to the biota of the European and African continents. Because effective conservation here will benefit so many, it is appropriate that the costs be shared as well.

CASE STUDY 7

Putting the Pieces Together: International Management of Cranes and Their Habitats

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The world's 15 species of cranes offer some of the most complex challenges imaginable to conservation managers, who potentially must come to grips with all possible aspects of conservation biology simultaneously. Crane conservation efforts must deal with biological, sociological, economic, and political issues, language and cultural barriers, funding challenges, international cooperation, and myriad other issues to succeed. Their successes offer a model from which others may learn.

The cranes (Family Gruidae) belong to one of the world's most ancient families of birds, with fossil records dating back more than 50 million years. The 15 extant species in the family (Figure 13.28) are widely distributed, occurring in more than 110 countries on five continents; only South America and Antarctica lack cranes (Johnsgard 1983). Primarily birds of open wetlands, grasslands, and savannas, cranes have in some cases been able to adapt to and even thrive within humanized landscapes; however, over the last 150 years cranes have had to cope with accelerated loss of habitat and other threats. As a result, cranes now constitute one of the world's most threatened bird families, with seven species currently included on the IUCN Red List of Threatened Animals, and four more likely to be added (Groombridge 1993; Meine and Archibald 1996).

Cranes have long commanded the respect and admiration of their human neighbors, a cultural value that now plays a critical role in drawing

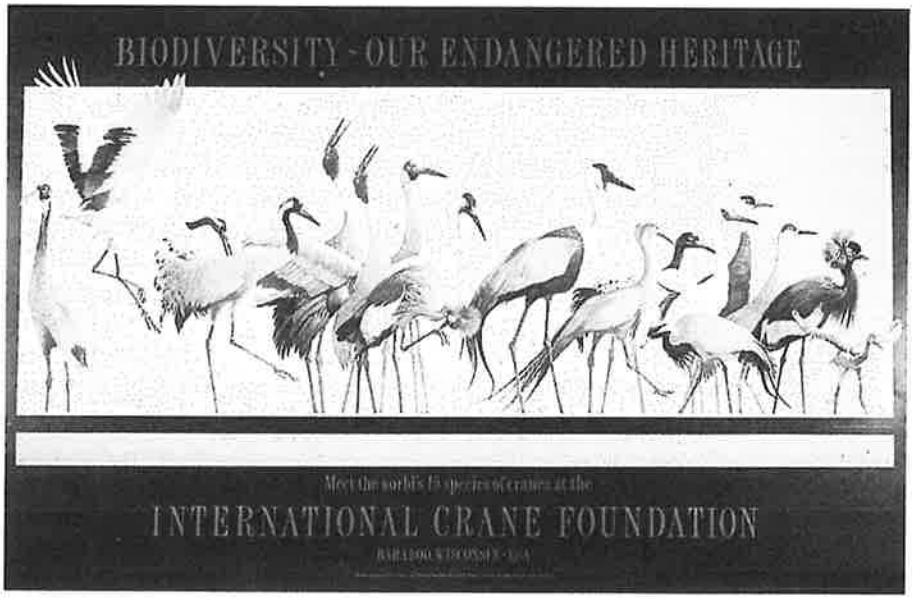

Figure 13.28 The world's 15 species of cranes are here depicted in a wall poster, that can be used as an attractive educational tool. (Original artwork by David Rankin; photograph courtesy of the International Crane Foundation .)

Table 13.1
Proposed Conservation Status of Cranes under the Revised IUCN Criteria

