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Author: Robert Clemens Ashley Herrod Michael A. Weston

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Lines in the mud; revisiting the boundaries of important shorebird areas

Robert Clemens¹‡, Ashley Herrod², and Michael A. Weston³

¹ School of Biological Sciences, Environmental Decisions Group, University of Queensland, St. Lucia, Qld 4072, Australia

² School of Biological Sciences, Monash University, Clayton, Vic. 3800, Australia.

³ Centre for Integrative Ecology, School of Life and Environmental Sciences, Faculty of Science, Engineering and the Built Environment, Deakin University, Burwood, Vic. 3125, Australia.

‡ Corresponding Author: r.clemens@uq.edu.au, 0425 805 087

Running title: Boundary setting for important shorebird areas.
Abstract

Many shorebird populations are declining throughout the world, concurrent with declines and degradation of wetland habitats. Such declines necessitate a more consistent approach toward conserving habitats used by shorebird populations. Individuals of many shorebird species congregate in specific areas during their non-breeding season. Worldwide, non-breeding areas are designated as ‘important’ for shorebird conservation based primarily on the abundance of birds found in an area. However, the boundaries of any area are often defined with incomplete information regarding how shorebirds use that habitat. This paper discusses examples in Australia where improved knowledge of shorebird habitat use led to the identification of very different boundaries of important shorebird areas than those identified originally. We highlight how simple questioning of those who count shorebirds in an area, led to an improved understanding of which areas were apparently used by the same local population of non-breeding shorebirds. Subsequent analysis of available count, recapture and/or home range data of particular shorebird species is needed to verify expert opinion regarding most of these boundaries. We review how enhanced boundaries improve the ability of shorebird monitoring to detect population changes; allow management of shorebird habitats at relevant spatial scales; and lead to appropriate designations of important areas. While the kinds of approaches to boundary setting described here are not new, they are not consistently applied worldwide. We suggest additional guidelines to those produced under the Ramsar Convention in regard to designating important areas. We also call for more studies on the movements of migratory shorebirds during the non-breeding season to direct more consistent boundary setting around important non-breeding habitats used by local populations of migratory shorebirds.

Keywords: Thresholds, Criteria, Expert Opinion, Ramsar, Wetlands, Protected Areas, Reserves
Introduction

Migratory shorebirds are a group of birds showing one of the largest and most widespread
population declines (International Wader Study Group 2003; Piersma, 2007; Stroud et al., 2006), and
these declines are becoming especially acute in the East-Asian Australasian flyway (Amano et al.,
2010; Minton et al., 2012; Nebel et al., 2008; Wilson et al., 2011). This is largely attributed to loss or
degradation of habitats that hold high numbers of shorebirds (Baker et al., 2004; Moores et al., 2008)
and the continuing loss of wetland habitats is of increasing conservation concern for these birds
globally (Hagemeijer, 2006). Further deleterious impacts are expected as the climate warms
(Finlayson et al., 2005; Junk et al., 2013).

Shorebirds are incredibly diverse and some species in Australia often occur in non-wetland
habitats such as Oriental Plover Charadrius asiaticus and Oriental Pratincole Glareola maldivarum,
are found in very low concentrations like Latham’s Snipe Gallinago hardwickii, or occupy a variety
of wetlands such as river edges, flooded pastures or artificial habitats (ARKive, 2013; Cardilini, et al.,
2013; Higgins & Davies, 1996; Marchant & Higgins, 1993; Weston, et al., 2009). However, one of
the unique traits many species of shorebird share, is their tendency to concentrate in large numbers at
some non-breeding habitats, something that results in large proportions of species’ populations being
supported in relatively few areas (Brown, et al., 2001). A key approach to conserving shorebirds has
been to identify ‘important areas’ for species that concentrate in large numbers in their non-breeding
distribution, and to manage these appropriately to ensure shorebird populations are maintained
(Kuijken, 2006; Mundkur, 2006). The current set of identified important shorebird areas is the
cornerstone of migratory shorebird conservation in Australia (Bamford et al., 2008; DEH 2006;
DEWHA 2009; Watkins, 1993). In Australia, like much of the globe, during the non-breeding season
wetlands support extremely high numbers of waterbirds (Boere & Stroud, 2006), and internationally
important areas for shorebirds are designated if the area supports over 20,000 waterbirds, or over 1%
of the flyway population of any species (Ramsar Convention Secretariat 2010; Table 1). The
Australian Federal Government also recognises any area with over 2,000 shorebirds or 0.1% of the
flyway population as being nationally important (DEWHA 2009; Table 1). The Ramsar criteria have been used to help define boundaries of important habitat in Australia, including the preference to include wetland 'complexes' or clusters of sites that are linked either hydrologically or through their use by a common population of animal (Ramsar Convention Secretariat 2010).

During the non-breeding season, one common way in which spatially separated shorebird habitats remain “ecologically linked” (Wright et al., 2010) is through the foraging and roosting behaviour of shorebirds. Shorebirds that forage across expansive tidal flats are forced to other areas when the flats become regularly inaccessible as they are covered by water during higher tides. At these times many shorebirds seek out relatively open and undisturbed roosting locations where they can rest and remain vigilant for predators (Colwell, 2010). Shorebird conservation has long recognised the need to protect these linked habitats to conserve the birds in an area, and growing evidence demonstrates the importance of roosting habitats that are close to foraging habitats, which reduce energetic expenditures of travelling between roosting and foraging locations (Rogers et al., 2006).

