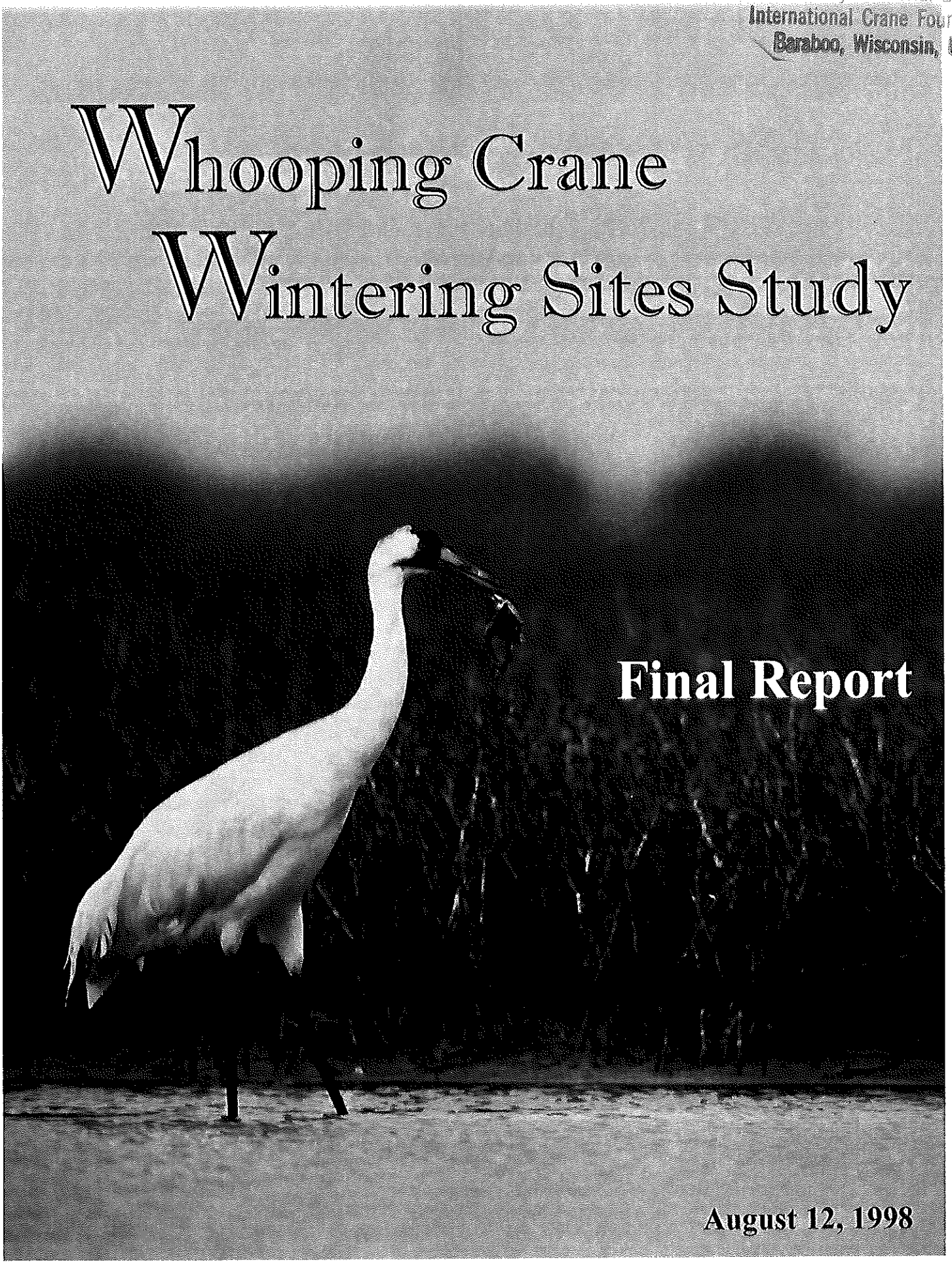
Whooping Crane Wintering Sites Study



Final Report

August 12, 1998

WHOOPING CRANE WINTERING SITES STUDY

Final Report

Submitted to:

The Canadian-United States Whooping Crane Recovery Team

August 12, 1998

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PREFACE

The need for a study of potential wintering sites for a new introduced population of migratory whooping cranes was discussed at the Canadian-United States Whooping Crane Recovery Team meeting in January of 1996. The final project design and enlistment of project team members were completed in May of 1996. Work on the project was started in May of 1996 and completed in August of 1998.

At the time of the commencement of the study, the members of the Canadian-United States Whooping Crane Recovery Team were as follows:

Dr. George Archibald, International Crane Foundation

Mr. Douglas Bergeson, Wood Buffalo National Park

Mr. Robert Bromley, Government of the Northwest Territories

Dr. George Gee, Patuxent Wildlife Research Center

Mr. Dale Hjertaas, Government of Saskatchewan

Mr. Bill Huey, Whooping Crane Conservation Association

Mr. Brian Johns, Canadian Wildlife Service

Dr. James Lewis, U.S. Fish and Wildlife Service

Mr. Steve Nesbitt, Florida Game and Fresh Water Fish Commission

Mr. Greg Tarry, Calgary Zoological Society

ACKNOWLEDGMENTS

Recovery Team

The entire Canadian-United States Whooping Crane Recovery Team provided guidance, input, and feedback at every major step of this project. George Archibald and Jim Lewis made major contributions to the conceptualization, design, and project team enlistment for the study. Dale Hjertaas and Brian Johns shared their methods and learnings from site assessment work that has been conducted in Canada. Steve Nesbitt shared his learnings from the Florida non-migratory population introduction project, and he identified key sites and personnel contacts in Florida. George Archibald, Jim Lewis, and Greg Tarry found the funding support needed to make the study possible.

Even before he became Co-Chairperson of the Recovery Team and Whooping Crane Coordinator for the U.S. Fish and Wildlife Service, Tom Stehn made major contributions to the development of site selection criteria and every subsequent aspect of the project. Tom's constant assistance throughout the study has been a major support to all involved in this work.

Financial Support

Financial support for this study was provided by the following organizations and individuals:

National Fish and Wildlife Foundation
U.S. Fish and Wildlife Service
Phipps Florida Foundation
Mrs. Janice Price Sampson
Calgary Zoological Society
Amoco Foundation

Contributors To This Report

Dr. Felipe Chavez-Ramirez and Dawn Sherry, from Texas A & M University at Kingsville, have been most deeply involved in the on-site ecological assessments of potential whooping crane wintering sites. In November and December of 1996, Felipe joined the principal investigator in visits to 20 sites throughout the U.S. southeast for initial rapid-assessment screening. After the two top sites were selected for further study, Felipe and Dawn have conducted in-depth assessments at these sites for the availability of crane-preferred food items throughout the wintering season and for the abundance and distribution of indicator species commonly found with wintering whooping cranes.

Dr. Gay Gomez was instrumental in developing the sociological criteria section of the Wintering Site Selection Criteria document. Gay also provided numerous contacts for site investigations in Louisiana.

Dr. Richard Urbanek has been a key technical advisor to the project team since the beginning of the study. Richard provided valuable feedback on the original project proposal; he visited potential wintering sites in South Carolina and Florida; he surveyed representatives from member states of the Mississippi Flyway Council; he shared his learnings from his work with migratory sandhill cranes; and he investigated possible migration routes for the new introduced population of whooping cranes.

Kevin Skerl conducted several Geographic Information Systems (GIS) analyses for this study. Initially, he searched land cover data bases to make sure that we did not miss any potentially good wintering sites in the southeastern U.S. Later, he analyzed possible migration routes for suitable stopover habitat for migrating whooping cranes. Finally, Kevin produced migration corridor maps to illustrate possible routes and their relationship to the current migration corridor of the Aransas/Wood Buffalo population of whooping cranes.

Dr. Julie Langenberg and Dr. Marilyn Spalding conducted initial assessments of potential health/disease problems at the two top candidate wintering sites.

Dr. Amy Richert participated in numerous discussions among project team members concerning the best approaches to conducting Geographic Information Systems (GIS) analyses of potential whooping crane migration corridors.

The photograph on the cover of the report was taken by Jeff Foott, Jeff Foott Productions, Inc. The cover design was provided by Human Technology, Inc.

Disclaimer

All of the above-named organizations and individuals made this study possible. However, only the principal investigator is responsible for the synthesis of the information and for the conclusions and recommendations presented in this report.

John R. Cannon, Ph.D.
Principal Investigator
McLean, Virginia
August 1998

INTRODUCTION

The recovery plans for the whooping crane (*Grus americana*) call for the establishment of two self-sustaining wild populations of cranes in addition to the one natural wild population that migrates between Wood Buffalo National Park in Alberta and the Northwest Territories of Canada and Aransas National Wildlife Refuge in Texas (Edwards et al. 1994; U.S. Fish and Wildlife Service 1994).

Establishment of these additional populations will reduce the likelihood that the species could become extinct in the wild. Additional populations that breed in locations other than Wood Buffalo National Park will provide insurance against the possibility that global climate changes or regional weather cycles (e.g., extended droughts) could make the current wetland breeding grounds unsuitable for crane nesting. Populations using additional wintering areas will provide a hedge against the possibility of catastrophic losses in the current natural wild population due to hurricanes or chemical spills in the Intracoastal Waterway along the coast of Texas.

If introduction efforts are successful, the first of these two new populations of whooping cranes will be a non-migratory population currently being established in the Kissimmee Prairie region of Florida. Again, if introduction experiments succeed, the second new population will be a migratory population established in Canada or the northern United States and migrating annually to a suitable wintering area in the southeastern United States.

The need to find a suitable wintering site and migration route for this second introduced population of whooping cranes provided the impetus for the current study.

METHODS AND RESULTS

This study involved the completion of the following major tasks:

Phase I.

Task 1. Review Literature
Task 2. Develop Preliminary Criteria
Task 3. Get Feedback on Criteria
Task 4. Revise Preliminary Criteria
Task 5. Assess GIS Capabilities
Task 6. Conduct GIS Search
Task 7. Interview State Personnel and Wetland Experts
Task 8. Develop Initial List of Wintering Sites
Task 9. Get Recovery Team Feedback
Task 10. Visit Selected Sites for Rapid Assessment
Task 11. Develop Short List of Wintering Sites
Task 12. Develop Phase II Plan
Task 13. Meet with Recovery Team

Phase II.

Task 14. Assess Existing Data and Data Needs
Task 15. Develop Detailed Site Research Protocols
Task 16. Conduct In-Depth Site Evaluations
Task 17. Analyze All Site Assessment Data
Task 18. Rank Wintering Sites
Task 19. Draft Final Report
Task 20. Get Feedback on Final Report
Task 21. Revise and Submit Final Report

Brief Description of Activities: Phase I

Based on the review of the literature and interviews with whooping crane experts, a preliminary set of site selection criteria was developed. These criteria were reviewed by the Whooping Crane Recovery Team and other crane experts. Based on the feedback from the review process, a revised set of site selection criteria was finalized and distributed to the Whooping Crane Recovery Team (see Appendix A).

Based on the final site selection criteria, and data on the current and former winter ranges of the whooping crane, a Geographic Information Systems (GIS) analysis was conducted to identify non-forested wetland areas larger than 9,500 hectares in the states of South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana. The results of this analysis were used as a "double-check" to ensure that no potential wintering areas in these six states were overlooked during the site nomination process of this study (see Appendix B).

Telephone interviews were conducted with more than 50 individuals in the above-mentioned six southeastern states. These individuals included the state directors of conservation and wildlife agencies, personnel of the U.S. Fish and Wildlife Service, science and stewardship directors of The Nature Conservancy, sanctuary managers of the National Audubon Society, and other public officials and private individuals with expertise in crane biology and/or southeastern state wetland ecology.