Taxon	Conservation status (proposed)
Black Crowned Crane (*Belearica pavonina*)	Vulnerable
West African Crowned Crane (*B. p. pavonina*)	Endangered
Sudan Crowned Crane (*B. p. ceciliae*)	Vulnerable
Grey Crowned Crane (*Belearica regulorum*)	Vulnerable
South African Crowned Crane (*B. r. regulorum*)	Endangered
East African Crowned Crane (*B. r. gibbericeps*)	Vulnerable
Blue Crane (*Anthropoides paradiseus*)	Critically Endangered
Demoiselle Crane (*Anthropoides virgo*)	Lower Risk (least concern)
Wattled Crane (*Bugeranus carunculatus*)	Endangered
Siberian Crane (*Grus leucogeranus*)	Endangered
Sandhill Crane (*Grus canadensis*)	Lower Risk (least concern)
Lesser Sandhill Crane (*G. c. canadensis*)	Lower Risk (least concern)
Canadian Sandhill Crane (*G. c. rowanii*)	Lower Risk (least concern)
Greater Sandhill Crane (*G. c. tabida*)	Lower Risk (least concern)
Florida Sandhill Crane (*G. c. pratensis*)	Lower Risk (near threatened)
Mississippi Sandhill Crane (*G. c. pulla*)	Critically Endangered
Cuban Sandhill Crane (*G. c. nesiotes*)	Critically Endangered
Sarus Crane (*Grus antigone*)	Endangered
Indian Sarus Crane (*G. a. antigone*)	Endangered
Eastern Sarus Crane (*G. a. sharpii*)	Endangered
Australian Sarus Crane (*G. a. gilii*)	Data Deficient
Philippine Sarus Crane (*G. a. luzonica*)	Extinct
Brolga (*Grus rubicundus*)	Lower Risk (least concern)
White-naped Crane (*Grus vipio*)	Vulnerable
Hooded Crane (*Grus monachus*)	Vulnerable
Eurasian Crane (*Grus grus*)	Lower Risk (least concern)
Whooping Crane (*Grus americana*)	Endangered
Black-necked Crane (*Grus nigricollis*)	Vulnerable
Red-crowned Crane (*Grus japonensis*)	Endangered

Note: See IUCN 1994 for a summary of the revised categories and criteria. Under the revised criteria, "Threatened" includes the categories "Critically Endangered," "Endangered," and "Vulnerable." (At the time of publication these listings for the cranes had only been proposed, and remain subject to further review by crane specialists.)

arctic breeding grounds and temperate wintering areas. It is also a center of diversity for cranes, with six species (four of which are threatened) occurring in the region (Halvorson et al. 1995).

International tensions have for decades prevented intensive development of the Amur Basin; however, in recent years, development pressures have been growing. A series of dams has been proposed for the Amur River, threatening the river itself and adjacent wetlands. Rapid agricultural conversion of wetlands in the associated Sanjiang Plain in China is depriving Red-crowned and White-naped Cranes and other wetland species of critical breeding habitat. In Russia, economic uncertainty has contributed to inefficient agriculture and exploitive forestry.

Since 1980, cranes have played a key role in stimulating regional conservation initiatives. Important wetlands in Russia and China have been protected, including international reserves at Lake Khanka on the Russia–China border and in the China–Mongolia–Russia border region. A Russian NGO, the Socio-Ecological Union (SEU), has established Muraviovka Park

attention to their biological plight. Even as cranes have declined in numbers, their beauty, dramatic migrations, and striking calls and behavior have inspired widespread conservation efforts. Since the early 1970s, a global campaign has been undertaken to develop conservation programs focused on cranes and the ecosystems that serve (in part) as crane habitat. This unusual effort, centered on a single family of birds, yet international in scope and integrated in its approach, offers lessons of broad relevance to conservation biologists. In contrast to management efforts involving particular species in a particular place, crane conservation offers an example of what might be called "meta-management"—coordinated efforts to conserve an entire group of species throughout the world.

Conservation Status of Cranes

The loss, degradation, and overexploitation of wetlands represent the most important threats to cranes, affecting their distribution, movement, and breeding success, and involving habitats used by migratory and nonmigratory species alike throughout the year (Archibald et al. 1981; Harris 1994). Species that use upland grasslands and savannas have also been heavily affected by conversion and degradation of these ecosystems. Because of the cranes' low reproductive potential—in most species, pairs do not breed until 3–5 years of age, and raise on average about one chick per year—increases in mortality caused by hunting, poisons, and powerline collisions can easily depress crane populations. Other important threats to cranes include dam construction, water diversions, urban expansion, invasive plant species, artificial concentration of populations, genetic and demographic problems associated with small populations, disturbance, lack of effective environmental law enforcement, and political instability. As a result of these multiple threats, 11 of the 15 species of cranes may be listed as threatened under the recently revised IUCN Red List criteria (Table 13.1).