Ecologically linked wetlands can also include separate wetlands within the home range of non-breeding shorebirds between which shorebirds regularly move for other reasons. These between-wetland movements are thought to be triggered largely by dynamic food availability, changes in water levels at inland wetlands, avoidance of predators or disturbance, or different habitat requirements in different weather conditions, tide heights, or time of day. Increasingly, these kinds of considerations are being used to determine appropriate boundaries around important shorebird habitats (EGA-RAC/SPA 2012; Wright et al., 2010), and we would suggest such considerations have often been followed in areas where well developed local shorebird expertise was sought out when establishing boundaries.

In Australia, the boundaries around important shorebird habitat attempt to include separate but ecologically linked habitats. At most tidal habitats, coarse boundaries define large areas while attempting to encompass most of the separate habitats used for foraging and roosting by groups of shorebirds within estuaries or other tidal areas. There are a few cases where officially mapped boundaries do not include nearby roosts that are within 100 m of the boundary, but generally,
interpretation of the boundary has not excluded such a roost from planning or management decisions. More distant roosts such as nocturnal or alternate roosts used during large spring tides may require expansion of boundaries if they are included. However, when looking at separate wetlands well outside the relatively contiguous habitat in which most roosts and adjacent feeding areas occur, the boundaries around important habitats like Ramsar sites have tended to combine separate wetlands based on them being relatively close together provided they are being used by similar species. There was little information on the way in which shorebirds used these clustered wetlands within or between years, or whether they were ecologically linked when boundaries were originally formed. In the decades after many of these areas were designated as important, our understanding of shorebird movement and the way in which local populations of shorebirds use their habitats has increased, yet the boundaries have largely not been revised.

As pressure on wetlands grows in Australia (Kingsford et al., 2005) and at migratory staging areas in East Asia (MacKinnon et al., 2012), there is a real need to draw boundaries that are as complete, and defendable as possible. However, growing understanding of how some local populations use wetland habitats in Australia has highlighted the many areas where information remains insufficient to rigorously define boundaries based on how habitats are linked ecologically. In addition, once established, boundaries are infrequently revised as better information becomes available. Incorrect boundaries around important shorebird habitats have three significant implications for shorebird conservation. First, the boundary of each important shorebird area forms an ideal unit of measure for broader population monitoring studies, which are required to estimate population sizes and trends (Colwell, 2010). Inappropriate boundaries reduce the sensitivity of monitoring programs, which are required to inform shorebird conservation (Haslem et al., 2008; Herrod, 2010; Purnell et al., 2010). The recognition of broad ecological units inclusive of clusters of wetlands, is increasingly being seen as a requirement for obtaining more comparable counts within and between seasons (EGA-RAC/SPA 2012).

Second, the boundary of each area forms the planning unit in which many conservation decisions are made (notwithstanding that these areas may span tenures and jurisdictions). A boundary
that is unnecessarily large may reduce the effectiveness of conservation decisions, while a boundary
that is too small will omit important portions of the habitat.

Third, inappropriate boundaries can reduce an area’s probability of meeting international
criteria for designation as ‘important’ (Clemens et al., 2010).

Here, we review the implications of defining important shorebird area boundaries that
disregard the ecologically relevant, independent, non-breeding areas used by non-breeding shorebird
populations. We also suggest simple guidelines, which build on those suggested by Ramsar criteria,
regarding how non-contiguous habitats used by shorebirds should be aggregated to form better
boundaries. Finally, we note that while long-term shorebird conservation will rely on many initiatives
(Colwell, 2010; Geering et al., 2007), improving our understanding of the boundaries of important
areas for shorebirds will enhance the adequacy of important areas as a shorebird conservation tool.
We find that the quickest way to improve boundaries is to inform decisions by increasing the number
and rigour of shorebird movement studies, something we argue should be focused at those areas
thought to be under greatest threat.

Implications of boundaries that disregard the way shorebirds use an area

1. Impacts to a monitoring program’s ability to detect population trends

Identification of population trends among migratory shorebirds is difficult largely due to the variation
in shorebird count data (Gosbell & Clemens, 2006; Ross et al., 2012; Wilson et al., 2011). However,
that variation can be reduced significantly when simultaneous counts are done in all the wetland
habitats known to be used by the same group of non-breeding birds (EGA-RAC/SPA 2012). In
Australia, recent work has highlighted how boundaries set decades ago are either too small or too big
to provide useful information on the changing populations of migratory shorebirds, i.e. when counts
are aggregated based on those historic boundaries.

