The Conservation of Wading Birds

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Abstract.—The conservation and management of wading birds, particularly colonial wading birds, has received considerable attention in the past 20 years. Critical issues over this period were status and trends (including endangered species), wetlands, nesting sites, aquaculture, critical habitats and international cooperation. There has been a considerable advance in basic knowledge and in the application of this knowledge to conservation issues. World wide action plans and flyway plans are in development. Issues for the next century include population based conservation, habitat conservation at both the local and landscape scales, wading birds as potential bioindicators of environmental stress, and activation of the strategic plans.

Key words.—Bioindicators, Ciconiiformes, contaminants, habitat, herons, ibis, population, storks.

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Wading birds—the herons, ibises, storks and flamingos—are large, showy birds, readily seen in the right places and so generally well appreciated by people. Many species live near humans, even nesting on houses and in city parks and feeding in pastures and meadows. A few species hold special places in the culture and history of certain regions. The White Stork (*Ciconia ciconia*) in Europe, the Sacred Ibis (*Eudocimus ruber*) in ancient Egypt, the Hadada (*Bostrychia hagedash*) and Marabou (*Leptoptilos crumeniferous*) in Africa, and the Adjutant Stork (*L. dubius*) in India come to mind. Most wading birds live in and near wetlands, as do a large portion of the world's human population. As the values and functions of wetlands have become better understood, so has appreciation for the place of wading birds within these ecosystems.

Conserving wading birds and managing their habitats have received quite a bit of attention this century, starting with widespread concern for the welfare of wading bird "rookeries" that contributed to the founding of the modern Conservation movement in North America. Another milestone, of sorts, occurred in 1976, when the North American Wading Bird Conference, held in Charleston, South Carolina, devoted a large portion of its agenda to discussing wading bird conservation (Sprunt *et al.* 1978). Much has happened in the ensuing 20 years. A large body of basic and applied research has developed. Population monitoring, directed management action, indirect conservation through wetland habitat protection, manipulation, and restoration, and the emergence of a professional society and international specialist groups devoted to their welfare are chapters in the contemporary conservation story for these species.

The purpose of this paper is to selectively review the state of wading bird conservation, with particular attention to progress and trends since 1976, especially how we have progressed on the big conservation issues identified by the mid 1970s. I will also suggest appropriate questions as elements of an agenda for the second century of wading bird conservation.

PROGRESS

Status and Trends

The role of wading birds as *cause celebre* for one of the most significant conservation issues peaked in the latter part of the Nineteenth Century. Around that time in various countries, hunting birds for plumes and market came under attack, attacks in which apparent decimation of wading bird populations figured prominently (e.g., Shufelt 1887). The Great Egret (*Ardea alba*) became a symbol of that concern in North America, and later a symbol of the Audubon movement.

With success comes complacency, and the decades that followed found little im-

provement in censusing wading bird populations. In the 1930s and early 1940s a few individuals, mostly wardens, reported on the status of wading birds. Unfortunately, many of the reports were of dubious accuracy and probably self-serving; counting techniques were primitive; most colony sites were inaccessible if known at all; aircraft were seldom available; and World Wars and economic depression provided significant interruptions in activity (Frohring *et al.* 1988).

So, it was a seminal contribution to the conservation of wading birds in North America that broad scale surveys and censuses of colonially nesting water birds were initiated in the 1970's under the leadership of Thomas Custer. Surveys in 1975 and 1976 along the North American Atlantic and Gulf coasts for the first time produced consistent information on numbers of various species at various sites (Osborn and Custer 1978, Portnoy 1978). About the same time retrospective evaluations were attempted (e.g., Ogden 1978), a national data center was established (McCrimmon 1978), and technical debates discussed what was being measured, how and why (Buckley and Buckley 1976, McCrimmon 1978, King 1978). The enthusiasm sparked by participation in these surveys and attendant institutional involvements was an underlying source of energy for the 1976 Wading Bird Conference.