The challenge in crane conservation has been to identify the combinations of actions that are available, and required, to respond to the highly varied circumstances on the ground. Conservation programs for cranes entail a wide range of actions, including: stronger legal protections; development of international agreements and cooperative international programs (including the United States–Canada Migratory Bird Treaty, the Ramsar Convention for wetlands protection, and the Convention on the Conservation of Migratory Species of Wild Animals); development of community conservation projects; establishment and management of protected areas; habitat protection, restoration, and management; monitoring and research; support for nongovernmental organizations; public education and professional training; and captive propagation and reintroduction. In some cases, as with the Whooping Crane, necessity has often been the mother of invention, dictating important short-term steps. In other cases, as with the endangered cranes of East Asia, conservationists have taken steps incrementally and opportunistically, amid complicated sociopolitical circumstances.

Three cases from around the world illustrate how crane conservationists have responded to need and opportunity.

Cranes of the Amur River Basin

The Amur River along the Russia–China border is the world's eighth longest river, and the longest without a dam on its main stem. Its basin is rich in species diversity, a reflection of its unique mix of elements from the northern coniferous forests, southern deciduous forests, and Eurasian steppes. For migratory birds, the Amur Basin is an important link between

Figure 13.29 Entrance to a crane refuge in the Amur Basin. (Photograph courtesy of the International Crane Foundation.)

(Figure 13.29), the first private nature reserve in Russia since 1917, by leasing prime crane habitat. Muraviovka is located amid farmlands; crucial community support has been fostered through an exchange program involving schoolteachers and student conservationists from the area and from the United States. In 1992, a landmark workshop brought together conservationists from six countries to share information and consider how to integrate conservation with development in the basin (Halvorson et al. 1995). Khinganski Nature Reserve, along the Amur River, has received vital financial support from a consortium of American zoos for an experimental reintroduction program for Red-crowned and White-naped Cranes. The American zoos have sent eggs to Khinganski for releases, while the Russians have sent captive cranes to bolster the genetic diversity of North America's captive population.

Eastern Sarus Cranes in Southeast Asia

The Eastern Sarus Crane (Figure 13.30), the rarest subspecies of Sarus Crane, formerly occurred throughout Indochina. Over the last 50 years it has been decimated throughout its historical range. Decades of war in Vietnam resulted in massive disruption of one of its last strongholds in the wetlands of the Mekong River delta. Extensive ditching, drainage, and conversion of the wetlands, along with the disturbance and hunting that often accompany warfare, were thought to have resulted in the loss of the subspecies. In 1984, however, local Vietnamese officials reported that the birds had reappeared at a 7500 ha impoundment, the Tram Chim wetland (Brehm Fund 1987). The exact location of this population's breeding grounds has yet to be determined, but Eastern Sarus Crane nests have recently been confirmed at three sites in northeastern Cambodia (Barzen 1994).

Following rediscovery of the flock, several international initiatives were immediately undertaken to protect the population and its habitats. The main wintering area in Vietnam was protected, and is now designated as the Tram Chim National Reserve. Research and management has since focused on restoration of the natural hydrologic processes of these wetlands. In the meantime, safeguarding wild resources has become more difficult as popu-

Figure 13.30 The Eastern Sarus Crane in the Tram Chim wetlands, Vietnam. (Photograph courtesy of the International Crane Foundation.)

lation pressures in Vietnam have resulted in many people being relocated to lands surrounding the reserve.

Broader conservation measures have also been undertaken. International cooperation on behalf of the Eastern Sarus Crane has been enhanced through a workshop convened at Tram Chim in 1990, and through the signing of a Memorandum of Agreement by Cambodia, Thailand, and the International Crane Foundation (ICF) in 1992. The agreement outlined plans to study the breeding grounds in Cambodia, to conduct collaborative field studies in the Mekong Delta, and to participate in international training programs. ICF has also sponsored the preparation of a population and habitat viability analysis for the subspecies. In 1994, a team of wetland managers from Vietnam visited natural floodplain wetlands in northern Australia to study and compare wetland management techniques. And in 1996, ICF, in partnership with several other NGOs, organized an international workshop on sustainable development alternatives in the Mekong River watershed. Such watershed-scale approaches will be increasingly important as the region's human population and its economies continue to expand.