The Western Lakes District Ramsar Site in Victoria, Australia (38°11” S, 143°21” E) provides
one example in which the shorebird area designated in 1982 was too small to capture all the habitats
that the same group of shorebirds has used in subsequent years (Figure 1). When the boundary was
set, high counts of shorebirds were used to designate which wetlands to include within a cluster of
important ephemeral and permanent wetlands. These lakes are scattered across an area of over
2,500 km² and vary in salinity, water level, and prey availability (Figure 1). A drought, which
extended from 2001 to 2009, dramatically altered the condition of many of these wetlands, and toward
the end of the drought over 90% of the shorebirds reported in the region were occupying lakes not
included in the original Ramsar boundary. Despite these large changes at wetlands, summing all
‘synchronous’ (i.e. conducted on the same day or weekend) non-breeding counts from the wetlands in
this region, some of which were 50 km apart, resulted in a remarkably similar time series of shorebird
abundance (BirdLife Australia; unpublished data). Comparable counts, let alone detection of
population trends, would not be possible without aggregating counts from all the wetlands in the
region that are in suitable condition on the weekend of the survey.

A more rigorous analysis of count data in the Gulf of St Vincent, South Australia (34°28’ S,
138°28’ E) highlighted another example where some of the traditionally identified shorebird sites
needed to be clustered to detect smaller changes in local shorebird populations in shorter time periods
(Purnell et al., 2010). The Gulf of St Vincent includes active saltworks, claypans, and traditional tidal
habitats spread along well over 100 km of coastline, a couple of which are separated by over 15 km.
Historically, the saltworks and other discrete habitats were considered separately with separate
boundaries, but long-held reports by counters of widespread movement of shorebirds between these
areas indicated the need to count all these areas simultaneously to achieve more comparable totals.
Power analyses based on synchronous counts and all available data indicated that if the entire Gulf of
St Vincent was counted, declines in Bar-tailed Godwit Limosa lapponica populations of 53%, 39% or
28% could be detected in twenty years with one, two or three counts per season respectively. If only
the largest site previously identified in the Gulf of St Vincent – Price Saltworks – was counted, the
size of declines that could be detected rose to 83%, 69% or 58% respectively (Purnell et al., 2010).
Failure to consider the entire Gulf when organising monitoring, resulted in a significant reduction in
monitoring sensitivity. Monitoring sensitivity is something increasingly required as threats to the
habitats used by these birds in close proximity to the city of Adelaide are growing concurrent with
widespread population declines in shorebirds.
A boundary that encompasses too large an area can have similar impacts on the sensitivity of
shorebird population monitoring. In 1982 the “Port Phillip Bay (Western Shoreline) & Bellarine
Peninsular Ramsar Site”, Victoria, Australia (38°13" S, 144°28" E) was formed along a diverse
coastline inclusive of saltworks, a sewage works, tidal wetlands, estuaries, and adjacent freshwater
wetlands which are separated by only 3 to 10km (Figure 2). For years, counts across these areas were
conducted at roughly the same time, and they were then aggregated. After decades of counting, most
counters agreed that there was little movement of shorebirds between these five relatively proximate
areas used by shorebirds. A study of banding data collected by the Victorian Wader Studies Group
since the 1970’s confirmed this, with over 98.5% of the 12,841 recaptured shorebirds being
recaptured from within the same independent shorebird area in which they were originally marked
(Herrod, 2010). These recaptures were from both within and between years, and again these data
indicated that the populations from the five areas were indeed independent, and should be analysed
separately. Similarly, detailed radio telemetry data as well as analyses of count data demonstrated that
throughout the year, shorebirds tended to remain in these smaller shorebird areas, and a lack of
negative correlation in count data from adjacent areas confirmed their independence between years
(Rogers et al., 2010). During recent analysis of the available count data from these five shorebird
areas, significant trends for Eastern Curlew Numenius madagascariensis, Common Greenshank
Tringa nebularia, and Sharp-tailed Sandpiper Calidris acuminata, were evident at several shorebird
areas when analysed independently, but were masked by no significant trend if data from these
separate shorebird areas were pooled across the Ramsar site as identified in 1982 (Herrod, 2010).

The above cases highlight just a few examples from the over 230 shorebird areas identified in
Australia on how a boundary that disregards how shorebirds use an area can significantly impact a
monitoring program’s ability to detect population trends. It is also clear that there are no clear ‘rules
of thumb’ when deciding how to clump separate wetlands, as shorebirds use different areas in very
different ways during the non-breeding season. This need to understand the local movements of
shorebirds in order to effectively monitor populations has long been held by shorebird biologists who
have studied non-breeding populations for decades (Minton, C. and Rogers, D. pers. comms). The
lack of any clear rules of thumb regarding when to clump separate wetlands, is best exemplified by
the differences in the treatment of separate wetlands along the coastlines of the Bellarine Peninsula,
and the Gulf of St Vincent. At the Bellarine Peninsula shorebirds use and return to relatively small
wetlands despite being relatively close together, while at the Gulf of St Vincent the birds move
somewhat regularly between separate wetlands spread across over 100km of coast. Habitats in both
areas include saltworks, and more traditional tidal habitats, and both areas are used by similar groups
of species. Further, there are no obvious differences in predation pressure or disturbance rates, but
further work would be needed to fully assess such a possible explanation. It is clear that the best scale
in which to organise monitoring, differs radically between these two regions. We expect that as more
studies on the local variations in shorebird ecology are conducted, some of the drivers of these
different patterns will be understood, and it is clear that in Australia as local movements of shorebirds
during the non-breeding season continue to become better understood, improvements in data
aggregation and monitoring will be possible.

