Eastern Sarus Crane PHVA

Khao Kheow Open Zoo
Chon Buri, Thailand

15-17 January 1997

Final Report

A contribution of the IUCN/SSC Conservation Breeding Specialist Group in collaboration with the Khao Kheow Open Zoo, Chon Buri, Thailand.

Sponsored by the International Crane Foundation (ICF).

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March 2000

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Grus antigone sharpii

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PREFACE

Preface

This Population Habitat and Viability Analysis (PHVA) arose from the convergence of multiple needs developing throughout Southeast Asia. By 1997, the remaining dry-season wetland habitat within Viet Nam's portion of the Mekong Delta had declined precipitously. Would there be enough habitat left within reserves like Tram Chim to support cranes? In Cambodia and Lao P.D.R., conservation agencies were keen to discover where and how many cranes might still occur within their borders. And if these birds were present, what was their status? In Thailand, there was a strong resolve to contribute to the conservation of Eastern Sarus Cranes, but how could this best be accomplished? Through re-introductions in Thailand? If so, where and how should these re-introductions be accomplished? Finally, Myanmar conservationists had just re-discovered the Eastern Sarus within their country. What was its status and how does the situation for cranes in Myanmar compare to circumstances in Southeast Asia? Did cranes in Myanmar ever mix with cranes in Southeast Asia?

During the middle of January, 1997, scientists and conservationists working in each country that harbors Eastern Sarus Cranes gathered at Khao Kheow Open Zoo for two days of collaboration. Through this meeting, the PHVA initiated a process that documented what we know about Eastern Sarus Cranes and then provided a framework through which participants could develop management recommendations that were as factually-based as possible. Through its objective approach, the PHVA process also guided participants in seeking a consensus that is represented in this report. Through the recommendations provided here, we have charted a course to gather more data, initiate management actions, develop supportive policies, and to repeat this process regularly. Now it is time to work!

And work we have. Already, several events have transpired during the two years between the completion of the PHVA and the publication of these proceedings. First, we have gathered new data that further defines the distribution of Eastern Sarus Cranes in Southeast Asia (Figure 1). It is my hope that as people evaluate and act upon the information contained in this report, they will add greatly to this body of knowledge.

Immediately following the PHVA, a Captive Management Workshop was held at the Khao Kheow Open Zoo (KKOZ). Fourteen representatives from captive centers holding Eastern Sarus Cranes in Thailand, Myanmar and Cambodia attended the workshop. During the two-day workshop, lectures on facilities, behavioral management, chick rearing and various release techniques were presented. The captive flock of Eastern Sarus Cranes at KKOZ and Bangpra Breeding Station provided the opportunity to practice capture and handling techniques and sex identification via the cranes' vocalizations and behavior. For future reference, a copy of the Cranes: Their Biology, Husbandry, and Conservation was distributed to each captive center represented at the workshop.

An exchange of staff between KKOZ and ICF for training had been discussed at the PHVA. The first step of this exchange occurred during the months of May - August 1997. Rob Nelson, a specialist trained at the International Crane Foundation, worked with cranes and personnel at Khao Kheow Open Zoo, Korat Zoo and the Royal Forest Department's Bangpra Breeding Station. Mr. Nelson's trip to Thailand complemented and continued the training started at the Captive Management Workshop. He assisted with improving the crane facilities, behavioral monitoring and provided constructive recommendations for additional improvements as funding and time allow. During the summer of 1999, a veterinarian from KKOZ hopes to study at ICF.

Shortly after Mr. Nelson left Thailand, ICF received word that a pair of Eastern Sarus Cranes at the Korat Zoo had laid two eggs. In September the first captive-bred Eastern Sarus Crane chicks hatched. The pair successfully raised one chick and the Korat staff raised the second. More encouraging news came in 1998 when two more pairs at Korat Zoo laid eggs and one chick was reared.

To benefit the wild Southeast Asia population, a new reserve management planning process was begun for Tram Chim National Reserve during 1997. The goal of this process was to establish Tram Chim National Park. "National Park" designation represents the highest protection status that Viet Nam can offer any of its wild areas. Vietnamese scientists conducted fieldwork in 1997 and 1998, and the first management meeting was hosted by Dong Thap Province in October, 1998. Here, a summary of research and park management efforts was presented and management recommendations were proposed. The report from this meeting was then sent to the national government in Hanoi and, in 1999, Tram Chim was declared a National Park. A second management meeting for Tram Chim is planned for June,1999. Additional fieldwork, conducted during the dry season of 1999, will help guide evaluation of recommendations.

Our knowledge of the distribution and abundance of the Eastern Sarus Crane is growing steadily. In 1997, a flock of Sarus Cranes was reported in Chokchai District, Thailand. Chokchai is near Korat. Though this location has not yet been plotted (we are unsure of Chokchai's location), this record offers hope for the re-establishment of Eastern Sarus Cranes in Thailand. If Sarus Cranes can be protected in Lao P.D.R. and Cambodia, and if appropriate habitat can be maintained in Thailand near the border with these countries, then there is a good chance that cranes may return to Thailand on their own.

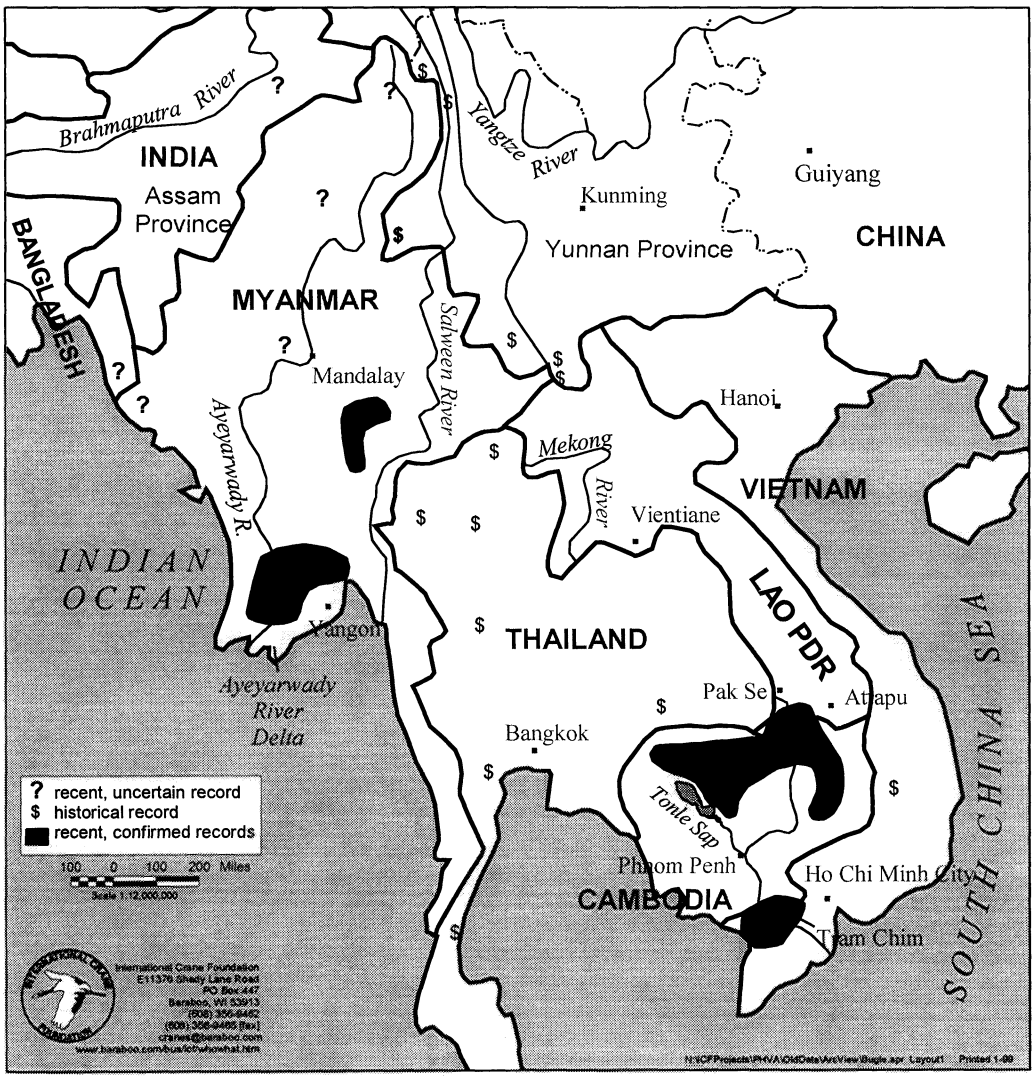
In 1998, seven cranes were captured at Tram Chim. Through cooperation with the Yamashina Institute for Ornithology of Japan, satellite transmitters were attached to four of these birds. These transmitters enabled us to track cranes to three new potential breeding areas, two south of the Sre Pok River and one likely nest site south of Preah Vihear Village (see Figure 2). Two of the birds with transmitters were members of the same pair. As interesting, one bird with a transmitter has since left the breeding area in late 1998, and has traveled to several new areas (these locations have not been plotted in Figure 2). This bird paused near the junction of the Sen River and the Tonle Sap and then flew to the very southern part of Takeo Province in Cambodia, near the border with Viet Nam. The Takeo location is from January and is not plotted in Figure 2. Finally, this same bird has recently moved to the Ha Tien Plain, located in the extreme southwestern portion of Viet Nam's Mekong Delta (also not plotted in Figure 2). The other birds are still in Cambodia on their breeding areas at this time (late March).

Since the PHVA meeting convened, Daw Tin Nwe Latt of the Myanmar Forest Ministry and Saw Tung Khaing of the Myanmar office of the Wildlife Conservation Society Office (WCS), have worked with ICF staff to conduct a series of crane surveys. Our knowledge of the range of Eastern Sarus Cranes has expanded as a result (Figure 1). We now have a greater understanding of the distribution of the breeding population in the delta of the Ayeyarwady River. Equally important, Sarus Cranes have been located in Rakhine State, near Myanmar's border with Bangladesh (Figure 1). It is not yet clear if these birds belong to the Indian Sarus subspecies (*Grus antigone antigone*), the Eastern Sarus subspecies (*G. a. sharpii*), or perhaps to a population that contains characteristics of both subspecies. These surveys have also located Sarus Cranes elsewhere in Myanmar, and helped to define the substantial conservation needs facing people and cranes there (Figure 2).

Clearly, more research and conservation actions on behalf of Eastern Sarus Cranes are needed. Now, through this process of consensus building within the PHVA, we have the opportunity to make important contributions that can help to protect this charismatic bird.

Jeb Barzen
Director, Field Ecology
International Crane Foundation

March 30, 1999



Past and Present Known Location Records for Eastern Sarus Cranes (Grus antigone sharpii) as of December, 1998.

Eastern Sarus Crane

Grus antigone sharpii

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EXECUTIVE SUMMARY AND RECOMMENDATIONS

Executive Summary and Recommendations

The Eastern Sarus Crane (*Grus antigone sharpii*), one of three subspecies, formerly occurred throughout Indochina but is now greatly reduced in distribution and numbers. It is currently listed as endangered. Flocks have been recently located in Myanmar, Cambodia, and Vietnam but the population may now be fragmented into 2 separate sub-populations. Total numbers are estimated to be between 1,000 and 1,600 birds. The subspecies was recommended for a full PHVA in the Crane Action Plan (1996).

Organization of a regionally based PHVA Workshop was undertaken by the International Crane Foundation in collaboration with biologists and officials from each of the range countries. The gracious offer of Khao Kheow Open Zoo (KKOZ) and the Zoological Parks Organization of Thailand (ZPO) to host the workshop at KKOZ was accepted. The Royal Forest Department of Thailand (RFD), World Wildlife Fund Thailand, Keidanren Nature Conservation Fund, and the Conservation Breeding Specialist Group also sponsored the meeting. The meeting was held 15-17 January 1997. Forty-nine people from range countries of the Eastern Sarus Crane participated, including 6 from Cambodia, 7 from Laos, 4 from Vietnam, 4 from China, 4 from Myanmar, and 19 from Thailand. The meeting was opened by Mr. Virot Pimmarnrotchanakoon of the RFD, Usum Nimmanheminda, Director of ZPO, and Pisit Na Pattaloong, Member of Parliament and Board member of ZPO. The morning and early afternoon of the first day were committed to presentations that focused upon the status of the Eastern Sarus Crane and its current and historical habitat in each of the range countries. These reports are included in the proceedings of this meeting. A presentation of the VORTEX model was also made. The design and guidelines for the workshop and the functions of facilitators were then explained.

Four working groups were formed with an initial assignment of people to the groups. The groups were 1) Southeast Asia wild population, 2) Myanmar and China (Yunnan Province) wild population, 3) life history and modeling, and 4) captive population. The groups were given the initial assignment to develop a list of the problems and needs for the species overall and in each country. This was accomplished before dinner. This list then served as a basis for the second task, begun in the evening, of assembling available information using a matrix-based data structuring tool. Assembly of information continued the second day with the added task of developing location-specific goals and management scenarios to correct the problems. Information was shared in plenary sessions each day and in informal exchanges between the groups. Formulation of recommendations began the second day and these were reviewed the second and third days when a general agreement with all of the recommendations was achieved. The reports from each of the working groups were drafted during the workshop process and are included in this document. The workshop was closed the evening of the third day with a multimedia slide show prepared by the KKOZ staff using pictures taken during the workshop followed with presentations of participation certificates and a closing address by the Chairman of ZPO, Lertrat Ratanavanich.

Recommendations

Southeast Asia Working Group (recommendations are listed in their order of priority)

1. Send copies of the PHVA report to appropriate range country government agencies.

2a. Obtain needed information on crane populations by a) marking birds in a coordinated program; b) surveying cranes on breeding, staging, and non-breeding habitats; c)surveying remaining habitat areas in Thailand (where birds have been extirpated); and d) estimate the magnitude of human-induced mortality on chicks and adults.

2b. Conduct draw downs at Tram Chim National Reserve in order to promote restoration of the Plain of Reeds and natural habitat of the Eastern Sarus Crane.

4. Provide technical training in basic data collection for government and local staff in Cambodia, Vietnam, Lao and Thailand. This can be done in conjunction with recommended surveys (see above).

5. Decrease the rate of chick or egg harvest by conveying information regarding provincial and national government wildlife laws to local villages in Dong Khaungtung and Xepian NBCA (Lao PDR) as well as in Stung Sen, Lomphat and Viachey protected areas (Cambodia).

6. Create management plans for Dong Khaungtung, Xepian, Stung Sen, Lomphat, Viachey, and Chekreing crane areas.

7. Conduct feeding studies on cranes in breeding areas and plant floating rice in non-breeding areas (at Tram Chim National Reserve) to provide food artificially in the dry season.

8. Create two breeding centers that will produce Eastern Sarus Cranes that can be put back into wild in Lao PDR and Cambodia.

9. Evaluate the condition of remaining non-breeding areas in Mekong Delta.

10. Increase protection efforts at Tram Chim.

11. Create nesting and resting areas at Tram Chim for crane use during the rainy season.

China and Myanmar (recommendations are <u>not</u> listed in their order of priority)

1. Survey for optimum habitat (Menghai county) that remains in Yunnan, China.

2. Develop a captive-breeding program for the Eastern Sarus Crane in China in preparation for reintroduction into its historical range.

3. Provide protection for the habitat and birds by education of local people and legislation.

4. Establish refuge areas in suitable locations.

5. Develop a release program that includes monitoring the population of released birds in the habitat and acquiring adequate founders to allow setting up a stable and genetically viable population in China.

6. Secure strong support from international agencies for financial and technical purposes and provide more influence on local government.

7. Increase information exchange with Southeast Asian countries for research and management.

8. Implement surveys to determine the ecology, abundance and distribution of cranes in Yunnan Province.

9. Develop a public education program for conservation of the Eastern Sarus Crane.

Captive Populations Working group (recommendations are <u>not</u> listed in their order of priority)

1. Establish the conditions needed to successfully and routinely breed Eastern Sarus Cranes at each facility participating in the captive program. This task will require improvements in facilities and training of staff.

2. Develop a regional captive management plan for Cambodia, China, Laos, Myanmar, Thailand, and Vietnam. This plan will require that all birds be uniquely marked, that a studbook is implemented, that a studbook keeper is appointed, and that each location maintain standard records.

3. Do not collect additional birds from the wild population for the captive programs. Where possible, utilize confiscated birds to expand the captive population.

4. Develop a plan to utilize and manage birds confiscated in Cambodia.
   Train staff to care for confiscated cranes.
   Develop criteria for returning confiscated birds to wild.

5. Eliminate the removal of crane chicks and eggs from the wild by local people or others. Develop a public awareness program about cranes, secure needed legislation, and seek enforcement of protection.

6. Develop eco-tourism programs for Eastern Sarus Cranes in selected locations.

7. Goals for the captive population based upon achieving captive breeding:

Year	# cranes in captivity	# breeding pairs
2002	90-95	8
2012	180-190	32

Eastern Sarus Crane

Grus antigone sharpii

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HISTORY

History of the Eastern Sarus Crane

By George W. Archibald

Until recently, there were perhaps four subspecies of Sarus (Grus antigone), the Indian Sarus (antigone), the Eastern Sarus (sharpii), the Philippine Sarus (luzonica), and the Australian Sarus (gilli). The Indian Sarus is the largest and best known of the subspecies and perhaps numbers as many as 25,000 individuals in areas of the northern plains of India where cranes are protected by the Hindu faith (Gole 1991). The Philippine Sarus was native to northern regions of the Luzon and was much smaller than the other subspecies (Hachisuka 1929). There is no evidence that cranes survive in the Philippines. All that remains of this island crane are several museum specimens. Undoubtedly due to its similarity to the Brolga (Grus rubicunda), the Australian Sarus went undetected by ornithologists until the 1960s although aboriginal people distinguished between Brolgas and the "Crane that dips its head in blood" for centuries (Lavery and Blackman 1969). There are several thousands of Australian Sarus and evidence they may be increasing.

The Eastern Sarus was first described in 1758 (Linnaeus 1758), long before anything was known about the Sarus in the Philippines (McGregor 1905) or Australia. It was distinguished from the Indian Sarus by its uniform steel gray color and lack of a white neck ring and white tertials. Eastern Sarus were widespread on expanses of wetlands from Burma to Vietnam and from Yunnan Province, China to the peninsula of Thailand. Until the 1950s, Thailand's great naturalist, Boonsong Lekagul recalls large flocks of Sarus on the plains near Bangkok (Lekagul, per comm., 1984).

In 1983, at International Crane Workshop in India, Thai ornithologists Ms. Bubphar Amget and Dr. Pilai Poonswaad reported that Sarus had vanished from Thailand (**83 Proceedings**). In 1984, the International Crane Foundation presented the Royal Forest Department of Thailand six Australian Sarus Cranes for captive propagation. At that time it was believed that the Eastern Sarus might be extirpated throughout its range on the Asian mainland. It was assumed that the Australian Sarus was closely related to the Eastern Sarus and had recently immigrated from Indochina to Australia, perhaps in the 1950s.

In Vietnam, during the dry season of 1984, local residents observed an unusual bird that had begun using wetlands diked to keep tree seedlings from burning in the dry season. Nguyen Xuan Truong, the former governor of Dong Thap Province, confirmed that these strange birds were Sarus Cranes. Dr. Le Dien Duc and his colleagues from the University of Hanoi followed up this discovery with surveys during 1985-1987. Dr. Duc announced this discovery to the world at the International Crane Workshop held in Qiqihar, China in 1987 (Duc 1991).

The area used by the cranes was called Tram Chim ("Bird Swamp"). The cranes arrived in November and departed in May, a period that coincides with the winter dry season when water levels of the Mekong are low and wide expanses of wetlands slowly dry (**Beilfuss 1991, Beilfuss & Barzen DATE**). Research was initiated in 1989. The largest single count of cranes at Tram Chim has been 1,052. Eventually, 9,000 hectares of wetlands were protected as Tram China National Reserve (**FIPI DATE**).

Not long after this discovery of Sarus in Vietnam, juvenile Sarus were captured in Cambodia and confiscated by conservation officers in Thailand. These cranes were rehabilitated at the Bangphra Crane Breeding Center, operated by the Royal Forest Department, Korat Zoo and Khao Khieo Open Zoo. It was noted that the birds from Cambodia were substantially larger than the Australian Sarus with bare red skin extending further down the upper portions of the neck. In 1997, Eastern Sarus bred in captivity for the first time at Korat Zoo. Thai conservationists hope eventually to re-establish Eastern Sarus in the wild of Thailand.

As wildlife research began in Cambodia and Laos in the early 1990s, Eastern Sarus were discovered in southeastern Laos near the border with Cambodia and in several areas of Cambodia including northeastern areas near Stung Treng and in northwest areas near Siam Reap (Barzen 1994). Unfortunately, comprehensive research in Cambodia has not been possible for security reasons.

Sarus have been spotted sporadically in western Yunnan Province. A chick had been captured in northwestern Yunnan in 1990 and is now residing in the Kunming Zoo. In 1996 a population was discovered in Myanmar (**Barzen, 1997**). Whereas the Sarus in Cambodia nest in pristine areas at considerable distances from humans, the Sarus on the Ayerarwady Delta live throughout the year in an agricultural landscape with scattered homes and villages (Barzen, 1997). Many of the people are devote Buddhists, where cranes are revered. As a result, the cranes are flourishing in close proximity.

The 15 years since the International Crane Workshop in India have been marked by significant discoveries of Eastern Sarus in Southeast Asia. The Population, Habitat and Viability Analysis Workshop, convened in Thailand in 1997, provided an opportunity for information exchange and planning among the range nations of the Eastern Sarus. The results of those deliberations are presented in this book.

I remain optimistic that - with widespread education, targeted research, habitat conservation, restoration and management, effective captive breeding and restocking - the Eastern Sarus Crane can flourish side by side with humans throughout their former range as they so beautifully do today on the Ayeyarwady Delta.

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Grus antigone sharpii

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CHINA AND MYANMAR: WILD POPULATION

Distribution, Threats and Needs of Eastern Sarus Crane In China and Myanmar

Workshop of Eastern Sarus Crane PHVA

Khao Kheow Open Zoo, Chonburi, Thailand

Group Facilitator. Mr. Kyaw Nyunt Lwin (Myanmar)

Participants. Prof Yang Lan, (China.)
Ms.Eleanor Briggs. (USA)
Mr.Pich Sam Ang. (Cambodia)
Ms,Tin Nwe Latt, (Myanmar)
Mr.Myo Hlaing. (Myanmar)
Mr.Kanchai Sanwong . (Thailand.)
Mr.Sounthaly Mountha.(Lao.PDR)
Ms.Xin Dai. (China)
Mr. Khin Maung Lin. (Myanmar)
Ms Chanpet Ratchanee. (Thailand)

(15 -17) January 1997.

1. Threats:

(1). Destruction of Habitat:

- Logging
- Cutting for production of charcoal
- Cutting for make crop land ,farming
- Shrimp and fish farming(aquaculture, in years to come)
- Economic development for plantation such as Coffee, Tea, Rubber etc.

(2). Destruction of Birds:

- poisoning
- hunting
- collection of eggs, young birds

(3). Wetland drained for farming and filled for construction

(4). People sometimes eat birds and eggs

(5). Desire to increase agricultural production by irrigation canals and changing kinds of rice used (effect hydrology)

(6). Use of insecticides and pesticides at forest, and cultivated land

2. Needs:

(1). Study and research of E. Sarus Crane habitats

(2). Education of local people about cranes

(3). Legal protection

(4). Study of E. Sarus Crane population (number and location)

(5). Organizations and staffs responsible for E. Sarus management

(6). Captive breeding for reintroduction

(7). International information network to discover changes on habitat and population at regional level(all south east Asia countries)

(8). Setting up of protected areas

(9). restoration of the habitats in possible areas

(10). Strong support from international community in technical, financial supports

(11). Sign agreement of CITES treaty(Myanmar)

(12). International organization for migration monitoring

(13) Bonn convention on migration species

(14). Ramsar convention--identify sites

(15). Biodiversity convention to protect all species

3. Matrix:

location	Threats	Qual. of habitat	Area	population
Myanmar				
1Ayeyarweatty Division	Poaching 10% nesting place destroyed for fish farming and banana plantation	Excellent & very little disturbance	34993/km2	400
2Bago Division	Poaching 70% insecticides and pesticides	Protected area	40/mile2(Moyingyi Lake)	+300
3Kayah State	Poaching 60% Illegal trade	Good & very little disturbance	240/mile2 (Mangpai Lake)	150
4Shan State	Poaching 40% Plantation.	***	248/mile2(Inle Lake)	100
China(Yunnan Province)				
Southwest:	Destruction of habitat -cultivated land	Poor	(Unit:ha)	9 Birds
-Mengla	-economic plantation		5110	
-Menghai			13730	
--Jinhong			3250	
		sub total:	22090	
2.Western Yunan	***			1 bird.
-Gengma		Poor(No crane)	3420	
-Reili			17470	
-Longchuan			27090	
		sub. total:	47980	
Northwest:	Geomorphologic factors			
-Gongshan	-high altitude	Intermediate	approx. 100	
-Zhongdian	-unfavorable climate	-birds stay for a short time	approx. 150	
	-no human disturbance	-no breeding	subtol. 250	
		Grand total:	***61960.***	960 birds

location	legal protection	Food	Historic records.	Natural catastrophies..	Reproduction
Myanmar.					
1.Ayeuarwady Division	Legally protected	Snail, Paddy, Field, all fish, small insects, bean etc.	None	Storm 4%,flooding4 %,.	Numbers of birds: 100male 60, female 40.
2. Bago Division	Legally protected		---	--None--	70 birds ,male 28 female 42.
3. Kayah State	Legally protected		---	--None--	30birds. male12, female18.
4.Shan State	Legally protected		---	--None--	25 birds. male7 female 18.
China (Yunnan Province)					
1. SW of Yunnan	legally protected.				
2.W. Yunnan.	legally protected		Yingging 602 in 1870s	-None-	--Nil--
3.NW. Yunnan	legally protected		-None-	-None-	--Nil--

Country,	Mortality rate	Carrying capacity trends.	Actual nest site sightings.	Migration.
Myanmar.	Age of bird.			
1.Ayeyawady division.	0 - 1 =80 % 1- 2 =40% 2- 3 =10%	800 trend 10 % decline.	11 nests	1-In country migration of habited quantity,
2.Bago division.	0 - 1 =80 % 1- 2 =40% 2- 3 =10%	450 trend 30 % decline.	-Nil-	Transboundary migration.
3 Kayah state.	0 - 1 =80 % 1- 2 =40% 2- 3 =10%	250 trends 15 % decline.	-Nil-	Transboundary migration.
4 Shan state.	0 - 1 =80 % 1- 2 =40% 2- 3 =10%	200 trends 10% decline.	-Nil-	Transboundary migration.
China.(Yunnan)				
SW.	0-1 40% 1-2 20% 2-3 <10%	>600 trend 15%-20% decline	Nil	Transboundary migration
W Yunan.	0-1 40% 1-2 20% 2-3 <10%	600 trend 15%-20% decline	Nil	***
NW Yunan.	0-1 40% 1-2 20% 2-3 <10%	200 trend 15%-20% decline	Nil	***
	Total.	***3100 birds.***		

Recommendations for Conservation of Eastern Sarus Crane in Yunnan, China and Myanmar

1. Survey of optimum habitat(Menghai county).
   Strong proposal for ecosystem survey such as natural environment , vegetation, living animals and biodiversity.

2. Apply captive breeding in China
   .acquire birds from other countries for breeding
   .training for the birds to adjust to the new environment
   .training of young birds to be ready for release to wild.

3. Monitoring the change of population of the released birds in the habitat.

4. Intensify the gene pools of the birds by getting new species of birds for breeding to set up a stable population in China.

5. Protection for the habitat and birds by education of local people and legal protection.

6. Strong support from international agencies for financial and technical purposes and more influence on local government.

7. Information exchange of the SEA countries both for research and management.

8. Implementation of surveys for population density, ecology, breeding pattern and migration pattern throughout the country.

9. Education of public for conservation of E. Sarus Crane.

10. Setting up of refuge areas in suitable locations.

Eastern Sarus Crane

Grus antigone sharpii

Population and Habitat Viability Assessment Workshop

Khao Kheow Open Zoo
Chon Buri, Thailand

15-17 January 1997

Report

SOUTHEAST ASIA WILD POPULATION

Southeast Asian Population

Group Members:

Oum Pisey (Cambodia) *Facilitator (first half) and Recorder (second half)*
Bernard O'Callaghan (Australia) *Recorder (first half)*
Jeb Barzen (USA) *Facilitator (second half)*
Thai Vinh (Vietnam)
Chhun Sareth (Cambodia)
Keomanivong Sythammevong (Lao PDR)
Boonhieng In Khamphay (Lao PDR)
Vongthong Yotleusai (Lao PDR)
Liangpaiboon Sanan (Thailand)
Pannacapituk Wanchai (Lao PDR)
Salumsey Phitthayaphone (Lao PDR)
Tran Le Ha (Vietnam)

From distribution data of Eastern Sarus Cranes it is clear that two distinct populations exist (Figure A). One population is restricted primarily to Myanmar and the western portion of Yunnan Province (China). The other population is restricted to southern Lao, northern Cambodia, and the Mekong Delta of Cambodia and Vietnam. Cranes that use to occur in Thailand could have belonged to either the Myanmar/China or the southeast Asia populations. If anecdotal reports are true, current crane sightings in Thailand may be of vagrants that come from the southeast Asia population. Our assumption is that cranes who breed in Lao and Cambodia move to areas where appropriate water conditions exist during the dry season. As the dry season progresses, wetland areas dry and cranes begin to concentrate. By late in the dry season, few wetlands remain and we assume that the majority of the southeast Asian crane population occurs in the Mekong Delta, probably at Tram Chim National Reserve (Vietnam). Population data from cranes that spend the non-breeding season at Tram Chim suggest that the southeast Asian population may be declining.

Our working group was represented by Lao, Thai, Khmer, and Vietnamese scientists who have worked with cranes. We also were represented by scientists from outside of this region who have experience working with Eastern Sarus cranes in southeast Asia. Our goal was to establish a set of prioritized recommendations that would promote the recovery of this species. Observations by all group members were included in our discussions and consensus was obtained in all cases.

To build our base of information, we first listed the general threats that we thought were relevant in the region (Table A). This process consisted of a simple brainstorming exercise and no priority was placed on any of the threats. Any threat listed by members of the group was listed.

Table A **Threats to Eastern Sarus cranes in Southeast Asia**:

* Seasonal migration of birds
* Changes in lifestyle
* Harvesting and hunting: collection of eggs, young birds, and shooting of adults
* Fire and burning
* Lack of information regarding the population of birds (especially Cambodia and Lao)
* Lack of awareness of the values of the birds
* Lack of management
* Lack of enforcement
* Lack of resources

After creating this list, working group participants re-examined the list and expanded upon it (Table B).

Table B **Expanded threats to Eastern Sarus Cranes in southeast Asia**

Lack of resources
* Human resources
* Financial resources

Changes in hydrology due to development projects

Irrigation

Human lifestyles
* Poverty and lack of meat (lack of money to buy food)
* Shifting cultivation in uplands
* Migration of people into unsettled areas

Fire and burning
* for conversion to rice paddy
* catching turtles and eggs
* to prepare forest for cultivation
* carelessness
* create new grassland
* intentional burning

Lack of information about the species
* Sex of crane (population)
* Genetic differences between SEA and Myanmar/China populations
* Breeding information
  - habitat
  - seasonality / patterns

- mortality rates
- location
- rate (no. times/ year)
- ages and lifecycles (age at first breeding and age at senility - life expectancy)

* Population status (endangered or not)
* Migration pattern
* Behavior: breeding, feeding, nesting
* Habitat requirements

Lack of awareness of cranes (conservation)

* By local people
  - hunting, etc
  - changing habitats
* By government
  - no conservation
  - no action plans
  - protected areas
* No education for poor people
  - no educational materials (such as posters to distribute to schools)

Lack of management

* Lack of funds
* Lack of numbers of staff and human resources
* Lack of trained staff in:
  - protected areas
  - birds
  - habitat management
  - field surveys
  - non-timber forest production
* Plans
* Vehicles and equipment
* Ecotourism (no infrastructure)
* Research

Lack of Enforcement

* Communication
  - among governmental units (National - Provincial- Local)
  - among international organizations
  - among NGO's
* Training and human resource development
* Good, integrated laws and regulations
* Community support

Third, we established a matrix that listed these threats by specific regions (Figure ?, Table 2). In addition to threats, we listed several other attributes for each region. Where it was known, size, number of birds, protection status, trends in the current population, and foods of the cranes were listed for each area.

As a form of analysis for this matrix we next listed these same areas and proposed what we wanted crane numbers to be in the future (Table 3). In this table we also listed the actions that might be required to obtain these future population goals.

Finally, we summarized our list of actions and listed them as recommendations (Table 4).

II) **Recommendation:**

1. **Send PHVA Reports To Appropriate Government Agencies**:

VN:

Prime Minister, Mr. Vo Van Kiet
Minister of Forestry, Mr. Nguyen Quang Ha
Minister of Technology, Science, and Environment
Department of Environment, Mr. Sinh
President of Dong Thap Province, Mr. Le Minh Chau

LAOS:

Ministry of Agriculture and Forestry,
Ministry of Foreign affairs - committee of Planning,
STENO (Science and Technology and Environment Office
CPAWM (

CAMBODIA:

MoE- Dept. nature and protected areas,
Ministry of Agriculture, Forestry and Fisheries-Dept. fishery and forestry.

THAILAND:

2. **Make More Information**

a) marking birds (coordinated):
- in non-breeding area :ICF/TCNR-Satellite radio.
-breeding area: NW population 10 chicks (capture flightless) and NE pop.10 chicks.
possibly done jointly between Lao-Khmer with some assistance from WCS, ICF, WI, and Webs.

b) Coordinated Surveys or counts:
*breeding area: NW pop.(khmer) Stung Sen marshes,
NE pop.(Lao:Dong khaung tung, Xe Pian-
jointly with
Cambodia:Virachey NP, Lomphat)
*staging area: Chekreing (khmer).
*non-breeding: conduct coordinated survey in Mekong Delta (VN/Khmer joint)

*survey for remaining habitat along Thai, Lao and Cambodian border .
*estimate the number of chicks in non-breeding season to estimate first year mortality

c) Estimate human caused mortality: chick-breeding area and adult -non-breeding area.

3. **Conduct Draw downs At Tram Chim Nature Reserve -** in order to promote restoration of the plain of reeds and natural habitats of ESCR.

a) conduct public education program for people living in buffer zone
to not burn grass

b) seek permission to conduct draw downs from:
Dong Thap province,
MoForestry,
Top government (Vo Van Kiet)
Scientists from top government (for example, CRES, Sub-Institute of Forestry)

c) conduct experiments in optimum level of draw downs.

d) establishment of poverty alleviation programs for people buffer area to provide alternatives to burning in the reserve.

4. **Provide Technical Training For Government And Local Staff -** in basic data collection:
Cambodia, VN, Lao and Thailand can do in conjunction with recommendation for surveys listed above.

5. **Convey Information Regarding Provincial And National Government Wildlife Laws** to local villagers in :
Dong Khaungtung and Xe Pian.NBCA,
Stung Sen, Lomphat and Vira Chey.

a) educate local villages about law and animal identification .

b) make contract with actual villages for protecting wildlife.

6. **Create Management Plans** for (this includes providing a better definition of boundaries for each of the reserves):
Dong Khaungtung, Xe Pian,
Stung Sen, Lomphat, Vira Chey, and Chekreing (non-breeding birds)

7. **Conduct Feeding Studies On Cranes** on :
a) breeding area: what do they eat?

b) non breeding areas: plant floating rice in reserve to provide artificial food in the dry season.

8. **Create 2 Breeding Centers** for release of crane back into wild: Laos, Cambodia.

9. **Evaluate Condition Of Non-Breeding Areas In Mekong Delta** .

10. **Increase Protection Effort At Tram Chim**:
a) build 6 more towers
b) improve buffer area mgt.
c) hire 30 more guards.

11. **Create Nesting/Resting Areas At Tram Chim** for crane use during the rainy season.

Eastern Sarus Crane

Grus antigone sharpii

Population and Habitat Viability Assessment Workshop

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Report

CAPTIVE POPULATIONS

Captive Management Working Group

Participants:

Summate Kamolorranath
Nim Sany
Kanya Keerate
Kohn Kum Vichit
Li Chun
Dr. Songchai
Kungphrom Urarika
Chanpet Ratchanee
Orasan Thovorn
Marianne Wellington
Seng Kim Hout
Myo Hlaing
Dr. Visit
Pattanarang San Rattapan
Dr. Punchai (Ku)
Rujirat Susapan
Rattana Wiboon Kosin
Wanchai Tunwattana
Poothong Songkrod

The working group consisted of at least one representative from each country. A total of 67 Eastern Sarus Cranes are in captivity. Twenty-six are housed as pairs in eight different captive centers. Only 2 females have produced eggs. One bird at Bangpra Breeding Center and the second one at the Korat Zoo. The second female to produce eggs in captivity laid eggs while at Korat Zoo. This pair was later transferred to the Chiang Mia Zoo and has not produced eggs since the transfer. Table 1 summarizes the current captive population and reproductive situation. Table 2 summarizes whether the cranes are on or off display and the staff available to care for the birds.

Table 1. Summary of Eastern Sarus Cranes in Captivity and Reproductive Status

Country	Institution	# M.F.U	# Pairs (target #)	Breeding pairs	Eggs Produced	Fertility
China	Beijing Zoo	1.2.0	1 (3)	1	0	0
	Zhalong Nat. Reserve	1.1.0	1 (1)	1	0	0
	Kunming	1.0.0	0 (2)	0	0	0
Myanmar	Rangoon Zoo	2.5.1	2 (2)	1	6	0
	Hlawga Park	1.0.0	0 (2)	0	0	0
Cambodia	Tamao Zoo	1.0.0	0 (4)	0	0	0
	Siemreap	1.1.0	1 (2)	0	0	0
Laos	Thu La Kom	0.0.2	0	0	0	0
Thailand	RFD: Bangpra	9.4.1	4 (6)	1	0	0
	TZO: Chang Mia Zoo	1.1.0**	1 (1)	1	1	0
	Korat Zoo	9.6.3	3 (5)	0	0	0
	Khao Kheow Zoo	0.0.12	0 (8)	0	0	0
Vietnam	Ho Chi Minh Zoo	0.0.1	0 (2)	0	0	0

*Males. Females. Unknown sex

** This pair laid eggs while at Korat Zoo though no chicks hatched. Fertility of eggs was unknown..

Table 2. Facilities and staff to care for cranes

Country	Institution	# of birds	Off Exhibit	Distance from people: meters	On Exhibit	Distance in meters	# keepers (senior keepers)	# of Vet	Curator
China	Beijing Zoo	1.0.0	No	NA	Yes	0	1 (1)	1	1
	Zhalong Center	1.1.0	Yes	0	N	NA	1	1	1
	Kunming Zoo	1.0.0	N	NA	Yes	1	1	1	1
Myanmar	Hlawga	1.0.0	N	NA	Y	3 – 4.5	1(0)	1	1
	Rangoon Zoo	2.5.1	N	NA	Yes	3 – 6	3(0)	2	2
Cambodia	Phnom Tamao Zoo	1.0.0	Yes	0-free range	N	NA	7(2)	2	0
	Siemreap	1.1.0	Yes	0-free range	N	NA	3 (1)	0	0
Laos	Thu La Kom	0.0.2	No	NA	Yes	0	1(1)	2	1
Thailand	RFD: Bangpra	9.4.1	Yes	2 m	Yes	2	5 (1)	0	1
	Chiang Mai Zoo	1.1.0	No	NA	Yes	0.5 m	1 (1)	2	1
	Korat Zoo	9.6.3	No	NA	Yes	4 m	2 (0)	2	1
	Khao Kheow	0.0.12	Yes	0	No	NA	1(1)	2	0
Vietnam	Ho Chi Minh Z.	0.0.1	No	NA	Yes	0	1 (1)	1	1

China: Two males and one female are in captivity. The one pair is a pair of Australian Sarus Cranes from ICF. The second male is from northern part of Yunnan. They have few birds in captivity. The pair they have do not produce eggs. They would like more cooperation and advice from ICF and other institutions in order to get more birds in captivity. Financial standing is good. They would need to build breeding facilities.

Myanmar: Eight birds are in captivity at the Rangoon Zoo and 1 bird at Mandalay. Sex of birds is unknown. No breeding has occurred. Problems that were identified are the need for financial support and captive management assistance. Currently there is no emphasis on breeding the Sarus Cranes but they will emphasize this after listening to people discuss population concerns and the trouble people are having getting the birds to breed in captivity.

