tellería (2000) | Spain | Bird Study |
| Fernández-Juricic et al. (2001) | Spain | Environmental Conservation |
| Fernández-Juricic et al. (2004) | Argentina | Biological Conservation |
| Finney et al. (2005) | England | Biological Conservation |
| Fowler (1999) | Argentina | Biological Conservation |
| Guillemain et al. (2007) | France | Biodiversity Conservation |
| Gutzwiller and Anderson (1999) | United States | Condor |
| Gutzwiller et al. (1998) | United States | Condor |
| Heil et al. (2007) | Argentina | Biodiversity Conservation |
| Holm and Laursen (2009) | Denmark | Ibis |
| Holmes (2007) | Macquarie Island | Journal of Wildlife Management |
| Holmes et al. (1993) | United States | Wildlife Society Bulletin |
| Holmes et al. (2005) | Macquarie Island | Biological Conservation |
| Holmes et al. (2006) | Macquarie Island | Polar Biology |
| Karp and Root (2009) | Peru | Biodiversity Conservation |
| Kerbiriou et al. (2009) | France | Journal of Applied Ecology |
| Kight and Swaddle (2007) | United States | Biological Conservation |
| Lafferty (2001) | United States | Biodiversity and Conservation |
| Langston et al. (2007) | England | Ibis |
| Liley and Sutherland (2007) | England | Ibis |
| Lord et al. (2001) | New Zealand | Biological Conservation |
| Madsen et al. (2009) | Svalbard | Polar Research |
| Mallord et al. (2007) | England | Journal of Applied Ecology |
| McClung et al. (2004) | New Zealand | Biological Conservation |
| McGowan and Simons (2006) | United States | Wilson Journal of Ornithology |
| Miller et al. (1998) | United States | Ecological Applications |
| Müllner et al. (2004) | Ecuador | Biological Conservation |
| Murison et al. (2007) | England | Ibis |
| Pearce-Higgins et al. (2007) | England | Ibis |
| Randler (2006) | Germany | European Journal of Wildlife Research |
| Rees et al. (2005) | Scotland | Biological Conservation |
| Regel and Pütz (1997) | Antarctica | Polar Biology |
| Rodgers and Smith (1995) | United States | Conservation Biology |
| Ruhlen et al. (2003) | United States | Journal of Field Ornithology |
| Sabine et al. (2008) | United States | Waterbirds |
| Skagen et al. (1991) | United States | Ecological Applications |
| Smith-Castro and Rodewald (2010) | United States | Journal of Field Ornithology |
| Stalmaster and Newman (1978) | United States | Journal of Wildlife Management |
| Taylor et al. (2007) | England | Ibis |
| Thiel et al. (2008) | Germany | Journal of Applied Ecology |
| Van Der Zande and Verstrael (1985) | Netherlands | Ardea |
| Verhulst et al. (2001) | Netherlands | Biological Conservation |
| Walker et al. (2006) | Argentina | Conservation Biology |
| Weimerskirch et al. (2002) | Crozet Islands | Journal of Experimental Biology |
| Yalden (1992) | England | Biological Conservation |
| Yalden and Yalden (1990) | England | Biological Conservation |
| Yasue (2005) | Canada | Journal of Ethology |
| Yasue and Dearden (2006) | Thailand | Journal of Applied Ecology |
| Zuberogoitia et al. (2008) | Egypt | Animal Conservation |
| No-effect or positive effect studies | | |
| Baines and Richardson (2007) | England | Ibis |
| Bouton et al. (2005) | Brazil | Waterbirds |
| Lefevre and Rodd (2009) | West Indies | Oikos |
| Lindsay et al. (2008) | New Zealand | Tourism Management |
| Marzluff and Neatherlin (2006)[a] | United States | Biological Conservation |
| Ratz and Thompson (1999) | New Zealand | Marine Ornithology |
| Riffell et al. (1996) | United States | Ecological Applications |
| Watson (1988) | Scotland | Biological Conservation |

[a] Only study where birds increased in abundance in the presence of human tourism.

behaviour (41 papers) found negative effects in 90% of studies. Negative effects were observed in all 11 papers on physiology (Table 1). Numerical responses were found to be negative in 28 papers, while five studies found no effect. The effects on reproductive success (33 papers) were mostly negative (85%) with only five reporting no effect on birds. Negative effects have been recorded for 70 individual species of birds of which 24 are threatened species (Table 1, Appendix 1).