The information from these interviews, the final site selection criteria, and the results of the GIS analysis, were used to develop an initial list of potential wintering sites for whooping cranes. This initial list of sites was refined during another round of telephone interviews with selected experts from the six southeastern states. The refined list of sites was then circulated to project team members, other expert advisors, and members of the Recovery Team for feedback and further refinement.

During November and December of 1996, brief site visits were made to all sites on the refined list of potential wintering areas. Twenty discrete site assessments were conducted. Dr. John Cannon, principal investigator, and Dr. Felipe Chavez-Ramirez, consulting avian ecologist, visited each of the twenty sites, spending approximately one-half day at each site. The goal of the visits was to make rapid assessments of the suitability of each site as a wintering area for whooping cranes. "Suitability" was defined as the degree to which a site met the Site Selection Criteria previously established (see Appendix A).

It should be noted here that Drs. Cannon and Chavez-Ramirez received excellent cooperation and assistance from the site managers and biologists at each site. These individuals included Federal, state, and local government employees as well as staff from private conservation organizations and private individuals with a commitment to wildlife conservation. These people provided transportation including helicopters, airboats, conventional boats, and land vehicles; and they enthusiastically provided their time, maps, research data, and other valuable assistance.

Based on the rapid assessment visits, and all previous information that had been collected about each site, the sites that were visited were organized into three broad categories: (1) Areas with excellent potential as wintering sites for whooping cranes; (2) Areas that may be suitable as wintering sites for whooping cranes, depending on answers to further questions; and (3) Areas that appear to be unsuitable as wintering sites for whooping cranes. The site-visit summary data forms that were used in this analysis are presented in Appendix C.

Following are the names of the visited sites grouped according to the above categories. There is no particular rank ordering within the broad categories.

Areas with excellent potential as wintering sites for whooping cranes:

St. Marks National Wildlife Refuge, Florida
Chassahowitzka National Wildlife Refuge, Florida (includes adjacent St. Martins Marsh Aquatic Preserve)
Marsh Island Wildlife Refuge, Louisiana (includes adjacent State Wildlife Refuge and Rainey Wildlife Sanctuary)

Areas that may be suitable as wintering sites for whooping cranes, depending on answers to further questions:

Lower Suwannee National Wildlife Refuge, Florida
Grand Bay Bioreserve, Mississippi and Alabama
Hancock County Marshes, Mississippi
Rockefeller Wildlife Refuge, Louisiana
Altamaha River Delta, Georgia (includes Wolf Island National Wildlife Refuge and Altamaha Wildlife Management Area)
Santee River Delta, South Carolina (includes Tom Yawkey Wildlife Center, Santee Coastal Reserve Wildlife Management Area, and Cape Romain National Wildlife Refuge)

Areas that appear to be unsuitable as wintering sites for whooping cranes:

Sabine National Wildlife Refuge, Louisiana
White Lake Marshes, Louisiana
Pascagoula River Delta, Mississippi
Hixtown Swamp, Florida
Putnam County Prairies, Florida
Paynes, Levy Lake, and Kanapaha Prairies, Florida
Okefenokee National Wildlife Refuge, Georgia
Ace Basin, South Carolina (includes Ace Basin National Wildlife Refuge, Donnelley and Bear Island Wildlife Management Areas, and Ace Basin National Estuarine Research Reserve)

Based on the results of the Rapid Assessment Site Visit process, all other information previously obtained, and additional data presented by Dr. Chavez-Ramirez at the February 1997 meeting of the Whooping Crane Recovery Team, the Team decided to focus the further evaluation efforts of this project on the top two candidate wintering sites. These selected sites were:

- Chassahowitzka National Wildlife Refuge and St. Martin's Marsh Aquatic Preserve, Florida, and
- Marsh Island Wildlife Refuge, Louisiana

Brief Description of Activities: Phase II

The evaluation activities conducted during Phase II of this study focused on the following six areas:

(1) Assessment of the availability of crane-preferred food items throughout the wintering season at the top two sites;

(2) Assessment of the potential for avian health/disease problems at the two sites;

(3) Assessment of the suitability of migration routes between the prairie provinces of Canada and the two sites;

(4) Assessment of the interest and receptivity of state officials and citizens in Florida and Louisiana related to a possible whooping crane introduction project;

(5) Assessment of the interest and receptivity of the member states of the Atlantic and Mississippi Flyway Councils related to a possible whooping crane introduction project; and

(6) Overall assessment of the relative suitability of the top two sites, by whooping crane experts who have visited both sites, using all of the information available at this point in time.

Brief summaries of the results of these assessment activities are presented below. Detailed information on the methods and results of these efforts can be found in the appendices cited.

(1) Assessment of the availability of crane-preferred food items throughout the wintering season at the top two sites:

Dawn Sherry and Felipe Chavez-Ramirez have concluded that both sites have adequate whooping crane food availability throughout the winter months to support a wintering population of whooping cranes. Food availability at both candidate sites is superior to food availability at Aransas National Wildlife Refuge. Sherry and Chavez-Ramirez have recommended that the selection of a wintering site should be based on factors other than whooping crane food availability (see Appendix D).

(2) Assessment of the potential for avian health/disease problems at the two sites:

Julie Langenberg and Marilyn Spalding have conducted preliminary health/disease risk assessments at both the Louisiana and Florida sites. They have tentatively concluded that neither site poses any known risks that would preclude that site from further consideration. Langenberg and Spalding have suggested that the selection of a wintering site should be based on factors other than avian health/disease risks, but they have also noted that there is a good possibility that there will be interaction between the current Florida non-migratory population and the experimental migratory population if the Chassahowitzka National Wildlife Refuge and St. Martin's Marsh Aquatic Preserve site is chosen. This probable situation does present potential health and management problems that need to be taken into consideration.

(3) Assessment of the suitability of migration routes between the prairie provinces of Canada and the two sites:

Kevin Skerl has conducted a GIS analysis of land cover and wetland stopover habitat available on the two possible migration routes suggested by Richard Urbanek at the 1997 Whooping Crane Recovery Team meeting (see Appendix E). Based on this analysis and discussions with Urbanek and members of the Webless Committee of the Technical Section of the Mississippi Flyway Council, the principal investigator has concluded that there is not a meaningful difference between the two possible migration routes in terms of habitat suitability for migrating whooping cranes.

(4) Assessment of the interest and receptivity of state officials and citizens in Florida and Louisiana related to a possible whooping crane introduction project:

Based on meetings with state officials in both states, the principal investigator and project advisors have concluded that both Florida and Louisiana are positively disposed towards a migratory whooping crane introduction project. Neither state has yet released a formal position statement on the proposed project, but officials have continuously stated their interest and willingness to consider a formal agreement to participate in such an introduction project.

At public meetings in both Florida and Louisiana, substantial interest has been expressed in the possibility of introducing migratory whooping cranes in the respective states. Following is a summary of the anonymous questionnaire responses of public meeting attendees in both states:

Question

How do you feel about the possibility of introducing a small flock of migratory whooping cranes in _____ (Louisiana or Florida)?

Responses

	Louisiana (N=68)	Florida (N=53)
Very Positive	73.5%	98%
Positive	10.3%	2%
Neutral	13.2%	0%
Negative	3.0%	0%
Very Negative	0%	0%

Note: The Florida meeting was held at the Public Library in Crystal River Florida in the evening, and the Louisiana meeting was held during working hours at the Wetland Research Center in Lafayette Louisiana. No attempt was made to obtain random or stratified samples of citizens for the questionnaire. Therefore, these results are not comparable between the two states, and the results should simply be considered as one-time straw polls that were taken at public meetings in December of 1997.

Based on all of our meetings, telephone interviews, site visits, other contacts, and the above questionnaire results, it is the conclusion of the principal investigator and project advisors that the citizens of both states are generally positively disposed towards a migratory whooping crane introduction project.

(5) Assessment of the interest and receptivity of the member states of the Atlantic and Mississippi Flyway Councils related to a possible whooping crane introduction project:

The principal investigator communicated by telephone with the Chairperson of the Technical Section of the Atlantic Flyway Council and the Chairperson of the Non-Game Committee of that Technical Section. The Atlantic Flyway people indicated that the Technical Section and the Council would follow the desires of Georgia and Florida in their decision about supporting a whooping crane introduction project. They also indicated that both the Flyway Council and the Technical Section are positively disposed towards a whooping crane introduction project. Based on discussions with state officials from both Georgia and Florida, it is the conclusion of the principal investigator and project advisors that both states are positively disposed towards a migratory whooping crane introduction project.

On March 3, 1997, the Mississippi Flyway Council approved the following recommendation that had been developed by its Technical Section:

> "That the Mississippi Flyway Council advise the U.S. Fish and Wildlife Service that it supports the concept of establishing a second migratory flock of whooping cranes."

In February of 1998, the principal investigator met with the Mississippi Flyway Council Technical Section, briefed the members on the status of the Whooping Crane Wintering Sites Study, and obtained the following responses to an anonymous questionnaire:

Question

How do you feel about the possibility of introducing an experimental/non-essential flock of migratory whooping cranes that would nest in the prairie region of Canada and migrate to a wintering site in either Louisiana or Florida?

Responses (N=38)

Very Positive	36.8%
Positive	50.0%
Neutral	13.2%
Negative	0%
Very Negative	0%

Also in February of 1998, the principal investigator met with the Webless Committee of the Technical Section of the Mississippi Flyway Council to discuss the details of the proposed introduction project and to obtain committee members' input on the suitability of possible migration routes for the new introduced population of whooping cranes.

Based on all of our contacts, the recommendation approved by the Mississippi Flyway Council, and the above questionnaire results, it is the conclusion of the principal investigator and project advisors that the member states of both the Atlantic and the Mississippi Flyway Councils are generally positively disposed towards a migratory whooping crane introduction project.

(6) Overall assessment of the relative suitability of the top two sites, by whooping crane experts who have visited both sites, using all of the information available at this point in time:

In addition to the first five assessments listed above, in the spring of 1998, whooping crane experts (N=5) who had visited both (1) Marsh Island Wildlife Refuge in Louisiana and (2) Chassahowitzka National Wildlife Refuge and St. Martin's Marsh Aquatic Preserve in Florida were asked to assess both candidate sites using the original Site Selection Criteria established at the beginning of the Whooping Crane Wintering Sites Study (see Appendix A).

The results of the expert rating process are summarized below:

Assessment Category	Florida	Louisiana
Mean Rating Based on **Ecological Criteria**	3.77*	4.23*
Mean Rating Based on **Sociological/Political Criteria**	4.39	3.78
Mean Rating Based on **Administrative Criteria**	3.82	3.73
Mean Rating Based on **Hazard Control Criteria**	3.17	3.76
Mean of **All Specific Criteria Ratings**	3.69	3.85
Mean of **Expert Overall Ratings**	3.60	4.00

*Scale Used: 5 = excellent, 4 = very good, 3 = good, 2 = fair, 1 = poor

MAJOR CONCLUSIONS BASED ON STUDY FINDINGS

Analysis and synthesis of all the information developed during this study lead to the following major conclusions:

1. Based on ecological criteria and hazard control criteria, Marsh Island Louisiana appears to be a somewhat better bet as a wintering site for whooping cranes.

2. Based on sociological/political criteria, Florida appears to be somewhat more receptive to an introduction project.

3. Overall, both sites appear to be acceptable as possible whooping crane wintering sites (no expert mean ratings below "good").

4. Neither of the potential migration routes considered appears to be clearly superior to the other, in terms of possible stopover habitat for migrating whooping cranes.

5. Representatives of the member states of both the Mississippi Flyway Council and the Atlantic Flyway Council appear to be supportive of a whooping crane introduction project.

MAJOR FACTORS STILL TO BE ASSESSED

Because the results of this study do not indicate that one particular wintering site and one particular migration route are clearly superior to all other options, it is important that the Whooping Crane Recovery Team consider additional factors that may have significant impact on the prospects for a successful introduction of a new population of migratory whooping cranes. Two of these additional factors are described briefly below.