In the following 20 years, estimating wading bird populations progressed. But in the USA, neither funding for monitoring programs nor the privately organized national data register persisted. Consortia of state governments, nongovernmental organizations and individuals, variously coordinated, filled some of the breach (e.g., Texas Parks and Wildlife Department 1988, Florida Game and Fresh Water Fish Commission 1991). By the early 1980s, 8 years of activity provided sufficient information for evaluation of regionwide status and trends (Spendelow and Patton 1988). Retrospective analyses sharpened (Kushlan and Frohring 1986, Frohring *et al.* 1988). Counting techniques were standardized, although they continued to be plagued by limited understanding of the accuracy and precision of census methodology (Hutchinson 1980, Buckley and Buckley 1980, Kushlan 1986, 1992).

The North American data base has been sufficiently robust to reflect large scale shifts in the population centers of 2 species, the White Ibis (*S. albus*) (from Florida to Louisiana) and the Wood Stork (*Mycteria americana*) (from South Florida to north Florida and Georgia). The conservation implications of these shifts are generally thought to be reduced habitat quality in southern Florida owing to man-induced hydrologic changes coupled with increased feeding opportunities due to aquaculture. Thus, we have reached the point, in North America, where large changes in local and to some extent regional populations can be charted.

Beyond the USA, over the past 20 years, there has been a confluence of interest in wading bird populations. One reason for this was activation of the Ramsar Convention, in which waterbirds provided one of the common standards for recognizing wetlands of international importance. Wetlands may be recognized that support more than 20,000 individuals of any waterbird species, regularly support substantial numbers of individuals from particular groups of waterfowl indicative of wetland values, productivity, or diversity, or regularly support 1% of individuals in a population (Ramsar Convention Bureau 1990). Given the importance of counting birds at specific wetland sites and knowing regional population levels, much effort has gone into censusing waterbirds. The International Waterfowl Census and other programs have resulted in significant increases in knowledge of the status of wading bird populations in many parts of the world (Rose and Scott 1994).

Some census programs are particularly enviable and serve as models for the future. The collaborative censuses of Grey Herons (*Ardea cinerea*) in England and White Storks in Europe are good examples. For these populations, a relatively small decrease would be detectable, and trends can be correlated with annual conditions on the summering or wintering grounds.

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Curry-Lindahl (1978). Confidence in the current status-classification of wading birds is high, primarily because of the tremendous amount of field work that has been accomplished in the last 20 years, attempting to clarify the status of apparently at-risk populations. Knowledge has especially increased in Asia and Australia. The general conclusion of this body of work is that most wading bird populations are not in danger of extinction and some, to the contrary, are expanding their populations and ranges.

For the exceptions, the situation is about the same as in 1976, or has improved very marginally, generally because of additional information. At present, 6 species (or subspecies) are recognized as being critically endangered (IUCN 1996): White-eared Night-heron (*Gorsachius magnificus*), Dwarf Olive Ibis (*Bostrychia (olivacea) bocagei*), Northern Bald Ibis (Waldrapp) (*Geronticus eremita*), Crested Ibis (*Nipponia nippon*), Black-faced Spoonbill (*Platalea minor*), and Giant Ibis (*Pseudibis gigantea*). Several additional species are considered endangered (IUCN 1996): Imperial Heron (*A. imperialis* - also known as the White-bellied Heron *A. insignis*), Australasian Bittern (*Botaurus poiciloptilus*), Chinese Egret (*Egretta eulophotes*), Oriental Stork (*C. boyciana*), Storm's Stork (*C. stormi*), Greater Adjutant, and White-shouldered Ibis (*Pseudibis davisoni*).