The seven studies that found no effect on birds included; a paper on the Eurasian Dotterel (*Charadrius morinellus*) in Scotland (Watson, 1988), one paper in England on the Black Grouse (*Tetrao tetrix*) (Baines and Richardson, 2007), two papers in New Zealand, one on Yellow-eyed Penguins (*Megadyptes antipodes*) (Ratz and Thompson, 1999) and another on the Stitchbird (*Notiomystis cincta*) (Lindsay et al., 2008), one paper in the United States on Passerines (Riffell et al., 1996), one paper from Brazil assessing Wood Storks (*Mycteria americana*) (Bouton et al., 2005) and one paper in the West Indies examining Frugivores (Lefevre and Rodd, 2009) (Appendix 1). Of these studies, three examined bird abundance; four examined behavioural changes; four examined nesting success and two examined evasion responses. The one paper that found a positive effect examined Corvids in the United States and

**Table 3**
Comparison of the concentration of research on impacts of nature-based recreation on birds compared to global avian species richness. Bird richness data sourced from Newton (2003). The research index is a measure of the ratio of relative research effort to relative richness.

| Ecozones | Number of papers | Bird Species Richness | Relative richness (%) | Relative effort (%) | Research index |
|---|---|---|---|---|---|
| Palearctic | 25 | 937 | 8.78 | 36.23 | 4.12 |
| Nearctic | 21 | 732 | 6.86 | 30.43 | 4.43 |
| Neotropical | 11 | 3370 | 31.60 | 15.94 | 0.50 |
| Australasian | 6 | 1590 | 14.91 | 8.70 | 0.58 |
| Antarctic | 4 | 200 | 1.88 | 5.80 | 3.09 |
| Afrotropical | 1 | 1950 | 18.28 | 1.45 | 0.08 |
| Indomalayan | 1 | 1700 | 15.94 | 1.45 | 0.09 |
| Oceanic | 0 | 187 | 1.75 | 0.00 | 0.00 |

found an increase in bird abundance in campgrounds (Marzluff and Neatherlin, 2006)(Table 1).

The most frequent non-motorised recreation activity examined was walking or hiking (74%), with 45 papers finding negative effects of these activities on birds (Table 1). The second most commonly assessed activities were standing or observing birds (viewing platforms, standing next to a nesting colony), examined in 15 papers, 14 of which found negative effects on the birds. Dog walking had a negative effect in all 11 papers that examined it. Running (6 papers), cycling/mountain biking (3) and canoeing (3 papers) all had negative effects although there were few papers examining these activities (Table 1). None of the 69 papers identified in the searches looked specifically at the effect of horse riding on birds. Forty studies looked at the effect of a single person, of which 37 found negative effects, and three found no effect (Table1). Forty-seven studies looked at groups of two or more people of which 41 found negative effects and six found no effect (Table 1).

Research was concentrated in a few climatic regions and habitats. Most papers were from cool temperate (30 papers) and warm temperate (17 papers) regions, with few in the polar, subantarctic, dry and tropical zones (three, four, eight and seven papers, respectively) (Table 1). In terms of habitat, the majority of the papers described research conducted in shoreline (24 papers) and wetland habitats (9 papers). Of these, only two papers found no effect of recreation on birds. There were fewer papers from other habitats including coniferous forests, montane, grassland, savanna or shrublands, desert or arid shrublands, deciduous forests, rainforest, broad-leaved evergreen forests and heathlands (Table 1).

The most commonly examined foraging guilds were insectivores, carnivores and crustaceovores/molluscivores with 34 papers examining at least one of these with only one paper each for nectarivores and frugivores (Table 1). These were also two of the papers that reported no effect from walking/hiking activities. All papers that examined granivores, folivores or crustaceovores/molluscivores reported negative effects from the activities assessed.

## 4. Discussion

### 4.1. Impacts on birds

Non-motorised nature based tourism and recreation, like motorised activities, has a range of negative effects on a wide range of bird species (Liddle, 1997; Buckley, 2004). Since the book chapter by Buckley (2004), more than 40 academic journal papers on the impacts of non-motorised tourism and recreation have been published (2003–2010). This reflects the continued interest in assessing this area of recreation ecology. Despite the increased research on this issue, the current analysis clearly shows that data are still limited for many locations, habitat types, bird groups and types of recreational activities. Of the academic papers analysed here, 14 were also reviewed by Buckley (2004), most of which were published pre-2000. The results of the current review are consistent with reviews of other types of human disturbance that were found to have a range of effects including on bird behaviour, distribution reproductive success and demographic and population responses (Hockin et al., 1992; Gill, 2007).