A. Separation from the Aransas/Wood Buffalo Population of Whooping Cranes:

A Recovery Team consensus needs to be reached concerning the importance of maintaining complete separation between the new experimental population to be introduced and the natural wild population of whooping cranes that migrates between Aransas National Wildlife Refuge in Texas and Wood Buffalo National Park in Canada (AWP).

Independent of the requirements of the U.S. Endangered Species Act (which state that, in order for a population to be designated as "experimental", it must be "wholly separate geographically from nonexperimental populations of the same species"), the Recovery Team needs to consider the possibilities of disease transmission and/or learning of inappropriate behaviors that might result from population mixing. Such outcomes could have a negative impact on the survival and growth of the AWP (see Appendix F: Site Selection Issue Paper).

B. Introduction in the Core versus the Periphery of the Historic Whooping Crane Winter Range:

A Recovery Team consensus needs to be reached concerning the importance of introducing the new experimental population within the core versus the periphery of the accepted historic range of the whooping crane. [Research on the success and failure of reintroduction projects has indicated that chances for success increase significantly if animals are reintroduced into the core of their historic range (see Appendix F: Site Selection Issue Paper)].

MAJOR RECOMMENDATIONS

Based on all of the findings of this study, and the assumption that the Whooping Crane Recovery Team will seriously consider the additional factors described above, the following recommendations are offered:

Alternative #1. Emphasize Separation

IF separation of the new experimental population from the AWP is extremely important, **AND** introducing the new population in the core of the historic range is less important, **THEN** it is recommended that:

a. Chassahowitzka National Wildlife Refuge and St. Martin's Marsh Aquatic Preserve in Florida should be selected as the wintering site for the new experimental population of migratory whooping cranes;

b. A nesting site farther east than Manitoba should be selected for the new population (e.g., Ontario, Wisconsin, the Upper Peninsula of Michigan, etc.); and

c. A migration corridor for the new population should be selected with a buffer of at least 400 kilometers between it and the migration corridor currently used by the AWP. For an example of such a migration corridor, see Figure 1, page 16.

Implementation of this recommendation would provide a 400-kilometer buffer between the AWP use areas and the use areas of the new experimental population (measured at the closest point between the two populations). This alternative also should avoid any problems that might occur as a result of the introduced whooping cranes mixing with sandhill cranes that are migrating in a different direction from the whooping cranes.

Alternative #2. Emphasize Core Of Historic Range

IF introducing the new population in the core of the historic whooping crane range is extremely important, **AND** separation from the AWP is less important, **THEN** it is recommended that:

a. Marsh Island Wildlife Refuge in Louisiana should be selected as the wintering site for the new experimental population of migratory whooping cranes;

b. Manitoba should be selected as the nesting site for the new population; and

c. A migration corridor, as illustrated in Figure 2, page 17, should be selected for the new population.

Implementation of this recommendation would provide a wintering site, a nesting site, and a migration corridor quite near to the core of the accepted historic range of the whooping crane. The buffer between the AWP use areas and the new population use areas would be 80 kilometers (measured at the closest point between the two populations). This alternative has the potential for introduced whooping cranes following sandhill cranes that are migrating to Texas. Such an outcome could lead to mixing between the introduced whooping cranes and the AWP.

Alternative #3. Compromise Strategy

IF some type of compromise strategy is desired, **THEN** it is recommended that:

a. Marsh Island Wildlife Refuge in Louisiana should be selected as the wintering site for the new experimental population of migratory whooping cranes;

b. A nesting site farther east than Manitoba should be selected for the new population (e.g., Ontario, Wisconsin, the Upper Peninsula of Michigan, etc.); and

c. A migration corridor, as illustrated in Figure 3, page 18, should be selected for the new population.

Implementation of this recommendation would provide a buffer of 230 kilometers between the AWP use areas and the use areas of the new population (measured at the closest point between the two populations) and a wintering site and migration corridor quite near to the core of the accepted historic range of the whooping crane. This alternative has the potential for introduced whooping cranes following sandhill cranes that are migrating to Florida, but such an outcome would not increase the chances of the introduced birds mixing with the AWP.

Supporting Recommendations

1. Regardless of which wintering site is selected, it is recommended that a Whooping Crane Wintering Site Survival Study be initiated as soon as feasible at the selected wintering site. Captive-raised whooping cranes would be released at the wintering site without being led on migration south. These birds would be studied to assess the adequacy of the selected site to support introduced wintering whooping cranes before extensive investments are made in training whooping cranes to migrate to the selected site. Later, when migrating cranes are brought to the site (assuming that the survival study yields positive results), the survival-study birds could remain as role models for survival at the site; or these birds could be removed if it were determined that their presence would be detrimental to the objectives of the migratory population introduction project.

2. If feasible, it is recommended that a similar survival study, without migration training, be conducted at the selected nesting site before introduced whooping cranes are trained to migrate between the nesting and wintering sites. Again, the goal of such a study would be to assess the adequacy of the selected nesting site to support introduced whooping cranes.

3. Regardless of which wintering site is selected, it is recommended that migration training experiments, using sandhill cranes as surrogates, be conducted using the selected migration corridor. The end points of the migration route could be varied somewhat to accommodate the different habitat preferences of sandhill cranes (e.g., an alternate wintering site might include more upland habitat and access to waste grain feeding resources).

Literature Cited

Edwards, R.S., S. Brechtel, R. Bromley, D. Hjertaas, B. Johns, E. Kuyt, J. Lewis, N. Manners, R. Stardom, and G. Tarry. 1994. National recovery plan for the Whooping Crane. Report No. 6, Recovery of Nationally Endangered Wildlife Committee, Ottawa, Ontario, Canada.

U.S. Fish and Wildlife Service (USFWS). 1994. Whooping Crane recovery plan. USFWS, DOI, Albuquerque, New Mexico.

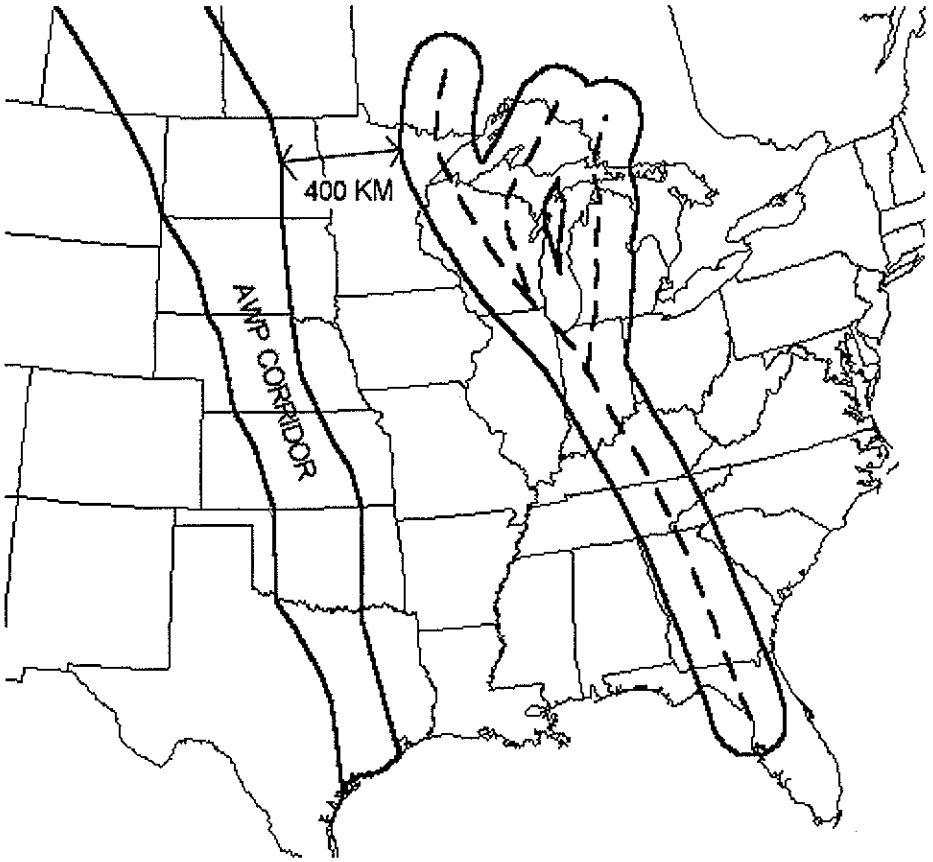

Figure 1. Alternative #1: Migration corridor with 400-kilometer buffer between the new experimental population and the AWP.

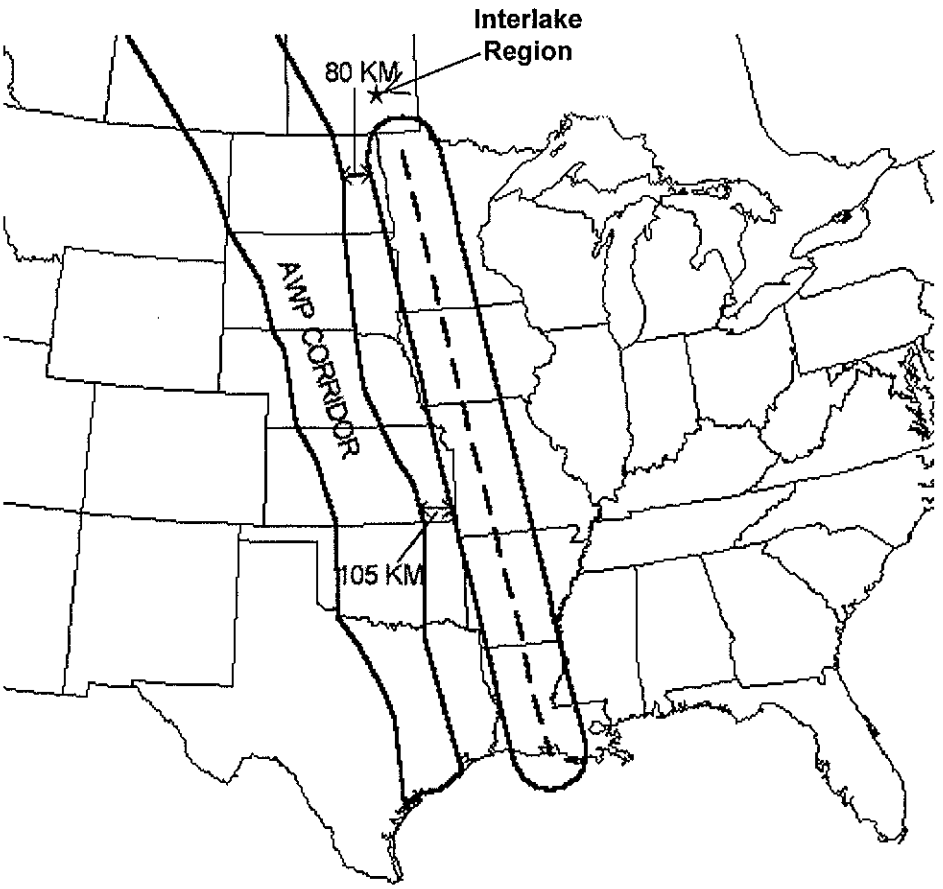

Figure 2. Alternative #2: Migration corridor from Manitoba to Marsh Island, Louisiana.