Geographically, wading bird populations appear most secure in Australia, South America, North America, and Africa, whereas populations appear to be at particular risk in Asia and, to some extent in western Europe. In Asia, human population increases, habitat destruction, and (in southeast Asia) warfare are thought to be the over-riding causes of wading bird population declines (Hancock *et al.* 1992). Possible risks to populations in Europe are particularly alarming because so much is known about population sizes of such species as the Grey Heron, European Spoonbill and White Stork and strong environmental laws exist. Decline of the White Stork in western Europe is understood to be due to modernization of farming practices. There are fears that the fall of Communism in eastern Europe will usher in improved agricultural practices that will similarly effect the stork there (Hancock *et al.* 1992). The Bald Ibis' status is a continuation of several centuries of decline in Europe, northern Africa and the middle East, generally attributed to climate change.

The Dwarf Olive Ibis was reduced on its island habitat by long-term hunting pressures (Hancock and Kushlan 1984, Hancock *et al.* 1992). The *Botaurus* bitterns, being cryptic and noncolonial, are some of our least known species and are a matter of concern, principally owing to lack of information to the contrary.

Curry-Lindahl noted 3 wading bird populations that became extinct in historic times. All were from islands. Since that time, knowledge of island wading birds has increased, and we know that the phenomenon is more interesting than could have been guessed in the mid 1970s (Olsen and Steadman 1979). One of Curry-Lindahl's extinct birds, the Dwarf Olive Ibis was rediscovered on Sao Tome Island in 1989, the first evidence since 1928 (Hancock *et al.* 1992). Much remains to be learned of island wading birds and their interactions with humans.

Contaminants

A significant, and perhaps dominating, issue of the mid 1970s was contaminants (Ohlendorf *et al.* 1978, Biskup *et al.* 1978). At the time, continent-wide surveys were in the process of demonstrating the extent of contamination and its notable effects, such as egg shell thinning (Ohlendorf *et al.* 1978). Contaminant fate and effects varied from place to place and species to species, and this variation was generally explainable relative to apparent exposures.

Twenty years later, a substantial body of information exists on burdens of organic materials (such as pesticides, herbicides, petroleum, industrial effluents, etc.), metals, and radionuclides in wading birds for North America and elsewhere (citations in Kushlan 1993). Once contaminant levels were known generally and for specific locales, questions could become more complex, seeking correlations and causal relationships between ex-

posure, persistent burdens, and effects. It has been documented or strongly inferred that contamination has caused egg shell thinning, genotoxicity, physiological responses such as induction of mixed function oxidases and metallothioneins, reduced reproduction, and direct mortality (citations in Kushlan 1993). One species, the Black-Crowned Night-Heron (*Nycticorax nycticorax*), enjoys a particularly large body of literature concerning exposure, fate and effects.

Such results have led to the suggestion that wading birds can be used as indicators of specific environmental effects and conditions (Custer *et al.* 1991, Kushlan 1993). It has been suggested particularly that the available bioindicators can be used effectively during the nesting season when adults, eggs and young are concentrated and available, and are sampling a restricted portion of the environment. The results of various studies are encouraging that judicious use of multiple indicators during nesting may be efficacious (Custer *et al.* 1991, Burger and Gochfeld 1992, Erwin *et al.* 1996).

There are few instances of population level impacts on wading birds. Population level effects of contaminants have been inferred in the case of White-faced Ibises (*Plegadis crini*) in western North America (King *et al.* 1978, Henny *et al.* 1985), but more recent range expansion is problematically linked to both reduction in pesticide exposure and habitat enhancement (Hancock *et al.* 1992). Contaminants have also been implicated in population declines of the Waldrapp (Parslow 1973).

However, most findings suggest most contaminant effects on wading birds appear to be sublethal. The Black Crowned Night Heron, for example, seems to thrive in some of the most despicable of estuaries. Thus, wading bird conservationists can turn their attention from worrying about the extent of exposure to the lethally persistent early generation contaminants toward a consideration of how we might use wading birds to examine and monitor sublethal effects of the modern generation of more environmentally subtle contaminants.

