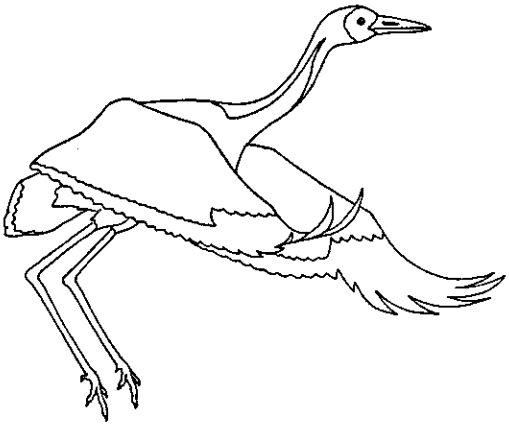
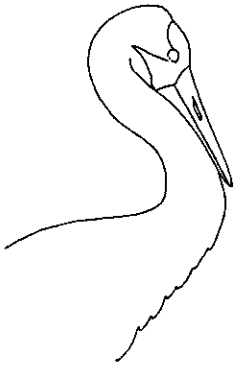
PART II. INTERNATIONAL PAPERS



CHAPTER 7
GENERAL CONSERVATION, BEHAVIOR, AND METHODS



PRESERVING WETLAND VALUES FOR PEOPLE AND WILDLIFE

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ABSTRACT

Wetlands, areas where water causes a recognizably different plant cover to develop, are highly productive ecosystems which are part of the earth's freshwater storage and supply systems. They support many unique forms of plants and wildlife, and improve the quality of waters flowing through them. Humans often destroy wetlands for short-term benefits and then suffer long-term consequences, such as flooding and soil erosion, without appreciating how the two events are linked. Wetlands buffer climatic extremes for wildlife, and are in themselves esthetically pleasing landscape features which will attract tourists to view them. Wetlands protection depends upon both (1) sound governmental policy and (2) thorough education of the local people using wetlands. Sustainable wetland uses, based upon ecologically sound local actions, have global impacts in terms of enhancing world ecosystem stability.

CHARACTERISTICS

Wetlands are places on the land where water lingers in significant quantity for a long enough time to cause features to develop that set these sites apart from other land areas (Nickerson 1978). One of these visible features is the vegetative cover, composed of plants that can tolerate water around their roots for long periods of time (up to three years) without apparent harm. Another less visible feature is the soil that develops under these waters. Finely divided organic matter, which is slow to decay owing to a lower oxygen concentration, may accumulate under water in depths up to several meters. It is primarily the water, however, that distinguishes a wetland, and the source of that water determines what type of wetland is formed (Motts and Heely 1973).

A *water-receiving wetland,* even if large, is generally a settling basin for waters which flow into it from higher land around it, either as rain and runoff, or as groundwater seeping out along its upper edges. It characteristically develops deep muds and/or peats, and its water surface is generally quite still. Often a hardpan or water-holding layer is developed in the soil below this wetland type, because inflowing water percolates downward to become part of the groundwater.

A *water-producing wetland* is formed at the site of a continuous subterranean groundwater upwelling; water continually leaves the area by a series of rills or by a more or less well-defined stream. These wetlands often serve as unfailing supplies of clean water for humans.

The two forms may be found together, with water outflow dominating during one part of the year, and water inflow dominating during the other part of the year. The important fact is, however, that they remain wetlands as long as water is present; they never change, or "succeed," into dry upland, in spite of all the erroneous statements about such a succession pattern in ecology textbooks (Drury and Nisbett 1973). Depending upon age and extent of sediment and mud consolidation, these wetlands first support herbaceous emergents, then herbaceous edge fringes and floating edge mats of vegetation, and finally at a still later time, water-tolerant shrubs and forest trees.

CLEANSING POWERS

Water is necessary for wetlands, and its flow is regulated by the wetland in several ways. A thick cover of vegetation physically retards water flow, slowing down floodwaters and thus at least temporarily impounding them. Slowed water quickly deposits its silt load, so that vegetated wetlands produce cleaner water by simply slowing up moving water. This thick mantle of vegetation also keeps sunlight away from the water surface, thus keeping water temperatures lower and lowering water loss by evaporation in drier times (Maltby 1986).

Because water runs more slowly through a vegetated wetland system, it takes time for water to get to the lower discharge point. The slowing of water makes it more probable that all water flowing through a wetland will, in the course of its transit, come in contact with finely divided organic matter as well as with the roots of living plants. Growing plants will extract most of the fertilizer elements from the water and even in winter, bacteria living anaerobically on the organic matter will denitrify water flowing over them very quickly and efficiently (Bartlett et al. 1979). Most organic pesticides and herbicides as well as a number of heavy metals will be absorbed onto the small organic particles, or may be taken up by some plants (Nickerson 1978). Another remarkable result is that polluting coliform bacteria and human enteriviruses are mostly removed during passage of fecal-contaminated water through a wetland (Maltby 1986). What emerges is cleaner and purer water than what went in. All these cleansing processes are not

visible, but are very real wetland functions which are to the immediate and ongoing benefit of humanity, especially when they occur on any streams that serve as a human water supply or source of recreational swimming waters.

PRODUCTIVITY

Wetlands can be characterized as being highly productive ecosystems because they build quantities of organic matter, utilizing minerals that enter them directly through growth of their plants, and indirectly by selective adsorption of polluting materials onto their organic particles. It is this lush plant growth and subsequent decay into detritus (tiny particles of organic matter) which feeds tiny animals; they in turn are fed upon by larger animals and they in turn are fed upon by certain bird species, such as herons. Other birds, such as most cranes and many species of duck, are largely vegetarians, directly eating quantities of the plant material produced by wetlands (Maltby 1986).

Wetland vegetation, while dependent upon water, also depends on fluctuation of the water level over time for its survival. Permanent flooding kills trees. Deep water remains open as a lake or pond because of "fetch", or wind-generated wave action. The shallower water areas, with levels which rise and fall rhythmically during a year's cycle, are the important part of these productive, cleansing, and stabilizing inland ecosystems.

ENVIRONMENTAL BUFFERING

People generally do not dwell in wetlands, which may be a reason for the tranquility and quiet solitude often associated with these ecosystems. Wetlands are often visited to enjoy these very attributes (Madson 1986). Animals and birds are often found concentrated in and around wetlands, where they may feed and breed relatively undisturbed. Wildlife of many kinds cannot exist without access to these wetlands because wetlands offer their own characteristic habitat ameliorations at different times of environmental stress throughout the year. Wetlands are cooler in hot weather, calmer in windy weather, unfrozen or warmer in cold weather, and wetter in dry weather. Wetlands act as buffers in the range of environments with which all wildlife must cope to survive. Since wetlands serve different kinds of wildlife at different times of the year, however, it is not possible to find all wetland-dependent animal species of an area present in any one of its wetlands at any one time.

A different amenity that wetlands offer is the fact that their presence adds to the quality of life for all humans. Just knowing the open space is there, and that cranes and other creatures exist because of that open space, makes wetlands rather special parts of our total ecosystem (Madson 1986; Manson 1986).

VALUES OF NETWORKS OF WETLANDS

Together, wetlands and wildlife form an interactive system; every wetland is important because these areas are bound together through common uses by populations of the same bird or animal at the same time. A single small wetland preserved as an ecosystem example is next to useless; the strength of the wetland-wildlife interaction depends on the network of wetlands developed in nature. Variations do occur in size of wetlands, and a very few really large ones exist at different places throughout the world. Their large size makes them even more precious, because there is then room for existence of environmental gradations which specially adapted wildlife species can utilize to advantage at different times (Lamb 1984). Thus every hectare of these larger wetlands, just as with every hectare of smaller ones, is uniquely valuable at some time of the year to some species. Reduction in size of any wetland by whatever means results in increased stress on its wildlife inhabitants, a change in its water regime, and a slow but inevitable change in its vegetative cover (Thibodeau and Nickerson 1985; Nickerson and Thibodeau 1986).

DESTRUCTION AND DRAINAGE

Destroying wetlands will surely mean destroying far more than their transient wildlife inhabitants. At the same time, doing away with wetlands by drainage or filling will not materially lessen the water flow into the area. The main result of such destruction is creation of aggravated flood conditions at one time of year and aggravated drought conditions at another time of year. A natural wetland modulates extremes of the water inflow-outflow curve; it moderates the environmental stress periods.

If these wetlands are truly important to us as people (and they are), why, one may ask, have they been traditionally regarded as worthless wastelands, fit mostly for filling (often with trash), dredging, damming, or cutting over? Wetland protection is really a matter of overcoming ignorance and greed by education (Bricẽno and Drake 1986). Traditional clearing, farming, and replanting practices do not work in the long run for wet areas. Drained water must go somewhere, and if it is forcibly concentrated, it often becomes a torrent rather than a gentle, slow-moving stream. Furthermore, fertility of the drained areas does not last: once accumulated organic matter is exposed to oxygen, it is rapidly decayed by bacteria, and the basis for high crop yields is gone. The soil can only be replenished by once again letting it become an underwater and thus anaerobic repository for organic material for a long period of years.

IMPOUNDED WATER

Dammed water, so enticing as a graphic method for prevention of downstream flooding and as a possible source of electrical power as well as an abundant irrigation supply, has drawbacks seldom thought about (Jackson 1984). When water is slowed, its silt load is dropped, as noted above. Dams abruptly halt fast-moving water. Many dams have had useful life spans of only 20 years before deposited silt completely filled their water-storage areas. Others, mistakenly built in nearly level country, simply transfer the floodwater upstream. The only way to assure longer dam life is to slow erosion rates to as near zero as possible in an entire catchment area. How many examples exist in

the history of dam-building where land management to lower the catchment erosion was the first consideration? It is generally a complete afterthought which becomes necessary as the dam begins to trap silt.

Irrigation water derived from the reservoir is not "pure," but has in it dissolved salts (chlorides and sulfates in particular) which accumulate on the surface and in the upper soils of irrigated fields because water evaporation leaves them behind. Depending on concentrations of these salts in the water, and they are always more than zero, the lifespan of irrigated fields is only 20-30 years; after this time, these accumulated salts render the fields unuseable for conventional agriculture (Jackson 1984). Once again, long-term effects are more costly to the human environment than the short-term gain.

FISHERIES VALUES

River systems also have fish living in them. The base of their food chain is invariably plant material. If sunlight does not penetrate into the river's waters because of silt turbidity, then the foodchain base is curtailed, and ultimately fish of harvestable size are both smaller and fewer in number. Wetlands, by cleansing water, have great importance. Furthermore, intact wetlands often serve as egg-laying and nursery areas both for these river fish and those organisms on which they feed. Significant parts of most open-water rivers and lakes are the wetlands that border some or all of their shores. It is these areas of vegetation-choked shallow waters, accessible from deeper waters, which are indispensible to a thriving fishery.

Deliberate rapid draining of a wetland or lake, even periodically, completely removes food fish — young fry and as well parent fish — and quickly leads to low yields of native fish in the area (Maltby 1986). Many river fish do not migrate far from the area of their hatching; thus new fish, unlike new water, do not continually flood into the lower reaches of a stream from upstream. Fish are really localized products. The quality and quantity of their local wetlands and connecting waters determine their abundance.

WETLANDS MANAGEMENT

The way in which wetlands are treated (managed) by humans determines their attractiveness and uses as recreational areas as well as their sustained productivity. Local uses of wetlands are often centuries old; the recent rash of wetland problems has developed because of human population increases and either a common belief that the "old" ways, developed when far fewer people were present, are still perfectly all right to pursue, or a faith that we can do what we like using modern technology, because we can easily replace what we destroy. There is no scientific evidence to indicate that replacement, or re-created, wetlands work like natural ones. We now know that the main limit to biological production of animal life is ultimately the size and reliability of its photosynthetic plant base. There is little room to maneuver. Plants must first trap the sun's energy before it is available to build and maintain animal bodies. This limit on animal production is called the *carrying capacity* of the ecosystem. In simple terms, there must be a wetland plant base developed which is large enough to support its partial harvest (by birds and humans) and still leave some organic material for the less obvious but highly important hidden functions noted earlier.

It is imperative that human use of wetlands and wetland products not be all-consuming; other organisms, both macroscopic and microscopic, require a share for their very survival (Maltby 1986). Details of many of the wetland processes noted above are still imperfectly understood. There is a real challenge to science: first to determine the basic means and conditions through which wetlands function, and second to develop sound methods by which this intriguing and important information may be put to use by people the world over to sustain their wetlands while still obtaining clean water, food, and fiber.

GOVERNMENTAL RESPONSIBILITY

A sound wetlands management policy adopted by governments is a basic step in civil law (Sayer and McNeely 1984; Heritage 1986). There are three levels of government that must consider such action. The first is on the local level, where people are living, where they get their firewood, their thatch, and some part of their food. These are the people who directly live with the constraints and links between wetlands, pollution, drinking water, floods, droughts, birds, wetland plants, and fish. Rational local regulations, developed with local input tempered by what is now known about wetlands, can be of great value in preventing loss of this public resource.

Larger provincial and federal governments are at the second level. In addition to protecting the people and their water and food supplies, the assurance of beauty in the landscape is a national responsibility and is a major reason tourists want to visit a country. Wetlands, in addition to all local concerns, are an integral part of the natural beauty, and thus their preservation and sound management is in the national interest.

At the third level, wetlands are of international concern, a fact recognized by the many nations that are signers of the Ramsar Convention Articles (Lamb 1984; McHugh 1986). Each wetland, especially one of the larger ones, is a unique ecosystem not found elsewhere on the planet. Protection of these resources, in whatever country they may occur, is in the best interests of every other country as well. Rain clouds and water are not respectful of international boundaries. Sound water regimes in one country mean more stable ecosystems for all its neighbors. Our planet is an ecologically integrated whole, a thing of great beauty done in marvelous detail. Cranes, as an example, do not "belong" to either China or the Soviet Union, yet their continued world presence — as hallmarks of beauty, of cultural values, and of naturalists' interest in both these countries — depends upon international cooperation to assure wetland ecosystems at both ends of their migration route. The same can be said of Siberia's and North America's eastern bar-tailed godwits *Limosa lapponica* (Crisp 1986), which winter

in New Zealand, and for a host of other migratory birds the world around.

There will be global impacts on wetlands ecosystems if all migratory birds are eliminated. They eat enormous quantities of insects, invertebrates, and small fish. They distribute plant seeds and vegetative propagules. They recycle phenomenal amounts of nitrogen and potash. Some species directly provide large amounts of human food. Their breeding colony concentrations, their pre-migratory gatherings and their migrations are truly inspiring phenomena to behold. All of these helpful and inspirational aspects of our beautiful natural world depend first and foremost on proper use and respect for our own local wetlands. Wetland protection is a goal well worth striving for, and one upon which we can build new dimensions of international understanding. As, in accordance with the World Conservation Strategy, we act locally to protect wetland resources, we can take solid comfort in the fact that these actions are good conservation with a cumulative impact on a global scale.

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NATURE MANAGEMENT: TO BALANCE WILDLIFE AND HUMAN USE

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ABSTRACT

Management is not the beginning of a process but the final step. Successful management has to start with long careful preparation. After an area is declared a reserve, the best thing is to do nothing and just look around. In management two different processes are recognized: external and internal influences. The external process is related to the influence of the surroundings on the area itself and of the area to its surroundings. External influences will sometimes be so large that it is hardly responsible to carry out any long-term management. The internal process is much more diverse, and gives the manager many possibilities. The ecological process and special preferences for management for certain animals or plants have to be discussed and decided. Preference for breeding cranes can mean that the vegetation has to be actively managed, rather than allowing the vegetation to develop without interference. Subjects such as recreation and a financial balance are also part of this overview. In a good management plan, one will find four different chapters. (1) Map, description, boundaries, country planning in surrounding areas; historical overview, buildings; geological and geomorphological information as far as necessary for management. (2) An inventory of botanical, ornithological, zoological values in different seasons; an inventory of the existing uses and the relation between these uses and the biological habitat; a description about research, both necessary and possible. (3) The real planning of the management, preferably in two parts: long term and short term; short term, for example, might be for five years; this has to be a real summing up of activities for each part of the reserve. (4) Financial and staff needs; real budget for each year and an estimation of income. Along with this document, it might be very useful to develop immediately a system for filing accounts of all the activities and the results in the field. A good system of recorded observations combined with management activities will give the basis for a new short-term management plan and provide information about the ecological processes we try to manage.

INTRODUCTION

In former times there was a certain balance between nature and man's living pattern. Man used to hunt awhile, then when animals became scarce, he moved a few miles away. If the new area was already occupied, conflict settled the matter of rights. Today, more people require much more careful management, a much more careful adjustment to supply and demand.

In economic theory, resources such as air, water, and nature in general are "free" commodities. One does not have to pay for their use. Nowadays, however, the cost of air and water is high. It is a flaw in economic theory not to take environmental conditions into account.

Economic processes in which nature is deeply involved are different from purely industrial processes. Nature follows a rather slow, complex process; it cannot be hurried. It takes three weeks for a chicken to hatch and nine months for a human being to be born. There are no economic processes imaginable that can shorten these times. The life cycle of certain plants can be shortened and accelerated, but the environmental conditions have to be carefully managed. If not, erosion, exhaustion of the area, and sand storms result: all happen through reckless management and the neglect of environmental conditions of our industrialized, agricultural processes. Millions of hectares are lost all over the world. Instead of trying to win these areas back, perhaps not for ourselves but for coming generations, we still continue to select the cheap option. Draining, clearing, and reclaiming are the easy ways for short-term profit and the basis for new environmental disasters. Of course, there are also examples of well-managed new reclamations and well-managed clearings. But have we tried to stop the speed of the desertification of large areas all over the world? If we could stop this process or at least slow it down, we would gain more than any new, well-planned drainage or irrigation project could accomplish. But there are absolutely too many areas all over the world that were good green areas in the past and are now useless for people and wildlife.

FUNCTIONS OF NATURE

Though water and air are basic for human life and can only be kept healthy under natural conditions, people neglect these resources and hope that everything will be all right. To build higher chimneys in order to prevent air pollution near a factory is not a contribution toward wise use of the environment, but only a cheap way to put aside real problems.

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For most biologists, natural diversity is a sign of a healthy environment. It is this diversity we are fighting to maintain and enlarge in limited areas through nature conservation.

Values of nature are related to ethics, aesthetics, and general respect for life. But its products, wild plants for example, can also be used to improve our agricultural plants as long as we do not exterminate these wild ones. The recreational value of nature for mankind is sometimes neglected and sometimes exaggerated. If sea and beach are important for so many people, why are they so polluted that they cannot be used any longer?

Our goal is natural diversity in numbers and in species, and also the courage to fight for this diversity. Large concentrations of geese and cranes might be the crowning glory of years of hard work in conservation and management. We are also fighting for the 204 different species of woodpeckers which all make different demands on their environment. If we lose one of these species, we are not only poorer than before, but we have also made another poor judgment about the use of our own surroundings. Nature management tries to balance all these different challenges.

RESERVES AND NATURE PARKS

Nature is no longer the natural environment of our society; nowadays it is no more than one claim in the process of country planning, a claim to be fought for. But natural limits are the reason for the existence of air and water pollution on such a large scale. The limits of using the atmosphere for absorbing our waste are being exceeded and are not in balance with the natural ways of dispersing waste.

Instead of working to solve these problems, we started to create nature reserves: places where nature is more important than human development, places where rare animals and plants can survive, places where people can enjoy the real nature of the past. I think reserves are a right answer, but they are not enough. Through our nature reserves we must fight for more responsible use of our entire environment. It is unacceptable that trees can no longer grow in large parts of Europe; they can no longer tolerate acid rain. We have already lost the lichens, and nobody worries; the sandstone buildings are affected and everyone is surprised; the lakes in northern Europe are suffering from the rain instead of being refreshed.

In general, the aim of setting aside natural areas is to preserve them from certain developments. It always seems to be a defensive, rather than a positive approach. Natural areas are a contribution toward a better environment with living green areas supporting a variety of wildlife and a balanced system which enhances the functioning of nature. Its surrounding area is sometimes completely different. A wetland might be surrounded by desert-like areas, a forest by cornfields, or a reedland by cities and villages. The reserve itself might be protected, but its survival is never guaranteed. We have to control the positive and negative influences of the unnatural surroundings upon our reserve and bring the whole area under management.

There are many ways of protecting an area. In general, it depends upon the political system of the country concerned whether an area has to be bought or can simply be declared a reserve. Sometimes a well-enforced country-planning act can achieve enough protection, but in most countries purchase is the only solution that will insure management and long-term protection. Where ownership is in doubt, it is best to delay a long-term management plan.

Depending upon aims, extent, and national possibilities, we have nature parks, national parks, landscape parks, nature reserves, hunting reserves, botanical reserves, etc. For all these labels there are no internationally, generally accepted definitions. For the contents of this paper, it is enough to realize that there are various types of nature reserves, and we shall only deal with them in a general way. To include more functions within a reserve, or to exclude others, only raises difficulties during the management process. But in principle there will be hardly any difference.

MANAGEMENT

If it is clear that an area is to be protected, one has to think precisely about management.

There are many reasons why it is necessary to manage an area. A forester manages his forest because he wants to find the best balance between planting trees and harvesting them, and in the meantime maintain an optimum forest ecosystem. A farmer manages his fields to balance production according to the seasons, the needs of his cattle, the amount of manure, etc. Some farmers now think that only production needs to be managed, and they leave the surrounding environment unprotected from their surplus manure and all the side effects of herbicides and pesticides. But management has to take into account all aspects of an operation, and decisions have to be made about how to resolve conflicts.