Human disturbances regimes vary in duration, intensity and periodicity which will alter the significance of their impacts on wildlife (Steidl and Powell, 2006). For example, being approached by a person may trigger a change in the behaviour or physiological processes in a bird (e.g. flight responses or increased heart rate). Although these responses tend to be short in duration they can have longer term effects as is the case of breeding birds being flushed from nests leaving eggs or chicks vulnerable to predation (Lord et al., 2001; Guillemain et al., 2007). In areas that are subject to frequent human disturbance, a reduction in breeding performance or the number of breeding sites may occur, which can have long term negative effect on populations (Pearce-Higgins et al., 2007). Although making a direct link between human disturbance and population level effects can be difficult (Bejder et al., 2009), the relative importance of a negative effect can be presented using a hierarchical model, whereby the significance of an effect will differ dependent on the scale of the disturbance (Fig. 1).

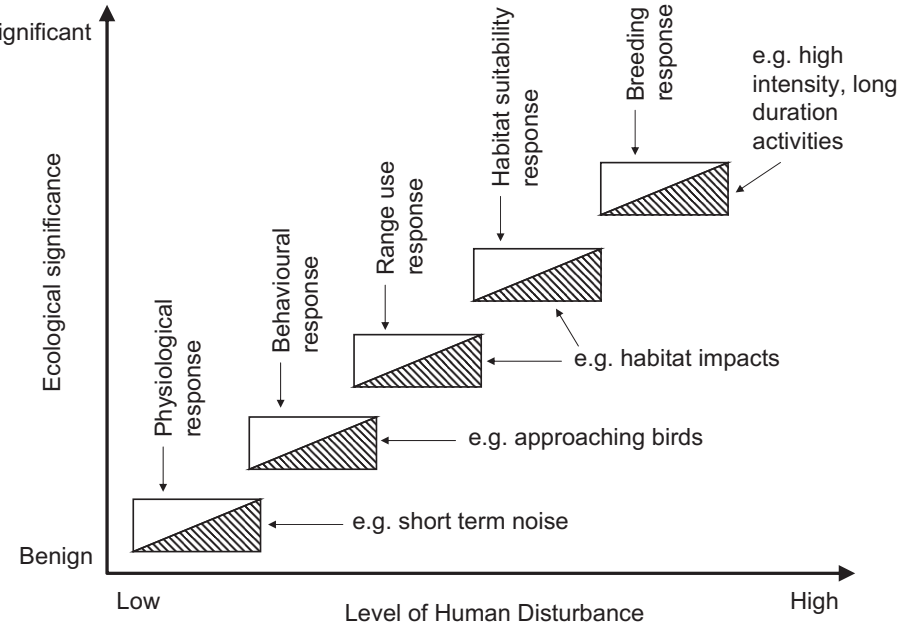


**Fig. 1.** Conceptual relationship between level of human disturbance which is a function of activity, its duration, intensity, extent and timing, and the likely ecological significance of its effects on bird populations.

Here we propose that the ecological significance of the disturbance response would be a function of the duration, intensity and extent of the disturbance. Within each of these stages there are also likely to be differences in individual versus population level responses dependent on a range of characteristics such as the species in question, age, sex, size, condition, reproductive status, availability of alternative habitat and disturbance history (Gill et al., 2001; Bejder et al., 2009).

The current literature about impacts on birds is dominated by papers that have found negative effects associated with tourism and recreation (Liddle, 1997; Buckley, 2004). There are different possible reasons why eight of the 69 academic papers analysed here found no effect on birds. First, it could be because there was no effect of the specific activities on the traits examined in the bird species studied. Second, there may have been a negative effect but it was not detected due to methodological issues such as the number of replicates used compared to the amount of variation in the traits measured. That is, there was a significant effect, but the research required more statistical power to detect a significant result e.g. type 1 error (Zar, 1996). Third, the response variable examined (behaviour versus physiology) may not have revealed the actual response of the bird or its longer term population level effects. For example, all 11 papers examining physiological responses found a negative response, while four of the 41 papers that looked at behavioural responses found no effect. Physiological responses may occur at lower levels of disturbance, compared to behavioural responses in wildlife, including birds (Liddle, 1997)(Fig. 1).