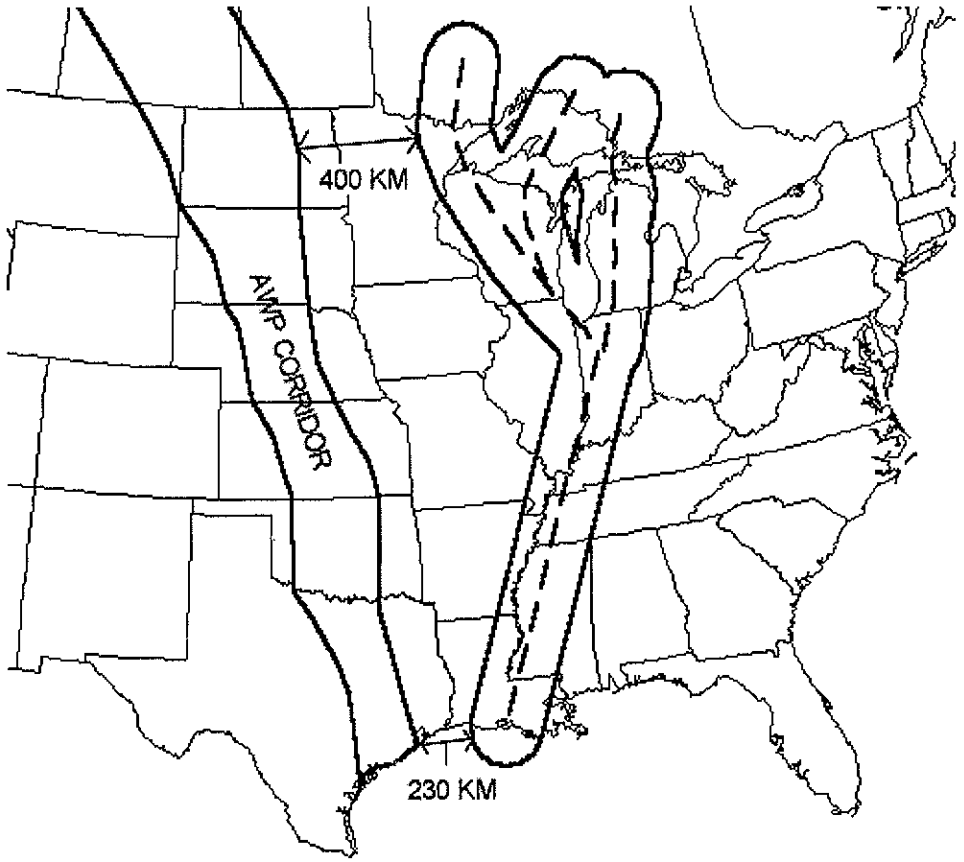

Figure 3. Alternative #3: Migration corridor to Marsh Island, Louisiana providing a 230-kilometer buffer between the new experimental population and the AWP.

APPENDICES

APPENDIX A

Wintering Site Selection Criteria

WHOOPING CRANE WINTERING SITES STUDY: SITE SELECTION CRITERIA

I. General Description of the Desired Area

Within the historic winter range of the whooping crane, a large (>9,500 hectares) protected area characterized by a complex of wetlands (either fresh or brackish). There should be minimal or no obstructions to long views by the cranes across the area. The habitat must support abundant, self-sustaining populations of blue crab and/or other "decapod crustaceans" (e.g., crayfish in fresh water ponds) and clams. In addition, there must be abundant and self-sustaining populations of crane-palatable plant foods such as wolfberry, acorns or an equivalent source of nutrition during periods when animal food sources might not be abundant. The area should be under public ownership and management or under the protection of a "conservation easement," "safe harbor agreement" or other form of long-term protection. Both local and state conservation authorities, and the local general public should be supportive of the presence of whooping cranes in this area.

II. Specific Criteria

A. Location: The site should be located in one of the Gulf Coast states or along the southern Atlantic seaboard from South Carolina to Florida (Allen 1952; Lewis 1995).

B. Area: In order to accommodate an eventual population of 100-500 cranes, the site area should be 9,500 to 75,000 hectares (Tom Stehn pers. comm.). [Note: all parts of the site do not need to be contiguous as long as there is safe and easy access for cranes among all parts of the habitat.]

C. Ecological Criteria

1. Macro-Habitat

The site should be primarily a permanent wetland characterized by a combination of many shallow ponds and vegetated flats with low vegetation structure to allow open visibility across the habitat. The site should provide relative isolation from human disturbance. Whether the water is fresh or brackish, the predominant features of the area should be shallow water, flat topography, and open visibility. There should be some adjacent areas of upland with brush for protection during extreme storm events (but not dense vegetation that would provide cover for predators). Based on habitat use of the current natural wild population, the prototype "best" winter habitat is salt marsh/salt flats as exemplified by Sundown Bay and vicinity on the eastern shore of Blackjack Peninsula at Aransas National Wildlife Refuge (Bent 1926; Stevenson & Griffith 1946; Allen 1952; Labuda & Butts 1979; Johnsgard 1983; Blankinship 1987; Stehn 1996).

2. Water

   a. Types: shallow ponds, lakes, bays, lagoons, and sloughs. According to the National Wetland Inventory classification system: estuarine, palustrine, or lacustrine wetlands (Allen 1952; Cowardin et al. 1979; Blankinship 1987; Armbruster 1990; Lewis 1995).

   b. Salinity: 0 parts per thousand (ppt) up to 28.5 ppt (Allen 1952; Hunt 1987). Hunt (1987) notes that cranes seek out fresh water sources if bay salinities are above 23 ppt. The site should include sources of fresh water to be used by cranes when salinities rise.

   c. Depth: Cranes avoid water deeper than 28 cm and prefer depths of 13-20 cm for roosting (Allen 1952; Ward & Anderson 1987; Armbruster 1990; Faanes et al. 1992; Lewis 1995).

   d. Area: Bodies of water large enough so that cranes can roost at least 15-20 meters from shore (Ward & Anderson 1987).

   e. Quality: Free from significant contaminants, disease pathogens, and toxic substances (e.g., lead shot residue) (Lyon et al. 1995a, 1995b).

3. Food: blue crabs, clams, and wolfberry fruit are the food items that have been consistently cited as most important to wintering whooping cranes in studies at Aransas during the past 50 years (Stevenson & Griffith 1946; Allen 1952; Blankinship 1976; Johnsgard 1983; Blankinship 1987; Hunt 1987; Hunt & Slack 1989; U.S. Fish and Wildlife Service 1994; Chavez-Ramirez 1996). All studies emphasize the importance of blue crabs, and the most recent study found that blue crabs and wolfberry fruit were the critical foods, but that "clams were not a significant contributor to the overall crane diets" (Chavez-Ramirez 1996, p. 35).

   In fresh water habitats, food items cited include: crayfish, snails, clams, frogs and toads and their egg masses, and insects (Allen 1952, 1956).

   For site screening purposes, the general food criteria can be stated as: self-sustaining and abundant populations of decapod crustaceans, an alternative animal food source, and an alternative plant food source. [Note: one alternative plant food source might be gleanings from agricultural fields if such fields were reasonably proximate to the wintering wetland area.]

4. Indicator Species

   The following animal species are likely to be found in wetland habitats that are suitable for wintering whooping cranes: wading birds (e.g., tricolored herons, snowy egrets, great egrets), white and glossy ibises, roseate spoonbills, mollusks, crustaceans, frogs, lizards, worms, aquatic insects, and small fish (Allen 1952; Chavez-Ramirez pers. comm.).

D. Sociological Criteria (adapted from Gay Gomez pers. comm.)

1. Acceptance of reintroduction and willingness to assume necessary responsibilities by:

   a. Local land owners, land managers, and land users of the reintroduction site and surrounding sites.

   b. Local and regional citizens and officials.

   c. State officials, organizations, and interested citizens.

   d. The state's U.S. Congressional delegation.

   e. Regional and national representatives of Federal agencies and national organizations.

2. Compatibility of reintroduction with current land use and management activities.

   a. Ecological compatibility.

   b. Cooperation from hunting groups in the education of local hunters about whooping cranes.

   c. No significant adverse economic or cultural impacts to local community.

   d. If needed, most use changes would be voluntary.

3. Stability of acceptance and compatibility over the long term.

E. Administrative Criteria

1. Ownership: site is publicly owned or subject to either perpetual easements from private owners or "safe harbor agreements" with private owners (Bishop 1988a, 1988b, 1992; U.S. Fish and Wildlife Service 1994; Lyon et al. 1995a, 1995b; Jim Lewis pers. comm.).

2. Federal, state, and local laws and regulations will protect site hydrology and freedom from contaminants (Bishop 1988b; Lyon et al. 1995a, 1995b).

3. Access is adequate for reintroduction activities (Nesbitt 1982; Bishop 1992; U.S. Fish and Wildlife Service 1994; Lyon et al. 1995a, 1995b).

F. Hazard Control: cranes can be adequately protected from (Bishop 1988b, 1992; Lewis & Cooch 1992; U.S. Fish and Wildlife Service 1994; Lyon et al. 1995a, 1995b):

1. Power line collisions.

2. Illegal hunting.

3. Encroaching human developments.

4. Pesticides/contaminants/toxic substances.

5. Avian disease pathogens.

6. Concentrations of predators.

7. Extreme weather events.

8. Other human disturbances (e.g., boat traffic, helicopter overflights, etc.).

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APPENDIX B

Geographic Information Systems (GIS) Analysis

Preliminary Wetland Assessment by Size Criteria for Whooping Crane Reintroduction to the Southeastern U.S.

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Introduction

The Whooping Crane Wintering Sites Study team has formulated a wintering area size criterion of a minimum of 9,500 ha (~23,500 acres) up to 75,000 ha (~185,000 acres). A preliminary assessment of wetland areas in the southeastern U.S. was performed using existing digital data and geographic information systems (GIS).

Methods

Six states in the historical wintering range of the whooping crane were the subject of this preliminary exercise: Louisiana, Mississippi, Alabama, Georgia, Florida and South Carolina. Several sets of digital wetland GIS data were available for this regional analysis, including National Wetland Inventory (NWI), Environmental Systems Research Institute's Digital Chart of the World (DCW), and United States Geological Survey (USGS) Land Use /Land Cover (LULC) maps. NWI maps are the preferred wetland data set, but are not available in digital format for significant sections of the region. NWI maps are also compiled at a detailed scale (both 1:100,000 and 1:24,000) which is not necessary at this level of assessment. NWI maps may be used later to help prioritize between wetland areas once a gross level assessment of wetland size is made. DCW data on the other hand is compiled at a scale which may filter out smaller but acceptable wetland areas, and is comprised of few distinct wetland classes. Additionally, both NWI and DCW data require significant data reformatting and stitching in order to be used in the ARC/INFO GIS environment at a broad regional scale.

USGS LULC data were considered appropriate due to the availability of almost full coverage for the states involved, map scale (1:250,000), and detailed land classification. Additionally, the Environmental Protection Agency (EPA) had already converted the original Geographic Information Retrieval and Analysis System (GIRAS) format to ARC/INFO format, and had run a needed macro (GIRASNEAT) to readjust georeferencing. The EPA made them all available via file transfer protocol (ftp). A total of 58 LULC coverages exist within the six state region. Data were available for all but one coverage (Palestine, LA).

USGS data are an assortment of land classifications compiled throughout the 1970s and 1980s. Each quadrangle may have been classified at different times. Land use/land cover was mapped and coded using the Anderson classification system (Anderson et al.1976) which is a hierarchical system of general (level 1) to more specific (level 2) characterization. There are 36 level 2 classes of land use/land cover, and this classification was indicated by the attribute LUCODE in all coverages. Of these, six are potential wetland classes:

Water
- 51 Streams and canals
- 52 Lakes
- 53 Reservoirs
- 54 Bays and estuaries

Wetland
- 61 Forested wetland
- 62 Nonforested wetland

For the purposes of this study, it was decided that three classes (52, 54, & 62) were most likely candidates for appropriate whooping crane wintering habitat. A goal of discovering any contiguous combination of these three water/wetland types with a total area > 9,500 ha was established.