Cambodia: Three birds are held in captivity in Cambodia. A male and female are maintained at Siemreap and a male at Phnom Tamao. The birds at Siemreap are housed in a very small pen, 5' x 7' at night and are free raging during the day. These birds were confiscated when they were less than one month old and hand-reared at the Wildlife Protection Office. Little to no money is currently budgeted to care for the animals at Siemreap; therefore, it is necessary to let them forage for food. Birds are not considered to be on public display due to no tourists coming to the office. The cranes still do have a lot of contact with people. Three staff members care for the cranes but only one (Nim Sany) has some training in the care of cranes. Phnom Tamao Zoo maintains one male Eastern Sarus Crane, the age of which was not discussed.

Thailand:

With the number of Eastern Sarus Cranes in captivity being higher than originally expected, discussions centered on improving management of birds in captivity and the reasons why birds were coming into captivity in the first place. A list by institution of the training needs requested can be found in Table 3. We hope that many of these issues can be addressed at the Captive Management Workshop to be held January 19-20 after the PHVA Workshop is completed.

Table 3. Priority of Training Requests for better Management of Eastern Sarus Canes in Captivity.

Country / Institution	Management Plan	Behavioral Management	Sexing Technique	Nutrition	Sanitation	Breeding & Rearing	Health care	Enrichment pens-behavior
Cambodia	1	3	5	6	7	4	8	2
China	1	5	3	7	6	2	4	8
Laos	1	4	3	7	8	2	5	6
Myanmar	1	4	7	8	**5**	**5**	3	6
Thailand Bangkok	5	7	8	3	4	1	2	6
Korat Zoo	1	2	8	4	6	3	7	5
Khao Kheow Open Zoo	1	3	2	5	8	7	6	4
Chiang Mai	1	4	2	3	6	7	8	5
Vietnam	1	7	8	4	5	2	6	3

Participants listed public education as the main purpose for maintaining birds in captivity. Breeding birds with the potential of supporting future releases was also very important. Currently the captive flock is not a self -sustaining population. The population growth has been due to placement of confiscated birds into zoos. Reintroduction discussions were tabled in order to focus on the captive management and confiscation issues.

Information about the captive cranes was collected and entered into the studbook maintained at Khao Kheow Open Zoo. Dr. Rattanapan Pattnarangsan (Tom) has agreed to be studbook keeper. He will work with the Captive Management working group suggesting potential transfer of cranes from one institution to another in order to create more potential breeding pairs. It was recommended to keep the captive birds from Myanmar/Yunnan and the Southeast Asia population separate at this time due to questions regarding genetic relationship. A copy of the studbook at the time of the PHVA is included.

Recommendations from Captive Management Working Group

Recommendations to create a regional Captive Management Working Group lead to discussions on how to go about this and who would represent each country. Songkrod

(Thailand) and Nim Sany (Cambodia) were nominated to help identify persons to participate and organize the working group. The group will try to meet within the next year.

1) Improve management of cranes to increase captive reproduction
    - Mark individual birds uniquely
    - Create and maintain good record keeping system (use of ARKS?)
    - Maintain regional studbook, Studbook keeper: Dr. Rattanapan Pattnarangsan at KKOZ
    - Identify needs, train staff
    - Improve facilities

2) Develop regional captive management plan. (Songkrod and Ms. Nim Sany will organize)

3) Develop plan to deal with confiscated animals in Cambodia

4) Prohibit collection of cranes from the wild to support captive management program. If needed, confiscated animals will be distributed to participating zoos if they can not be returned to the wild.

Discussions of illegal collection of animals and steps proposed to correct the problem

Illegal collection of birds from the wild is of high concern in Cambodia. Currently, small number of crane chicks is being brought into captivity due to the cost of travel, ability to care for the chicks and the high amount of stress to the birds. Wildlife Protection Agency has submitted stronger legislation to be adopted concerning the poaching of all birds, including the Eastern Sarus Carne.

The average number of crane chicks confiscated each year ranges between 15-20. Cambodia would like to place them in current captive centers. This amount of birds should be able to supply the current collection plans of the institutions, therefore, it is not recommended to collect birds from the wild for the captive population.

Eggs and chicks less than one month of age are the most common age group of cranes collected from the wild. These birds become highly imprinted on people. All confiscated animals have problems with improper imprinting. The live mammal trade is not as much of a problem since most mammals are killed for skin, food, and carcass. Usually birds are alive when they are confiscated. People collect eggs and birds. One example is peacocks being collected for their tail feathers. Reptiles collected from the wild often have their mouths sown shut. This makes transportation of the animals safer for people but prevents the animal from eating.

A major concern for the conservation of birds in Cambodia is the fact that people collect the eggs and chicks of all species including storks, cranes and ibis. These birds become a source of food or items for trade. This is traditionally how many Cambodians have survived. It is very expensive for wildlife officers to confiscate animals due to difficult travel conditions. Many animals would die once officers collected them due to length of travel to centers that can maintain the animals. Currently centers, which can take confiscated animals, have limited facilities and staffing to care for large numbers of animals.

Summary of collection and/or trade

Birds: 22,000 eggs of storks and ibis, 300 stork chicks
Crane: in 1994 - 3 chicks were collected in Siemreap
1995 - 4 chicks
1996 - 5 chicks
Northeast Cambodia 15 more chicks were confiscated

Cambodia wants to enforce confiscation regulations by:
*Increasing public awareness
*Increase fines and punishment for anyone collecting birds illegally. Changed legislation has already been submitted for review. It will take 1.5 years to decide if this will be accepted.

Current Law enforcement:
First offense: person has to make agreement not to repeat offense and pays fine
Second: person goes to jail for 3-5 months
Drafting new legislation:
First offense: person makes agreement and pays 10 time price of animal (1,500 baht = $60 US)
Second offense: Fine doubles and go to jail for 1 year
Third offense: Double fine and double jail term

Birds go to government. Government needs to do something with animals whether it is placement at a zoo or attempt to release back into wild.

Correcting the problems of illegal harvesting of animals is a very difficult situation. Local people are dirt poor and traditionally have survived by harvesting the wild animals. The Cambodian government is working on developing programs to help local people.

Recommendations for stopping illegal taking of birds and placement of those confiscated:

1) Develop public awareness of cranes and legislation
    - 1997 create posters
    - Eco-tourism - cranes very beautiful, bring in birding
    - Strategy: Send representatives a posters and video cassette with information on identification of birds and that they are protected species.

2) 1997 write proposal to develop small group of officers who are trained to evaluate the potential of returning birds back to the wild. Have teams identified in 1998.

3) Need to develop criteria for returning birds to wild and management including the information collection process: knowledge of chick's history (age, how long in captivity, location collected).
    - If chick recently collected from the wild, decide what to do with the chicks Determine age, location of collection. Evaluate potential of returning chick back to parents. Give small stipend for person to protect and monitor the chick and its parents. This stipend will also help with education of the local people by putting a lot of attention at site of collection.

4) Training of staff to care for the animals
    - Currently on Nim Sany has been trained on the rearing of crane chicks and proper handling techniques.

5) Facilities needed for rehabilitation of birds to be reintroduced
    - Flight ability of birds to be reintroduced is very important.
    - Address imprinting concerns

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Report

WILD POPULATION MODELING

Population Modeling

I Input Parameters And Sensitivity Analysis

It was agreed in the workshop that the two populations - one in the Myanmar-China region and one in the South East Asia region (Laos, Cambodia and Viet Nam) – would be modeled as two separate populations. They are considered to be distinct with minimum natural exchange. Through discussions among workshop participants, two preliminary sets of values for VORTEX input parameters were established for the two populations. The results of modeling were presented immediately to the workshop participants to receive feedback and to stimulate thinking. The lack of appropriate population monitoring data made quantitative estimation of vital parameters (birth rates and death rates) for both populations impossible. Thus many of the preliminary values of input parameters were merely the "best guesses" or "agreement" among workshop participants. A **Base Model** was then developed for each population, which differed from the preliminary models mainly in reproduction and mortality rates. Values for reproduction and mortality of the whooping crane population were used as estimates. These base models were used as the scenarios for the sensitivity analysis of the responses of Eastern Sarus crane populations to variations in values of input parameters including reproduction, adult mortality, chick mortality, the effects of catastrophes, loss of habitat, and harvesting or removals of birds from the populations.

1. Parameter values

Inbreeding depression: Since the Sarus crane populations in Myanmar-China region (**M/C population**) and in the South East Asia (**SEA population**) are currently greater than 500, and there are no data indicating that these populations ever experienced a bottleneck, it is unlikely that inbreeding has had a significant effect on population viability of cranes in both areas. Inbreeding could become a factor in their viability if the populations decline in size but is not likely to affect the populations over the 100 year time projections used in these simulations.

Reproduction: The Eastern Sarus cranes are monogamous and the sex ratio of adult birds is about 1:1 (Meine & Archibald 1996). It was assumed that all adult males are potential mates (i.e. none of the adult males are excluded from the breeding population). The age of first breeding for both males and females was set at 4 years, an estimate that was used in the PHVA report for the Whooping crane (Mirande and Cannon, 1995). Maximum breeding age for both males and females was set at 25 years, a rather conservative estimate as compared to a maximum breeding age of 40 for the Whooping crane (Mirande & Cannon 1995). Although a maximum clutch size of 3 may rarely occur, based on an observation made by Archibald on the crane population in Tram Chim in 1991 (see Tran, 1994), we have used a size of two since three appears to be an unusual event. The clutch size of 2 was used with the proportions of females producing a clutch size of 0, 1, and 2 set with a variable proportion of birds producing clutches in different scenarios but with a constant proportion of 88% producing a clutch with one

chick and 12% with 2 chicks of those producing chicks. The proportion of female birds that produce different clutch sizes (88% with one and 12% with 2) was derived from the 29 -year period of Aransas records (1938-39 through 1966-67) (see Mirande & Cannon 1995) that were used for the base models. This portion of the data set was selected because during that period, egg removal was not applied to the Aransas/Wood Buffalo Whooping crane population. These estimates was used for both the M/C and SEA populations.

Mortality: The preliminary estimations of mortality rates at the workshop were not based on any quantitative data. Initial runs of these scenarios with some suggested values indicated very rapid extinction of the populations which does not fit the observations on the trends in sizes of the populations over the past several decades. It then was decided to use values for reproduction and mortality from the detailed information on the Whooping crane population in the **Base** models (Tables 1-3 listing SARUS4 scenario results). The Aransas/Wood Buffalo Whooping crane population has a detailed long term monitoring record of reproduction and age dependent mortality rates. These mortality rates of the Whooping crane population were used for the Eastern Sarus crane with the necessary assumption that there is not much difference in the natural (undisturbed) reproduction and mortality rates between these two species. Mortality rates of Whooping crane used were derived from the 57-year data set (1938-39 through 1994-95) which yielded 27% for age 0-1 and 10% for all ages above one (Mirande & Cannon 1995). These values of reproduction and mortality were used for both the SEA and the M/C Sarus crane populations.

Catastrophe. For the SEA and M/C populations, a flood catastrophe was suggested with a probability of occurrence of 2% with a severity on reproduction of 0.4 and on survival of 0.9 Additional catastrophes were added separately in some scenarios (SARUS5A or SARUS5B in the tables): one at a frequency of 6.6%, reproduction severity of 0.2 and a survival severity effect of 1.0 (no effect) and another at a frequency of 5.0% with a reproduction effect of 1.0 and survival severity of 0.9.

Population size and carrying capacity: The initial population sizes of SEA and M/C population were set at 1000 and 600 individuals respectively. The carrying capacity for the SEA population was set at 5000 and for the M/C population, carrying capacity was estimated at 3000. Both values for K were 5-fold greater than the estimated population sizes reflecting the inference that the estimated stability of population sizes for the past two decades have been the result limiting factors such as chick and adult removals. Losses of habitat, as a result of intrusions for rice production, are projected at –1% for 20 years for the SEA population and –2.5% for 20 years for the M/C population.

Harvesting: The effect of harvesting was not included in the base models, but was explored in sensitivity analyses of the base models (scenarios SARUS6A.and SARUS6B in the tables). Harvesting was included in the modeling to reflect the effect of adult bird hunting and chick removals on the crane populations. For the SEA population, the harvesting rate was estimated at 30 chicks per year (equal numbers of males and females since the sexes cannot be distinguished in the chicks) for the first 20 years of the

100 year simulation. For the M/C population, 12 adults, (6 males and 6 females) were harvested every year for the first 20 years.

2. Sensitivity analysis

One of the advantages of VORTEX is the ability to analyze, through stochastic simulations, the projection of the population dynamics using a range of values of the input parameters. This exploration - sensitivity analysis - can be used to test the relative impacts of internal and external factors (e.g. carrying capacity or chick mortality) on the growth rate and viability of the population studied. It can also estimate the level at which a factor might result in a negative growth rate and thus increased risk of extinction of the population.

For the Eastern Sarus crane, harvesting and declining carrying capacity of the environment were identified at the workshop as major threats to both the SEA and the M/C populations. Several rates of adult bird and egg or chick harvesting were tested to evaluate their effects on the crane populations. A decreasing trend in environmental carrying capacity for both populations is likely to happen in the near future. As evaluated by the participants, the pace of habitat loss may be more rapid in the distribution areas of the smaller M/C population. The probabilities of survival or viability of the two populations were simulated at two rates of declining carrying capacity, either -1% per year for the M/C population or -2.5% per year for the SEA population for 20 years. Carrying capacity was also set at 1500 and 3000 to determine if the lower K had an effect on risk of extinction under each of the combinations of mortality and reproductive rates.

For the SEA population, the Tram Chim wetland reserve in Viet Nam is probably the most important non-breeding area. The water level inside the reserve is now actively controlled by a system of dikes and water gates (Beifuss & Barzen 1995). Under political pressure from the provincial government, Tram Chim managers tend to keep a high water level inside the reserve all year round in order to protect areas of melaleuca forest from fires. High water level during the dry season has limited the areas of suitable habitat for the cranes. In the years of high water level, fewer cranes may use Tram Chim wetlands and some may be forced to land on other wetlands nearby where they may encounter higher mortality rates due to hunting or unsuitable habitat.

There was a wide range of chick mortality estimates suggested by workshop participants. We tested chick mortality rates of 27% (the base rate for the whooping crane population which is not exploited), 32%, and 37% to explore their effects on the populations. The effects of recruitment rates on the populations were varied with the proportion of clutches produced annually set at 37, 42, or 47% with the proportion of clutch sizes produced set at 88% for one and 12% for two chicks in each case.

II Results Of Vortex Simulations

All simulations were run for 100 years with 500 iterations using VORTEX version 8.1.

1. The Base Model

The **BASE** scenario had the following parameter values: Single population modeled with extinction defined as no birds of one or both sexes surviving. Inbreeding depression and density dependence were not included. Concordance in EV between reproduction and mortality was not considered to occur in the cranes. Age of first reproduction of females and males was set at 4 years, maximum breeding age at 25 years, sex ratio at hatching 50.0 per cent of males (equal), and with monogamous mating and all adult males in the breeding pool. Proportion of females producing clutches and fledging chicks annually was set at 42% with EV = 12.5, and with 88% producing clutches of size 1 and 12 % of size 2 as derived from the whooping crane data. Mortalities of the 0-1 age class = 27 $\pm$18% and of all older age classes = 10 $\pm$ 7% again based on the whooping crane data. The primary catastrophe values, used in all scenarios, were set at a frequency estimate = 2% with 0.4 severity effect on reproduction and 0.9 severity effect on survival. A starting population size of 600 with a stable age distribution, and K = 3000 was used for the base model representing the M/C population. The larger starting population and larger estimated carrying capacity of the SEA population would ameliorate adverse effects of marginal values in the M/C population scenarios. Habitat decline and removals were not included in the BASE scenario.

The results for this model (scenario SARUS4.010 in Table 2) yielded a deterministic r = 0.02, a stochastic r = 0.013, a mean final population size of 1818 (SD = 897) which is triple the starting population but still well under the estimated carrying capacity of 3000. There was a zero probability of extinction (PE) in 100 years. The generation time was calculated as 10.2 years for females and males yielding about 10 generations for the 100 years of the projections. Mean heterozygosity loss was 1.24% in 100 years or about 0.12 percent per generation. It is likely that this loss would be at least partially counterbalanced by the gain of new heterozygosity through mutation. The sex distribution remained equal with 1214 adults and 604 1-3 year olds in the final population. The time course of the increase in the population from the starting value of 600 (Figure 9) to 1818 at 100 years is slow with a doubling time of about 55 years. This is a low growth rate making the populations vulnerable to relatively small sustained increases in mortality or declines in reproduction.

2. Sensitivity analyses

Introduction

Sensitivity analyses were run to explore the relative impacts of different values of population parameters on the population growth rates ('r') and projected final mean population size ('N') of surviving populations after 100 years (Figures 1 – 8). The parameters examined included: (a) three rates of adult mortality (8, 10, or 12%) and their interaction with either chick or adult harvesting for 20 years (Figures 1 – 2); (b) proportion of females producing clutches each year (37, 42, or 47%) and the interaction with the three rates of annual adult mortality (Figures 3 – 4); (c) proportion of females producing clutches each year (3 rates) and the interaction with three rates of annual chick

mortality (27, 32, or 27%) (Figures 5 – 6); and the (d) interaction of the three rates of annual adult mortality with two different additional catastrophes (A or B) and two rates of habitat loss (-1% or -2.5% for 20 years) (Figures 7 – 8). The output values for all of the scenarios are tabulated in Tables 1-15.

A total of 540 scenarios were run representing all of the possible combinations of the above parameter values. All values of 'r' or 'N' across the iterations of scenarios with one value of a given parameter were then averaged (for example 180 scenarios each for 8, 10, and 12% adult mortality respectively) for comparison with averages for other values of the parameter and of other parameters. It is these averages that are plotted in Figures 1 – 8. These values allow only a relative (since they are means across a large number of different conditions) comparison of the impact of a particular parameter on population growth rate and mean final population size at 100 years.

Examination of the probability of extinction (PE column in the Tables) at 100 years provides another indicator of the viability of the populations. The mean population sizes at 100 years reported in Tables and in the Figures are for surviving populations only. The mean times to extinction (Mean TE) for populations going extinct are given the last column of the Tables.

The time series figures (9 – 15) present the mean population size (N) results for 500 iterations at 10 year intervals for the 100 years of the projections under the conditions specified for each figure.

Adult mortality and the effects of chick and adult harvest

The effects of 8, 10, and 12% adult mortality on the mean population growth rate (r) in the base scenarios were compared with and without the addition of chick or adult harvests for 20 years (Figure 1). As expected the mean growth rate over all scenarios declines with increasing adult mortality. Chick removals (15 male and 15 female chicks annually for the first 20 years) have a greater effect on decreasing the mean population growth rate than adult removals (6 males and 6 females annually for the first 20 years). Both types of removal have an adverse effect on population growth rates when compared to the growth rates without removals.

The effects of 8, 10, and 12% adult mortality on the mean final surviving population size in the base scenarios and in scenarios with the addition of chick or adult harvests for 20 years (Figure 2) reflect the differences in population growth rates. As expected the final population size is lower with increasing adult mortality and is below carrying capacity for 10 and 12% adult mortalities. Chick removals (15 male and 15 female chicks annually for the first 20 years) had a greater effect on decreasing the mean population size and the growth curve (Figure 9) than the removal of the adults in accord with the differences in effects on the population growth rates.

The PE increases significantly with the increase in adult mortality and is further increased with removals of adults of chicks from the population during the first 20 years

of the simulations. The risk of extinction is 2-3 times higher with the removals of the chicks than the adults.

Proportion of females producing clutches and adult mortality

The effects of 8, 10, and 12% adult mortality on the mean population growth rate were compared in scenarios with 47, 42, or 37% of females producing a clutch each year (Figure 3). As expected the growth rate declines with a decreasing proportion of females producing a clutch (increasing interbirth interval). If the base adult mortality rate is 10% in the wild population then the clutching rate needs to be at least 42% for the population to be stable.

The effects of 8, 10, and 12% adult mortality on the mean final surviving population size were compared in the scenarios with the 47, 42, or 37% of females producing a clutch each year (Figure 4). The mean final population size at 100 years declines with decreasing proportion of females producing a clutch (increasing interbirth interval). The time course of population growth at 8 (Figure 10) and 10% (Figure 11) adult mortality indicate that at 10% adult mortality the proportion of females producing chicks each year needs to be between and 40 and 47%, if the population size is to be stable or grow. The probability of extinction also increases with the reduction in reproduction.

Effects of chick mortality and female productivity

Comparison of the effects of 27, 32, and 37% chick mortality on the mean population growth rate in scenarios with 47, 42, or 37% of females producing a clutch each year indicated that the effects of chick mortality were additive (Figure 5). Adult mortality was held constant at 8% per year. As expected the growth rate declines with increasing chick mortality and decreasing proportion of females producing a clutch (increasing interbirth interval). However with only 8% adult mortality (which is lower than the 10% observed for whooping cranes) nearly all combinations have a positive growth rate.

The effects of 27, 32, and 37% chick mortality on the mean final surviving population size were compared in scenarios with 47, 42, or 37% of females producing a clutch each year (Figure 6). Adult mortality was held constant at 8% per year. The final mean population size declines with increasing chick mortality and decreasing proportion of females producing a clutch (increasing interbirth interval). However, all of the populations, except at the highest chick mortality and lowest reproductive rate, increased in numbers from the starting population size of 600 birds. Although the growth in population size over time for 8% adult mortality (Figure 10) was consistently lower with increasing chick mortality throughout the 100 years of the projections, all increased in size by 4 to 5-fold. In contrast at 10% adult mortality, a chick mortality of less than 37% is needed for the population to grow (Figure 14). The increase in chick mortality results in an increased risk of extinction which is further increased with a reduction in chick production.

Effects of additional catastrophes and habitat loss

Comparison of the effects of additional catastrophes: (1) SARUS5A, Cat. A, frequency = 6.6%, reproductive severity = 0.2 , and survival severity = 1.0; or (2) SARUS5B, Cat B, f = 5.0%, rs = 1.0, and ss = 0.9) indicated that they had similar effects on the population growth rate decreasing them by about one-third (Figure 7). The two rates of habitat loss: (1) (SARUS6A, -1% for 20 years or (2) SARUS6B, -2.5% for 20 years at the three levels of adult mortality (8, 10, & 12%) had only a small effect on the mean stochastic population growth rates as would be expected since neither mortality or reproductive rates are affected by a the decline in habitat.

Comparison of the effects of two additional catastrophes (5A, Cat. A frequency = 6.6%, reproductive severity = 0.2, and survival severity = 1.0; 5B, Cat B, f = 5.0%, rs = 1.0, and ss = 0.9) indicated only a small effect on mean final population size (Figure 8). The two rates of habitat loss (-1% or -2.5% for 20 years) at three levels of adult mortality (8, 10, & 12%) reduced the mean final surviving population size to levels approximating the reduced carrying capacity at the 8% adult mortality rate which allows growth to near capacity. .

Effect of mismanagement of water level at Tram Chim Reserve

High water level kept during the dry season at Tram Chim reserve was modeled as an additional catastrophe. High water level in Tram Chim would not affect reproduction assuming that Tram Chim would not be used as a breeding area by the Eastern Sarus cranes. However, additional animals might be killed if they moved in surrounding areas. If this resulted in an increase of annual adult mortality to only 12% from the base rate of 10%, the growth rate would be negative (r = -0.008) and the population size would decline slowly over the 100 year period with a mean population size of 491 (as compared to 1891 for an adult mortality of 10%) and would eventually become extinct.

3. Summary for the Myanmar-China and South East Asian populations.

The differences in demographic parameters between these two populations considered in these models were in starting population size (M/C=600, SEA=1000), carrying capacity (M/C=3000, SEA=5000), chick removal only from the SEA population, adults harvested from the M/C population, and the use of the Tram Chim wetland reserve by the SEA population with an attendant possible increase in adult mortality. The basic demographic observations for both populations are that both are estimated to have been stable at about the same size for the last two decades. This suggests that conditions are such that the growth rate may be fluctuating around zero. The model projections indicate that the populations under the base conditions with no losses due to removals should have increased by about 33% during this time which likely would be detectable.

With a 2% annual growth rate or decline rate it might take at least 5 years to reliably to detect a change in population size. The population growth curves in Figures 9 and 12 indicate that an adult mortality of 12% would result in a very slow rate of population decline. This could not easily be detected over a 10-20 year period except by noting that the population is not growing at the expected rate with the carrying capacity much higher than the population size. Thus the suggested losses of adult cranes from the SEA population might be sufficient to account for the observation that the population is stable in size.

Losses of chicks from the M/C population at the suggested rate of 30 per year over the past 20 years would have resulted in about a 33% reduction in population size. This likely would be detectable. This suggests either that the loss is not consistently so severe or that the females losing chicks might return to breeding the next year rather than skipping a year or that other sources of mortality are less than expected from the whooping crane data.

4. ***References:***

Beifuss, R. & Barzen, J. 1994. Hydrological wetland restoration in the Mekong delta, Vietnam. Pp. 453-468 in W.J. Mitsch ed., *Global wetland: Old World and New.* Elsevier, New York.

Meine, C. & Archibald, G. 1996. The Cranes: Status Survey and Conservation Action Plan. IUCN, Gland, Switzerland, and Cambridge, U.K. 294 pp

Mirande, C. & Cannon, J. 1995. Computer Simulation of Possible Futures for tow Flocks of Whooping Cranes. Program in Sustainable Development and Conservation Biology, University of Maryland, College Park, Maryland. (Available in the Briefing Book)

Whooping Crane PHVA Report.

Tran, T. 1994. The Eastern Sarus Crane: Population Viability Analysis. Land Recourses Program, University of Wisconsin - Madison. (Available in the Briefing Book).

Table Pattern of the sets of simulation scenarios with results tabulated in Tables 1-15. Set SARUS4 included one catastrophe (flood) with a frequency of 0.2, severity effects on reproduction (SR) of 0.4 and on survival (SS) of 0.9. Set SARUS5A added a second catastrophe to the scenarios in Set 4 with a frequency of 6.6% and SR of 0.2 and SS of 1.0. Set SARUS5B added a different second catastrophe (water mismanagement at Tram Chim Reserve) to the scenarios in Set 4 with a frequency of 5.0% and SR of 1.0 and SS of 0.9. Habitat loss was added to the conditions of Set 4 in Sets SARUS6A (1% loss per year for 20 years) and SARUS6B (2.5% loss for 20 years). All file numbers are in the first column of the tables (SARUS??.XXX).

File #	Chick Mort.	%Clutches=0	K
001	27	42	3000
004	32		
007	37		
010		47	
013			
016			
019		37	
022			
025			
055	27	42	1500
058	32		
061	37		
064			
067			
070			
073			
076			
079			

Removal of 15 male and 15 female chicks each year for 20 years

028	27	42	3000
031	32		
034	37		
037			
040			
043			
046			
049			
052			

Removal of 6 male and 6 female adults each year for 20 years

082	27	42	3000
085	32		
088	37		
091			
094			
097			
100			
103			
106			

Each of these sets of 36 scenarios were run with 8, 10, and 12% adult mortality for a set of 108 scenarios as noted in the table legends. These 108 scenarios were run with the addition of habitat loss for 20 years 1% in sets 6A and 2.5% in 6B; or the addition of a second catastrophe in sets 5A and 5B for a grand total of 540 scenarios.

Base Scenario Output File For VORTEX

```
VORTEX 8.10 -- simulation of genetic and demographic stochasticity

SARUS4.010
Wed Feb  3 21:58:09 1999


  1 population(s) simulated for 100 years, 500 iterations

  Extinction is defined as no animals of one or both sexes.

  No inbreeding depression

  First age of reproduction for females: 4    for males: 4
  Maximum breeding age (senescence): 25
  Sex ratio at birth (percent males): 50.00


Population: Myna
  Monogamous mating; all adult males in the breeding pool.

   47.00 percent of adult females produce litters.
   EV in % adult females breeding = 13.50 SD

   Of those females producing litters, ...
    88.00 percent of females produce litters of size 1
    12.00 percent of females produce litters of size 2

   27.00 percent mortality of females between ages 0 and 1
    EV in % mortality = 18.000000 SD
   10.00 percent mortality of females between ages 1 and 2
    EV in % mortality = 7.000000 SD
   10.00 percent mortality of females between ages 2 and 3
    EV in % mortality = 7.000000 SD
   10.00 percent mortality of females between ages 3 and 4
    EV in % mortality = 7.000000 SD
   10.00 percent mortality of adult females (4<=age<=25)
    EV in % mortality = 7.000000 SD
   27.00 percent mortality of males between ages 0 and 1
    EV in % mortality = 18.000000 SD
   10.00 percent mortality of males between ages 1 and 2
    EV in % mortality = 7.000000 SD
   10.00 percent mortality of males between ages 2 and 3
    EV in % mortality = 7.000000 SD
   10.00 percent mortality of males between ages 3 and 4
    EV in % mortality = 7.000000 SD
   10.00 percent mortality of adult males (4<=age<=25)
    EV in % mortality = 7.000000 SD

    EVs may be adjusted to closest values possible for binomial
distribution.
    EV in mortality will be concordant among age-sex classes
       but independent from EV in reproduction.

  Frequency of type 1 catastrophes: 2.000 percent
    with 0.400 multiplicative effect on reproduction
```

and 0.900 multiplicative effect on survival

Frequency of type 2 catastrophes: 0.000 percent
with 1.000 multiplicative effect on reproduction
and 1.000 multiplicative effect on survival

Frequency of type 3 catastrophes: 0.000 percent
with 1.000 multiplicative effect on reproduction
and 1.000 multiplicative effect on survival

Initial size of Myna: 600
(set to reflect stable age distribution)

Age	1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24	
25	Total											
	37	33	29	26	22	20	17	16	13	12	11	9
8	7	6	6	5	4	4	3	3	3	2	2	
2	300	Males										
	37	33	29	26	22	20	17	16	13	12	11	9
8	7	6	6	5	4	4	3	3	3	2	2	
2	300	Females										

Carrying capacity = 3000
EV in Carrying capacity = 0.00 SD

Animals harvested from Myna, year 19 to year 20 at 1 year intervals:
15 females 1 years old
15 males 1 years old

Deterministic population growth rate (based on females, with assumptions of
no limitation of mates, no density dependence, and no inbreeding depression):

r = 0.020 lambda = 1.020 R0 = 1.221
Generation time for: females = 10.24 males = 10.24

Stable age distribution:

Age class	females	males
0	0.074	0.074
1	0.053	0.053
2	0.047	0.047
3	0.041	0.041
4	0.036	0.036
5	0.032	0.032
6	0.028	0.028
7	0.025	0.025
8	0.022	0.022
9	0.019	0.019
10	0.017	0.017
11	0.015	0.015
12	0.013	0.013
13	0.012	0.012
14	0.010	0.010
15	0.009	0.009
16	0.008	0.008
17	0.007	0.007
18	0.006	0.006

19	0.005	0.005
20	0.005	0.005
21	0.004	0.004
22	0.004	0.004
23	0.003	0.003
24	0.003	0.003
25	0.003	0.003

Ratio of adult (>= 4) males to adult (>= 4) females: 1.000

Population 1: Myna

Year 10

N[Extinct] =	0,	P[E] =	0.000			
N[Surviving] =	500,	P[S] =	1.000			
Population size =		723.41	(10.66	SE,	238.31	SD)
Expected heterozygosity =		0.998	(0.000	SE,	0.000	SD)
Observed heterozygosity =		1.000	(0.000	SE,	0.001	SD)
Number of extant alleles =		629.26	(5.69	SE,	127.29	SD)

Year 20

N[Extinct] =	0,	P[E] =	0.000			
N[Surviving] =	500,	P[S] =	1.000			
Population size =		810.22	(18.53	SE,	414.24	SD)
Expected heterozygosity =		0.996	(0.000	SE,	0.001	SD)
Observed heterozygosity =		0.999	(0.000	SE,	0.001	SD)
Number of extant alleles =		455.58	(5.53	SE,	123.60	SD)

Year 30

N[Extinct] =	0,	P[E] =	0.000			
N[Surviving] =	500,	P[S] =	1.000			
Population size =		984.87	(25.51	SE,	570.53	SD)
Expected heterozygosity =		0.995	(0.000	SE,	0.002	SD)
Observed heterozygosity =		0.997	(0.000	SE,	0.002	SD)
Number of extant alleles =		365.58	(5.31	SE,	118.71	SD)

Year 40

N[Extinct] =	0,	P[E] =	0.000			
N[Surviving] =	500,	P[S] =	1.000			
Population size =		1161.40	(32.76	SE,	732.59	SD)
Expected heterozygosity =		0.994	(0.000	SE,	0.003	SD)
Observed heterozygosity =		0.996	(0.000	SE,	0.003	SD)
Number of extant alleles =		312.79	(5.08	SE,	113.63	SD)

Year 50

N[Extinct] =	0,	P[E] =	0.000			
N[Surviving] =	500,	P[S] =	1.000			
Population size =		1289.22	(34.35	SE,	768.11	SD)
Expected heterozygosity =		0.993	(0.000	SE,	0.004	SD)
Observed heterozygosity =		0.995	(0.000	SE,	0.004	SD)
Number of extant alleles =		277.39	(4.79	SE,	107.19	SD)

Year 60

N[Extinct] =	0,	P[E] =	0.000			
N[Surviving] =	500,	P[S] =	1.000			
Population size =		1414.24	(37.50	SE,	838.42	SD)
Expected heterozygosity =		0.991	(0.000	SE,	0.006	SD)

```
     Observed heterozygosity =    0.993 (  0.000 SE,   0.005 SD)
     Number of extant alleles =  251.82 (   4.52 SE,  101.02 SD)

Year 70
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =   500, P[S] = 1.000
     Population size =          1559.47 (  39.94 SE,  893.15 SD)
     Expected heterozygosity =    0.990 (  0.000 SE,   0.007 SD)
     Observed heterozygosity =    0.992 (  0.000 SE,   0.006 SD)
     Number of extant alleles =  232.42 (   4.26 SE,   95.31 SD)

Year 80
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =   500, P[S] = 1.000
     Population size =          1652.98 (  40.66 SE,  909.27 SD)
     Expected heterozygosity =    0.989 (  0.000 SE,   0.009 SD)
     Observed heterozygosity =    0.991 (  0.000 SE,   0.008 SD)
     Number of extant alleles =  216.01 (   4.02 SE,   89.89 SD)

Year 90
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =   500, P[S] = 1.000
     Population size =          1764.48 (  41.40 SE,  925.72 SD)
     Expected heterozygosity =    0.988 (  0.000 SE,   0.010 SD)
     Observed heterozygosity =    0.990 (  0.000 SE,   0.009 SD)
     Number of extant alleles =  203.38 (   3.79 SE,   84.79 SD)

Year 100
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =   500, P[S] = 1.000
     Population size =          1818.39 (  40.12 SE,  897.08 SD)
     Expected heterozygosity =    0.988 (  0.000 SE,   0.011 SD)
     Observed heterozygosity =    0.989 (  0.000 SE,   0.010 SD)
     Number of extant alleles =  192.34 (   3.58 SE,   80.02 SD)


In 500 simulations of Myna for 100 years:
  0 went extinct and 500 survived.

This gives a probability of extinction of 0.0000 (0.0000 SE),
  or a probability of success of          1.0000 (0.0000 SE).

Mean final population for successful cases was 1818.39 (40.12 SE, 897.08
SD)

   Age 1       2       3   Adults    Total
  113.36   99.26   88.66  606.83    908.10  Males
  113.46  100.35   88.52  607.95    910.28  Females

During years of harvest and/or supplementation
  mean growth rate (r) was -0.0292 (0.0037 SE, 0.1154 SD)

During years without harvest or supplementation,
  mean growth rate (r) was 0.0137 (0.0005 SE, 0.1136 SD)

Across all years, prior to carrying capacity truncation,
  mean growth rate (r) was 0.0128 (0.0005 SE, 0.1138 SD)
```

```
319 of 15000 harvests of females could not be completed because of
insufficient animals.
279 of 15000 harvests of males could not be completed because of
insufficient animals.

Final expected heterozygosity was      0.9876 ( 0.0005 SE,  0.0107 SD)
Final observed heterozygosity was      0.9892 ( 0.0004 SE,  0.0097 SD)
Final number of alleles was            192.34 (   3.58 SE,   80.02 SD)
**********************************************************************
*
```

FIGURE LEGENDS

Introduction: A series of sensitivity analyses were run to explore the relative impacts of different population parameters on the the population growth rates ('r') and projected final mean population size ('N') of surviving populations after 100 years (Figures 1 – 8).

Parameters examined included:

(a) three rates of adult mortality (8, 10, or 12%) and their interaction with either chick or adult harvesting for 20 years (Figures 1 – 2);

(b) proportion of females producing clutches each year (37, 42, or 47%) and the interaction with the three rates of annual adult mortality (Figures 3 – 4);

(c) proportion of females producing clutches each year (3 rates) and the interaction with three rates of annual chick mortality (27, 32, or 27%) (Figures 5 – 6); and the

(d) interaction of the three rates of annual adult mortality with two different catastrophes (A or B) and two rates of habitat loss (1% or 2.5% for 20 years) (Figures 7 – 8).

A total of 540 scenarios were simulated representing all of the possible combinations of the parameter values. All values of 'r' or 'N' across the iterations of scenarios with one value of a given parameter were then averaged (180 scenarios) for comparison with averages for other values of the parameter and of other parameters. It is these averages from 180 scenarios that are plotted in Figures 1 – 8. Thus these values allow a relative comparison of the impact of a particular parameter on populaton growth rate or and mean final population size at 100 years.

The time series figures (9 – 15) present the mean population size (N) results for 500 iterations at 10 year intervals for the 100 years of the projections .

Figure 1. Comparison of the effects of 8, 10, and 12% adult mortality on the mean population growth rate (r) in the base scenarios (single catastrophe, no removals, no habitat loss) and in scenarios with the addition of chick or adult harvests for 20 years. As expected the mean growth rate over all scenarios declines with increasing adult mortality. Chick removals (15 male and 15 female chicks annually for the first 20 years) have a greater effect on decreasing the mean population growth rate than adult removals (6 males and 6 females annually for the first 20 years). Both types of removal have an adverse effect on population growth.

Figure 2. Comparison of the effects of 8, 10, and 12% adult mortality on the mean final population size in the base scenarios and in scenarios with the addition of chick or adult harvests for 20 years. As expected the final population size decreases well below carrying capacity with increasing adult mortality. Chick removals (15 male and 15 female chicks annually for the first 20 years) have a greater effect on decreasing the mean final population size than adult removals (6 males and 6 females annually for the first 20 years). The populations with 8% adult mortality are able to recover almost to base

scenario values at 100 years. The serial population size plots (Figures 9 & 15) are informative of this recovery process through time.

Figure 3. Comparison of the effects of 8, 10, and 12% adult mortality on the mean population growth rate in scenarios with 47, 42, or 37% of females producing a clutch each year. As expected the growth rate declines with a decreasing proportion of females producing a clutch (increasing interbirth interval). If the base adult mortality rate is 10% in the wild population then the clutching rate needs to be at least 42% for the population be stable.

Figure 4. Comparison of the effects of 8, 10, and 12% adult mortality on the mean final surviving population size in the scenarios with the 47, 42, or 37% of females producing a clutch each year. The mean final population size at 100 years declines with decreasing proportion of females producing a clutch (increasing interbirth interval). See Figures 10 and 11 for the time course of population growth

Figure 5. Comparison of the effects of 27, 32, and 37% chick mortality on the mean population growth rate in scenarios with 47, 42, or 37% of females producing a clutch each year. Adult mortality was held constant at 8% per year. As expected the growth rate declines with increasing chick mortality and decreasing proportion of females producing a clutch (increasing interbirth interval). However with only 8% adult mortality (which is lower than the 10% observed for whooping cranes) nearly all combinations have a positive growth rate.

Figure 6. Comparison of the effects of 27, 32, and 37% chick mortality on the mean final surviving population size in scenarios with 47, 42, or 37% of females producing a clutch each year. Adult mortality was held constant at 8% per year. The final population size declines with increasing chick mortality and decreasing proportion of females producing a clutch (increasing interbirth interval). However, all of the populations, except at the highest chick mortality and lowest reproductive rate, increased in numbers from the starting population size of 600 birds. The changes over time for 8% adult mortality (Figure 10) show consistent differences throughout the 100 years of the projections.

Figure 7. Comparison of the effects of two additional catastrophes (5A, Cat. A, frequency = 6.6%, reproductive severity = 0.2 , and survival severity = 1.0; 5B, Cat B, f = 5.0%, rs = 1.0, and ss = 0.9) and two rates of habitat loss (6A, -1% or 6B, -2.5% for 20 years) at three levels of adult mortality (8, 10, & 12%) on population growth rates.

Figure 8. Comparison of the effects of two additional catastrophes (5A, Cat. A frequency = 6.6%, reproductive severity = 0.2, and survival severity = 1.0; 5B, Cat B, f = 5.0%, rs = 1.0, and ss = 0.9) and two rates of habitat loss (-1% or -2.5% for 20 years) at three levels of adult mortality (8, 10, & 12%) on mean final surviving population size.