2. Impacts to habitats; inadvertent loss or impact, inappropriate management

The use of an inappropriate geographic scale leads to conservation plans or decisions either irrelevant
to much of the area under consideration, that omit important non-contiguous habitats, or that fail to
recognise the way in which shorebirds use space to meet their needs. As some of these habitats are
increasingly threatened and encroached upon by human activities, the need to adequately identify and
plan to minimise impacts is growing. Stakeholders trying to protect shorebird habitats, as well as
those interpreting legal protections, would benefit from increasing clarity around important habitat
boundaries. Similarly, managers would increase chances of successfully managing local populations if
the scale of the area they need to manage was well understood.

While a large boundary can accommodate planning for indirect impacts from things like
catchment sources, in some cases large shorebird area boundaries create uncertainty regarding the
particularly sensitive parts of the habitat within those boundaries. This is especially true in large tidal
habitats where foraging and roosting habitats are not well understood or mapped. In many of
Australia’s important shorebird areas, recent precise mapping of roosting, and occasionally foraging,
habitat (Clemens et al., 2008; Rogers et al., 2010) has improved the precision of planned actions
specific to shorebirds. Similarly, a large boundary could potentially lead to unnecessary planning or management in areas that are not used by the shorebirds.

A more common problem in Australia is the omission of ‘linked’ habitats, with a significant portion of the habitat required by a local population of shorebirds not included in either the official boundary, or in management plans, such as the Western District Lakes Ramsar Site (Figure 1). This kind of problem is most common at ‘complexes’ of inland wetlands where the population of birds using the wetlands shifts between lakes, depending on annually varying conditions. Failing to protect or adequately manage all of these alternative habitats could have obvious impacts on the shorebirds that use these areas.

The approach to shorebird planning and management in North America avoids many of these complications by taking a regional approach to planning and management which focuses on achieving landscape level carrying capacity through maintaining adequate roosting and foraging habitat at a regional level (Brown, et al., 2001; Potter, et al., 2007). Almost, by default this keeps those areas with regular large concentrations of shorebirds in the planning sphere, but it importantly allows for those parts of the landscape that are deemed most limiting to shorebird populations to be the places where active management is prioritised (Potter, et al., 2007). Such a rigorous approach focuses management rightly on where it is most needed, and identification of parts of the landscape thought to be most limiting for shorebirds has not been attempted yet in Australia. However, we argue that planning at a finer scale such as shorebird area-based approaches likely accelerates population responses to management when site fidelity is high, and probability of finding new habitats is relatively lower as is the case in many parts of Australia.

Managers of shorebird habitat have a number of tools available to them, but it is critical that shorebird use of an area is properly understood to use those tools effectively. At coastal sites some of the management tools or methods include restoration of tidal flows through removal of coastal barriers, building artificial roosts, or attempting to restore coastal ecology and invertebrate prey populations (Atkinson et al., 2001; Burton et al., 1996). At inland wetlands dams, control of river flows or wetland water levels, purposeful allocation of water to wetland areas, creation of new wetlands etc. are just some of the many options available to shorebird habitat managers (Colwell,
increasing invertebrate prey densities while ensuring water is shallow enough to make food accessible, or providing open undisturbed places for the birds to roost. In the example of the Western Lakes District (Figure 1), water allocation or other habitat improvements at one wetland would only be effective or useful if conditions at all the other wetlands in the complex were not sufficient to maintain the local population. In other words it would be easy to improve conditions at one lake (Lake Murdeduke) for shorebirds, but it would likely have little impact on the population if conditions were better at other lakes. On the other hand, habitat management at one lake may be critical to maintain shorebird numbers in the region if the condition of all other lakes is poor. In the Bellarine Peninsula region (Figure 2), however, there are many separate areas in close proximity which birds tend not to move between. In such a case, habitat improvements, or active management such as done for waterbirds at the Werribee/Avalon Shorebird Area will primarily benefit the population that uses that area, and in the short-term at least, not tend to benefit all the birds found in the region.

When wetlands are slated to be impacted by human activity, the creation or restoration of wetlands as offsets are becoming increasingly appealing for some governments (Maron et al., 2012), and while we feel compelled to point out that offsets rarely work equally for all shorebirds (Wright et al., 2010), they also require considerations that are scale appropriate. Wright et al. (2010) highlight how it is important to consider the site fidelity of any species when determining the potential success of an offset or creation of new habitat, as shorebirds with high site fidelity may not move as readily or successfully to alternative habitats that are far from the habitat which was lost. In that context we would expect larger short-term impacts to shorebirds when offsets are placed outside the existing shorebird area, and again these areas vary widely in size so scale becomes an important consideration. In Australia, two hundred and thirty seven shorebird areas have been identified which varied greatly in size (1.5 - 600,000 ha; 10,419 ±49,200 ha; Clemens et al., 2006).

We argue that understanding the areas used by local populations of non-breeding shorebirds can help ensure that important habitats are not inadvertently lost, impacted, or inappropriately managed and that efforts are not expended in cases where they will have little benefit. In cases of boundaries that are either too small or too large, improving the shorebird area boundary and mapping...
the important habitats within those boundaries more precisely (Rogers et al., 2010) improves the scale and precision of any management actions or plans. As Piersma (2007) points out, people throughout the globe are conducting unintended massive-scale experiments on the impacts of habitat loss and degradation on shorebird populations. Understanding the scale of habitat use by shorebirds will help ensure we can better interpret the results of these unintended experiments, and formulate strategies to further limit losses.