Some organizations put management on a completely wrong footing. As soon as an area has been declared a reserve, they start building hides, roads, information centers; they plant trees and make other changes. It is better to do nothing at first, other than try to get acquainted with the area. Provisions to observe the behavior and preferences of the animals are enough. Later, a real plan can be developed on the basis of such information. A negative example is the Tablas de Daimiel in Spain which was declared a national park. A large infrastructure was created, with hides all around for viewing the large numbers of waterfowl living in the area. After a couple of years, the information center was empty and the hides and the park were too. The managers forgot that waterfowl need water, and that it is not possible to have a wetland surrounded by hundreds of hectares of irrigated cornfields.

There are two large groups of influences and activities in a nature reserve:

1. External: a. Influence of the regional environment on the reserve itself
   b. Influence of the reserve on its surroundings

2. Internal: a. Ecological processes within the area
   b. Management bias toward some animals
   c. Bias toward some plants
   d. Recreation
   e. Other functions of the area
   f. Financial balance

From these considerations, a management plan can be developed. Only in the plan can you deal with matters involving people. This paper provides some theory, from which detailed individual management plans can be developed.

First, a more detailed description of various influences is necessary before a management plan can be followed.

EXTERNAL INFLUENCES

1. a. Influences of the regional environment on the reserve

As mentioned earlier, there is a possibility of profound environmental influence from the outside. Planning a nature reserve close to an air-polluting factory is not wise. To prevent the building of such a new plant near your reserve is commendable. It is wise to plant trees around the factory, but that action does not make a nature reserve, nor will the area ever become one. Reserves have a completely different function. They should not be surrounded by polluting factories, farms and cities, although if there is no choice, it is always better to accept such an area than to have nothing. The reserve in the center of the harbor in Tokyo, Japan, is not easy to manage. Completely surrounded by pollution, it is restricted in its possibilities, but it is also an excellent educational project, a victory for conservation, and a living warning system with real birds giving the signals. One should not try, however, to develop biological processes sensitive to air pollution.

Indirect environmental influences are even more difficult to comprehend: pesticides found at the South Pole, or acid rain in Scandinavia from factories over 1,000 km away. Such processes cannot be controlled in a single nature reserve. We can only use the reserves to show the disastrous influence of these processes and to fight against the irresponsible use of pesticides and lax industrial procedures.

In general, small nature reserves will suffer greatly because of their surroundings, but again there are conceivably several reasons why establishment of such reserves is justified. Only their possibilities are restricted.

1. b. Influence of the Reserve on its Surroundings

The nature reserve will sometimes have an influence on its surroundings. Sometimes the chief influence is educational, promoting the acceptance of reserves. A rabbit coming from the grounds of a neighbor whom you do not like is always unwelcome. It is better to become good friends with your neighbor than to start a discussion as to whether the rabbit really causes damage.

But again it is the scale of your reserve that is really important. A small area does not disturb, and cannot contribute, much; but large areas will have an impact. Certain animals and plants will not stay in the reserve and will penetrate the surrounding area. Such behavior can be taken into account in the management plan itself. One of the considerations in the management of an area must be that its surroundings will not suffer inordinately. If it is a reserve for elephants, it is not acceptable for large groups to destroy the agricultural areas outside the reserve each night. The reserve is probably too small. A certain degree of influence, however, should be acceptable.

It is much more difficult to measure beneficial effects. Owls will eat mice in the surrounding fields, and the reserve might provide some beneficial influence in the micro climatological conditions. Although hedges are seldom nature reserves, ones sees the difference between agricultural areas with hedges and those without. Partridges, pheasants, birds of prey, and songbirds define the richness of an agricultural area intersected by hedges, and they are all absent from areas with monocultures. Quality is never easy to measure, but loss of quality is easy to see and difficult to repair.

External influences should be considered very carefully. Following study, the boundaries of an area may need to be changed.

INTERNAL INFLUENCES

2. a. The Ecological Process

It will be difficult to speak in general terms about the internal processes of the area. One of the most important questions will concern the type of vegetation and the degree of its succession. To answer such questions, botanical knowledge is necessary. Common sense is also important, as basic alternatives have to be considered. If the vegetation has reached its climax (e.g., forests, sea shore, dunes, or lakes), a management process will be completely different from a situation in which the vegetation has yet to pass through several stages (e.g., young forests, shallow water, moors grazed by sheep, or meadows).

I am not suggesting that the first types are stable and the second dynamic. They are all dynamic botanical processes that require sound judgment as to their use. A forest may be a climax situation, botanically speaking, but fire, storm, and age will always change the area. Forests of different ages, including open areas, will often be present in a natural situation. The same will be true near a sea shore where the salt water determines a certain type of low vegetation.

In situations where the vegetation itself is still undergoing change, sometimes caused by human activities, management becomes another factor for change. Much nature management in the world attempts to slow down the natural ecological processes in favor of a certain type of ecosystem that would be rarer under natural circumstances. Perhaps after changing so much in our environment, it is necessary that we do a bit more work on our reserves.

As a result of diking rivers, open areas that regularly flood no longer exist within parts of Europe. We created inland meadows for our cattle. Wintering geese also use such meadows. Geese can only use such meadows if the grass is low in winter. If we create such areas, we have to reintroduce flooding, which will be difficult to do in many situations, or we have to maintain this special type of landscape by grazing or mowing. We have to do exactly what the former users did who created this kind of area, but our aim is different. It is always possible to look for a combination of these aims.

These remarks can only be made by an author who has lived for a long time in a small country. Of course there are many situations in which marshes and meadows do exist in a natural way, sometimes with human use, and after a thousand years they will remain the same. Endless marshes can be a complete system of endless water reserves and, therefore, all vegetation processes between water and land will always be present, including the natural variety. There are too many examples, however, of unexpected and unpredicted side effects of activities near large nature areas. Care must be exercised. The vast marshes of the Everglades in Florida, U.S.A., are severely affected by an altered water regime in this region and are artificially managed so that the area remains open and with little forest penetration. Former marshes that have been changed into dry, quite uninteresting forests through lack of water and proper management are legion. Wetlands all over the world suffer from changes in their surroundings, and frequently management efforts are necessary to remove these influences.

In forests we are generally concerned with intense human use that makes reserves difficult to manage. It is hard predict whether a man-made forest will ever grow into a natural forest again, with the same variety of tree species as there was before human interference. Even if such processes were to take hundreds of years, it is important to set aside areas where they can take place. Nature management is not something for our generation, but for the generations to come.

In small areas one must decide upon one among a number of choices for the ecological processes. After a choice is made, it should be adhered to: a new system with each new manager is disastrous. Once the choice has been made to allow the ecological process to develop undisturbed, the same policy must be followed for the next hundred years, unless significant influences from the outside prove the decision unviable. Short-term results should not be demanded; let nature take its time.

Large areas are perhaps easier to manage after a decision is made, but the decision is extremely important for the future of the area. Politically-minded people who have no knowledge of ecological processes should never be involved in the management practice, even though they are involved in the establishment of the reserve. Nothing is more harmful to the future of a reserve than the intervention of influential people in internal matters. After the establishment of a reserve, management is a technical, not a political, process.

2. b. Special Preference Toward Some Animals

Since nature offers limited possibilities, it is difficult to develop complete, natural ecosystems in all reserves. There will be special reserves for breeding cranes, for tigers, and perhaps for dragonflies. In theory it is not easy to defend such preferences, but in practice they are necessary because of the limited area of reserves and the sometimes conflicting conditions required by different species. In a huge marsh, a crane will always find a square meter needed for its nest. But this chance will be reduced practically to zero if the marsh is very small and natural succession is to continue. If the marsh is especially established as a reserve for breeding cranes, one has to manage water and vegetation. Cranes will respond by breeding in the well-managed site. But in a small area one should not bring too many conflicting interests together. Cranes, wild boars, human visitors, undisturbed botanical processes, and harvesting of sphagnum can all be combined on 10,000 ha but not on 5 ha. If you prefer to preserve a traditional crane-breeding territory on your 5 ha site, you must exclude all other activities. You must carry out a restricted management plan or give up the cranes. One should not ask the impossible of the small site.

The greatest satisfaction derived from a well-executed management plan will always be the spontaneous establishment of new species or the enlargement of an existing colony. This is a human perspective, however, and not always the best ecological one. "More" is the human assessment of success; ecologically, just a balanced minimum is much more attractive. A huge colony of herring gulls *Larus argentatus* is a challenge to the manager, but perhaps not the best size colony within which vegetation and other seabirds can build up a balanced community. Management is not for just many of one species, but is for a balanced system which can survive by itself.

Bias toward certain species, however, is sometimes necessary. Some animals have evolved into such bizarre specialists that they can never survive in our society. One of the challenges for nature conservation is to find solutions for these specialists and to create an environment in which the remaining variety of species can survive. Some species pose many problems. If giant pandas *Ailuropoda melanoleuca* ate grass instead of bamboo, or if black-necked cranes *Grus nigricollis* did not breed only in marshes 4,000 m high in the mountains, management would be much easier. The challenge for the politician is to create opportunities for the variety of ecological requirements and, for the manager, to bring them to fruition.

2. c. Botanical Preferences

An area with rare plants or a special type of vegetation may be especially managed in accordance with biological preferences. Most types of vegetation, however, will develop naturally if the circumstances conform to the conditions required by these communities. Many of the North European heaths evolved several hundreds of years ago after the land was deforested. Keeping these areas open, with their own botanical and zoological community, is one

of the aims of nature conservation in these countries. Although we now know how to manage such areas, acid rain and general air pollution destroy this process; it is unlikely that we can maintain the heather community in these countries.

Orchids are also plants for which people wish to give a certain priority. Some species of orchids grow together in dense communities, but a nature reserve is not a flower garden and should not be managed as if it were. In general, it is best to develop and manage the whole community in which orchids appear and disappear according to ecological laws.

Preference for certain plants is sometimes easily combined with the desire to harvest and to slow down the natural succession. Reed *Phragmites communis* is a good example. Reed is an early pioneer in waterland margins. It grows in water 2-3 m deep and can grow for many years under rather dry conditions. If it is possible to control the growth of reed (by harvesting or burning), the marsh will keep its original character for centuries. If this harvesting can be combined with a sound financial approach, it will be a successful management tool. If commercialization of the reed harvest becomes the chief aim, however, the activity cannot be accepted in a nature reserve. Commercial harvesting must be part of the preconceived management plan. But if protection is dependent upon the commercial harvest, results will never be acceptable and will become a source of many conflicts. It is better not to pretend to have a nature reserve if reed harvesting is the main aim of the area.

Here again, some preference for certain communities or species is acceptable within certain limits. Once a choice is made, it should be supported. The area will be ruined if each well-meant management idea is immediately carried out. If processes have to be readjusted, this should be done carefully and step by step. If grazing an area is no longer acceptable, it is not wise to stop it all at once. If grazing has occurred for many centries, it does not matter if it goes on for a couple of years more. First you have to know what grazing is doing, biologically speaking, and then make the appropriate decisions. Finding the balance between acceptance, biological desirability, and political wisdom will challenge the manager.

2. d. Recreation, Interpretation, and Education

Even more wisdom will be needed to tackle problems arising from people's preferences for the reserve.

Never tell people that the nature reserve is paid for with their taxes and therefore it should be managed as they wish. For then people will think that a nature reserve is a sort of cheap television, where one can watch tigers eating deer, see mating animals all over the place, and make other thrilling observations! In general, nature reserves are rather dull areas, but with a certain beauty. Of course it is fitting to show people the results of conservation. They should watch from the outside, realizing that beyond the hills it is even more beautiful as long as it is not touched. It is impossible to show a thousand people an eagle's nest up close. Nature has its own rights, and we should not let an environment be overrun by people who do not know what to see.

I have intentionally chosen a rather negative approach to recreation. There are too many instances in which nature is shown to the public, then nature disappears, then the people. There are few instances in which large numbers of tourists can enjoy wildlife. Some of the African parks are exceptions. Most of the large animals in the world are so rare, so afraid of people, or so nocturnal that it is difficult to see them. Seals and many bird species are also exceptions. In particular, birds breeding in colonies are easier objectives than the solitary breeding crane. The fact that it is impossible to show more than ten people the nest of a particular crane does not make this bird less important than a white stork which has its nest on a village telephone pole.

If people do not have the "right" to disturb nature inside (or outside) reserves and parks, what possibilities exist for exposing them to life inside the reserves? The possibilities are boundless, even within the limits of responsible use. To open an area to various recreational opportunities is extremely important for its acceptance as a reserve and for conservation in general. Several issues, however, must be considered, including policies toward cars, restaurants, overnight facilities, hides, guided tours, information centers, and free entrance versus a fee.

As a general rule, recreational use should occur along existing paths so that adequate undisturbed areas remain for wildlife. A recreational management plan will be necessary after one has formulated the ecological aims. Large inaccessible areas will contribute greatly toward the purposes of the reserve and the imagination of the public. Knowledge of the area and the different processes involved is necessary before visitors can be shown bird life. Through a reed-tunnel, limited numbers of people can be brought into the center of a cormorant colony, an experience no one will ever forget. Local conditions enabled managers to carry out such a project. For most colonies, however, too much of the environment would have to be changed to achieve this kind of result: the birds would probably abandon the area before the first visitors could watch them closely. It is much easier to give people an impression of the area. Vegetation and landscape are easy to show, but because of television people expect too much from a simple visit.

It is dangerous to start special attractions for the public too soon. It is much better for the reserve to establish itself over a period of many years, and to learn where the attractions are and how to manage them for public benefit. New roads should not be made, but sometimes existing ones must be reevaluated. Recreation must be limited so that natural processes can unfold with as little disturbance as possible.

Few example exist of well-organized national parks in which large numbers of people can enjoy themselves. In general, these parks have geological formations like caves, waterfalls, etc. Natural beauty seems to be more easily managed than living nature. For example, it is easier to show people a sunset than the flight of a nightjar, which happens at the same time. The distance of the sunset is

accepted; the nightjar is always too far away.

In general, cars should not be admitted to reserves and parks. Although a few animals are less afraid of cars than of people on foot, the speed of cars is not compatible with the aims of the area. Transport by silent boats through certain areas is ideal (but here, too, some water areas should not be visited).

All special facilities, such as restaurants and overnight places, should be located near, but not inside, the park, except of course where a park can develop a special use for "trekking" with overnight facilities in hides. Even an attractive hotel inside a nature park will cause disturbance and other problems; if there is a choice between developing one inside or outside the park, I would always suggest placing it outside.

It is important to use reserves and parks for education and interpretation, as long as people are left free to enjoy themselves in their own way.

A large park needs a staff of officers who can provide guided tours, interpretative routes, information centers, and school programs. These are essential for the area, both for long-term nature conservation and for best use of the amenities within the area. If properly managed, recreational use is desirable. My aim here is to stress management of recreational use combined with conservation of resources.

2. e. Other Functions

As already mentioned, it is possible to combine several functions within a nature reserve.

To take reeds again: as reed, *Scirpus*, grass, and even trees afford valuable products, it is interesting to see whether there is some possibility of using these products, not as a new demand on the area, but in support of the proposed, most desirable management.

As we have seen, there are many occasions when natural processes have to slow down. This means harvesting. A profit on the harvest is always welcome.

A profit from hunting is also welcome. If the regulation of certain species is desirable as a result of the aims of the reserve, there is nothing wrong with allowing organized hunters to help achieve this goal. But if hunting becomes an aim in itself, it is better not to organize such an activity within the reserve.

Raising pheasants for shooting should not occur in a reserve. There are enough places outside the reserves, in forest and agricultural areas, where such activities can take place. Politicians usually favor combining activities, such as hunting or flying of model airplanes, in nature reserves. These activities do not support the aims of the reserve and therefore cannot be justified.

A nature reserve is not a buffer between a polluting factory and a city. It needs a buffer for its own purposes. Country planning should show careful judgment, because long-term, well-managed processes are very difficult to replace or relocate.

2. f. Financial Aspects

Nothing is obtained without money, even in nature. In each political system, the means of establishing the reserve will differ. The system itself will determine whether people have free access to a protected area, or whether the manager can demand a fee. A fee creates expectations; people will happily pay to see something in the wild. A well-equipped information center, guided tours, information staff: people are willing to pay for such services, but they are reluctant to pay to enter an area without the expectation of seeing something alive. Money cannot be charged for a sunset.

Sometimes national park managers make poor financial decisions. Let us imagine a park (60,000 ha) with a small staff of 10 people and subsidized by the national government. Each year over a million visitors come to the park to enjoy nature. The ministry responsible for national parks must pay these few staff each year and also buy suppplies for an information center. Visitors' fees do not go to the national park or to the appropriate ministry, but rather to the ministry of tourism which in the name of the park organizes visits by tourists. Such an approach is wrong. It takes a single strong hand to manage and organize a park or reserve. This "hand" does not deal only with plants and birds and enthusiastic bird lovers, but it manages the entire operation, trying to maintain a financial balance. Excluding the costs of once-only purchases, some areas can be managed easily with an annual financial balance, especially in larger areas where a nearby hotel pays annual fee, or where several facilities exist, and where some products can be sold. Such management demands sharp financial acumen together with sound knowledge of the possibilities of the area. If a bus company is not willing to pay a fee for the privilege of bringing thousands of people to the reserve, another company should be found.

Many small reserves, with limited aims and recreational possibilities, are expensive to maintain. This cannot be helped. Local politics, special expenses, or special ecological processes sometimes in a fenced-off area, can make it necessary to collect fees to support the aims of such an area. Tolls should be collected on roads leading through it.

Financial problems should be taken in stride. Nature offers a unique experience if it is well-managed. As nature reserves are developed, the public, with ever more leisure time, will use them.

This approach is rather "western." In many less-developed countries, such an approach could be more emphasized. Fish farms and certain agricultural activities, as long as they are in accordance with the aims of the reserve, can be acceptable. In providing firewood, local fishing, hunting, and guided tours, a nature reserve is a living system. Well-managed, it will offer attractions for thousands of years.

Nature reserves will never yield high returns on investment. For those who have lost confidence in the Bank of England, a nature reserve is no alternative!

THE MANAGEMENT PLAN

Once the aims of a protected area are agreed upon, a management plan can be drawn up. To continue to discuss aims at this stage will cause frustration.

If the area is safe, if people know what they want, and if information about the area is available, then the plan should be developed without hesitation. There are four parts in a management plan:

Basic Information (Mainly A-biotic)

Many factors must be taken into account. A map should be developed, preferably one on which it is possible to note the various components of management and recreation. Depending upon the scale of the area, sometimes 1:25,000 and 1:5,000 maps are a necessity. For special projects within the boundaries, large-scale maps are useful.

The boundaries of an area, in place already or planned for the future, must be defined not only on maps but also in the field. Since boundary disputes are common, they should be anticipated in the management process. In many countries there is a country-planning system, where future plans which might have an influence on the reserve can be taken into account. It is also important to gain acceptance for the area itself as well as for a buffer around it as soon as possible. It is helpful to persuade local authorities to learn about the plan by being involved in the process.

A description of the area, including its history, must be provided. In many cases there will be a local "expert" who has lived all his life near the area and can give a lot of basic information. If there are buildings, it is wise to make a decision about their disposition as soon as possible. Historical buildings require maintenance, but they will also be a drawing card for the future. Vulnerable ecological processes should not be developed close to such sites. Useless buildings, or buildings which might give more problems than pleasure, should be demolished as quickly as possible before other interests arise. It is always better to have buildings outside the area rather than inside. Even a warden who lives inside the area will soon need electricity, a school bus, and water, all disturbances which are better left outside.

Geological and geomorphological maps and descriptions are useful. From these descriptions one can learn a great deal about hydrological processes and come to understand vegetation differences in the field that are related to soil structure and other geomorphological data. It is not necessary, however, to wait until these data are available. With some simple aids, such as a borer and altimeter, it is possible to get started.

The Ecological Inventory (Biotic Information)

It is important to have available an inventory of biological processes and data relating to plants and animals, preferably based on several years' observation.

Of course it is impossible to know everything before beginning management of an area, but some key information is necessary. For mammals, one should know about rare species, large herds, where the mammals stay, diurnal or nocturnal habits, etc.

For birds, locate colonies, large birds of prey, concentrations of birds during winter or migration, rare species with special needs, etc.

Management must consider more than just mammals and birds, but one is restricted. Additional information about reptiles, amphibians, fish, and insects are most welcome.

A vegetation map is essential for good management. Maps again can be very rough or very detailed. Forest-marsh-water doesn't give much information, but a subdivision into different types of forest, different ages, different management in the past gives much more information. More detailed vegetation maps of certain parts of the area are important, for example where one wants to follow the succession. Detailed knowledge about plants, vegetation, and their succession is necessary to develop a good inventory.

During the process of gathering these types of information, ideas about management are developed. It is essential, therefore, that those who are responsible for management are involved in at least part of the process. It is not necessary to know all the birds or all the plants, but a certain knowledge of processes is essential.

If the area under consideration is a new lake in bare surroundings, the inventory will be short; much more attention will need to be given to the planning of new activities. If the new area is a complex thousands of years old, however, and contains marshes, meadows and forests, the inventory will be proportionately long; one shouldn't start many activities soon. The different processes do not have to be described in great detail. Their description constitutes only a kind of enumeration of possibilities and necessities which have to be taken into account.

It is also important to describe the existing use of certain areas — agriculture, hunting, cattle grazing, etc. After describing these uses, record any influences on vegetation or other animals. If it is clear that overgrazing by cattle takes place, this problem has to be resolved before the establishment of the reserve. In some situations cattle contribute greatly toward the biological diversity of the reserve. But could this role instead fall to native mammals? Any processes involved, as well as the numbers of cattle, must be recorded precisely.

Another important matter needs to be considered - research. Biological research, and also agricultural, sociological, and economic research, depend entirely upon the size and structure of the area and on what kind of research is acceptable. Small reserves are not very attractive for basic research, but it is interesting to find out how they contribute toward the value of the surroundings in which one lives. As for biological research, two different types are relevant.

Fundamental research or development of instructional materials for schools and universities are always possible. The unique aims of the reserve, however, are more important than the research possibilities it offers. If there is a vulnerable bird colony in the reserve, any research program must show an awareness of its presence. That colony must be preserved by the manager. Thus research is only possible when the reserve itself is the primary concern.

