# General Introduction

## Guidelines for the Management of Migratory Shorebird Habitat in Southern East Coast Estuaries

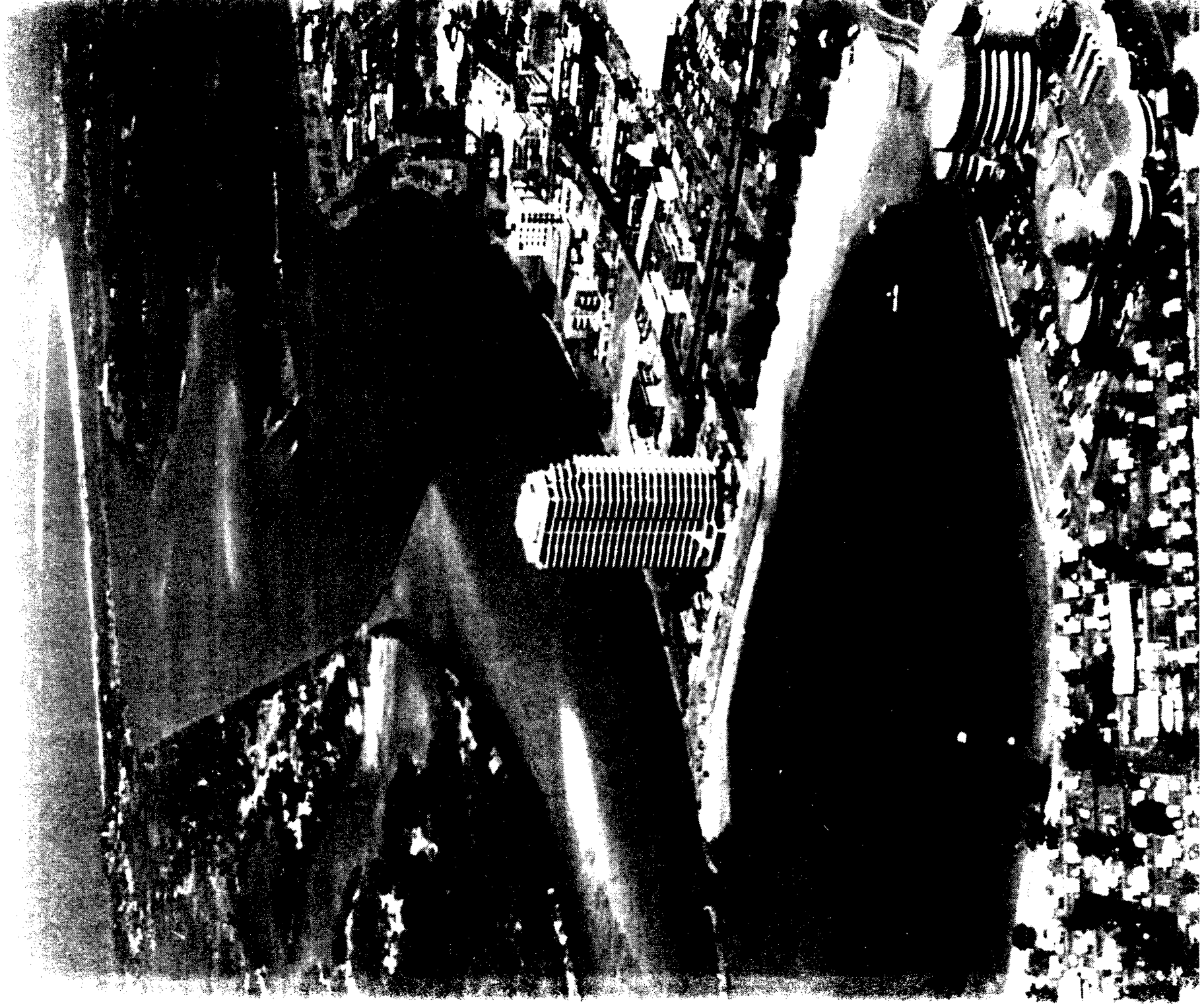
**Summary:** This research provides guidelines for the management of migratory shorebird (wader) habitat in estuaries, by providing both principles and specific habitat criteria. The need for clearly defined criteria has been expressed by authors of management strategies and surveyed estuary managers.