3. **Impact to designation, overlooking cumulative importance of wetland complexes**

Presently, the importance of areas for shorebirds in the non-breeding season is based solely on the abundance of shorebirds reported using that area. However, when the areas identified during counting are smaller than the important shorebird area, a mismatch in the scale of the area counted and that being assessed for importance results. This is not uncommon when separate count areas are not aggregated appropriately. Increased precision of shorebird area mapping has recently resulted in a more appropriate representation of the average annual maximum count that was used to designate importance, providing a better reflection of the populations of shorebirds using each area (Clemens et al., 2008). Studies of shorebirds using wetland complexes in central North America have resulted in similar understandings of how wetlands might be clustered to accurately reflect the number of shorebirds regularly using habitats (Albanese & Davis, 2013; Albanese, et al., 2012; Farmer & Parent, 1997; Farmer & Wiens, 1999). These small unpredictably available wetlands in central North America have long been recognised as areas that shorebirds regularly move between (Skagen, et al., 2008), yet historically they were not treated collectively when designating the importance of wetlands (Haig et al., 2008). In these wetland complexes, many individual wetlands would not meet international criteria on their own, so aggregation is critical to represent the true importance of the wetlands for local populations. However, in such unpredictable landscapes the potential low regularity in which thresholds are met, allows possible serendipitous designations of importance if quantification of the value of these habitats is not ensured. In cases where the fitness benefits of a wetland complex have been quantified (Farmer & Wiens, 1999; Potter, et al., 2007), and the extent of the complex that shorebirds are responding to has been identified (Albanese, et al., 2012) aggregating counts from the
complex when conditions are suitable to determine if it meets designation thresholds seems logical,
particularly if such conditions occur at least once a decade (Overdijk & Navedo, 2012).
In Australia there are individual ephemeral wetlands which have been designated as
internationally important despite only meeting thresholds when conditions are suitable, something
which may happen only once a decade. However, we are not yet aware of any shorebird area in
Australia where at least one of the wetlands in a wetland complex does not meet international
thresholds of importance. These complexes include wetlands that birds regularly move between where
at least one wetland meets thresholds in any year, and may or may not include satellite wetlands that
do not meet international thresholds individually. We, however, see no reason while regular use of
complexes that cumulatively meet thresholds of abundance could not be designated as important
(Figure 3).
An area’s importance, and therefore its likely protection, is related to the abundance of
shorebirds found there. We suggest that a wetland which supports fewer migratory shorebirds, but that
which move regularly to other wetlands, needs to be assessed for ‘importance’ based on the
cumulative abundance from all the wetlands the shorebirds regularly move between. Despite meeting
criteria for importance, it would appear that these connected, non-contiguous habitats can be
disregarded by planners, managers and those charged with assessing potential impacts of human
activities. This is especially true in areas where there has been limited monitoring and movement
studies.

Towards better boundaries

In light of the inconsistent ways in which boundaries of important shorebird areas are often
established, we propose guidelines in addition to those already promoted internationally (Ramsar
Convention Secretariat 2010) to further promote more consistent designations of important shorebird
area boundaries (Figure 3). These guidelines highlight how further information on local shorebird
movements will be required before all guidelines can be met, but we suggest that long established
boundaries can be updated as this information becomes available. One example of a recently
designated boundary which could clearly be improved includes Yubu-do Tidal Flat in the Republic of
Korea. While the recognition of the most important remaining site for shorebirds in the Republic of
Korea marks a huge positive step for waterbird conservation in the flyway, we wonder about the
implications of the current boundary of the site which at present, leaves out much of the available
mudflats used for foraging as well as important alternative roosts in the area. We are therefore hopeful
that further guidelines will improve the way in which future boundaries are designated, and existing
boundaries are revised.

Differences in the methods used to identify important shorebird area boundaries are
unsurprising given our varied understanding of how shorebirds use individual non-breeding habitats
throughout their widespread geographic ranges (Colwell, 2010; Kuijken, 2006; Matthews, 1993).
Historically, a lack of information led to practical limitations when defining boundaries of important
shorebird areas. For example, the available information on the abundance and distribution of
shorebirds has often been in the form of a shorebird count geo-referenced to a single point, or
sometimes in more detailed maps of the area counted (BirdLife Australia Unpubl. Data). In Australia,
these counts were intersected with wetland maps (areas where water is the primary factor controlling
the environment, including the associated biodiversity; Ramsar Secretariat, 2009); and the entire
contiguous wetland habitat was designated as ‘important’ for shorebirds if criteria were met (Table 1).
If formal recognition of the site was sought, e.g. designation as a Ramsar wetland of international
importance, the boundary must have also met geopolitical considerations and grown to encompass all
co-occurring values which also met wetland importance criteria.