The other type of research is directly related to management itself: basic work such as making inventories, ringing and measuring birds, and also experiments to ascertain the best possible management proposal. A wide range of

activities is important to planning the future of the area, if the reserve is to be well managed. No small portion of a project should lead immediately to specific management proposals. All research results have to be integrated with other data into an overall management plan.

If a researcher looks into the spider fauna of an area, he may find that many vulnerable spiders are lost during mowing time. His first advice will be: no mowing. But to refrain from mowing might not be good for the spiders, since a mown, regularly disturbed area is their preferred habitat. Also, mowing is related to management of the vegetation and the breeding of some birds that prefer short vegetation. A solution might be to mow a little earlier in the season and hope enough spiders survive the disturbance.

While it is worthwhile to understand all the processes in an area, each new piece of knowledge does not necessarily lead toward new and revolutionary management practices.

Management Plan

All these ideas, thoughts, inventories, and considerations contribute to the ultimate task: the creation of a management plan. This plan will be a description of activities for the area as a whole, and for the various parts, together with the proposed outcome.

First, a long-term plan has be developed which provides a prospectus for the first 10-50 years. It deals in detail with borders, environmental, zoological and botanical aspects are noted, and a measurement scheme is constructed.

Sometimes it is wise to present such a plan to the local community or to discuss it with the local authorities in order to involve them in the planning process and to make certain that the country planning authority in the region is informed about proposed activities. Presenting a plan to a wide audience has advantages.

Second, the short-term management plan is developed, a document intended only for internal use. For the area as a whole, and for each clearly identifiable part of the reserve, it is essential to mention all necessary activities to be undertaken and during what time of the year.

Two examples will suffice:

"C15" Heron colony. No access from March-July, except one day (good weather) in June for general count of nests and juveniles. (University's ornithological department and "X" involved). In November, planting of oak trees in eastern part.

"C16" Young forest timber. Possible site for overspill of colony in 10 years' time, but trees now too young for herons. Botanical survey in July. Planting oak trees at western edge (November).

Additional information about the C15 area will appear in another section, including area in hectares, water level, botany, ornithology, number of herons in different years, possible disasters caused by storm or fire.

Plans for one to five years are a prerequisite of good management. Sometimes five-year plans are sufficient, but in complicated situations where a variety of activities take place, it is better to have annual plans.

It is not advisable to divide information on activities into different chapters. Activities in "C15" have to be mentioned all together under C15, as it is impossible to develop a daily or monthly work schedule if the whole plan has to be read each time. Even if there are separate chapters for special subjects, such as recreation, it is necessary also to transcribe the actual activities under the area numbers.

If a picnic area in "B6" is to be developed next year, this information will be under B6; and there is still time to develop this plan in detail. This year the road from B1-B7 has to be repaired. A management plan is an enumeration of activities, but in this context "doing nothing" is also an activity. The well-planned non-activity is just as important as any undertaking.

Working from the general overview toward the details will prevent mistakes. To list all kinds of work in a certain area is far easier than to create a long-term management plan in which processes are described and integrated. But a short-term management plan without the support of a long-term plan will nearly always fail.

Finances and Personnel: Result or Limiting Factor

Few plans are developed for which staff and money are immediately available to the extent one would desire. Of course plans should be realistic, always taking into account their feasibility. But feasibility is not a limiting factor, since a good management plan should be "sold" to those who made the decision to create a reserve.

Management activities are necessary and will cost money. Sometimes, it is more economical to have one's own personnel to carry them out; sometimes, it is cheaper and better to involve local contractors. Each area and each country has its own approach.

For basic activities such as carrying out inventories, guarding, interpreting, distributing information and the like, management needs its own personnel. In general, small nature reserves require relatively more personnel than large ones. The types of work will determine how many people are needed.

Thus finances and numbers of personnel are the result of the plan. If it is necessary to readjust these figures, then the management plan itself must be readjusted.

At this time, it must also be decided whether local people are to carry out certain management activities, such as cutting reed, grazing, guiding tours, wood-cutting, hunting, and fishing. If it is possible to reach favorable agreements for enclosing areas and creating a sound financial basis for management, the aims of the reserve will be furthered. But many examples illustrate a promising beginning after which local economic activities soon threatened the reserve!

Title of ownership and purpose of the area must be made clear to prevent usurpation of a reserve that prospers.

EVALUATION REPORTS

Regular reports of activities and observations should be kept. Using the same maps and the same compartment numbers, as shown in the management plan, makes record

keeping easier. Information thus preserved is available at once for a new plan.

Reports relating to the management of the area should not contain biological observations alone, but should also give an overview of the management activities. For large areas, an annual report will be helpful, but for smaller areas simple data-gathering will be enough.

In general, it will be impossible to collect data on all biological phenomena which are of interest in the area. But a selection can be made of 10-20 species of animals and plants. Not only rare ones, but also one or two samples of common species will show how such a population changes in relation to management activities. Cranes, certain birds of prey, colony breeders, woodpeckers: all are key species for management reports. Results should contribute toward the management plan itself, but basic management directions should not be changed too quickly.

A computer is not necessary in collecting or processing the data. A computer may encourage the collecting of useless data even where no good program exists. The initial collection of data can easily be done with a simple filing system from which systematic lists can be developed. Later, a computer could be used to advantage.

CLOSING REMARKS

This overview of management is not a manual for a plan. It may be of assistance in thinking about such plans without fear. If help is needed in a country where no specialized information is available in a particular field, visiting a school or a local manager in another country may afford experienced counsel. Inviting specialists to one's own area is another possibility, but is not always feasible. Specialists can offer ideas and general advice, but only the persons living in an area have knowledge enough to draft a plan.

BIRD CASUALTIES FROM COLLISIONS WITH A 500 KV TRANSMISSION LINE IN SOUTHWESTERN VICTORIA, AUSTRALIA

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ABSTRACT

A survey was undertaken of bird casualties from collisions with a 500 kv transmission line in Western Victoria, Australia where it crossed farmland with a mosaic of wetlands. The survey was done for four consecutive days at four weekly intervals from August 1985 to August 1986 and included a period of time when the transmission line was not energized. The remains of a total of 130 individuals of 20 species and two other genera were found. Black swan *Cygnus atratus* and straw-necked ibis *Threskiornis spinicollis* comprised 35% and 29% respectively of all birds found. Most species were water birds, some being nocturnal. Remains were found in every survey period and recently killed birds were found in most months. Additional species were found during random inspections at other sites along the same transmission line including two brolgas *Grus rubicundus*. It is probable that casualties were higher; scavengers and predators would have removed birds and dense vegetation would have obscured others. Suggestions are made as to the siting of transmission lines in relation to wetlands and breeding colonies.

INTRODUCTION

The incidence of avian collisions with power transmission lines has been documented elsewhere in the world (McKenna & Allard 1976; Willard 1977; McNeil et al. 1985; Olendorff and Lehman 1986). But most have involved lines near to, or crossing, large expanses of water. No published information is available for Australian conditions. Anecdotal evidence is available, however, particularly the incidence of brolgas striking power lines (D.M. White pers. comm.; authors' personal observations).

The southeastern area of Australia is the most densely populated area in the nation, resulting in larger numbers of public facilities and associated industrial development. In order to provide a reliable, secure and more economic electricity supply, a power grid is proposed to link up three states, New South Wales, Victoria, and South Australia. There is an existing link between Victoria and New South Wales (Figure 1, from Kinhill Stearns 1986).

An existing 500 kv transmission line runs through Western Victoria, terminating at the Alcoa Aluminum Smelter at Portland. This line crosses an extensive wetland area and effectively bisects the main brolga breeding areas in southeastern Australia. This region also supports colonial nesting species (see Figure 2) such as straw-necked ibis, sacred ibis *Threskiornis aethiopica*, Australian pelican *Pelecanus conspicillatus*, royal spoonbill *Platalea regia* and cormorants *Phalacrocorax* spp. (Cowling and Lowe 1981; Arnol et al. 1984; Blakers et al. 1984; authors' personal observations).

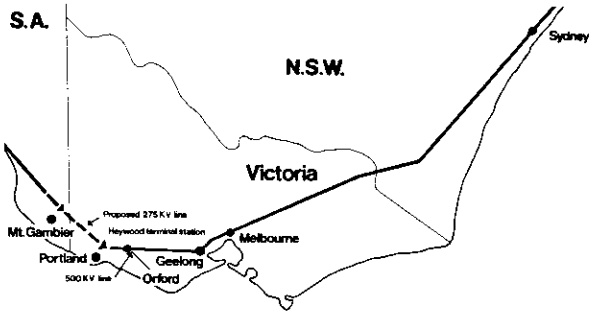

Figure 1. Three state interconnection.

In order to achieve the three-state link across Western Victoria, the relevant state authorities (State Electricity Commission of Victoria [SECV] and the Electricity Trust of South Australia [ETSA] propose to run a 275 kv transmission line between a terminal station near Heywood, Victoria to an area north of Mt. Gambier in South Australia. There are six alternative route options (Figure 3, from SECV & ETSA 1986). The six alternative routes were rated by us in wildlife values using data obtained from previous wildlife surveys carried out in southwestern Victoria (W.B. Emison, unpublished data). Three ratings — high, medium and low — were allocated on the basis of species diversity, species significance, and species known to be at risk from collisions with transmission lines.

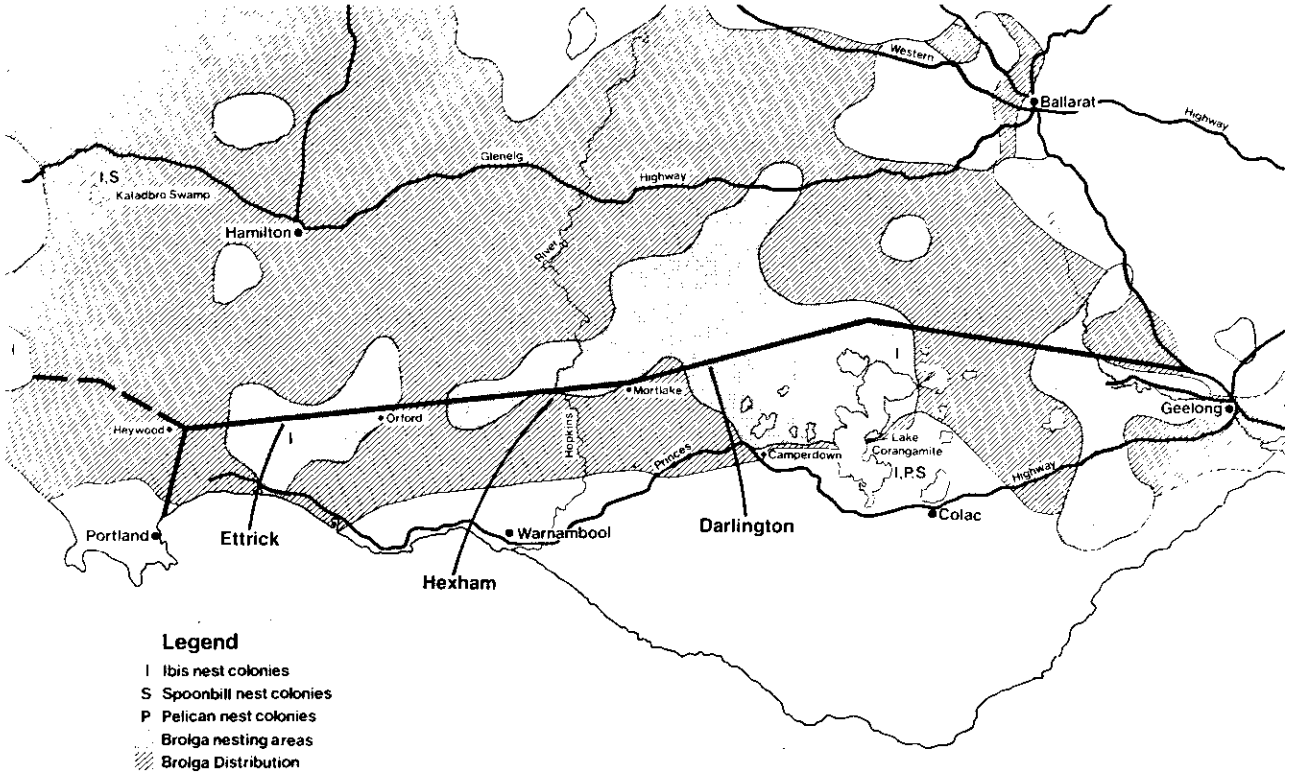

Figure 2. Route of existing 500-kv transmission line in western Victoria, with nest areas of cranes and colonial water birds.

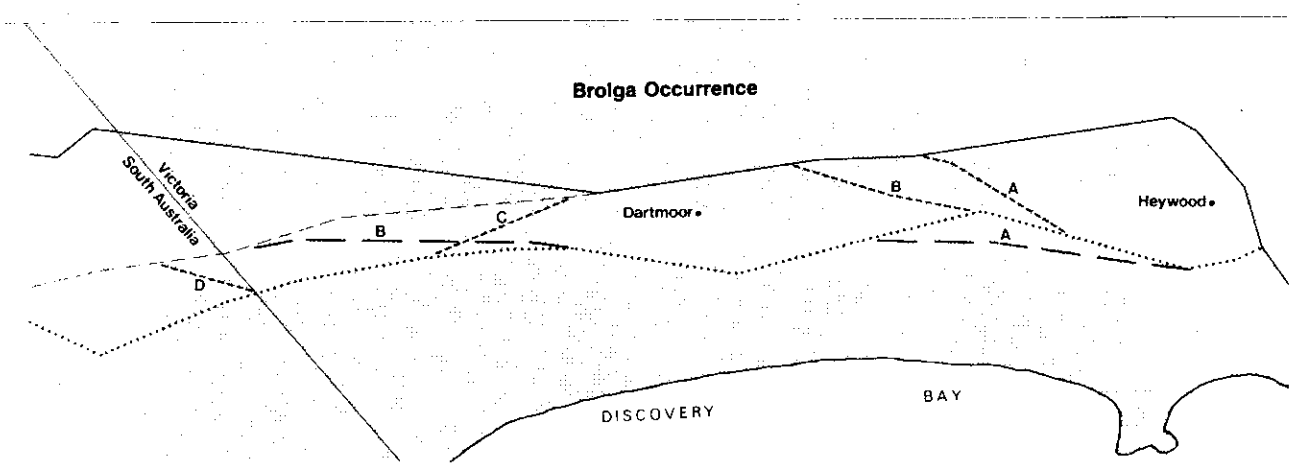

Figure 3. Proposed 275 kv transmission line Victoria to South Australia.

To assist in the preparation of an Environmental Effects Statement (EES), we undertook a survey of a 6 km transect of the existing 500 kv line, with geographic conditions similar to the proposed 275 kv line, to obtain data on bird mortalities.

The survey on the existing 500 kv line was undertaken from August 1985 to August 1986 and included a period from August 1985 to April 1986 when the line was not energized, and May to August 1986 when the line was energized. The line consists of six groups, each of four main conductors, and two single-cable lightning conductors or earth wires above (Figure 4).

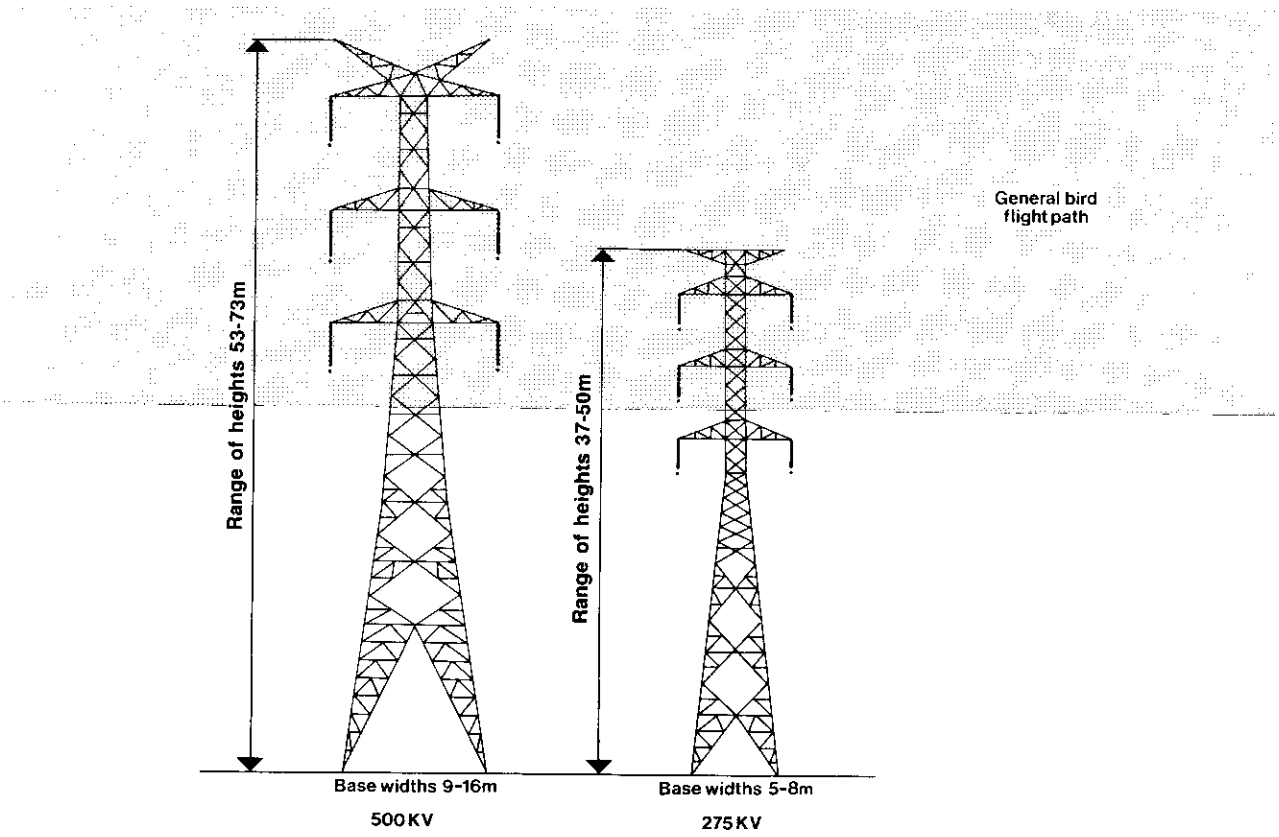

Figure 4. Line structures 500 kv and 275 kv.

METHOD

Originally two study sites were selected. One site was at Darlington, a cropping/grazing area on basalt plains containing swamps and lakes, where a brolga collision had been recorded; the transmission line also cuts at right angles to the Mount Emu Creek at this site. The other site was at Orford, a grazing area containing a mosaic of small wetlands or swamps (each < 3 ha) and remnant eucalypt woodland. The bulk of the survey, however, was restricted to the Orford area (Figure 1). The nearest comparable weather station is at Heywood, 40 km west of Orford, which has an annual rainfall of 837 mm with 547 mm (65%) falling from May to October.

The survey was conducted over 12 months, on four consecutive days once every four weeks as soon after daylight as practicable. Two transects were walked, one under the transmission line, and a parallel control approximately 500 m north of the transmission line.

Two people walked a zigzag course in opposite directions under the line, commencing from about the middle of the transect. The 6 km transect included the area extending out approximately 50 m on either side of the line. Binoculars were used to scan the area for dead and injured birds and to assist in identification of live birds whose presence and movements were also recorded. All carcasses and remains were collected and removed in order to prevent duplication. Weather conditions at the time (wind, temperature, rain, fog, and cloud) were recorded to determine whether they had any influence on collisions. The condition of the swamps and pastures was also noted. The survey was completed by returning to the start point via the control transect. On alternate days the control was surveyed first. The surveyors also alternated on the half sections walked in order to remove bias. The condition of dead birds was noted (fresh, old), and the occurrence of predators in the area was recorded. Specimens that we could not accurately identify were sent to the National Museum of Victoria for confirmation.

Random spot checks at other locations were also made under the transmission line to indicate the spread of collisions. Other instances of collisions were also reported to us (Richard Weatherly pers. comm.).

OBSERVATIONS AND RESULTS

Dead Birds and Bird Movements at Orford

A total of 126 individuals of 20 species was collected under the transmission line (Table 1). The remains of four additional individuals that could not be accurately identified were also collected. In addition a further 10 individuals of six species were noted at this site prior to the survey. These included four straw-necked ibis, two starlings, one sacred ibis, one Pacific black duck *Anas superciliosa*, one black swan and one Australian magpie.

Only three dead birds were found on the control transect, two Australian magpies and one little raven *Corvus mellori*.

Most identified species (14) were water birds, the others being birds of grassland and woodland.

A total of 75 bird species was recorded alive during the survey. Thirty-two of these species were seen flying through the transmission lines or earth wires.

Five species found dead under the transmission line were not recorded live during the survey. These were the blue-billed duck, buff-banded rail, marsh crake, coot and feral pigeon. The purple swamphen was recorded on only three occasions, yet eight dead birds were found. The black swan, which comprised about 35% of dead birds found (45 of 130), totaled less than 2% of live birds seen (135 of 12,763).

We were unable to study bird movements at night. Most of the birds found under the transmission line, however, are known to fly at night or in twilight conditions. The raven, feral pigeon and skylark are not known to do so.

The reactions of birds to the transmission line were variable. Factors assumed to influence their reactions included light and wind conditions and whether they were flying singly or in small or large flocks. Large flocks of birds were more likely to be disrupted by the transmission line than were small flocks or single birds. This was particularly noticeable with the ibises where flocks were "broken up" when attempting to cross the line. Some birds veered away from the line rather than cross it.