All coverages were downloaded from the EPA ftp site, decompressed, and built (given topology) in workstation ARC/INFO 7.04. Polygons with any of the three wetland designations were clipped from each LULC coverage and placed into one large regional coverage. This large coverage was then cleaned (dangles and intersections removed and topology created) using CLEAN with a fuzzy tolerance of approximately 0.39. This large tolerance was due to the resolution of the data, and may have resulted in the removal of some smaller (< 70 ha) wetland polygons. This coverage was then projected from geographic format (standard latitude/longitude) into Albers Conical Equal Area projection. This was necessary to do m^2 area analysis. An additional attribute (WET) was then added to the coverage to easily discern between wetland (WET=1) and non-wetland (WET=0) polygons within wetland areas. Boundaries between contiguous wetlands were dissolved by WET (DISSOLVE function) to create generalized wetland and non-wetland polygons.

Since this coverage was to be exported to the personal computer (PC) environment for map production, additional manipulation was necessary to accommodate PC ARC/INFO 3.5 limitations. Another attribute (SIZE) was added to the coverage. This attribute was calculated as SIZE = AREA / 10,000,000 for all wetland polygons to convert m^2 to thousands of hectares. This was necessary for keeping constant area attributes in m^2 since grid overlay and subsequent reprojection would affect polygon areas. A grid was then generated for overlay of the region to address arcs/polygon limitations inherent in the software. The coverage and grid were then reprojected into geographic format to facilitate map production. An overlay (UNION function) of the regional coverage and the grid resulted in a file that would import into the PC environment.

Maps were produced using ARC/VIEW 2.0 indicating all LULC wetlands, and highlighting those where SIZE > = 9.5 (i.e., 9,500 ha). Background basemap information also includes DCW Drainage layers (streams, rivers, & lakes) to aid in location and identification of wetlands. Federal land ownership was also plotted as it was readily available and might be useful in site identification and prioritization.

Results & Discussion

Results indicate contiguous wetlands of sufficient area to be found in coastal Louisiana, coastal South Carolina, and throughout inland and coastal Florida. Georgia, Mississippi, and Alabama revealed no non-forested wetlands of appropriate size.

Interpretation of the results should keep in mind the limitations of the data and the effects of several manipulations and conversions. The minimum resolution of the data is in the hundreds of m^2, indicating that the data quality is certainly generalized, resulting in some lost data when CLEANed. Quadrangles may not be temporally consistent with contiguous quadrangles, complicating analysis. Slight deviations in map boundaries resulting from GIRAS to ARC conversions left some polygons undissolved. This is why all wetlands are shown, to enable visual inspection of proximal wetlands (see draft maps). Finally, since there may exist wetlands of sufficient area that are proximal but not contiguous naturally, there may be additional suitable wetlands that this GIS modeling did not reveal. Again, inspection of maps may indicate such areas (e.g., the coasts of GA and SC).

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APPENDIX C

Rapid Assessment Site Visit Forms

AREAS WITH EXCELLENT POTENTIAL AS WINTERING SITES FOR WHOOPING CRANES:

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 26, 1996 State: Florida

Site Name: St. Marks National Wildlife Refuge

Ownership: U.S. Fish and Wildlife Service

Site Location: At the "Big Bend" of the Florida Gulf Coast, near St. Marks, FL and Panacea, FL.

Contact Person: Joe Reinman Phone: 904-925-6121

I. Area:

Overall size: 68,000 acres

Shallow wetland size: 32,000 acres Water Depth: 0-36 inches Salinity: 1-25 ppt

Reticulation (open water connections): Good Tide Amplitude: 24 inches

II. Primary Vegetation: Juncus roemerianus, Spartina spp.

Average Height: .5-1 meter Crane Visibility: Good

III. Food Sources: Blue crab (abundant), fiddler crab, snails.

IV. Indicator Species: All herons and egrets, white ibis.

V. Hazards: Predators: bobcat and some coyote. Upland hunting of deer, turkey, hog, and squirrel. No waterfowl hunting now, but may open one unit to waterfowl hunting. The biggest potential hazard may be airboats. Unlike Chassahowitzka NWR, St. Marks NWR does not own the water bottoms (marsh below mean high water is Florida sovereign land), so refuge has limited control over airboats. Refuge has one full-time law enforcement officer and three staff with law enforcement as collateral duty.

Isolation: Fair to Good

VI. What ecological/biological data currently exist on the site? Refuge has limited data. Other data may be available from Wakulla County (fishermen use data) and from the University of Florida and Florida State University. Crab harvest data may be available from the state.

VII. Overall rating as wintering site for whooping cranes:

(5)	4	3	2	1
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Habitat looks very good for whooping cranes. There is a very broad expanse of salt marsh with low vegetation and numerous open shallow-water areas. Blue crab is said to be extremely abundant. Food resources, human activity, and other hazards should be evaluated. We recommend further study of this site.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 25, 1996 State: Florida

Site Name: Chassahowitzka National Wildlife Refuge

Ownership: U.S. Fish and Wildlife Service

Site Location: Gulf Coast between Homosassa and Chassahowitzka, FL.

Contact Person: Cam Shaw Phone: 352-563-2088

I. Area:

Overall size: 31,000 acres (plus 23,000 acres in state preserve to the north)

Shallow wetland size: 31,000 acres (+ 23,000) Water Depth: 0-36 inches Salinity: 12-25 ppt

Reticulation (open water connections): Good Tide Amplitude: 18-24 inches

II. Primary Vegetation: Juncus roemerianus, Spartina spp.

Average Height: .5-1.5 meters Crane Visibility: Good

III. Food Sources: Blue crab (abundant), clams.

IV. Indicator Species: All herons (abundant), all egrets (abundant), wood stork.

V. Hazards: Very few predators. 7,600-acre sanctuary closed to all public entry from October 15 to February 15. Two airboat routes cross the refuge.

Isolation: Good

VI. What ecological/biological data currently exist on the site? Air quality and water quality data.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	1
(Excel.)	V.Good	Good	OK	Poor

VIII. Comments: Excellent open, shallow water habitat with large expanses of flats and ponds similar to Aransas NWR. Plenty of room to expand northward up the Gulf Coast into similar habitat. Few hazards and good isolation. Blue crab is said to be abundant, but food resources should be evaluated. We recommend further study of this site.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 20, 1996 State: Louisiana

Site Name: Marsh Island Wildlife Refuge

Ownership: State of Louisiana

Site Location: Off the coast of Southcentral Louisiana, 5 miles south of Cypremort Point, LA.

Contact Person: Edmund Mouton Phone: 318-373-0032

I. Area:

Overall size: 80,000 acres

Shallow wetland size: 80,000 acres Water Depth: 6-18 inches Salinity: 1-15 ppt

Reticulation (open water connections): Good Tide Amplitude: 18-36 inches

II. Primary Vegetation: Scirpus spp., Spartina spp., Juncus spp.

Average Height: < 1 meter Crane Visibility: Good

III. Food Sources: Blue crab, fiddler crab, mud crab, crayfish, snails, clams.

IV. Indicator Species: Great blue heron, little blue heron, black-crowned night heron, great egret, snowy egret, roseate spoonbill, white ibis.

V. Hazards: No hunting permitted. There is general public access by boat for fishing, but boats can not get into the interior marshes. The state provides a patrol and law enforcement presence 24 hours a day. Helicopter overflights could be a potential problem (there is supposed to be a 2000-foot ceiling). Vulnerable to storm surge in hurricane or extreme weather events. Predators include alligators and coydogs (coyote/dog mix).

Isolation: Good

VI. What ecological/biological data currently exist on the site? Blue crab and shrimp harvest data are available from the Seafood Division of the Louisiana Department of Wildlife and Fisheries. The Fur and Refuge Division of the same department conducts on-going monitoring of temperature, rainfall, water levels, salinity, and percent inundation. Faculty and students from several universities are conducting research projects at Marsh Island.

VII. Overall rating as wintering site for whooping cranes:

(5)	4	3	2	1
Excel.	V.Good	Good	OK	Poor

VIII. Comments: The isolated off-shore location, low vegetation structure, shallow ponds, and abundant food resources combine to make this site a top candidate for wintering whooping cranes. In addition, the adjacent 13,000-acre State Wildlife Refuge and 26,800-acre Rainey Wildlife Sanctuary provide a buffer and/or additional potential crane habitat to the west. We recommend further study of this site.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 19, 1996 State: Louisiana

Site Name: Rainey Wildlife Sanctuary **[here considered as an adjunct to Marsh Island]**

Ownership: National Audubon Society

Site Location: Southwestern Louisiana, 13 miles southwest of Intracoastal City, LA.

Contact Person: Timmy Vincent Phone: 318-893-8206

I. Area:

Overall size: 26,800 acres

Shallow wetland size: 26,800 acres Water Depth: 12-18 inches Salinity: 1-6 ppt

Reticulation (open water connections): Poor Tide Amplitude: 18 inches

II. Primary Vegetation: Scirpus americanus

Average Height: < 1 meter Crane Visibility: Good

III. Food Sources: Blue crab, crayfish.

IV. Indicator Species: Great blue heron, tricolored heron, great egret.

V. Hazards: Access to the sanctuary is highly controlled, but shrimp fishermen that pass through the area, "will shoot anything they want -- they're crazy!"

Isolation: Good

VI. What ecological/biological data currently exist on the site? Study conducted by Jack Meeder (unpublished). Data were never fully analyzed but something may be available from National Audubon Society research department in Tavernier, Florida or from Mike Duver at The Nature Conservancy.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	(2)	1
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Most of the sanctuary is impounded marsh, managed to maintain freshwater marsh habitat. Muskrat activity has major impact on vegetation.

AREAS THAT MAY BE SUITABLE AS WINTERING SITES FOR WHOOPING CRANES, DEPENDING ON ANSWERS TO FURTHER QUESTIONS:

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 25, 1996 State: Florida

Site Name: Lower Suwannee National Wildlife Refuge

Ownership: U.S. Fish and Wildlife Service

Site Location: Gulf Coast near Suwannee, FL.

Contact Person: Ken Litzenberger and Henry Sansing Phone: 352-493-0238

I. Area:

Overall size: 52,000 acres

Shallow wetland size: 13,000 acres Water Depth: 0-48 inches Salinity: 12-25 ppt

Reticulation (open water connections): Good Tide Amplitude: 24-36 inches

II. Primary Vegetation: Juncus roemerianus, Cladium jamaicense, Spartina spp.

Average Height: .5-2 meters Crane Visibility: Good

III. Food Sources: Blue crab, fiddler crab, periwinkle snail.

IV. Indicator Species: Wading birds.

V. Hazards: Deer hunting, limited waterfowl hunting, fishing. Poaching of deer and "anything they can sell."

Isolation: Fair to Good

VI. What ecological/biological data currently exist on the site? Very limited.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	1
Excel.	(V.Good)	Good	OK	Poor

VIII. Comments: Extensive marsh flats with low vegetation, but a narrower strip of marsh than at Chassahowitzka NWR. Good habitat as part of a string along the Gulf coast. Potentially a good habitat expansion area if birds were introduced at either Chassahowitzka NWR or St. Marks NWR.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 21, 1996 States: Mississippi and Alabama

Site Name: Grand Bay Bioreserve

Ownership: Combination (State of Mississippi, State of Alabama, Federal, and Private)

Site Location: Southeastern corner of Mississippi and southwestern corner of Alabama, near Orange Grove, MS and Grand Bay, AL.

Contact Person: Dave Ruple, Scott Hereford. Phones: 601-385-5860 (Ruple); 601-497-6322 (Hereford)

I. Area:

Overall size: 22,000-70,000 acres (depending on acquisitions)

Wetland size: 15,000-20,000 acres Water Depth: 12-60 inches Salinity: 1-25 ppt

Reticulation (open water connections): Good Tide Amplitude: 18 inches

II. Primary Vegetation: Full range of freshwater to saltwater species

Average Height: .5-1 meter Crane Visibility: Good

III. Food Sources: Blue crab, snails, clams.

IV. Indicator Species: Great blue heron, tricolored heron, great egret.

V. Hazards: Gulf Intracoastal Waterway off shore. Fairly heavy human use of surrounding areas. There is little waterfowl hunting.