Wetlands

An important issue 20 years ago was loss of wetland habitat (Curry-Lindahl 1978, Kushlan 1978). In retrospect, this concern was rather imprecisely formulated. In the last 20 years, protection of wetlands has become securely imbedded in the core of public policy, not only in North America but increasingly around the world. Discussion now is less about the value of preserving wetlands, and more about how much, where, what kind, values and functions, on site or off site mitigation. Internationally, 2 organizations, the Ramsar Bureau and Wetlands International, have a global portfolio to protect wetlands for their many uses, in part, migratory waterbirds. Regionally important are such programs and policies as the No Net Loss policy of the USA and Canadian governments, the Medwet program that was sponsored by the European Commission, and community-based wetland management plans now being formulated in developing countries. Twenty years ago, few would have envisioned the extent of protection activities for wetlands around the world.

Nonetheless, it remains true that loss of wetland area and less dramatic loss of hydrological and ecological function are continuing problems in supporting wading bird populations. The most informative habitat issue of the last 20 years is encapsulated by what appears, at this time, to be the final crash of wading bird populations in the Florida Everglades. Populations that once numbered in the tens to hundreds of thousands have been reduced to remnants as a response to changed hydrologic conditions, in what by any standards is a huge area of remaining wetland (over 1-million ha). If a few levees and resultant water management can, over a period of a few decades, reduce the largest concentration of wading birds on a continent to a pittance, no wetland habitat is safe indefinitely.

Extensive studies of wading birds in several wetlands have provided exceptional insights into the use of those habitats by wading birds. Among the general results are an enhanced appreciation for the role of tidal, seasonal and inter-year variation in water

depths, species differences in using habitats under various conditions, differences among individual species, the interaction of feeding behavior, prey availability and feeding success, and the complementary roles of food availability in winter and summer. Although these results are specific to a location, many are generalizable such that it would be quite possible to manipulate many wetlands to enhance their quality for wading birds.

Nesting Sites

Nesting site management was an issue 20 years ago, and remains so today (Curry-Lindahl 1978). In the mid 1970s colony site protection was an overriding theme (Buckley and Buckley 1976), as was the realization that wading birds would use artificial sites and that these might have important population consequences (Parnell and Soots 1978).

Over the past 20 years, a tremendous amount of basic and applied research has been conducted on habitat preferences, requirements and the factors affecting nesting site use. A number of generalizations have emerged from this research. These include that wading birds will change nesting sites if alternative sites are available (the tendency differing among species); most colony sites degrade with time as the nesting substrate changes; and feeding areas of specific types, area, and sequencing of availability are needed within species-specific distances from colony sites (Kushlan 1983, Parnell *et al.* 1988, Hafner and Fasola 1992).

One result of such information is increased support for the need for active management of wading birds (rather than mere protection), especially their nesting and related feeding sites (e.g., Kushlan 1983, Parnell *et al.* 1988, Perennou *et al.* 1996). The management and even creation of nesting sites will become even more important as the number of potential colony sites is reduced through development and other habitat modifications.

One of the best examples of the interaction of research and active management is in northern Italy, where a program of research, conservation and monitoring of the heron colonies in the Po Valley is carried out with great distinction by Mauro Fasola (Fasola and Alieri 1992). Colony sites are protected, monitored, and managed, while feeding sites are known. It is also instructive that the viability of these colonies, the core of the European night heron population, may be threatened by anticipated changes in rice cultivation.

In developed countries, both government and non-governmental organizations, backed by laws and public policies, are active partners in protecting and managing wading bird nesting sites. In other parts of the world, conditions are less conducive to government or NGO intervention. There, it is primarily cultural beliefs of the people and economic imperative of population growth, that determine the protection given to wading bird colony sites (Hancock *et al.* 1992).

Aquaculture

The role and importance of aquaculture to wading birds was noted by the mid 1970's (Mott 1978). In that era the issue was primarily one of control. In the interim, the issue has become much more complex.