Strong winds blew some of the smaller species through the area of the lines and, on one occasion in September 1985, a group of four yellow-billed spoonbills *Platalea flavipes* which was flying downwind was unable to gain enough height to fly over the lines even after two attempts at flying back into the wind to do so. They eventually chose to land rather than cross through the lines. Weather conditions at the time were rain squalls with wind strength Force 4 on the Beaufort Scale.

Ibis flocks in the early morning and in fog also appeared to have difficulty in detecting the line. Deaths were still recorded after the line became energized.

Species		Aug 85	Sept 85	Oct 85	(Pasture Long) Nov 85	Dec 85	Jan 86[a]	(Swamp Dry) Feb 86	(Pasture Short) Mar 86	Apr 86	May 86[b]	June 86[b]	July 86[b]	July Aug 86[b]	Aug 86[ab]	Totals
Podiceps poliocephalus	Hoary-headed grebe													1F		1
Ardea novaehollandiae	White-faced heron	1														1
Botaurus poiciloptilus	Australian bittern					1										1
Threskiornis aethiopica	Scred ibis	2											1	1F		4
Threskiornis spinicollis	Straw-necked ibis	10	5	5(F1)	1F	2		3(F1)	1	4	3		2(F1)	2		38
Cygnus atratus	Black swan	9(F2)	15	5	2	1	1F	1	2(F1)	3	1	1F	3F	1		45
Tadorna tadornoides	Australian shelduck	1	1													2
Chenonetta jubata	Maned duck													1F		1
Oxyura australis	Blue-billed duck									1F						1
Coturnix novaezelandiae	Stubble quail									1F						1
Rallus phillippensis	Buff-banded rail													1F		1
Porzana pusilla	Marsh crake							2								2
Porzana tabuensis	Spotless crake							1								1
Porphyrio porphyrio	Purple swamphen		1F		1		2F	2F	1	1						8
Fulica atra	Coot													1F		1
Columba livia	Feral pigeon								1							1
Alauda arvensis	Skylark														1	1
Anthus novaeseelandiae	Richards pipit			1			1F									2
Sturnus vulgaris	Common starling		1						1		2	1	1	2F		8
Gymnoprhina tibicen	Australian magpie			1	2	1			1					1F		6
Ardeiformes or Anseriformes	Duck or swan spp.								1							1
Coturnix spp.	Quail spp.										1					1
Corvus spp.	Raven spp.	1														1
	Unidentified		1													1
		24	24	12	6	5	4	9	8	10	7	2	7	11	1	130

Note: During September 1985 a local farmer removed three straw-necked ibis carcasses prior to survey being done.

[a] Transect surveyed 2 days only.

[b] Transmission line energized.

[c] F = Birds recently killed.

Table 1. Birds found dead under 500 kv transmission line at Orford.

Some bird species that regularly crossed through the line, particularly the long-billed corella *Cacatua tenuirostris* and brown falcon *Falco berigora,* were not found dead.

Some of the smaller species found dead — for example, marsh crake and common starling — were encountered simply by chance, usually when an observer had stopped to record movements of live birds. It was especially difficult to find dead birds during the spring and early summer due to the density and height of the pasture. Some paddocks were not stocked during this period for the purposes of hay production and the pasture height was recorded at up to 0.5 m.

During the winter and early spring when the wetlands were full of water, parts of the transects were submerged and detours had to be made. Skeletal remains of birds were found under the transmission line when the wetlands had dried and access was again possible.

On 11 of 14 times the survey was done, freshly killed birds were found. Avian predators, for example the brown falcon, were recorded on 13 of the survey periods and on four occasions a fox *Vulpes vulpes* or a feral cat *Felis catus* were recorded. Most of the dead birds found had been at least partially eaten. The only exceptions were two straw-necked ibises, one of which was injured when found and later died, a maned duck which was still warm when collected, a spotted crake, a marsh crake and two common starlings.

Dead Birds at Darlington

This area was checked on three occasions in June, August, and September 1985. In June 1985 a brolga with a badly dislocated wing and severe bruising was found. The bird died while undergoing veterinary treatment.. In addition, six dead black swans and one white-faced heron were collected. In August 1985 four dead straw-necked ibis were collected and in September 1985 two dead black swans.

Dead Birds at Hexham (two locations)

In August 1985 six species were found at one location, including nine black swans and one each of the following: brolga, coot, sacred ibis, purple swamphen, and silver gull *Larus novaehollandiae.*

At a second location, twenty species were found over an extended period. Those species not found elsewhere were white-eyed duck *Aythya australis,* grey teal *Anas gibberifrons,* wedge-tailed eagle *Aguila audax,* black shouldered kite *Elanus notatus,* barn owl *Tyto alba,* and grey shrike-thrush, *Colluricinla harmonica.* More than one specimen each of the two ducks were found, and one specimen each of the other species. Of those bird species that were found at other sites as well as at Hexham, the most significant one was an individual Australasian bittern.

Dead Birds at Ettrick (two locations)

At one location in June 1986, four black swans and one sacred ibis were collected.

At a second location in October 1986, five black swans, six straw-necked ibis, one sacred ibis, and two Australian shelduck were collected. This count was done at 1500 hours. The sacred ibis was very fresh and still bleeding. This site is about 350 m north of Ellangowan Swamp, which contains an ibis breeding colony.

DISCUSSION

The results clearly show that a wide range of species are at risk from collisions with transmission lines, including nocturnal species (owls, bitterns).

The highest numbers of casualties were found during the first two months of the study and could be the result of an accumulation of birds over a period of time prior to the start of the study.

The majority of birds found were physically large species (for example, black swan, ibises, and ducks) which were easy to see and which would be difficult for predators to remove totally from the immediate area. Smaller species are more easily concealed by long pasture and native vegetation. There is therefore a possible bias in our results toward the larger species. Other researchers have also indicated the probability of injured birds (usually larger species) hiding and dead birds (smaller species) being removed from the area by scavengers or predators (McNeil et al. 1985).

In support of this premise, on the second day of the survey in November 1985, a live, injured straw-necked ibis was found in a well-vegetated shallow freshwater marsh located directly under the transmission line. The bird had broken its wing some time previously as the injury had putrefied and become infested with fly larvae. It was not possible to catch the bird at that time, and when we returned two hours later the bird lay dead at the edge of the swamp.

One farmer, who owned property crossed by transmission lines, told us that he made a practice of removing bird carcasses when sheep were lambing in the paddock, in an effort to reduce the presence of foxes among the lambing ewes. The potential for farm dogs to locate and remove carcasses cannot be discounted. Whenever we met farmers during the survey they were accompanied by dogs. The dog of one surveyor (P Du G) participated in the survey on one occasion. It was responsible for the discovery of the blue-billed duck.

Black swans breed opportunistically on wetlands throughout the area. Black swans are a mobile species known often to fly at night (Frith 1977). Being large birds with a body weight in excess of 5 kg and a wingspan up to 2 m, the swans are not able to take rapid evasive action. Brolgas also have a similar lack of maneuverability.

We recorded one pair of swans raising young in a nest directly beneath the transmission line. This particular pair was probably not at risk as the birds would fly well below the transmission line when approaching or leaving the nest site.

The transmission line was also within the area used by feeding flights of sacred and straw-necked ibis. Two breeding colonies of these species occur within 25 km of the study site.

The transmission line towers average approximately 60 m in height. The two lightning conductors or earth wires and the top two sets of main conductors appeared to coincide with the flight altitude favored by many species in their

general movements throughout the area (Figure 4).

Many of the birds probably collided with the transmission line at night or under low light conditions. It is also likely, however, that some collisions occurred during the day particularly among flocking birds and those species that find it difficult to maneuver in strong winds.

When the transmission line became energized, bird collisions continued to occur despite the fact that under damp atmospheric conditions the transmission line emitted an audible crackling noise. Over 20% of bird deaths were recorded on the five occasions that the line was energized.

We are of the opinion that most deaths occur by collision with the earth wires. These are single, small diameter cables and are less visible than the large diameter and grouped main conductors.

CONCLUSION

Our results indicate that bird deaths will occur no matter where a transmission line is located. But the potential exists for higher levels of mortality to occur where the line bisects extensive wetland areas and/or flight paths of birds. The vicinities of breeding colonies of water birds, and breeding and flocking areas of brolgas, appear to be especially sensitive areas.

Ideally, it would be preferable for transmission lines to be placed underground. Where this is not considered practicable (in Australia the cost of such an undertaking is prohibitive), it is suggested that the transmission lines be sited as far away as possible from important wetland areas, particularly those that support breeding colonies and breeding and flocking sites of species at risk from collision.

If this is not practicable, efforts should be made to site the lines parallel to important flight paths. Consideration should also be given to making wires more visible or to increasing the gaps between the lightning conductors and the top set of main conductors.

The preferred option for the proposed 275 kv line from Heywood to South Australia is the southernmost route which avoids the important wetland system to the north.

ACKNOWLEDGMENTS

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COMPENDIUM OF CRANE BEHAVIOR PART 1: INDIVIDUAL (NONSOCIAL) BEHAVIOR

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ABSTRACT

This paper provides the organizational framework, nomenclature, and abbreviated descriptions for all conspicuous nonsocial behavioral units for all 15 species of cranes. We present eight generalized functional classes of behavior. These classes include about 90 discrete motor patterns that constitute the nonsocial repertoire of all cranes. We present this compendium to facilitate information exchanges among students of crane behavior and to encourage interest in future detailed studies of the descriptive ethology of each species.

INTRODUCTION

In the field of ethology, there is a fundamental need for standardized terminology in describing animal behavior. Several descriptive terms are often used even for clearly homologous behavioral acts. For example, the action pattern wherein a bird elevates its feathers, then gyrates violently in left-right rotation about the body axis, is termed "Shaking" for ducks (Nice 1962), "Body/Wing-Shaking" for jungle fowl *Gallus gallus* (Kruijt 1964), "Rouse" for the bald eagle *Haliaeetus leucocephalus* (Gerrard et al. 1973), and "Ruffle-shake" for the golden eagle *Aquila chrysaetos* (Ellis 1979). This lack of uniformity in naming even the most basic action patterns is characteristic of the ethological literature today.

While it is inappropriate to impose a rigid system of action pattern titles for all avian species, because different birds do different things, it is important to standardize terminology for homologous action patterns where possible. In this report, we attempt to create a framework of terms, general enough to embrace the variation inherent in a family comprised of 4 genera and 15 species, yet sufficiently precise to allow biologists to identify homologous behavioral acts for any crane species. To do this we identify, describe, classify, name, and report primary context of performance for all known nonsocial behavioral acts for the family Gruidae. Our statements of function and context are not to be considered final or all-inclusive. Indeed, we know that many of the "nonsocial" action patterns presented here appear elsewhere as components of social displays.

Although crane behavior is receiving increased attention worldwide, incomplete ethograms are available for only two species, the red-crowned crane *Grus japonensis* (Masatomi and Kitagawa 1975) and the sandhill crane *Grus canadensis* (Voss 1976; Nesbitt and Archibald 1981; Tacha 1981). Before crane behavior can be adequately evaluated and compared, a standard lexicon including its basic components must be developed.

The behavioral repertoire of even a solitary vertebrate is a complex matrix of intricately interwoven elements. Because an individual animal does not behave in a vacuum, the description of its behavior is further complicated by variability in hormonal states, social situations, and environmental conditions. In order to tease apart, define, and classify each strand of this web, it is necessary to impose a classification scheme that is, to some degree, arbitrary and artificial. Because of the difficulty of this task, this compendium should be viewed as an initial attempt, something to be expanded and modified through time. Also, this paper is not an ethogram, a complete description of the behavioral repertoire of a single species. We present it, however, in the hope that ethograms for all species will develop from this framework.

The units of animal behavior are hereafter called "ethons" (Ellis [1979]; synonymous with Hailman's [1982] "behavioral outputs," Lehner's [1979] "behavioral acts," and Grier's [1984] "acts"). For brevity and clarity, we use the nonspecific term "ethon" (akin to ethology and ethogram) in reference to both active and static behavioral units including all postures, reflexes, sensory acts, action patterns, and even complex social displays. Behavioral se-

quences such as a Foraging bout (composed of the ethons Peck, Probe, Swallow, etc.) are at a higher level of organizational complexity than the ethon and are herein called "activities." A performance bout for an activity consists of a series of performances of one or more ethons.

In naming and classifying ethons and activities, we employed the following conventions. Each was given a brief descriptive title, the first word of which was capitalized. These titles were hyphenated (e.g., Ruffle-shake) if consisting of more than one word, and titles for ethons (but not activities) were in bold face where they first appeared in the classification outline. In choosing ethon and activity titles, we preferentially used the earliest published term, if suitable. Some terms were chosen from the literature on cranes; a few were derived from behavior studies for other bird groups, and others were adapted from the general literature for animal behavior (especially Heymer 1977). Previously published terms were sometimes altered to fit our conventions for verb tense, capitalization, and hyphenation. In generating new terms, we sought brief, unambiguous titles (e.g., homonyms were avoided) that most precisely described the action.

In identifying individual ethons, considerable variability in complexity was allowed. The simplest ethons are reflexes and postures (e.g., Blink and Lie); the most complex are social displays (such as Arching and Warping, described by Masatomi [1983a]). At the other end of the complexity spectrum, some reflexes (e.g., iris dilation) are either so simple or so unlikely to be under voluntary control that we omitted them. It is often possible to detect the use of some sensory abilities (e.g., sight and hearing), hence their inclusion. For others (e.g., taste and smell), detection is difficult, so we omitted them from this paper.

Our division of the behavioral repertoire into social and nonsocial categories, while convenient and realistic for most ethons, is somewhat forced for a few. Surely the exaggerated Preflight-posture conveys a message to flock mates (Tacha 1984) in addition to aligning the bird for takeoff. Even more obvious, the cold weather contraction of the red, featherless cap (Crown-contraction) is included below with other nonsocial thermoregulatory ethons although the expansion of the cap (Crown-expansion), and even the existence of a highly pigmented bare cap, is associated with its role in social display. Finally, from this paper on nonsocial behavior, we exclude all vocalizations (viewing these as primarily social in nature) and all other ethons relating to both inter- and intraspecific social interactions (including parental and filial behavior) except where there is good evidence that these ethons are routinely performed solo.

Before moving into the compendium, a few other conventions must be mentioned. First, the term "adult," as used in the text, refers to fully grown, rather than sexually mature, birds. Second, except where we state that a certain ethon is known to be performed by one or a few species, we either know or believe that the ethon is performed by all species. Upon reading the paper, it will become obvious that, in contrast to social behavior which varies greatly from species to species, the nonsocial repertoire is much alike for all cranes. Finally, the descriptive ethology of the red-crowned crane by Masatomi and Kitagawa (1975), very important in influencing subsequent behavioral studies, is cited so frequently that we gave it a special abbreviation (MK) in the text that follows. Another paper by Masatomi (1983b) presents much of the behavioral repertoire of several species of cranes. Unfortunately it is available only in Japanese.

This paper is based heavily on our observations of all 15 species of cranes in captivity (ca 270 cranes of 2 species at the Patuxent Wildlife Research Center and ca 110 birds of 15 species at the International Crane Foundation) and, to a lesser extent, 14 species in the wild. Although we believe the behavioral repertoire presented below is nearly complete for the 9 or 10 better-studied species, additional field work with the less-studied species (hooded *Grus monacha*, wattled *Bugeranus carunculatus*, demoiselle *Anthropoides virgo*, black crowned *Balearica pavonina* and black-necked cranes *Grus nigricollis*) may result in the identification of a few more ethons.

Undue emphasis on the behavior of captive animals can be a disadvantage. Many ethons disappear, appear out of context, or appear distorted in captivity. Although this report depends heavily on observations of captive cranes, we believe this emphasis has worked to our advantage. For example, we describe 13 ethons for food gathering and food handling whereas previous field studies, hampered by long distance observations and screening vegetation, reported only a few (MK; Voss 1976; Tacha 1987). Similar lack of detail is characteristic of field-based descriptions of Preening and Bathing.

The benefits derived from closeup observation of captive birds are even more evident for social displays. Voss (1977), in a field season working with wild sandhill cranes, observed the Crouch agonistic display only once. By contrast, in a single hour walking through the sandhill crane colonies at the Patuxent Wildlife Research Center, it is possible to elicit Crouch from a score of birds. In the same amount of time, Crouch can be elicited from a half dozen species at the International Crane Foundation. A lifetime of field observations may yield fewer detailed observations of some complex social displays than a single season with our captive flocks. After elaborating on the usefulness of observations on captive birds, we must also state that the value of field studies to validate behavior observed in captivity is self-evident.

THE BEHAVIORAL REPERTOIRE OF CRANES

I. HATCHING: several motor patterns are likely involved in the Hatching activity. The ethon best studied is the **Surge-pip** (Johnson 1969, Surge-pip), wherein the chick convulsively surges against the shell while the musculus complexus of the dorsal surface of the neck either tilts the head back so the egg tooth pips and then cuts the shell or the musculus complexus holds the head in position so that respiratory and skeletal muscular convulsions break the shell (see Brooks and Garrett 1970; Hartman et al. 1987).

II. POSTURES

A. **Lie** (MK, Sit): the posture of an incubating adult with ankles and breast supported on the substrate (see Figure 1). Young birds sometimes Lie prone on one side with legs splayed. Nonincubating, healthy adults seldom Lie, and then, only with legs folded beneath the body.

Figure 1. Lie.

B. **Sit** (MK, Heel-standing; Voss 1976, Hock posture): like Lie, but the breast is lifted above the substrate and not supporting. The tarsus is roughly parallel to the substrate. The heel, and usually the feet, are supporting (see Figure 2).

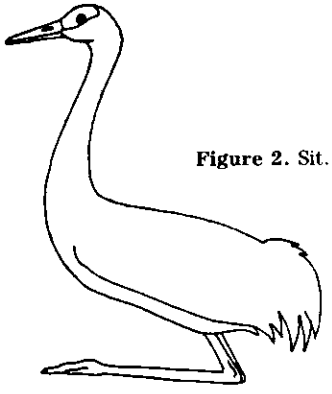

Figure 2. Sit.

C. **Stand** (MK, Stand or Bipedal Stand): both feet are supporting. African crowned cranes *Balearica* sp. routinely roost in trees (Walkinshaw 1964) and have toes capable of grasping limbs. The other 13 species of cranes typically stand only on the ground; perching in trees,however, has been observed once for a common crane *Grus grus* (Kitagawa and Archibald pers. obs.).

D. **One-leg-stand** (MK, Unipedal standing): one foot is supporting; the other foot is elevated (or at least nonsupporting) and often tucked out of sight in the feathers of the abdomen and breast. Most commonly seen in cold weather.

III. SLEEP-RELATED BEHAVIOR

A. **Head-droop-sleep** (MK, Down-sleeping): one or both eyelids are at least partially closed. Chicks often Sleep with head on substrate. Adults often doze with bill tip drooping downwards, sometimes touching the neck (see Figure 3).

B. **Head-tuck-sleep** (MK, Back-sleeping): Sleeping with the bill resting on or in the feathers of the dorsum.

C. **Head-tuck-watch** (MK, Sleep-like-resting): like Head-tuck-sleep, but with eyes open.

IV. SENSORY-RELATED BEHAVIOR: because of the difficulty of relating observable motor responses to sensory abilities for taste, smell, touch, and proprioception, we report none below. While the visual ethons listed below are normally associated with vision in air, underwater gazing has also been observed in the whooping crane *Grus americana*, is very important for the Siberian crane *Grus leucogeranus* which feeds heavily on submerged vegetation (Sauey 1975), and may be important for several other species. In the Siberian crane, underwater gazing is performed with the nictitating membrane covering the cornea (M. Nagendran, pers. comm.).

A. **Blink**: the rapid movement of the nictitating membrane as it flashes across the cornea, then quickly refolds along the anterior margin of the eye. Analogous to but not homologous with the mammalian blink wherein the upper and/or lower eyelids quickly close, then reopen. Blink lubricates the cornea and protects it from mechanical injury.

B. **Monocular-gaze** (MK, Gaze): sideways viewing with one eye dominant as evidenced by a unilateral cocking of the head (see Figure 4). May sometimes be confused with the cocking of the head associated with Listening.

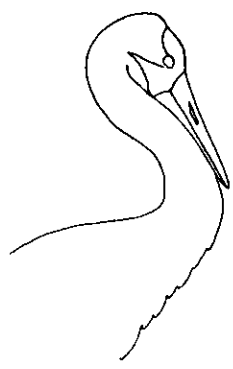

Figure 3. Head-droop-sleep.

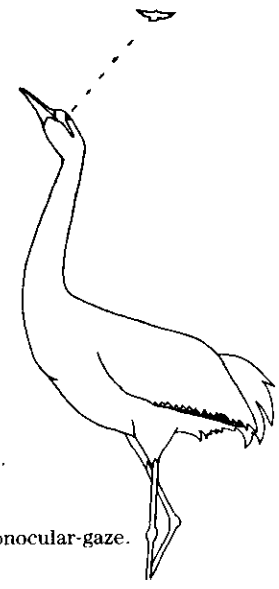

Figure 4. Monocular-gaze.

C. **Binocular-gaze** (MK, Gaze): forward viewing with both eyes.

D. **Listen**: other than a lateral cocking of the head (IV B) and obvious responses to sudden sounds, a crane does little to indicate that it is Listening.

V. MAINTENANCE BEHAVIOR

A. Care of the Body Surface: this category includes 17 action patterns and 4 activities (i.e., Preening, Oiling, Feather-painting, and Bathing).