Development in and around estuaries frequently impacts on shorebird habitat. The guidelines from this research relate to these impacts on shorebird habitat, rather than the diverse causes of the impacts. The impacts dealt with are: habitat loss and fragmentation, changes to vegetation, erosion and deposition, changes to tide, salinity and nutrients, changes to invertebrate populations, and the disturbance of shorebirds.

The guidelines are relevant to a coast-wide scale within the study region, while being applicable to specific sites within estuaries. They complement and build on existing management guidance from shorebird and wetland surveys, shorebird and estuary studies, reviews and management plans.

The shorebirds dealt with are the trans-equatorial migrant Charadrii (whimbrel, godwits, plovers, sandpipers etc) which feed on the intertidal estuarine flats of the southern east coast of Australia from spring to autumn. The guidelines are developed using simple habitat suitability models based on work by the U.S. Fish & Wildlife Service.

They are presented in six papers: feeding habitat use, feeding habitat management criteria; feeding habitat assessment criteria; nocturnal use; the food resource; and roosting habitat use and criteria. General conclusions are summarised, and four appendices provide measurement techniques, management strategies, requirements of constructed roosts, and an example of guideline use.



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# Guidelines for the Management of Migratory Shorebird Habitat in Southern East Coast Estuaries

## General Introduction

### Purpose of the Research

This research aims to provide guidelines for the management of estuarine habitat for migratory shorebirds, and aims to make the guidelines as specific, quantified and useful as possible.

The need for such research and guidelines has been shown by:

(i) national and New South Wales state reviews of migratory shorebird management needs (Smith 1991, Watkins 1993), expressed in their recommendations for research;

(ii) corporate goals defined in the New South Wales National Parks & Wildlife Service (NPWS) Corporate Strategy and related documents (Llewellyn & Smith 1991; NPWS 1991. Also RAC 1993a);

(iii) views expressed by many estuary managers (eg. N.P.W.S. district superintendants, rangers, Fisheries officers, E.P.A. officers) during a survey of estuary managers' opinions conducted by the author throughout coastal New South Wales in 1991; and

(iv) the demand for clearly defined management guidelines from managers, developers and consultants which has been experienced by the author during nine years in wetland management research with the NSW N.P.W.S. and two years in private consultancy practice in southeast Queensland.

Plate 1 *Tweed River estuary, northern New South Wales, showing foreshore development in foreground, channel works at left, and Ukerebagh Nature Reserve, right background.*

*Issues Addressed*

Management issues are many on estuaries (Barnes 1974; Butlin 1976; Elkingon 1977; Williams 1990; Bildstein *et al.* 1991; Ivanovici *et al.* 1992), and issues in the protection of migratory shorebird habitat are a significant component (Morris 1983; Davidson & Pienkowski 1987; Lane & Sagar 1987; Geering & Driscoll 1994; Driscoll 1995). Table III.1 (Appendix III) lists 77 potential "threats" to shorebird habitat caused directly or indirectly by people. No doubt there are more - the potential threats are as diverse as human activity is on estuaries (Kenchington 1991), and estuaries are often centres of human endeavour or recreation (see Chapter 1: Introduction). They are also concentrations of migratory shorebird habitat (Blakers *et al.* 1984; Smith 1991).

As the human influx to coastal Southeastern Australia increases (Yapp 1986; HORSCERA 1991; Hulsman *et al.* 1993; RAC 1993b), people and migrating shorebirds seem on a collision course in their use of estuaries (eg. Burgess & Woolmington 1981; Woodall & Watson 1988; *Peninsula Post* 1995). Reliance on protected areas for shorebird conservation will not be enough (Collett 1974; Knights 1991). Shorebird needs will have to be integrated with human needs (Shepherd 1981; Boyd 1988; DEH 1993; Harding 1995). Because this will need compromises in land use (Robinson *et al.* 1988; Driscoll 1993a; Laubhan & Fredrichson 1993; McDonnell & Pickett 1993), a rational basis will be needed to guide and justify management decisions (Munda 1994).