In the context of reducing the impact of birds on aquaculture, there are few conservation areas where less progress has been made in 20 years. Practical approaches to managing conflicts are essentially the same as 20 years ago. Yet, throughout the world, and increasingly in North America, wading birds are killed due to their perceived or real conflict with aquaculture or with exploited fish stocks. With thousands of wading birds being killed legally, and many more illegally, the population consequences need detailed study. This remains, world wide, one of the most serious threats to wading bird conservation. We need research on practical ways to control wading birds at aquaculture facilities and we need to have this information before facilities are built.

The reverse side of the issue is important too. Throughout the world, fish farms and the like, are food sources for wading birds. These may be sufficient to enhance survival, population growth, or stability. For example, it would appear that the center of wading bird numbers in North America are the fish and crayfish farms of Louisiana (Fleury and

Sherry 1995). A similar situation may be occuring in Europe and southern Asia. As aquaculture increases, the consequences—both positive and negative—for wading birds are little appreciated.

Critical Habitats and International Collaboration

Curry-Lindahl (1978) discussed the importance of identifying critical habitats for wading birds. An important undertaking in international conservation in the past decade has been a program to do just that. The Important Bird Areas program, sponsored by BirdLife International, has been defining important areas for species, including wading birds. These sites provide the basis for regional and flyway reserve networks.

In the past 20 years, a tremendous advance has occurred in organized international conservation efforts of importance to wading birds. The Ramsar Convention and Wetlands International have been noted previously. A related initiative, which has crystallized in the past 20 years, is the maturation of international wading bird specialist groups, which are sponsored in partnership with Wetlands International (taking the lead), BirdLife International and the International Union for the Conservation of Nature. We have specialist groups for each of the wading bird groups: herons; storks, ibises and spoonbills; and flamingos. Each consists of up to hundreds of specialists working towards understanding the biology and conservation of these birds.

Twenty years ago, it would have been hard to conceive that enough information and expertise would exist to create worldwide strategic plans for the conservation of wading birds. Yet each specialist group is writing action plans for their species. Together, these will constitute an action plan for wading birds worldwide.

QUESTIONS FOR THE TWENTY-FIRST CENTURY

Population Conservation

One of the great advances of the past 20 years was to solidify the understanding that the most appropriate unit of wading bird conservation is not the colony nor the species, but the population (Kushlan 1992). The most fundamental question is: What constitutes a population of conservation concern? Whereas population delineation is relatively clear for isolated, disjunct or peripheral groups of birds, it is quite confused for wide ranging species that occupy large portions of a continent. In such cases one is challenged with the question of scale: for Great Egrets, as an example, is the proper scale for conservation planning and action the Florida peninsula, the eastern United States, North America, North and South America, or worldwide? The Great Egret is a big white bird with few distinguishing characteristics, and it turns out that we may not even appreciate its species limits correctly (Hancock *et al.* 1992).

As wading bird populations are not generally distinguishable from each other morphometrically, other characters are needed to evaluate population limits. The most encouraging of these new characters are biochemical and genetic, and we now have in hand the tools needed to start answering such questions (Kushlan 1992): What are the patterns of genetic variability? What is a definable genetic population? How might this information help create schemes to conserve distinctive genetic stocks or genetic diversity across a species' range?

A second issue is population estimation. In the past 20 years, significant advances have occurred in understanding the sizes of some species segments, at least within broad confidence limits (Rose and Scott 1994; McCrimmon *et al.*, In press). However, accuracy of wading bird population estimates has improved little over the same period. Accuracy of aerial counts is particularly suspect. We need to ask very fundamental questions such as: How can wading birds be censused and monitored on a population basis using modern sampling theory, modeling, and such techniques as mark/recapture analytical methodology?

A third issue is census data management. In the mid 1970s we were greatly optimistic that hard earned data on wading bird nest-

ing numbers could be archived and made easily available to managers and scientists who needed it. Unfortunately, this hope has not been realized. The International Waterfowl Census is maintained by Wetlands International and is made available periodically in published form. In North America the national data register did not persist. There is no plan to manage and easily transmit critical population data in real time to anyone who needs them. How can modern technology and electronic information transfer systems be put to the use of creating monitoring data bases that are readily accessible to both scientists and managers? What analytical tools can be used to interpret status and trends in such inherently messy data, and to appropriately address issues of temporal and geographic scale?