1. **Crown-twitch**: a spasmodic front to back jerking of the exposed (naked) crown. Occasionally observed for sandhill, red-crowned, and whooping cranes, but may be present in others. Not yet reported for wattles or other bare areas. Performed in an apparent attempt to dispel insects.
2. **Bill-flick**: a quick left-right jerk of the bill sometimes performed in series or at intervals. Dislodges foreign matter from the bill.
3. **Head-rub** (Kruijt 1964, Head-rub): a slow to rapid rubbing of the inverted head (crown, face, or bill) on the dorsum or wing. Presumably serves to relieve itching, to dislodge debris, and to distribute uropygial oil (V 7).
4. **Fluff** (Voss 1976, Fluff): the elevation (erection) of the feathers of one zone or of the entire body (see also VI A).
5. **Sleek** (Voss 1976, Sleek): the smoothing (depression) of the feathers in one zone or over the entire body (see also VI B).
6. **Preen** (MK, Preen): an activity involving the following four ethons.
   a. **Dig-in** (Ellis 1979, Dig-in): as the bill is swept in a series of rapid, low-amplitude arcs, the tip of the bill is worked down through the feather layers toward some underlying spot which is then Nibbled.
   b. **Nibble** (Kruijt 1964, Nibble): rapid, low-amplitude, open-close bill movements while in contact with the plumage or integument.
   c. **Comb-out** (Kruijt 1964, Comb; Ellis 1979, Comb-out): nibbling a long feather from base to tip while slowly sweeping the bill in an arc.
   d. **Stroke** (Kruijt 1964, Combing or Stroking; Voss 1976, Back-Slicking): the bill is swept in broad side-to-side arcs, as for Bill-wipe (V A 11) and somewhat like Head-rub, but with the beak either on the feather surface or, very often, not actually contacting the plumage.
7. **Oil** (MK, Oiling): an activity involving Head-rub or Nibble of the uropygial tuft, and Bill-wipe, Preen, Head-rub, and Stroke to apply oil to feathers.
8. **Feather-paint** (Voss 1976, Feather painting): an activity that involves grasping mud or vegetation in the bill (Bite action pattern is used: VIII A 5) and wiping these on the plumage (Stroke V A 6d). Feather-painting is performed frequently by Siberian (Sauey 1985) and sandhill cranes (Drewien 1973), infrequently by common cranes (Libbert 1956) and hooded cranes, and is unknown for the other species.
9. **Scratch** (MK, Scratch; Heymer 1977, Direct-Scratch): the foot is flicked against the head or upper neck so that the nail or pad of usually the middle toe makes contact with and removes debris from feathers, skin, or bill (see Figure 5).

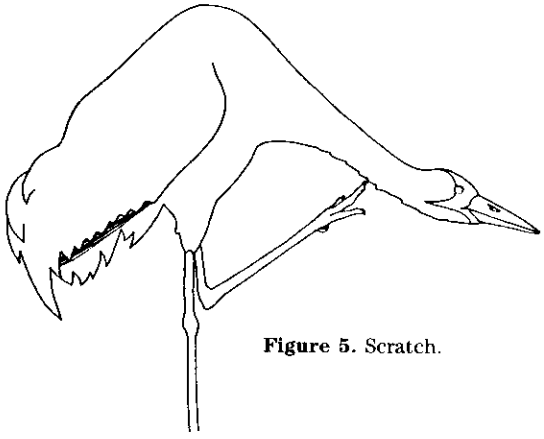

Figure 5. Scratch.

10. **Leg-flick** (MK, Leg-shaking): as the bird One-leg-stands, the tarsus and dorsal surface of the other foot slap one to several times upward and sometimes against the abdomen. The action sometimes dislodges debris (or snow) from the foot and is used to bed the foot in the feathers of the abdomen, especially in cold weather (see also V D 3).
11. **Bill-wipe** (Ellis 1979, Bill-wipe): the bill is cleaned by rubbing against vegetation or substrate.
12. **Bathe** (MK, Bathe): an activity involving the following action patterns and usually performed while Sitting or Standing in water.
   a. **Bill-slosh**: the side-to-side thrashing of the submerged bill.
   b. **Head-neck-dip**: the rapid plunging of the head and neck into and out of the water.
   c. **Wing-thrash**: the plunging of one or both wings into the water and violently thrashing the submerged wing(s).
   d. **Roll-slosh**: performed by rolling over briefly on the back and thrashing the wings. Seldom observed.
   e. **Belly-slosh**: the belly is thrust forward and upward rapidly through the water, then less rapidly returned to prethrust position. Performed in one or more brief series.

B. Comfort Movements: Shaking

1. **Head-shake** (MK, Head-shake and Head-neck-shake): the bill, extended until approximately parallel to the axis of the neck, is gyrated in a brief series of rapid cycles about the axis of the neck. Also appears in close association with 2, 3, and 4 below.

2. **Ruffle-shake** (MK, Body-wing-shake; Voss 1976, Ruffle): a vigorous churning of the body in rapid left-right cycles about the axis of the body (see Figure 6). During a performance, the loosely folded wings flop at the sides and usually the head is lowered. It often follows Fluff and, in captive birds, is frequently seen within a few seconds after a bird is released. This ethon is perhaps merely the full expression of Shiver-shaking and Wing-shaking.

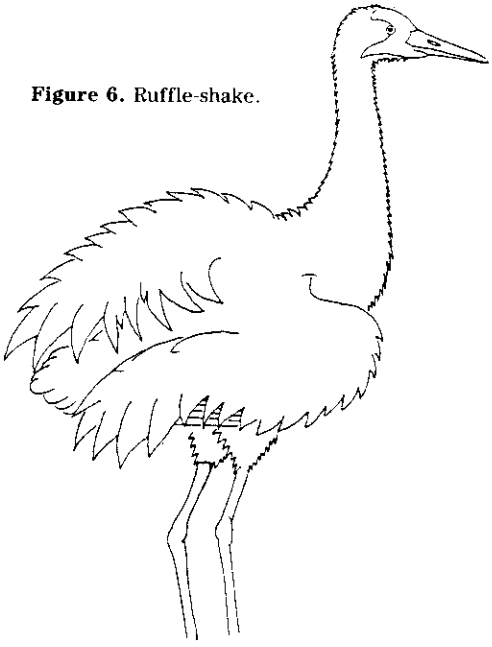

Figure 6. Ruffle-shake.

3. **Shiver-shake**: like Ruffle-shake but the frequency of the cycles is higher and the amplitude of the rotation is decreased.
4. **Wing-shake**: (MK, Wing-shake): like Ruffle-shake but performed more slowly and with little body rotation. The folded wings are violently and loosely flopped at the sides but, unlike Ruffle-shake, the wings are shaken simultaneously in symmetry not in left-right rotation.
5. **Tail-shake** (Ellis 1979, Tail-shake): a brief spasmodic rustling of the rectrices caused by the rapid quivering of the pygostyle.
6. **Tail-wag**: a brief side-to-side sweeping of the rectrices. A typical bout consists of several similar left-right cycles performed rapidly but more slowly than for Tail-shake. Much more frequently performed than Tail-shake.

C. Comfort Movements: Stretching

1. **Yawn** (MK, Yawn; Voss 1976, Jaw-stretch): the involuntary opening of the mouth, stretching of the mandibles wide apart and straining in the extended position. Often indistinguishable from Gape (VIII C 2).
2. **One-leg-stretch** (MK, Leg-stretch): probably an incomplete (partial) performance of Side-stretch. One leg is extended and stretched down and/or back.
3. **Side-stretch** (MK, Leg-stretch; Voss 1976, Wing-leg-stretch): the extension of the wing and leg of one side and lateral deflection of the tail beneath the extended wing followed by a brief straining interval (see Figure 7). Often performed by chicks while Lying, otherwise performed while One-leg-standing.

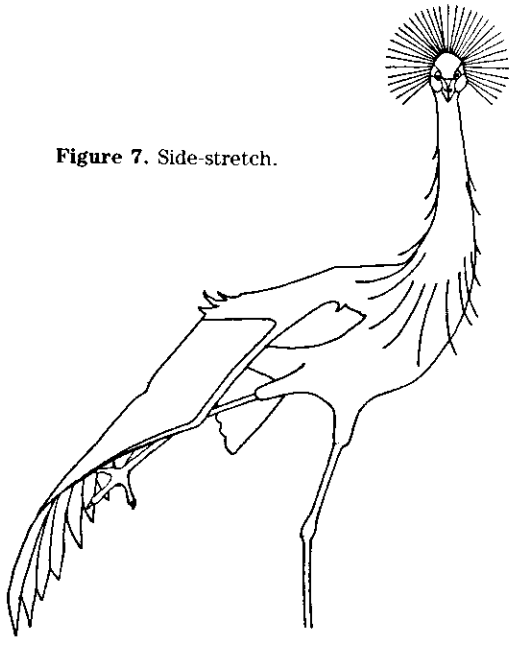

Figure 7. Side-stretch.

4. **Two-leg-stretch** (MK, Rump-raising): both legs are simultaneously extended downward (or in Lying chicks, backward), resulting in a lifting of the rump area. Seen mostly in Lying chicks.
5. **Two-wing-spread-stretch** (Voss 1976, Lateral-wing-stretch): both wings are maximally spread to the side and strained briefly.
6. **Bow-stretch**(MK, Wing-raising; Voss 1976, Bow-stretch): the body axis is depressed anteriorly as both folded wings are raised until nearly touching over the back (see Figure 8). The bird briefly strains.

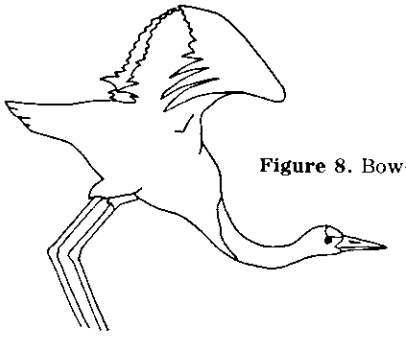

Figure 8. Bow-stretch.

D. Other Comfort Movements
   1. **Rise-flap** (MK, Wing-flap): the body axis is raised anteriorly and the crane performs several deep horizontal flaps (see Figure 9).

Figure 9. Rise-flap.

   2. **Wing-fold:** the drooping (or extended) wing is quickly lifted to its folded position at body side. Occasionally seen in all individuals, but performed more frequently by fatigued chicks.
   3. **Leg-flick**: this action pattern, described in V A 10, appears in three related contexts: as a means of removing snow or debris from the foot, as a precursor to One-leg-stand, and probably also as a comfort movement.

VI. THERMOREGULATORY AND RESPIRATORY: in addition to the ethons described below, this category includes cold weather performances of Leg-flick, One-leg-stand and Leg-tuck Flight (VII C 1).
   A. **Fluff** (Voss 1976, Fluff): birds control the amount of heat loss or gain by adjusting the degree of erection of the contour feathers. Fluff is the elevation of the feathers as when Preening or when cold. See also V A 4.
   B. **Sleek** (Voss 1976, Sleek): compression of the plumage aids in radiative heat loss by decreasing the insulation capacity of the plumage. Performed by moderately overheated cranes. See also V A 5.
   C. **Ruffle**: hyperelevation of the feathers, performed by an extremely overheated crane and typically accompanied by Panting. Allows for convective heat loss by exposing underlying skin areas.
   D. **Pant** (MK, Pant): rapid breathing with bill at least slightly agape. Allows for evaporative heat loss from the buccal cavity and other moist surfaces of the respiratory system.
   E. **Cough**: a spasmodic exhalation with bill agape resulting in a brief barking or honking sound.
   F. **Sneeze**: like Cough, but bill is closed or nearly so and the resulting sound is quieter. Exhalation is partially nasal.
   G. **Shiver**: a high frequency, low amplitude trembling of the body associated with heat loss and perhaps fear and/or anger.
   H. **Crown-contraction/Crown-expansion** (Voss 1977, Red-crown-expansion): species with featherless areas on the head and neck, expanded for social display, contract these zones in very cold weather presumably to minimize heat loss (see Figures 10, 11). This expansion and contraction is at least partially under voluntary control and is mediated by subcutaneous muscles. For some species, this ethon is more appropriately entitled **Wattle-contraction** or, in general, **Bare-skin-contraction.**

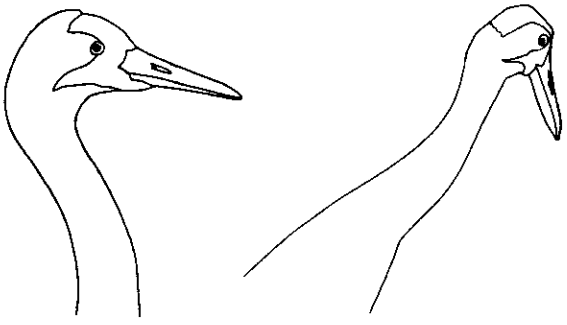

Figure 10. Crown-contraction. **Figure 11.** Crown-expansion.

   I. **Crest-flare**: some degree of crest or crown flaring is possible in African crowned cranes. Observations of captive birds suggest that the flared crown is sometimes used to shade the drooped head. Further observations are needed to clarify this association.
   J. **Neck-sun** (MK, Neck-sunning): an inactive bird orients its head and/or neck to maximize insolation.
   K. **Wing-spread-droop** (MK, Wing-spread-sunning): like Neck-sun, but performed with neck retracted and one or both wings drooped, often contacting the substrate, especially if the bird is Sitting.
   L. **Wing-spread-hold**: both wings are widely spread and oriented to allow insolation. Particularly common in African crowned cranes (see also VII B 1).
   M. **Urohidrosis**: a form of Defecation (see VIII C 4) wherein the crane ejects excrement onto the scaled portions of its legs. Presumably promotes cooling through evaporation as hypothesized for storks Ciconiidae and New World vultures Cathartidae (Rea 1983). Performed occasionally by red-crowned and whooping cranes and perhaps others.

VII. LOCOMOTORY

A. Ambulatory

1. **Waddle**: the bird in Sit posture moves forward or backward by shuffling its tarsi across the substrate. Rarely observed; occasionally seen in chicks or incubating adults.
2. **Walk** (MK, Walking): alternate stepping while in Stand posture. Unlike Running, performed slowly and with at least one foot on the substrate at all times. An exaggerated "high-stepping," performed when traversing unstable ground or while in deep water (Pukinsky and Ilyinski 1977), appears similar to the gait used by sandhill cranes and perhaps other species while approaching the nest.
3. **Run** (MK, Running): like Walking but step length is greater and both feet are sometimes off the substrate. Flapping usually accompanies Running, especially in adults. One form, a rhythmic canter performed with the wings mostly closed, is often seen in large chicks.
4. **Hop**: cranes normally proceed by Walking rather than by Hopping, a form of locomotion common to many small passerines. Occasionally, injured cranes or birds in One-leg-stand in very cold weather will, even in the wild, move short distances by a unipedal skipping action.
5. **Leap**: accompanied by Flapping, cranes often jump vertically when Dancing or fighting, or Leap may be performed solo. Similar to Spring-up (VII B 4) and sometimes signals intention to Fly (Tacha 1984).

B. Transitional Action Patterns (those following, preceeding or signaling intention to Fly): see also Tacha (1984).

1. **Wing-spread-hold**: most often seen for adults in association with the Dance, as a component of Attack, before or after Rise-flap (V D 1), and as a flight intention movement. The wings are spread and held open (see also VI L).
2. **Preflight-posture** (Tacha 1984, Neck-stretch and Neck-stretch-wings-spread): the head is elevated, and the bill is held horizontal or slightly depressed at the tip (see Figure 12). The neck is arched slightly and extended maximally forward. Most often, the wings are held closed or slightly spread. Sometimes they are mostly spread (Tacha 1984). Usually precedes Flight. Two versions are present in the whooping crane: the feathers of the neck base are either Fluffed or Sleeked. The fluffed version likely signals fear or avoidance.
3. **Run-flap** (MK, Dashing and Take-off; Tacha 1984, Neck-stretch-wings-spread-run): Cranes launch by two methods: either they Run while Flapping until they lift off (see Figure 13), or they Spring-up (VII B 4).

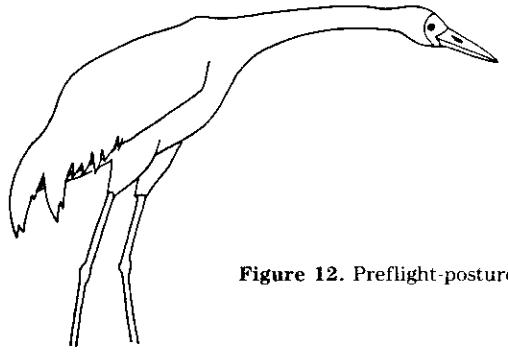

Figure 12. Preflight-posture.

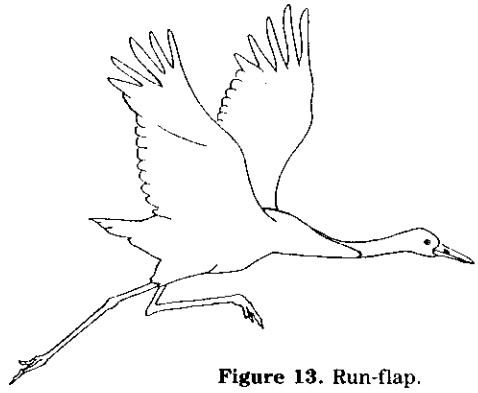

Figure 13. Run-flap.

4. **Spring-up**: launching directly into flight without a preliminary Run-flap performance (see Figure 14). Spring-up is used under extremely alarming conditions, as in response to an attack by a nearby predator.

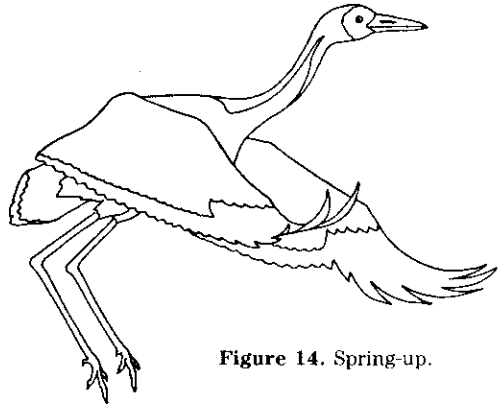

Figure 14. Spring-up.

5. **Alight** (MK, Landing): like the Parachute component of Flight (VII C 3), the legs dangle, the leading edges of the wings are turned upward to affect a stall, and the bird floats downward and forward (see Figure 15).

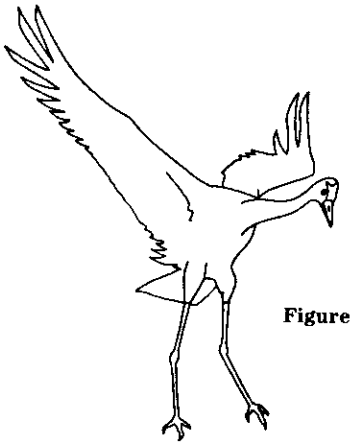

Figure 15. Alight.

C. Flight. an activity consisting of at least the following three ethons.
   1. **Flap** (MK, Flap): crane Flight, except during the launch, is facilitated by rather shallow Flaps. In Flapping Flight the legs trail behind, except in extremely cold weather when both legs are sometimes tucked out of sight in the feathers of the breast and abdomen (Walkinshaw 1953; Nesbitt 1978). Leg-tuck Flight has been observed for four species, but is probably present in all fifteen.
   2. **Soar** and **Glide** (MK, Soar and Glide): Gliding and Soaring are perhaps most important on migration when great distances are traversed, but cranes routinely Glide for short distances and brolgas *Grus rubicunda* often Soar at midday, presumably to escape the heat of northern Australia (Archibald and Swengel 1987). While these two action patterns are morphologically much alike or identical, they are functionally somewhat different: Soar is used to rise on an updraft or thermal whereas Gliding is used for straight-line travel. Under the right conditions, most, but perhaps not all, species soar (Johnsgard 1983).
   3. **Parachute** (MK, Downward-gliding): grading into Alight (VII B 5), this variation differs from normal Flight in that the legs dangle to some degree and, when fully performed, the wings are rotated downward posteriorly to promote stalling, and the neck is partially retracted (see Figure 16).

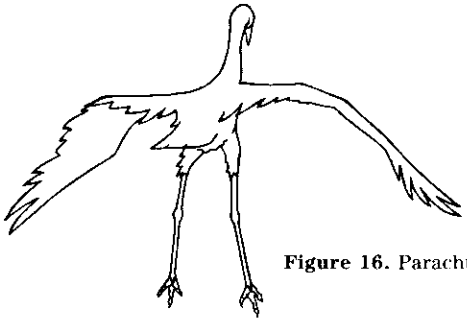

Figure 16. Parachute.

D. **Swim** (MK, Swimming): consists of floating and leg paddling, and is most often performed by chicks, although adults are fully capable of Swimming.

VIII. INGESTION, EGESTION, AND EXCRETION (food-related activities and action patterns): Tacha (1987) divided ingestion-related activities into three classes: Gleaning, Probing, and Drinking. Most of the food-related action patterns listed below have not been described previously in the literature on crane behavior. Scratching of the substrate, although reported for the sandhill crane (Guthery 1972 *in* Voss 1976), is believed to be unimportant or absent.

A. Foraging: an activity class that includes the food-gathering and food-handling action patterns listed below and other activities such as Walking in search of food and Binocular-gazing.
   1. **Stab**: a high-amplitude, forceful bill thrust directed toward a large food item or other object. The motor pattern is probably equivalent to Probing the substrate. A variation of Stab is performed by black-necked and Siberian cranes foraging for submerged animals in turbid water. They repeatedly plunge the head and bill into the water and contact prey somewhat by chance.
   2. **Probe** (Tacha 1987, Probe): like Stab, but the blow is directed at the substrate.
   3. **Peck**: a low-amplitude and low-energy bill thrust often terminated by the grasping of an object.
   4. **Nibble**: as for the Nibble component of Preen (V A 6 b), the bill performs rapid, low-amplitude, open-close movements while in contact with an object.
   5. **Bite**: grading into Nibble, but with greater amplitude of head movement and intensity of grasping. In addition, the grasping action is usually performed only once for Bite rather than in rapid series as for Nibble. Some head twisting may accompany the Bite.
   6. **Tug**: bite accompanied by a neck retraction (pulling) motion.
   7. **Thrash**: an object is grasped firmly in the bill (Bite), then shaken violently with rapid side-to-side and, to a lesser degree, long-axis rotational movements. Cranes often Thrash larger food items in water, but sometimes do so on dry ground.
   8. **Bash**: a firmly grasped (Bitten) object is slapped (usually repeatedly) against the ground or a solid object.
   9. **Bill-flick**: as illustrated by Tacha (1987), cranes flick soil and other debris out of a shallow pit excavated by their Probing activities. During the Bill-flick, the head is rotated quickly about the axis of the neck so that the bill tip is swept to one side in a

shallow arc, then quickly returned to its vertical orientation.