Isolation: Fair

VI. What ecological/biological data currently exist on the site? Federal environmental assessment and land use plan developed for the proposed establishment of Grand Bay National Wildlife Refuge. Report by The Nature Conservancy supporting the establishment of the NWR.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	1
Excel.	V.Good	(Good)	OK	Poor

VIII. Comments: Because of the current and planned protected areas and good salt marsh habitat, this site should be reconsidered if none of the top candidate sites is acceptable.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 22, 1996 State: Mississippi

Site Name: Hancock County Marshes

Ownership: Combination (State of Mississippi and Private)

Site Location: Southwestern corner of Mississippi at the Pearl River delta, near Pearlington and Ansley, MS.

Contact Person: Dave Ruple Phone: 601-385-5860

I. Area:

Overall size: 20,000-25,000 acres (depending on acquisitions)

Wetland size: 20,000-25,000 acres Water Depth: 12-60 inches Salinity: 18 ppt

Reticulation (open water connections): Fair Tide Amplitude: 18 inches

II. Primary Vegetation: Juncus spp., Spartina spp.

Average Height: .5 meter at sea rim; 1.5-2 meters interior. Crane Visibility: Fair

III. Food Sources: Interior - Blue crab, fiddler crab, snails; Sea rim - Blue crab, fiddler crab, periwinkle snail, razor clam, other clams and snails.

IV. Indicator Species: Great blue heron, tricolored heron, little blue heron, great egret, snowy egret, white ibis.

V. Hazards: Open to public access and public hunting on state property (but not much there to hunt). Heavily fished.

Isolation: Poor to Fair

VI. What ecological/biological data currently exist on the site? None

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	1
Excel.	V.Good	Good (2.5)	OK	Poor

VIII. Comments: If the top sites are not acceptable, this area should be reconsidered. The first step would be to see what the habitat quality and ownership status are on the Louisiana side of the border.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 18, 1996 State: Louisiana

Site Name: Rockefeller Wildlife Refuge

Ownership: State of Louisiana

Site Location: Southwestern Louisiana, Gulf coast to Route 82 between Grand Chenier and Pecan Island, LA.

Contact Person: Guthrie Perry Phone: 318-538-2276

I. Area:

Overall size: 80,000 acres

Shallow wetland size: 80,000 acres Water Depth: 18-24 inches Salinity: 0-30 ppt

Reticulation (open water connections): Fair to Good Tide Amplitude: 18 inches

II. Primary Vegetation: Full range of freshwater to saltwater species

Average Height: < 1 meter Crane Visibility: Good

III. Food Sources: Blue crab, shrimp.

IV. Indicator Species: Great blue heron, tricolored heron, great egret, snowy egret, white ibis, roseate spoonbill.

V. Hazards: No hunting on the refuge, but intense hunting (including snow geese) on adjacent areas.

Isolation: Fair to Good

VI. What ecological/biological data currently exist on the site? Several research reports and theses.

VII. Overall rating as wintering site for whooping cranes:

5	4	(3)	2	1
Excel.	V.Good	Good	OK	Poor

VIII. Comments: There are some large areas similar to Aransas NWR (particularly Lake 14, south of Unit 14). Some areas have open water and good reticulation, while others are closed in with dense vegetation. Intensive hunting of snow geese and other waterfowl on adjacent private lands is a concern.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 29, 1996 State: Georgia

Site Name: Altamaha River Delta

Ownership: Combination (U.S. Fish and Wildlife Service, State, and Private)

Site Location: Atlantic seaboard near Darien, GA.

Contact Person: John Robinette (USFWS) and Mike Harris (GA DNR)
Phones: 912-652-4415 (Robinette), 912-262-3336 (Harris)

I. Area:

Overall size: 20,000 acres of salt marsh

Shallow wetland size: 20,000 acres (salt marsh). Water Depth: 0-96 inches. Salinity: 1-35 ppt.

Reticulation (open water connections): Good. Tide Amplitude: 7-9 feet

II. Primary Vegetation: In fresh areas: Spartina cynosuroides; In brackish areas: Spartina alterniflora, Juncus roemerianus

Average Height: 1-1.5 meters in salt, 2-3 meters in fresh. Crane Visibility: Poor to Good.

III. Food Sources: Blue crab, fiddler crab, shrimp.

IV. Indicator Species: Tricolored heron, great egret, snowy egret, white ibis.

V. Hazards: Intracoastal Waterway borders the best potential crane use areas. Hunting and fishing nearby. State DNR biologist notes that winter is very cold (freezing temperature occurs frequently); shrimp leave the area or sometimes die off.

Isolation: Fair

VI. What ecological/biological data currently exist on the site? Unknown.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2.5	2	1
Excel.	V.Good	Good		OK	Poor

VIII. Comments: Salt marsh vegetative structure (e.g., at Wolf Island NWR) is similar to Aransas NWR. There are extensive mud flats at low tide. Tidal amplitude is great (7-9 feet), so water is quite deep in the marsh during high tides. Freezing weather is a concern.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: December 1, 1996 State: South Carolina

Site Name: Cape Romain National Wildlife Refuge (Santee River Delta area)

Ownership: U.S. Fish and Wildlife Service

Site Location: Atlantic seaboard south of Georgetown, SC and near McClellanville, SC.

Contact Person: George Garris Phone: 803-928-3368

I. Area:

Overall size: 64,000 acres

Shallow wetland size: 30,000 acres Water Depth: 0-8 feet Salinity: 10-30 ppt.

Reticulation (open water connections): Good Tide Amplitude: 5-8 feet

II. Primary Vegetation: Spartina spp.

Average Height: 1-1.5 meters Crane Visibility: Fair to Good

III. Food Sources: Blue crab, shrimp, clams, possibly wolfberry.

IV. Indicator Species: Great blue heron, tricolored heron, snowy egret, white ibis, glossy ibis.

V. Hazards: Predators: Alligator. No waterfowl hunting in refuge, but heavy waterfowl hunting on adjacent lands. Limited deer, rail, and raccoon hunting on Bull Island in the refuge. Open public access for fishing and boating in all refuge areas year-round. Cold weather is a possible hazard to food resources.

Isolation: Fair

VI. What ecological/biological data currently exist on the site? Unknown

VII. Overall rating as wintering site for whooping cranes:

5	4	(3)	2	1
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Refuge has large areas of open salt marsh. However, except for the Tom Yawkey Wildlife Center (see site visit form), all lands adjacent to Cape Romain are dedicated to waterfowl management and hunting. Large tidal amplitude may be a problem (water too deep at high tide, little water remaining in saltmarsh flats at low tide). Freezing weather is a concern.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: December 2, 1996 State: South Carolina

Site Name: Santee Coastal Reserve Wildlife Management Area (Santee River Delta area)

Ownership: State

Site Location: Atlantic seaboard south of Georgetown, SC at the mouth of the Santee River

Contact Person: Tommy Strange Phone: 803-546-8665

I. Area:

Overall size: 24,000 acres

Shallow wetland size: 12,000 acres Water Depth: Controllable Salinity: 0-30 ppt.

Reticulation (open water connections): Poor Tide Amplitude: No tide in impoundments; 4-5 feet in open salt marsh

II. Primary Vegetation: In salt marsh: Spartina spp., Borrichia frutescens, Distichlis spicata. In impoundments: Spartina cynosuroides, scirpus robustus, juncus roemerianus

Average Height: 1 meter Crane Visibility: Poor to Fair

III. Food Sources: Blue crab.

IV. Indicator Species: Tricolored heron, white ibis (thousands), glossy ibis, wood stork.

V. Hazards: Waterfowl hunting six days per week in WMA. All impoundments are hunted. Predators: Alligator, bobcat, a few coyote. Freezing weather is a possible hazard to food resources. Intracoastal Waterway nearby.

Isolation: Poor

VI. What ecological/biological data currently exist on the site? State data related to waterfowl management.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	1.5	1
Excel.	V.Good	Good	OK		Poor

VIII. Comments: Freezing weather is a concern. Impoundments are too small and closed in to have adequate visibility for cranes. The area is managed for waterfowl, and hunting is the primary focus.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: December 2, 1996 State: South Carolina

Site Name: Tom Yawkey Wildlife Center (Santee River Delta area)

Ownership: State (property and endowment willed to the state by Tom Yawkey)

Site Location: Atlantic seaboard south of Georgetown, SC between Winyah Bay and the mouth of the Santee River

Contact Person: Bob Joyner Phone: 803-546-6814

I. Area:

Overall size: 20,000 acres

Shallow wetland size: 8,000 acres Water Depth: 18-24 inches in impoundments; 0-7 feet in open marsh
Salinity: 10-12 ppt. in impoundments; 1-35 ppt. in open marsh

Reticulation (open water connections): Poor in impoundments; Good in open marsh

Tide Amplitude: No tide in impoundments; 4-5 feet in open salt marsh

II. Primary Vegetation: In salt marsh: Spartina spp., Borrichia frutescens. In impoundments: Scirpus robustus, Ruppia maritima.

Average Height: < 1-3 meters Crane Visibility: Fair

III. Food Sources: Blue crab, fiddler crab, shrimp, periwinkle snail.

IV. Indicator Species: Great blue heron, tricolored heron, great egret, snowy egret, white ibis, glossy ibis, wood stork, rail.

V. Hazards: Predators: Alligator (873 gators over 6 feet long), bobcat (abundant). No hunting, but heavy waterfowl hunting in all adjacent areas. Freezing weather is a possible hazard to food resources.

Isolation: Fair

VI. What ecological/biological data currently exist on the site? Studies of invertebrates and shore birds conducted by Dr. Louise Webber of Emory University. Research is encouraged.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	1
Excel.	V.Good	Good	OK	Poor

2.5

VIII. Comments: Area is too small by itself, and adjacent state lands are dedicated to waterfowl hunting (see Santee Coastal Reserve WMA site visit form). Tidal amplitude may be a problem in open marsh areas. Phragmites invasion is a problem, and freezing weather is a concern.

AREAS THAT APPEAR TO BE UNSUITABLE AS WINTERING SITES FOR WHOOPING CRANES:

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 18, 1996 State: Louisiana

Site Name: Sabine National Wildlife Refuge

Ownership: U.S. Fish and Wildlife Service

Site Location: Southwestern Louisiana, 22 miles south of Sulphur, LA.

Contact Person: Diane Borden-Billiot Phone: 318-762-3816

I. Area:

Overall size: 125,000 acres

Shallow wetland size: 125,000 acres Water Depth: 12-18 inches Salinity: 0-14 ppt

Reticulation (open water connections): Poor to Fair Tide Amplitude: 18-24 inches

II. Primary Vegetation: Spartina patens, Scirpus spp., Sagittaria spp.

Average Height: < 1-2.5 meters Crane Visibility: Fair to Good

III. Food Sources: Blue crab, shrimp, crayfish.

IV. Indicator Species: Great blue heron, tricolored heron, great egret, snowy egret, white ibis, white-faced ibis, roseate spoonbill.

V. Hazards: Some power lines; Limited hunting (25-35% of refuge hunted 3 times per week); Poaching. Predators include bobcat, coyote, and possibly red wolf. The refuge is closed to boating from October 15 to March 15.

Isolation: Good

VI. What ecological/biological data currently exist on the site? Very Little.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	(1)
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Large size of protected area is a big plus, but, particularly in the freshwater marsh areas, vegetation density is very high with mats of root systems below the water surface. Cranes would have difficulty obtaining food items. There is not much open water acreage.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 19, 1996 State: Louisiana

Site Name: White Lake Marshes

Ownership: Amoco Oil Company

Site Location: Southwestern Louisiana, 12 miles south of Gueydan, LA.