Where there is a significant change in bird responses to a specific effect, it can sometimes be difficult to determine if the effect is positive, negative or neutral. For example, an increase in the abundance of Corvids near a campground (Marzluff and Neatherlin, 2006), may be positive in the short term, and may also be confined to this group of species (i.e. commensal with humans). However, its long term effects may be positive, negative or neutral, particularly on other avian species within the community. Correspondingly, a decline in the abundance of predatory birds due to tourism and recreation, as was found by Skagen et al. (1991), could have short term positive effects on its subordinate or prey species. Even such commonly assessed responses of birds to human disturbance as avoidance behaviour may reflect the relative availability of alternative habitats, rather than the actual fitness costs to the birds (Gill et al., 2001).

### 4.2. Limits of current research

The geographical spread of research identified in the current review does not correspond well with bird diversity or with areas that may experience high levels of non-motorised nature based recreation activities. While the United States, Europe and South America have been reported on extensively, research from countries in Central America, Asia, Africa and mainland Australia is almost completely absent. There were few studies of recreational impacts for three ecozones with high bird species richness; Indomalayan, Afrotropical and Australasian (Table 3). The only paper that examined the effects on birds in the Afrotropical ecozone looked at shorebird breeding performance in South Africa (Baudains and Lloyd, 2007). However, nature based tourism, including bird tourism, is a large part of many economies in southern and eastern Africa, which are areas of high bird diversity (Lindsey et al., 2005; Hawkins et al., 2007). For the Indomalayan ecozone, there was one paper which looked at the effect of tourism developments on the habitats of Malaysian plovers in Thailand (Yasue and Dearden, 2006). For the Australasian region there were five papers in New Zealand, but only one from mainland Australia. The Australian paper found a reduction in the abundance in birds on trails in forests used by walkers and dogs on the outskirts of the largest city, Sydney (Banks and Bryant, 2007). Yet Australia is a bird biodiversity hotspot with over 800 species recorded, many of which are endemic parrots and honeyeaters (Simpson and Day, 2004) and nature based recreation is popular (Jones and Nealson, 2005).

There is limited research on the impacts of non-motorised recreation on important guilds of birds such as nectarivores and frugivores, and only one paper examined impacts on each of these guilds in our review. Nectarivores and frugivores assume important ecological roles in many communities, for both pollination and seed dispersal (Paton and Ford, 1976; Stocker and Irvine, 1983; Moran et al., 2009). The disturbance of birds through recreational activities may be an important contributory factor affecting these ecological processes. Local human disturbance can modify the foraging behaviour of bird species, including frugivores (Kirika et al., 2008). Any activity that affects bird's searching or handling time could impact on the birds capacity to feed on certain fruits (Martin, 1985), particularly in areas that are heavily utilised for tourism or recreation.

A wide range of methods and approaches have been used to research the effects of nature based tourism and recreation on birds (Liddle, 1997; Buckley, 2004). This combined with the gaps in research in terms of groups of birds, locations and types of activities assessed, limits the capacity to make direct comparisons among studies (Liddle, 1997; Buckley, 2004). The development of a few standardised methods for assessing impacts on birds would assist in the capacity to make generalisations about the relative sensitivity of different groups of birds, and for different types of activities. However, selection of easily assessed responses can be complicated, as short term effects may not reflect longer term population level responses to disturbance (Gill et al., 2001; Steidl and Powell, 2006).

### 4.3. Management implications

For managers of protected areas and other nature based recreation destinations the most important results of this review is that even relatively 'low' impact activities such as walking or hiking where visitors do not deliberately disturb animals can have negative effects on birds ranging from changes in physiology to reduced reproductive success. Therefore, when zoning, providing facilities, and managing the use of facilities, they need to take into account the source, range and intensity of potential impacts and methods to manage these impacts (Hill et al., 1997) that address short and long term responses (Steidl and Powell, 2006). As such managers may need to reduce the use of some areas all the time or at critical times such as nesting and fledging, limit the number of users to small groups, and/or limit the types of activities particularly those that are likely to have greater impacts such as dog walking (Buckley, 2004).