10. **Bill-side-push**: when Foraging, vegetation and soil are moved from the target area not only by the Bill-flick, but also by a forceful lateral push by the bill against the vegetation or the wall of the excavated pit.
11. **Bill-push-open**: the third action pattern serving to expose the probe site. The mandibles are forcefully pushed open while the bill is deep in the feeding pit.
12. **Bill-wipe**: treated also under Care of the Body Surface (V A 11). While foraging, cranes wipe debris from the bill by rubbing on vegetation or substrate. Sometimes observed in close association with foraging bouts.
13. **Stomp**: crowned cranes flush insects by slapping a foot against the ground or vegetation (Pomeroy 1980).

B. Swallowing: whether eating or Drinking, all variations of the Swallowing action patterns, described below, include in-out tongue movements and up-down throat movements.

1. **Nibble-swallow**: with the bill pointing downward (usually), a small food item (or some other object) is moved toward the pharynx by Nibbling movements (VIII A 4).
2. **Toss-swallow** (MK, Eat): larger food items are moved into the pharynx by a jabbing movement of the head coordinated with grasping and releasing movements of the bill resulting in the object moving approximately 2 cm up the bill with each toss cycle. In the wild, Toss-swallow is routinely used to move solid objects, but captive whooping cranes sometimes drink from a watering cup by tossing water.
3. **Drink or Scoop-swallow** (MK, Drink): cranes typically Drink by scooping water into the bill, then lifting the head and opening and closing the bill in rapid cycles.
4. **Neck-pump**: objects not moving easily in the upper esophagus are forced up or down by a pumping or craning of the neck accompanied by Swallowing movements.

C. Egestion and Excretion

1. **Bill-shake**: the bill, while held approximately perpendicular to the axis of the neck, is swept in a series of rapid, high-amplitude, left-right arcs. Expels objects and fluids from the pharynx, nares, and bill. Often performed with bill open and often accompanied by Coughing and Sneezing (VI E, F).
2. **Gape**: voluntary opening of the mouth to the full extent. Empirically, much like Yawn (V C 1) but without the straining component common to stretching ethons. Serves to move objects in the pharyngeal region.
3. **Vomit**: fluids and solid objects are expelled from the bill in part by Gaping, Bill-shaking and Neck-pumping motions. Also important, however, are the not readily visible contractions of the upper digestive tract and the abdominal muscles forcing food (and other material) up the esophagus. Vomit, a reflex probably only partially under voluntary control, is somewhat different from Regurgitate, a type of parental feeding behavior common in many bird taxa but not cranes.
4. **Defecate**: feces are expelled vertically downward in a fluid jet, sometimes following a slight squatting motion (posterior movement of the body and/or elevation of the rump). See also Urohidrosis (VI M).

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SAMPLING METHODS FOR AERIAL CENSUSES OF NESTING FLORIDA SANDHILL CRANES IN CENTRAL FLORIDA

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ABSTRACT

Florida sandhill crane *Grus canadensis pratensis* nests on the Webb Wildlife Management Area in central Florida were aerially surveyed from mid-January through mid-May during 1986, as part of an evaluation of potential release sites for a third flock of whooping cranes *G. americana*. A systematic (versus random) aerial sampling design was developed that used fixed-strip transects. A Loran C (Long Range Navigation) receiver enabled us to repeat transects between flights. By combining the data from unique nest sightings over the 10 nest surveys, the 1986 breeding population was estimated at 211 ± 62 breeding pairs for the 405 km^2 study area. The advantages of systematic transects are discussed in relation to the problems involved in aerial censuses.

INTRODUCTION

Aerial surveys using either photography or trained observers can be an effective method of censusing crane populations. When a species or its nest is large or conspicuous, and the census area is large and not readily accessible by ground, aerial surveys may be the only practical means to obtain the necessary data. While a total count of a crane population using aerial techniques may be a desired objective, it can be difficult and expensive to achieve because total counts require good maps, complete coverage of the census area, and an assurance that all animals are counted (Norton-Griffiths 1975).

A preferred and less expensive alternative to a total population count is aerial sampling. There are three basic aerial sampling methods: transect, quadrat, and block. Transect sampling, counting animals while flying in a straight line from one side of the sampling unit to the other, is the most popular method and offers several advantages. It is cost effective, physically comfortable for the observer, and easy to navigate and orient. With respect to statistical analyses, transects produce a lower variance and sampling error than blocks or quadrats. This is because transects tend to reduce the effect of animals clumping together (Norton-Griffiths 1975).

From 1984-1986 the University of Florida Department of Wildlife and Range Sciences conducted aerial transect surveys for nesting Florida sandhill cranes in central Florida. The Florida sandhill crane is a nonmigratory subspecies that occurs from Okeefenokee Swamp in southeast Georgia south to the Florida Everglades in southeastern U.S.A. In central Florida, this subspecies has a long nesting season, extending from January through the end of May.

The nest surveys were part of a larger study designed to evaluate three Florida sites proposed for whooping crane reintroduction (see Bishop and Collopy 1987). The objectives of the nest surveys were to: (1) map the seasonal distribution of nesting pairs and (2) estimate the density of the Florida sandhill crane breeding population on the three sites and their surrounding areas. This paper reviews the aerial methodology and data analyses used for nesting surveys during 1985 and 1986. Results for the 1986 breeding season on one of the proposed sites, the Webb Wildlife Management Area, are presented.

STUDY AREA

The Webb Wildlife Management Area (WMA) consists of 26,454 ha in Charlotte County, Florida. The study area included not only the potential whooping crane release site, but also surrounding private lands, primarily along the southern and eastern borders. For 1986, the study area comprised 405 km^2.

The Webb WMA has flat topography and is characterized by poorly drained, sandy soils with an underlying clay hardpan. Dominant vegetation cover consists of two similar types: broad saw palmetto *Serenoa repens* prairies (44%) and pine flatwoods (28%), characterized by South Florida

slash pine *Pinus elliottii* and an understory of saw palmetto and wiregrass *Aristida* spp.. Freshwater marshes, wet prairies, and intermittent ponds comprise 21% of the land area and are scattered throughout the management area (Florida Department of Transportation 1978). Cattle grazing is permitted on all but 3,100 ha of the Webb WMA. Cattle ranching and timber are the major land uses on large private tracts that adjoin the Webb WMA to the east. Portions of the north, south, and west sides of the Webb are settled with housing developments.

Annual rainfall on the Webb WMA averages approximately 126 cm, and is unevenly distributed through the year. Over 70% of the rainfall occurs during the wet season from May to October.

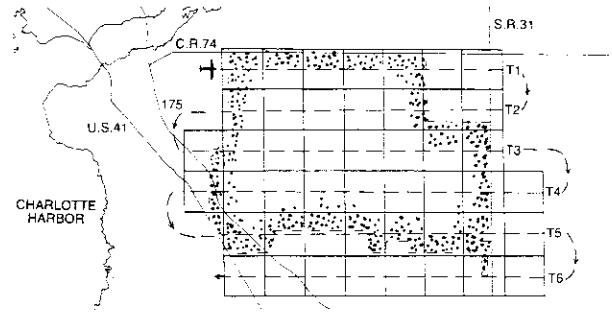

Figure 1. Layout of a systematic aerial fixed-strip transect survey using 3 km × 3 km grid mapping on the Webb Wildlife Management Area, Florida. Boundaries of Management Area are shaded.

DATA COLLECTION

Aerial sampling for Florida sandhill crane nests was considered the most accurate and efficient means of estimating the size of the local breeding population due to the large size of the study area, the heterogeneous terrain, and the long breeding season. For 1986, bi-weekly aerial surveys began 15 January and ended on 8 May.

We used systematic aerial fixed-strip transects during our aerial surveys. Compared to random sampling, systematic sampling is the most efficient means of mapping the distribution of animals, and for comparisons over time of numbers observed on a specific site. Systematic sampling also avoids the navigational problems associated with random transect sampling (Caughley 1977). When our study began, systematic aerial fixed-strip transect sampling was already being used successfully in the Florida Everglades National Park (South Florida Research Center 1985) to estimate wading bird populations and their spatial distributions.

With systematic aerial transect sampling, predetermined and consistently-spaced parallel transects are flown across the study area. Initially, a grid system is established, then flight lines are spaced to bisect each row of grid squares (Figure 1). For our study, a 3 km × 3 km grid system was drawn on the study map. Six east-west flight lines were determined for a total of 135 km. Transect lengths ranged from 20.1-25.4 km. Our transect boundaries usually were landmarks such as powerlines, roads, or lakes.

The survey plane was a four-seat, high-winged, single-engine Cessna 172 Skyhawk. A high-wing aircraft was required to assure an unobstructed downward view and to define our transect strip. Our plane was equipped with an Apollo I Loran C receiver manufactured by II Morrow, Inc., Salem, Oregon. The Loran C is a radio navigation system consisting of a chain of 3 - 5 fixed land-based stations transmitting in the low frequency band of 100 KHz. Each station transmits synchronized pulses at precise time intervals. The Loran C receiver tracks the transmitting stations and converts their signals to the user's actual geographic position (II Morrow Inc. 1983).

In addition to providing present position coordinates, the Loran C receiver can be programmed with starting and ending latitude and longitude points for each transect. The transect can be repeated accurately by means of the Loran C receiver's panel-mounted course deviation indicator. Depending on the model, however, the Loran C receiver may need to be calibrated at a known point before beginning each survey to assure accurate repetition of transects.

The Loran C receiver continuously displays the plane's current position either as latitude and longitude coordinates, or as the nautical distance to the desired destination. We recorded the Loran C location of each nest along with a quick hand-drawn picture of the wetland's shape. For our study, we found that nautical distance was faster and less confusing to read and record than the current longitude. After each flight we were able to pinpoint the nest using a combination of 1:24,000 Mark Hurd aerial photograph maps and United States Geological Survey topographic maps.

For each survey, our starting point was chosen randomly from one of the four study area corners. We selected 91 m and 145 km/hr as the optimum plane height and speed for spotting nests and for aircraft safety. Each of two observers, one in the front with the pilot and the other in the back seat directly behind the pilot, recorded all active nests detected within a 200 m interval. Thus, 13% of the total study area was sampled during each survey. The 200 m fixed-strip width for each observer was established by maintaining a constant plane height and defining each observer's visual boundaries. Each observer's strip width was defined by that area viewed between two streamers attached to the wing struts and marks on the windows. The exact position of the streamers and window marks were calculated using a method outlined by Pennycuick and Western (1972).

Florida sandhill cranes in central Florida generally build their nests with emergent vegetation in relatively small, shallow wetlands less than 1 m deep (Walkinshaw 1981; this study). Nests on dry land are rare and have been reported on only a few occasions during this century. Although sandhill cranes are difficult to observe from fixed-wing aircraft because of their cryptic coloration, their nests usually are large and conspicuous. Because the cranes often build more than one nest initially, we counted a nest only if: (1) a crane was on it, (2) an egg was visible, but

there was no crane present, or (3) adult cranes and chicks were on the nest.

DATA ANALYSIS

In order to estimate the breeding population we used a ratio-estimation method for unequal length transects. This method was popularized by Jolly (1969) and is referred to as the Jolly II method.

The density of breeding pairs/km^2, for each survey was estimated using the following formula:

$$\hat{R} = \frac{\Sigma y}{\Sigma z}$$

where y is the number of nests counted in the transect, and z is the area (transect length multiplied by total strip width) of a sample transect.

The estimated population size for each survey is:

$$\hat{Y} = \hat{R} \times Z$$

where Y is the estimated breeding population, Z is the total area of the census zone, and R is the estimated density.

The sample error of Y, SE (Y), is estimated as $\sqrt{\mathrm{var}(\hat{Y})}$ where

$$\mathrm{var}(\hat{Y}) = (N(N-n)/n)\,(S_y^2 - (2 \times \hat{R} \times S_{zy}) + (\hat{R}^2 \times S_z^2)$$

In this formula, N is the number of potential transects (the number of transects flown divided by the proportion of the area covered, 0.133 for our surveys), n is the number of transects in the sample, S_y^2 is the variance in number of nests counted in the transects, S_{zy} is the covariance between the nests counted and the area per transect, and S_z^2 is the variance between the areas of all the sample transects.

The 95% confidence interval (C.I.) of $\hat{Y}$ is:

$$\text{C.I.} = \pm\, t \times SE(\hat{Y})$$

where t is for n-1 degrees of freedom, and $SE(\hat{Y}) = \mathrm{Var}(\hat{Y})$.

In order to estimate the breeding population for the entire season, only unique nests (no repeat sightings) were totaled for each transect for all flights combined. Density, total breeding pairs, and sample error were calculated using the above formulas. Final estimations were then adjusted downward to account for renesting. We used a 35% adjustment figure based on a recent study of incidence of renesting in Florida sandhill cranes (Nesbitt, pers. comm.).

All our analyses were calculated quickly and efficiently on a microcomputer using a LOTUS© 1-2-3 spreadsheet program. The formulas used can be obtained by writing the senior author c/o the International Crane Foundation.

RESULTS and DISCUSSION

In 1986, 38 unique nests were observed on transects during 10 aerial surveys conducted between January and May. The distribution of the nests indicated a very low use of areas along the south and southeast portions of the study area (Figure 2). Our southernmost transect was on private

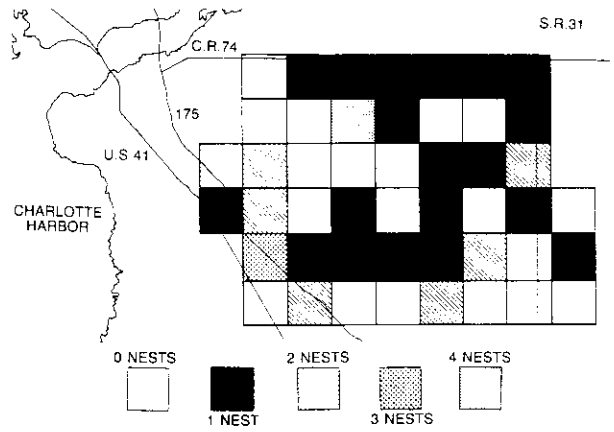

Figure 2. Spatial distribution of Florida sandhill crane nests by 3 km × 3 km grid cells observed during 10 systematic aerial transect surveys on the Webb Wildlife Management Area, Florida, January-May, 1986. No repeat sightings were included.

lands which included few large, undeveloped parcels with suitable nesting habitat.

For the 1986 breeding season, the adjusted density and total population estimates for the season are 0.52 breeding pairs/km^2 and 211 ±62 breeding pairs, respectively, for the 405 km^2 study area. We are confident that this is a reasonable estimate of the breeding population for this area given the water conditions in 1986.

When a 1986 breeding population estimate is calculated for each observer, the front seat observer's estimate was 222 ± 54, and the back seat observer's 200 ± 119. While the estimated means are not far apart, the back seat observer's variance is over four times that of the front seat observer's. This larger variance may indicate a back seat disadvantage both for viewing and for passenger comfort.

Estimated densities ranged from 0.04-0.20 breeding pairs/km^2 per flight. The corresponding estimated total breeding population ranged from 15 ± 24 to 83 ± 71 per flight (Figure 3). Peak nesting occurred on 12 March, approximately the same time (9 March) as during the 1984 nesting season (Bishop and Collopy 1987). The low numbers of nests counted in transects, and the high variability between transects for each survey and over the whole season may make the assumption of normality inappropriate. For 8 of the 10 flights, the 98% confidence intervals for our population estimate contained negative numbers, when in reality the lowest possible value can only be zero. A statistical theory correction could be made by increasing the number of transects or increasing the number of nests sighted.

Transect repeatability, as measured by nest resightings, was 29% (n = 11) for the season. Of the 11 nests resighted 6 were resighted the following survey (11-14 days later), 3 were resighted 2 surveys (27-28 days) later, 1 nest was resighted 3 surveys (42 days later) and another resighted 4 surveys (59 days) later. We believe that transect repeatability could have been improved significantly if: (1)

there had been a navigator to keep the pilot on course and to monitor plane height, (2) we had not had to use multiple pilots (4 pilots during 10 flights), and (3) the Loran C receiver had been the same model throughout all surveys.

On 30 January, a four-seat Jet Ranger 206-BIII helicopter was used to test how flight speed effects nest detectability. Transects flown the previous day in a fixed-wing aircraft were repeated by helicopter using the same methods described above, except that the speed was maintained at approximately 120 km/hr. The estimated total number of breeding pairs and the confidence intervals were calculated using the same analyses as for the fixed-wing aircraft surveys.

Eight nests were seen from the helicopter, as compared with two nests seen from the fixed-wing aircraft the previous day. Only one of the two nests from the previous day was relocated, and it was empty. The large difference between the two surveys can in part be explained by problems with transect repeatability. The aircraft were equipped with different models of Loran C receivers. The Apollo I Loran C receiver, used in our fixed-wing aircraft, calculates latitude to 0.01 minutes (20 m). The helicopter we used contained a Arnav R-20 Loran C receiver (manufactured by Arnav Systems, Portland, Oregon) that calculates latitudes within 0.10 minutes (200 m) and could not be recalibrated for our known fixed spot, forcing us to readjust all of our flight line latitudes. In addition, the 200 m strip width seen from the helicopter was not at the same angle as that set for the observers in the fixed-wing aircraft.

Two transects flown during the helicopter survey had been purposely altered from the previous day: flight latitude over one transect was changed due to logistical problems with television towers, and the other transect had been extended. Five of the eight nests observed from the helicopter were on these two transects.

The results of our helicopter survey on the Webb WMA suggest an advantage in nest detectability using helicopters. In this instance, there was a large difference in population estimates between the fixed-wing and helicopter survey (Figure 3). Three similar helicopter surveys on our other two study areas, however, did not yield results that were consistent with those obtained on the Webb WMA. On one study area no nests were observed from the helicopter whereas the previous day two nests had been observed with the fixed-wing aircraft (unpublished data, this study). While helicopter surveys may increase the numbers of nests observed, the higher costs associated with helicopter surveys, as much as 2.5-4x the cost of a fixed-wing survey, may be prohibitive.

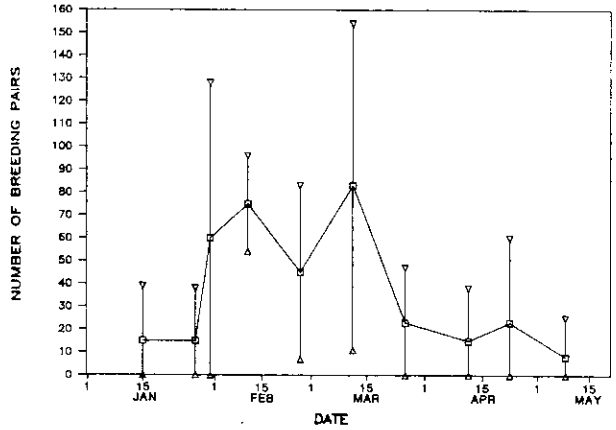

Figure 3. Estimated population of breeding pairs ± 95% confidence intervals, by flight for Webb Wildlife Management Area, Florida, January-May, 1986.

CONCLUSIONS

Systematic aerial transect sampling is an excellent sampling method to use when cranes or their nests are easily detected, habitat is relatively flat and heterogeneous, and a precise population count is not essential. When compared with other methods to estimate populations, systematic aerial transect sampling methodology has several advantages:

1. A large area can be covered quickly and efficiently. It can be an excellent method for a large-scale, ecosystem study.

2. The method gives a good indication of nesting over time; it reveals both the distribution and the spatial patterns of nests.

3. It requires minimum manpower; observers and pilots, however, should be well trained.

4. With proper control over the variables such as plane height, flight line, and Loran C receiver calibration, transects can be repeated accurately.

5. Loran C receivers are relatively inexpensive (US $750-$8,000).
   a. The system is available worldwide including the United States, parts of Japan, the Mediterranean, North Sea regions, the Arabian Peninsula, U.S.S.R. and, more recently, parts of the People's Republic of China.
   b. The Loran C receiver allows you to pinpoint a nest and later visit the nest on the ground.

Disadvantages of systematic aerial transect sampling include:

1. Population estimates may be accurate but not precise.

2. It is difficult to control the transect repeatability. Ideally, there should be a navigator, a skilled pilot, and several trained observers that can work well as a team.

3. There is a potential for a counting bias due to detectability problems. This bias can be difficult to measure.

4. Pilot error such as banking or flying at incorrect heights will effect the strip width.

5. The conductivity of the Loran C signals, and the accuracy of the Loran C receiver can be affected by certain terrains, adverse weather conditions, time of day, and proximity to Loran C transmitting towers.

ACKNOWLEDGMENTS

We especially thank the principal pilot, Paul Eddy, and our second observer, Mark Franklin, for flying the nest surveys. Personnel at the Webb Wildlife Management Area have been helpful throughout the project. This study was supported by the University of Florida's School of Forest Resources and Conservation, the Florida Game and Fresh Water Fish Commission, National Audubon Society, U.S. Fish and Wildlife Service, Cooperative Fish and Wildlife Research Unit, the Henry and Kathryn Mills Charity Foundation, and the Florida Chapter of the Sierra Club. The senior author thanks the International Crane Foundation, the International Programs in the Institute for Food and Agricultural Science and the Graduate School, University of Florida for travel grants to attend this conference.