More rigorous methods for defining boundaries around the ‘functional unit’ of non-breeding
habitat have long been used for waterbirds (Tarnisier, 1985), where the functional unit includes the
area used by a ‘local population’ to “meet both roosting and foraging needs in winter” (Colwell,
2010). In Australia, a ‘functional unit’ or ‘shorebird area’ includes all contiguous and non-contiguous
areas of habitat between which there is a frequent interchange of birds, i.e. the estimated home range
of shorebirds during the peak of the non-breeding season (November – February). This is based on
Ramsar recommendations which encourage adjacent, non-contiguous habitats to be recognised as a
cluster of wetlands under a variety of circumstances, including if they are “linked in their use by a
common population of animal” (Ramsar Convention Secretariat 2010). Such allowances while
common or expanded on in parts of Europe or Africa (EGA-RAC/SPA 2012; Wright et al., 2010),
have not been applied universally, largely due to a lack of information on local populations when
boundaries were set. Further, and unfortunately it is rare that boundaries are revised once established,
despite better information becoming available.

Recent work in Australia has highlighted how decisions on when to aggregate adjacent areas
are not always initially obvious with clumping of some habitats over 50 km apart, while separating
other habitats that were less than 10 km apart (Clemens et al., 2006). Interestingly, recent studies in
Australia have also confirmed shorebird area boundaries initially identified by questioning local
expert counters who had been monitoring shorebirds in an area for over two decades were correct
through either: analyses of 25 years of count data revealing strong negative correlation between
counts at separate locations which were later aggregated into one shorebird area (Haslem et al., 2008);
the absence of negative correlation in long-term count data, justifying keeping proximate adjacent
areas separate (Rogers et al., 2010); the consistency of annual count totals when counts in the Western
Lakes region from lakes that have large variation in their counts individually and are over 50 km apart
were aggregated (Birds Australia Unpubl. Data); detailed mapping of shorebird roosting and foraging
habitat (Clemens et al., 2008); identification of the spatial distribution of recaptured birds (Herrod,
2010); or determination of home range by radio telemetry (Rogers et al., 2010).

For two reasons, understanding when boundaries should clump non-contiguous wetlands is
best done at the species level. First, different species use different areas in different ways, with some
wandering more than others in search of food or roosting locations (Colwell, 2010). In some
localities, some species keep to very small areas during the non-breeding season, such as the separate
local populations or ‘functional units’ of Dunlin Calidris alpina that were identified within large salt
field habitats in Portugal (Luis & Goss-Custard, 2005). In such cases, the understanding of how to
aggregate data for each species is important when analysing monitoring data, but the overall shorebird
area boundary should grow to include the local non-breeding home range of the widest ranging
species that regularly meets criteria. In order to avoid growing the boundary infinitely we suggest
some simple rules on where to draw the outer line of the boundary (Figure 3). We suggest no
individual wetland habitat should be included in the overall shorebird area boundary unless it
regularly holds at least 2,000 shorebirds, or 0.1% of the flyway population of a species which when
aggregated meets criteria. Additionally, to meet international criteria at least 20% of the population in
that smaller wetland must be known to move regularly to habitats in adjacent wetlands that
cumulatively meet international thresholds. Here, 20% is an arbitrary figure which avoids clumping
based on evidence of movement of only a few birds, while ensuring that count variation over 20% due
to movement is limited by clumping areas. For our purposes, we consider foraging and roosting
habitat to be so clearly linked, that such habitats are considered in the same way as contiguous habitat,
so under no circumstances would roosts from a shared wetland boundary be excluded just because
they were slightly outside the contiguous wetland boundary. We also point out that analyses in
Australia have indicated that 2,000 shorebirds or 0.1% of the flyway population are reasonable
thresholds to capture significantly larger percentages of flyway populations without resulting in
unreasonable numbers of new significant wetlands (Clemens et al., 2010). Similar work in other parts
of the globe may reveal more appropriate national or regional thresholds, especially in places where
there are complexes of many smaller wetlands none of which meet thresholds individually.

Second, species vary in the frequency with which they return to, or remain in non-breeding
habitats. Boundary setting as we are recommending here will work especially well for those species
that show high site fidelity within and between non-breeding seasons. Such fidelity has been
documented for many migratory shorebirds and is more common at coastal habitats with consistent
food availability (Burton & Evans, 1997; Herrod, 2010; Rehfsch et al., 2003). Those species which
do not show high non-breeding site fidelity and move across their non-breeding distributions widely
(Alcorn, et al., 1994; Kingsford 1999), will have to continue to rely on boundaries based on
overlaying high counts and contiguous wetland boundaries, until the fitness benefits of such habitats
can be quantified as is increasingly being done in North America (Farmer & Wiens, 1999; Potter, et
al., 2007). Once fitness benefits are established, we advocate treating ephemeral complexes when
conditions are suitable in the same way as more regularly used complexes. Similarly, additional
provisions which protect ‘emergency sites’ (i.e. those used by a substantial portion of a species
population during adverse conditions) would also enable flexibility, in turn assisting in conserving
migratory shorebirds (Overdijk & Navedo, 2012). However, if fitness benefits of the habitat have not been otherwise established, we recommend that if over 80% of the shorebirds using a non-breeding habitat are not thought to remain in an area throughout the non-breeding season or return to an area between seasons, separate habitats should not be clumped based on the abundance of those species.