Table III.1 also lists 51 "impacts" on shorebirds and shorebird habitat resulting from the listed threats. Amid the complexity of conflicting land use interests in estuaries, it is more manageable for guidelines to address the resultant impacts on migratory shorebird habitat than each disparate cause. These impacts can be classed into:

1) habitat loss and fragmentation;
2) changes to vegetation;
3) erosion, deposition or changes to substrate;
4) changes to tidal regime, salinity regime, and nutrient regime;
5) changes to invertebrate populations;
6) disturbance to birds; and
7) pollution.

Classes 1-6 are addressed directly in this research, by examining the ranges of natural habitats selected by the birds. The research can contribute indirectly to the application of existing pollution management guidance for estuaries (eg. Coffey 1973; Miller & Connell 1980; Axelrad *et al.* 1981; Howarth *et al.* 1982; Garmen & Sutherland 1983; Anink *et al.* 1985; Skidmore 1989) by defining habitat needs. Other management issues addressed by the research are: the identification and evaluation of estuarine shorebird habitat for management, environmental impact assessment and reserve selection; the invertebrate food resource; and nocturnal habitat needs of migratory shorebirds.

*Scale*

The research operates at two contrasting scales simultaneously - local applicability to small estuarine sites, and coast-wide regional relevance - because this is required of guidelines.

Habitat management in estuaries requires decisions affecting particular mudflats, sections of foreshore, sandbanks, even individual mangrove trees, yet each decision must be made in a wider context (Odum 1982; Adam 1985; Laudenslayer 1986). Guidelines should be applicable as widely as possible for cost effectiveness.

The region of application aimed for in this research is the range of relatively discrete estuaries on the east coast of Australia north to, but excluding, the large sheltered intertidal complex of Moreton Bay (Roy 1984) (see Chapter 2 Discussion: *Regional Coverage and Application*). This corresponds almost entirely to the political boundaries of New South Wales, in which most fieldwork was conducted (see Chapter 1: Methods; Acknowledgements).

There is a compromise between breadth of regional application and site specific accuracy - can the same guidelines be applied in the Towamba River and the Tweed River? How much error is acceptable in each, to accommodate both? The research aims to quantify this error by testing, but essentially the guidelines must be viewed and used as such - research-based guidance in the considered management of each site (Chalk 1986; Zeide 1991).

*Existing Management Guidance*

Surveys and informal observations, field studies, literature reviews and management plans have provided the basis for shorebird habitat management to date.

Surveys have identified the resource. Bell & Edwards (1980), Adam *et al.*(1985), West *et al.*(1985), ARSFC (1988), Hyland & Butler (1988) and Wettin *et al.* (1993) documented the estuarine wetland resource. Most shorebird surveys have been estuary specific, for example: Tweed (Martindale 1987), Richmond (Gosper 1981, 1983; Holmes 1988; Dettmann 1989), Clarence (Martindale 1984), Port Stephens (Pegler 1980), Hunter (van Gessell & Kendall 1974; Gosper 1981), Central Coast (Morris 1975), Parramatta (Harris 1988; Morris *et al.* 1990), Botany Bay (SPCC 1979; Morris 1986), Lake Illawarra (Wood 1985; Chafer 1991), Shoalhaven (Morris 1973; Pegler 1983), and Merimbula (Day & Hutchings 1984).

These have concentrated on major estuaries and major aggregations of shorebirds. Regional surveys (eg. Milledge 1980; FOC 1982; Lawler & Porter 1990a; Lawler 1994a; Chafer 1995) have added information about smaller estuaries, although many remain unsurveyed (Smith 1987). Most surveys have been one-off and many are now dated. The Australasian Wader Study Group and the New South Wales Wader Study Group conduct regular counts on a small sample of sites to monitor trends (Alcorn 1988, 1990, 1992; Barter 1993; Hewish 1990).