Contact Person: Wayne Sweeney Phone: 318-433-0067

I. Area:

Overall size: 75,000 acres

Wetland size: 50,000 acres (most is not shallow) Water Depth: 24-60 inches Salinity: 0 ppt

Reticulation (open water connections): Poor Tide Amplitude: no tide

II. Primary Vegetation: Panicum hemitomon, Sagittaria falcata

Average Height: 1-2 meters Crane Visibility: Poor

III. Food Sources: Limited (as evidenced by the fact that roseate spoonbill and white ibis nest here but forage elsewhere in nearby agricultural fields). There are crayfish in a 7,000 acre impoundment that is dewatered annually for waterfowl.

IV. Indicator Species: Great blue heron, black-crowned night heron, great egret, and a few white ibis and roseate spoonbill.

V. Hazards: Gulf Intracoastal Waterway abuts the property on the north. There is waterfowl hunting on the Amoco property that is controlled by Amoco, and there is heavy waterfowl hunting (including snow geese) on adjacent properties. Amoco has very fast speed boats that use the narrow water trails through the marsh.

Isolation: Fair

VI. What ecological/biological data currently exist on the site? None.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	(1)
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Most of the marsh is covered with dense, tall vegetation. Where there are open-water areas, the water is quite deep (> 3 feet). Where water is less deep, the substrate is choked with submergent vegetation.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 21, 1996 State: Mississippi

Site Name: Pascagoula River Delta

Ownership: Combination (State, Federal, and Private)

Site Location: Southeastern Mississippi, near Gautier, MS.

Contact Person: Dave Ruple Phone: 601-385-5860

I. Area:

Overall size: 15,000 acres

Wetland size: 15,000 acres Water Depth: 12-60 inches Salinity: 3 ppt

Reticulation (open water connections): Poor Tide Amplitude: 12-18 inches

II. Primary Vegetation: Spartina spp., Scirpus spp., Juncus spp.

Average Height: 1-2 meters Crane Visibility: Poor

III. Food Sources: Unknown, probably limited (as evidenced by the sparsity of indicator species).

IV. Indicator Species: A few great blue heron and great egret.

V. Hazards: Interstate route #10 bisects the area. There is a petroleum refinery on the river. There is open public access and heavy recreational use of the area. There is little waterfowl hunting.

Isolation: Poor

VI. What ecological/biological data currently exist on the site? None.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	(1)
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Most of the delta is covered with dense, tall vegetation. There are few open, shallow areas.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 23, 1996 State: Florida

Site Name: Hixtown Swamp

Ownership: Combination (Water District, Paper Companies, Private Farms)

Site Location: Madison County, north of Interstate Route #10, between Greenville and Madison, FL.

Contact Person: Howell Waring Phone: 904-973-2788

I. Area:

Overall size: 23,000-30,000 acres

Wetland size: 10,000 acres Water Depth: 12-60 inches Salinity: 0 ppt

Reticulation (open water connections): Fair Tide Amplitude: No tide

II. Primary Vegetation: Pontederia cordata and a variety of other freshwater species (Wooded swamp with pockets of open water)

Average Height: Varies Crane Visibility: Poor

III. Food Sources: Unknown. Sandhill cranes winter in the swamp.

IV. Indicator Species: None seen.

V. Hazards: Area is heavily hunted for deer and waterfowl. Open to public access. Crops on adjacent farms are sprayed with pesticides.

Isolation: Poor

VI. What ecological/biological data currently exist on the site? Water Management District has studied the area.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	(1)
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Too wooded, not enough open areas. Many hazards.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 23, 1996 State: Florida

Site Name: Putnam County Prairies

Ownership: Private

Site Location: Putnam County, southwest of Keystone Heights, FL. An area of about 10 square miles centered approximately at the intersection of routes #100 and #26.

Contact Person: Steve Nesbitt Phone: 352-955-2230

I. Area:

Overall size: Several small wet prairies in the area

Wetland size: < 10,000 acres Water Depth: 0-24 inches Salinity: 0 ppt

Reticulation (open water connections): Poor Tide Amplitude: No tide

II. Primary Vegetation: Panicum hemitomon, Paspalum notatum, Pontederia cordata

Average Height: .5-2 meters Crane Visibility: Poor

III. Food Sources: Aquatic vegetation, oak mast, waste corn/grains. Sandhill cranes present.

IV. Indicator Species: None seen.

V. Hazards: Roads, fences, power lines, human activity.

Isolation: Poor

VI. What ecological/biological data currently exist on the site? None

VII. Overall rating as wintering site for whooping cranes: 5 Excel. 4 V.Good 3 Good 2 OK (1 Poor)

VIII. Comments: Clogged habitat, not enough open water areas. Many hazards. Not isolated.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 24, 1996 State: Florida

Site Name: Paynes Prairie

Ownership: Mostly State (80-90%)

Site Location: Two and one-half miles south of Gainesville, Alachua County, FL.

Contact Person: Steve Nesbitt Phone: 352-955-2230

I. Area:

Overall size: 21,000 acres (plus other small wet prairies in the area)

Wetland size: 5,000 acres Water Depth: 0-40 inches Salinity: 0 ppt

Reticulation (open water connections): Poor Tide Amplitude: No tide

II. Primary Vegetation: Panicum hemitomon, Pontederia cordata

Average Height: .5-1.5 meters Crane Visibility: Poor to Fair

III. Food Sources: Crayfish, aquatic insects, grass hoppers, aquatic vegetation, oak mast. Sandhill cranes present.

IV. Indicator Species: Wading birds.

V. Hazards: Peanut toxicosis, power lines, human activity.

Isolation: Poor

VI. What ecological/biological data currently exist on the site? Water management district and state reports.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	(1)
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Open areas decreasing due to encroachment of woody plants. Not enough open, shallow water areas. Sandhill crane use of these areas is decreasing annually.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 27, 1996 State: Georgia

Site Name: Okefenokee National Wildlife Refuge

Ownership: U.S. Fish and Wildlife Service

Site Location: Southeastern corner of Georgia, between Waycross, GA. and the Florida border.

Contact Person: Sara Aicher Phone: 912-496-7366

I. Area:

Overall size: 393,000 acres

Shallow wetland size: 59,000 acres of wet prairie. Water Depth: 0-60 inches. Salinity: 0 ppt

Reticulation (open water connections): Fair. Tide Amplitude: No tide (but 12 inches flux).

II. Primary Vegetation: Pontederia cordata, Xyris iridifolia, Lacnanthes caroliniana, Nymphaea odorata, Bidens beckii, Carex spp.

Average Height: < 1 meter Crane Visibility: Poor

III. Food Sources: Unknown at present. Bennett and Bennett (1987) found: amphipod crustaceans, insect larvae, crayfish, sirens, amphiumas, frogs, and tadpoles. It is estimated that there are currently about 200 resident and 1,000 migratory sandhill cranes in the refuge.

IV. Indicator Species: Great blue heron, great egret, white ibis.

V. Hazards: High mortality of sandhill cranes (cause unknown). Bennett and Bennett (1987) found that mortality (11%) exceeded recruitment (9.4%) for resident sandhills. A recent study by the University of Georgia found unsafe levels of mercury in the swamp. Refuge staff have found elevated levels of mercury in fish. DuPont has proposed to mine for titanium on the eastern border of the swamp. Predators include alligator, bobcat, and black bear. Populations of sandhill cranes, wood ducks, colonial nesting birds, and fish have been declining in recent years. Deer hunting in the upland, no hunting in the swamp.

Isolation: Fair to Good

VI. What ecological/biological data currently exist on the site? Limited data since Bennett and Bennett (1987). University of Georgia study on mercury levels.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	(1)
Excel.	V.Good	Good	OK	Poor

VIII. Comments: Wooded areas are extensive with only small open prairie areas in between. There are many potential hazards. The best estimate is that the resident sandhill crane population has declined by 50% in the last 10 years. Refuge staff and Georgia state biologists indicate that fisheries and other bird populations have also been declining in recent years.

WHOOPING CRANE WINTERING SITE VISIT FORM

Date: November 30, 1996 State: South Carolina

Site Name: Donnelley and Bear Island Wildlife Management Areas (in Ace Basin)

Ownership: State

Site Location: Atlantic seaboard north of Beaufort, SC and south of Ashepoo, SC.

Contact Person: Dean Harrigal Phone: 803-844-8957

I. Area:

Overall size: 20,000 acres

Shallow wetland size: 6,000 acres Water Depth: Controllable Salinity: 0-20 ppt.

Reticulation (open water connections): Poor Tide Amplitude: No tide in impoundments; 4-5 feet in open marsh

II. Primary Vegetation: In fresh areas: Eleocharis spp., Nymphaea spp., Zizania aquatica, Typha latifolia; In brackish areas: Spartina alterniflora, Juncus roemerianus; In impoundments: Ruppia maritima, Panicum virgatum

Average Height: < 1-1.5 meters Crane Visibility: Poor

III. Food Sources: Blue crab, shrimp in brackish marsh.

IV. Indicator Species: Great blue heron, little blue heron, tricolored heron, great egret, snowy egret, white ibis, glossy ibis, wood stork.

V. Hazards: Predators: Bobcat, raccoon, a few coyotes. Extreme hunting pressure (waterfowl, deer, quail, dove, small game, raccoon, opossum). There are no areas in Ace Basin that are closed to hunting. Cold weather (wood stork and osprey migrate south for the winter).

Isolation: Poor

VI. What ecological/biological data currently exist on the site? Clemson University has conducted some studies in the Ace Basin area.

VII. Overall rating as wintering site for whooping cranes:

5	4	3	2	(1)
Excel.	V.Good	Good	OK	Poor

VIII. Comments: The areas visited are too heavily wooded and too heavily hunted. Areas in the basin that might be suitable for cranes are quite small. Freezing weather is a concern.

APPENDIX D

Assessment Of Whooping Crane Food Availability At Potential Wintering Sites

EVALUATION OF POTENTIAL WHOOPING CRANE WINTERING SITES IN LOUISIANA AND FLORIDA

A Report
By

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INTRODUCTION

Currently there is only a single, natural wild population of Whooping Cranes (*Grus americana*). This population overwinters in the coastal salt marshes of Aransas National Wildlife Refuge and Matagorda Island National Wildlife Refuge, which are located in the Texas Coastal Bend Region. A single population is vulnerable to widespread natural or human-caused disaster and to buffer against this possibility, the Whooping Crane Recovery Plan calls for the establishment of two new and distinct populations of cranes. In conjunction with this effort, an ongoing search is being conducted for suitable breeding and wintering areas.

Cannon and Chavez-Ramirez began the search for a new potential wintering site in the fall of 1996. Based on a preliminary screening conducted of 20 different sites, three were deemed to have excellent potential. It was decided that more in depth research should be conducted the following winter to further evaluate suitability over a complete winter. Results of a preliminary site evaluation conducted during the winter of 1996-97, indicated two potentially suitable sites for Whooping Crane reintroduction (Chavez-Ramirez 1997). One area was Marsh Island Wildlife Refuge and Game Preserve, located off the central coast of Louisiana. The other area was Chassahowitzka National Wildlife Refuge and St. Martin's Marsh Aquatic Preserve, which are located on the coast of the Gulf of Mexico in Florida, between the towns of Homosassa and Chassahowitzka. Although preliminary data suggested that both sites had food items available for a new Whooping Crane population, more data were needed to determine the availability of food items throughout the entire winter season.

The single most important food items for wintering Whooping Cranes are Blue Crabs (Hunt and Slack 1989, Chavez-Ramirez 1996). However, Whooping Cranes are opportunistic feeders and will take a variety of mollusks, crabs and other species when foraging in the marsh and other areas (Allen 1952; Chavez-Ramirez et al. 1996). Environmental factors such as water temperature or salinity may be important factors influencing the abundance of these species, particularly during severe winter weather. There is evidence to suggest that blue crabs hide

under substrate or move away from shallow marsh waters when temperatures reach less than 17-19° C (Chavez-Ramirez pers. obsv.).