Figure 9. Time series, at 10 year intervals, of mean population sizes comparing the base scenario (no removals) with the inclusion of chick (15 males and 15 females) or adult

removals (6 males and 6 females) for 20 years. The K was set at 3000. The populations with removals recover after the removals are stopped but do not reach carrying capacity or reach the numbers of the base scenario population even after 100 years. (The scenarios are 4.010, 4.091, and 4.037 in Table 2).

Figure 10. Time series, at 10 year intervals, of mean population sizes comparing scenarios (no removals) with clutching rates of 37, 42, or 47%. Adult mortality was 8% in all of these scenarios. The K was set at 3000. The population with a mean 47% clutching rate plateaus at about 2700 after 70 years. (The scenarios are 4.010, 4.001, and 4.019 in Table 1).

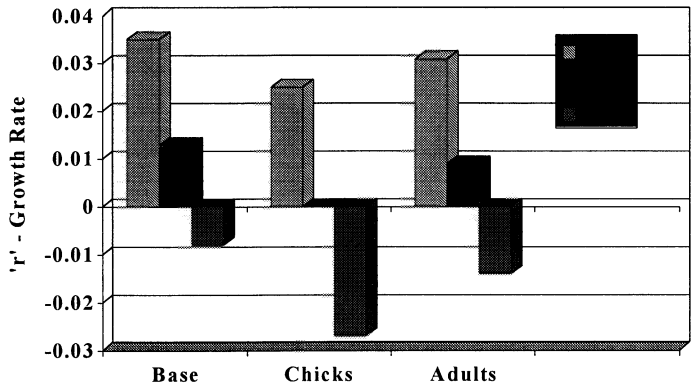
Figure 11. Time series, at 10 year intervals, of mean population sizes comparing scenarios (no removals) with clutching rates of 37, 42, or 47%. Adult mortality was 10% in all of these scenarios. The K was set at 3000. The population with a mean 47% clutching rate plateaus at about 2700 after 70 years. The population size in the scenario with 37% clutching rate declines slowly over the 100 years. (The cenarios are 4.019, 4.010, and 4.001 in Table 2).

Figure 12. Time series, at 10 year intervals, of mean population sizes comparing scenarios (no removals) with adult mortalities of 8, 10, or 12%. Clutching rate was 47% and chick mortality was 27% in all of these scenarios. The K was set at 3000. The population with a mean 47% clutching rate plateaus at about 2700 after 70 years. The mean population size in the scenario with 12% adult mortality declines slightly over the 100 years. (The scenarios are 4.010, 4.010. and 4.010 from Tables 1, 2, and 3).

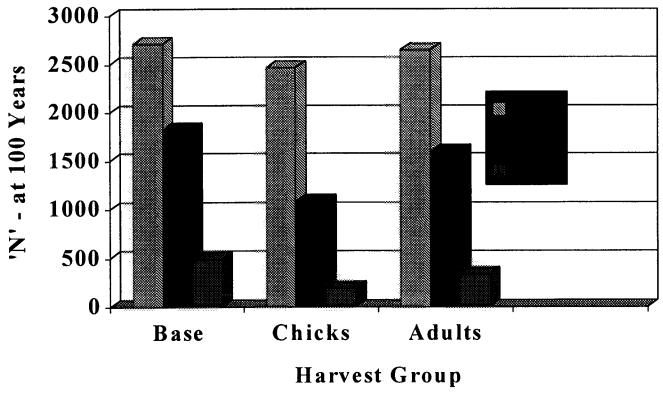
Figure 13. Time series, at 10 year intervals, of mean population sizes comparing scenarios (no removals) with chick mortality rates of 27, 32, or 37%. Adult mortality was 8% in all of these scenarios. The K was set at 3000. All populations increased under these conditions. The population with a mean 27% chick mortality rate plateaus at about 2700 after 70 years. (The scenarios are 4.001, 4.004, and 4.007 from Table 1).

Figure 14. Time series, at 10 year intervals, of mean population sizes comparing scenarios (no removals) with chick mortality rates of 27, 32, or 37%. Adult mortality was 10% in all of these scenarios. The K was set at 3000. The population with a mean 27% chick mortality rate plateaus at about 2700 after 70 years. The scenario with 37% mortality did not increase. (The scenarios are 4.001, 4.004, and 4.007 from Table 2).

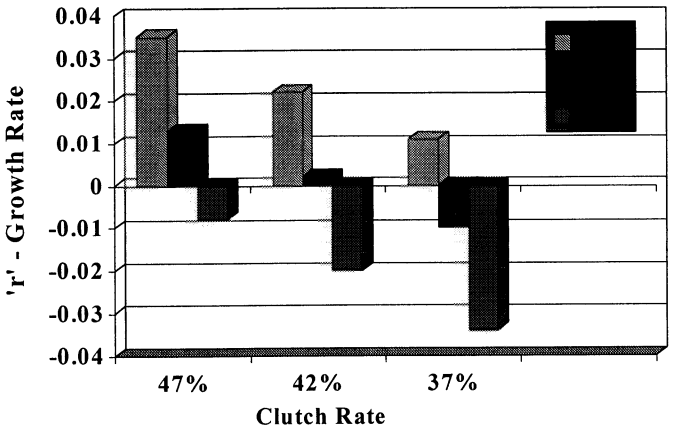
Effects of Chick or Adult Harvest and Adult Mortality on Population Growth Rates



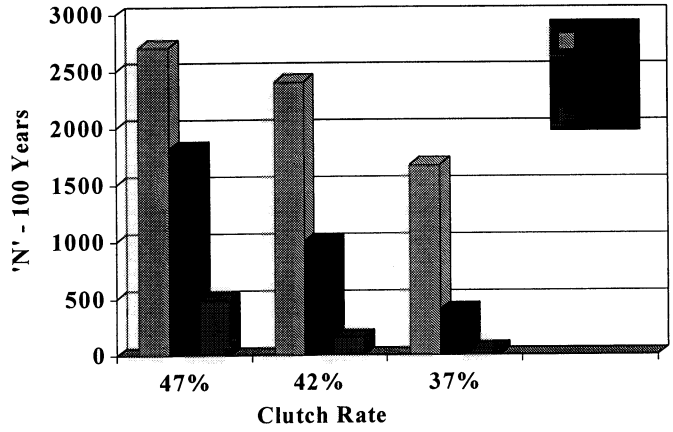
Effects of Chick or Adult Harvest and Adult Mortality on Mean Population Size



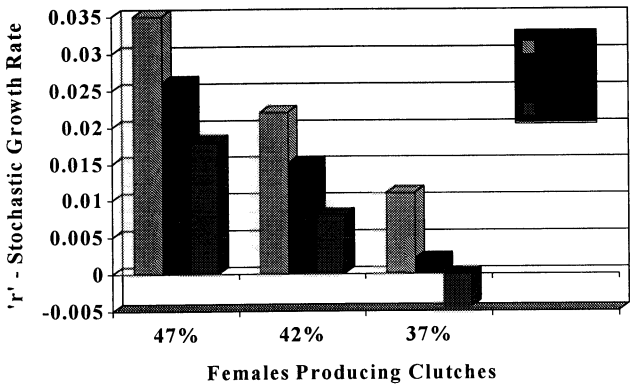
Effects of % Females Producing Clutches and Adult Mortality on Population Growth Rates



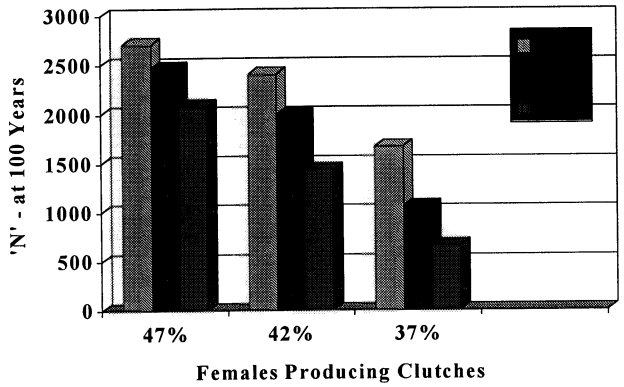
Effects of % Females Producing Clutches and Adult Mortality on Mean Population Size



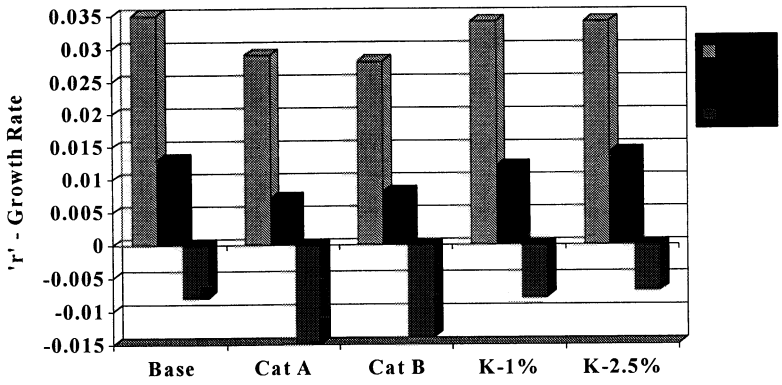
Effects of Chick Mortality and % Females Producing Clutches on Mean Population Growth Rate with 8% Adult Mortality



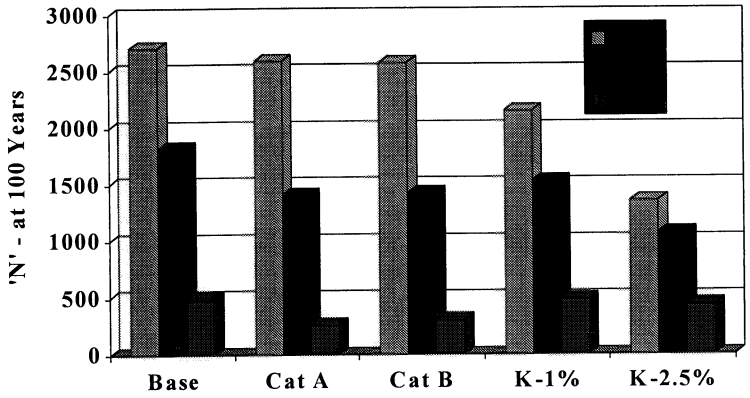
Effects of Chick Mortality and % Females Producing Clutches on Mean Population Size with K=3000 & 8% Adult Mortality



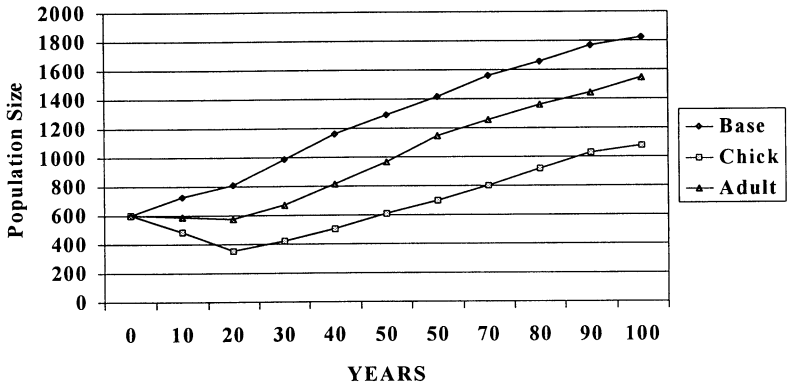
Effects of Catastrophes, Habitat Loss, and Adult Mortality on Population Growth Rates



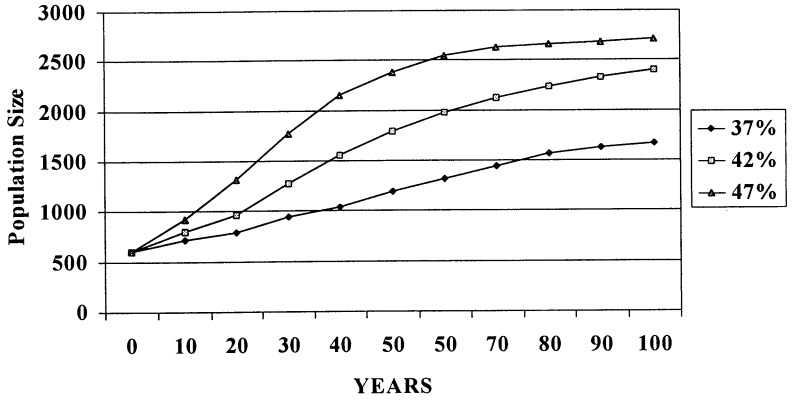
Effects of Catastrophes, Habitat Loss, and Adult Mortality on Mean Population Size



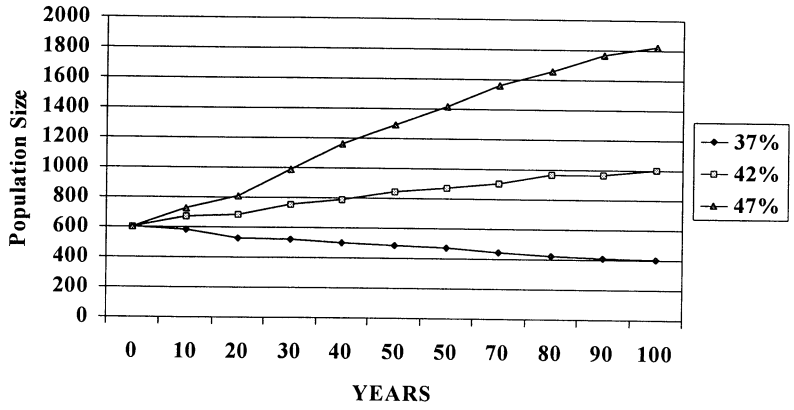
Effects of Chick or Adult Removals on Crane Population Size Over 100 Years



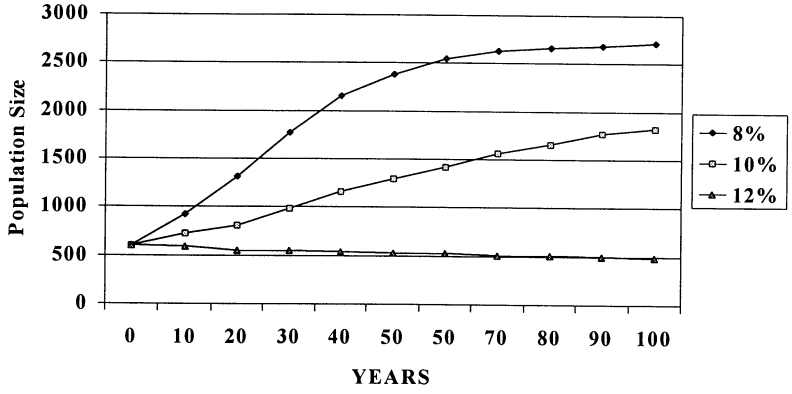
Effects of Clutching Rate with 8% Adult Mortality on Crane Population Size Over 100 Years



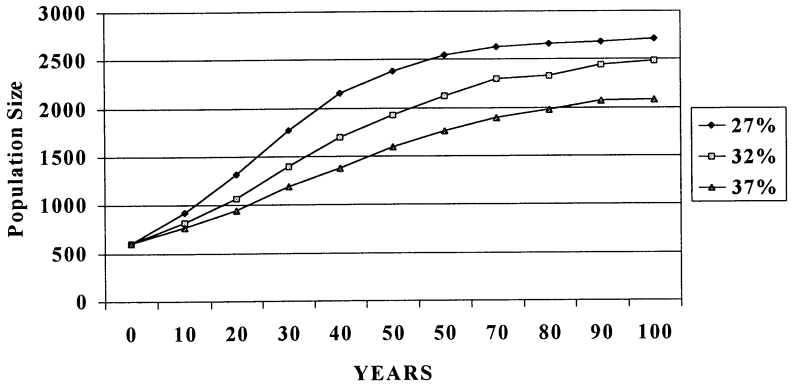
Effects of Clutching Rate with 10% Adult Mortality on Crane Population Size Over 100 Years



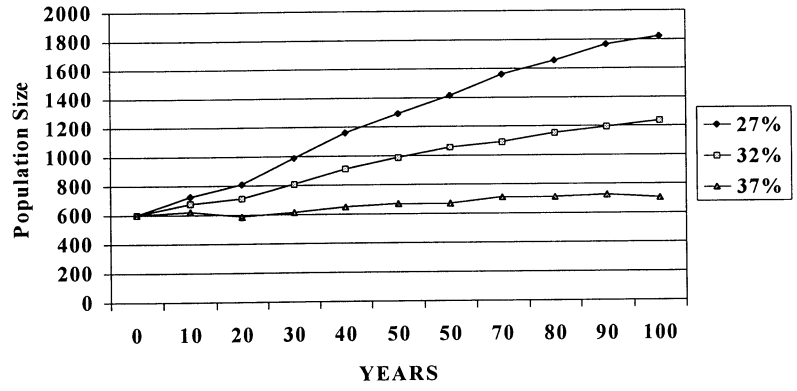
Effects of Adult Mortality on Crane Population Size Over 100 Years



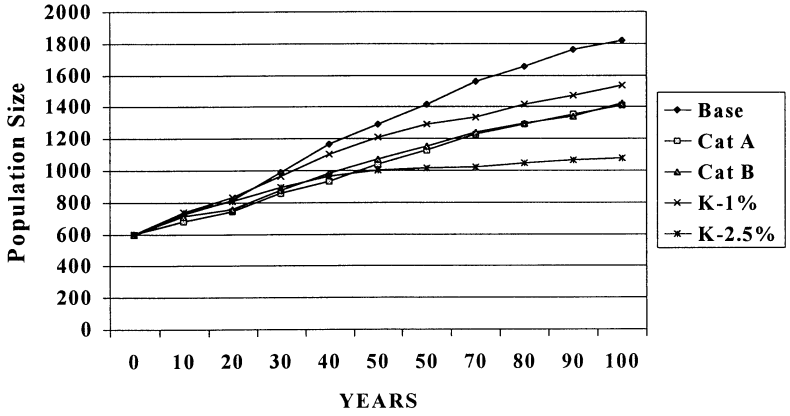
Effects of Chick Mortality with 8% Adult Mortality on Crane Population Size Over 100 Years



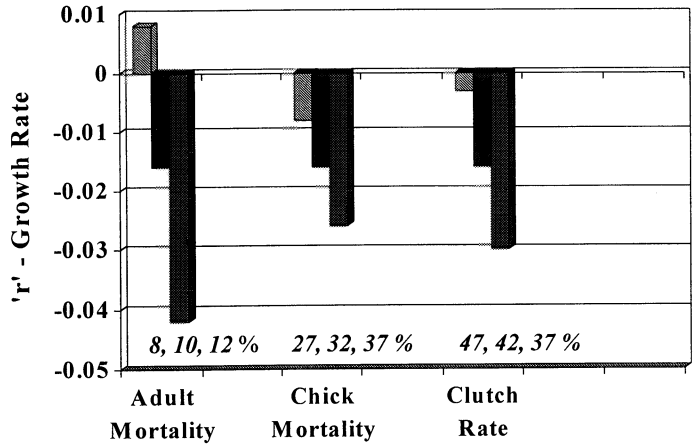
Effects of Chick Mortality with 10% Adult Mortality on Crane Population Size Over 100 Years



Effects of Catastrophes or Removals with 10% Adult Mortality on Crane Population Size Over 100 Years



Relative Effects of Adult & Chick Mortality & Clutch Rates on Population Growth Rates



Eastern Sarus Crane

Grus antigone sharpii

Population and Habitat Viability Assessment Workshop

Khao Kheow Open Zoo
Chon Buri, Thailand

15-17 January 1997

Report

STUDBOOK AND

SIMULATION MODELING DATA TABLES

EASTERN SARUS CRANE Studbook

(Grus antigone sharpii)
Status: All
Compiled by: Sumate Kamolnorranath thru International Crane Foundation
Report ordered by Studbook Number

SPARKS v1.42
2 Feb 1999

Stud #	Sex	Hatch Date	Sire	Dam	Location	Date	Local ID	Event	Death-Date	Tag/Band	Name
TH1	M	29 Sep 1989	WILD	WILD	KORAT	29 Oct 1989	KORATA	Capture			KORAT-A
TH2	F	29 Aug 1989	WILD	WILD	KORAT	29 Oct 1989	KORATB	Capture			KORAT-B
						5 Apr 1994		Death	5 Apr 1994		
					[Death by: Self Inflicted Injuries □ Mounted or Preserved: KHON KHAEN UNIVERSITY □ Generalized □ Trauma]							
TH3	M	3 Oct 1989	WILD	WILD	KORAT	29 Oct 1989	KORATC	Capture			KORAT-C
TH4	F	29 Oct 1989	WILD	WILD	KORAT	29 Oct 1989	KORATD	Capture			KORAT-D
					BANGKOK	6 Jul 1993	UNK	Transfer			
TH5	M	15 Nov 1989	WILD	WILD	KORAT	26 Nov 1989	KORATE	Capture			KORAT-E
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH6	F	26 Oct 1988	WILD	WILD	KORAT	26 Nov 1989	KORATF	Capture			KORAT-F
TH7	F	14 Nov 1989	WILD	WILD	KORAT	9 Dec 1989	KORATG	Capture			KORAT-G
TH8	M	24 Oct 1989	WILD	WILD	KORAT	9 Dec 1989	KORATH	Capture			KORAT-H
TH9	M	3 Oct 1989	WILD	WILD	KORAT	18 Dec 1989	KORATI	Capture			KORAT-I
						13 Aug 1990		Death	13 Aug 1990		
					[Death by: Other/Unknown □ Bury □ Unknown (after Autopsy)]						
TH10	M	20 Dec 1989	WILD	WILD	KORAT	5 Jan 1990	KORATJ	Capture			KORAT-J
					CHIANGMAI	15 Mar 1993	UNK	Transfer			
TH11	F	10 Oct 1989	WILD	WILD	KORAT	20 Feb 1989	KORATK	Capture			KORAT-K
					CHIANGMAI	15 Mar 1993	UNK	Transfer			
TH12	F	14 Sep 1987	WILD	WILD	KORAT	14 Sep 1990	KORATL	Capture			KORAT-L
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH13	M	8 Sep 1991	WILD	WILD	KORAT	23 Sep 1991	KORATM	Capture			KORAT-M
TH14	M	8 Aug 1991	WILD	WILD	KORAT	23 Sep 1991	KORATN	Capture			KORAT-N
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH15	M	23 Aug 1991	WILD	WILD	KORAT	23 Sep 1991	KORATO	Capture			KORAT-O
TH16	M	13 Sep 1991	WILD	WILD	KORAT	23 Sep 1991	KORATP	Capture			KORAT-P

TH17	F	29 Aug 1991	WILD	WILD	KORAT	23 Sep 1991	KORATQ	Capture			KORAT-Q
TH18	F	7 Oct 1991	WILD	WILD	KORAT	7 Dec 1991	KORATS	Capture			KORAT-S
TH19	M	25 Oct 1991	WILD	WILD	KORAT	25 Oct 1992	KORATT	Capture			KORAT-T
TH20	F	25 Oct 1991	WILD	WILD	KORAT	25 Oct 1992	KORATU	Capture			KORAT-U
TH21	F	30 Jul 1991	WILD	WILD	KORAT	30 Jan 1992	KORATW	Capture			KORAT-W
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH22	M	19 Aug 1993	WILD	WILD	KORAT	19 Oct 1993	01/37	Capture			01/37
TH23	M	4 Aug 1993	WILD	WILD	KORAT	19 Oct 1993	02/37	Capture			02/37
TH24	M	19 Sep 1993	WILD	WILD	KORAT	19 Oct 1993	03/37	Capture			03/37
TH25	F	28 Sep 1993	WILD	WILD	KORAT	19 Oct 1993	04/37	Capture			04/37
TH26	M	~ 1994	UNK	UNK	CAMBODIA	~ 1994	UNK	Capture		01	
					KHAOKHEOW	~ Feb 1995	960007	Transfer			
TH27	F	~ 1994	UNK	UNK	CAMBODIA	~ 1995	UNK	Capture		02	
					KHAOKHEOW	~ Feb 1995	960008	Transfer			
						20 Mar 1996		Death	20 Mar 1996		
					[Death by: Infection Associated □ Bury □ No Autopsy Planned]						
TH28	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		03	
					KHAOKHEOW	~ Feb 1995	960009	Transfer			
TH29	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		04	
					KHAOKHEOW	~ Feb 1995	960010	Transfer			
TH30	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		05	
					KHAOKHEOW	~ Feb 1996	960011	Transfer			
TH31	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		06	
					KHAOKHEOW	~ Feb 1996	960012	Transfer			
TH32	?	~ 1993	UNK	UNK	CAMBBODIA	~ 1993	UNK	Capture		07	
					KHAOKHEOW	~ Feb 1995	960013	Transfer			
TH33	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		08	
					KHAOKHEOW	~ Feb 1995	960014	Transfer			
TH34	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		09	
					KHAOKHEOW	~ Feb 1995	960015	Transfer			
TH35	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		10	
					KHAOKHEOW	~ Feb 1995	960016	Transfer			
TH36	?	~ 1993	UNK	UNK	CAMBODIA	~ 1995	UNK	Capture		11	
					KHAOKHEOW	~ Feb 1996	960017	Transfer			

TH37	?	~ 1994	UNK	UNK	CAMBODIA	~ 1994	UNK	Capture		12	
					BANGKOK	~ Sep 1995	UNK	Transfer			
					KHAOKHEOW	~26 Jun 1996	960022	Transfer			
TH38	?	~ 1994	UNK	UNK	CAMBODIA	~ 1994	UNK	Capture		13	
					BANGKOK	~ Sep 1995	UNK	Transfer			
					KHAOKHEOW	~26 Jun 1996	960023	Transfer			
TH41	?	~ Jun 1996			CAMBODIA	~ Jul 1996	UNK	Capture			N1
					KORAT	~ Aug 1996	UNK	Transfer			
TH42	?	~ Jul 1996			CAMBODIA	~ Jul 1996	UNK	Capture			N2
					KORAT	~ Aug 1996	UNK	Transfer			
TH43	?	~31 Jul 1996			KHORAT	~18 Sep 1996		Death	~18 Sep 1996		N3
					[Death by: Other/Unknown □ Unknown □ Unknown (after Autopsy)]						
TH44	?	~10 Jul 1996			CAMBODIA	~10 Jul 1996	UNK	Capture			N4
					KORAT	~ Aug 1996	UNK	Transfer			
TH45	?	~10 Jul 1996			CAMBODIA	~10 Jul 1996	UNK	Capture			N5
					KORAT	~ Aug 1996	UNK	Transfer			
						~ Aug 1996		Death	~ Aug 1996		
					[Death by: Infection Associated □ Unknown □ Generalized □ Bacterial]						
TH46	?	~ Jul 1996			CAMBODIA	~ Jul 1996	UNK	Capture			N6
					KORAT	~ Aug 1996	UNK	Transfer			
TH47	M	~ 1990			CAMBODIA	~ 1990	UNK	Capture		R.0074	PATTAYA 3
					FORESTRY	17 Nov 1991	UNK	Transfer			
TH48	M	~ 1984			CAMBODIA	~ 1991	UNK	Capture		R.0069	TAO
					FORESTRY	~ Sep 1991	UNK	Transfer			
TH49	F	~ 1991			CAMBODIA	~ 1993	UNK	Capture		R.0081	KHAOKHEOW
					FORESTRY	19 Jun 1994	UNK	Transfer			
TH50	F	~ 1986			CAMBODIA	~ 1986	UNK	Capture			
					FORESTRY	25 Aug 1991	UNK	Transfer			
TH51	M	~ 1990			CAMBODIA	~ 1990	UNK ltf	Capture		R.0072	PATTAYA 1
					FORESTRY	17 Nov 1991	UNK	Transfer			
TH52	F	~ 1990			CAMBODIA	~ 1990	UNK	Capture		R.0073	PATTAYA 2
					FORESTRY	~ Nov 1991	UNK	Transfer			

TOTALS: 18.15.17 (50)

BANGKOK Dusit (Bangkok) Zoological Park
71 Rama V Rd., Bangkok 10300, Thailand, 66 2 2811039x432.

CAMBBODIA _____

CAMBODIA _____

CHIANGMAI Chiangmai Zoological Garden
Huaykaew Rd., Chiangmai 50000, Thailand, 66 053 221179.

FORESTRY _____

KHAOKHEOW Khao Kheow Open Zoo
P.O. Box 6, Bang Phra, Siracha, Chonburi, Thailand, 20210, 66 38 311561.

KHORAT Nakhon Ratchasima Zool. Park
111 M 1 Tumbol Chaimongkon Ampur, Nakhon Ratchasima, Thailand, 30000, 66 01 9552597.

KORAT _____

EASTERN SARUS CRANE Studbook
Restricted to: (Grus antigone sharpii)
Status: Living by 2 Feb 1999 Report ordered by: current (last) location...

Stud #	Sex	Hatch Date	Sire	Dam	Location	Date	Local ID	Event	Death-Date	Tag/Band	Name
TH1	M	29 Sep 1989	WILD	WILD	KORAT	29 Oct 1989	KORATA	Capture			KORAT-A
TH3	M	3 Oct 1989	WILD	WILD	KORAT	29 Oct 1989	KORATC	Capture			KORAT-C
TH5	M	15 Nov 1989	WILD	WILD	KORAT	26 Nov 1989	KORATE	Capture			KORAT-E
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH6	F	26 Oct 1988	WILD	WILD	KORAT	26 Nov 1989	KORATF	Capture			KORAT-F
TH7	F	14 Nov 1989	WILD	WILD	KORAT	9 Dec 1989	KORATG	Capture			KORAT-G
TH8	M	24 Oct 1989	WILD	WILD	KORAT	9 Dec 1989	KORATH	Capture			KORAT-H
TH12	F	14 Sep 1987	WILD	WILD	KORAT	14 Sep 1990	KORATL	Capture			KORAT-L
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH13	M	8 Sep 1991	WILD	WILD	KORAT	23 Sep 1991	KORATM	Capture			KORAT-M
TH14	M	8 Aug 1991	WILD	WILD	KORAT	23 Sep 1991	KORATN	Capture			KORAT-N
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH15	M	23 Aug 1991	WILD	WILD	KORAT	23 Sep 1991	KORATO	Capture			KORAT-O
TH16	M	13 Sep 1991	WILD	WILD	KORAT	23 Sep 1991	KORATP	Capture			KORAT-P
TH17	F	29 Aug 1991	WILD	WILD	KORAT	23 Sep 1991	KORATQ	Capture			KORAT-Q
TH18	F	7 Oct 1991	WILD	WILD	KORAT	7 Dec 1991	KORATS	Capture			KORAT-S
TH19	M	25 Oct 1991	WILD	WILD	KORAT	25 Oct 1992	KORATT	Capture			KORAT-T
TH20	F	25 Oct 1991	WILD	WILD	KORAT	25 Oct 1992	KORATU	Capture			KORAT-U
TH21	F	30 Jul 1991	WILD	WILD	KORAT	30 Jan 1992	KORATW	Capture			KORAT-W
					FORESTRY	30 Mar 1993	UNK	Transfer			
TH22	M	19 Aug 1993	WILD	WILD	KORAT	19 Oct 1993	01/37	Capture			01/37
TH23	M	4 Aug 1993	WILD	WILD	KORAT	19 Oct 1993	02/37	Capture			02/37
TH24	M	19 Sep 1993	WILD	WILD	KORAT	19 Oct 1993	03/37	Capture			03/37
TH25	F	28 Sep 1993	WILD	WILD	KORAT	19 Oct 1993	04/37	Capture			04/37

Totals: 12.8.0 (20)

EASTERN SARUS CRANE Studbook

Restricted to: (Grus antigone sharpii)

Status: Living by 2 Feb 1999 — Report ordered by: current (last) location...

Stud #	Sex	Hatch Date	Sire	Dam	Location	Date	Local ID	Event	Death-Date	Tag/Band	Name
Chiangmai Zoological Garden, Chiangmai 50000, , Thailand											
TH10	M	20 Dec 1989	WILD	WILD	KORAT	5 Jan 1990	KORATJ	Capture			KORAT-J
					CHIANGMAI	15 Mar 1993	UNK	Transfer			
TH11	F	10 Oct 1989	WILD	WILD	KORAT	20 Feb 1989	KORATK	Capture			KORAT-K
					CHIANGMAI	15 Mar 1993	UNK	Transfer			
Totals: 1.1.0 (2)											
Khao Kheow Open Zoo, Siracha Chonburi, , Thailand											
TH26	M	~ 1994	UNK	UNK	CAMBODIA	~ 1994	UNK	Capture		01	
					KHAOKHEOW	~ Feb 1995	960007	Transfer			
TH28	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		03	
					KHAOKHEOW	~ Feb 1995	960009	Transfer			
TH29	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		04	
					KHAOKHEOW	~ Feb 1995	960010	Transfer			
TH30	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		05	
					KHAOKHEOW	~ Feb 1996	960011	Transfer			
TH31	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		06	
					KHAOKHEOW	~ Feb 1996	960012	Transfer			
TH32	?	~ 1993	UNK	UNK	CAMBBODIA	~ 1993	UNK	Capture		07	
					KHAOKHEOW	~ Feb 1995	960013	Transfer			
TH33	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		08	
					KHAOKHEOW	~ Feb 1995	960014	Transfer			
TH34	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		09	
					KHAOKHEOW	~ Feb 1995	960015	Transfer			
TH35	?	~ 1993	UNK	UNK	CAMBODIA	~ 1993	UNK	Capture		10	
					KHAOKHEOW	~ Feb 1995	960016	Transfer			
TH36	?	~ 1993	UNK	UNK	CAMBODIA	~ 1995	UNK	Capture		11	
					KHAOKHEOW	~ Feb 1996	960017	Transfer			
TH37	?	~ 1994	UNK	UNK	CAMBODIA	~ 1994	UNK	Capture		12	
					BANGKOK	~ Sep 1995	UNK	Transfer			
					KHAOKHEOW	~26 Jun 1996	960022	Transfer			
TH38	?	~ 1994	UNK	UNK	CAMBODIA	~ 1994	UNK	Capture		13	
					BANGKOK	~ Sep 1995	UNK	Transfer			
					KHAOKHEOW	~26 Jun 1996	960023	Transfer			
Totals: 1.0.11 (12)											

EASTERN SARUS CRANE Studbook

Restricted to: (Grus antigone sharpii)
Status: Living by 2 Feb 1999
Report ordered by: current (last) location...

Stud #	Sex	Hatch Date	Sire	Dam	Location	Date	Local ID	Event	Death-Date	Tag/Band	Name
Dusit (bangkok) Zoological Park, Bangkok 10300, , Thailand											
TH4	F	29 Oct 1989	WILD	WILD	KORAT	29 Oct 1989	KORATD	Capture			KORAT-D
					BANGKOK	6 Jul 1993	UNK	Transfer			
Totals: 0.1.0 (1)											
Unknown Location, , ,											
TH41	?	~ Jun 1996			CAMBODIA	~ Jul 1996	UNK	Capture			N1
					KORAT	~ Aug 1996	UNK	Transfer			
TH42	?	~ Jul 1996			CAMBODIA	~ Jul 1996	UNK	Capture			N2
					KORAT	~ Aug 1996	UNK	Transfer			
TH44	?	~10 Jul 1996			CAMBODIA	~10 Jul 1996	UNK	Capture			N4
					KORAT	~ Aug 1996	UNK	Transfer			
TH46	?	~ Jul 1996			CAMBODIA	~ Jul 1996	UNK	Capture			N6
					KORAT	~ Aug 1996	UNK	Transfer			
TH47	M	~ 1990			CAMBODIA	~ 1990	UNK	Capture		R.0074	PATTAYA 3
					FORESTRY	17 Nov 1991	UNK	Transfer			
TH48	M	~ 1984			CAMBODIA	~ 1991	UNK	Capture		R.0069	TAO
					FORESTRY	~ Sep 1991	UNK	Transfer			
TH49	F	~ 1991			CAMBODIA	~ 1993	UNK	Capture		R.0081	KHAOKHEOW
					FORESTRY	19 Jun 1994	UNK	Transfer			
TH50	F	~ 1986			CAMBODIA	~ 1986	UNK	Capture			
					FORESTRY	25 Aug 1991	UNK	Transfer			
TH51	M	~ 1990			CAMBODIA	~ 1990	UNK ltf	Capture		R.0072	PATTAYA 1
					FORESTRY	17 Nov 1991	UNK	Transfer			
TH52	F	~ 1990			CAMBODIA	~ 1990	UNK	Capture		R.0073	PATTAYA 2
					FORESTRY	~ Nov 1991	UNK	Transfer			
Totals: 3.3.4 (10)											

TOTALS: 17.13.15 (45) **4 Institutions**

Table 1. Effect of a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **8% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS4.001	8	27	42	3000	0.028	0.022	0.109	0	2405	680	99.17	0
SARUS4.004	8	32	42	3000	0.021	0.015	0.114	0	1997	897	98.95	0
SARUS4.007	8	37	42	3000	0.014	0.008	0.119	0	1434	931	98.5	0
SARUS4.010	8	27	47	3000	0.039	0.035	0.111	0	2711	420	99.38	0
SARUS4.013	8	32	47	3000	0.032	0.026	0.115	0	2479	627	99.25	0
SARUS4.016	8	37	47	3000	0.025	0.018	0.122	0	2079	807	99.02	0
SARUS4.019	8	27	37	3000	0.016	0.011	0.11	0	1668	905	98.82	0
SARUS4.022	8	32	37	3000	0.01	0.002	0.114	0.002	1060	865	98.09	78
SARUS4.025	8	37	37	3000	0.003	-0.005	0.121	0.004	662	705	97.28	72.5
								S= 0.006				
SARUS4.055	8	27	42	1500	0.028	0.023	0.108	0	1263	261	99.03	0
SARUS4.058	8	32	42	1500	0.021	0.015	0.113	0	1118	361	98.86	0
SARUS4.061	8	37	42	1500	0.014	0.007	0.121	0	877	442	98.34	0
SARUS4.064	8	27	47	1500	0.039	0.034	0.11	0	1352	197	99.14	0
SARUS4.067	8	32	47	1500	0.032	0.027	0.115	0	1300	261	99.04	0
SARUS4.070	8	37	47	1500	0.025	0.018	0.123	0	1113	365	98.79	0
SARUS4.073	8	27	37	1500	0.016	0.011	0.109	0	1011	409	98.58	0
SARUS4.076	8	32	37	1500	0.01	0.003	0.114	0	746	461	98.12	0
SARUS4.079	8	37	37	1500	0.003	-0.005	0.12	0.006	500	406	97.3	81.7
								S=0.006				
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS4.028	8	27	42	3000	0.028	0.011	0.115	0.004	1762	1021	97.13	65.5
SARUS4.031	8	32	42	3000	0.021	0.002	0.12	0.016	1147	985	96.45	61.1
SARUS4.034	8	37	42	3000	0.014	-0.007	0.13	0.036	711	804	94.37	74.3
SARUS4.037	8	27	47	3000	0.039	0.025	0.114	0	2464	700	98.65	0
SARUS4.040	8	32	47	3000	0.032	0.015	0.12	0.004	1983	960	97.85	51.5
SARUS4.043	8	37	47	3000	0.025	0.006	0.128	0.014	1439	1032	96.65	58
SARUS4.046	8	27	37	3000	0.016	-0.004	0.119	0.03	840	888	95.53	63.9
SARUS4.049	8	32	37	3000	0.01	-0.014	0.125	0.062	413	530	92.99	67
SARUS4.052	8	37	37	3000	0.003	-0.022	0.132	0.1	236	390	90	68.1

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
								S=0.266				
Effects of removal of 6 male and 6 female adults per year for 20 years from the population .												
SARUS4.082	8	27	42	3000	0.028	0.019	0.109	0.002	2252	792	98.86	87
SARUS4.085	8	32	42	3000	0.021	0.011	0.116	0.004	1711	918	98.42	87
SARUS4.088	8	37	42	3000	0.014	0.002	0.121	0.008	1069	887	97.51	43.3
SARUS4.091	8	27	47	3000	0.039	0.031	0.11	0	2648	492	99.21	0
SARUS4.094	8	32	47	3000	0.032	0.022	0.118	0.002	2341	740	98.91	10
SARUS4.097	8	37	47	3000	0.025	0.014	0.123	0.002	1877	927	98.51	27
SARUS4.100	8	27	37	3000	0.016	0.006	0.112	0.002	1329	957	98	17
SARUS4.103	8	32	37	3000	0.01	-0.003	0.117	0.01	800	786	96.77	47.4
SARUS4.106	8	37	37	3000	0.003	-0.011	0.124	0.024	440	565	95.13	69.3
								S=0.154				