Local naturalists, often amateur birdwatchers, contribute greatly to the management of their areas, eg. Coleman (undated), van Gessell and Kendall (1974), van Gessell (1976), Smith and Chafer (1985) and Chafer (1986). This is a very effective source of management information which relates well to specific sites. Channels for this input are either informal (eg. advice of an individual or club sought by a local manager) or via consultancies on particular issues, often as part of environmental impact assessments. Much valuable information is amassed in consultants' reports which are unavailable to wider audiences.

Field studies have contributed the bulk of ecological principles and consequently management principles. Local studies have mainly been done in response to major environmental impact assessments or estuary land-use issues: Kooragang Is. (Dames & Moore 1978, Clarke & van Gessell 1982; Buckney 1987); Towra Pt. (ALS 1978); Port

Botany/Kingsford-Smith Airport third runway (Butlin 1976; Kinhill 1990, 1991; FAC 1992; Adam 1993; Blumer 1993); Lake Macquarie (Winning 1990); Lake Illawarra (Chafer 1989, 1991); Tuggerah Lakes (Croft & Wettin 1980); Wallis Lake (CWS 1985); Shoalhaven River (Kingsford 1990); Clarence River (Holmes 1983).

Studies and reviews of other aspects of estuarine ecology have also contributed, eg. fisheries (Pollard 1974; Middleton 1985; Burchmore *et al.* 1993), invertebrates (Anderson *et al.* 1981; Clarke & Miller 1983; Hutchings & Recher 1982; Jones *et al.* 1986; Jones & Candy 1981; McCormick 1978; Powis & Robinson 1980; Rainer 1984), seagrass (West 1983; Larkum *et al.* 1989; Poiner *et al.* 1992), mangroves (Clarke & Hannon 1971; Clough 1982; Hutchings & Saenger 1987), soils (Beers 1962; Lin & Melville 1992), nutrients (McComb & Lukatelich 1986), currents (Rochford 1951; Williams 1983; Mann & Lazier 1991), geomorphology (Bird 1968; Scholer 1974; Bayley 1975, 1980; Cheng 1981), and the interactions among these (Goodall 1983; King *et al.* 1991; Mitsch *et al.* 1988).

These principles have enabled the development of general estuary management guidelines, eg. NSW Fisheries (undated); Collett and Hutchings (1978); Hutchings and Wilkinson (1980); Middleton *et al.* (1984); Catlan and Williams (1985); Williams (1986); NSW Govt. (1989); Brookhouse (1990); Dunston (1990); Public Works (1990,1991a).

Studies of shorebird ecology in other parts of Australia and even overseas have been used to fill the knowledge gaps, eg. Dann (1981, 1983, 1993), Thomas and Dartnall (1971a), Thompson (1991b, 1993), Tulp and de Goeij. (1994), in Australia, and work in temperate North America (eg. Recher 1966; WHSRN 1996), the North Sea (eg. Goss-Custard 1977; Evans *et al.* 1984) and elsewhere. Lane (1987) continues as the most comprehensive, if generalised, compilation of management information on Australian shorebirds.

Aspects of shorebird biology, taxonomy and distribution studied by the Australasian Wader Studies Group and state groups (published in *The Stilt*) can relate to the management of estuaries (eg. references in *Migratory Shorebirds*, below). Complex issues are largely left to overseas researchers - such as the effects of habitat loss on shorebird populations (eg. Lum 1978; Goss-Custard 1977; Goss-Custard & Durell 1990; Evans *et al.* 1991; Meire 1991; Goss-Custard *et al.* 1993), the effects of habitat creation on shorebird populations (eg. Rundle & Frederikson 1981; Davidson & Evans 1986; Dickson &

McKeating 1993; Helmers 1992, 1993), the effects of human disturbance on shorebirds (Burger 1981; Myers 1983), the interaction of shorebird populations and their food resources (eg. Burger 1977; Botton *et al.* 1994), and effects of pollution on survival and reproduction (eg. Wolfe 1977; van Straalen 1994).

Literature reviews and bibliographies have collated published information. Miles (1975), Pressey and Harris (1988), Winning (1991) and AHC (1992) gathered national or state wetland literature. Mills (1989) and Lawler and Porter (1990b) are examples of bibliographies specific to a district. Smith (1991) reviewed shorebird information to provide a management strategy for shorebirds in New South Wales, including prioritising important sites. Watkins (1993) did the same in a national context.