The guidelines we have provided here rely primarily on developing a better understanding of how migratory shorebirds use habitats in the non-breeding season, and their extent of movement between habitats both within and between seasons. As monitoring of shorebirds in an area continues, we have observed how the understanding of local movement improves boundaries when they are revised. However, we recognise that often observation alone is insufficient to learn about such movements, especially in staging habitats. In such cases banding or telemetry studies can accelerate an understanding of where to set optimal boundaries. Setting boundaries that are always inclusive of the best understanding of the ecologically relevant home range of a local non-breeding population of migratory shorebirds, can lead to areas being identified as important, that are very different to those identified initially, and inherently require updating as more information on home-ranges becomes available (Clemens et al., 2006; Haslem et al., 2008).

Conclusions

Ideally, the designation of important non-breeding areas would be based on several factors: 1) an understanding of the connectivity of shorebird habitats during migration, 2) an understanding of the availability of suitable food resources, 3) knowledge of area-specific limiting factors and carrying capacity, 4) inherent differences in networks of ephemeral versus coastal habitats, and 5) an understanding of shorebird habitat use and movement throughout non-breeding distributions (Colwell, 2010). Presently, that kind of comprehensive information is lacking, yet planning decisions continue to be made that prioritise areas based on abundance (which have potential to impact shorebird populations) and that are based on monitoring which could be more sensitive if done at the appropriate scale. We argue that the use of more specific guidelines to identify important non-breeding shorebird habitat provides consistency, transparency, and comparability in the identification of important shorebird areas. Continued efforts to maximise the match between boundaries and the
non-breeding home range of shorebirds found within those boundaries, will mark a step forward in
improving shorebird conservation decision making, required in light of the enormous challenges these
birds will continue to face in the long-term. The quickest way to improve shorebird area boundaries is
to increase the number and rigour of shorebird movement studies (Haig et al., 1998), focusing in those
areas thought to be under greatest threat, and where clumping wetlands might lead to areas meeting
conservation designation thresholds that would not otherwise be met.

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Table 1. Summary of the kinds of criteria used to identify significant shorebird areas throughout the world. Note that many approaches involve a hierarchy of classifications.

<table>
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<th>Protocol</th>
<th>Shorebird trigger criteria for site recognition as ‘important’</th>
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| **Ramsar Convention (1971)** | Any shorebird area on the globe can be identified as being internationally significant if it regularly supports:  
  - at least 20,000 waterbirds, or  
  - at least 1% of the individuals in a population of one species or sub-species of waterbird.  
  These areas are flagged as internationally important in Australia. |
| **East Asian-Australasian Shorebird Site Network (1996)** | Two categories of site importance:  
  1. "Internationally significant sites" (same criteria as used for Ramsar above except that waterbirds have been replaced with "shorebirds").  
  2. "Nationally important sites" were recommended as:  
     - areas with 10,000 or more shorebirds, or  
     - for areas that support 1% or more of the individuals of the Australian population of a species or sub-species. |
| **Western Hemisphere Shorebird Reserve Network (1985)** | Three categories of site importance:  
  1) "Hemispheric Sites" hold at least 500,000 shorebirds annually or 30% of the biogeographic population for a species,  
  2) "International Sites" hold at least 100,000 shorebirds annually or 10% of the biogeographic population for a species, and  
  3) "Regional Sites" hold at least 20,000 shorebirds annually or 1% of the species biogeographic population for a species. |
| **Second tier of nationally important sites (UK):** | Nationally important sites are:  
  - where 1% or more of the national population of a non-breeding species or sub-species has been recorded  
  - where semi-natural habitats hold at least 70 breeding species, 90 non-breeding species, or 150 transient species, or  
  - where pre-set index thresholds for different habitat types are exceeded by cumulative scores of the species present that related to the national breeding population. |
| **Sites of Special Scientific Interest** |  
| **Australia’s draft national significant impact guidelines under the EPBC Act** | Nationally important shorebird areas are:  
  - identified as internationally important, or  
  - support at least 0.1% of the flyway population of a single species, or  
  - support at least 2000 migratory shorebirds, or  
  - support at least 15 shorebird species. |
Figure 1. The Western District Lakes Ramsar Site boundary (Victoria, Australia; 38°11' S, 143°21'E) formed in 1982 was not large enough to capture the areas used by the local shorebird population when conditions at inland wetlands changed in later years. In recent years, over 90% of the shorebirds that use this wetland complex were found at Lake Elingamite, Lake Martin and Lake Colac, all of which are outside the historic Ramsar boundary. Other areas that were used by large numbers of shorebirds historically, like Lake Murdeduke (far right) have not been used by important numbers of shorebirds in recent years. Variation in counts across time is reduced significantly when all counts from the wetlands in this complex are aggregated. In wetland complexes that are dynamic with respect to water level, condition, or prey availability, boundaries need to be large enough to include all potential habitat between years, and there is a scale at which aggregating counts from these areas results in comparable between-year totals; in this case the wetlands within a 2500km² area.
Figure 2. The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site boundary, Victoria, Australia (38°13' S, 144°28' E) designated in 1982, and the five smaller independent separate shorebird areas which have more recently been identified, as well as the various 'count areas' that are routinely counted during regular monitoring. Expert counters identified shorebird habitat, and the areas usually counted, and then identified shorebird area boundaries that included all habitat known to be used by five independent populations of shorebirds during the non-breeding season. Treating these five areas independently in analyses allows smaller changes in populations to be detected. Note also how one shorebird area which regularly meets international criteria was not included in the original Ramsar boundary. Each of these five independent areas meets international criteria, and management in one area is expected to benefit only the shorebirds within that one area, not all the birds within the Ramsar site.
Figure 3. Proposed guidelines in a dichotomous key for establishing boundaries around important habitats for migratory shorebirds, with a focus on when to 'cluster' non-contiguous habitats, that build on guidelines currently promoted internationally (Ramsar Convention Secretariat, 2010). We encourage those who identify larger boundaries than these guidelines indicate, but suggest that these guidelines should provide the minimum number of non-contiguous habitats that should be clustered to form one important 'site' inclusive of all ecologically linked habitats. Information sufficient to address these guidelines is essential for every important shorebird site, and will often require studies on local shorebird movements.