Table 2. Effect of a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **10% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS4.001	10	27	42	3000	0.008	0.002	0.113	0	999	809	98.02	0
SARUS4.004	10	32	42	3000	0.002	-0.006	0.119	0.004	593	641	96.74	95
SARUS4.007	10	37	42	3000	-0.006	-0.014	0.126	0.018	313	458	95.03	88.3
SARUS4.010	10	27	47	3000	0.02	0.013	0.114	0	1818	897	98.76	0
SARUS4.013	10	32	47	3000	0.012	0.005	0.119	0	1234	886	98.27	0
SARUS4.016	10	37	47	3000	0.005	-0.004	0.127	0.008	706	701	97.13	86.3
SARUS4.019	10	27	37	3000	-0.004	-0.01	0.115	0.008	401	474	96.19	89.3
SARUS4.022	10	32	37	3000	-0.01	-0.018	0.122	0.026	201	281	93.81	87.4
SARUS4.025	10	37	37	3000	-0.017	-0.027	0.131	0.078	102	177	90.35	85.9
								S=0.142				
SARUS4.055	10	27	42	1500	0.008	0.002	0.112	0.002	698	419	98.02	81
SARUS4.058	10	32	42	1500	0.002	-0.006	0.119	0	473	410	96.67	0
SARUS4.061	10	37	42	1500	-0.006	-0.013	0.126	0.014	293	325	95	92.9
SARUS4.064	10	27	47	1500	0.02	0.014	0.114	0	1092	374	98.67	0
SARUS4.067	10	32	47	1500	0.012	0.006	0.119	0	851	436	98.25	0
SARUS4.070	10	37	47	1500	0.005	-0.003	0.128	0.002	560	426	97.01	97
SARUS4.073	10	27	37	1500	-0.004	-0.012	0.117	0.018	311	305	95.84	89.1
SARUS4.076	10	32	37	1500	-0.01	-0.019	0.122	0.026	176	214	93.82	89.5
SARUS4.079	10	37	37	1500	-0.017	-0.027	0.131	0.088	98	126	91.02	84.7
								S=0.150				
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS4.028	10	27	42	3000	0.008	-0.014	0.127	0.06	407	551	91.54	74.9
SARUS4.031	10	32	42	3000	0.002	-0.024	0.134	0.136	233	331	88.64	65.9
SARUS4.034	10	37	42	3000	-0.006	-0.035	0.145	0.274	110	207	84.06	67.8
SARUS4.037	10	27	47	3000	0.02	0	0.121	0.024	1078	927	96.06	73.4
SARUS4.040	10	32	47	3000	0.012	-0.009	0.129	0.024	584	690	93.51	51.3
SARUS4.043	10	37	47	3000	0.005	-0.02	0.14	0.12	330	492	90.59	71.9
SARUS4.046	10	27	37	3000	-0.004	-0.031	0.134	0.192	116	169	85.98	71
SARUS4.049	10	32	37	3000	-0.01	-0.041	0.143	0.334	56	75	82.43	67.7
SARUS4.052	10	37	37	3000	-0.017	-0.051	0.152	0.508	38	53	79.35	65.5

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
								S=1.672				
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS4.082	10	27	42	3000	0.008	-0.004	0.116	0.018	732	735	96.51	53.9
SARUS4.085	10	32	42	3000	0.002	-0.012	0.124	0.03	423	543	94.41	65.3
SARUS4.088	10	37	42	3000	-0.006	-0.022	0.135	0.102	220	358	92.11	57.1
SARUS4.091	10	27	47	3000	0.02	0.009	0.117	0.004	1542	960	98.05	52
SARUS4.094	10	32	47	3000	0.012	0.001	0.122	0.008	989	822	96.8	59
SARUS4.097	10	37	47	3000	0.005	-0.01	0.133	0.052	560	661	94.87	60.3
SARUS4.100	10	27	37	3000	-0.004	-0.02	0.125	0.084	250	360	92.45	62.6
SARUS4.103	10	32	37	3000	-0.01	-0.026	0.132	0.122	150	236	90.39	60.2
SARUS4.106	10	37	37	3000	-0.017	-0.037	0.143	0.272	80	140	86.53	68.8
								S=0.692				

Table 3. Effect of a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **12% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS4.001	12	27	42	3000	-0.012	-0.02	0.119	0.036	163	201	93.34	85.9
SARUS4.004	12	32	42	3000	-0.019	-0.029	0.129	0.114	89	127	89.2	84
SARUS4.007	12	37	42	3000	-0.026	-0.038	0.14	0.248	45	63	85.17	82.8
SARUS4.010	12	27	47	3000	-0.001	-0.008	0.117	0.008	491	561	96.29	87.5
SARUS4.013	12	32	47	3000	-0.008	-0.017	0.125	0.016	216	263	93.95	90.5
SARUS4.016	12	37	47	3000	-0.015	-0.025	0.135	0.092	127	198	91.74	84.2
SARUS4.019	12	27	37	3000	-0.024	-0.034	0.128	0.17	59	86	87.02	85
SARUS4.022	12	32	37	3000	-0.031	-0.043	0.139	0.328	29	35	82	81.4
SARUS4.025	12	37	37	3000	-0.038	-0.049	0.147	0.506	22	24	79.62	81.2
								S=1.518				
SARUS4.055	12	27	42	1500	-0.012	-0.021	0.12	0.038	157	183	92.45	81.1
SARUS4.058	12	32	42	1500	-0.019	-0.029	0.129	0.116	85	109	89.47	83.9
SARUS4.061	12	37	42	1500	-0.026	-0.037	0.139	0.236	48	56	85.8	84
SARUS4.064	12	27	47	1500	-0.001	-0.006	0.115	0.002	451	364	96.7	92
SARUS4.067	12	32	47	1500	-0.008	-0.016	0.125	0.022	243	285	94.44	88.2
SARUS4.070	12	37	47	1500	-0.015	-0.025	0.134	0.074	130	210	90.52	84.5
SARUS4.073	12	27	37	1500	-0.024	-0.035	0.129	0.172	53	78	86.26	86.5
SARUS4.076	12	32	37	1500	-0.031	-0.041	0.136	0.29	37	54	84.29	83.7
SARUS4.079	12	37	37	1500	-0.038	-0.05	0.147	0.514	22	28	79.12	78.9
								S=1.464				
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS4.028	12	27	42	3000	-0.012	-0.045	0.147	0.414	60	138	80.06	68.6
SARUS4.031	12	32	42	3000	-0.019	-0.056	0.156	0.578	35	45	77.31	62.6
SARUS4.034	12	37	42	3000	-0.026	-0.068	0.163	0.758	24	27	75.32	61.1
SARUS4.037	12	27	47	3000	-0.001	-0.027	0.135	0.196	198	321	88.35	68.4
SARUS4.040	12	32	47	3000	-0.008	-0.039	0.147	0.346	81	113	83.58	68.6
SARUS4.043	12	37	47	3000	-0.015	-0.05	0.155	0.522	52	71	81.49	66.6
SARUS4.046	12	27	37	3000	-0.024	-0.063	0.154	0.698	32	53	77.45	62.7
SARUS4.049	12	32	37	3000	-0.031	-0.073	0.163	0.806	19	27	72.55	60.4
SARUS4.052	12	37	37	3000	-0.038	-0.088	0.168	0.938	12	10	70.7	56

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
								S=5.256				
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS4.082	12	27	42	3000	-0.012	-0.029	0.129	0.152	110	149	88.76	69.5
SARUS4.085	12	32	42	3000	-0.019	-0.039	0.142	0.294	67	108	85.74	64.5
SARUS4.088	12	37	42	3000	-0.026	-0.049	0.155	0.496	41	54	82.04	67.1
SARUS4.091	12	27	47	3000	-0.001	-0.014	0.122	0.044	336	421	94.23	59
SARUS4.094	12	32	47	3000	-0.008	-0.026	0.137	0.154	189	306	90.6	63.3
SARUS4.097	12	37	47	3000	-0.015	-0.037	0.149	0.29	89	181	86.66	65.5
SARUS4.100	12	27	37	3000	-0.024	-0.045	0.143	0.36	39	49	82.42	65.5
SARUS4.103	12	32	37	3000	-0.031	-0.059	0.16	0.606	22	25	78.11	61
SARUS4.106	12	37	37	3000	-0.038	-0.07	0.171	0.758	18	20	76.67	57.6
								S=0.154				

Table 4. Effect of a **second catastrophe** on the viablity at 100 years of crane populations under the conditions of **8% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the second catastrophe was set at 6.6% (on average once every 15 years), with 0.2 severity on reproduction (80% reduction in clutchs), and 1.0 on survival (no reduction in survival across all age classes) in the year of the catastrophe. This second catastrophe is estimated effects of flooding for the ???
Population.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5A.001	8	27	42	3000	0.023	0.016	0.111	0	2065	822	99.04	0	0
SARUS5A.004	8	32	42	3000	0.016	0.01	0.117	0	1563	911	98.55	0	0
SARUS5A.007	8	37	42	3000	0.009	0.002	0.12	0	1040	820	98.13	0	0
SARUS5A.010	8	27	47	3000	0.034	0.029	0.112	0	2595	530	99.31	0	0
SARUS5A.013	8	32	47	3000	0.027	0.021	0.117	0	2244	764	99.13	0	0
SARUS5A.016	8	37	47	3000	0.02	0.012	0.123	0	1731	938	98.8	0	0
SARUS5A.019	8	27	37	3000	0.011	0.004	0.113	0	1175	854	98.36	0	0
SARUS5A.022	8	32	37	3000	0.005	-0.002	0.116	0.002	754	713	97.67	0	78
SARUS5A.025	8	37	37	3000	-0.002	-0.011	0.122	0.008	401	502	96.09	0	76.5
SARUS5A.055	8	27	42	1500	0.023	0.017	0.112	0	1169	335	98.93	0	0
SARUS5A.058	8	32	42	1500	0.016	0.011	0.114	0	991	410	98.64	0	0
SARUS5A.061	8	37	42	1500	0.009	0.003	0.121	0	751	454	97.97	0	0
SARUS5A.064	8	27	47	1500	0.034	0.027	0.113	0	1295	242	99.07	0	0
SARUS5A.067	8	32	47	1500	0.027	0.02	0.118	0	1173	340	98.95	0	0
SARUS5A.070	8	37	47	1500	0.02	0.012	0.124	0	1025	407	98.65	0	0
SARUS5A.073	8	27	37	1500	0.011	0.005	0.112	0.004	822	456	98.28	0	84.5
SARUS5A.076	8	32	37	1500	0.005	-0.003	0.117	0.004	572	445	97.48	0	97.5
SARUS5A.079	8	37	37	1500	-0.002	-0.01	0.123	0.016	361	341	96.29	0	84.9
Effects of removal of 15 male and 15 female chicks per year for 20 years.													
SARUS5A.028	8	27	42	3000	0.023	0.005	0.115	0.01	1343	1002	96.8	0	49.8
SARUS5A.031	8	32	42	3000	0.016	-0.003	0.121	0.018	860	839	95.6	0	68
SARUS5A.034	8	37	42	3000	0.009	-0.015	0.131	0.074	424	566	92.75	0	66.9
SARUS5A.037	8	27	47	3000	0.034	0.017	0.117	0.002	2050	922	98.07	0	47
SARUS5A.040	8	32	47	3000	0.027	0.009	0.122	0.004	1617	1016	97.36	0	91
SARUS5A.043	8	37	47	3000	0.02	-0.001	0.129	0.018	1017	910	95.9	0	65.4

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5A.046	8	27	37	3000	0.011	-0.01	0.121	0.044	549	653	94.12	0	68.9
SARUS5A.049	8	32	37	3000	0.005	-0.019	0.128	0.088	283	421	90.9	0	67.3
SARUS5A.052	8	37	37	3000	-0.002	-0.029	0.136	0.184	145	271	87.62	0	71.4
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.													
SARUS5A.082	8	27	42	3000	0.023	0.013	0.112	0.002	1825	953	98.55	0	27
SARUS5A.085	8	32	42	3000	0.016	0.005	0.119	0.01	1345	958	97.85	0	38.6
SARUS5A.088	8	37	42	3000	0.009	-0.003	0.124	0.016	813	806	96.63	0	45.5
SARUS5A.091	8	27	47	3000	0.034	0.025	0.113	0	2462	650	99.04	0	0
SARUS5A.094	8	32	47	3000	0.027	0.017	0.119	0.002	2026	890	98.69	0	35
SARUS5A.097	8	37	47	3000	0.02	0.008	0.126	0.012	1472	961	98.24	0	66.3
SARUS5A.100	8	27	37	3000	0.011	-0.001	0.116	0.012	894	805	97.11	0	40.8
SARUS5A.103	8	32	37	3000	0.005	-0.009	0.12	0.022	520	628	95.63	0	66.5
SARUS5A.106	8	37	37	3000	-0.002	-0.017	0.128	0.062	301	399	93.87	0	65.2

Table 5. Effect of a **second catastrophe** on the viablity at 100 years of crane populations under the conditions of **10% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the second catastrophe was set at 6.6% (on average once every 15 years), with 0.2 severity on reproduction (80% reduction in clutchs), and 1.0 on survival (no reduction in survival across all age classes) in the year of the catastrophe. This second catastrophe is estimated effects of flooding for the ???
Population.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS5A.001	10	27	42	3000	0.003	-0.004	0.115	0.004	674	658	97.18	95
SARUS5A.004	10	32	42	3000	-0.004	-0.012	0.121	0.018	382	503	95.61	82.9
SARUS5A.007	10	37	42	3000	-0.011	-0.02	0.129	0.042	185	269	93	85.2
SARUS5A.010	10	27	47	3000	0.014	0.007	0.116	0	1406	929	98.49	0
SARUS5A.013	10	32	47	3000	0.007	-0.001	0.123	0.002	855	762	97.62	74
SARUS5A.016	10	37	47	3000	0	-0.009	0.129	0.008	473	568	96.17	87.8
SARUS5A.019	10	27	37	3000	-0.009	-0.016	0.119	0.014	240	301	94.87	83.6
SARUS5A.022	10	32	37	3000	-0.015	-0.024	0.125	0.052	113	145	91.75	84.9
SARUS5A.025	10	37	37	3000	-0.022	-0.032	0.135	0.144	66	100	88.51	85
SARUS5A.055	10	27	42	1500	0.003	-0.003	0.116	0.002	577	434	97.28	100
SARUS5A.058	10	32	42	1500	-0.004	-0.013	0.124	0.016	292	312	95.01	84.8
SARUS5A.061	10	37	42	1500	-0.011	-0.019	0.128	0.04	196	241	93.82	89
SARUS5A.064	10	27	47	1500	0.014	0.008	0.117	0	933	433	98.22	0
SARUS5A.067	10	32	47	1500	0.007	0	0.122	0.002	655	432	97.59	93
SARUS5A.070	10	37	47	1500	0	-0.009	0.13	0.016	406	364	96.07	83.4
SARUS5A.073	10	27	37	1500	-0.009	-0.016	0.119	0.03	232	254	94.49	87.1
SARUS5A.076	10	32	37	1500	-0.015	-0.024	0.125	0.076	125	165	92.15	86.2
SARUS5A.079	10	37	37	1500	-0.022	-0.033	0.135	0.15	59	71	87.54	85.1
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS5A.028	10	27	42	3000	0.003	-0.021	0.129	0.108	242	335	90.33	67.1
SARUS5A.031	10	32	42	3000	-0.004	-0.03	0.139	0.178	119	192	87.07	67
SARUS5A.034	10	37	42	3000	-0.011	-0.043	0.147	0.408	70	114	85.02	65.9
SARUS5A.037	10	27	47	3000	0.014	-0.007	0.127	0.042	729	784	94.07	66.8
SARUS5A.040	10	32	47	3000	0.007	-0.016	0.132	0.088	384	513	91.63	71.3
SARUS5A.043	10	37	47	3000	0	-0.027	0.143	0.18	201	336	88.62	65.6
SARUS5A.046	10	27	37	3000	-0.009	-0.036	0.139	0.268	91	170	83.66	70.7
SARUS5A.049	10	32	37	3000	-0.015	-0.048	0.148	0.474	50	67	79.98	68.4

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS5A.052	10	37	37	3000	-0.022	-0.062	0.158	0.682	29	38	76.71	63.4
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS5A.082	10	27	42	3000	0.003	-0.009	0.12	0.026	481	528	95.16	62.5
SARUS5A.085	10	32	42	3000	-0.004	-0.019	0.128	0.062	236	344	92.52	64.8
SARUS5A.088	10	37	42	3000	-0.011	-0.031	0.142	0.186	115	181	89.18	59.5
SARUS5A.091	10	27	47	3000	0.014	0.001	0.121	0.02	1080	872	97.01	51.3
SARUS5A.094	10	32	47	3000	0.007	-0.007	0.126	0.034	616	667	95.72	49.8
SARUS5A.097	10	37	47	3000	0	-0.016	0.135	0.074	335	463	93.54	58
SARUS5A.100	10	27	37	3000	-0.009	-0.025	0.128	0.112	158	225	91.04	65.6
SARUS5A.103	10	32	37	3000	-0.015	-0.033	0.137	0.19	84	154	87.82	67.8
SARUS5A.106	10	37	37	3000	-0.022	-0.044	0.146	0.382	46	54	84.62	66.8

Table 6. Effect of a **second catastrophe** on the viablity at 100 years of crane populations under the conditions of **12% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the second catastrophe was set at 6.6% (on average once every 15 years), with 0.2 severity on reproduction (80% reduction in clutchs), and 1.0 on survival (no reduction in survival across all age classes) in the year of the catastrophe. This second catastrophe is estimated effects of flooding for the ???
Population.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5A.001	12	27	42	3000	-0.017	-0.026	0.124	0.07	97	116	90.05	0	85.2
SARUS5A.004	12	32	42	3000	-0.024	-0.035	0.134	0.212	59	75	86.83	0	84.2
SARUS5A.007	12	37	42	3000	-0.031	-0.043	0.143	0.352	35	54	84.25	0	81.4
SARUS5A.010	12	27	47	3000	-0.006	-0.015	0.121	0.008	260	322	94.41	0	81
SARUS5A.013	12	32	47	3000	-0.013	-0.023	0.13	0.068	165	271	91.16	0	86.4
SARUS5A.016	12	37	47	3000	-0.02	-0.031	0.137	0.13	88	147	88.1	0	84
SARUS5A.019	12	27	37	3000	-0.029	-0.04	0.135	0.292	41	55	84.33	0	84
SARUS5A.022	12	32	37	3000	-0.036	-0.046	0.142	0.416	25	33	79.3	0	83.3
SARUS5A.025	12	37	37	3000	-0.043	-0.055	0.149	0.65	18	20	77.47	92	79.2
SARUS5A.055	12	27	42	1500	-0.017	-0.026	0.124	0.078	115	147	90.84	0	84.5
SARUS5A.058	12	32	42	1500	-0.024	-0.034	0.133	0.182	63	80	88.16	0	83.2
SARUS5A.061	12	37	42	1500	-0.031	-0.041	0.142	0.328	36	42	83.53	0	82.4
SARUS5A.064	12	27	47	1500	-0.006	-0.015	0.122	0.018	256	282	94.64	0	85.8
SARUS5A.067	12	32	47	1500	-0.013	-0.022	0.128	0.058	161	204	92.38	0	84.5
SARUS5A.070	12	37	47	1500	-0.02	-0.03	0.137	0.122	77	105	88.36	0	78.5
SARUS5A.073	12	27	37	1500	-0.029	-0.04	0.133	0.286	37	49	84.58	0	83.4
SARUS5A.076	12	32	37	1500	-0.036	-0.047	0.142	0.46	27	32	80.99	0	81.4
SARUS5A.079	12	37	37	1500	-0.043	-0.055	0.15	0.646	16	16	77.28	92	78.9
Effects of removal of 15 male and 15 female chicks per year for 20 years.													
SARUS5A.028	12	27	42	3000	-0.017	-0.051	0.15	0.516	41	58	77.43	98	66.7
SARUS5A.031	12	32	42	3000	-0.024	-0.064	0.16	0.708	26	37	75.5	77	62.7
SARUS5A.034	12	37	42	3000	-0.031	-0.072	0.165	0.778	18	24	73.1	68	59.6
SARUS5A.037	12	27	47	3000	-0.006	-0.034	0.142	0.276	123	175	85.89	0	69.9
SARUS5A.040	12	32	47	3000	-0.013	-0.046	0.15	0.454	69	200	82.27	0	65.6
SARUS5A.043	12	37	47	3000	-0.02	-0.059	0.161	0.63	35	53	77.64	82	63.1
SARUS5A.046	12	27	37	3000	-0.029	-0.072	0.16	0.828	16	17	70.91	68	61.7

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5A.049	12	32	37	3000	-0.036	-0.082	0.164	0.89	16	19	71.68	59	56.9
SARUS5A.052	12	37	37	3000	-0.043	-0.095	0.171	0.958	12	9	70.6	52	52.6
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.													
SARUS5A.082	12	27	42	3000	-0.017	-0.038	0.137	0.294	73	108	86.21	0	68
SARUS5A.085	12	32	42	3000	-0.024	-0.048	0.151	0.448	39	46	82.02	0	68.2
SARUS5A.088	12	37	42	3000	-0.031	-0.056	0.16	0.576	28	31	79.08	93	62.1
SARUS5A.091	12	27	47	3000	-0.006	-0.021	0.129	0.09	209	322	91.72	0	60.2
SARUS5A.094	12	32	47	3000	-0.013	-0.032	0.139	0.184	103	162	86.95	0	66.8
SARUS5A.097	12	37	47	3000	-0.02	-0.042	0.152	0.336	57	90	83.32	0	64.3
SARUS5A.100	12	27	37	3000	-0.029	-0.056	0.154	0.554	27	35	80.66	93	63.2
SARUS5A.103	12	32	37	3000	-0.036	-0.064	0.163	0.69	20	23	76.95	82	60.7
SARUS5A.106	12	37	37	3000	-0.043	-0.079	0.176	0.834	16	16	75.76	66	54.1

Table 7. Effect of a **second catastrophe** on the viablity at 100 years of crane populations under the conditions of **8% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the second catastrophe was set at 5% (on average once every 20 years), with 1.0 severity on reproduction (no reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe. This second catastrophe is estimated effects of drought for the ???
Population.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS5B.001	8	27	42	3000	0.023	0.018	0.111	0	2138	808	99.07	0
SARUS5B.004	8	32	42	3000	0.016	0.01	0.115	0	1619	927	98.65	0
SARUS5B.007	8	37	42	3000	0.009	0.002	0.124	0.002	981	832	97.98	83
SARUS5B.010	8	27	47	3000	0.034	0.028	0.114	0	2577	537	99.24	0
SARUS5B.013	8	32	47	3000	0.027	0.021	0.118	0	2283	740	99.13	0
SARUS5B.016	8	37	47	3000	0.02	0.013	0.124	0	1750	920	98.8	0
SARUS5B.019	8	27	37	3000	0.011	0.004	0.113	0	1185	859	98.33	0
SARUS5B.022	8	32	37	3000	0.005	-0.002	0.117	0	729	678	97.49	0
SARUS5B.025	8	37	37	3000	-0.002	-0.01	0.124	0.012	449	555	96.25	91.8
SARUS5B.055	8	27	42	1500	0.023	0.017	0.111	0	1161	333	98.9	0
SARUS5B.058	8	32	42	1500	0.016	0.01	0.117	0	956	418	98.54	0
SARUS5B.061	8	37	42	1500	0.009	0.002	0.122	0.002	696	436	97.94	96
SARUS5B.064	8	27	47	1500	0.034	0.028	0.113	0	1318	238	99.06	0
SARUS5B.067	8	32	47	1500	0.027	0.021	0.118	0	1214	318	98.94	0
SARUS5B.070	8	37	47	1500	0.02	0.012	0.124	0	1004	422	98.54	0
SARUS5B.073	8	27	37	1500	0.011	0.004	0.114	0	787	447	98.15	0
SARUS5B.076	8	32	37	1500	0.005	-0.003	0.117	0	547	426	97.42	0
SARUS5B.079	8	37	37	1500	-0.002	-0.01	0.123	0.014	369	356	96.22	87.7
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS5B.028	8	27	42	3000	0.023	0.004	0.117	0.014	1316	998	96.84	60.3
SARUS5B.031	8	32	42	3000	0.016	-0.005	0.125	0.028	767	808	94.43	64.7
SARUS5B.034	8	37	42	3000	0.009	-0.015	0.133	0.074	399	524	92.41	63.5
SARUS5B.037	8	27	47	3000	0.034	0.019	0.119	0.008	2273	826	98.36	49.8
SARUS5B.040	8	32	47	3000	0.027	0.009	0.124	0.01	1642	1026	97.08	51
SARUS5B.043	8	37	47	3000	0.02	-0.001	0.132	0.026	993	921	95.71	67.8

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS5B.046	8	27	37	3000	0.011	-0.011	0.123	0.056	562	663	93.65	67.5
SARUS5B.049	8	32	37	3000	0.005	-0.02	0.131	0.09	273	412	90.76	68
SARUS5B.052	8	37	37	3000	-0.002	-0.031	0.139	0.204	136	208	87.64	69
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS5B.082	8	27	42	3000	0.023	0.014	0.113	0.002	1905	907	98.57	20
SARUS5B.085	8	32	42	3000	0.016	0.006	0.118	0.006	1355	927	97.87	14.7
SARUS5B.088	8	37	42	3000	0.009	-0.005	0.127	0.024	770	784	96.09	60.2
SARUS5B.091	8	27	47	3000	0.034	0.025	0.114	0.002	2405	691	98.98	25
SARUS5B.094	8	32	47	3000	0.027	0.016	0.121	0.01	2012	874	98.71	41.2
SARUS5B.097	8	37	47	3000	0.02	0.007	0.127	0.012	1432	969	97.81	40.7
SARUS5B.100	8	27	37	3000	0.011	0	0.115	0.016	982	868	97.35	58.1
SARUS5B.103	8	32	37	3000	0.005	-0.009	0.122	0.028	530	599	95.7	50.2
SARUS5B.106	8	37	37	3000	-0.002	-0.018	0.13	0.066	285	410	93.27	66.8

Table 8. Effect of a **second catastrophe** on the viablity at 100 years of crane populations under the conditions of **10% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the second catastrophe was set at 5% (on average once every 20 years), with 1.0 severity on reproduction (no reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe. This second catastrophe is estimated effects of drought for the ???
Population.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5B.001	10	27	42	3000	0.003	-0.004	0.116	0.004	660	616	97.08	0	76
SARUS5B.004	10	32	42	3000	-0.003	-0.011	0.122	0.002	384	474	95.54	0	78
SARUS5B.007	10	37	42	3000	-0.011	-0.021	0.13	0.038	183	252	92.46	0	84.9
SARUS5B.010	10	27	47	3000	0.015	0.008	0.116	0	1420	913	98.44	0	0
SARUS5B.013	10	32	47	3000	0.007	0	0.124	0	932	846	97.48	0	0
SARUS5B.016	10	37	47	3000	0	-0.008	0.129	0.006	538	618	96.19	0	67
SARUS5B.019	10	27	37	3000	-0.009	-0.017	0.122	0.022	235	320	94.27	0	85.3
SARUS5B.022	10	32	37	3000	-0.015	-0.025	0.128	0.076	123	172	91.46	0	84.5
SARUS5B.025	10	37	37	3000	-0.022	-0.033	0.137	0.162	65	90	87.47	0	83
SARUS5B.055	10	27	42	1500	0.003	-0.004	0.116	0.002	520	414	97.17	0	100
SARUS5B.058	10	32	42	1500	-0.003	-0.012	0.123	0.02	313	318	95.46	0	84.9
SARUS5B.061	10	37	42	1500	-0.011	-0.02	0.13	0.04	169	195	93.42	0	88.7
SARUS5B.064	10	27	47	1500	0.015	0.008	0.116	0	932	413	98.39	0	0
SARUS5B.067	10	32	47	1500	0.007	0	0.123	0.004	665	441	97.6	0	78
SARUS5B.070	10	37	47	1500	0	-0.009	0.131	0.01	411	387	95.78	0	86.6
SARUS5B.073	10	27	37	1500	-0.009	-0.016	0.121	0.014	232	261	94.37	0	82.1
SARUS5B.076	10	32	37	1500	-0.015	-0.025	0.128	0.08	121	159	91.22	0	89.5
SARUS5B.079	10	37	37	1500	-0.022	-0.034	0.137	0.19	68	95	86.8	0	84.1
Effects of removal of 15 male and 15 female chicks per year for 20 years.													
SARUS5B.028	10	27	42	3000	0.003	-0.023	0.132	0.138	254	351	89.41	0	65
SARUS5B.031	10	32	42	3000	-0.003	-0.033	0.142	0.256	153	277	86.24	0	69.8
SARUS5B.034	10	37	42	3000	-0.011	-0.044	0.152	0.39	64	107	81.57	0	69.8
SARUS5B.037	10	27	47	3000	0.015	-0.007	0.127	0.04	714	783	93.95	0	66.3
SARUS5B.040	10	32	47	3000	0.007	-0.016	0.134	0.09	411	543	91.51	0	66.2
SARUS5B.043	10	37	47	3000	0	-0.029	0.146	0.218	184	312	87.82	0	66.4
SARUS5B.046	10	27	37	3000	-0.009	-0.038	0.142	0.29	80	131	83.28	0	68.3

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5B.049	10	32	37	3000	-0.015	-0.049	0.15	0.458	49	92	79.42	0	64.6
SARUS5B.052	10	37	37	3000	-0.022	-0.06	0.159	0.634	27	41	74.82	83	64.1
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.													
SARUS5B.082	10	27	42	3000	0.003	-0.01	0.122	0.036	497	560	94.74	0	58.1
SARUS5B.085	10	32	42	3000	-0.003	-0.02	0.131	0.09	250	371	92.63	0	60.4
SARUS5B.088	10	37	42	3000	-0.011	-0.028	0.14	0.146	133	229	89.11	0	60.3
SARUS5B.091	10	27	47	3000	0.015	0.002	0.12	0.016	1083	866	97.19	0	61.6
SARUS5B.094	10	32	47	3000	0.007	-0.007	0.126	0.034	653	700	95.94	0	54.8
SARUS5B.097	10	37	47	3000	0	-0.017	0.137	0.078	324	455	92.76	0	51.4
SARUS5B.100	10	27	37	3000	-0.009	-0.025	0.131	0.124	157	225	90.53	0	60.6
SARUS5B.103	10	32	37	3000	-0.015	-0.035	0.14	0.246	75	90	87.83	0	66.5
SARUS5B.106	10	37	37	3000	-0.022	-0.046	0.153	0.402	52	70	84.43	0	60.2

Table 9. . Effect of a **second catastrophe** on the viablity at 100 years of crane populations under the conditions of **12% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the second catastrophe was set at 5% (on average once every 20 years), with 1.0 severity on reproduction (no reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe. This second catastrophe is estimated effects of drought for the ???
Population.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5B.001	12	27	42	3000	-0.017	-0.025	0.124	0.066	112	160	90.19	0	85.8
SARUS5B.004	12	32	42	3000	-0.024	-0.034	0.135	0.166	56	78	86.71	0	84.3
SARUS5B.007	12	37	42	3000	-0.031	-0.043	0.146	0.374	41	54	84.28	0	79.6
SARUS5B.010	12	27	47	3000	-0.006	-0.014	0.121	0.014	307	416	94.69	0	86.4
SARUS5B.013	12	32	47	3000	-0.013	-0.022	0.13	0.062	156	195	91.83	0	83.5
SARUS5B.016	12	37	47	3000	-0.02	-0.032	0.142	0.198	81	117	88.23	0	85
SARUS5B.019	12	27	37	3000	-0.029	-0.04	0.134	0.286	39	45	84.54	0	82.7
SARUS5B.022	12	32	37	3000	-0.036	-0.046	0.142	0.404	24	33	78.83	0	80.6
SARUS5B.025	12	37	37	3000	-0.043	-0.055	0.151	0.656	17	18	76.53	90	78.9
SARUS5B.055	12	27	42	1500	-0.017	-0.026	0.124	0.078	101	129	90.86	0	85.7
SARUS5B.058	12	32	42	1500	-0.024	-0.034	0.134	0.188	59	85	86.83	0	85.1
SARUS5B.061	12	37	42	1500	-0.031	-0.044	0.145	0.4	34	47	82.59	0	82.9
SARUS5B.064	12	27	47	1500	-0.006	-0.014	0.121	0.022	278	291	94.79	0	88.8
SARUS5B.067	12	32	47	1500	-0.013	-0.022	0.129	0.07	149	190	92.3	0	81.2
SARUS5B.070	12	37	47	1500	-0.02	-0.032	0.14	0.176	78	111	89.06	0	84.1
SARUS5B.073	12	27	37	1500	-0.029	-0.04	0.135	0.302	37	44	84.19	0	83.4
SARUS5B.076	12	32	37	1500	-0.036	-0.048	0.144	0.478	21	28	80.04	0	82.6
SARUS5B.079	12	37	37	1500	-0.043	-0.055	0.152	0.628	17	19	77.65	90	77.4
Effects of removal of 15 male and 15 female chicks per year for 20 years.													
SARUS5B.028	12	27	42	3000	-0.017	-0.053	0.153	0.572	48	64	78.55	91	65.5
SARUS5B.031	12	32	42	3000	-0.024	-0.062	0.159	0.684	36	56	75.63	77	62.5
SARUS5B.034	12	37	42	3000	-0.031	-0.079	0.169	0.886	20	24	68.8	60	59.1
SARUS5B.037	12	27	47	3000	-0.006	-0.032	0.14	0.22	119	212	85.81	0	68.2
SARUS5B.040	12	32	47	3000	-0.013	-0.045	0.151	0.422	65	120	81.86	0	67.2
SARUS5B.043	12	37	47	3000	-0.02	-0.059	0.165	0.636	39	55	77.44	83	62.3
SARUS5B.046	12	27	37	3000	-0.029	-0.072	0.163	0.802	20	26	72.98	66	60.1

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	Med.TE	MeanTE
SARUS5B.049	12	32	37	3000	-0.036	-0.084	0.167	0.888	16	13	73.56	57	55.1
SARUS5B.052	12	37	37	3000	-0.043	-0.096	0.171	0.954	10	9	61.69	50	51.8
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.													
SARUS5B.082	12	27	42	3000	-0.017	-0.038	0.142	0.292	68	99	86.13	0	64.6
SARUS5B.085	12	32	42	3000	-0.024	-0.049	0.154	0.458	47	75	82.84	0	62
SARUS5B.088	12	37	42	3000	-0.031	-0.06	0.165	0.636	24	41	78.05	86	62.4
SARUS5B.091	12	27	47	3000	-0.006	-0.022	0.131	0.114	213	323	91.77	0	57.5
SARUS5B.094	12	32	47	3000	-0.013	-0.032	0.143	0.206	99	130	87.39	0	65.4
SARUS5B.097	12	37	47	3000	-0.02	-0.046	0.157	0.44	67	181	85.94	0	62
SARUS5B.100	12	27	37	3000	-0.029	-0.054	0.153	0.53	28	34	79.29	96	63.2
SARUS5B.103	12	32	37	3000	-0.036	-0.066	0.166	0.702	19	23	74.85	78	59.2
SARUS5B.106	12	37	37	3000	-0.043	-0.08	0.18	0.836	16	17	70.68	65	54.6

Table 10. Effects of a **1% per year decline in carrying capacity (K)** for 20 years with a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **8% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6A.001	8	27	42	3000	0.028	0.022	0.109	0	1955	522	99.16	0
SARUS6A.004	8	32	42	3000	0.021	0.016	0.113	0	1675	685	98.92	0
SARUS6A.007	8	37	42	3000	0.014	0.007	0.119	0	1188	738	98.51	0
SARUS6A.010	8	27	47	3000	0.039	0.034	0.11	0	2148	342	99.33	0
SARUS6A.013	8	32	47	3000	0.032	0.026	0.116	0	1971	499	99.21	0
SARUS6A.016	8	37	47	3000	0.025	0.018	0.121	0	1727	615	99.02	0
SARUS6A.019	8	27	37	3000	0.016	0.01	0.111	0	1396	695	98.71	0
SARUS6A.022	8	32	37	3000	0.01	0.003	0.113	0	992	714	98.2	0
SARUS6A.025	8	37	37	3000	0.003	-0.005	0.119	0.008	556	526	97.27	83.3
SARUS6A.055	8	27	42	1500	0.028	0.022	0.108	0	1013	215	98.92	0
SARUS6A.058	8	32	42	1500	0.021	0.014	0.114	0	891	284	98.72	0
SARUS6A.061	8	37	42	1500	0.014	0.007	0.121	0	724	338	98.25	0
SARUS6A.064	8	27	47	1500	0.039	0.033	0.112	0	1066	180	98.98	0
SARUS6A.067	8	32	47	1500	0.032	0.026	0.115	0	1015	203	98.94	0
SARUS6A.070	8	37	47	1500	0.025	0.017	0.122	0	909	275	98.7	0
SARUS6A.073	8	27	37	1500	0.016	0.011	0.11	0	861	298	98.66	0
SARUS6A.076	8	32	37	1500	0.01	0.003	0.116	0	652	372	97.9	0
SARUS6A.079	8	37	37	1500	0.003	-0.005	0.12	0.002	447	340	96.79	99
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS6A.028	8	27	42	3000	0.028	0.012	0.113	0	1525	767	97.61	0
SARUS6A.031	8	32	42	3000	0.021	0.001	0.12	0.03	1080	813	96.13	67.8
SARUS6A.034	8	37	42	3000	0.014	-0.008	0.127	0.04	625	658	94.23	71
SARUS6A.037	8	27	47	3000	0.039	0.025	0.114	0	2025	516	98.68	0
SARUS6A.040	8	32	47	3000	0.032	0.017	0.119	0	1718	724	98.03	0
SARUS6A.043	8	37	47	3000	0.025	0.006	0.128	0.018	1278	807	96.77	70.9
SARUS6A.046	8	27	37	3000	0.016	-0.003	0.116	0.028	823	719	95.83	64.6
SARUS6A.049	8	32	37	3000	0.01	-0.013	0.123	0.062	423	513	93.04	64.2

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6A.052	8	37	37	3000	0.003	-0.024	0.134	0.128	220	331	89.22	66.6
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS6A.082	8	27	42	3000	0.028	0.018	0.11	0	1834	617	98.69	0
SARUS6A.085	8	32	42	3000	0.021	0.011	0.114	0.004	1447	730	98.41	55.5
SARUS6A.088	8	37	42	3000	0.014	0.003	0.123	0.008	1011	750	97.59	32.5
SARUS6A.091	8	27	47	3000	0.039	0.03	0.111	0	2115	387	99.14	0
SARUS6A.094	8	32	47	3000	0.032	0.022	0.116	0	1924	542	98.97	0
SARUS6A.097	8	37	47	3000	0.025	0.013	0.125	0.004	1524	723	98.32	19
SARUS6A.100	8	27	37	3000	0.016	0.006	0.111	0.002	1188	749	98.04	44
SARUS6A.103	8	32	37	3000	0.01	-0.003	0.116	0.01	754	672	96.61	39.8
SARUS6A.106	8	37	37	3000	0.003	-0.012	0.125	0.044	414	491	95.12	56

Table 11. Effects of a **1% per year decline in carrying capacity (K)** for 20 years with a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **10% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6A.001	10	27	42	3000	0.008	0.002	0.113	0	922	679	97.96	0
SARUS6A.004	10	32	42	3000	0.002	-0.005	0.119	0.008	568	538	97.13	80
SARUS6A.007	10	37	42	3000	-0.006	-0.013	0.126	0.018	335	422	94.92	88.4
SARUS6A.010	10	27	47	3000	0.02	0.012	0.115	0.002	1532	710	98.75	72
SARUS6A.013	10	32	47	3000	0.012	0.005	0.12	0	1098	709	98.16	0
SARUS6A.016	10	37	47	3000	0.005	-0.003	0.125	0.006	689	616	97.38	97.3
SARUS6A.019	10	27	37	3000	-0.004	-0.011	0.116	0.016	366	403	96.03	86
SARUS6A.022	10	32	37	3000	-0.01	-0.02	0.123	0.028	178	253	93.09	80.7
SARUS6A.025	10	37	37	3000	-0.017	-0.026	0.131	0.068	111	211	90.91	85.6
SARUS6A.055	10	27	42	1500	0.008	0.002	0.113	0	617	355	97.83	0
SARUS6A.058	10	32	42	1500	0.002	-0.005	0.117	0.01	457	335	97.08	91.4
SARUS6A.061	10	37	42	1500	-0.006	-0.015	0.127	0.04	259	259	94.91	86.6
SARUS6A.064	10	27	47	1500	0.02	0.013	0.114	0	876	296	98.59	0
SARUS6A.067	10	32	47	1500	0.012	0.004	0.12	0.004	683	356	98.06	97.5
SARUS6A.070	10	37	47	1500	0.005	-0.002	0.125	0	510	348	97.17	0
SARUS6A.073	10	27	37	1500	-0.004	-0.011	0.116	0.012	311	288	95.48	85.5
SARUS6A.076	10	32	37	1500	-0.01	-0.019	0.122	0.028	179	202	93.74	87.9
SARUS6A.079	10	37	37	1500	-0.017	-0.028	0.132	0.1	100	127	89.72	84.5
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS6A.028	10	27	42	3000	0.008	-0.013	0.124	0.05	402	484	92.68	63.9
SARUS6A.031	10	32	42	3000	0.002	-0.025	0.135	0.17	212	288	89.61	66.3
SARUS6A.034	10	37	42	3000	-0.006	-0.034	0.144	0.264	120	180	85.78	64.5
SARUS6A.037	10	27	47	3000	0.02	0	0.123	0.028	963	772	95.8	71.3
SARUS6A.040	10	32	47	3000	0.012	-0.01	0.129	0.052	578	629	93.47	65.4
SARUS6A.043	10	37	47	3000	0.005	-0.02	0.14	0.102	302	433	89.87	68.5
SARUS6A.046	10	27	37	3000	-0.004	-0.032	0.135	0.216	110	179	86.4	69.3
SARUS6A.049	10	32	37	3000	-0.01	-0.041	0.144	0.344	76	134	83.56	65.9