When one considers that visitation of many protected areas is for the express purpose of engaging with wildlife, including birds, the potential for wildlife disturbance is likely to be greater in these regions. Furthermore, bird watching is increasing as a global recreational activity (Cordell and Herbert, 2002). Consequently, the relative effects on birds, particularly where approached on foot, or where observers spend a considerable amount of time viewing birds from vantage points within the natural habitat, require further investigation. Calls for empirical evidence of the impacts of such bird watching activities have previously been made (Şekercioğlu, 2002), and while there are an increasing body of research on this topic, there are still important gaps.

### 4.4. Conclusions

The database of academic papers produced in this review is far from complete, as it concentrated on recent research published in academic journals in English. However, based on the results of this and previous reviews of recreation and ecotourism impacts on birds (Liddle, 1997; Buckley, 2004), it still appears that non-motorised recreation activities have a range of negative effects on birds, but there remain large research gaps on this topic. This includes for certain groups of birds such as nectarivores and frugivores, for popular activities like mountain bike riding and horse riding, and locations with high bird diversity and high levels of nature based tourism like Asia, central America, Africa and mainland Australia.

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## Appendix 1

Sources and respective species or guild studied.

| Author (year) | Scientific name(s)/Groups | Common name(s) |
|---|---|---|
| Negative effect | | |
| Aben et al., 2008 | Many | Perching Birds |
| Anderson and Keith, 1980 | *Larus heermanni*, *Pelecanus occidentalis calijornicus* | Heerman's Gulls, Brown Pelican |
| Arroyo and Razin, 2006 | *Gypaetus barbatus* | Bearded Vulture |
| Aubad et al., 2010 | Many | Forest Birds |
| Banks and Bryant, 2007 | Many | Perching Birds |
| Baudains and Lloyd, 2007 | *Charadrius marginatus* | White-fronted Plover |
| Beale and Monaghan, 2004 | *Rissa tridactyla*, *Uria aalge* | Kittiwake, Guillemot |
| Burger and Gochfeld, 1998 | *Gallinula chloropus*, *Porzana carolina*, *Plegadis falcinellus*, *Egretta caerulea*, *E. tricolour* | Common Gallinule, Sora Rail, Glossy Ibis, Little Blue Heron, Louisiana Heron |
| Burger and Gochfield, 2007 | *Aptenodytes forsteri* | Emperor Penguin |
| Cardoni et al., 2008 | Anatidae, Rallidae, Podicipedidae, Ciconiiformes, Passeriformes | Ducks, Swans, Rails, Coots, Grebes, Herons, Ibis, Egret, Perching Birds |
| Ellenberg et al., 2007 | *Megadyptes antipodes* | Yellow-eyed Penguin |
| Eske Holm and Laursen, 2009 | *Limosa limosa* | Black-tailed Godwit |
| Fernández-Juricic, 2000 | *Pica pica*, *Turdus merula*, *Sturnus unicolour*, *Columba palmbus* | Magpie, Blackbird, Starling, Wood Pigeon |
| Fernández-Juricic and Tellería, 2000 | *Turdus merula* | Blackbird |
| Fernández-Juricic et al., 2001 | *Passerdomesticus*, *Turdus merula*, *Columba palumbus*, *Pica pica* | House Sparrow, Blackbird, Wood Pigeon, Magpie |
| Fernández-Juricic et al., 2004 | *Zonotrichia capensis*, *Molothrus badius*, *Turdus chiguanco*, *Columba palumbus* | Bay Winged Cowbird, Golden-billed Saltator, Chiguanco Thrush, Wood Pigeon |
| Finney et al., 2005 | *Pluvialis apricaria* | Golden Plover |
| Fowler, 1999 | *Spheniscus magellanicus* | Magellinic Penguin |
| Guillemain et al., 2007 | *Anas* spp. | Ducks |
| Gutzwiller and Anderson, 1999 | *Parus gambeli*, *Turdus migratorius*, *Catharus guttatus* | Mountain Chickadee, American Robin, Hermit Thrush |