Management plans and similar documents provide more localised management guidance if shorebirds are considered, eg. PEC (1979) and Public Works (1991b) for the Tweed River improvements, NPWS (1984) and NPWS (1987) for Myall Lakes and Botany Bay National Parks, and Thompson *et al.* (1989) and McEnally & Thompson (1989) for pollution contingency planning in Botany Bay and the Hunter River estuary, but such planning is only available for some areas. Management plans can imply general principles, although application of these outside the subject areas can be difficult.

These surveys and studies inform estuary managers of *what* they should conserve for shorebirds, in general terms, and *why*, but less clearly define *how* the resource can be conserved. There is a lack of specific methodologies and criteria to use in estuarine management for shorebirds (Straw 1994). Managers have been asked to assimilate general ecological principles and integrate these into practical management decisions (Frith 1973).

Managers have achieved this through necessity to date, but it is, in effect, asking them to "fly by the seat of their pants". With the increasing pressures on estuaries, it will be neither fair nor effective to expect managers to learn by experience, if ecological principles can be taken further to actually provide the guidance needed (Cherfas 1987; Constable 1991). This research is an exploration of this next step - an attempt to go beyond principles and provide quantitative guidance.

## Migratory Shorebirds

The migratory shorebirds (wading birds or waders) dealt with in this research are the trans-equatorial migrant Charadrii of the East Asian-Australasian flyway, which use estuarine intertidal flats as feeding habitat: the curlews (*Numenius*), whimbrels, godwits, greenshanks, plovers (*Pluvialis* and *Charadrius*), tattlers, knots and sandpipers of our estuaries (Marchant & Higgins 1994; Higgins & Davies 1996) (see Appendix I for names).

These birds breed in the high latitudes of northern Asia (a minority may breed in the western North American arctic (Barter 1989a,c) on tundra, taiga and high plateau (Demen'ev & Gladkov 1969; Tomkovich 1995). Most feed on invertebrates in or on the soft wet soil of shallow or intermittently flooded wetlands (Holmes 1966; Holohan & Schmidt 1993). They breed during the long days of the arctic summer between May and July, when melted ice forms enormous and very productive wetlands (Kondratyev & Gromadzka 1992).

As the short arctic summer turns into cold autumn in August, conditions deteriorate (Green *et al.* 1977; Clark *et al.* 1993). Adult waders and their newly fledged young migrate southward through Asia along what is considered the world's most threatened flyway (Parish 1985,1987; Danielson & Skov 1989; Gill *et al.* 1994; Melville 1996). They stop to feed on productive temperate and tropical coastal wetlands as they go (White 1975; Parish *et al.* 1987), on a journey which may span 13 000 kilometres (Barter & Wang 1990; Baker *et al.* 1995). By late August and September they are arriving in Australia (Alcorn *et al.* 1994), in time for the austral summer and the resulting high invertebrate productivity in our wetlands (Tulp & de Goeij 1991, 1994).

The birds occupy the wetlands of Australia (Thomas 1970; Lane 1987; Kingsford *et al.* 1993; ANCA 1995), and some reach New Zealand (Parish *et al.* 1987) or even subantarctic islands (Merton 1970; Tideman & Copley 1988). Certain species and subpopulations range over the mosaic of wetland availability across Australia (Campbell 1986; Cox 1990; Maher 1991; Kingsford & Porter 1993; Kingsford *et al.* 1994; Hutchison 1995), but most concentrate on consistantly reliable coastal wetlands (Watkins 1993) which they know and may return to season after season (Driscoll 1993c, 1995). On the southern east coast of Australia, it is the tidal estuaries which provide most of the soft, intermittently flooded feeding grounds needed. The estuaries support the great bulk of the coast's migratory shorebirds (Smith 1991).