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6A.052	10	37	37	3000	-0.017	-0.054	0.153	0.546	34	52	78.2	67.1
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS6A.082	10	27	42	3000	0.008	-0.004	0.117	0.016	672	606	96.52	56.3
SARUS6A.085	10	32	42	3000	0.002	-0.012	0.124	0.032	398	476	94.13	49.1
SARUS6A.088	10	37	42	3000	-0.006	-0.023	0.135	0.102	202	265	91.51	57.1
SARUS6A.091	10	27	47	3000	0.02	0.008	0.115	0.002	1312	747	98.03	96
SARUS6A.094	10	32	47	3000	0.012	-0.001	0.124	0.016	856	696	96.92	35.6
SARUS6A.097	10	37	47	3000	0.005	-0.009	0.133	0.038	520	555	95.11	44.8
SARUS6A.100	10	27	37	3000	-0.004	-0.018	0.122	0.048	213	298	92.97	62
SARUS6A.103	10	32	37	3000	-0.01	-0.028	0.134	0.146	135	194	90.16	58.9
SARUS6A.106	10	37	37	3000	-0.017	-0.038	0.145	0.268	67	110	85.58	63.2

Table 12. Effects of a **1% per year decline in carrying capacity (K)** for 20 years with a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **12% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6A.001	12	27	42	3000	-0.012	-0.02	0.119	0.034	171	207	93.13	82.9
SARUS6A.004	12	32	42	3000	-0.019	-0.03	0.13	0.106	78	109	88.73	84.1
SARUS6A.007	12	37	42	3000	-0.026	-0.037	0.138	0.236	50	63	85.64	84.6
SARUS6A.010	12	27	47	3000	-0.001	-0.008	0.117	0.004	488	519	96.26	72
SARUS6A.013	12	32	47	3000	-0.008	-0.017	0.125	0.034	222	291	93.69	83.1
SARUS6A.016	12	37	47	3000	-0.015	-0.025	0.134	0.076	124	172	91.2	85.5
SARUS6A.019	12	27	37	3000	-0.024	-0.034	0.128	0.146	51	64	86.42	85
SARUS6A.022	12	32	37	3000	-0.031	-0.041	0.137	0.286	33	46	82.61	83.1
SARUS6A.025	12	37	37	3000	-0.038	-0.051	0.147	0.548	21	28	78.65	80.5
SARUS6A.055	12	27	42	1500	-0.012	-0.02	0.12	0.038	164	194	92.74	84.9
SARUS6A.058	12	32	42	1500	-0.019	-0.03	0.131	0.126	84	114	88.69	84.1
SARUS6A.061	12	37	42	1500	-0.026	-0.037	0.138	0.238	47	65	85.94	81.9
SARUS6A.064	12	27	47	1500	-0.001	-0.008	0.116	0.008	384	304	96.24	74.3
SARUS6A.067	12	32	47	1500	-0.008	-0.016	0.125	0.036	241	250	93.72	84.2
SARUS6A.070	12	37	47	1500	-0.015	-0.024	0.134	0.078	123	156	91.1	81.1
SARUS6A.073	12	27	37	1500	-0.024	-0.034	0.129	0.166	56	77	86.84	86
SARUS6A.076	12	32	37	1500	-0.031	-0.042	0.137	0.31	34	50	83.53	80.1
SARUS6A.079	12	37	37	1500	-0.038	-0.05	0.146	0.526	19	17	80.81	79.5
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS6A.028	12	27	42	3000	-0.012	-0.044	0.145	0.388	62	90	81.22	63.8
SARUS6A.031	12	32	42	3000	-0.019	-0.056	0.155	0.58	37	46	77.04	64.6
SARUS6A.034	12	37	42	3000	-0.026	-0.067	0.163	0.738	24	32	73.44	61.1
SARUS6A.037	12	27	47	3000	-0.001	-0.027	0.134	0.154	164	251	88.02	68.6
SARUS6A.040	12	32	47	3000	-0.008	-0.036	0.146	0.302	117	214	85.06	68.2
SARUS6A.043	12	37	47	3000	-0.015	-0.048	0.156	0.468	58	87	79.98	65
SARUS6A.046	12	27	37	3000	-0.024	-0.061	0.155	0.656	21	25	69.79	63.8
SARUS6A.049	12	32	37	3000	-0.031	-0.077	0.162	0.834	16	18	68.2	58.2

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6A.052	12	37	37	3000	-0.038	-0.091	0.17	0.922	11	10	65.54	52.8
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS6A.082	12	27	42	3000	-0.012	-0.028	0.13	0.144	122	165	89.43	65.3
SARUS6A.085	12	32	42	3000	-0.019	-0.039	0.141	0.284	63	115	85.28	68.1
SARUS6A.088	12	37	42	3000	-0.026	-0.052	0.157	0.492	33	42	79.88	61.9
SARUS6A.091	12	27	47	3000	-0.001	-0.014	0.122	0.048	320	369	93.97	62.4
SARUS6A.094	12	32	47	3000	-0.008	-0.025	0.134	0.122	171	263	89.58	63.9
SARUS6A.097	12	37	47	3000	-0.015	-0.035	0.148	0.26	100	157	87.48	63.4
SARUS6A.100	12	27	37	3000	-0.024	-0.047	0.145	0.442	46	63	83.52	66.9
SARUS6A.103	12	32	37	3000	-0.031	-0.057	0.157	0.578	23	24	78.28	61.7
SARUS6A.106	12	37	37	3000	-0.038	-0.068	0.166	0.734	17	22	73.83	60.4

Table 13. Effects of a **2.5% per year decline in carrying capacity (K)** for 20 years with a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **8% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6B.001	8	27	42	3000	0.028	0.023	0.108	0	1273	271	99.03	0
SARUS6B.004	8	32	42	3000	0.021	0.015	0.112	0	1120	362	98.85	0
SARUS6B.007	8	37	42	3000	0.014	0.006	0.121	0.002	820	455	98.21	100
SARUS6B.010	8	27	47	3000	0.039	0.034	0.11	0	1355	211	99.15	0
SARUS6B.013	8	32	47	3000	0.032	0.026	0.116	0	1258	277	99.04	0
SARUS6B.016	8	37	47	3000	0.025	0.018	0.122	0	1158	356	98.93	0
SARUS6B.019	8	27	37	3000	0.016	0.01	0.11	0	994	409	98.69	0
SARUS6B.022	8	32	37	3000	0.01	0.004	0.114	0	787	445	98.25	0
SARUS6B.025	8	37	37	3000	0.003	-0.007	0.124	0.01	453	389	96.85	85
SARUS6B.055	8	27	42	1500	0.028	0.022	0.109	0	636	131	98.5	0
SARUS6B.058	8	32	42	1500	0.021	0.015	0.113	0	578	168	98.33	0
SARUS6B.061	8	37	42	1500	0.014	0.008	0.119	0	492	199	98.04	0
SARUS6B.064	8	27	47	1500	0.039	0.034	0.11	0	678	96	98.59	0
SARUS6B.067	8	32	47	1500	0.032	0.025	0.115	0	635	131	98.53	0
SARUS6B.070	8	37	47	1500	0.025	0.018	0.124	0.002	592	160	98.36	98
SARUS6B.073	8	27	37	1500	0.016	0.01	0.11	0	541	184	98.18	0
SARUS6B.076	8	32	37	1500	0.01	0.003	0.114	0	447	208	97.78	0
SARUS6B.079	8	37	37	1500	0.003	-0.006	0.121	0.002	316	217	96.68	33
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS6B.028	8	27	42	3000	0.028	0.01	0.114	0	1040	447	97.37	0
SARUS6B.031	8	32	42	3000	0.021	0.001	0.12	0.026	786	493	96.41	65.7
SARUS6B.034	8	37	42	3000	0.014	-0.008	0.127	0.02	474	446	93.74	66
SARUS6B.037	8	27	47	3000	0.039	0.024	0.115	0.004	1288	298	98.42	58.5
SARUS6B.040	8	32	47	3000	0.032	0.016	0.118	0.002	1145	403	97.99	33
SARUS6B.043	8	37	47	3000	0.025	0.005	0.128	0.004	839	502	96.6	52.5
SARUS6B.046	8	27	37	3000	0.016	-0.004	0.119	0.016	572	467	94.63	71.3
SARUS6B.049	8	32	37	3000	0.01	-0.012	0.124	0.05	389	396	93.27	64.4

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6B.052	8	37	37	3000	0.003	-0.024	0.134	0.136	223	303	89.48	69.1
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS6B.082	8	27	42	3000	0.028	0.018	0.111	0.002	1220	317	98.75	18
SARUS6B.085	8	32	42	3000	0.021	0.011	0.115	0	1019	431	98.17	0
SARUS6B.088	8	37	42	3000	0.014	0.002	0.122	0.006	763	478	97.41	55.7
SARUS6B.091	8	27	47	3000	0.039	0.03	0.11	0	1341	222	98.99	0
SARUS6B.094	8	32	47	3000	0.032	0.023	0.116	0	1254	299	98.85	0
SARUS6B.097	8	37	47	3000	0.025	0.014	0.124	0.002	1079	416	98.28	49
SARUS6B.100	8	27	37	3000	0.016	0.006	0.112	0	886	445	97.86	0
SARUS6B.103	8	32	37	3000	0.01	-0.002	0.118	0.018	642	455	97.02	51.4
SARUS6B.106	8	37	37	3000	0.003	-0.011	0.124	0.036	388	387	95.09	59.3

Table 14. Effects of a **2.5% per year decline in carrying capacity (K)** for 20 years with a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **10% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6B.001	10	27	42	3000	0.008	0.001	0.113	0.002	711	428	97.85	91
SARUS6B.004	10	32	42	3000	0.002	-0.007	0.119	0.01	471	407	96.55	90.2
SARUS6B.007	10	37	42	3000	-0.006	-0.014	0.125	0.01	270	294	94.99	92.4
SARUS6B.010	10	27	47	3000	0.02	0.014	0.114	0	1074	381	98.69	0
SARUS6B.013	10	32	47	3000	0.012	0.006	0.119	0	850	448	98.23	0
SARUS6B.016	10	37	47	3000	0.005	-0.003	0.126	0	535	410	97.21	0
SARUS6B.019	10	27	37	3000	-0.004	-0.011	0.116	0.004	328	326	95.79	80
SARUS6B.022	10	32	37	3000	-0.01	-0.019	0.124	0.036	188	234	93.57	84.1
SARUS6B.025	10	37	37	3000	-0.017	-0.027	0.13	0.074	92	131	90.15	88.2
SARUS6B.055	10	27	42	1500	0.008	0.001	0.113	0	424	211	97.5	0
SARUS6B.058	10	32	42	1500	0.002	-0.006	0.119	0.006	321	215	96.59	83
SARUS6B.061	10	37	42	1500	-0.006	-0.014	0.126	0.018	207	186	94.76	84.2
SARUS6B.064	10	27	47	1500	0.02	0.013	0.115	0	572	169	98.18	0
SARUS6B.067	10	32	47	1500	0.012	0.005	0.12	0	468	207	97.64	0
SARUS6B.070	10	37	47	1500	0.005	-0.004	0.128	0.006	339	221	96.63	92.7
SARUS6B.073	10	27	37	1500	-0.004	-0.011	0.116	0.008	236	186	95.69	92.8
SARUS6B.076	10	32	37	1500	-0.01	-0.018	0.122	0.024	163	161	93.71	86.8
SARUS6B.079	10	37	37	1500	-0.017	-0.027	0.131	0.102	98	115	90.63	84.7
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS6B.028	10	27	42	3000	0.008	-0.013	0.124	0.058	373	383	92.63	69.1
SARUS6B.031	10	32	42	3000	0.002	-0.024	0.135	0.146	201	265	89.16	66.4
SARUS6B.034	10	37	42	3000	-0.006	-0.035	0.146	0.274	104	156	85.06	70.9
SARUS6B.037	10	27	47	3000	0.02	0	0.122	0.026	758	501	95.44	62.7
SARUS6B.040	10	32	47	3000	0.012	-0.009	0.129	0.04	504	466	92.92	72.6
SARUS6B.043	10	37	47	3000	0.005	-0.021	0.14	0.142	282	358	90.47	68.4
SARUS6B.046	10	27	37	3000	-0.004	-0.031	0.134	0.184	118	176	85.43	68.7
SARUS6B.049	10	32	37	3000	-0.01	-0.041	0.143	0.33	66	100	82.54	65.2

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6B.052	10	37	37	3000	-0.017	-0.053	0.152	0.532	40	62	77.54	65.2
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS6B.082	10	27	42	3000	0.008	-0.003	0.115	0.01	583	436	96.61	59
SARUS6B.085	10	32	42	3000	0.002	-0.012	0.124	0.042	360	356	95.03	50.3
SARUS6B.088	10	37	42	3000	-0.006	-0.023	0.135	0.124	196	226	92.18	55.2
SARUS6B.091	10	27	47	3000	0.02	0.009	0.115	0.008	990	436	98.02	48
SARUS6B.094	10	32	47	3000	0.012	0	0.123	0.022	701	466	96.89	64.8
SARUS6B.097	10	37	47	3000	0.005	-0.008	0.13	0.024	442	397	95.63	43.4
SARUS6B.100	10	27	37	3000	-0.004	-0.018	0.122	0.058	256	367	93.45	63.3
SARUS6B.103	10	32	37	3000	-0.01	-0.027	0.132	0.132	136	181	90.42	60.9
SARUS6B.106	10	37	37	3000	-0.017	-0.037	0.142	0.258	68	102	86.27	67.7

Table 15. Effects of a **2.5% per year decline in carrying capacity (K)** for 20 years with a **single catastrophe** on the viablity at 100 years of crane populations under the conditions of **12% adult mortality**, variable chick mortality, and variable rates of clutch production. The frequency of the the catastrophe was set at 2% (on average once every 50 years), 0.4 severity on reproduction (60% reduction in clutchs), and 0.9 on survival (10% reduction in survival across all age classes) in the year of the catastrophe.

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6B.001	12	27	42	3000	-0.012	-0.021	0.12	0.034	145	168	92.66	85
SARUS6B.004	12	32	42	3000	-0.019	-0.028	0.127	0.094	89	111	89.81	85.7
SARUS6B.007	12	37	42	3000	-0.026	-0.037	0.139	0.222	51	78	84.74	82.4
SARUS6B.010	12	27	47	3000	-0.001	-0.007	0.116	0.004	439	385	96.42	90
SARUS6B.013	12	32	47	3000	-0.008	-0.015	0.124	0.028	241	258	94.48	79.5
SARUS6B.016	12	37	47	3000	-0.015	-0.025	0.136	0.098	128	167	90.88	82.7
SARUS6B.019	12	27	37	3000	-0.024	-0.034	0.128	0.184	56	70	87.36	84.9
SARUS6B.022	12	32	37	3000	-0.031	-0.042	0.138	0.294	32	47	82.41	82.8
SARUS6B.025	12	37	37	3000	-0.038	-0.05	0.147	0.534	22	26	79.13	81.3
SARUS6B.055	12	27	42	1500	-0.012	-0.02	0.12	0.034	139	136	92.46	84.6
SARUS6B.058	12	32	42	1500	-0.019	-0.03	0.13	0.106	72	81	88.48	85.8
SARUS6B.061	12	37	42	1500	-0.026	-0.037	0.138	0.234	48	58	86.21	81.9
SARUS6B.064	12	27	47	1500	-0.001	-0.008	0.118	0.01	288	205	95.92	67.4
SARUS6B.067	12	32	47	1500	-0.008	-0.017	0.126	0.036	179	162	93.24	80.4
SARUS6B.070	12	37	47	1500	-0.015	-0.026	0.136	0.09	111	136	90.06	80.3
SARUS6B.073	12	27	37	1500	-0.024	-0.034	0.129	0.182	56	65	87.99	82.8
SARUS6B.076	12	32	37	1500	-0.031	-0.043	0.138	0.338	27	30	82.54	82.4
SARUS6B.079	12	37	37	1500	-0.038	-0.05	0.147	0.528	23	34	78.84	80.9
Effects of removal of 15 male and 15 female chicks per year for 20 years.												
SARUS6B.028	12	27	42	3000	-0.012	-0.044	0.144	0.396	62	94	80.91	66.1
SARUS6B.031	12	32	42	3000	-0.019	-0.056	0.155	0.586	35	50	75.65	63.9
SARUS6B.034	12	37	42	3000	-0.026	-0.066	0.162	0.732	30	49	73.64	61
SARUS6B.037	12	27	47	3000	-0.001	-0.026	0.134	0.184	179	227	89.12	69.9
SARUS6B.040	12	32	47	3000	-0.008	-0.038	0.146	0.316	98	143	84.06	70
SARUS6B.043	12	37	47	3000	-0.015	-0.052	0.158	0.532	50	96	79.72	66.4
SARUS6B.046	12	27	37	3000	-0.024	-0.061	0.155	0.648	27	33	73.91	62.5
SARUS6B.049	12	32	37	3000	-0.031	-0.076	0.164	0.83	14	11	71.41	58.5

Population	% A Mort	%Cmort	%Clutch	K	det.r	stoc.r	SD(r)	PE	N	SD(N)	Het	MeanTE
SARUS6B.052	12	37	37	3000	-0.038	-0.085	0.168	0.894	13	13	67.15	54.9
Effects of removal of 6 male and 6 female adults per year for 20 years from the population.												
SARUS6B.082	12	27	42	3000	-0.012	-0.03	0.132	0.188	117	170	88.5	63.2
SARUS6B.085	12	32	42	3000	-0.019	-0.04	0.144	0.282	60	100	83.47	65.4
SARUS6B.088	12	37	42	3000	-0.026	-0.053	0.159	0.524	37	44	82.66	62.1
SARUS6B.091	12	27	47	3000	-0.001	-0.014	0.122	0.044	305	315	93.83	70.5
SARUS6B.094	12	32	47	3000	-0.008	-0.026	0.135	0.15	160	193	91.29	67.1
SARUS6B.097	12	37	47	3000	-0.015	-0.038	0.149	0.286	81	110	86.46	64.8
SARUS6B.100	12	27	37	3000	-0.024	-0.047	0.146	0.436	39	46	82.05	65.1
SARUS6B.103	12	32	37	3000	-0.031	-0.056	0.155	0.57	28	34	79.53	64.5
SARUS6B.106	12	37	37	3000	-0.038	-0.071	0.172	0.768	19	23	75.4	58.7

Eastern Sarus Crane

Grus antigone sharpii

Population and Habitat Viability Assessment Workshop

Khao Kheow Open Zoo
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15-17 January 1997

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Eastern Sarus Crane

Grus antigone sharpii

Population and Habitat Viability Assessment Workshop

Khao Kheow Open Zoo
Chon Buri, Thailand

15-17 January 1997

Report

COUNTRY REPORTS

Union of Myanmar
Ministry of Forestry
Forest Department

EASTERN SARUS CRANES IN MYANMAR

(Paper presented to Eastern Sarus Crane PHVA held at Khao Kheow Open Zoo, Chonburi, Thailand)

Ms Tin Nwe Latt
Park Interpreter
Hlawga Park.

January, 1997.

Introduction

B.E. Smythies, in his 1953 edition of " The Birds of Burma." described Sarus Crane, *Grus antigone,* as occuring throughout Burma, being commoner in Northern and Central Burma and the Shan State than elsewhere, probably because it prefers grass plains to paddy-fields.

Since then, there was no other formal report on the bird until 1983 when J A Sayer and Saw Han saw a 6-month old *Grus antigone sharpii* in captivity in Loikaw, Shan State and reported it. In 1994, 1995 and 1996, the author and associates from the Wildlife and Sanctuaries Division of the Forest Department sighted 3 birds in Mohingyi Lake and 4 to 9 birds in Inle Lake for three consecutive years and reported it to the International Waterfowl Research Bureau (Wetlands International). In August, 1996, the author accompanied Jeb Barzen of International Crane Foundation in his survey trips of four townships in Ayeyarwaddy Division and co-authored a preliminary report on the status of the bird. In October, November and December 1996, the author surveyed another five townships in Ayeyarwaddy Division, three townships in Bago Division and one township in Sagaing Division.

This report is the summary of all the trips which the author made in 1996, specifically for the status survey of the Eastern Sarus Crane, *Grus antigone sharpii.*

Survey Results

The Ayeyarwaddy Division is situated in the delta area of the River Ayeyarwaddy and covers about 13557 sq: miles. Marshes, paddy-fields, ponds, lakes, creeks etc are the principal landscapes of the Division. The eels, snails, snakes, mice and fish are abundant in this ecosystem, and they form the natural diet of the Sarus Cranes and other wetland birds.

Surveys for Sarus Crane, *Grus antigone sharpii* , were conducted in about half the area of this Division in 1996.

Nyaungdon Township :

On 18th October, the local forest officer informed us of the presence and abundance of cranes at the border of Nyaungdon and Ma-Ubin townships. According to him, about fifty cranes could be found in the rainy season, breeding in this area and eggs are often stolen by local villagers. The birds are also sometimes captured for the Zoos and the pet-keepers.

Pantanaw Township :

On 25th August, the headman and the villagers of Kyondainggyi Village told us about the three pairs of cranes which they saw on 22nd August in the nearby paddy-fields.

On 20th October, at 0930 hrs, we saw 26 cranes, not far from a group of 47

Black-winged stilts and one Glossy Ibis. The place was a marshland, about two miles east of Zaletaw Village. There was no paddy-field in the area. It could be reached by foot for about one hour and again by boat for about 30 minutes from Zaletaw Village. The place is believed to be a roosting place of the cranes (see photo). The villagers who guided us to the place told us that they found about 100 cranes in the same place two weeks earlier.

Kyaunggon Township

On 24th August, we saw 6 cranes at Thegon Village, Sapaiyon Village and in the paddy-fields near Daka Creek. In the evening, we saw 8 cranes at Pauk Ngu Field in association with 4 Painted Storks, 53 Black-headed Ibises and 50-100 Lesser Tree Ducks. Pauk Ngu Field is a significant wetland area, about three miles from Sapaiyon Village. On 23 rd August, we found one captive crane at Thit-seint -Kone Village which we believed came from Thegon Village. Cranes sometimes sold at Kyaunggon Town are believed to come from Thegon Village and Pauk Ngu Field.

At Payagyigon Village, local villagers sighted 14 cranes in the nearby paddy-fields in September, 1996.

Einme Township and Myaungmya Township

We were informed by local villagers at Nisat Gyi Village on 27th August that cranes, numbering about 50, could be found in the paddy-fields about two miles east of the village and that some of them lived there throughout the year.

On 20th October, we visited Myaungmya Township. We learned from the local forest officer that no cranes were found in this township.

On 21st October, we were informed by the villagers of Bwettan Village that two cranes were seen by them in the nearby paddy-fields about three months ago. The cranes, they said, stayed there for about three days.

Wakema Township

On 26th August, we saw 37 cranes in the paddy-fields about two furlongs west of Kyontayeik Village. We found the same day one nest in the paddy-fields about two miles north of the village. This nest had one egg. We were also informed that there was one nest south of the village. On 27th August, we went by boat to a place about two miles south-west of the village which, villagers said, was a roosting place of the cranes. On arrival there, we saw only foot-prints and fallen feathers and we believed that 20-24 birds had roosted here the previous night. On our way back to the village, we saw 42 cranes feeding in the paddy-fields about two miles west of the village, some of them being pretty close to the farmers who were working in the paddy-fields.

On 19th October, we visited Kyontayeik village again in the evening to check the egg which we saw on 26th August. We were told that the chick had hatched from the egg. We visited the nest and took photograph of it. On our way back to the village, we saw three cranes flying in the north-west direction. Then we saw two adults and one

chick which, we found, could not flee as quickly as the adults when we followed them. Villagers told us that the cranes roosted at the pagoda which was about three miles north-west of the village. On 20th October, while we were in the paddy-fields about one mile west of the village, looking for the cranes, we saw a flock of 38 cranes flying to the east of the village.

On 19th October, we found two cranes near a nest in a paddy-field one mile north-east of Kyonpadi Village in the morning. We were told that the nest was looked after by two staff members of the Irrigation Department, one of whom owned the paddy-field and that eggs were laid in the same nest for three consecutive years. On 20th October, we visited Kyonpadi Village again in the afternoon to look for another nest which, we were told, existed south-west of the village. We were informed by the farmer that the nest was destroyed by him for reason of not wanting the birds to interfere with his plantations. He said that the birds built the nest for the second time and that he destroyed the second nest also. We saw two cranes on our way back to the village.

On 25th August, we visited Sa Pa Yo Village which was situated in Shwelaung area. we found one nest near Sa Pa Yo Village and two cranes about 200 meters from the nest. The nest was empty but not destroyed. We were told that one villager had seen the eggs in the nest a fortnight ago. It seems likely that the eggs were stolen since there were no broken shells nearby.

On 26th August, we visited Shwelaung Village in the afternoon. About two miles south-west of the village, we found a nest which had one egg. According to Jeb Barzen, the nest was an old one and the egg was laid about two days ago. He said that the second egg would be laid within the next few days. We did not see the birds nearby. We were infomed that about 20-30 cranes lived in this area throughout the year.

We were told that there was one captive crane at a house in Shwelaung Village.

Ma-Ubin Township and Kyaiklat Township

On 24th October, we visited Ma-Ubin Township. We went to Kazan Village, Alegyoung Village, Yegyaw Village, Kana Village, Kyonwagyi Village and Kangon Village. These villages are parts of Mithwegyoung Village and are situated at the border between Ma-Ubin Township and Nyaungdon Township. There are only about ten households in each village. The area is a wetland with very thick vegetation. Snails and eels are abundant in the area.

At Kangon Village, one villager took us to a nest where he saw the eggs about two days ago. On arrival there, we found the nest empty. We were later told that the eggs were taken by villagers from Kana Village for food.

We were informed that the cranes were found in this area throughout the year.

On our way back to Ma-Ubin Township at about 1800 hours, we saw 4 cranes flying from north to south near Mithwegyoung Village. We also saw 94 Black Kites roosting on Kokko trees along the Mithwe Creek.

On 25th October, we went to Yelegale Village which is about 30 miniutes' drive from Ma-Ubin Township. At Yelegale Village, we were told that 20-50 cranes

could be found near the village in August-September. The cranes had now retreated to deep-water areas away from the village. We explored the area by boat and found one nest between Thategon Village and Hngettawyo Village. In the nest, we found two eggs. One egg had recently hatched with blood-clots still attached to the shell. The other egg had darker shell. We also saw two groups of cranes, one group with 3 birds and the other with two birds. The birds in the two groups were of different sizes. The 3-bird group was only about two furlongs from the nest.

In the afternoon, we explored the area south-west of Ma-Ubin by motor-boat. We were told that the area between Letpangon Village and Thaikkon Village was called "Gyo-gyar Kwin" or "Crane Ground" because it was inhabited by about 50-100 cranes in August and September. We did not find any bird in the area. We were also informed of 35 cranes at Thabyedon Village in Kyaiklat Township. We stopped the night at the village, but did not find any crane.

On 26th October, we found one crane between Thabyedon Village and Natmugon Village. A nest was reported in a paddy-field at Natmugon Village, but when we looked for it, it was gone. It is believed that the nest was destroyed and the eggs eaten by the owner of the paddy-field. On our way from Natmugon Village to Kanzugyi Village, we saw one pair of cranes feeding in the tall grasses. We saw two more cranes between Kanzugyi Village and Kondangyi Village. Since this area is quite close to Hngettawyo Village, we think that the two birds we saw between Kanzugyi Village and Kandangyi Village were the same birds we saw at Hngettawyo Village on 25th October.

At Ma-Ubin Town , we saw 3 captive cranes at one monastry and one captive crane at another monastry.

Hinthada Township

On 30th October, the local forest officer sent out his assistants, at our request, to various parts of the township to gather information on the cranes. We learned that there was no wild population of the crane in the township. We also learned that there was one captive crane in Hinthada Township.

Thartawaw Township and Letpadan Township, Bago Division

On 31 st October, we crossed the River Ayeyarwaddy from Hinthada Town to go to Thartawaw Town and Letpadan Town. Between Thartawaw Town and Letpadan Town, there is a big lake which was auctioned off by the Government to fish-mongers. We learned from them that there were two cranes last year in their lake. They did not see any crane this year.

We also learned that Painted Stroks and Pelicans were hunted in the lake. We believed that cranes might also be hunted if the birds landed in the lake. We found bird-trapping nets and other hunting tools in their possession. We saw four Painted Storks in the vicinity of the lake.

Bago Township, Bago Division

Three cranes were reported yearly in the January bird censuses of 1994,1995 and 1996 at Mohingyi Wetland Bird Sanctuary. But when surveys were conducted in August and October, 1996, cranes were not found there. In 1995, a crane nest was found at the Sanctuary and photographed. On 29th December, 1996, many cranes were reported as seen in the paddy-fields in Waw Township which is about three miles from the Sanctuary.

Sagaing Township, Sagaing Division

On 23rd December, we visited Padu Village and saw 5 Common Cranes and 4 Black-necked Cranes, but not Sarus Cranes.

On 24th December, we sent one staff member of Mandalay Zoo to Sayaygyi Village to check the occurence of cranes. According to him, about 300 Common Cranes and 5 Black-necked Cranes were seen, but not Sarus Crane in the area.

According to U Myo Hlaing, Veterinary surgeon of Mandalay Zoo, who visited Padu Village on 10th and 11th of November, Sarus Cranes, Common Cranes and Black-necked Cranes were reported as found in that area.

Eastern Sarus Cranes in Captivity

The numbers of Eastern Sarus Cranes currently held captive are as follows:

a.	Yangon Zoo	8 No
b.	Hlawga Park	1 No
c.	Thitseintkone Village, Kyaunggon Township	1 No
d.	Nyaung-Ngu Village, Wakema Township	1 No
e.	Ma-Ubin Township	4 No
f.	Hinthada Township	1 No
	Total	16 No

Discussions and Recommendations

Compared to other range countries, Myanmar is believed to have a population of Eastern Sarus Cranes viable for in-situ conservation. Immediate measures should be conducting further surveys and research, educating the local populace on the conservation and setting up of protected area systems in Ayeyarwaddy Division. For these activities, we believe we would need international co-operation in terms of technical and financial support.

---- End ----

Union of Myanmar
Ministry of Forestry
Forest Department

WETLANDS OF MYANMAR

(Paper presented to Eastern Sarus Crane PHVA held at Khao Kheow Open Zoo, Chonburi, Thailand)

U Myo Hlaing,
Veterinary Surgeon,
Mandalay Yatanabon Zoo.

January , 1997.

INTRODUCTION

Myanmar with a total area of 676, 575 sq km lies between latitudes 10 and 29 N and longitudes 92 and 101 E. Altitudes range from sea level to 5800m in the extereme north. The mountain ranges along the western border with India and Bangladesh reach 3000m and the Shan plateau in the east averages 1800m to 2500m. The country is traversed by a number of great rivers flowing from north to south, namely the Ayeyarwaddy, the Chindwin, the Thanlwin and the Sittaung. Apart from the northern uplands of Kachin State, the climate is generally tropical monsoonal with the heaviest rains during the south-west monsoon from May to October.

WETLANDS

With a coastline of 2278 km, several very large estuarine and delta systems and numerous offshore islands, Myanmar possesses a great wealth and diversity of coastal wetland habitats. Mangrove forests cover an estimated 5200 sq km in the Ayeyarwaddy Delta and on the Rakhine and Tanintharyi coasts and offshore islands.

Inland wetland sites are permanent freshwater bodies of Inle Lake, Indawgyi Lake, Mong Pai Lake, Mohingyi Lake and over 40 major reservoirs covering about 2100 sq km. The seasonally inundated floodplains of the main river systems covering an estimated 60,000 sq km during the monsoon season also form important wetlands. In addition, there are several man-made impoundments, tanks and village ponds.

SURVEYS

The FAO/UNDP Nature Conservation and National Parks Project (1980) conducted preliminary surveys of over 20 sites for protection, and several of these were wetlands, notably the southern Ayeyarwaddy Delta, Inle Lake, Mong Pai Lake, Mohingyi Lake and Gyobyu Reservoir. Since 1987, Wildlife and Sanctuaries Division of the Forest Department has had conducted surveys and research in 21 wetland sites.

LEGISLATION

The Forest Department was responsible for wildlife protection under the Burma Forest Act, 1902 which provided for the making of rules to control hunting and fishing in Reserved Forests. The 1902 Forest Act was enhanced by the 1936 Burma Wildlife Protection Act, and the wetland sites of Wethtigan, Moscos Island, Thamihla Island, Inle Lake and Mohingyi Lake were constituted as sanctuaries under this Act.

The 1936 Act was repealed and replaced by 1994 Act which provides for more efficient protection of both the species and the habitats.

WETLANDS OF INTERNATIONAL IMPORTANCE

The following wetland sites are considered internationally important for designation under Article 2 of the Ramsar Convention:

a. Indawgyi Lake
b. Upper Ayeyarwaddy and Mogaung Chaung
c. Inle Lake
d. Kaladan Estuary, Hunter's Bay and Combermere Bay
e. Ayeyarwaddy Delta

a. INDAWGYI LAKE

Location	:	25° 03'-25° 15'N, 96° 18'-96° 25' E
Area	:	120 sq km
Wetland type	:	Freshwater lake and associated marshes,
Fauna	:	Wintering anatidae, Masked Finfoot has been recorded.

b. UPPER AYEYARWADDY AND MOGAUNG CHAUNG

Location	:	25° 45' N, 96° 40' E to 23° 30' N, 96° 00' E
Area	:	Area of wetlands unknown; approximately 30 km of the Ayeyarwaddy River and 90 km of the Mogaung Chaung.
Wetland type	:	Rivers and streams, oxbow lakes and marshes, seasonally flooded grasslands and swamp forests.
Fauna	:	Large numbers of comb duck, spot-billed duck, northern shoveler, common crane, bar-headed goose, cotton teal, black stork, great crested grebe, several species of snipes, egrets and herons, cormonants and darters (IWRB census 1992, 1994). Several species of wintering waterfowls, white-winged wood duck, pink-headed duck and gharial were reported from this weltand.

c. INLE LAKE

Location	:	20° 27'-20° 40' N, 96° 52'-96° 57' E
Area	:	158 sq km
Wetland type	:	Freshwater lake and associated marshes, rice paddies.
Fauna	:	A very important area for waterfowl. Wintering waterfowls, sarus crane, wintering birds of prey, Jerdon's bushchat, pipits and warblers, Inle carp.
Conservation measures	:	Constituted as sanctuary in 1985.

d. KALADAN ESTUARY, HUNTER'S BAY AND COMBERMERE BAY

Location	:	18° 40' - 20° 30' N, 92° 40' - 94° 10' E
Area	:	4999 sq km
Wetland type	:	Shallow seabay straits, estuaries, deltas, sea beaches, mangrove swamps.
Fauna	:	Estuarine crocodiles, both resident and migratory waterfowls (whistling duck, comb duck) Openbill stork and Gulls.

e. AYEYARWADDY DELTA

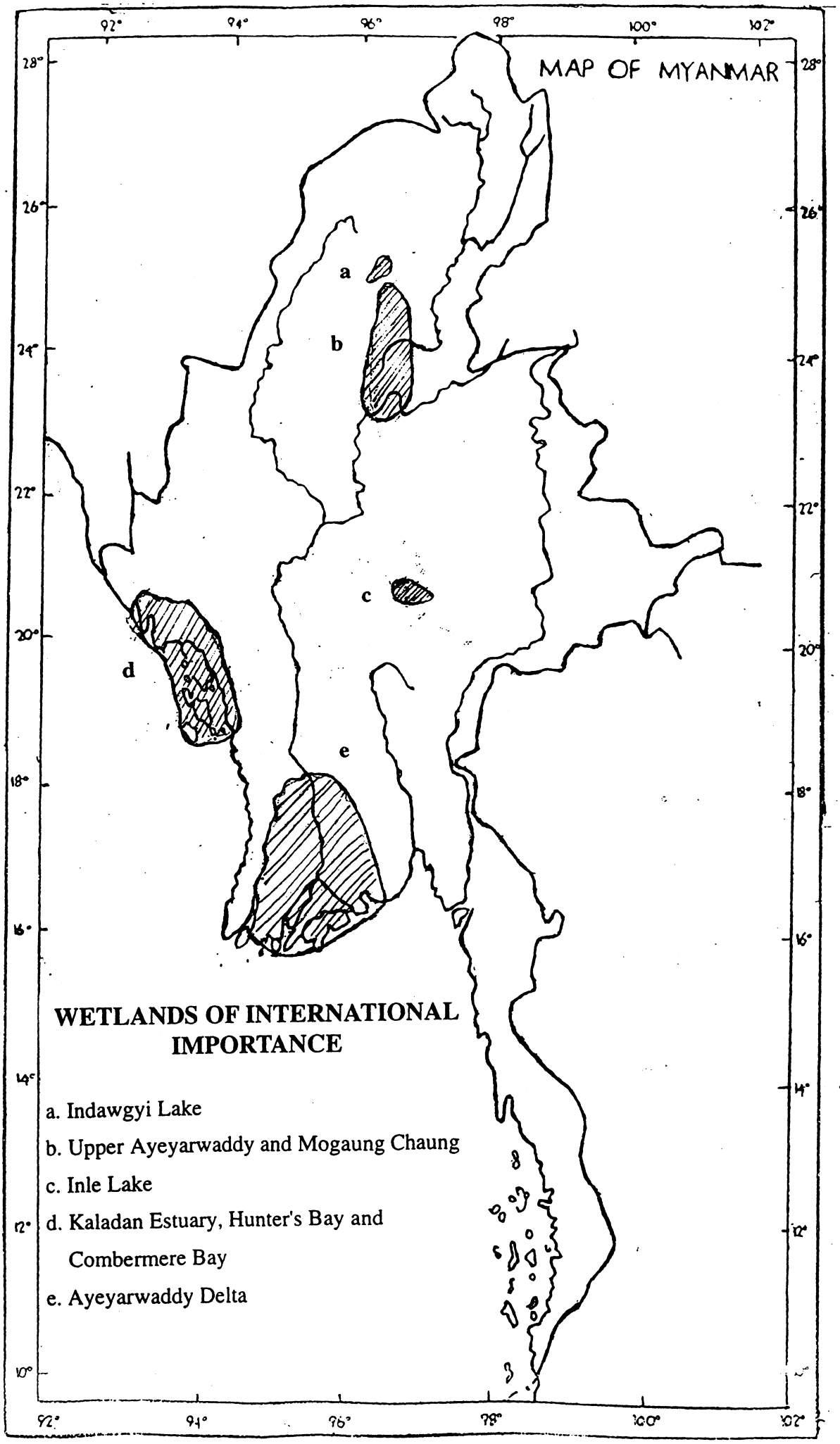
Location	:	16° 55' - 18° 15' N, 94° 15' - 96° 20° E
Area	:	34993 sq km

Wetland type	:	Estuaries, deltas, intertidal mudflats, mangrove swamps, mangrove forests, rice paddies.
Fauna	:	Commerical fish species, resident and migratory waterfowls, crocodiles, elephants, wild dogs, otters, leopards, marine turtles,

DISCUSSIONS

Wetlands of Myanmar are also under pressure, as in other parts of the world, due to population growth. Research and conservation measure are needed for effective protection of both the habitats and the inhabitants in these wetland sites.

---- End ---


MAP OF MYANMAR
92°
94°
96°
98°
100°
102°
28°
26°
24°
22°
20°
18°
16°
14°
12°
10°
a
b
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e
WETLANDS OF INTERNATIONAL IMPORTANCE
a. Indawgyi Lake
b. Upper Ayeyarwaddy and Mogaung Chaung
c. Inle Lake
d. Kaladan Estuary, Hunter's Bay and Combermere Bay
e. Ayeyarwaddy Delta

The Distribution and Captivity of Sarus Crane in Yunnan Province of China

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Summary

In China, Sarus Crane (*Grus antigone*) only distributes in the southern and western parts of the Yunnan Province (Cheng Tso-Hsin, 1987). According to the several researches done by ornithologists of Kunming Institute of Zoology (KIZ), and the observation of the captured cranes (2 Australia Sarus Cranes, *Grus a. gilli*, from the ICF, 1 Sarus Crane, *Grus antigonei*, from the Nothwestern of Yunnan), we have following summary about the crane's distribution and the breeding situation in Yunnan Province of China.