Rare and severely declining species continue to pose important issues. The critically endangered and endangered species require immediate action, including additional field study, habitat management, and, perhaps, captive breeding for reintroduction. In addition to those considered endangered, 8 additional species are considered to be vulnerable and 14 more near threatened (IUCN 1996). For each of these species, specific research and management questions need to be answered in order to assure their conservation.

Habitat Conservation

Despite an excellent knowledge base, we need to know more about habitat use, especially during nesting. Significant advances in understanding have occurred in specific areas, but generalizations are hard to come by. We need to continue to address such questions as: What are the feeding locations used by specific populations at different times of year? What are the places used by the greatest numbers of individuals and greatest number of species along a flyway and can those data be used as a basis for establishing flyway reserve networks? What habitat features can be enhanced for the benefit of specific wading birds? How can the important functioning of the ecosystems supporting these sites be maintained?

Although these remain complex questions, we have new tools that allow such questions to be addressed at regional and landscape scales. How can we conserve and manage a matrix of habitat fragments within a landscape to conserve biodiversity while allowing wise use of natural resources by humans? How do we preserve the range of functions within patches in the landscape that will support wading birds over annual and multi-year cycles? The scaling up of our thinking and research from the colony site to the landscape, and from the wetland patch to the matrix of patches is now possible using GIS, spatially explicit modeling, and such conceptual frameworks as patch dynamics and metapopulations. Thus, we have new and interesting ways to ask old habitat questions.

Wading Birds as Indicators

Many lines of evidence suggest that wading birds can become useful indicators of environmental conditions (summarized by Kushlan 1993). While the hope of 20 years ago was that population numbers and trends would reveal environmental insults, this has been realized only when the changes were huge (such as the wading bird population crashes in the Everglades). However, we now understand that it is the resilience of most wading bird species to insult, that allows sublethal indicators of exposure and effect to be used as probes of their environment. The question is: Can the responses of wading birds to environmental stressors be used to specifically probe changing environmental conditions in the habitat they are sampling?

Action

Finally, the need is for action, but action deliberately taken, results oriented, monitored and evaluated. An important beginning is the creation of Action Plans for species groups and flyways (e.g., Hafner *et al.*, In press; Anonymous 1996). These are now under development by international specialist groups and other international groups such as Wetland International. These plans seek to answer such questions as: What are the status

and conservation issues of various populations of wading birds? What are the most viable strategies to accomplish the sustainable management of wading bird populations?

With these plans in place, regional data gaps will become apparent and general guidelines for conservation action will be elucidated for species, populations, regions, and flyways. Thereafter, attention will need to shift to regional and local action plans to obtain place-specific information and undertake appropriate conservation action where it does the most good, at the local scale.

Another understanding to emerge in the last 20 years is the value of a regional and biodiversity approach. Given limited resources, it is likely that future wading bird conservation will seldom stand alone. Wading birds may be useful on occasion as megafauna symbols, keystone species, or sentinels of environmental stressors and enjoy a value of their own. However, in most cases they will need to be conserved and managed within larger schemes of biodiversity conservation and landscape management. An important challenge will be to address the question: How can wading bird conservation be placed within the context of ecosystem, landscape, and diversity conservation?

Thus, after 20 years, most of the big issues of wading bird conservation remain. However, new scientific and analytical tools, world wide networks of wading bird specialists, and a world wide conservation movement provide an entirely different context. The specific questions being addressed can be formulated differently than in the past to take advantage of these advances. Concepts such as Conservation of Biodiversity, Wise Use of Resources, and No Net Loss of Wetlands provide firm foundations for the future work of wading bird conservationists worldwide.

LITERATURE CITED

Anonymous. 1996. Asia-Pacific migratory waterbird conservation strategy: 1996-2000. Wetlands International - Asia Pacific, Publication 117, Kuala Lumpur, and International Waterfowl and Research Bureau - Japan Committee, Tokyo.