Blue Cranes in Southern Africa

The Blue Crane is endemic to southern Africa, with the vast majority of the population occurring in eastern and southern South Africa. It remains abundant in parts of its range, but has declined significantly since the mid-1970s, and its distribution is now the most restricted of the 15 crane species.

As recently as 1980, there was little conservation concern about the Blue Crane. The species, however, has occasionally caused considerable crop damage, and intentional and unintentional poisoning by farmers, as well as extensive loss of its grassland habitat to afforestation, have significantly affected both its distribution and numbers (Allan 1994). Although the total population is still estimated at 21,000, its rapid decline has caused great concern and a spate of conservation activity among South African conservationists. Recent measures include stricter legal protection for the species; local and national surveys of the population; expanded field research; increased attention to habitat management (through, for example, appropri-

ate fallowing and planting of lure crops), particularly on private lands; the emergence of several NGOs with Blue Crane conservation programs; and development of educational programs focusing on the species.

Especially important have been the efforts of the Overberg Crane Group, which in 1993 developed *A Conservation Programme for the Blue Crane in the Overberg* (Scott and Scott 1996). This comprehensive program emerged from a 1992 Blue Crane workshop, involving broad representation from the local community. The program's goals are to assess the status of the Blue Crane in the Overberg region, address problems that cranes have caused for farmers, and expand conservation measures. Nine specific conservation projects were outlined, and coordinators have been assigned to monitor progress and provide feedback to the group. Conservation agency officials contribute to the program as part of their assigned duties, while volunteers from the farming community, universities, and other institutions also participate. The Overberg Program has met with considerable success. Farmer participation, for example, was key to developing a simple solution to the problem of Blue Crane depredations in sheep feedlots. A single low strand of wire, strung entirely around the feeding trough, does not impede access of sheep to their food, but does impede cranes, which are unwilling to enter such a confined space. The work of the Overberg Crane Group provides a useful model for conservationists elsewhere.

Coordinating Crane Conservation Response

As these examples illustrate, cranes provide important opportunities to build conservation programs that combine various goals, activities, and techniques. Limits of time, money, and personnel have forced crane conservationists to develop ways of coordinating their efforts at the regional and international levels. A number of mechanisms and organizations have emerged to help integrate the various components of a balanced and comprehensive conservation program.

Recovery Teams and Recovery Plans. The U.S. Endangered Species Act of 1973 provides for the development and implementation of recovery plans for endangered species. These plans are prepared and periodically updated by recovery teams appointed by the U.S. Secretary of the Interior. The U.S. Whooping Crane Recovery Team was appointed in 1976, and the USFWS published its first Whooping Crane Recovery Plan in 1980. The plan has been revised twice, in 1986 and in 1994 (USFWS 1994). The Canadian Whooping Crane Recovery Team was established in 1987 to coordinate recovery activities within Canada. Its first plan was published in 1988 and revised in 1994 (Edwards et al. 1994).

Recovery activities have been closely coordinated between the two nations. In 1995, a Memorandum of Understanding on Conservation of the Whooping Crane was signed, calling for the preparation of a combined plan and the formation of a single recovery team comprising five U.S. and five Canadian members. These steps are especially important as precedents for other nations that share endangered migratory crane populations. For example, in 1995, representatives of the range nations of the rare Central and Western populations of the Siberian Crane met for the first time in Moscow, laying the foundation for the establishment of a Siberian Crane Recovery Team.

International Crane Foundation (ICF). Since 1973, the International Crane Foundation (located in Baraboo, Wisconsin, U.S.A.) has carried out conservation programs around the world. ICF's programs in field ecology, aviculture, research, education, and training have helped to strengthen the

(A) (B)

Figure 13.31 (A) The International Crane Foundation, near Baraboo, Wisconsin, has facilities for holding and rearing the world's 15 species of cranes, including (B) these endangered Whooping Cranes. (A, photograph courtesy of David Thompson, International Crane Foundation; B, by G. K. Meffe.)

global network of crane conservationists. Its publications, including workshop proceedings as well as *The ICF Bugle*, a quarterly newsletter, provide communication links for that network. The Ron Sauey Memorial Library for Bird Conservation serves as a central repository for the world's scientific literature on cranes, their habitats, and their conservation.