Distribution of Sarus Crane in Yunnan Province

The earliest record of Sarus Crane in Yunnan was in 1868 and on March, 1873. Dr. John Anderson, an explorer of the England, fund the Sarus Crane and got 2 specimen at the Tsitkaw, boundary area of China and Burma , and claimed to see a large flock of over 600 cranes at Poonsee (Rothschild, 1926). On 26 March, 1959, the team of birds research (KIZ) fund a pair of Sarus Cranes and got a specimen (Grus a. sharpii) at the basin of Menglun township, Mengla County, Xishuangbanna Prefecture. On 28 February, 1960, same team saw 5 Sarus Cranes (adult and young) at a swamp of Mengpong township, Mengla county; a pair looking for food at the rice field of Meng Ar of Menghai County, Xishuangbanna Prefecture. On August, 1973, a wreckage of a Sarus Crane (Grus. a. sharpii) was fund by the team at a swamp of Dongshaofang village, Gongshan County of Nujian Prefecture (Altitude: 3250 m). In winter of 1986, a young Eastern Sarus Crane (Grus. a. sharpii, forsaken young bird) was taken by local people at Napahai Nature Reserve, Zhongdian County, Diqing Prefecture and was sent to Cuxion Prefecture Zoo. From 1992, the crane was sent and kept in Kunming Zoo. Based on the those description, we have table 1. and map 1 to show the historical distribution of Sarus Crane in Yunnan.

Table 1. The Place of Sarus Crane Found in Yunnan Province of China

Date	*County*	*Site*	*Longitude (E)*	*Latitude (N)*	*Altitude (m)*	*No.*	*Recorder*
Mar. 1868	Yingjiang	Tsitkaw	97°35'	24°28'	1005	2	Anderson
Mar. 1875	Yingjiang	Poonsee	97°34'	24°27'	950	600	Anderson
Mar. 1959	Mengla	Menglun	101°21'	21°52'	580	5	KIZ
Feb. 1960	Mengla	Mengpong	101°20'	21°14'	500	2	KIZ
Feb. 1960	Menghai	Meng Ar	100°25'	22°15'	600	2	KIZ
Aug. 1973	Gongshan	Dongshaofang	98°06'	27°07'	3150	1	KIZ
Win. 1986	Zhongdian	Napahai	99°07'	27°06'	3260	1	KIZ

The historic distribution sites can be seen clearly in the Map 1. The Map of Sarus Crane Historical Distribution in the Yunnan Province of China.

Habitats Assessment

Tsitkwa and Poonsee (given name by Dr. Anderson) are located between the Shanshiti and Xiashiti of the Yingjian County of Dehong Tai and Jinbo Nationality Autonomous Prefecture. Before 1950, this place had a large area of overflow swamp along the Dayingjian River, the branch of Irrowardi. Due to the food requirement for increasing population (10 times compared present and before 1950), most of the swamp was dried for paddy fields. Some irrigation facilities have been established to stop the overflow of the Dayingjian River. The swamp has disappeared and the habitat for Sarus Crane at this site is not more available.

Menglun and Mengpong are 2 big basins in Mengla County. Around and inside the basin, there are some hills which growth of density tropical forest. Down the hills there were many small pieces of swamp formed by the rich streams before 1960. After that time, many people come from inland of China to set up the rubber tree farms in Mengla. They cut the tree (elevation lower than 800 m) to plant the rubber tree. This coursed of the swamp drought and the Sarus Crane's habitat lose.

Meng Ar is a basin with large area of paddy field (around the basin is the forest) in Menghai County. The Sarus Crane some time likes to stay the edge of forest to look for food in paddy field with the common crane (*Grus grus*), little egret *(Egretta garzetta*), intermediate egret (*Eggretta intermedia*). Due to the heavily using of the medical fertilizer and antcides, the Sarus Crane has not be seen in this area for a long time.

Donshaofang is located at the northern site of Gaoligongshan range, a platform of high mountain. In winter and spring, it covers with snow. In summer and autumn, the place becomes a marshland which attracted the fly passed Sarus Crane to stay there for a short time. Now, this place is disturbed by local villagers frequently in summer. The ornithologist of KIZ fund one shoot crane there on August, 1973. (the wreckage of the bird kelp in KIZ). After that time, nothing was fund for several researches.

Napahai is the only protected marshland in the Yunnan Province. In summer, Napahai Nature Reserve is covered with water of 100-500 mm deep. In winter, most of land was drought, only parts of land also has water. In night, the water become ice. At day time, ice is melt by sunshine that make the land into the marshland. Many species of waterfowl such as black-necked crane (*Grus nigricollis*), common crane, bar-headed goose *(Anser indicus*) pass winter at there. During summer, the large area of marshland may attract the Sarus Crane which fly upon throughout the valley of Mekong River to find breeding area due to the drought of other habitat like the Indochina delta or the critical disturbance of people. Napahai also face the problem that local people wants to dry the place for developing grassland to feed their increased livestock .

Other Sites We can see 2 types of habitat available for Sarus Crane, the flood lands of rivers and the basins. The main rivers are Mekong (1170 km in Yunnan), Saline (547 km) and the branches (Dayingjian: 168 km; Reilijian: 332 km; Dulongjian 80 km) of Irrowardi. Along the valley of the rivers, there are many different size of flood

land which 1/5th of its elevation is lower than 800 m. Throughout the visiting trip, local people mention a lot that some time they find Sarus Crane were looking foods in flood swamp or paddy field. For example, when a team of research arrived the Lishu Township (N24^0 15', E100^0 32') of Yunxian County on March 1991, local people told the researcher that they saw a pair of Sarus Crane were looking for foods at the harvested paddy field near the Mekong River. At Nanding River (23^0 46', E99^0 18', the breach of Salwen) of Gengma County, local people also fund cranes at there some time. In southern and western parts of Yunnan, there are 27 basins which area is over 1,000 ha, elevation is lower than 1000 m. According to the records of several visiting trip, most of them were habitat of the Sarus Crane before 1960's. The important basins is listed in Table 2.

Table 2. List of Important Basins May Suitable For Sarus Crane in Southern and Western Parts of Yunnan Province, China

Name of Basin	Located County	Area (ha)	Latitude (N)	Longitude (E)	Altitude (m)	Watershed Belong
Mengzhe	Menghai	12,530	21° 57'	100° 14'	950	Mekong
MengAr	Menghai	1,200	22° 25'	100° 15'	620	Mekong
Mengpong	Mengla	1,670	21° 14'	100° 20'	680	Mekong
Menglun	Mengla	1,820	21° 52'	101° 21'	720	Mekong
Mengmang	Mengla	1,520	21° 12'	101° 20'	650	Mekong
Menghang	Jinhong	3,250	21° 42'	100° 59'	780	Mekong
Mengdin	Gengma	3,420	23° 32'	99° 15'	820	Salwen
Mengjiao	Changyan	850	23° 12'	99° 08'	860	Salwen
Xiangang	Luxi	1,400	24° 25'	98° 49'	820	Irrowadi
Zhefang	Luxi	10,302	24° 21'	98° 24'	783	Irrowadi
Yingjian	Yingjian	12,000	24° 42'	98° 06'	690	Irrowadi
Xiema	Yingjian	870	24° 52'	97° 54'	720	Irrowadi
Lonchuan	Lonchuan	24,220	24° 26'	98° 07'	934	Irrowadi
Husha	Lonchuan	2,870	24° 29'	98° 01'	780	Irrowadi
Reili	Reili	17,470	24° 01'	97° 59'	779	Irrowadi
Lianhe	Lianhe	4,060	24° 48'	98° 26'	890	Irrowadi

Discussion Based on above analysis, we may have some conclusions as: (1) The suitable habitat for breeding of Sarus Crane has disappeared in Yunnan due to the cultivated land development in resent 50 years. It is means that no large swamp which close to original forest left for large flock of cranes. So this time there are no fixed population of Sarus Crane in Yunnan is reasonable. (2) It is possible to see cranes at some basin and flood land of river occasionally even though it depends on the toleration of Sarus Crane at people's disturbance as egrets and common crane. Another way it also depends on the local people's conservation efforts. (3) This is some thing new that the Sarus Crane was fund at plateau (Donshaofan and Napahai). Despite we didn't know the exactly reason, but the real happened thing showed us that the Sarus Crane has the habit of migration from one habitat to another habitat. The Napahai may be the Northern part (N27° 07') that the Sarus Crane appeared even it's not a normal habitat for them.

Captivity

Don and Painless (Grus a. gilli female and male) came from ICF in 1994. Through 2 years meticulously raising, the pair of cranes has used to the atmosphere of the Wildlife Saving Center of Yunnan Forestry Department (see the picture). The raising cage is 50 m^2 and was divided into two parts (7 m^2 room, 43 m^2 activity land with grass planted). The center follows the diet of ICF to give food to the pair of Crane and gave the living fish twice a week. No any disease was observed during the two years raising. From April to September, perusing and dancing were observed, but no any mating and egg activities.

Jinkun (Grus a. shapii), a male, age: 10 years, total length: 151.2 mm, height: 142 mm, bill: 168 mm, tarsus: 305 mm, weight: 8600g (information source: Nie Zhuhong, Yang Mei, Kunming Zoo). The crane was captured by local people in Napahai in winter of 1986. Before August of 1992, the youth crane was raised in Zoo of Cuxion Prefecture, after that time it was moved to Kunming Zoo. The exhibition cage is about 15 m^2, no need any heating equipment even when the temperature fall down to the 0° C in winter. The crane looks health and activity. It can be see that the crane has used to the weather of Kunming and the man made foods. The diet is showed in Table 3 and Table 4.

Table 3. Daily Foods for Jinkun

Feeding Time	Mixed Food (steamed)	Green Food (vegetable)	Animal Food (living fish)	Apple	Grain (corn, wheat)	Total (per day)
10:30	200g	50g	400g	once/	100g/3 days	
15:30	200g	50g		a week		920g

(Nie and Yang)

The contents of steamed mixed food can be seen in Table 4.

Table 4. Contents of Steam Mixed Foods

Contents	Corn-flour	Wheat-flour	Wheat-bran	Fish-meal	Bone-meal	Sugar	Water
%	63.8	7.4	10.6	5.3	0.2	5.3	7.4

(Nie and Yang)

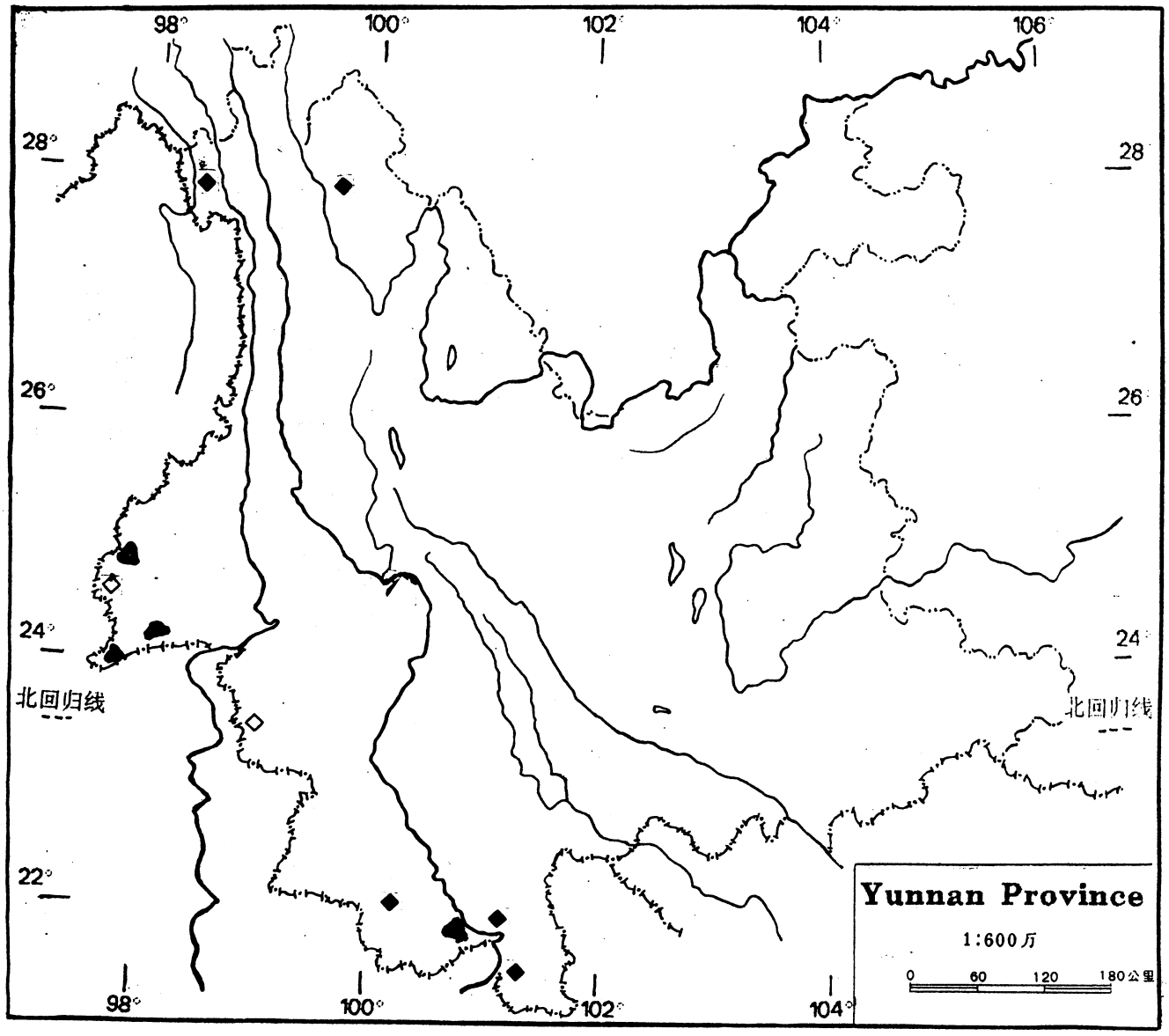
During April to June of 1996, the crane has been observed to has the obvious activity of dancing and red neck more than other time. Jinkun is mature enough to need a mate.

Conservation Issue

Yunnan is the northern part of the distribution site of the Eastern Sarus Crane. Due to the habitat loss, this species may final disappear from Yunnan also China forever. For solving the problem, we must take eyes closely at the crane. In 1989, the Chinese government has listed the bird to the first class of national protective species. But it means nothing if we didn't take effective actions soon to protect them.

(1) To develop a program to monitor the changes of the habitat and the population.
(2) To enhance the wareness of public for protecting the most beautiful bird in the world.
(3) To establish an information system for evaluation the distribution situation.
(4) To recover some swamps in Xishuangbanna for reintroducing the Sarus Crane.
(5) To strength the cooperation with other countries and international organizations in Sarus Crane's Conservation.

本图上国界线按照地图出版社一九八九年出版的《中华人民共和国地图》绘制。



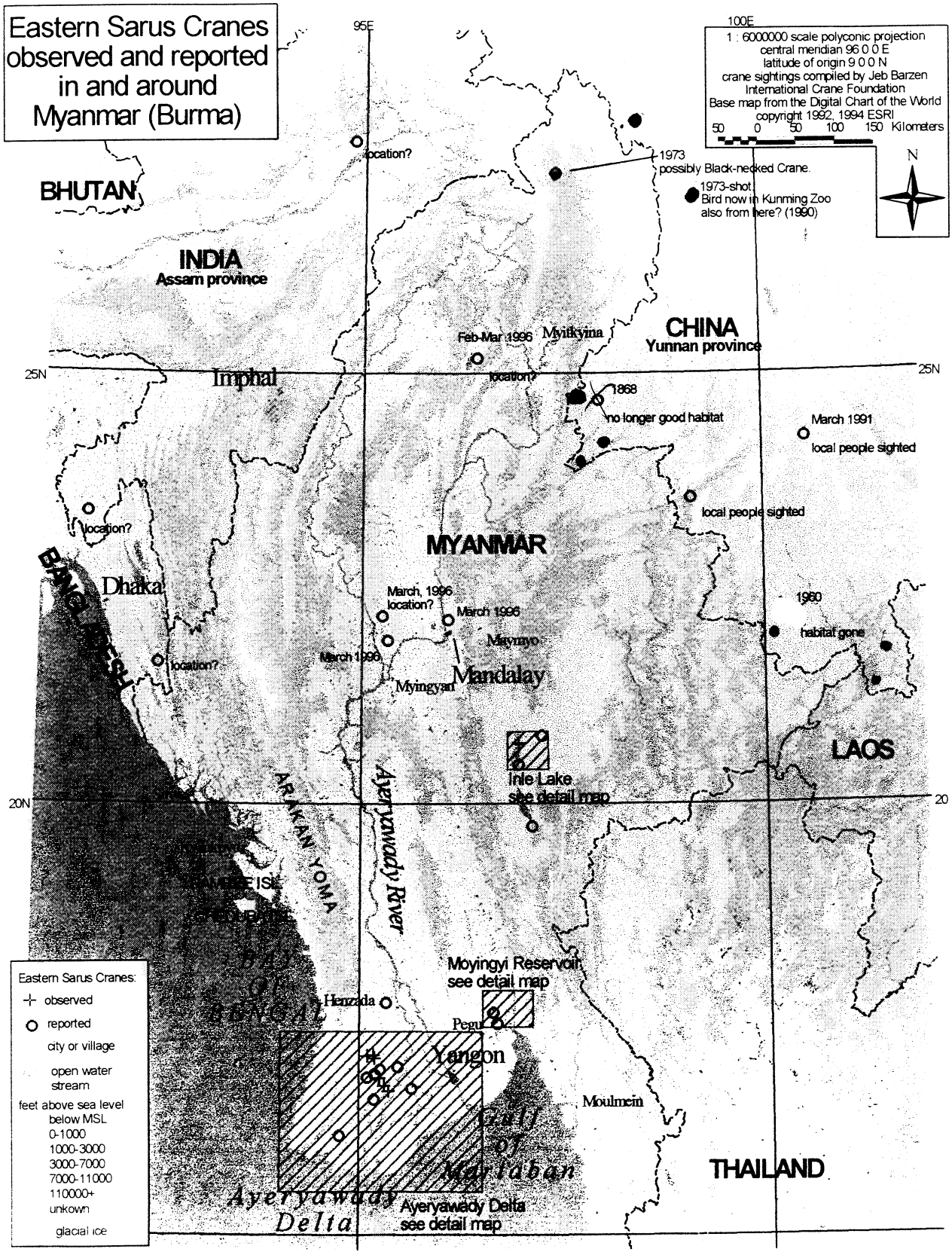
◆ Specimen collection Site ◇ Visiting site

The map of Eastern Sarus Crane distribution in Yunnan, China

TABLE 1. Hydrology Data of Main Natural Lakes In Yunnan Province

Name	WS	WSA (km^2)	WFI ($m,m^3/Y$)	SL (km)	ED (m)	LD (m)	Elevation (m)	AREA (km^2)	WST ($m,m^3/y$)	SC	BNC	CC	PS
Dianchi	Changjiang	2853	700	150	5	8	1885	306	1570		#	#	+
Erhai	Mekong	2565	830	117	11	22	1974	250	2880			*	+
Wuxianhu	Red	1057	350	91	87	162	1720	212	18500				
Yanzhonghai	Red	192	40	32	20	30	1770	31	602			*	
Xingyunhu	Red	325	70	36	9	12	1723	39	230			*	
Qiluhu	Red	363	60	64	4	15	1731	42	194			*	
Yilonghu	Red	326	40	86	3.5	7	1411	42	120			*	
Datunhai	Red	285	30	49	1.3	2.7	1280	12	34			*	
Changqiaohai	Red	167	30	20	1.7	2.5	1281	10	13			*	
Qinshuihai	Changjiang	235	70	13	20	30	2188	7	140		*	*	
Chenghai	Changjiang	318	110	45	26	37	1503	79	2700			*	
Lukuhu	Changjiang	248	70	44	40	94	2685	52	2072		*	*	+

Remarks: WS=watershed; WSA=watershed Area; WFI=water flew in/per year; SC=sounding length; ED=everage depth; LD=largest depth; WST=water storage; SC=sarus crane; BNC= black-necked crane; CC=common crane; m,m^3/year=million cubic meter/per year. # = historic record, * = present record; PS=protected status; + = protected.


Eastern Sarus Cranes observed and reported in and around Myanmar (Burma)
95E
100E
1 : 6000000 scale polyconic projection
central meridian 96 0 0 E
latitude of origin 9 0 0 N
crane sightings compiled by Jeb Barzen
International Crane Foundation
Base map from the Digital Chart of the World
copyright 1992, 1994 ESRI
50 0 50 100 150 Kilometers
N
location?
1973
possibly Black-necked Crane.
1973-shot.
Bird now in Kunming Zoo
also from here? (1990)
BHUTAN
INDIA
Assam province
CHINA
Yunnan province
Feb-Mar 1996
Myitkyina
location?
25N
Imphal
1868
no longer good habitat
March 1991
local people sighted
local people sighted
location?
MYANMAR
BANGLADESH
Dhaka
March, 1996
location?
March 1996
Maymyo
March 1996
Myingyan
Mandalay
location?
1980
habitat gone
LAOS
Inle Lake
see detail map
20N
20
ARAKAN YOMA
Ayeryawady River
Moyingyi Reservoir
see detail map
Henzada
Pegu
Yangon
Moulmein
Gulf of Martaban
THAILAND
Ayeryawady Delta
Ayeryawady Delta
see detail map
Eastern Sarus Cranes:
observed
reported
city or village
open water
stream
feet above sea level
below MSL
0-1000
1000-3000
3000-7000
7000-11000
110000+
unkown
glacial ice

MANAGEMENT OF BIODIVERSITY OF WETLAND IN THAILAND

Sch[illegible]nhikorn
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Wetlands in Thailand include many important hahitats and ecosystems which support high biological diversity. Wetlands are also very important economically, they provide valuable resources such as timber and fisheries products, water supply and flood control. In the past decades, wetlands in Thailand have heen seriously threatened by encroachment and industrial development as a consequence of rapid increase of human populations. In terms of biodiversity conservation, several important types of wetlands as described in details by Scott (1989) occur in Thailand. These are intertidal mudflats and mangroves, freshwater swamp forests, freshwater lakes and ponds and associated marshes, reservoirs and rice paddies.

Mangroves and mudflats are found in the Gulf of Thailand and along the east and west coasts of the peninsula. These ecosystems are of great importance as breeding, nursery and feeding ground for fishes and other aquatic species. Mangrove forests also support diverse species of mammals. Intertidal mudflats are extremely important for resident and over-wintering shorebirds.

Freshwater wetlands such as reservoirs, lakes, ponds and marshes are important habitats for wintering and passage shorebirds and watterfowl. These areas are also critical to large number of resident wading and waterbirds as feeding and nesting sites. Freshwater swamp woodlands are essential as roosting and nesting sites for lager waterbirds such as storks, cormorants and herons. Peat swamp forests in southern Thailand are botanically rich and many species of trees are endemic to this specialized habitat. These forests are also of great importance to the conservation of amphibians, reptiles and other species of endangered fishes.

Wetlands in Thailand are managed by government agencies from different Ministries with very little or no coordination, which more often than not, leads to conflicts among these agencies, and resulting in ineffective and uncoordinated wetlands management and conservation. For example, in the past two decades, because of high demand from foreign markets for prawns and other selected fisheries products, the Department of Fisheries has encouraged fishermen and farmers to grow more prawns and fishes for export, as a result, huge areas of mangrove forests under Royal Forest Department's jurisdiction were illegally encroached and cleared for the establishment of fish and prawn ponds. Untreated waste from these ponds has polluted and further degraded the coastal waters and ecosystems.

Many freshwater wetlands in Thailand are managed by Royal Forest Department(RFD) as Non-Hunting Areas. Since most of these non-hunting areas are located on public land under jurisdictions of other goveranmental agencies, many problems and conflicts arose and conservation efforts are sometimes impeded or compromised.

In January 1992, The Royal Forest Department held a seminar on wetland management in Bangkok, this seminar brought together university researchers, offcials from different government agencies, NGO representatives including the IUCN Regional Wetland representative. The seminar resulted in 10 resolutions aimed at solving problems and conflicts in wetland administration and management among government agencies. One of the resolutions is to set up a National Wetland Committee to help guide and coordinate the nation's wetland management plans and programs. Subsequently, in May 1992, a National Wetland Sub-committee was formed under the National Environment Board which is chaired by the Prime Minister. The sub-committee acts as an advisory body to coordinate wetland plans and programs. It has also appointed a working group to draft a National Wetland Policy, and measures to be taken in wetland conservation and management. The first draft of the National Wetland Policy was completed in August 1994, and on September 20-22, 1994, a public hearing workshop was held to revise and refine the draft policy, the final national policy is expected in early 1995.

Royal Forest Department (RFD), under the ministry of Agriculture and Cooperatives, is one of the government agencies that has mandate in managing a number of wetland sites in Thailand, most of which are known as Non-Hunting Area.

Non-Hunting Areas are designated mostly on government land for protection of certain species of wildlife, and have a vital role in providing resting, feeding and nesting ground for numerous species of wildlife, particularly the migratory species such as waterfowl and open-billed storks. A total of 48 non-hunting areas, ranging from 0.08 sq.km. to 457 sq.km. and cover an area of about 0.8 % of the country area. Non-Hunting Areas differ from wildlife sanctuaries in that country generally are smaller in size, and activities such as fishing, recreation and tourism are not generally prohibited.

Twenty three wetlands have been garzetted under the Wild Animals Reservation and Protection Act (WARPA) B.E.2503 (1960), which was amended in B.E.2535 (1992). The amended act strictly prohibited certain activities in these protected areas. Table 1, list wetlands which are designated as Non-Hunting Areas under WARPA as of 1992.

In order to maintain and conserve wetland biodiversity, the Royal Forest Department is striving to protect representatives of all type of wetlands by given these areas legal protective status either as Non-Hunting Areas or wildlife sanctuaries.

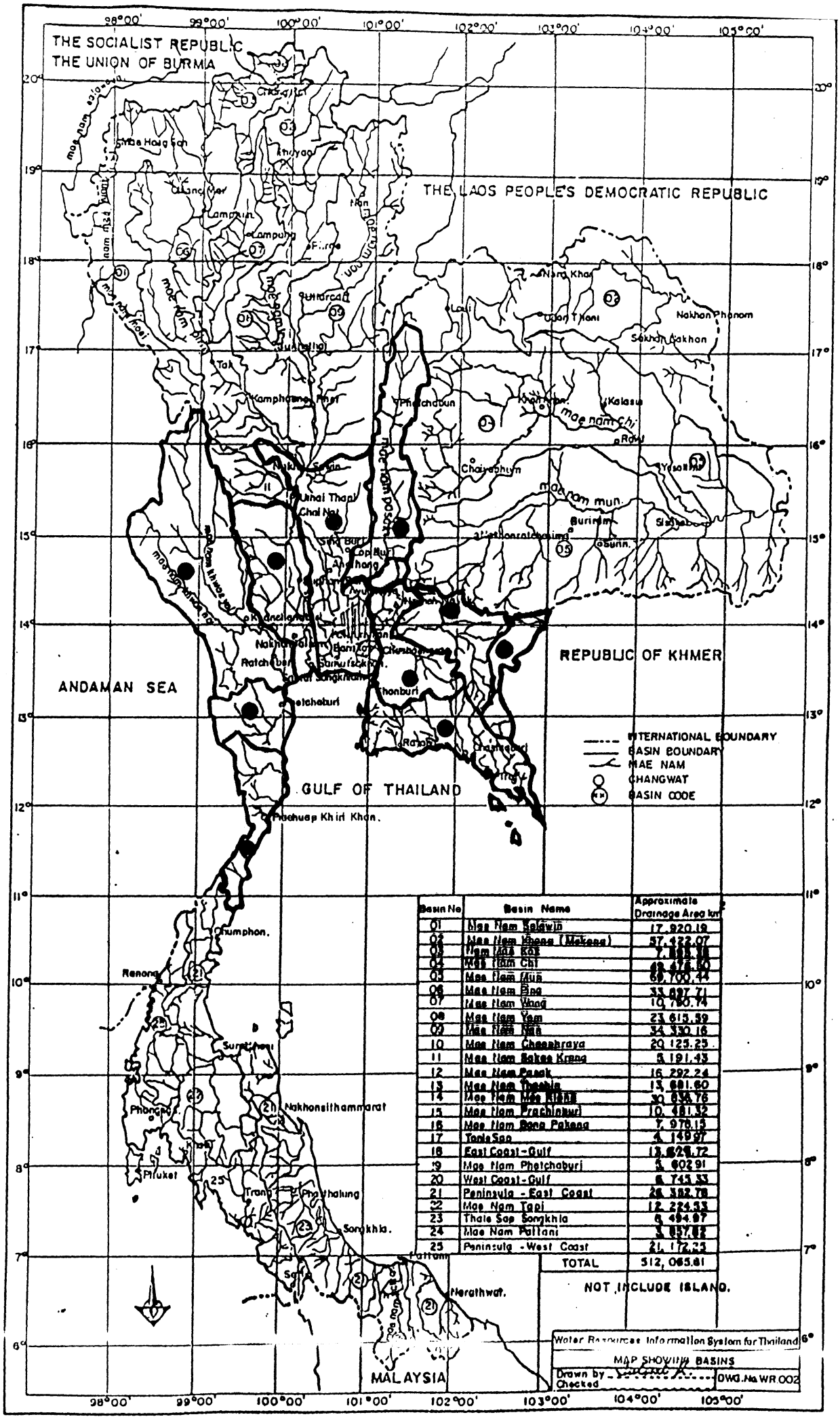
For better and more effective management of important wetlands, management plans of these areas are also being prepared.

Table 1. List of wetland sites under WARPA as of 1992

Number	Wetland Sites	Province	Established	Area(ha)
1 *	Phu-khieo	Chaiyaphum	1972	156,000
2 *	Talay-noi	Songkhla, Phattalung, Nakhon Si Thammarat	1975	45,700
3 *	Bung-borapet	Nakhon Sawan	1975	21,280
4 *	Papru	Narathiwat	1975	16,000
5 *	Nong-tung-thong	Surat Thani	1975	6,150
6 *	Bangphra Reservior	Chon Buri	1976	1,356
7 *	Taley-sarp	Songkhla, Phattalung	1976	36,466
8 **	Wat Pailorm	Pathum Thani	1978	11

9 **	Koh-libong	Trang	1979	47,000
10*	Huai-jaw-rakhemag	Buri Ram	1980	620
11*	Sanambin	Buri Ram	1980	570
12*	Huai-talad	Buri Ram	1980	709
13*	Nong-waeng	Chaiyaphum	1980	17
14*	Bung-kong-long	Nongkhai	1982	1,094
15*	Bung-Chawag	Chai Nat, Suphan Buri	1983	320
16*	Klong-lam-chan	Trang	1984	5,400
17*	Parang-gai	Pattani	1984	25
18***	Palane-pakpanang	Nakhon Si Thammarat	1984	5,672
19*	Nong-hua-koo	Udon Thani	1985	11
20*	Talesarp-nong-bong-kai	Chiang Rai	1985	433
21*	Nong-nam-kao	Phitsanulok	1985	57
22*	Pru-kang-kow	Songkla	1986	76
23*	Lampao	Kalasin, Udon, Thani, Khon kaen	1988	33,750

* Freshwater wetland, ** Island, *** Mangrove-Mudflat



Basin No	Basin Name	Approximate Drainage Area km²
01	Mae Nam Salawin	17,920.19
02	Mae Nam Khong (Mekong)	57,422.07
03	Mae Nam Kok	7,858.18
04	Mae Nam Ing	13,474.50
05	Mae Nam Yom	19,700.44
06	Mae Nam Nan	33,027.71
07	Mae Nam Wang	10,780.74
08	Mae Nam Yom	23,615.59
09	Mae Nam Nan	34,330.16
10	Mae Nam Chaophraya	20,125.25
11	Mae Nam Sakae Krang	5,191.43
12	Mae Nam Pasak	16,292.24
13	Mae Nam Thachin	13,881.60
14	Mae Nam Mae Klong	30,696.76
15	Mae Nam Prachinburi	10,481.52
16	Mae Nam Bang Pakong	7,978.13
17	Tonle Sap	4,149.97
18	East Coast-Gulf	13,829.72
19	Mae Nam Phetchaburi	5,602.91
20	West Coast-Gulf	8,743.33
21	Peninsula - East Coast	26,382.78
22	Mae Nam Tapi	12,224.53
23	Thale Sap Songkhla	8,494.87
24	Mae Nam Pattani	5,857.82
25	Peninsula - West Coast	21,172.25
	TOTAL	512,065.81

NOT INCLUDE ISLAND.

Water Resources Information System for Thailand

MAP SHOWING BASINS

Drawn by _____ DWG.No.WR.002

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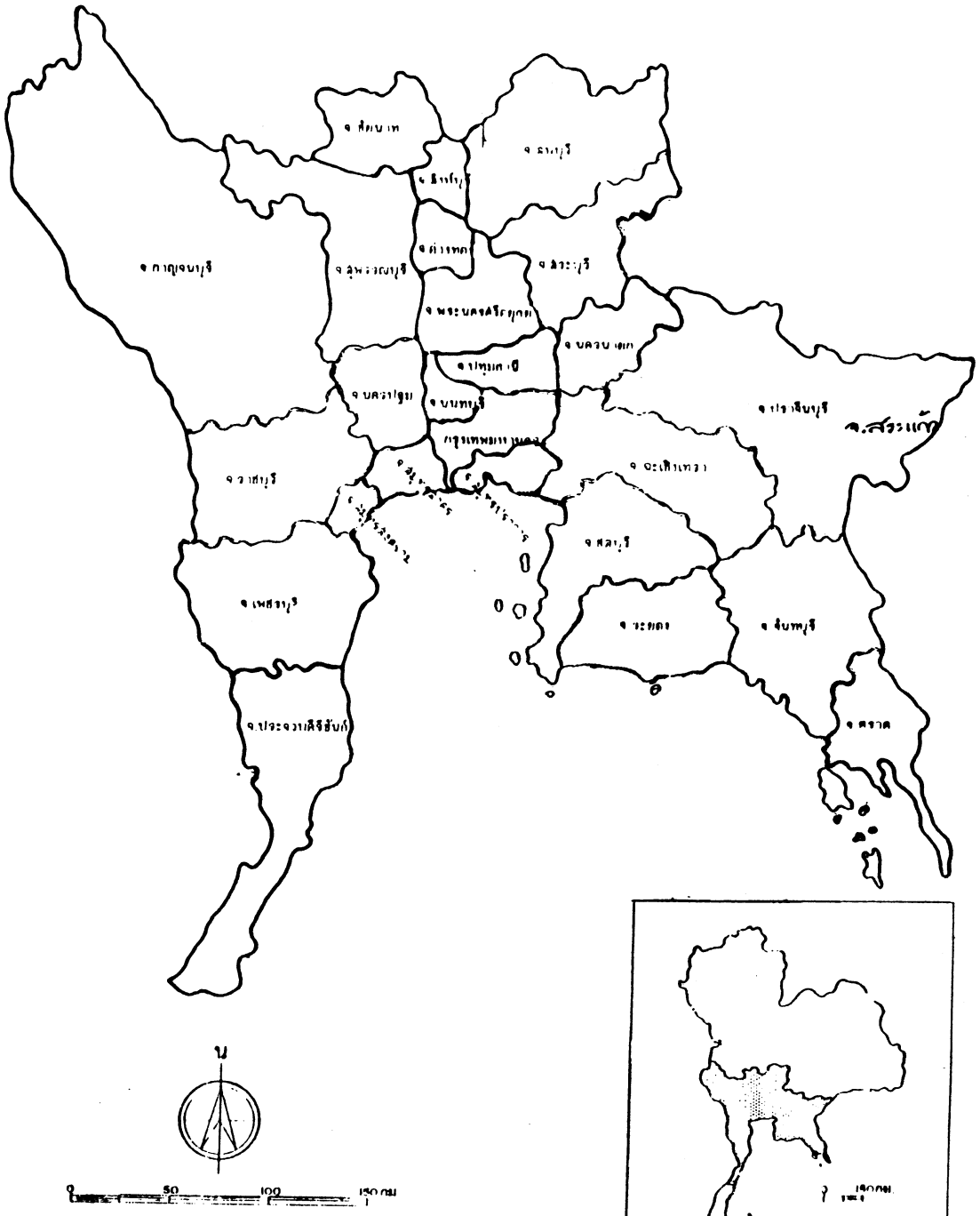


ภาคกลาง
และ ภาคตะวันออก

REGION MAP

(The Central and the East)

The Status of Eastern Sarus Crane in Southern Lao PDR

Prepared for:

The Population and Habitat Viability Analysis Workshop
Khao Keow Open Zoo, Thailand
January 15 - 17, 1997

The Eastern Sarus Crane (*Grus antigone sharpii)* and other waterbirds have declined rapidly over the last 20 years. Now most large waterbirds that occur in southeast Asia are endangered of extinction and many conspicuous species, like the crane, are critically endangered. In Lao PDR very little is known about the distribution and abundance of most large waterbirds, in particular, Sarus Crane. Two independent Sarus Crane surveys were conducted in southern Lao PDR, both in 1996.

Survey of Sarus Cranes in the Dong Khanthung Area

The first survey was conducted August 1996 in the Dong Khanthung Area, Champasak Province, Lao PDR (see map 1&2). This survey was sponsored by the International Crane Foundation and undertaken by the Centre for Protected Areas and Watershed Management, Department of Forestry with assistance from the Wildlife Conservation Society. The survey consisted of village interviews, forest surveys, and one six-hour aerial survey of the Dong Kahnthung area. The results of this survey are quite encouraging.

Several reports of Sarus Crane were recorded while conducting the village interviews. A villager from Ban Bung Ngam reported that Sarus Cranes breed in August to October near their village. Other reports describe cranes dancing around small wetlands in June. Cranes also nested in Nong Bean wetland during the 1995 nesting season. Many villagers described the recent decline of cranes and other large waterbirds over the past five years. One villager from Ban Pho stated that cranes were common in the area before about 1981, but have dramatically declined. A man from Ban Phonthong (near Pak Se) obtained two crane chicks from the Dong Khanthung Area military personnel. This record confirms that cranes are still nesting in the Dong Khanthung area. Other species of interest that were seen or reported during this survey include: Purple Heron *Ardea purpurea,* Painted Stork *Mycteria leucocephala,* Woolly-necked Stork *Ciconia episcopus,* Black-necked Stork *Ephippiorhynchus asiaticus,* Greater Adjutant *Leptoptilos dubius,* Lesser Adjutant *Leptoptilos javanicus,* Asian Openbill *Anastomus oscitans,* White-winged Duck *Cairina scutulata.*

Survey of Sarus Cranes in Xe Pian National Biodiversity Conservation Area

The second survey was conducted in Xe Pian National Biodiversity Conservation Area, Attapu and Champasak Provinces in September 1996 (see map 1&2). This survey was less encouraging in terms of Sarus Crane findings, however, quality habitat still exists. Villagers from Ban Sompoy and Ban Hat Gai both reported seeing cranes in 1996. One man from Ban Samkhang in Khong district reported seeing a single crane and finding a nest with two eggs in August 1996. Other species of interest that were seen or reported include: Woolly-necked Stork *Ciconia episcopus* and River Lapwing *Vanellus duvaucelii.*

Future Actions and Recommendations

The principle threat to Sarus Crane and other large waterbirds in southern Lao is continued hunting and disturbance of the wetlands utilized by these species for feeding and nesting. Sarus Cranes still likely breed and nest in the Ban Xot, Dong Khanthung, and Xe Pian areas but in very small numbers. The availability of appropriate habitat does not appear to be the limiting factor, however, constant disturbance around nesting areas must be limited. Nesting cranes in Lao will likely increase in numbers if human-caused mortality is reduced or eliminated. The future survival of this crane depends on the level of hunting and egg taking.

This year the Wildlife Conservation Society plans to conduct two more surveys in the Dong Khanthung area, one in the dry season and one in the wet season to gather further details on crane abundance and distribution.

Future management plans should be created for the crane and other large waterbird conservation.

A full scale extension and education program should be implemented to heighten the overall awareness of local villagers living in and around crane habitat. WCS is continuing the distribution of endangered waterbird posters to aid in this campaign.

The district government should continue incorporating wildlife into their development plans.