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ROCKET-NETTING GREATER SANDHILL CRANES ON THEIR BREEDING GROUNDS AT SENEY NATIONAL WILDLIFE REFUGE

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ABSTRACT

During April and August-October, 1984-86, 175 greater sandhill cranes *Grus canadensis tabida* were captured by rocket-netting on their breeding grounds at Seney National Wildlife Refuge, Michigan. Most capture attempts were made on drawn down pools or in upland fields. Bait was ear corn or shelled corn placed 3.5 m in front of each folded 15-17 x 10-12-m net. An upward rocket angle of 27° safely minimized escape. Most netting sites were selected so that they could be checked from a vehicle 200-900 m away. Rockets were detonated from blinds constructed of conifer branches and live trees positioned on island or upland ridges 50-175 m from each net. Most efficient use of time and manpower was achieved by entering the blind from the back side of the ridge, out of view of birds on the netting site, after cranes were seen near the bait pile. With few exceptions, rockets were detonated only when all birds had heads down and were standing no closer than 2.5 m in front of the net. Normally each net firing was directed at a small number of birds (two to five). Mean capture rate was 2.9 cranes per shot (N = 65 shots). These procedures resulted in a low casualty rate; observed condition of birds at release and subsequent resightings revealed that one bird died and another sustained a serious wing injury. Both casualties could have been avoided with technique or equipment modifications. Bait piles were frequently revisited by previously captured birds. Limited spring netting suggested no adverse effects on nesting behavior. The major problem associated with the technique was consumption of bait by Canada geese *Branta canadensis*.

INTRODUCTION

Previous efforts to capture migratory sandhill cranes have been made primarily on migration stopover or wintering areas and usually were directed at large numbers of birds (Wheeler and Lewis 1972, Ramakka 1979, Tacha et al. 1981, Williams 1981). We have concentrated on capturing individual adult pairs, especially those with fledged young, on their breeding grounds at Seney National Wildlife Refuge (hereafter called Seney) in the Upper Peninsula of Michigan. We have determined nest locations, movements, territory size, and breeding success of individual pairs, and have charted the migration route, including stops and wintering areas. Individual color-marking and radio-tagging of the cranes on Seney have been essential to satisfying these objectives, and rocket-netting has been the only effective technique for capturing these adults and fledged young.

STUDY AREA

All capture attempts were made on Seney (38,630 ha), which consists of about 65% wetlands, mainly sedge *Carex* spp. and cattail *Typha latifolia* marshes and sphagnum *Sphagnum* spp. bogs, and 35% uplands dominated by red pines *Pinus resinosa*, jack pine *P. banksiana*, aspen *Populus tremuloides*, and northern hardwoods. More than 2,800 ha of open water are contained in 26 major pools, 21 of which have water control structures. Several pools were normally drawn down during summer and provided the primary rocket-net sites. The refuge also contains several isolated upland meadows that were good capture sites. During August 1984 to October 1986, rocket-netting was attempted on 33 different sites in 24 general areas (Figure 1).

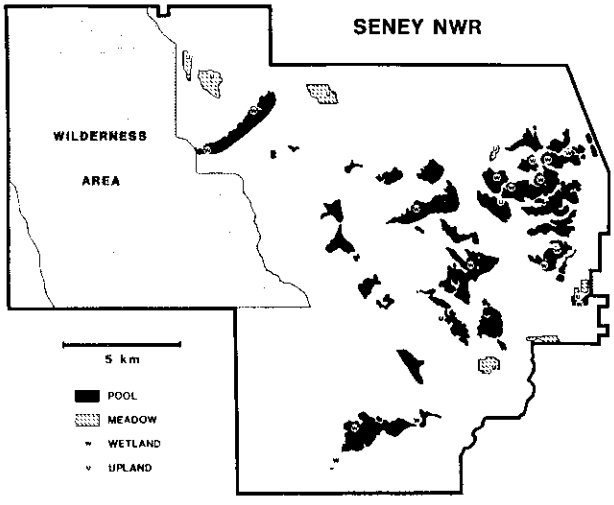

Figure 1. General areas of Seney NWR where sandhill cranes were rocket-netted, 1984-86.

METHODS AND MATERIALS

One to seven rocket nets were operated concurrently during 24 August to 30 September 1984, 16 April to 10 May 1985, 1 August to 11 October 1985, 14 to 28 April 1986, and 1 August to 8 October 1986. During 1984 we caught cranes opportunistically, but during 1985-86 our priorities, in order of importance, were to capture and color-mark (1) successful parents (i.e., adult pairs with fledged chicks), (2) adult pairs without chicks, and (3) subadults. Normally a transmitter was placed on one adult, usually the male, of each pair, and all birds captured were uniquely marked with vinyl leg bands. Because successful parents could potentially be used in future attempts to cross-foster endangered whooping cranes *Grus americana*, any capture-related mortality of successful parents was considered unacceptable; net setup and operation were therefore designed to minimize risk.

Each net setup consisted of a net, three to four rockets, anchor stakes, and a two-conductor wire connecting the charges in the rockets to a detonator in a blind. Nets were 15.0 to 17.2 m in length, 10.3 to 12.0 m in width (the dimension projected forward during a shot), 0 to 0.5 m in skirt width, 25 to 40 mm mesh, and 11 to 32 kg in weight. We preferred to fold nets fanwise in 0.5-m-wide folds on a clean, flat surface and carry the nets rolled to each site. This procedure made nets easier to fold, eliminated foreign matter in the nets, facilitated transfer of nets to sites, and resulted in low profile of the net on the ground. If a site proved unproductive, the folded net could be easily rerolled and transferred to another site.

We used three types of rockets, 3.4 - 3.7 kg in weight, having shaft lengths of 235 - 550 mm. Rockets were shot out of the ground, so the longer shafts made aiming and stabilizing rockets easier. Launching stakes were not used. Rockets were aimed upward at an angle of 25° - 34°. In 1986, angles of 24 set rockets were determined by sliding a tight-fitting mailing tube, about 1 m long, over the nose of the rocket and measuring the critical distance from the base of the rocket to the feet of an observer standing directly in front of the rocket and sighting into the mailing tube. The angle was then calculated as the arctan (1.61 m/critical distance). The numerator (1.61 m) was the distance of the observer's eye above the ground.

During 1986 we examined the effects of altering the horizontal angle of the rocket (as measured from the back edge of the net) on net deployment. We measured rocket-landing points of five shots made with all rockets pointed straight and five shots with the outer rockets inset about 2 m from the ends of the folded net and angled outward (about 7°) to shoot the corners -i.e., aimed to the points at which the end rockets should land if the net landed fully spread (Figure 2).

Most sites were prebaited for several days before the net was set. Bait consisted of ear corn or a mixture of ear and shelled corn. Bait sites were established in areas where cranes had been seen consistently. About 25 kg of bait were arranged in a discrete pile about 0.4 m wide and 2.2 to 4.0 or 5.0 m long. A short pile was used when the set was made

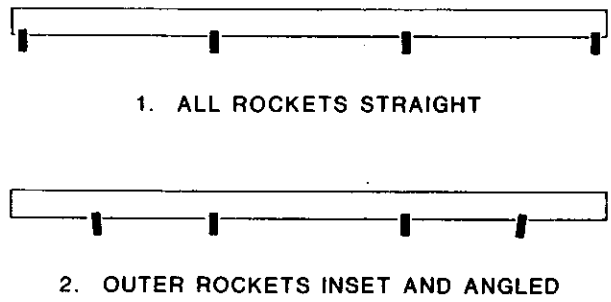

Figure 2. Two methods of positioning rockets used in tests of net development (not to scale).

to catch a pair or a pair with a chick. Longer piles were used when larger groups were expected to use the site. Husks were removed from ear corn; otherwise cranes pulled ears off the pile and fed on them elsewhere. The distance from the center of the pile to the front of the net, 3.5 m, was critical because shots were made only when birds were at the pile and had heads down. Birds in this position had low probability of either escape or injury. With few exceptions, no shots were made unless all birds were at least 2.5 m in front of the folded net, which was camouflaged with hay or natural vegetation. Rocket charges were detonated with generator-powered blasting machines, 10 or 50 blasting cap capacity.

All detonations were made from blinds constructed of cut conifer branches woven into existing vegetation or into cut trees placed in post holes. Cranes showed no aversion to these natural-appearing blinds. Each blind was located on an elevated site 50 - 175 m from the net ($\bar{x}$ = 85 m, n = 4). Good visibility of the net site was crucial: the bait pile, camouflaged net, and birds' position relative to these reference points must be obvious. Sighting through binoculars was necessary at most sites; normally, it was desirable to see a bird's feet to verify its exact position. The best angle of sight from blind to net, relative to the net, was 45°. This angle gave good perspective to determine both that the birds were the correct distance from the net and that they were not too far from either end of the bait pile. All blinds were located so that they could be entered without the netter being seen by birds at the net site.

Two methods were used to operate the nets. The first method was of limited value and involved waiting in the blind for birds to arrive in early morning. This method was feasible only when birds consistently fed at the same site each day, as in certain upland fields during August and early September.

The more versatile and efficient method of operating the nets involved checking several net sites from a vehicle stopping at vantage points along a driven route. These vantage points were 200 - 900 m from the net sites. Most sites had check points at least 400 m away because at less than this distance the vehicle often caused the cranes to stop feeding or to flush from the site. This method worked especially well on drawn down pools. A series of net sites was checked until one containing cranes was found; we then moved the

vehicle out of view and proceeded on foot or by canoe to the blind along a trail blocked from the net site by islands or elevated land. This procedure allowed birds to be captured at any time of day, and personnel time was expended only at productive capture sites.

A crew of one to five people processed captured birds. The tarsi of each captured bird were first taped together. Cranes were then removed from the net and placed in burlap bags for processing.

RESULTS AND DISCUSSION

During 1984-86, 175 different individuals were captured by rocket-netting (Table 1). Eleven recaptures included two birds each caught three times. Except for four individuals recaptured to affix or replace transmitters, intentional recaptures were avoided. Banded birds, especially subadults, often returned to bait sites. Captures per trap-day decreased ten-fold from late summer 1984 to late summer 1986 (Table 1). Although some of the poor trap success in 1986 resulted from inadequate manpower and avoiding shots at birds already banded, most was due to decreased trappability of the cranes. Trappability appeared inversely related to food supply on drawn down pools. During late summer 1984, optimal draw down conditions for netting cranes existed. Four large pools had been drawn down in late June to early July. During August and September these relatively barren flats were very attractive to cranes. In 1986, however, some pools, especially those most used by cranes, were still drawn down in their second season, and supported lush vegetation growth. Cranes therefore had many alternative foods and did not respond well to bait.

Period	Max. no. nets	No. trap-days	No. shots	No. new birds captured	No. recaptures	Captures per trap day
1984						
Aug.-Sept.	2	55	17	71	1	1.31
1985						
April	2	ND[a]	1	2	0	–
Aug.-Oct.	7	274	29	66	6	0.26
1986						
April	4	33	6	7	3	0.30
Aug.-Oct.	5	239	12	29	1	0.13
Total			65	175	11	

Table 1. Results of rocket-netting sandhill cranes on Seney, 1984-86.

[a]No data.

Trappability also appeared inversely related to crane reproductive success. Fall recruitment of fledged young of the year in 1984, a good year for netting cranes, was 4.7 juveniles/100 adults. During 1985 recruitment was 8.9 juveniles/100 adults. During 1986, a poor trapping year, recruitment was 11.2 juveniles/100 adults. Because production of young is related to level of environmental stress on the population, a bad year for the cranes apparently is a good year for capturing them and vice versa.

In April, birds were already dispersed on territories. In 1986 early snowmelt made netting feasible (Table 2). Birds fed mainly in the upland meadows in mornings and evenings, where they were particularly attracted to earthworms. Wetlands were flooded in April and were not practical to trap. During August to September cranes were attracted to grasshoppers Acrididae in the meadows. They fed on corn after leaving the roost and before grasshoppers became active. Most captures were made on drawn down pools. Cranes were present on drawn down pools during morning and evening, and frequently at mid day. They used pools for roosting and loafing, as well as for feeding. Use of pools was unpredictable. A site with 60 cranes one day might have none the next. Most capture attempts were made in the evening. If no shot was possible - for example, if the birds were never in position - another attempt usually could be made the next morning, because birds present during evening roosted there that night if undisturbed.

	April upland	Aug.-Oct. upland	Aug.-Oct. drawn-down pool
Morning	1	31	48
Midday	2	0	23
Evening	9	8	64
Total	12	39	135

Table 2. Total sandhill crane captures by season, habitat, and time of day on Seney, 1984-86. Morning = <1200, midday = 1200-1600, evening = >1600.

Effects of Net Setup on Capture Success

We prefer a large, light-weight net. Most birds captured were caught under the leading edge of the net; therefore, a forward thrust dimension of 12 m is recommended to reduce escape. Anchor lines can be lengthened to increase forward thrust on narrower nets. A standard 21-kg net was acceptable, but a 32-kg net was too heavy, in terms of transport, extension, and safety to birds. An 11-kg net, the weight we preferred, usually extended fully when shot, did not slow appreciably when wet, was easy to carry to and from sites, and required only three rather than four rockets for adequate propulsion. The 11-kg net also had 40 cm^2 mesh rather than the 25 to 32 cm^2 mesh of the other nets. The larger mesh size minimized escapes because the wrists of the greater sandhills went through the mesh, and were thus held. No serious injuries resulted from this type of entrapment.

We believe we have identified the lowest vertical rocket angle to catch birds safely and still minimize escapes (with the bait pile centered 3.5 m from the net). From a sample of 24 rockets in 1986, this angle was calculated as 27.3° ±0.28° (1 SE). The critical distance was 3.13 m ±0.039 m (1 SE). During 1984 the rocket angle was not measured, but escape rate was low. During 1985, when more emphasis was placed on catching successful parents, the rocket angle was raised slightly to further reduce chance of injury. The

estimated angle used that year was 29 - 34°. Of 98 attempted captures, 74 were successful; the escape rate was 24.5%. In 1986 the rocket angle was lowered to the recommended 24.5° - 29.5° ($\bar{x}$ = 27.3°). Of 42 attempted captures, 40 were successful; the escape rate was only 4.8%, and bird safety was not compromised.

The literature contains little information on the effects of forward rocket aiming on net trajectory. Dill (1969) suggested insetting the outer rockets and aiming them toward the point at which the forward corners of the net should land if the net were fully spread when it hit the ground. We found that the outer rockets, because they have less weight to pull and the entire load is on the inside, are drawn inward when all rockets are aimed straight ahead; the result is a triangle firing (Figure 3A). Insetting and directing the end rockets outward help compensate for this course alteration and result in a fuller net spread (Figure 3B). When rockets are aimed straight ahead the net contains folds that tend to trap birds that are brought down underneath. With insetting of the outer nets, the fuller net spread helps prevent escape of birds that move toward the corners when the net is shot; once down, however, the birds have a slightly better chance of escape because they can move under the net until they reach the edge. We prefer aiming all rockets straight ahead when the goal is to capture three or fewer birds, and insetting the outer rockets for larger numbers.

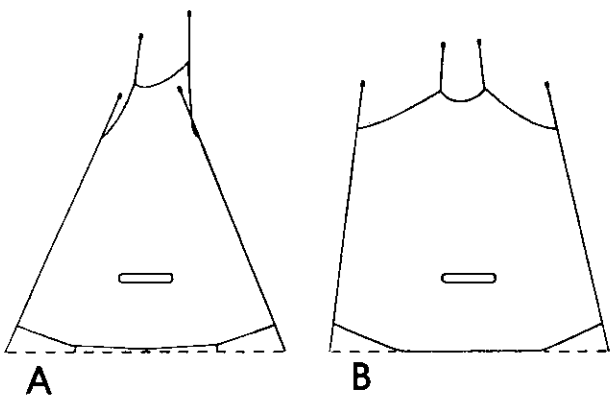

Figure 3. Deployments of the same net when (a) all rockets were aimed straight forward and (b) the outer rockets were inset 2 m and aimed outward approximately 7° (see Figure 2). This example typifies the effects of rocket positioning on net spread.

Casualties

Of 186 captures and recaptures, only one crane died and another sustained a debilitating wing injury as a result of netting. We know that our casualty rate has not been underestimated because 97% of our individually color-marked birds have been resighted, mostly during migration at Jasper-Pulaski Fish and Wildlife Area in Indiana, including all of those which we had any reason to suspect might have been injured. The only mortality occurred in 1984 during the only shot made at a large flock (more than 30 birds) at a flooded site. The bird appeared normal at release, but later died. The greater the number of cranes present, the lower the probability of having all cranes in position for a safe shot. In the Central Flyway, where shots are typically made at large numbers of flocking birds, known net-associated mortalities of 7% (Wheeler and Lewis 1972), 10% (Ramakka 1979), and 15% (Tacha et al. 1981) have resulted. Our other casualty was a bird that sustained a dislocated wing that was caught under one of the net's snag lines when the shot was made. Snag lines, used to tie the skirt into the body of some older nets, should be removed from nets used to capture cranes.

Effects of Netting on Crane Behavior

Netting cranes just prior to or early in incubation had no effect on reproductive performance. On 18 April 1986, both adults of one pair were netted just prior to egg-laying. They hatched two chicks on 25-26 May. On 24 April the male of another pair was netted shortly after initiation of incubation. This pair hatched two chicks on 21-22 May. The male of a third pair was caught on 26 April; a nest with two eggs, though later destroyed by a predator, was found being incubated on 13 May. Distances from trap-site to nest for the above three pairs were 0.9, 0.9, and 1.4 km, respectively.

Rocket-netting did not disrupt family groupings. Parents and chicks resumed normal family structure after release, even when one of the parents escaped capture. Release of birds after dark also did not affect survival or family integrity. Fast processing time has been emphasized in some studies (for example, Melvin et al. 1983). We, on the other hand, hold the birds for whatever time is necessary to ensure that color bands and/or transmitters are securely attached. For adults with transmitters, this time is at least one-half hour. As a result we have had no transmitter losses and, to the best of our knowledge, no loss of any color bands. Holding birds for this additional time has had no effect on subsequent survival or behavior.

Problems With Capturing Cranes

A serious problem with capture was that during certain periods, for example late 1986, cranes were not interested in the bait. We found no solution to this problem.

Problems with rocket-netting equipment are common but are almost always related to improper handling of charges and equipment (Sharp and Smith 1986). Our netting operations were relatively free of equipment-related malfunctions. We had problems with poor net deployment caused by wet charges in late summer and autumn 1986. These problems resulted from (1) prolonged (up to a month) stay of rockets on drawn down pools without firing, and (2) use of improperly sealed charges from one of our two suppliers. We recommend twisting and doubling over the end of the bag covering the charge, and then taping the doubled end.

Our only other equipment-related problem was ground fire during April 1986. During summer and autumn trapping periods, the soil and vegetation were damp and we had no fires. In spring 1986, however, a fire resulted from every shot and holes were burned in several nets.

The major problem with capturing cranes by rocket-netting on Seney was consumption of bait by other animals, primarily Canada geese, white-tailed deer *Odocoileus virginianus*, raccoons *Procyon lotor*, and black bears *Ursus americanus*. The major bait consumers were geese, especially in September to early October, when large migratory flocks would destroy a bait pile within hours after its establishment. Geese were a problem on all drawn down pools during summer and autumn, although sometimes they acted as decoys to attract cranes to the netting sites. Deer and bears were primarily a problem on upland sites, and both, like geese, completely eliminated corn piles once they became accustomed to feeding at a site. Raccoons were a problem on drawn down pools, not primarily by depleting bait but by feeding in groups on the piles during morning and evening and thus keeping cranes from using the bait.

SUMMARY

Drawn down pools provided the greatest potential for capture of sandhill cranes during August to October. Netting sites were established so that they could be checked from a remote vantage point, and blinds were located so that they could be entered without detection of the netter by cranes on the netting site.

Isolated upland meadows were good capture sites in April and August to early September. Late summer capture attempts at these sites were made by waiting in the blind before arrival of birds in early morning.

Fewer birds escaped when rockets were aimed upward at approximately 27° from the ground surface. Shots were made only when cranes were near the bait pile, which was located 3.5 m from the front of the net.

Injuries were avoided by making shots only when cranes were at least 2.5 m from the front of the folded net and had heads down. Of 186 captures and recaptures only 1 mortality and 1 serious injury resulted.

Capture success per effort expended varied greatly between late 1984 and late 1986.

ACKNOWLEDGMENTS

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CAPTURING CRANES WITH ALPHA-CHLORALOSE (AN ORAL TRANQUILIZER)

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ABSTRACT

This paper outlines the steps needed to capture wild cranes using bait treated with the chemical compound alpha-chloralose (an oral tranquilizer). Bait sites are selected where cranes are already feeding in early morning. Cranes are then conditioned to eat untreated bait. Narcotized cranes can be captured within 1-2 hours after feeding on alpha-chloralose treated bait. Recovery time ranges from 2-48 hours. This capture technique should only be used by qualified personnel under a strictly controlled situation. In the United States the use of alpha-chloralose is restricted to investigational use in laboratory research. Scientists are cautioned to comply with all their in-country wildlife regulations before using this capture technique.

PREBAITING

Goal: condition the birds to fly in to your bait site early in the morning on a regular basis and to remain in this area after feeding.

1. *Selecting the bait site*

Select a bait site where cranes are regularly feeding.

Do not try to lure cranes into an area that they do not already use because they will feed and then fly off.

Choose an upland area that is open and where the cranes can be easily observed.

NEVER bait cranes close to a lake or a wetland because when drugged they may go into the water and drown.

There should be *NO* human activities in the area, including livestock grazing, that could frighten the birds.

If you need a blind or hide from which to observe the birds, it should be approximately 100 m away from the bait site; it should be erected > 1 week before capturing so that cranes become accustomed to it.

If cranes are accustomed to vehicles, observe them from the vehicle parked approximately 100-200 m from the site.

2. *Bait*

Use either whole, shelled corn or shelled peanuts, or another large grain.