ICF maintains a "species bank" of threatened cranes on-site, and is one of the three primary breeding facilities for the Whooping Crane (Figure 13.31). ICF has successfully bred all 15 species in captivity, developing new techniques that have been used in the propagation of other endangered birds. ICF's ex situ efforts now focus on the rarest species (primarily the Siberian and Whooping Cranes), and on the integration of captive crane management with field conservation measures (including crane reintroduction, ecosystem restoration, and habitat management programs). ICF also provides training opportunities for biologists, managers, and educators, and supports a wide range of public education projects at its headquarters and around the world.

IUCN/SSC Crane Specialist Group. In 1970 the International Council for Bird Protection (now BirdLife International) asked George Archibald (then conducting doctoral studies on crane biology at Cornell University) to organize a World Working Group on Cranes. Some 40 crane researchers joined the working group. In 1973, Archibald and Dr. Ron Sauey cofounded the International Crane Foundation to carry out the Working Group's activities. Core members of the group in turn formed the IUCN Crane Specialist Group. Reports of the group's activities appear regularly in *Species*, the newsletter of the IUCN Species Survival Commission. In 1996, the group published its first conservation action plan (Meine and Archibald 1996).

Crane Working Groups. Crane working groups have played a key role in supporting research, information exchange, and development of conservation programs. Crane working groups have been organized at the regional, national, and local levels. At the regional level, working groups are active in North America and Europe. A Soviet Working Group on Cranes was active until 1989. An East Asian working group is now forming to coordinate activities in this most species-rich region. National-level working groups are best developed in Europe. China's crane researchers formerly met on a regular basis, but economic constraints have impeded meetings in recent years. Local groups include the Friends of the Brolga in southeastern Australia and the Highlands and Overberg Crane Groups in South Africa. Several local

Figure 13.32 Training workshops, such as this one in Maun, Botswana, are critical for gaining the support and sharing the information needed to accomplish the many and complicated objectives in crane conservation. (Photograph courtesy of the International Crane Foundation.)

working groups in South Africa have recently joined together under the umbrella of the South African Crane Working Group.

Global Captive Crane Working Group. The appropriate integration of captive propagation techniques with field management techniques is a critical need that challenges the ingenuity of conservationists. For example, avicultural research has yielded methods for testing the viability of eggs in wild Whooping Crane nests. One egg can be removed from nests that have two viable eggs, and either brought into captivity or placed in a nest where both eggs are bad. With few exceptions—the West African Crowned Crane, Wattled Crane, and Hooded Crane—all the species can now reliably be bred in captivity. Based on this success, the emphasis in captive programs has shifted from management of individual birds to management of healthy populations to meet conservation needs. In 1993, a Global Captive Crane Working Group was organized to set regional target populations, define genetic and demographic objectives, allocate limited space among species, and coordinate work with field conservation projects. In addition, captive management techniques have now been summarized in a crane propagation and husbandry manual (Ellis et al. 1996).

Crane Workshops and Meetings. Since 1975, some 35 national, regional, international, and species-specific crane workshops and meetings have been held (Figure 13.32). These gatherings provide important forums for information exchange, allowing scientists and conservationists from throughout the world to meet and learn from one another. Proceedings from most of the workshops have been published, making this information available to an even broader audience.

Lessons for Conservation Biologists

Each of the 15 crane species requires a different suite of conservation actions to ensure a secure future, and crane conservationists have had to integrate conservation programs under diverse circumstances. A number of basic guiding principles can be derived from this collective experience.