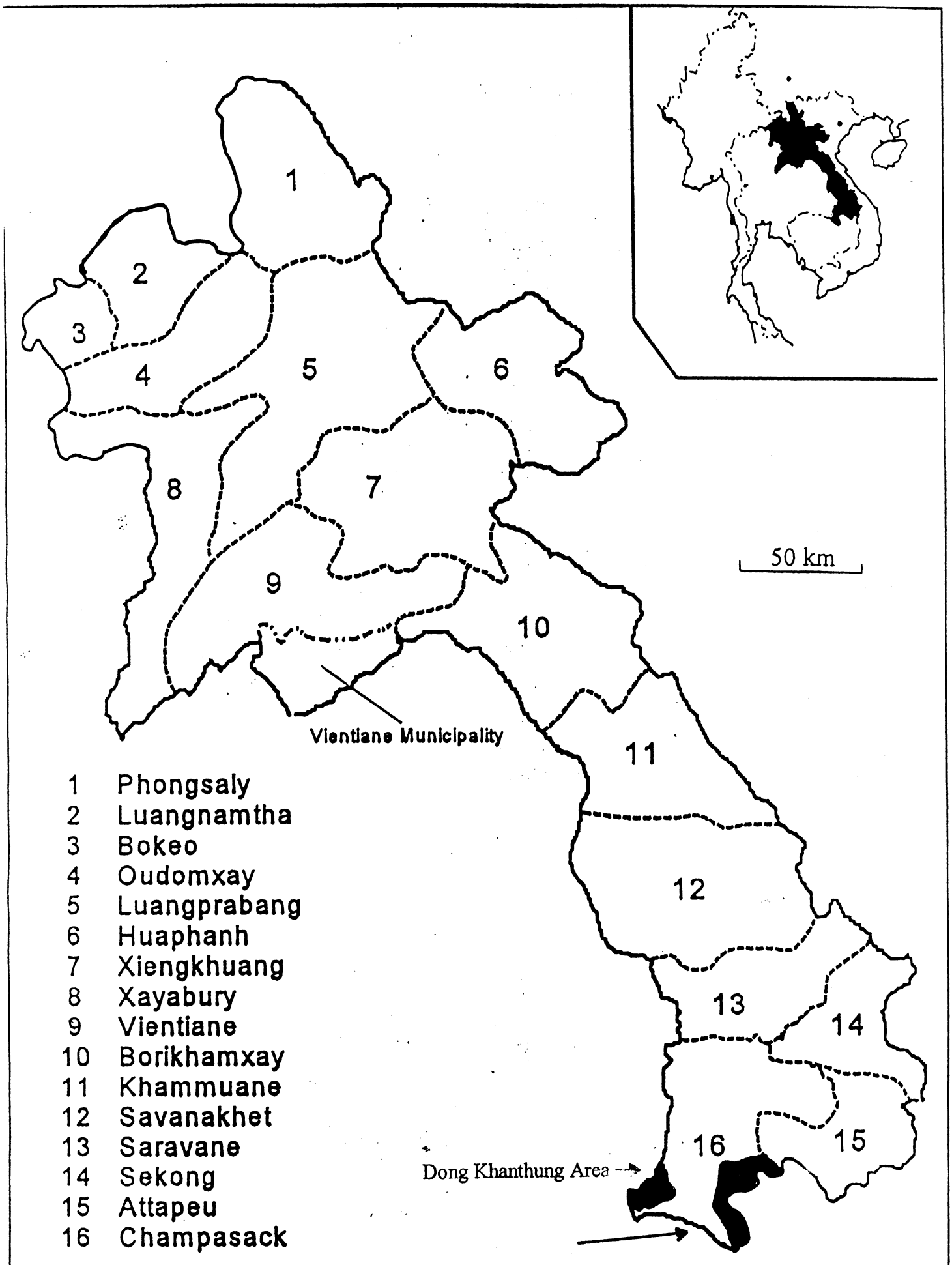
At their request, district staff should receive wildlife conservation training as soon as possible. This will allow for better cooperation and integration of wildlife issues into the local government.

Reference:

International Crane Foundation. 1996. Preliminary Report of a Survey of Sarus Cranes and Other Wildlife in the Dong Khanthung Area, Champasak Province, Lao PDR..

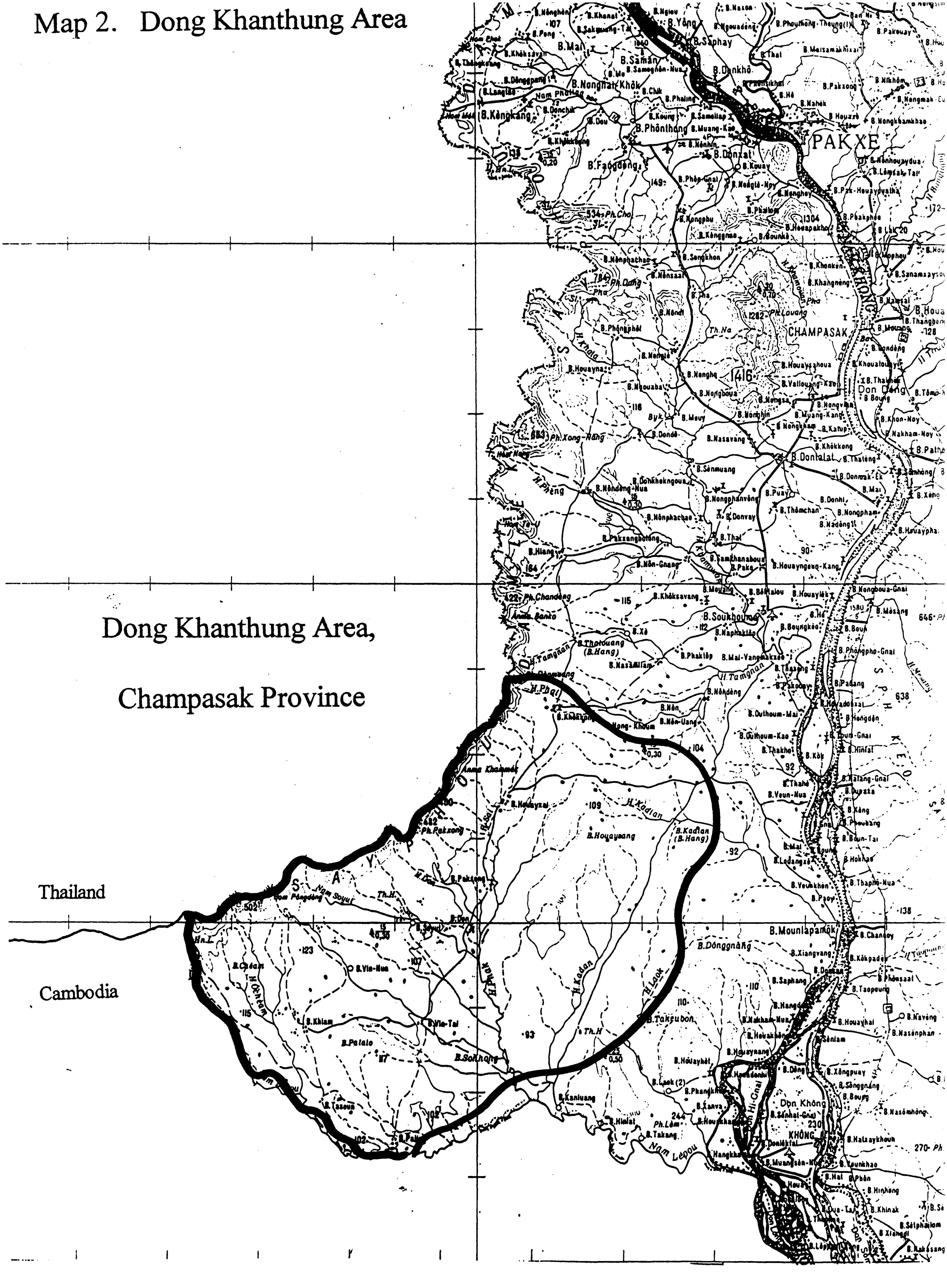
The Wildlife Conservation Society. 1996. Preliminary Report of a Survey of Sarus Cranes and Other Wildlife in Xe Pian NBCA, Attapu and Champasak Provinces, Lao PDR.

Map 1. Lao Provinces

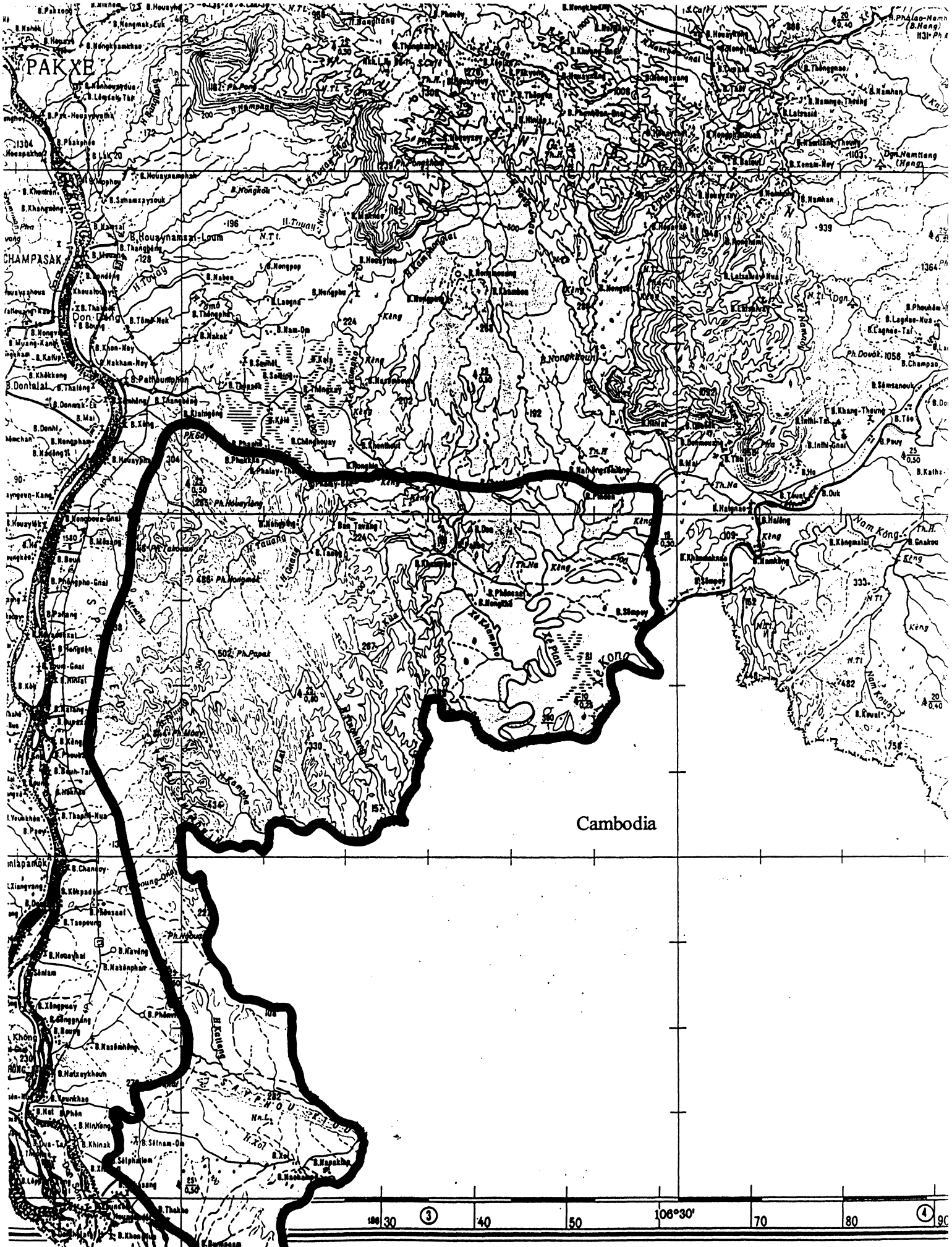


1 Phongsaly
2 Luangnamtha
3 Bokeo
4 Oudomxay
5 Luangprabang
6 Huaphanh
7 Xiengkhuang
8 Xayabury
9 Vientiane
10 Borikhamxay
11 Khammuane
12 Savanakhet
13 Saravane
14 Sekong
15 Attapeu
16 Champasack

Map 2. Dong Khanthung Area



Map 3. Xe Pian National Biodiversity Conservation Area



THE STATUS OF WETLAND IN LAO PDR

I. Background

Lao PDR is land-locked. mountainous country in South East Asia. bordered by China to the North , Vietnam to the East, Cambodia to the South, Thailand to the West and the Union of Mynmar to the North-West. The total land areas is 236,800 Sq.km, the population surveyed in 1995 are 4,600 000 persons ; there are 18 provinces . It is rather sparsely by numbers of different ethnic group , broadly categorized in to Lao Loum , Lao Theung and Lao Soung (Speaking Lao Languages and inhabitting low and mid elevation area)

The climate is tropical with highland form during the monsoon ; The mean temperature is 25 degree, with the amplitude about 10 degree, the mean annual rainfall 1,500 mm (May-October) , and during the six months of dry season (November - April) , the relative humidity is 70 - 85 % .

II. Wetlands

II.1 general Information

Lao PDR has much of the western border formed by the Mekong river , along 1,700 Km and about 88 % of Lao peoples live within the Mekong drainage basin . The Mekong river , its major tributaries and alluvials plains form the only extensive natural wetland ecosystem in the country . There are fourteen major mekong tributaries in Laos, and there are no large natural lakes and indeed few lakes or swamps of any appreciallе size away from the Mekong valleys . It is possible that there are small lakes , swamps , ponds , pool , marches and reservoirs .

The country has a number of wetland areas which are of international significance, including the Mekong River, the xepains- xekhampho-Boung Nong Ngom complex, the khonefalls- seephandone cataracts, the xekong plains, the xechamphone- Nongloung wetland, and the Nakai plateau, and possibly the soukoum wetland .
the major national significance of the coutry 's wetlands probably lies in their role as the most important source of protein for the majority of the population . in most rural parts provide between seventy and ninety persent of the animal protein in people's diet for many of these people , not yet or barery in the cash economy, there is no affordable substitute source of protein .

II.2 Wetland Areas

There are various estimates of area of wetland in the Lao PDR, ranging from 590 square kilometres (khamphet Roger, 1991a) to21,800 square kilometres (5th Agricultural development project , 1989 ,cited in SUAN , 1989). the truth is that untill accurate mapping can be carried out, backed up by ground surveys, the area of wetland can not be kown precisely.

As a part of the wetland management programme of the Mekong secritariat , the wetland unit of the departmet of forestry mapped and classifid the weyland within 50 kilometres of the Mekong mainstream using 1: 250,000 Landsat images. Their results are presented in table 1. Due to the scale of the mapping, the lack of groun truthing and inexperience in interpretation of satelline images it is questionnable whether any reliance can be placed on these figures .

There is considerable reliance on wetland benefits among the sixty-six percent of the population that lives by subsistence agriculture and fisheries.

Wetland products form an important part of local and regional economies. Infact , in what is in much of the country a subsistence economy , there are generally no affordable substitutes for these products. This applies particularly to wetland organisms harvested as protein sources.

Apart from the rple of flood water s in replenishing fish stocks and agriculture soil, the waters of the Mekong and its tributaries are economically signification fpr the Lao PDR for the Hydropower generation, Irrigation and Transport values.

III. Implementing of Wetland Management Agency

Lao PDR has been carrying out a Wetland Management Programme since 1990, by the Centre for Protected Area and Watershed Management (Wetland Management Unit) , Department of forestry , Ministry of Agriculture aaaand Forestry .

Objectives

- To undertake the country's wetland inventory and classification .
- To collect , analyse and compile Wetland Data
- To Assess the status of wetland and Manage theWetlands.
- To propose the guidlines for manage the natural wetland and their biological resources, meanwhile improving the quality of present wetland environment in order to maintain wetland function and hence the better quality of life for the population living around or near the wetland area .

work Completed

+ Cooperation with the Mekong Secretariat (MRCS)

The Wetland Project in Lao PDR supported by the Mekong Secretariat sin 1990, supported

by the Mekong Secretariat for some activities on pilot areas, to collect some data of NongChanh and That Luang Wetland in Vientiane Prefecture as following :

1. Mapping survey In Lao PDR on the scale 1 : 100.000 to 1: 250.000 , and field survey .
2. Experimentation on aquatic plants product on sewage water Wetland in the prefecture Vientiane .

3. Collection of water sample and analysis in water quality laboratories at 8 station on the 2 pilot Wetland site , (NongChanh march and ThatLuang Swamp in prefecture Vientiane) .
4. Analysis on sediment, benthos phyto / 200 plankton (NongChanh and ThatLuang Wetla nd

+ Cooperation with The world conservation Union (IUCN)
-Implemented the interim inventory of 30 wetland sites in the middle and the south part of Lao PDR 1993-96, to make the compiled information available to those with responsibilities for Wetland conservation and management , provide a basis both for planning further data collection , but more importantly to assist in the development of management approaches to the problems that the threaten sustainable Wetland utilization in Lao PDR .

+ Wetland classification
Based on the classification of Dugan 1990, IUCN, MRCS, and the Lao wetland team (1993):

There are 4 types of wetland in Lao PDR

- Lacustrine
- Palustrine
- Marshes , swamps
- Man made/ Artificial

+ Training of staff concern

+ Cooperation with the International Agencies and other Donor's countries

+ Coordinate with other relevant government agencies and local government

Future Plan
- Compile all existing data available
- Use of the existing regulation (Water and Forestry Law) into the management Plan
- Propose the National wetland Strategy
- Investigate and collect data on the distribution of the remaining areas
- Carry out the socio-economic survey and the utilisation of wetland
- Select and designate a wetland site to manage as a Management Model and Training Center
- Survey of the wetland's wildlife (key spp. and migratory Birds)
- Training of the staff concern (central and local)
- Public Awareness/ Outreach Program
  . produce and distribute Posters, Leaflets , booklets etc...
  . Get people involve in the Management Planning Process
- Selection of a wetland site to be access to the International Agencies (Ramsar Convention.)
  . follow up the submitted documents

- Continuous the cooperation with the International Agencies and other Donor's countries
(Technical Assistance/ Funding)

Continuous the coordination with other relevant government agencies and local government
(Support and implementation of the wetland conservation and Management Plan)

Cambodian Wetland Overview and Identification.

By Oum Pisey & Pich Sam Ang
Ministry of Environment.

Phnom Penh January 13,1997.

I- **Introduction** :

Cambodia is one of the countries in south-east Asia,has territory of 181,035 sq km with distance from east towest is about 560 km and north to south 440 km .The country boundary is approximately 2,600 km one sixth of this is the coastline.

Cambodia is entirely rich in wetland environment .Over 30 %of the country is wetland. Following internationally accepted criteria for wetland identification (defined by the Ramsar Convention) more than 20 % (or36,500sq km) of the Kingdom can be classified as wetlands,representing over 5% of the Asia's whole area of wetlands have been divided into four main areas :

* The Mekong River (468 km in length) and its flood plain.

* Great Lake/ Tonle Sap Lake(rainy season :13,000 sq km,dry season :2,500sq km)and its flood plain :500 km in length and 110 km in wide.

* Stung Sen(3,000 sq km) and

* Coastal estuaries.

Furthermore,it has numerous other wetlands notably streams,ponds,fersh water swamp and marshes,mudflats,mangroves,seagrass bed and coral reef ect.

Most Cambodian culturally and economically depend on wetlands.They live in the wetland area and the central part of Cambodia ,being essentially a large wetland comprising flood plains and flooded forest,has been exploitated by them for many years .Wetland products include fish,edible plant, animals,medicine and fuelwood.

This project has been strongly supported by the Ministry of Environment and the Wetlands International while Cambodia needs to be identified and protected its wetlands and resources.

It is important that the Ministry of Environment firstly produce this report and it may be the key report for setting up Cambodian data base in the near future .

II **Objectives** :

This project is aiming to:

1) Provide capacity building to MoE's staff in understanding the benefits and values of wetlands.

2) Overview the key wetlands areas throughout Cambodia.

3) Brief surveys to significant wetland areas in order to identify and classify them.

4) Identify the current uses and threats to wetland areas .

III- **Methodology**:

The project is employed by 6 staffs united the wetland working group from the wetland office. It was devided into 4 steps :

- Step I : all members of wetland working group had to be trained in wetland Identification and survey. This period took about 3 weeks then
- Step II : started compile relevant documents, maps and all of them did the desk study.
- Step III : all member of the wetland working group had chances to wetland area both fresh water and coastal wetlands in order to verify on what they have done with the desk study and
- Step IV : Compile final report of Cambodian wetland overview and identification and release them.

IV- **Identification and classification of wetlands:**

The following identifications are based on the definition of wetlands on Ramsar convention an area of marsh, reed, peatland or water swamp, whether natural or artificial, temporary or permanent, with water that is static, flowing, fresh brackish or salt, including marine waters, the depth of which at low tide does not exceed six meters, map studying and field surveys to the main wetland areas throughout the Kingdom as well as the aerial survey report from the previous report.

As a result of wetland working group, approximately 29 sites of wetlands in Cambodia have been identified as significant habitats, cultural, and international important sites for migratory birds. Amongst those sites have also been classified into: freshwater, brackish and marine wetlands.This identification based on the criteria of size,biodiversity richness,habitat and home range of species,culture,landscap and recreation.

1) **Freshwater wetlands**:

This type of wetlands include the central reaches of Mekong River, and its floodplain, Tonle Sap (Great Lake), associated Lakes and its tributaries and creek systems.

About 21 main sites have been studied and chosen:

a)- ***Boeung Pring Flooded Forest:***

- Coordinates: 11^0 14' 30" - 11^0 31' 00"N;
  103^0 17' 00" - 105^0 27' 30"E;
- Location: It is situated in Prey Veng Province about 30 km from Neak Loeung District Town in the North-East.
- Total Area: 16,000 ha
  - Water surface : 6,000 ha
  - Marshes : 10,000 ha
- Altitude
- - Average : 6.3 m
- - Maximum : 8 m
- Wetland types:
  Lakes, flooded forest, marshes
- Soil types:
  Brown alluvial and cultural hydromorphic.

b)- ***Kratie River system and Marshes:***

- Coordinates:
  12^0 06' 00" - 13^0 14' 00"N;
  105^0 42' 00" - 106^0 10' 00"E;
- Location:
  It locates in Kratie province, a part of Mekong River.
- Total Area : 142,250 ha
  - Water surface : 55,000 ha
  - Marshes : 87,250 ha
- Altitude:
  - Average : 56 m
  - Maximum : 63 m
- Wetland types:
  - Rivers, Creek system flooded forest and ricefield.
  - Water surface 16,750 ha
  - Marshes: 129,500 ha
- Altitude:
  - Average : 54 m
  - Maximum : 63 m

- Wetland types:
  Streams, flooded forest and Marshes:
- Soil types:
  Acid lithosols, Grey hydromorphic and Red Yellow podzols.

c)- *Tonle Sekong River system:*

- Coordinates : 13^0 31' 00" - 14^0 28' 00"N;
  105^0 57' 30" - 106^0 27' 00"E;
- Location :
  This area locates approximately 10 km from Stung Treng Town, in the north-east.
- Total Area: 34,750 ha
  - Water surface : 16,250 ha
  - Marshes : 18,500 ha
- Altitude:
  - Average : 53.14 m
  - Maximum : 62 m
- Wetland types:
  River system, and flooded forest.
- Soil types:
  Grey hydromorphic, Acid lithosols, and Brown Alluvial.

d)- *Tonle Sap Creek System:*

- Coordinates : 12^0 56' 00" - 13^0 34' 00"N;
  106^0 17' 10" - 107^0 31' 00"E;
- Location :
  Approximately 30 km Ratanakiri provincial town in the South.
- Total Area: 157,500 ha
  - Water surface : 14,875 ha
  - Marshes : 142,625 ha
- Altitude:
  - Average : 130 m
  - Maximum : 203 m
- Wetland types:
  Creeks, streams, Marshes, and flooded forest.
- Soil types:
  Brown alluvial, Acid lithosols, and plinthite podzols.

e)- *Tonle Sesan Creek System:*

- Coordinates : 13^0 29' 00" - 14^0 10' 00"N;
  106^0 05' 00" - 107^0 26' 00"E;
- Location :
  It situates about 35 km from Ratanakiri town, originating from Virachey National Park in South-West.

- Total Area: 146.250 ha

f) *Stung Treng Mekong River flooded forest* :

- Coordinates : 13^0 12' 00" - 13^0 56' 00" N
  105^0 51' 00" - 106^0 04' 00" E
- Location :
  The site is located in the north and south of Stung Treng Province town, along with the Mekong River.
- Total Area : 48,000 ha
  - Water surface : 33,000 ha
  - Marshes : 15,000 ha
- Altitude :
  - Average : 49.33 m
  - Maximum : 62 m
- Wetland types :
  - River system flooded forest and Agricultural farming.
- Soil types :
  - Acid Lithosols and grey hydromorphic.

Note : This Area has been proposed as a Ramsar site and approved recently by Cambodian National Assembly.

g) *Peam chileang Lakes, creeks system* :

- Coordinates :
  12^0 00' 00" - 12^0 20' 00" N
  105^0 26'00" - 105^0 42' 00" E.
- Location :
  About 10 km from Kampong Cham town, in the North east.
- Total Area : 63,750 ha
  - Water surface : 7,500 ha
  - Marshes : 56,250 ha
- Altitude :
  - Average : 9.1 m
  - Maximum : 15 m
- Wetland types :
  Lakes, creek system and marshes.
- Soil types :
  Brown alluvial and ragur.

h) *Prasat tuyo lakes, flooded forest forest and marshes.*

- Coordinates :
  - 11^0 03' 30" - 11^0 27' 30"N
  - 105^0 00'00" - 105^0 16' 30" E
- Location :
  It situates in the east of Phnom Penh about 57 km.

- Total Area : 72,000 ha
  - Water surface : 7,000 ha
  - Marshes : 65,000 ha
- Altitude :
  - Average : 7 m
  - Maximum : 10 m
- Wetlands types :
  Lakes, flooded forest, marshes, Ricefields, lotus pond.
- Soil types :
  Brown Alluvial.

I) *Boeung Veal Samnap :*

- Coordinates : 11^0 31' 45" - 11^0 39' 00" N
  105^0 00' 15" - 105^0 07'30" E.
- Locates :
  Approximately located 10 km in the North-east of Phnom Penh.
- Total Area : 10,850 ha
  - Water surface : 2,800 ha
  - Marshes : 8,050 ha.
- Altitude :
  - Average : 9 m
  - Maximum : 12 m
- Wetlands types :
  Lakes, flooded forest, marshes.
- Soil types :
  Clay, Alluvial.

j) *Boeung Prang lowland ricefields :*

- Coordinates : 11^0 31' 15" - 11^0 39' 00" N
  105^0 6' 40" - 105^0 13' 45" E.
- Locates :
  Loacted 11 km in the North-east of Phnom Penh.
- Total Area : 12,600 ha
  - Water surface : 1,700 ha
  - Marshes : 10,900 ha.
- Altitude :

- Average : 6 m
- Maximum : 9 m

- Wetlands types :
  Lakes, flooded forest,ricefields and marshes.
- Soil types :
  Clay, Alluvial.

k) ***O Chang Rung lake and flooded forest :***

- Coordinates : 12^0 33' 30" - 12^0 50' 00" N
  103^0 54' 00" - 104^0 13' 00" E.
- Locates :
  Situated approximately 25 km in the north of Pursat Provincial Town .
- Total Area : 55,000 ha
  - Water surface : 11,500 ha
  - Marshes : 43,500 ha.
- Altitude :
  - Average : 15.3 m
  - Maximum : 20 m
- Wetlands types :
  Lakes, flooded forest, marshes and ricefields.
- Soil types :
  Grey, hydromorphic and mud.

l) ***Upper Stung Sen creeks system and marshes :***

- Coordinates :
  $13^0$48'00"- $14^0$12'00"N
  $104^0$32'00"- $105^0$60'00"E
- Location :
  It located about 55km in the south-west of Preah Vihear Provincial Town.
- Total Area : 80,000ha
  - Water surface : 10,000ha
  - Marshes : 70,000ha
- Altitude :
  - Average : 80.9m
  - Maximum : 117m
- Wetland types :
  Creek system, marshes and ricefield.
- Soil types :
  Acid lithosol, Grey hydromorphic, Plinthite podzols, and Red yellow podzols.

m) Phum Moat Peam Lakes and Flooded Forest :

- Coordinates :
  $13^0$04'00"- $13^0$21'30 N
  $103^0$41'10"- $104^0$08'15" E
- Location :
  Situated 15km in the south of Siem Reap Provincial Town.
- Total Area : 45,000ha
  - Water surface : 3,000ha
  - Marshes : 42,000ha
- Altitude :
  - Average : 2.5 m
  - Maximum : 3 m
- Wetlands types :
  Lakes, flooded forest, ricefields and marshes.
- Soil types :
  Lacustrine Alluvials.

N) Boeung Veal Damrei lakes, and flooded forest :

- Coordinates :
  12^0 50 ' 00"- 1307' 00 N
  104^0 06 '00"- 104^0 19' 30" E
- Location :
  About 20 km from Phum Kampong where is on high way No 6 in the south of Siem Reap Provincial Town.
- Total Area : 45,000ha
  - Water surface : 15,000ha
  - Marshes : 30,000ha
- Altitude :
  - Average : 15.2 m
  - Maximum : 26 m
- Wetlands types :
  Lakes, flooded forest, ricefields and marshes.
- Soil types :
  Lacustrine Alluvials.

O) ***Lower Stung Sen lakes and Creek system.***

- Coordinates :
  12^0 34' 00"- 12^0 48 ' 00 N
  104^0 26 ' 00"- 104^0 49' 00" E
- Location :
  Situated about 15 km in the west of Kampong Thom Provincial Town.
- Total Area : 61,200ha

- Water surface : 10,000ha
- Marshes : 51,200ha

- Altitude :
  - Average : 52.25 m
  - Maximum : 213 m
- Wetlands types :
  Lakes, creek, flooded forest, ricefields and marshes.
- Soil types :
  Lacustrine Alluvials.

P) ***Boeung Chhmar creek system and flooded forest :***

- Coordinates :
  12^0 43' 00"- 12^0 53' 30" N
  104^0 11' 00"- 104^0 23' 30" E
- Location :
  About 23 km from Phum Krakor (Pursat Province, in the North).
- Total Area : 33,000ha
  - Water surface : 20,000ha
  - Marshes : 13,000ha
- Altitude :
  - Average : 24 m
  - Maximum : 59 m
- Wetlands types :
  Lakes, creek, flooded forest, ricefields and marshes.
- Soil types :
  Lacustrine Alluvials.

Q) ***Boeung veal Pok lakes, river system and flooded forest :***

- Coordinates :
  12^0 19' 00"- 12^0 36' 00" N
  104^0 30' 00"- 104^0 45' 00" E
- Location :
  10 km from Kampong chhnang Provincial Town.
- Total Area : 56,500ha
  - Water surface : 20,000ha
  - Marshes : 36,000ha
- Altitude :
  - Average : 198 m
  - Maximum : 545 m
- Wetlands types :
  Lakes, creek, flooded forest, ricefields and marshes.

- Soil types :
  Acid Lithosols, lacustrine Alluvials.

r) Boeung Thom Lakes, river system and flooded forest:

- Coordinates :
  $12^0$07'00"- $12^0$34'00" N
  $104^0$41'00"- $105^0$07'00"E
- Location :
  It situated about 5km in the last of Kampong Chhnang Town.
- Total area :72,500 ha.
  -Water surface :35,000 ha.
  -Marshes :37,500 ha.
- Altitude :

  -Average :20.7m
  -Maximum: 26m
- Wetland types :
  Lakes,river system ,flooded forest,ricefield and marshes .
- Soil types :
  Lacustrine alluvial and panols.

S)Stung Daun Try flooded forest,rivers and lakes :

- Coordinates:
  $12^0$44'30"-$13^0$06'00"N
  $103^0$31'40"-$103^0$58'00"E.
- Location:

60 km from Pursat Provincial town in the north -east .

- Total area :103,000ha
  -Water surface:11,200ha
  -Marshes :91,800ha
- Altitude :
  -Average :19m.
  -Maximum:52 m
- Wetland types :

Flooded forest ,rivers,lakes,marshes and ricefield.

- Soil types:

Alluvial and mud.

T) Stung Sangke flooded forest,streams and lakes :

- Coordinates :
  $13^0$12'30"-$13^0$20'00"N

$103^0$34'00"-$103^0$45'00"E

- Location:
  Located about 40 km from Battambang Provincial town in the north -east .
- Total area :22,00 ha
  -Water surface:6,000 ha
  -Marshes :16,000 ha
- Altitude:
  -Average:3.5 m
  -Maximum:5 m
- Wetland types :
  Flooded forest, streams, lakes and marshes.
- Soil types :
  Alluvial, clay and mud

2) **Brackish wetlands :**

These types of wetlands are located on the coastline plateau and linked the sea .The water component is seasonally changed into brackish during rainy season and salt during dry season .The main vegetations exist in these wetlands are mangroves,rear mangroves, which supported the habitats of reptiles,small mammal and aquatic spesies . Approximately two different ecosystem wetland areas are identified :

A)Stung Metoek mangrove and Creek system:

- Coordinates:
  $11^0$32'00"-$11^0$51'00" N
  $102^0$51'00"-$103^0$06'00"E

- Location :
  It is situated about 1 km in the north Koh Kong provincial town.

- Total area :22,500 ha.
  -Water surface :10,000 ha
  -Marshes : 12,5000 ha.
- Altitude :
  -Average :116,6m.
  -Maximum :153 m.

- Wetland types :
  Mangroves ,creek system ,rear mangroves and shrimp pond .
- Soil types :
  Coastal complex.

B) Prek Piphot Creek System and Swamp mangroves :

- Coordinates :
  $11^0$04'30" - $11^0$19'00" N
  $103^0$18'30"- $103^0$36'30"E
- Location :
  Located 10km in the North of Sre-Ambil, Koh Kong Province
- Total Area : 21,250ha
  - Water Surface : 12,750ha
  - Marshes : 85,000ha
- Altitude :
  - Average : 62m
  - Maximum : 262m
- Wetland types :
  Mangroves, Creek system, mud, sand and little rear mangroves.
- Soil types :
  Acid lithosols, and Alumisols.

3)- **Marine wetlands :**

It locates in shore area with not much different habitat from the brackish wetlands. However, the water is permanently unchanged .It could be moved on the water table when rainy season starts.

As a result, about 6 areas area identified as significant and internationally important habitats for migratory bird and marine aquatic species .

A)Kampong Marshes and Salt pond:

- Coordinates:
  $10^0$24'30"-$10^0$33'30"N
  $104^0$24'00"-$104^0$36'00"E
- Location :

Approximately 2 km in the east of Kep town.

- Total area :17,500 ha
  -Water surface :2,500 ha
  -Marshes: 15,000 ha.
- Altitude:
  -Average :89,7 m
  -Maximum: 144m
- Wetland types :

Salt pond, marshes, mangroves ,swamp,sand and seagrass.

- Soil types :

Coastal complex .

B) Prek Kampong Bay,Creek system,mangroves and marshes:

- Coordinates :
  $10^0$30'00"-$10^0$41'00"N
  $104^0$08'30"-$104^0$18'00E
- Location :

Kampot provincial town .

- Total area: 16,250 ha
  -Water surface:7,500 ha
  -Marshes :8,800 ha.
- Altitude:
  -Average:94 m
  -Maximum:351 m
- Wetland types :

Mangroves,swamp,sandand creek system.

- Soil types :

Coastal complex and red yellow podzols.

C) Prek Toek Sap Creek system,Mangroves,and Marshes :

- Coordinates:
  $10^0$24'00"-$10^0$37'30"N
  $103^0$40'00"-$103^0$59'00"E

- Location :

15 km in the east of ream Navy Base ,Sihanouk Ville .

- Total area :21,250 ha
  -Water surface:12,250 ha
  -Marshes :8,750 ha
- Altitude:
  -Average:328 m
  -Maximum:564 m
- Wetland types :

Mangroves,creek system,coral reef seagrass and rear mangroves.

- Soil types :

Acid lithosols,and red yellow podzols.

D)Chhok Veal Renh.

- Coordinates:
  $10^0$35'00"- $10^0$43'10"N
  $103^0$47'30"-$103^0$58'30"E
- Location :

170 km in the south- west of Phnom Penh.

- Total area:14,900 ha
  -Water surface:n/a

-Marshes :n/a

- Altitude :
  -Average:3 m
  -Maximum:5 m.

- Wetland types :

Mangroves,marshes,rear mangroves and ricefield.

- Soil types:

Peat,mud,and sand.

E)Koh Kapik Ramsar site:

- Coordinates:
  $11^0$24'00"-$11^0$32'00"N
  $102^0$59'10"-103^0 09'45"E

- Location:

It is in Koh Kong province and associated islets of KohKong district.

- Total area :12,000 ha
  -Water surface:n/a
  -Marshes: n/a.

- Altitude :
  -Average :3.3 m
  -Maximum: 5 m
- Wetland types :

Estuary,mangroves ,creek and tidal mud flats.

- Soil types :

Mud ,sand and peat.

F) Prek Kampong Som Mangroves,Swamp and Marshes :

- Coordinates :
  $11^0$01'30"-$11^0$09'00"N
  $103^0$37'30"-$103^0$45'15"E

- Location :

About 52.5 km in the north of Sihanouk Ville.

- Total area : 10,800 ha
  -Water surface :3,300 ha
  - Marshes : 7,500 ha

- Altitude :
  - -Average:2.5 m
  - -Maximum: 10 m
- Wetland types:

mangroves ,swamp,marshes and ricefield .

- Soil types :mud ,sand and brown soil.

V- PRESENT SITUATION OF CAMBODIAN WETLANDS :

Cambodian wetlands have been long reknown among the remaining in the world -less disturbed ecosystems . For their richer resources and biodiversity, they have been reknown as the most productive ecosystems, providing very enormous benefits to most of Cambodian people and playing the vital role, moreover, as homes for the wide variety of wildlife, especially of waterbirds , fishes and reptiles.

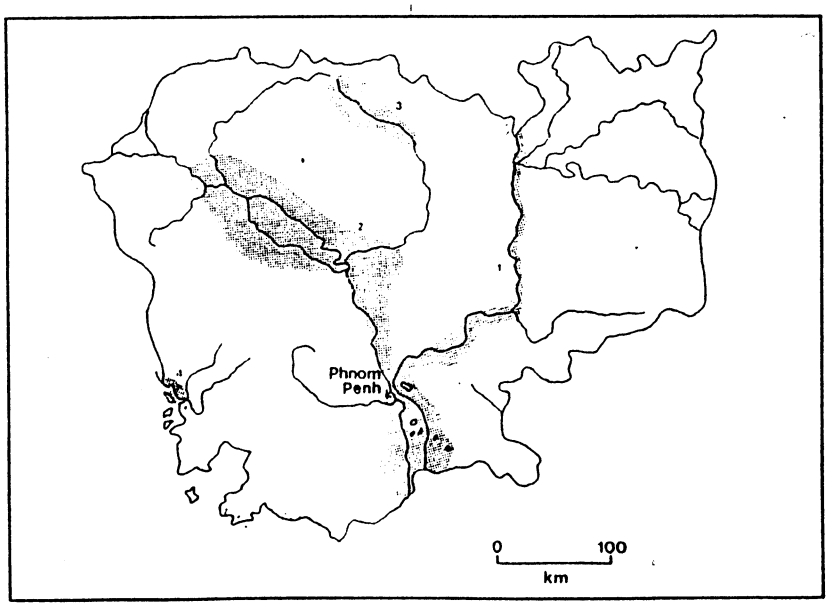
According to the " Directory of Asian wetlands " (Scott and Poole,1989) a huge area of 3.65 M.ha in Cambodia has been considered as the internationally significant wetlands . This amount present a relatively greater percentage (20,2%) if compared with those of neighboring countries wetlands The areas of wetlands of international significance , together with the percentage of country's wetlands and of Asia wetlands can be presented in the table .....as followings:

Table 1 : Area of wetlands of international significance in Indochina
[(adapted from Scott & poole (1989)]

Country	Areas of Wetland (Sq.km)	%of Country's land $ (by area)	%of Asia Wetlands (by area)
Vietnam	58,100	17.6	7.9
Cambodia	36,500	20.2	5.0
Thailand	25,100	4,9	3.4
Laos	2,220	0.9	0.3

The location of these internationally significant wetlands over Cambodia are distributed to the 4 major water sources and shown in the map as below :

Map of wetlands of international significance



Source : Directory of Asian wetlands
(Scott and Poole , 1989)

It is necessary to notice these potentially important wetland as of the classification in accordance with location and kinds of water as following :

*** Freshwater Or Inland Wetlands :**

1- Mekong river and its dependent backswamps and associated floodplain
2- Tonle sap-great lake and the associated areas ;
3- Stoeng Sen northein highregion . plain

*** Salt or Coastal Wetlands :**

4- Bays, rivers and estuaries system in koh kong province.