| Gutzwiller et al., 1998 | Passerines | Perching Birds |
| Heil et al., 2007 | passerines (45 species) | Perching Birds |
| Holmes, 2007 | *Pygoscelis papua*, *Aptenodytes patagonia*, *Eudyptes schlegeli* | Penguins |
| Holmes et al., 1993 | Falcinoformes | Grassland Raptor |
| Holmes et al., 2005 | *Eudyptes schlegeli* | Royal Penguin |
| Holmes et al., 2006 | *Pygoscelis papua* | Gentoo Penguin |
| Karp and Root, 2009 | *Opisthocomus hoazin* | Hoatzin |
| Kerbiriou et al., 2009 | *Pyrrhocorax pyrrhocorax* | Chough |
| Kight and Swaddle, 2007 | *Sialia sialis* | Eastern Bluebird |
| Lafferty, 2001 | Many | Shorebirds, Gulls and Terns, Landbirds |
| Langston et al., 2007 | *Caprimulgus europaeus* | European Nightjar |
| Liley and Sutherland, 2007 | *Charadrius hiaticula* | Ringed Plover |
| Lord et al., 2001 | *Charadrius obscurus aquilonius* | New Zealand Dotterel |
| Madsen et al., 2009 | *Anser brachyrhynchus*, *Branta leucopsis*, *Branta bernicla hrota* | Pink-footed Goose, Barnacle Goose, Brant Goose |
| Mallord et al., 2007 | *Lullula arborea* | Woodlark |
| McClung et al., 2004 | *Megadyptes antipodes* | Yellow-eyed Penguin |
| McGowan and Simons, 2006 | *Haematopus palliatus* | American Oystercatcher |
| Miller et al., 1998 | Passerines | Perching Birds |
| Műllner et al., 2004 | *Opisthocomus hoazin* | Hoazin |
| Murison et al., 2007 | *Sylvia undata* | Dartford Warbler |
| Pearce-Higgins et al., 2007 | *Pluvalis apricaria*, *Calidris alpina* | Golden Plover, Dunlin |
| Randler, 2006 | *Fulica atra* | Coot |
| Rees et al., 2005 | *Cygnus c. cygnus* | Whooper Swan |
| Regel and Putz, 1997 | *Aptenodytes forsteri* | Emperor Penguin |
| Rodgers and Smith, 1995 | Pelecaniformes, Ciconiiformes, Charadriiformes | Pelicans, Storks, Cormorants, Waders |
| Ruhlen et al., 2003 | *Charadrius alexandrinus* | Snowy Plover |
| Sabine et al., 2008 | *Haematopus palliatus* | American Oystercatcher |
| Skagen et al., 1991 | *Haliaeetus leucocephalus*, *Corvus brachyrhynchos*, *Larus glaucescens* | Bald Eagle, American Crow, Glaucous-winged Gull |
| Smith-Castro and Rodewald, 2010 | *Cardinalis cardinalis* | Northern Cardinals |
| Stalmaster and Newman, 1978 | *Haliaeetus leucocephalus* | Bald Eagle |
| Taylor et al., 2007 | *Burhinus oedicnemus* | Stone-curlew |
| Thiel et al., 2008 | *Tetrao urogallus* | Western Capercaillie |
| Van der Zande and Verstrael, 1985 | *Falco tinnunculus* | Kestrel |
| Verhulst et al., 2001 | *Haematopus ostralegus* | European Oystercatcher |
| Walker et al., 2006 | *Spheniscus magellanicus* | Magellinic Penguin |
| Weimerskirch et al., 2002 | *Diomedea exulans* | Wandering Albatross |
| Yalden, 1992 | *Actitis hypoleucos* | Common Sandpiper |
| Yalden and Yalden, 1990 | *Pluvialis apricaria* | Golden Plover |
| Yasue, 2005 | *Charadrius semipalmatus*, *Calidris minutilla* | Semi-palmated Plover, Least Sandpiper |
| Yasue and Dearden, 2006 | *Charadrius peronii* | Malaysian Plover |
| Zuberogoitia et al., 2008 | *Neophron percnopterus* | Egyptian Vulture |
| No-effect or positive effect | | |
| Baines and Richardson, 2007 | *Tetrao tetrix* | Black Grouse |
| Bouton et al., 2005 | *Mycteria americana* | Wood Stork |
| Lefevre and Rodd, 2009 | Frugivore | Fruit-eating Birds |
| Lindsay et al., 2008 | *Notiomystis cincta* | Stitchbird |
| Marzluff and Neatherlin, 2006[a] | Corvids | Corvids |
| Ratz and Thompson, 1999 | *Megadyptes antipodes* | Yellow-eyed Penguin |
| Riffell et al., 1996 | Passerines | Perching Birds |
| Watson, 1988 | *Charadrius morinellus* | Eurasian Dotterel |

[a] Only study where birds increased in abundance in the presence of human tourism.

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