- *Conservation measures must be solidly grounded in the natural sciences, but should also involve the social sciences, humanities, law, education, economics, and other fields.* Fortunately, cranes are among the best-studied groups of organisms on earth. Effective conservation, however, requires that scientific knowledge be linked with an understanding of the human dimensions of the challenge—the social forces and trends that affect crane populations and habitats. Consequently, in situ conservation programs must be broadly conceived, and must combine research with legal protection, habitat protection and management, education, community participation, and other components. All of these features can and must contribute to balanced programs that sustain crane populations, crane habitats, and local human communities.
- *Conservation measures should be envisioned at multiple scales of time and space.* Conservation programs for cranes have spanned broad temporal and spatial scales, from highly localized and immediate efforts to save threatened habitats and populations, to longer-term programs in, for example, ecosystem restoration, watershed-scale planning, and maintenance of viable populations in captivity.
- *Conservation measures should seek to harmonize species-oriented and ecosystem-oriented approaches.* As well-known birds that serve as "umbrella" and "flagship" species, cranes have drawn attention to, and provided protection for, a broad array of other species as well as the processes that maintain ecosystem health. In the long run, cranes must be viewed within a larger landscape, watershed, or ecosystem context, and conservation activities must be coordinated at these scales. In particular, managers must appreciate the roles of flooding, fire, vegetation change, and other processes in these dynamic systems.
- *Conservation measures should take into account biological attributes and processes at all levels of the biological hierarchy.* Crane conservation has required attention to problems at the genetic, individual, population, subspecies, species, and family levels. Especially in the case of the Whooping Crane and the other highly endangered species, these problems need to be considered simultaneously to minimize risk.
- *Conservation measures should work across national, cultural, and ecological boundaries.* Because most cranes are migratory, and all occur in more than one country, successful conservation requires a clear consensus on goals and responsibilities among parties from different parts of the species' range, constant communication of reliable scientific information, and support from various governments, international institutions, and nongovernmental organizations.
- *Conservation measures should seek to address local community development and conservation needs in an integrated fashion.* Efforts to conserve cranes—especially the 12 species occurring in Asia and Africa—are interwoven with the challenges of local sustainable development. Wild resources of wetlands and their watersheds cannot be conserved without active involvement, and leadership, from the resource users. In many cases, local people have vital clues to the best solutions for the threats confronting cranes.
- *The relationship between in situ and ex situ conservation measures should be well defined.* Captive propagation and reintroduction programs should be undertaken only as a last resort, and not as a substitute for in situ programs. Should ex situ programs become necessary, they should be developed based on clear goals and management guidelines. Priority should be placed on the maintenance and enhancement of genetic diversity

within crane populations, on safe and effective methods for reintroduction, and on assurance of high-quality care for captive cranes.

- *Education should be integrated into all conservation programs.* Ultimately, the conservation of cranes requires an informed public that understands and supports activities that sustain cranes and their habitats. Throughout the world, crane conservation programs have taken advantage of the opportunity that cranes provide for communicating basic information about wetlands and endangered species management.

Cranes, along with much of the world's biodiversity, will face difficult circumstances in the coming decades. History provides somber lessons about the speed with which even abundant species can become threatened. Although the survival (or, in some cases, recovery) of the cranes cannot be assured, many steps can be taken to enhance their chances. Compared with the prospects 50 years ago—when most crane species and populations were dwindling, scientific knowledge was scarce, and conservation efforts were essentially nonexistent—there is reason for cautious optimism. And in safeguarding cranes, we may ensure a more secure future for other members of the ecosystems in which cranes occur, including people.

Questions for Discussion

1. Black-footed ferrets were reintroduced into the wild in several small, isolated populations. Discuss the possible genetic consequences of this aspect of the recovery plan and the possible implications for the ferrets' long-term susceptibility to canine distemper. What alternative approaches might be possible?

2. There is currently considerable debate about the best way to manage endangered species. At the extremes, one school of thought holds that a species-based approach is essential, while the other school argues that we cannot protect all species, so we should shift to an ecosystem-based approach. In the context of the studies presented here, discuss the pros and cons of each approach. Are they mutually exclusive approaches to biodiversity protection?

3. Computer models of sea turtle conservation options (Crouse et al. 1987) show that protecting the larger juveniles and adults will result in faster recovery of populations than protecting eggs and hatchlings. Because of this, some conservationists argue that protection of nests and eggs is misguided, and that we should concentrate our efforts on protecting the larger, older turtles. Others argue that new turtles can only come from eggs, and that if we abandon protection of early life stages, the species will still go extinct as the older individuals die off from natural causes and are not replaced due to excessive egg and hatchling mortality. What do you think?

4. The Australian Aboriginal peoples are becoming important players in sea turtle conservation and management, partly because of their long-term use and knowledge of the various species. Are there indigenous peoples near you that have lived on the land long enough to have gained insight that would be relevant and useful to conservation managers? How might you incorporate them into local management scenarios?

5. Compare the Conservation Area approach to multiple use of public lands in Costa Rica with the multiple-use approach taken by the U.S. Bureau of