Biskup, M. L., R. W. Risebrough and J. L. Dusi. 1978. Pages 113-116 *in* Wading birds. (A. Sprunt IV, J. C. Ogden, and S. Winckler, Eds.) Research Report No. 7. National Audubon Society, New York.

Buckley, P. A. and F. G. Buckley. 1976. Guidelines for protection and management of colonial waterbirds. National Park Service Report, Boston, MA.

Buckley, P. A. and F. G. Buckley. 1980. What constitutes a waterbird colony? Reflections from the northeastern United States. Colonial Waterbirds 3: 1-15.

Burger, J. and M. Gochfeld. 1992. Temporal scales in ecological risk assessment. Archives Environmental Contamination and Toxicology 23: 484-488.

Curry-Lindahl, K. 1978. Conservation and management problems of wading birds and their habitats. Pages 83-98 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.) Research Report No. 7. National Audubon Society, New York.

Custer, T. W., B. A. Rattner, H. M Ohlendorf and M. J. Melancon. 1991. Herons and egrets proposed as indicators of estuarine contamination in the United States. Proceedings of the International Ornithological Congress 20: 2474-2479.

Erwin, R. M., J. G. Haig, D. B. Stotts and J. S. Hatfield. 1996. Reproductive success, growth and survival of Black-crowned Night Herons (*Nycticorax nycticorax*) and Snowy Egret (*Egretta thula*) chicks in coastal Virginia. Auk: 113: 119-130.

Fasola, M. and R. Alieri. 1992. Conservation of heronry sites in north Italian agricultural landscapes. Biological Conservation 62: 219-228.

Fleury, B. E. and T. W. Sherry. 1995. Long-term population trends of colonial wading birds in the southern United States: the impact of crayfish aquaculture on Louisiana populations. Auk 112: 613-632.

Florida Game and Freshwater Fish Commission. 1991. Florida atlas of breeding sites for herons and their allies. update 1986-89. Florida Game and Freshwater Fish Commission, Nongame Wildlife Program Technical Report 10, Tallahassee, Florida.

Frohring, P. C., D. F. Voorhees and J. A. Kushlan. 1988. History of wading birds in the Florida Everglades: a lesson in the use of historical information. Colonial Waterbirds 11: 328-335.

Hafner, H. and M. Fasola. 1992. The relationship between feeding habitat and colonial nesting herons. Pages 194-201 *in* Managing Mediterranean wetlands and their birds (C. M. Finlayson, G. E. Hollis and T. J. Davis, Eds.) International Waterfowl Research Board Special Publication 20.

Hafner, H., R. V. Lansdown, R. Butler and J. A. Kushlan. In press. Action plan for the conservation of the Ardeidae. International Waterfowl Research Board and International Union for the Conservation of Nature.

Hancock, J. and J. Kushlan. 1984. Herons handbook. Harper & Row, New York.

Hancock, J. A., J. A. Kushlan and M. P. Kahl. 1992. Storks, ibises, and spoonbills of the world. Academic Press, London.

Henny, C. J., L. J. Blus and C. S. Hulse. 1985. Trends and effects of organochlorine residues on Oregon and Nevada wading birds, 1979-83. Colonial Waterbirds 8: 117-123.

Hutchinson, A. 1980. Estimating numbers of colonial seabirds: comparison of techniques. Colonial Waterbirds 3: 235-244.

IUCN. 1996/ 1996 IUCN red list of threatened animals. (J. Bille and B. Groombridge, Eds.). International Union for the Conservation of Nature, Gland, Switzerland.

King, K. A. 1978. Colonial Wading Bird survey and census techniques. Pages 155-160 *in* Wading birds. (A.

Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

Kushlan, J. A. 1978. Feeding ecology of wading birds. Pages 249-298 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

Kushlan, J. A. 1983. Special species and ecosystem reserves: colonial waterbirds in US national parks. Environmental Management 7: 201-207.