[1] Present address: International Crane Foundation, E-11376 Shady Lane Rd., Baraboo, Wisconsin 53913-9778 U.S.A.

3. *Presenting the bait*

With a shovel, dig five to ten small areas about 1 m apart; cranes will be attracted to the turned soil.

Put a small pile of bait *on top* of each disturbed area. You can then monitor how well they eat *and* you can more easily find your bait site.

Sprinkle the rest of the bait *near* your bait piles.

Put out bait either *late* afternoon, when the birds have left for the day/*OR early morning before* the birds arrive.

If many birds use the bait site and there is a lot of aggression, create one to two other bait sites each with five to ten bait piles; each bait site should be 50 m from the others.

4. *How often to bait*

For each bait site use 2.5 - 3.0 liters of bait, creating the five to ten small areas and also scattering some of the bait nearby.

Bait every other day until birds are eating bait regularly WITHIN 2 HOURS AFTER LEAVING THE ROOST IN THE MORNING.

Early morning feeding on bait is *very important* later when you capture cranes with drugs because dosage rates are calculated assuming the cranes have an empty stomach when they eat.

APPROXIMATELY 3-5 days before capturing, bait the site every morning before the cranes arrive.

Limiting amounts of bait avoids waste and reduces the problems caused by other animals feeding on the bait.

Limited bait gets cranes accustomed to fly directly to bait site early in the day so they will find the bait.

BEFORE A CAPTURE ATTEMPT, MAKE SURE CRANES EAT ALL THE BAIT (2.5-3.0 LITERS) IN ONE DAY.

5. *What to watch for at bait sites*

Make sure cranes arrive early in the morning; if cranes are using the bait site only in the afternoon, *do not capture cranes there!!*

MAKE SURE THE CRANES *STAY ON THE BAIT SITE FOR 2-3 HOURS FIRST THING IN THE MORNING.*

It is not good to select a bait site where cranes fly in and feed for only a short time and then fly to another site.

Do not select a bait site where cranes fly in to feed after feeding somewhere else earlier.

Make sure cranes eat all the bait.

Make sure other grain-eating birds such as crows (corvids) and blackbirds (icterids), and mammals such as cows, mice and pigs are not coming to the site and eating. These other animals can cause serious problems on capture days.

Make sure there is no possibility of human disturbance that will frighten the birds.

Make sure birds are accustomed to the blind or the vehicle.

CAPTURING

FIRST RULE: DO NOT CAPTURE CRANES WITH DRUGS ON A COLD DAY (<3°C) OR ON A RAINY DAY BECAUSE THE ALPHA-CHLORALOSE LOWERS THE BODY TEMPERATURE OF THE CRANES.

SECOND RULE: ONLY CAPTURE IN THE MORNING, NEVER IN THE AFTERNOON.

THIRD RULE: IF CRANES HAVE NOT EATEN THE BAIT BY 2 HOURS AFTER LEAVING THE MORNING ROOST, DO NOT CAPTURE THAT DAY. INSTEAD PICK UP THE DRUGGED BAIT, TRY AGAIN ANOTHER DAY.

1. *Bait dosage per crane and how many cranes to catch*

Total bait depends on the amount of crane use on the site and the number of cranes you want to capture.

Each crane should eat approximately 140 cc bait (i.e., 1/2 cup dry measure bait).

Do not try and catch more than 12-15 cranes per attempt; there should be a team of 3-4 people to catch cranes.

2. *What drug is used to capture*

Use alpha-chloralose ($C_8 H_{11} Cl_3 O_6$) - this is an oral tranquilizer. It comes in a fine white powder, and is odorless and almost tasteless.

Alpha-chloralose is available in the United States BUT CURRENTLY ITS USE IS RESTRICTED TO HIGHLY CONTROLLED EXPERIMENTS USING INVESTIGATIONAL TECHNIQUES IN LABORATORY RESEARCH.

Alpha-chloralose can be purchased from:

Fisher Scientific Headquarters
50 Fadem Road
Springfield, New Jersey 07081 U.S.A.
(phone: 201-467-6400)
cost: six 10g bottles for US$87.90

Eastern Chemical
P.O. Box 2500
Smithtown, New York 11787 U.S.A.
(phone 516-273-0900)
cost: 1 kg for US$100

Outside of the United States alpha-chloralose can be purchased through representatives of Fisher Scientific.

3. *How much alpha-chloralose drug to mix with the bait*

Premeasure the dosage of alpha-chloralose *very carefully* on a properly calibrated triple-beam balance scale or any other highly sensitive metric scale that will measure to 0.01 g accuracy.

Find the proper dosage from Table 1 for use with whole shelled corn or shelled peanut bait. Mix the appropriate dosage of alpha-chloralose with 2840 cc bait (equals10 dry measure cups bait). This amount will catch 20-30 cranes if feeding is normal.

If < 30 cranes are using a site, put out a portion of the batch. Calculate 140 cc (1/2 cup) treated bait per bird. YOU SHOULD NOT TRY TO CATCH MORE THAN 15 CRANES UNLESS YOU ARE EXPERIENCED WITH THE TECHNIQUE.

IT IS BEST TO START WITH THE LOWER RECOMMENDED DOSES AND GAIN EXPERIENCE BEFORE USING HIGHER DOSES OF ALPHA-CHLORALOSE.

Large grains are preferred bait, however, if using a small grain for bait such as rice, wheat, or barley USE A SLIGHTLY LOWER DOSAGE.

Species	Average species weight (kg)	Alpha-chloralose dosage (grams) PER 2840 cc bait
Black-crowned *Balearica pavonina*	3.63	3.2 - 3.6
Grey-crowned *Balearica regulorum*	3.50	3.2 - 3.6
Stanley *Anthropoides paradisea*	5.15	4.4 - 5.0
Demoiselle *Anthropoides virgo*	2.40	2.1 - 2.4
Wattled *Bugeranus carunculatus*	7.90	6.8 - 7.7
Brolga *Grus rubicundus*	6.02	5.2 - 5.9
Eastern Sarus *Grus antigone sharpii*	6.40	5.6 - 6.3
Indian Sarus *Grus antigone antigone*	7.40	6.4 - 7.3
White-naped *Grus vipio*	5.63	4.9 - 5.5
Sandhill *Grus canadensis rowani*	3.95	3.5 - 3.8
Sandhill *Grus c. canadensis*	3.46	3.0 - 3.4
Sandhill *Grus c. tabida*	4.70	4.0 - 4.5
Sandhill *Grus c. pratensis*	4.30	4.0 - 4.5
Black-necked *Grus nigricollis*	5.93	5.2 - 5.8
Common *Grus grus grus*	5.27	4.6 - 5.2
Common *Grus g. lilfordi*	4.30	3.8 - 4.2
Hooded *Grus monacha*	3.74	3.3 - 3.7

Table 1. Recommended alpha-chloralose dosage (grams) for 2840 cc bait[a].
[a]For use with whole shelled corn or shelled peanut bait. If using a small grain for bait such as rice, wheat, or barley USE A SLIGHTLY LOWER DOSAGE.

Remember: premeasure your alpha-chloralose drug dosage CAREFULLY. Too much will overdose the cranes, and they can die!!!

Note: the recommended dosages are based on the assumption that the birds are feeding well, that there is no aggression from other cranes and no other food items available to distract the cranes.

4. *Temperature and alpha-chloralose dosage*

Cold weather (< 3 °C) often causes birds to eat more and eat faster, thus increasing the consumption and the effect of the drug.

Cold weather also increases the tranquilizing effect of the drug and cranes are more susceptible to hypothermia.

IT IS BEST NOT TO CAPTURE IN COLD WEATHER. IF CAPTURING IN COLD WEATHER CANNOT BE AVOIDED, HOWEVER, REDUCE SLIGHTLY THE DOSAGE OF ALPHA-CHLORALOSE USED ON THE BAIT.

5. *Mixing the alpha-chloralose and the bait for capture*

If the bait is whole, shelled corn, FIRST sift the corn to get rid of small pieces. Sifting the corn prevents small grain-eating birds, crows (corvids), and blackbirds (icterids) from eating the drugged bait and attracting raptors and other predators that will harass or distract the cranes. Small drugged birds can also frighten the cranes.

In a bucket, wet the bait with water for 1 minute.

Drain off all excess water.

Sprinkle the premeasured alpha-chloralose drug on the bait while stirring (folding) with a spoon.

Do not have free water in the bucket with the bait. Water dilutes the dosage.

NOTE: Prepare the bait with alpha-chloralose < 1 hour *before* putting it out on the bait site; otherwise the drug will fall off as it dries.

6. *At the bait site on capture day*

REMEMBER: *DO NOT* CAPTURE CRANES ON A COLD DAY (< 3 °C) OR RAINY DAY.

REMEMBER: *DO NOT* BAIT OR CAPTURE CRANES CLOSE TO A LAKE OR WETLAND.

Clear the bait site of any untreated bait before presenting treated bait.

BEFORE THE BIRDS ARRIVE, put the drugged alpha-chloralose bait IN PILES of approximately 140 cc *only* on the five to ten small areas. DO NOT SCATTER THE BAIT.

DRUG AT ONE SITE ONLY. If you have nearby one or more additional bait sites you have maintained because of too many cranes and previous problems with aggression, REMEMBER to put 2.5-3.0 liters of regular, untreated bait *WITH NO ALPHA-CHLORALOSE* on these separate bait sites; this will discourage aggression between narcotized birds and birds that did not consume drugged bait.

Have your nets and capture equipment ready.

Make sure there are no humans nearby or domestic animals which might disturb the cranes.

7. *How to know when a crane is drugged and how long to wait before capturing*

Cranes eating drugged bait show evidence of narcosis (sleepiness) within 20 minutes to 1.5 hours.

Usually cranes stop feeding after 30-60 minutes and will begin preening; they may fall asleep standing up, or will fall down several times, or will walk aimlessly.

All humans should wait *out of sight* for 1-2 hours after the birds begin feeding on the drugged bait. This will allow the alpha-chloralose time to affect the cranes.

DO NOT WAIT MUCH MORE THAN 2 HOURS TO BEGIN CATCHING THE CRANES AS THE DRUG EFFECTS WEAR OFF.

After 1 to 2 hours (usually 2 hours) begin to pick up the drugged cranes.

If a crane does not show any symptoms of narcosis and flies off a long distance 45 minutes or so after feeding the crane probably did not eat enough drugged bait and can be assumed to recover.

8. *Capturing the cranes*

Anyone catching a crane should wear safety glasses.

Drugged cranes should be approached *quietly* and *slowly* from *behind* with a *LONG-HANDLED NET* (Figure 1).

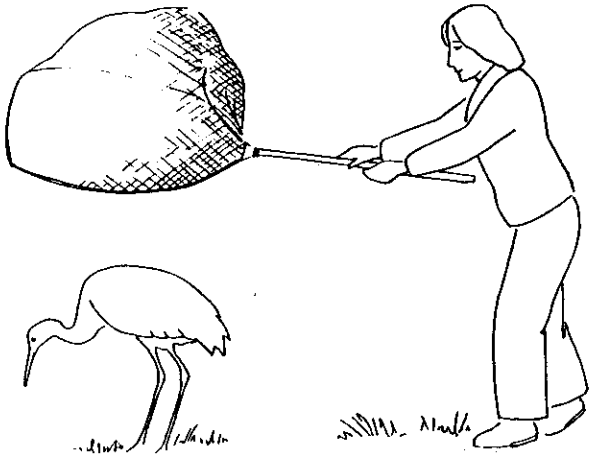

Figure 1. Drugged cranes should be approached quietly and slowly from behind with a long-handle net.

FIRST capture any bird in danger of collapsing in water and cranes that appear to be LEAST tranquilized - approach them slowly and allow them to walk away from other tranquilized cranes because if these cranes are frightened they may disturb additional, lightly tranquilized cranes that otherwise could be caught.

Some cranes that are adequately tranquilized for capture may walk aimlessly, sometimes in circles, these birds *can* and *should* be captured. Do not assume they are alert and safe from predators.

Be careful not to frighten cranes.

Be careful not to mishandle cranes.

If a drugged crane flies from the area, locate and capture the crane as quickly as possible. Drugged cranes are vulnerable to both predator attacks and attacks by cranes that have not eaten any drugged bait.

On the capture site sedated cranes may be attacked by fresh, underdrugged late arrivals. Such late arrivals can often be driven off by a slight disturbance. BUT be careful not to flush drugged cranes.

9. *How to hold the crane*

After catching the crane, fold the wings against the crane's body, wrap one arm around the trunk, and position the crane against your side (Figure 2).

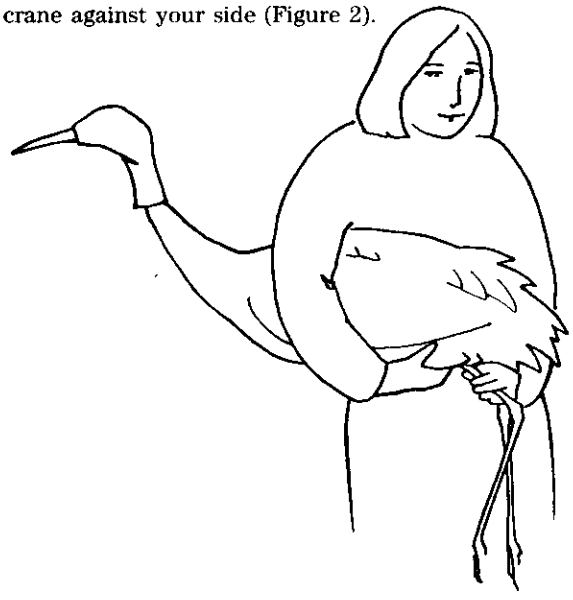

Figure 2. Captured cranes should be removed from the bait site immediately. Fold the wings against the crane's body, wrap one arm around the trunk, and position the crane against your side. Legs should be grasped above the tibio-tarsal joint. Hood the crane to minimize stress and movement.

The crane's head and neck should face what is behind you; this prevents the crane from striking your face.

Grab legs *at the tibio-tarsal joint* (ankle, *not the foot*) with the free hand.

DO NOT RESTRAIN CRANE LEGS CLOSE TO THE TOES, THIS OFTEN CAUSES PERMANENT CRIPPLING TO THE CRANES.

Cover the crane's head with a sock or hood, being careful not to inhibit breathing; the cover will quiet the crane.

Put the crane in a sack or other restraining device but leave the head and neck outside the sack; secure the wings against the crane's body by wrapping a light fabric, duct tape, or velcro strips around the outside of the sack (Figure 3).

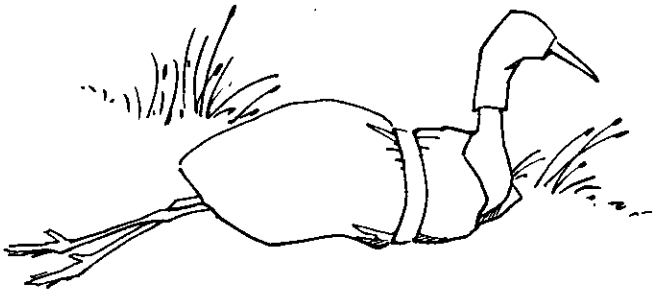

Figure 3. Temporarily restrain the crane using a sack or other device secured around the trunk. Secure the legs together above the tibio-tarsal joints with a light fabric, tape, or velcro strips. **Do not** restrain cranes for long periods of time.

Secure legs *above* the tibio-tarsal joints - a light fabric, surgical tape, duct tape, or velcro strips can be used to hold legs together.

KEEP CRANES WARM IF WEATHER IS COLD.

KEEP CRANES IN THE SHADE IF WEATHER IS WARM.

IMMEDIATELY AFTER ALL DRUGGED CRANES ARE CAPTURED, MOVE THEM TO THE SITE WHERE YOU WILL BAND THEM AND ALLOW THEM TO RECOVER.

10. *Before leaving the bait site*

FIRST, IT IS VERY IMPORTANT TO PICK UP *ANY* REMAINING DRUGGED BAIT SO THAT OTHER CRANES OR ANIMALS CANNOT EAT DRUGGED BAIT.

SECOND, *IMMEDIATELY* PUT OUT FRESH, UNTREATED BAIT (*NO* ALPHA-CHLORALOSE) in case you overlooked any drugged bait.

HANDLING CAPTURED CRANES AND RECOVERY TIMES

1. *Obvious effects of alpha-chloralose*

Alpha-chloralose is a general depressant.

Alpha-chloralose reduces body temperature.

Alpha-chloralose reduces respiration.

Alpha-chloralose lowers heartbeat.

Alpha-chloralose causes increased mucous production.

Alpha-chloralose causes cranes to drool and gurgle.

Alpha-chloralose causes water to discharge from eyes.

Alpha-chloralose causes loose, runny feces.

2. *Banding and weighing.*

Minimize the physical exertion of the bird.

Remove the sack, but leave the hood on the crane to minimize stress. Make sure the hood does not impede breathing.

Weigh, measure, and band the bird while it lies on its sternum.

Watch for stress.

Always maintain control of the crane's legs and upper neck.

Watch your safety - drugged birds are *AS STRONG AND AS DANGEROUS* as normal birds. They will use their feet and beak!!! Wear your safety glasses!

After banding and weighing, remove hood and release the bird into holding cage until it has recovered from drugs.

3. *Holding cage/or tent*

When possible, the holding cage should be close to the capture site.

Cage or tent should be high enough for birds to stand erect but not so tall that they will fly and injure themselves.

Cage floor should be dirt or sand, and *not* be smooth plastic, wood, or cement.

The sides of the cage should be covered to reduce stress.

Cage roof should be covered on hot, sunny days.

Cage should be predator proof.

Keep cranes dry and warm if weather is rainy or cold; keep them in the shade if weather is hot and sunny; remember that alpha-chloralose lowers the body temperature.

Initially, DO NOT put water in the cage with the cranes because drinking will speed up drug absorption and can

cause an overdose; also a drugged crane may inadvertently drown if its head falls in the water bowl.

If cranes are held for > 8 hours/and or held overnight, you can put fresh water in the cage but only in a small, shallow container.

Keep the public away from the cranes

DO NOT CONFINE CRANES WHERE OTHER DOMESTIC OR CAPTIVE BIRDS HAVE BEEN OR ARE PRESENTLY CONFINED BECAUSE domestic and captive birds frequently harbor diseases that wild cranes have not previously been exposed to and to which the *wild cranes could be very susceptible.*

If a cage is used repeatedly, the ground or floor should be cleaned or disinfected routinely after every capture event.

4. *Recovery from drug effects and releasing the cranes*

Cranes will be incapacitated anywhere from 2-48 hours; do not release them until they have completely recovered.

Recovery time varies depending on amount of bait consumption, general condition of the individual, and ambient temperature.

A crane is probably recovered if it holds its head up normally and walks alertly and briskly with no shaking or quivering in legs, vocalizes when you approach it, and attempts to defend itself or acts aggressively.

DO NOT RELEASE RECOVERED CRANES < 1 HOUR BEFORE SUNSET AS CRANES NEED TIME TO REORIENT THEMSELVES BEFORE ROOSTING.

WHEN IN DOUBT, HOLD CRANES OVERNIGHT.

CRANES SHOULD BE RELEASED AT THE BAIT SITE WHERE THEY WERE CAUGHT, OR DIRECTLY FROM THE HOLDING CAGE *ONLY IF* IT IS VERY CLOSE TO THE BAIT SITE.

5. *First aid for heavily sedated cranes*

Heavily sedated cranes will lie motionless in unnatural positions (on the back or side) even 1 hour after capture. Arrange them in a natural position with the head pointing down.

These heavily sedated birds should especially be protected against cold by wrapping them in blankets or keeping them close to heat.

Keep heavily sedated birds *DRY*.

Keep heavily sedated birds head up if possible.

Periodically, a heavily sedated crane should be held up and shaken or stimulated by manipulating its legs and wings (BE GENTLE!!).

Heavily sedated cranes often regurgitate bait or mucous - BEWARE OF ASPIRATION (BREATHING INTO THE LUNGS THE BAIT OR MUCOUS)—TRY TO CLEAR MOUTH AND THROAT BY HOLDING CRANE UP, WITH NECK AND HEAD DOWN AND MOUTH OPEN - gravity will do the rest.

On the capture site sedated cranes may be attacked by fresh, underdrugged late arrivals. Such late arrivals can often be driven off by a slight disturbance. BUT be careful not to flush drugged cranes.

Do not assume drugged birds can defend themselves.

GOOD LUCK AND REMEMBER SAFETY FOR BOTH THE CRANES AND YOU COMES FIRST!!!!

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Appendix I. Equipment needed to capture cranes.

necessary equipment:

small shovel and/or spade
bait: whole shelled corn, shelled peanuts, or other large grain
water (to wet grain)
alpha-chloralose (premeasured)
bucket and spoon
binoculars and telescope
watch
safety glasses for all people handling cranes
long-handled nets (3-4)
sacks or other restraining devices to hold cranes
soft cloth, duct tape, gauze, elastic leg wrapping or velcro to tie legs, and to tie wings against torso
socks/or other kind of hood to cover crane heads

holding cage: tent or netted cage - sides covered, floor not smooth

scale (accurate to 0.01 g) to measure alpha-chloralose
scale (accurate to 0.1 g) to weigh cranes
rope for scale (or means to hang scale for weighing cranes), and for tent or tarps
data forms and color-code sheets
banding permits
banding box:
- bands - color and aluminum
- pvc cleaner and pvc glue OR rubber cement
- cotton swabs
- pocket knife
- pliers
- file
- scissors
- wire cutters (that will cut plastic bands too)
- razor blades
- calipers
- ruler
- hydrogen peroxide
- coagulant (ferric subsulfate solution) for cranes
- first aid instructions

first aid box
topical ointment

optional equipment:

2-way radios
chairs
blankets for cranes (if < 3°C)

Appendix II. Suggested references.

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