The main wetland type together with the area can be provinded by " Cambodia land Cover Map " and shown in the table ..... as below :

Table Main Wetland Type In Cambodia	
1- Flooded evergreen forest	361,700 ha
2- Mosaic of flooded forest , fallow land	157,200 ha
3- Swampy vegelation	379,100 ha
4- Grassland susceptible to flooding	822,900 ha
5- Paddy fields (Rainfed rice) (with or without palm trees)	2,686,300 ha
6- Receding rice fields	29,300 ha
7- Mangrove	61,400 ha
8- Open water areas , lakes , rivers	487,600 ha
* TOTAL Main wetland areas	: 4,985,500 ha 27,46%
* From Total Cambodia's land	: 18,153,500 ha

Source : Land use Classification of Cambodia , 1991
* Data from Area Statistic 1992 /93
(Cambodia Land Cover Atlas , MS for FAO Project)

Indeed , around half of Cambodia could be observed as of the seasonnally inundated areas , dependent on the Mekong River and Tonle Sap-great Lake annual Flooding regime .

The detaited Land use troughout Cambodia is shown in table .....

1/- CURRENT USE OF CAMBODIAN WETLANDS :

It is evident that most of the Mekong and Tonle Sap-Great Lake plains systems constitute the potential areas, for both economic and environmental developments . Well known as the Central Plains , these areas have been long inhabited and used by most of cambodian people because of their potentially productive system components, upon wich humans and wildlife depend their live . Therefore, both inland and coastal wetlands become the most actively exploited areas , and more affected by many human activities.

The main activities on wetlands are : Agriculture , Settlement, Nature Conservation , Tourism/Recreation, Transport and Navigation and Various Developments .

A- Agriculture

Because of their good soils that are suitable for many crops. wetlands are traditionally and preferrably used as agricultural lands by cambodian farmers (85-90% of total cambodia's population) .

Among the agricultural activities, it is to notice some importants as follows:

a- Cropping : generally practiced in most parts of cambodian central plains. for such an activity , the main crops. that are usually harvested are : rice, maize , bean , soybean , potatoe , tobacco , etc.....

The majority of rice croppings is pratically occured on the plains , moisted by seasonal rains of the southwest monsoon in the rainy or wet season , lasting from May to October . But the harvesting period for "Rainfed Rice " can last on between May and early January . The Rainfed rice area is more than 2.6M.ha ($^1/_7$ of Cambodia) .

A relatively small area is distibuted to the receding rice fields (29,300ha) on the flooded plains (See Table 2). But this is reportedly more and more increased , for purpose of agriculture production expansion , mainly in rice and other crops. Sequently, the wetland areas together with related resources , are observed lost at a critical rate for such a conversion to agricultureal lands. (The case in Takeo province could be example for this).

The river bank platation is another factor contibuting to river and lake environment degradation by causing partly the encreased sedimentation and siltation and water quality problem from the chemical fertilizers and pesticides use:

Source : Directory of Asian wetlands
(Scott and Poole , 1989)

It is necessary to notice these potentially important wetland as of the classification in accordance with location and kinds of water as following :

*** Freshwater Or Inland Wetlands :**

1- Mekong river and its dependent backswamps and associated floodplain
2- Tonle sap-great lake and the associated areas ;
3- Stoeng Sen northein highregion . plain

*** Salt or Coastal Wetlands :**
4- Bays, rivers and estuaries system in koh kong province.

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The detaited Land use troughout Cambodia is shown in table .....

The water supply for irregation within and around wetland areas is uncontestably not problem for crop havesting . For this purpose , the canal systems and other necessary infrastructure had been unproprely constructed , mainly in the period of Pol Pot's regime , making some modifieation in natural processes of wetland ecosystems.

b- Fishing come as second activity (or 2nd. job) after rice cropping , and has been more preferrablly practiced by local people. There aree some cambodian villages installed in the middle of lake and river or wetland systems, where the villagers have, since a long time , the fishing as " primordial job "and , therefore , the big part of their live depend on " Fish Resource ". But there has been since last decade bigger problem of fishing activities , that could be among other nationwide concerns. The modern techrique and large scale fishing or fishery industry , togother with illegal and destructive fishing practices , have been often occured on the wetlands (both inland and coastal) and become likely the nearly complete replacement of in new recent years of long lasting traditional fishing, more sustainable during all the pre - war-period .

All the above mentioned fishing activities are undeniably among the factors , affecting negatively and seriously our "Wetland Ecosystems "in general , and our valuable " Fishery Resource " in particular . As the result , a critical decline in fishery production had been met during the period from 1960,1970,1980 and 1990 respectively (see table 3 below) :

Table 3 Fishery Production Statistics

Year	inlannd fishery Production(T)	Mmarine Fishery Production(T)	Agriculture Production(T)	TOTAL Production(T)
1960	138,000	40,000		178,000
1970	77,000	43,000	5,800	125,800
1980	18,000	1,300		19,300
1990	65,100	39,900	6,400	111,400

Soure : Excerpt from Fishery Production statistics by Departmment of Fishery (Min . of Agriculture)

- Unknown date :

Since few recent years , the fishermen have said about the slightly generated incomes , for reason of very small amount of captured fishes, due to dramatic decline of fishstocks, resufted from the unsustainable use. This had been truely happened and is further continuing to be as increasingly seious human induced impacts that must be properly resolved. In this regards , the illegal fishing

and all destructive pratices in fishing must be highly considered and reduced and totaly eliminate.

As illegal activities, it is to include the fishing by foreign veshels, that is often of large scale for purpose of fishery industry at one hand , and fishing by local people in the closed season and illegal exportation of seedling of some important fish species at the other hand . Other inappropriate and destructive practices are :

- The use of harmful fishing materials (Trawsling nets, pushnets, very mall mesh-nets , that can either catch young and juvenile fishes, including the exessive by - catched , or destroy the seagrasses and other weeds of bottom- habitats .

- The dynamite fishing and electric shocks are very harmful , because they kill indiscriminately fishes and many other aquatic live as the result , many important fishes are drastically declined and become rare and endairgered , and many others are being dramatically threatened (Ex. Irrawaddy dolphins , snake-head-fishes,...)

- The aquaculture : fish ponds , shrimp ponds, cage-fish farrming , block-trap net (accross the rivers) tree-branch -traps (Samras : local name) ect..... are additionnal unproper and long term affecting factors for fish population and wetland environment as well . The water quality problem (Pollution of waters), siltation of rivers and lakes can be caused as parts of further challenges . The fish farming, including cage-fish culture could be examined, furthermore , as cause of the increasingly excessive by-catch , affecting more and more seriously the fishstocks. (some aspects of destructive fishing are shown in Annex I.b)

- The indiscriminate collection of shellfishes (oysters, snails,...) could be mentioned as another affecting causes of degradation of wetland ecosystem comporents .

*** Hunting / Poaching of Waterbirds :**

Cambodian Wetlands are also reknown four their bountiful waterbirds . Million of them had been depended on the expremely richer-in-fish wetlands. In Cambodia annually in the past .

But at present time , these breeding and feeding grounds have been seriously degraded, and subsequently , a big part of natural habitats (managroves), coral reefs, segrasses, other seaweads in marine and coastal areas, flooded forests

and other aquatic plants / weeds in the freshwater wetlands) , and fishstocks have been dramatically declined since the last recent years , due to various human activities. The Valuable Wetland Biodiversity , especially the waterfowl has been extreniely lost as the concerned sequence .

The use of poison and modern teehniquee in catchinq waterbirds, alonq with the hookig, farming like the poultry in the house, collection of Bind eggs and young Birds , are of the destructive practices , causing massive loss of water -birds in the nearest future .

Collection of fuelwood and other materials :

During the last decade , wetland habitats, mainly mangroves , mellaleuca and other coastal tree species have been and continue to be cut for many purposes, such us collection of firewood, charcoal production , shrimp culture, fishing and construction materials , etc... At the another side, the flooded forests are under the same threats, but the most detrimentus effects for these outstanding crucial resources are likely to be caused by the conversion to agricultureal lands , rather than by fuelwood and materials collection .

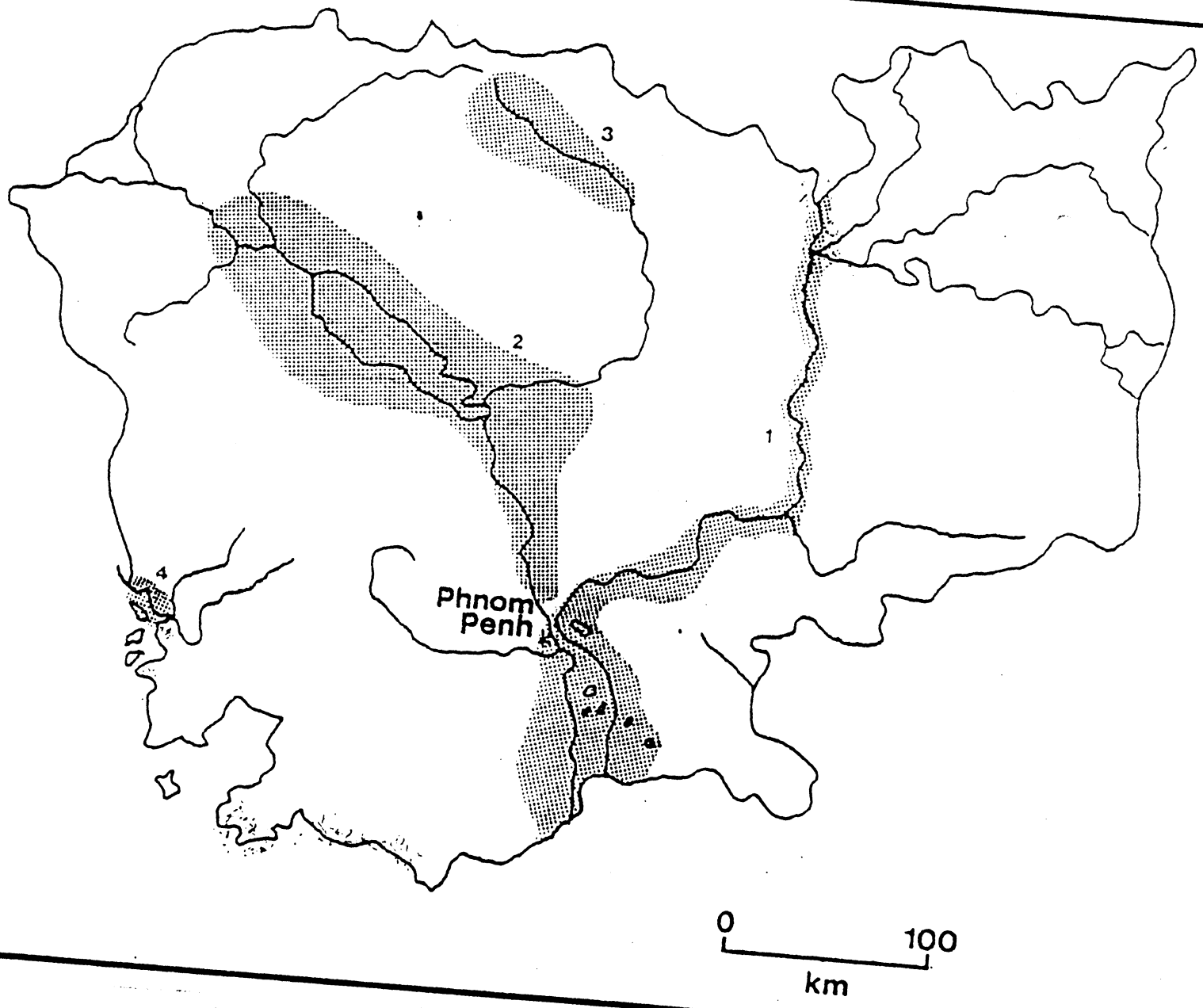
B- Settlement :

It is very evident , that the central plain is the most populated area (more than 100/km^2) in Cambodia, because the majority of Cambodian people is farmer, preferring to inhabit the good soils , productive lands for agriculture production , as their major job, and the traditional main crop is rice, so a wide rate of Cambodian Wetlands has been lost for settlemment , practically adjacent to rice fields(or wetlands). Sometimes, local people like to construct their houses on the lakes , rivers, and many of them along the river banks (riverine settlement) in the intention to easely and directly use waters- this may cause pollution to waters of both inland and coastal wetland areas from the domestie waste waters and from livestock waste- So , The disturbance to natural habitats and wetland biodiversty deterioration, together with water quality problem have been and will be unvoidafoly mel where the settlement become more and more heavy ..

Fuelwood collection activities are shown in annex I-d

c/- Prairies / livestocks feeding grounds and duck-farms :

Because there are some parts , known as grasseslands susceptibles to flooding (822,900 ha, total .....) or even marshes and swamps, totaling some 29,00ha (Area statistic-1992-93-Cambodia land cover atlas , MS.fro FAO Project) Cambodian wetlands can be also of important prairies or livestock feeding , farming grounds . during the dry season . Several Ducks Farms (domestic ducks)


3
2
1
4
Phnom
Penh
5
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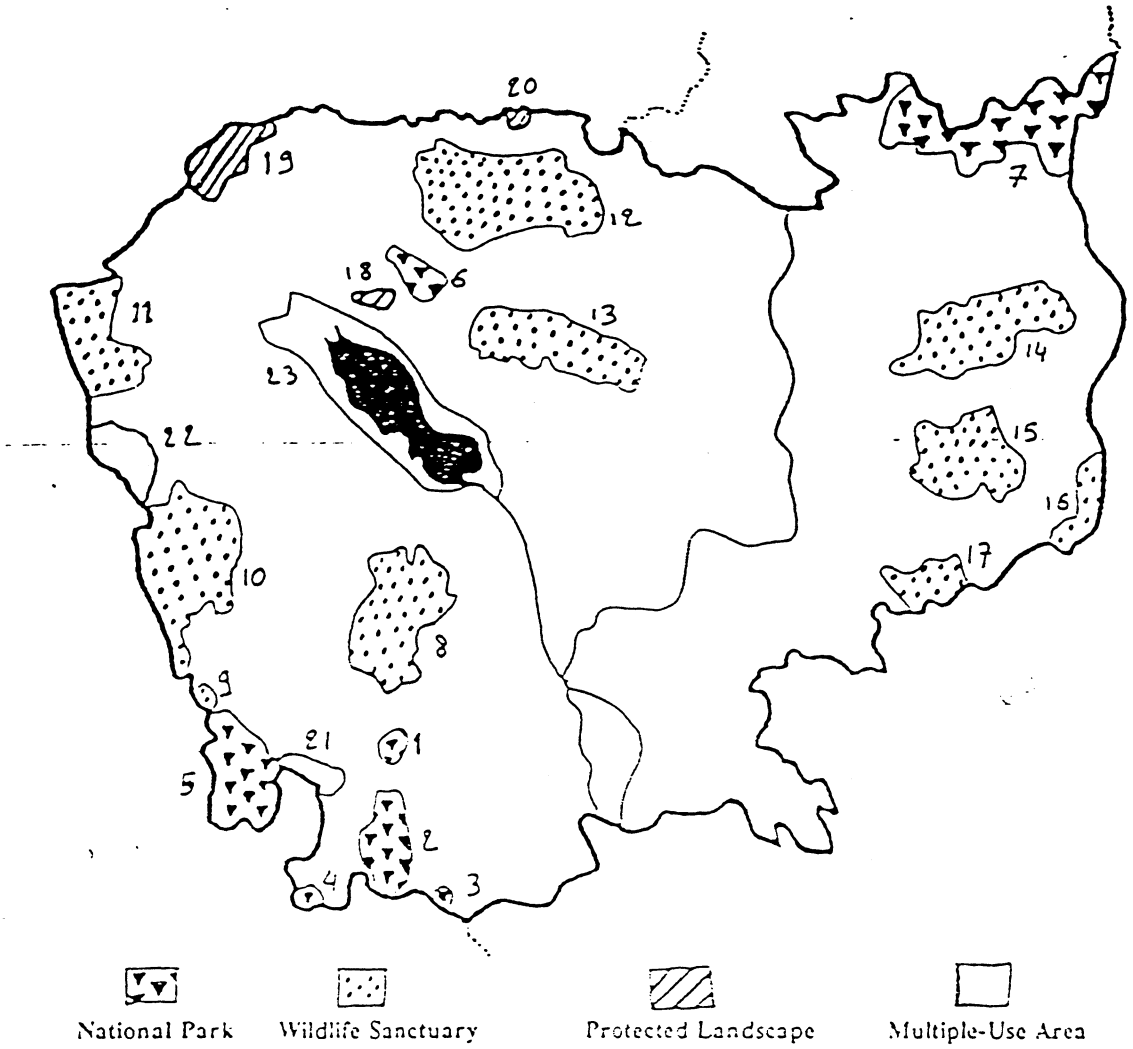
100
km

Map 3 - Protected Areas in the Kingdom of Cambodia (By Royal Decree 1-11-1993)



Reference:

National Parks

1. Kirirom (35,000)	2. Phnom Bokor (140,000)	3. Kep (5,000)
4. Ream (15,000)	5. Botum Sakor (171,250)	6. Phnom Kulen (37,500)
7. Virachey (332,500)		

Wildlife Sanctuaries

8. Phnom Aural (253,750)	9. Peam Krasob (23,750)	10. Phnom Samkos (333,750)
11. Roneam Daunsam (178,750)	12. Kulen Promptep (402,500)	13. Boeung Per (242,500)
14. Lomphat (250,000)	15. Phnom Prich (222,500)	16. Phnom Nam Lyr (47,500)
17. Snoul (75,000)		

Protected Landscapes

18. Angkor (10,800)	19. Banteay Chhmar (81,200)	20. Preah Vihear (5,000)

Multiple-Use Areas

21. Dong Peng (27,700)	22. Samlaut (60,000)	23. Tonle Sap (316,250)

Source: Royal Decree , 'Creation and Designation of Protected Areas', 1 November 1993.

SUSTAINABLE DEVELOPMENT PRINCIPLES FOR MIXED CULTURAL/NATURAL PROTECTED AREAS

* Development should not degrade the resource base upon which it depends.

* Strive to achieve maximum cultural, ecological and economic diversity.

* Maximize uniqueness and authenticity of product.

* Archaeological and environmental conservation can be tools to stimulate economic development

* Short-term benefits should not take precedence over long-term costs.

* Economic benefits must be equitably distributed.

* Development activities must be based on local value systems.

* Direct and indirect economic leakages should be minimized.

* Use of local resources should be maximized to benefit local people.

* Developers must pay for all costs of negative impacts.

* Development must be undertaken within a legal regulatory framework.

* Zoning is a tool to achieve resource compatibility.

* "Plan as you proceed" within a strategic framework and vision.

Population and Habitat Viability Analysis Workshop for the Eastern Sarus Crane
Khao Kheow Open Zoo, Chonburi, Thailand
15 - 7 January 1997
*****

THE MANAGEMENT OF TRAM CHIM WETLAND RESERVE DONG THAP PROVINCE, VIET NAM

Thai Vinh
Director, Tram Chim National Wetland Reserve.

I. Background

1. Location: Tram Chim is located in Tam Nong District, Dong Thap Province (10 37 - 10 45 N; 105 28 - 105 36 E), being adjacent to six villages: Tram Chim, Tan Cong Sinh, Phu Tho, Phu Duc, Phu Hiep and Phu Thanh B. Tram Chim lies about 25 km west of the Mekong river, near the border with Cambodia.

2. Area: 7612 hectares.

3. Local people:

There are 31,229 people living surrounding Tram Chim, with an average density of 410 people/sq km. The natural growth rate is 2.18% per year. The local people earn their living by rice cultivation, fishing, wood gathering and hunting of wild animals including birds. They depend heavily on the natural resources of the Reserve for their living.

Income of local people:

Rich families: 38.2%
Middle families: 27.2%
Poor families: 34.6%

II. Management issues

In 1985, Dong Thap Province decided to choose Tran Chim as an area for the restoration of wetlands of the Plain of Reeds. That year, a system of dikes was built to circle 5000 ha of wetland in Tram Chim and melaleuca forest was replanted within the area. Since then, the ecological conditions of Tram Chim has gradually improved and now Tram Chim is the home to a wide variety of plants and animals. More than 130 native plants, 40 species of freshwater fish, and almost 200 species of water birds - of which 13 species are rare or endangered are found living in Tram Chim. Tram Chim is currently the only protected wetland in the Plain of Reeds.

Many scientists and environmental groups, both Vietnamese and foreigners, have conducted scientific research and field observations in Tram Chim and concluded that Tram Chim is an important wetland of the lower Mekong basin. The International Crane Foundation, IUCN, WWE, and the Brehme Fund have been sponsoring many research and management activities in Tram Chim, as well as helping to improve the infrastructure of Tram Chim.

On May 18, 1992 the Vietnamese Prime Minister signed the 169/CT Order urging the concerned agencies to cooperate in protecting the Sarus crane and wetlands of Tram Chim. A feasible study was conducted later on, coordinated by the Institute of Forestry Planning of Southern Viet Nam, and a management plan was prepared as the result of the study. The management plan was presented to the Viet Nam government and on February 2, 1994 the government declared Tram Chim as a national wetland reserve.

Goals of Tram Chim Reserve

- To preserve typical wetland ecosystems of the Mekong delta
- To restore wild wetland landscape of the Plain of Reeds
- To protect habitats of wetland organisms, particularly water birds
- To conserve native plants and animals
- To provide a place for the study of wetland and natural resources management

Activities

a) Infrastructure: melaleuca planting, tree planting on dikes, building canals for fire protection.
b) Water control: ICF donated $72,000 in 1991 and $34,500 in 1995 for the construction of six water gates in A1 and A2 zones. Water control is an important activity of Tram Chim because maintaining a proper water level is critical for the restoration of Tram Chim wetlands. The dikes, water gates, guard stations, observation towers, and instruction signs are well maintained.
c) Social activities: Prepared and implemented a buffer zone management plan for Tram Chim. Participated in flood protection and soil conservation projects in Tan Cong Sinh and Phu Cuong villages. Working with Can Tho University, OXFAM AMERICA, and the U.K Embassy in Viet Nam in a project of helping poor people of Tan Cong Sinh village.
d) Scientific research:
   - Monitoring populations of the Sarus crane and some other species of water birds (sponsored by ICF)
   - Surveying aquatic resources and studying water chemistry (sponsored by the Mekong Committee)
   - Developing an economic model for the people living in the buffer zone (sponsored by the Royal Holloway Institute for Environmental Research, University of London, U.K.)

- Applying solar energy equipment in 10 guard stations (sponsored by the Department of Science, Technology and Environment, Ho Chi Minh City)..

III. Challenges and immediate actions

The development of Tram Chim reserve is a major concern of Dong Thap Province. So far Tram Chim has been receiving tremendous support from many agencies and scientists. However, some obstacles still remain:

- The objective of biodiversity conservation in Tram Chim has not been set up clearly.
- There has not been a plan for developing eco-tourism in Tram Chim in a way that does not conflict with conservation objectives.
- The living conditions of local people are so low and need to be improved.
- The operational budget is too small, and does not meet the requirements of Tram Chim management.

The Sarus crane in Tram Chim

- The number of cranes coming to Tram Chim seems to have declined recently.
- It seems that Tram Chim wetland does not provide a habitat large enough for the crane population.
- Area of Eleocharis sedge, which tuber is the main source of food for Sarus crane, is getting smaller and smaller due to the expansion of rice fields and changes in water quality.
- The rapid urbanization of Tam Nong town and agricultural development of the surrounding area would have profound negative impacts on the crane population.
- The number of local people is increasing rapidly, particularly due to immigration. The area of the reserve which is occupied illegally is getting larger and larger, thus deceasing the amount of reserve for cranes and other wildlifes.
- There exists a conflict between maintaining melaleuca forests and preserving Sarus crane in Tram Chim. To protect melaleuca forests from fire it is needed to keep a high water level inside the Reserve. The high water level is however not suitable for *Eleocharis* grassland which is used by the crane as feeding areas, and as a result, it would limits the number of cranes migrating to Tram Chim.

Some proposed immediate actions

1) Further zoning of A1 and A2 zones into A1-1, A1-2, A1-3, A1-4 and A2-1, A2-2, A2-3 and A2-4 subzones for a better water level control, satisfying both melaleuca fire protection and the maintenance of feeding and resting areas for cranes.
2) Making A4 zone an area of producing additional food (e.g. corn) for cranes. It requires an estimated $6000 to $8000 per year to implement this plan.
3) Building more observation towers and guard stations.
4) Conducting field studies on resource utilization habits, mating and mortality of the Sarus crane in Tram Chim.

5) Improving living conditions of the local people living in the buffer zone, making them aware of the importance of wetland conservation in Tram Chim.
6) Conducting surveys of the Sarus crane populations living in other areas of the Mekong delta (see Appendix 1 for a list of areas), coordinating with other Provinces in the Mekong delta to attain a more comprehensive Sarus crane protection program.

Tram Chim is a valuable asset not only of Viet Nam but of the whole world. We hope that Tram Chim will continue to receive support from friends around the world to help conserving wetlands and the Sarus crane.

Appendix 1

1. Places where cranes can be found in the Mekong delta

a. Dong Thap Province

Tam Nong District: Tram Chim
Tan Hong District: Bac Chan
Cao Lanh District: Gao Dong
Thap Muoi District: Dong Cat

b. Long An Province

Vinh Hung District

c. An Giang Province

Tri Ton District

d. Kien Giang Province

Hon Dat District

e. Soc Trang Province

Thanh Tri District

2. Crane Death

Some cranes were found dead in Tram Chim, probably due to eating foods contaminated with pesticides.

1993: two birds died (found in A1 zone)
1994: one bird died (found in A1 zone)
1996: 1 bird died (found in A2 zone)

In Dong Thap Province, particularly in Tram Chim people is aware of the importance of crane conservation, but elsewhere in the Mekong delta cranes might be hunted. Therefore in the Mekong delta, the Sarus crane may suffer a higher mortality rate outside of Tram Chim during non-breeding seasons.

3. Method of monitoring crane population in Tram Chim

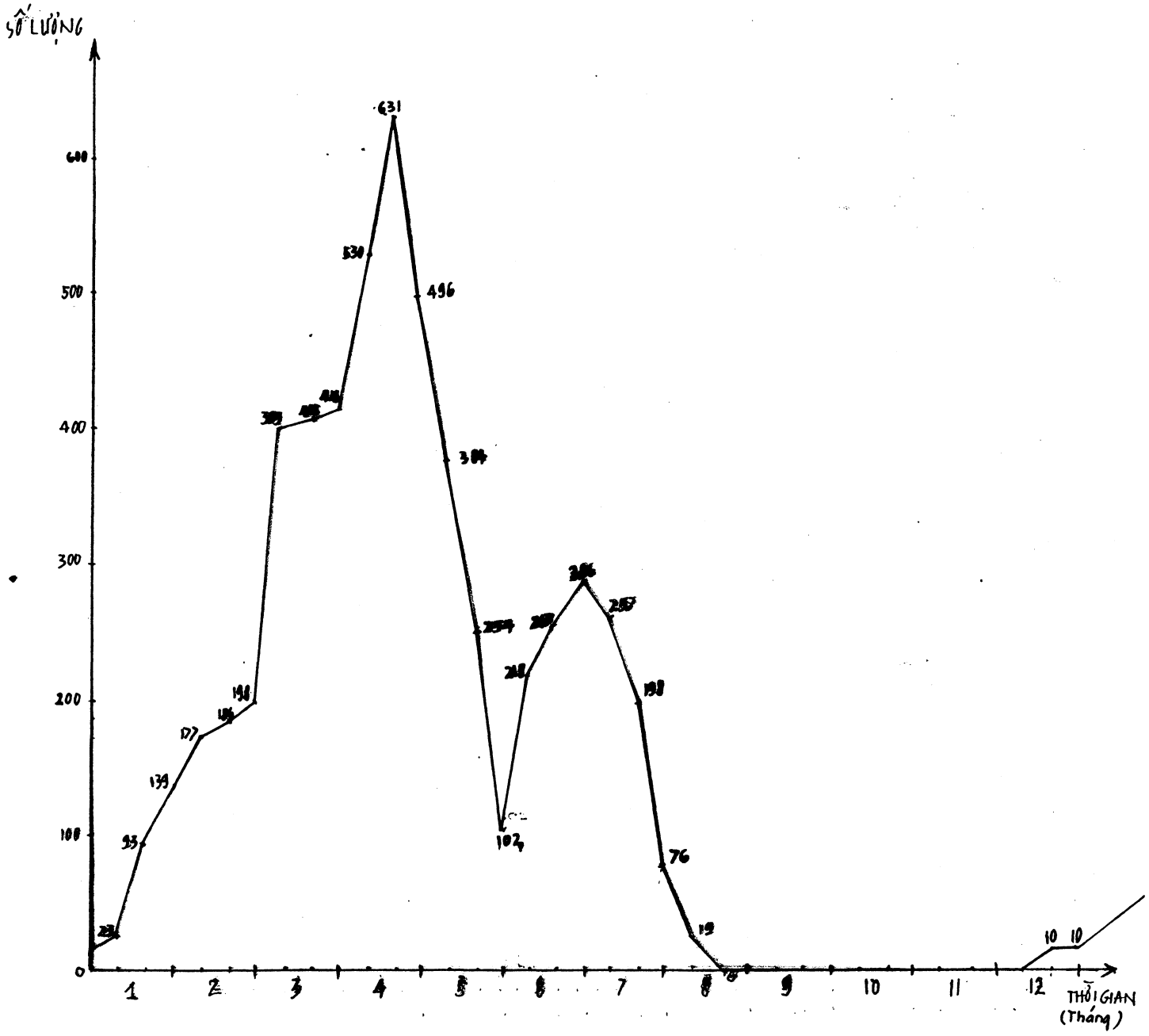
In 1996, cranes are counted on the 1st, 10th and 19th every month from January to August. Cranes were observed by binoculars at dawnfrom the guard towers surrounding Tram Chim as they fly out from their night-time roosts .

4. Wetland sites that should be surveyed for the presence of Sarus crane

Dong Thap Province: Tan Hong, Thap Muoi and Cao Lanh Districts
Long An Province: Vinh Hung
An Giang Province: Tri Ton
Kien Giang Province: Hon Dat
Soc Trang Province: Thanh Tri

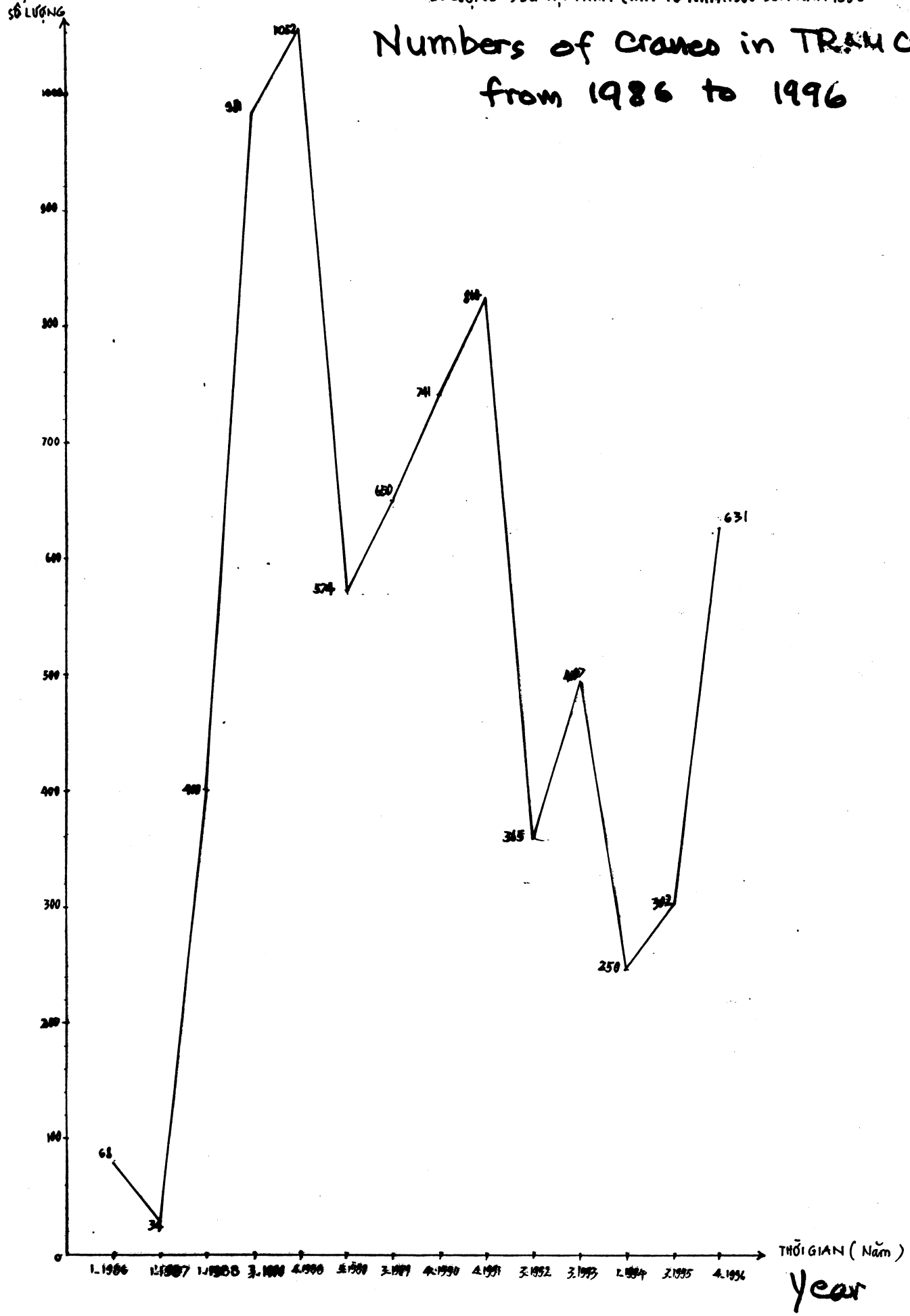
SỐ LƯỢNG SẾU TẠI TRẠM CHIM NĂM: 1996

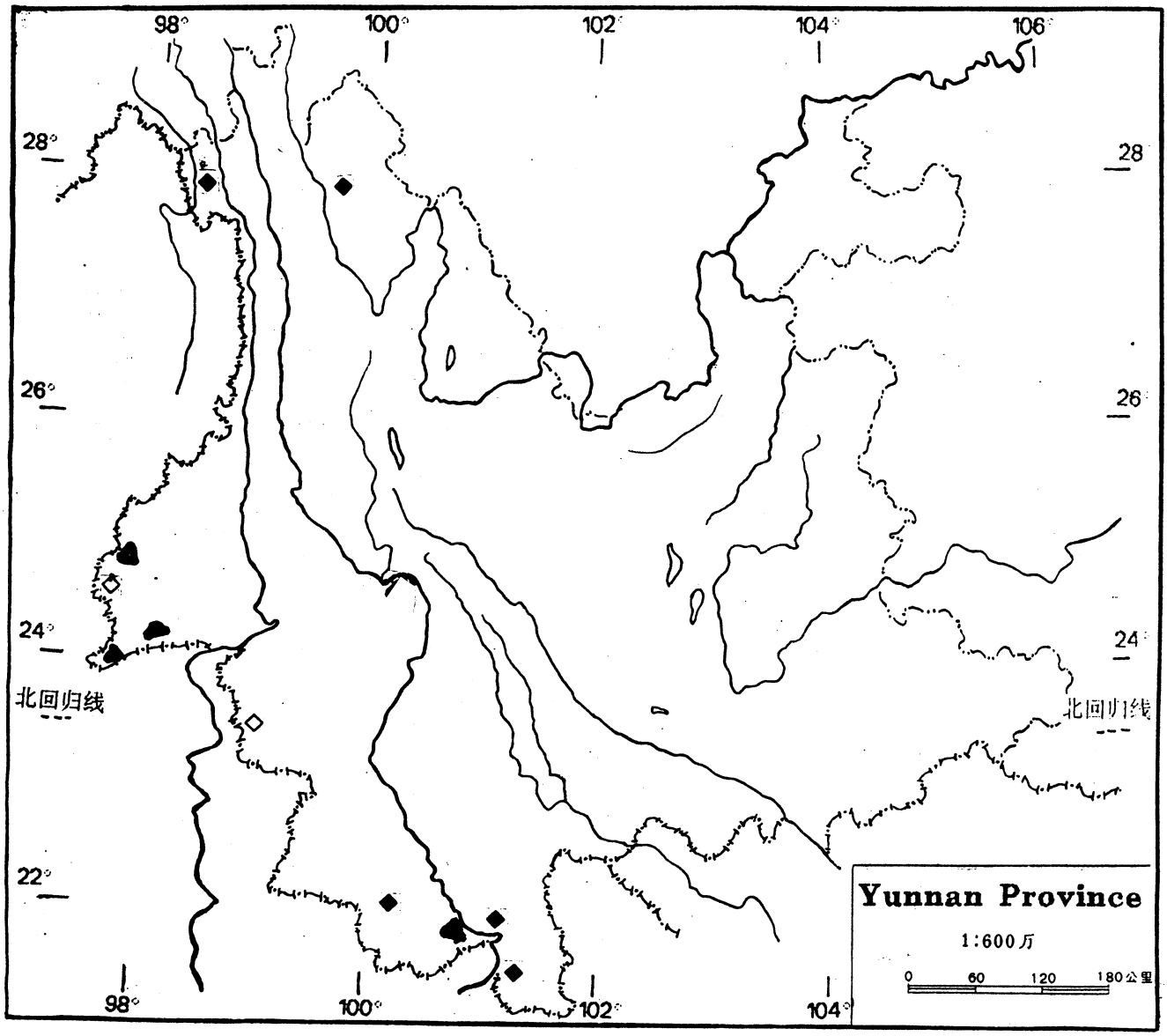
Crane population at Tram Chim in 1996.



SỐ LƯỢNG SẾU TẠI TRÀM CHIM TỪ NĂM:1986 ĐẾN NĂM:1996

Numbers of Cranes in TRÀM CHIM from 1986 to 1996





本图上国界线按照地图出版社一九八九年出版的《中华人民共和国地图》绘制。

The map of Eastern Sarus Crane distribution in Yunnan, China


CHINA
QINGHAI
GANSU
SHAANXI
HENAN
SICHUAN
HUBEI
HUNAN
GUIZHOU
YUNNAN
GUANGXI
LANZHOU
XI AN
ZHENGZHOU
WUHAN
CHENGDU
CHONGQING
CHANGSHA
GUIYANG
KUNMING
Lhasa
Tanggula Shan
Nyainqentanglha Shan
ARUNACHAL PRADESH
ASSAM
NAGALAND
MEGHALAYA
MANIPUR
TRIPURA
MIZORAM
BANGLADESH
DHAKA (DACCA)
CALCUTTA
CHITTAGONG
MYANMAR
Mandalay
YANGON (RANGOON)
THAILAND
KRUNG THEP (BANGKOK)
Chieng Mai
LAOS
Viangchan (Vientiane)
VIETNAM
HANOI
HAIPHONG
Hue
Da Nang
CAMBODIA
Phnom Penh
HO CHI MINH (SAIGON)
Nanning
Zhanjiang
Haikou
Andaman Islands (India)
Nicobar Islands (India)
60
G
H
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K
L

Appendix 2

NUMBER OF CRANES COMING TO TRAM CHIM

Counting date	Number	Counting date	Number
5 Jan 1986	46	21 Feb 1995	159
6 Jan 1986	68	22 Mar 1995	302
		19 Nov 1995	7
6 Jan 1987	34	1 Dec 1995	7
8 June 1987	17	10 Dec 1995	14
		19 Dec 1995	18
Jan 1988	400		
Mar 1988	981	1 Jan 1996	23
Apr 1988	1052	10 Jan 1996	93
May 1988	572	19 Jan 1996	139
July 1988	24	1 Feb 1996	177
		10 Feb 1996	186
Mar 1989	665	19 Feb 1996	198
		1 Mar 1996	399
31 Jan 1990	442	10 Mar 1996	405
7 Feb 1990	401	19 Mar 1996	416
14 Mar 1990	568	1 Apr 1996	350
1 Apr 1990	741	10 Apr 1996	631
		19 Apr 1996	496
1 Mar 1991	162	1 May 1996	384
1 Apr 1991	814	10 May 1996	254
		19 May 1996	102
15 Mar 1992	365	1 Jun 1996	218
21 Mar 1992	230	10 Jun 1996	267
		19 Jun 1996	286
18 Feb 1993	133	1 July 1996	257
25 Feb 1993	293	10 July 1996	198
4 Mar 1993	388	19 July 1996	76
18 Mar 1993	497	1 August 1996	19
7 Apr 1993	445		
23 Apr 1993	332		
25 Jan 1994	250		
5 Feb 1994	193		
8 Mar 1994	271		