Kushlan, J. A. 1986. Colonies, surveys, and sites: the terminology of colonial waterbird research. Colonial Waterbirds 9: 119-120.

Kushlan, J. A. 1992. Population biology and conservation of colonial wading birds. Colonial Waterbirds 15: 1-7.

Kushlan, J. A. 1993. Colonial waterbirds as bioindicators of environmental change. Colonial Waterbirds 16: 223-251.

Kushlan, J. A. and P. C. Frohring. 1986. The history of the southern Florida Wood Stork population. Wilson Bulletin 98: 368-386.

McCrimmon, Jr., D. A. 1978. The collection, management and exchange of information on colonially nesting birds. Pages 187-196 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

McCrimmon, Jr., D. A., S. T. Fryska, J. C. Ogden and G. S. Butcher. In press. Nonlinear population dynamics of six species of Florida Ciconiiformes assessed by Christmas Bird Counts. Ecological Applications 7.

Mott, D. F. 1978. Control of wading bird predation at fish-rearing facilities. Pages 131-132 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

Ohlendorf, H. M., E. W. Klaas and T. E. Kaiser. 1978. Environmental pollutants and eggshell thinning in Black-crowned Night Heron. Pages 63-82 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

Ogden, J. C. 1978. Recent population trends of colonial wading birds on the Atlantic and Gulf Coastal plains. Pages 137-154 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

Olsen, S. L. and D. W. Steadman. 1979. The humerus of *Xenibis*, the extinct flightless ibis of Jamaica. Proceedings of the Biological Society of Washington 92: 23-27.

Osborn, R. G. and T. W. Custer. 1978. Herons and their allies: Atlas of Atlantic coast colonies, 1975 and 1976. FWS/OBS-77-08, Washington, DC.

Parnell, J. F. and R. F. Soots, Jr. 1978. The use of dredge islands by wading birds. Pages 105-112 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

Parnell, J. A., D. G. Ainley, H. Blokpoel, B. Cain, T. W. Custer, J. L. Dusi, S. Krebs, J. A. Kushlan, W. F. Southern, L. E. Stenzel and B. C. Thompson. 1988. Colonial waterbird management in North America. Colonial Waterbirds 11: 129-169.

Parslow, J. L. F. 1973. Organochlorine insecticide residues and food remains in a Bald Ibis *Geronticus eremita* chick from Birecik, Turkey. Bulletin of the British Ornithological Club 93: 163-166.

Perennou, C., N. Sadoul, O. Pineau, A. Johnson and H. Hafner. 1996. Management of nest sites for colonial waterbirds. Conservation of Mediterranean Wetlands - 4. Tour du Valat, Arles, France.

Portnoy, J. W. 1978. A wading bird inventory of coastal Louisiana. Pages 227-234 *in* Wading birds. (A. Sprunt, IV, J. C. Ogden and S. Winckler, Eds.). Research Report No. 7. National Audubon Society, New York.

Ramsar Convention Bureau. 1990. Proceedings of the fourth meeting of Conference of the Contracting Parties. Ramsar Convention Bureau, Gland, Switzerland.

Rose, P. M. and D. A. Scott. 1994. Waterfowl population estimates. IWRB Publication 29. Slimbridge, UK.

Spendelow, J. A. and S. R. Patton. 1988. National atlas of coastal waterbird colonies in the contiguous United States: 1976 - 1982. U.S. Fish and Wildlife Service, Biological Report 88 (5). Washington, DC.

Sprunt IV, A., J. C. Ogden and S. Winckler (Eds.). 1978. Wading birds. Research Report No. 7. National Audubon Society, New York.

Shufelt, R. W. 1887. The wanton destruction of the Florida heronries. Science 10: 47-48.

Texas Parks and Wildlife Department. 1988. Texas Colonial Waterbird Census Summary - 1988. Wildlife Division - Texas Parks and Wildlife Department, Special Administrative Report.