Their time on the estuaries is critical to their survival. For adults, the rigours of raising young, followed by a plumage moult (Barter 1989b), and their prodigious journey of migration, leaves them in need of a period of secure recuperation and uninterupted feeding to regain body condition (Kerston & Piersma 1987). For young, it is a time for maturing and learning the skills of survival (Wells 1968; Meire 1991; Sutherland & Goss-Custard 1991). When the austral autumn days shorten, those shorebirds which are ready to breed and have built up sufficient reserves of fat (Thomas & Dartnall 1970; Gudmundsson *et al.* 1991; Lindstrom & Piersma 1993; Piersma 1994) begin to moult again into bold or colourful breeding plumage (Thomas & Dartnall 1971b), and leave our estuaries for the great journey north (Tulp *et al.* 1994).

Only a small non-breeding proportion of the population remains through the southern winter (Alcorn *et al.* 1994), mostly of first year birds maturing for the following season (Summers & Waltner 1979; Hewish 1990; Thompson 1993), but the importance of the estuaries as shorebird habitat remains, awaiting the return of the flocks in spring.

## Habitat Modelling

Models of habitat use are descriptions of an organism's habitat - in words or numbers. Both are used in this research. As such they are simplifications (Fretwell 1987), reducing the complex flux of causes and effects which determine habitat selection to comprehensible basics (Breckling 1992) for the purpose of understanding and predicting the organism's future habitat needs (Salwasser 1986; Lincoln Smith 1991).

The models used in this research are as simple as possible, without losing their usefulness as descriptors and predictors (Thomas 1986). They are kept simple because the aim is to provide basic, easily used but effective guidelines for resource managers - guidelines which deal with each discrete feature to be managed. Elaborate data transformation and manipulation is avoided to retain direct understanding of what the data is reflecting in reality, a necessity in such generalisations. However, oversimplifications such as habitat suitability indices (Schamberger *et al.* 1982) have also been avoided.

Habitat modelling techniques have been intensively studied and developed during the last 15 years (eg. Capen 1981; Briedman *et al.* 1984; Verner *et al.* 1986; Norton 1990),

and computer-intensive techniques have been developed in Australia and used to effect for broad-scale spatial analysis to predict the occurrence (presence/absence) of animals, plants and communities for resource management (eg. Austin 1987; Braithwaite *et al.* 1989; Austin *et al.* 1990) and reserve selection (eg. Margules *et al.* 1988; Margules 1989). Effective smaller scale modelling of vertebrate habitats incorporating gradients of both habitat attributes and habitat use are less common (eg. Ferrier 1985; Diefenbach & Owen 1989; Ingelby *et al.* 1989) and have not always been successful (eg. Ingelby and Westoby 1992).

Simple models can be as effective as complex procedures for the purpose of management guidance. Ross *et al.* (1993) produced effective models of fingerling habitat for the U.S. Fish & Wildlife Service by simply defining the ranges of the habitat selected by the animals from the bivariate space of fingerling number/habitat-attribute plots. The approach of Ross *et al.* is used as a basis for the techniques developed in this research. It is an approach made possible by the fundamental understanding of the ecosystem laid down by previous work (see *Existing Management Guidance*, above).

Predictive modelling of shorebird habitat in Australian estuaries is rarely attempted (or validated (Hurley 1986; Layman & Barrett 1986)), partially because basic assumptions of niche occupation and separation may not be met (van Horne 1983; Schamberger & O'Neil 1986; Lewis & Nelson 1988) (see Chapter 2: Methods, and discussions in Thompson 1991b). Thompson (1991b, 1993) modelled spatial and temporal habitat selection of a suite of species in Moreton Bay and examined the change in distribution with migration. Congdon & Catterall (1994) provided a descriptive model of Eastern Curlew habitat use in Moreton Bay. Pegler (1981) was less successful predicting habitat use on the Botany Bay/Georges River and Port Stephens estuaries.