Dichotomous Key

1a. Counters have recorded shorebird abundance during at least 5 counts conducted over at least three years (go to 2)

1b. Counters have not recorded shorebird abundance during at least 5 counts conducted over at least three years Not Important

2a. Area covered during count includes the entire contiguous wetland, or no additional counts in other parts of the wetland were conducted at roughly the same time (go to 3)

2b. Area covered during count includes part of the contiguous wetland, and other parts of the wetland were conducted at the same time (go to 4)

3a. Congregatory waterbird abundance regularly exceeds 2,000, or is greater than 0.1% of the species biogeographic population Not Important

3b. Congregatory waterbird abundance is regularly less than 2,000 or does not include more than 0.1% of any species biogeographic population

4a. Sum of available roughly synchronous counts throughout area of contiguous habitat inclusive of any roosts used by birds that use the feeding habitat within the contiguous habitat exceeds 2,000 total waterbirds, or is greater than 0.1% of the species biogeographic population (go to 5)

4b. Sum of available roughly synchronous counts throughout area of contiguous habitat and associated roosts is less than 2,000 total waterbirds, or is less than 0.1% of the species biogeographic population Not Important

5a. Counts of individuals of a species are used to assess thresholds, and at least one of those species is known to exhibit high site fidelity, with at least 80% of the surviving individuals returning to the non-breeding area each year, and thought to remain in one area throughout the peak of the non-breeding season (go to 6)

5b. Counts of individuals of a species are not used to assess thresholds, or no species exhibit high site fidelity, with no evidence that at least 80% of the surviving individuals return to the non-breeding area each year or remain in one area throughout the peak of the non-breeding season (go to 7)

6a. During periods of the non-breeding season when shorebirds are not actively migrating, no significant movement of shorebirds has been observed to adjacent wetlands (count area believed to represent a closed population of non-breeding shorebirds), or...
no roughly synchronous counts are available from adjacent wetlands ........ (go to 7)

6b. During periods of the non-breeding season when shorebirds are not actively migrating, significant movement of shorebirds has been observed to adjacent wetlands ........................................ (go to 8)

7a. Sum of available roughly synchronous counts throughout area of contiguous habitat is less than 20,000 total waterbirds, or is less than 1% of the species biogeographic population ......... Nationally Important

7b. Sum of available roughly synchronous counts throughout area of contiguous habitat is greater than 20,000 total waterbirds, or is greater than 1% of the species biogeographic population ........ Internationally Important

8a. Sum of available roughly synchronous counts throughout area of all habitats between which there is regular shorebird movement is less than 20,000 total waterbirds, or is less than 1% of the species biogeographic population ............. Nationally Important

8b. Sum of available roughly synchronous counts throughout area of all habitats between which there is regular shorebird movement is greater than 20,000 total waterbirds, or is greater than 1% of the species biogeographic population ............ Internationally Important

Contiguous wetland\(^d\) includes all habitats associated with one body of water, where water is the controlling factor in the condition of that habitat, and for our purposes because shared feeding habitats and roosting habitats are so obviously linked we consider all roosts associated with feeding habitat within the contiguous habitat to be part of the contiguous wetland.

Congregatory\(^e\) = Shorebirds that do not congregate in large numbers in the non-breeding season will require different mechanisms to identify important habitat (Clemens et al., 2010).

Regularly\(^d\) = The majority of counts conducted when conditions were appropriate exceed the threshold with a minimum of five counts conducted over at least three years (as per Ramsar), maximum counts during the non-breeding season can be used once minimum amount of data is exceeded, especially important in areas with relatively low detection probabilities.

Waterbird abundance regularly exceeds 2,000, or is greater than 0.1% of the species biogeographic population\(^e\). These thresholds capture a significant additional proportion of the flyway population while not adding unreasonable numbers of significant wetlands (Clemens et al., 2010). Similar work in other parts of the globe may reveal more appropriate national or regional thresholds, especially in places where there are complexes of many smaller wetlands that generally don’t meet thresholds individually.

Not Important\(^f\) = For the large congregations of shorebirds that these abundance thresholds are intended to protect. Other metrics of habitat importance could identify the wetland as important.

Significant movement\(^e\) = includes regular movement by over 20% of the birds to adjacent wetlands, evidence of movement will be strongest in telemetry studies, but multiple years of resighting studies of individually marked birds, analyses of decades of comprehensive regional data, or questioning experts who have been actively monitoring in a region for decades can all provide the required information.