Current research is examining habitat use on the Richmond estuary (Bob Moffat, David Rohweder pers comm.), Clarence estuary (Greg. Clancy, Mark Williams pers. comm.), Parramatta estuary (Iain Taylor pers. comm.), and Hunter estuary (David Geering pers. comm.), and occurrence of shorebirds over time on the Shoalhaven estuary (Chris Chafer pers comm.). Using the term "model" in its more general sense, patterns of shorebird habitat selection have been described in Victoria (Dann 1994) and on the Hunter (Clark & van Gessell 1982), Parramatta (Harris 1988), Botany Bay (ALS 1978), Lake Illawarra (Chafer 1991) and the northern rivers of New South Wales (Martindale 1984, 1987).

These models provide the basis for our understanding of shorebird habitat needs and have provided general management principles. The modelling in this research is intended to complement and build upon this knowledge by providing quantified management criteria (Toth *et al.* 1986).

## Geographic Modelling

A current trend in conservation management is the broad-scale spatial analysis and prediction of species occurrence. This uses geographic information system-based, remotely sensed geographical data, and ground or aerial sampling of species occurrence, to predict distributions by extrapolation (Ferrier & Smith 1990). Examples are: Woinarski and Braithwaite (1993); Burrough (1988); Gillison and Brewer (1985); Schuster (1991); Tidemann & Wilson (1992).

Such projects are undertaken either before or after species-habitat relationships are determined. If in-depth determinations are made first by research using induction (Romesburg 1981), the relationships identified can be used as a validated and quantified basis for spatial mapping (Ferrier & Smith 1990). If the broad scale, superficial surveys are made first, they can be used to generate hypotheses for subsequent investigation (Braithwaite 1991; Taplin 1993), a process labelled retroduction (Romesburg 1981). The pressing and broad scale needs of land managers make the cost- and time-saving geographical approach appealing, but wildlife-habitat relationships may be affected by factors not measurable at such broad and superficial scales, leading to a flawed foundation for subsequent understanding.

Geographic modelling has not been adopted in shorebird habitat management in south-eastern Australian estuaries, although it was proposed (Geoff Smith pers.comm.). It lends itself to understanding the spatial and temporal dynamics of shorebird habitat use (Flemming 1989; Thompson 1991a), both in the region and in less accessible parts of the flyway. The research presented in this thesis can lay a foundation, at an appropriate scale, for the future broadscale spatial and temporal modelling of migratory shorebird habitat use in southern east coast estuaries.

## Plan of the Thesis

The thesis presents the research in six papers:

Chapter 1 examines use of intertidal feeding habitat in estuaries by common shorebird species and species number, by comparing shorebird abundance with a suite of habitat features, and examines species co-occurrence;

Chapter 2 develops and presents guide values for use as criteria in the maintenance or provision of shorebird feeding habitat, based on the habitat features indicated to be important correlates of shorebird abundance;

Chapter 3 develops and presents keys for the prediction of the conservation value to shorebirds of intertidal flats in estuaries, based on the numbers of shorebirds recorded feeding on sampled flats with equivalent features;

Chapter 4 compares shorebird use of intertidal flats by day and night, because impacts on shorebird habitat which occur at night also need managing, and the guide values are developed from daytime use of the habitat;

Chapter 5 relates the benthic invertebrate food resource of shorebirds in estuaries to shorebird occurrence for general management principles, because direct impacts on invertebrate populations (eg. over-harvesting, pollution) cannot be managed by the maintenance of physical habitat criteria alone; and

Chapter 6 describes high tide roosting habitat and provides criteria for its maintenance, because this is a second important shorebird habitat in estuaries.

A summary of general conclusions extracts the take-home messages of the research for shorebird conservation in estuaries. In addition there are four appendices providing supplementary information relevant to management of estuaries for shorebirds:

Appendix II describes the measurement techniques used in the research because these are also needed to apply the guidelines;

Appendix III considers a range of shorebird management issues in estuaries and suggests management strategies for each. It is extracted from a sister document (Lawler 1994b) now out of print, to make the thesis a more useable management tool;

Appendix IV provides advice on the construction of shorebird roosting sites, based on the research reported in Chapter 6 and recent research undertaken for the Queensland Government. Provision of high tide roosts is increasingly necessary on highly developed shores (Driscoll 1993b,c); and

Appendix V describes an actual environmental impact assessment which used the keys developed in Chapter 3, as an example of their use, and reports their performance.

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