In addition to an evaluation of the food resource availability, indicator species may also be utilized to determine suitability of a site for reintroduction of a species (Morrison et al. 1992). Whooping Cranes show a high degree of overlap in patterns of foraging habitat use with some species of wading birds, particularly with Great Egrets (*Casmerodius albus*) (97%) and Tricolored Herons (*Egretta tricolor*) (91%) (Chavez-Ramirez and Sherry, unpublished data). Because of the significant overlap in habitat use patterns, wading birds can be used as indicator species of potential Whooping Crane foraging habitat. Although Whooping Cranes and wading birds have different diets, they utilize similar habitats, namely shallow, open water areas to forage for their preferred food. Other species, however, such as ibises and spoonbills, overlap in food resource use with cranes. Therefore, determination of distribution, dispersion and abundance of wading birds throughout each site can give an indication as to the extent of suitable habitat.

The overall objective of this study was to determine the suitability of two sites for potential introduction of a new migratory flock of Whooping Cranes. The specific objectives of this study were to determine abundance and distribution of blue crabs (*Callinectes sapidus*), snails (*Littorina, spp.*; *Melampus, spp; Cerithidea, spp.*), and clams (*Rangia, spp; Geukensia, spp.*) and their variation throughout the winter months in Marsh Island Wildlife Refuge, Chassahowitzka National Wildlife Refuge and St. Martin's Marsh Aquatic Preserve. The abundance of blue crabs in relation to environmental variables such as temperature and salinity was also examined. To determine potential wintering site suitability, food availability at both potential reintroduction sites was compared to food availability at Matagorda Island National Wildlife Refuge, where Whooping Cranes currently winter. As a second measure of suitability, the presence and abundance of Great Egrets and Tricolored Herons was evaluated and compared between sites.

STUDY AREAS

All the study sites were located in coastal regions of the Gulf of Mexico. Matagorda Island National Wildlife Refuge is located in the coastal bend region of Calhoun County Texas (Fig. 1). It is a barrier island, 62 km long, which varies from 1.2 to 7.3 km wide. The salt marsh areas are located on the west side, and the habitat consists of vegetated flats dominated by glasswort (*Salicornia virginiana*), saltwort (*Batis maritima*) sea-oxeye daisy (*Borrichia frutescens*), wolfberry (*Lycium carolinianum*), saltgrass (*Distichlis spicata*), smooth cord grass (*Spartina alterniflora*) and wind tidal flats dominated by mudflat grass (*Eleocharis parvula*), saltgrass, and cordgrasses (Chavez-Ramirez and Slack 1995).

Marsh Island Wildlife Refuge and Game Preserve is located off the southern coast of Louisiana between Vermillion Bay and the Gulf of Mexico (Fig 2). Prominent marsh vegetation includes wire grass (*Spartina patens*), three corner grass (*Scirpus americanus*), and black needle rush (*Juncus roemerianus*). Shrub species such as salt bush (*Baccaris halimifolia*) and marsh elder (*Iva frutescens*) occur along spoil banks. There are also several tree species including: hackberry (*Celtis laevigata*), Chinese tallow (*Sapium sebiferum*), chinaberry (*Melia asedrarach*), Toothache tree (*Zanthoxylum clava-herculis*) and Huisache (*Acacia farnesiana*).

The study site in Florida encompassed two adjacent areas (Fig. 3). The St. Martin's Marsh Aquatic Preserve, which is located in Citrus county, and the Chassahowitzka National Wildlife Refuge, which is located in both Citrus and Hernando counties. The Preserve is composed of open water, inlet bays, tidal rivers and creeks, and salt marsh. The major plant community associations found here include salt marsh, oyster reef, tidal flats, marine grassbeds, mangrove forest and hammock islands. The majority of research was conducted in the salt marsh areas. The dominant plant species here are black needle rush (*Juncus roemerianus*), salt grass (*Distichlis spicata*) and smooth cordgrass (*Spartina alterniflora*). Additionally, there are many areas of marine grassbeds, vegetated by such grasses as turtle grass (*Thalassia tetudinum*) and shoalgrass (*Halodule wrightii* and *Ruppia maritima*). The water in these areas is known for

its high clarity (St. Martins Marsh Aquatic Preserve Management Plan. Department of Natural Resources. September 9, 1987). The adjacent site is the Chassahowitzka National Wildlife Refuge, which is located directly south of St. Martin's and has similar vegetation communities.

METHODS

Visits to each of the study areas were conducted once a month, for 3-4 consecutive days, from November 1997 through March 1998 (Table 1). During each visit to a site information on blue crab, mollusk, and wading bird abundance was collected at each of the sites as described below.

BLUE CRAB ABUNDANCE

We determined blue crab distribution and abundance using commercial crab traps baited and set out in shallow, open water areas throughout the study sites. On Matagorda Island, a total of 10 traps were set out each month, while in Marsh Island and St. Martin's, 15 and 9 traps were set out, respectively. We checked crab traps 24 and 48 hours later. Each crab trapped was counted, measured (length of the carapace from tip to tip) and sex was recorded. Prior to release, crabs captured after 24 h were marked to evaluate recapture rates at a different time. Overall mean abundance, reported as mean crabs per trap, and standard errors were calculated. Environmental data collected at all blue crab trapping sites included water temperature (°C) and salinity (ppt). During February and March in Louisiana 4 traps were modified with a smaller mesh to evaluate the number of small crabs that might be missed with the regular commercial mesh which only retains crabs > 6 cm. The abundance of blue crabs trapped per month and between sites was evaluated with a 2-way ANOVA (Zar 1984).

MOLLUSK PRESENCE AND ABUNDANCE

We measured the abundance of clams, snails and crabs at each site using twenty-five $0.5m^2$ quadrats placed throughout the high marsh areas along each of four transects measuring 250 m. Transects were placed in sites so that apparently different habitats (based on aerial photographs) were sampled. In the Florida site, two transects were located in Chassahowitzka NWR and two were located in St. Martin's. All four transects in Florida were located in different habitat types in order to maximize habitats sampled within the area. All individuals located in quadrats were identified to species and tallied. Crab burrows were also counted, because the presence and density of burrows indicates the presence and activity of several species of fiddler crabs (*Uca panacea*, *U. rapax*, *U. spinicarpa*, and *U. longispinalis*) (Powers 1975, Mouton and Felder 1996). Presence and abundance of wolfberry (*Lycium carolinianum*) was also noted if present in quadrats. Abundance of mollusks and crabs is reported as density (# / 0.5 m^2). When appropriate conditions were met (sample sizes and presence of an item in more than one site) sites and/or months were compared using appropriate ANOVA and t-tests. When density of an item was lower than 0.01 per quadrat at a site, statistical comparisons were not performed due to the large number of zeros in the data set.

WADING BIRDS

To determine distribution and abundance of wading birds throughout each study site, we conducted 2 aerial surveys over Marsh Island, Louisiana, and 3 aerial surveys over Chassahowitzka/St. Martin's, Florida. Inclement weather events prevented more aerial surveys at these sites. Fourteen transects, approximately 1.6 km apart (east to west), were flown in a north to south direction over Marsh Island for a total linear distance of 135 km flown during each survey. The transects in Marsh Island were conducted during 5 December 1997 and 13 February 1998. Five transects were flown over Chassahowitzka/St. Martin's from north to south, also approximately 1.62 km apart (east to west), for a total linear distance flown of 60 km per survey. Surveys were conducted in Florida during 21 January, 20 February, and 1 April, 1998. Surveys for wading birds are generally conducted between 100 and 200 feet in order to locate and identify species more easily (Chavez-Ramirez and Slack 1995). Due to flying restrictions in Florida, surveys could not be conducted below 500 feet, which made the locating and differentiating between Tricolored and Great Blue Herons extremely difficult; therefore Tricolored Herons were not tallied at this site. Wading bird abundance was compared among sites by summarizing number encountered per km flown.

RESULTS

MOLLUSK AND CRAB RICHNESS

A total of 5 species of mollusks and no crab species were identified from plots sampled in Texas. In Louisiana we encountered a total of 10 species of potential invertebrate prey items including 6 mollusks and 4 crab species within the plots, while in Florida we identified 9 potential invertebrate prey species including 7 mollusk and 2 crab species (Table 2).

BLUE CRAB ABUNDANCE

Louisiana ($\bar{X} = 2.1 \pm 0.29$, N = 138) and Florida ($\bar{X} = 1.8 \pm 0.27$, N = 90) both had greater overall abundance of blue crabs than Texas ($\bar{X} = 0.6 \pm 0.08$, N = 90). Texas had statistically significant lower numbers than both Florida (P = 0.0008) and Louisiana (P = 0.0001), while Florida and Louisiana did not differ significantly (P = 0.48). In Florida, there were no significant differences in crab abundance between months except between November and January (P = 0.23, Fig. 4). Louisiana had greater variability of blue crab abundance among months, while Texas showed virtually no variability in blue crab captures per month (Fig. 4). During February and March in Louisiana a mean of 6 (±0.02) crabs < 6 cm in length were captured in a total of 12 trap days.

Blue crab abundance showed only a slight positive relationship to temperature in Louisiana (r = 0.17) and Texas (0.23); however, it was slightly negatively correlated with temperature in Florida (r = -0.72). In all three sites, crab abundance was negatively correlated with salinity (TX, r = –0.19, LA, r = –0.15, and FL, r = –0.02).

MOLLUSK PRESENCE AND ABUNDANCE

Overall, burrow density (# / $0.5m^2$) was significantly different (P < 0.0001) among sites with the greatest density observed in Florida ($\bar{X} = 11.2 \pm 0.44$, N = 475), followed by Louisiana ($\bar{X} = 5.3 \pm 0.26$, N = 500), while Texas had the lowest density ($\bar{X} = 3.3 \pm 0.21$, N = 500). Louisiana had a lower density of burrows per quadrat than Florida and also had lower variability in burrow density throughout the winter season (Fig. 5).

Only two species, coffee bean snails and marsh periwinkles occurred in all three sites (Table 2). Florida was the only site with a significant density of coffee bean snails ($\bar{X} = 3.1 \pm 0.4$, N = 475), while Texas ($\bar{X} = 0.04 \pm 0.01$, N = 500) and Louisiana ($\bar{X}$ 0.01 = ± 0.01, N = 500) both had very low densities overall. However, density of coffee bean snails showed considerable variation throughout the winter season in Florida, and was absent during November (Fig 6). Marsh periwinkles were present at all sites but at very low densities overall at all three

sites: Texas ($\bar{X}$ = 0.004 ± 0.002, N = 500); Louisiana ($\bar{X}$ = 0.04 ± 0.01, N = 500); and Florida ($\bar{X}$ = 0.06 ±0.02, N = 475) (Fig. 7).

Several species recorded in Louisiana and Florida, but not Texas, included ribbed mussels, olive snails, fiddler crabs, wharf crabs and marsh clams (Table 2). Ribbed mussels occurred in significantly greater densities (P = < 0.001) in Florida ($\bar{X}$ = 0.27 ± 0.06, N = 475) than in Louisiana ($\bar{X}$ = 0.01 ± 0.006, N = 500), with greater variability in the occurrence of ribbed mussels in Florida throughout the winter (Fig. 8). Two different species of olive snails (*Neritina reclivata* and *Olivella, spp.*) were identified in Louisiana and Florida, respectively. The olive snails in Louisiana occurred at a greater overall density ($\bar{X}$ = 1.37 ± 0.14, N = 500) than the species in Florida ($\bar{X}$ = 0.10 ± 0.06, N = 475) (Fig. 9). The two crab species (fiddler and wharf crabs) had similar overall densities at both sites. Fiddler crab density in Florida ($\bar{X}$ = 0.04 ± 0.01, N = 475) was slightly greater, but not statistically significant (P = 0.26), than in Louisiana ($\bar{X}$ = 0.02 ± 0.006, N = 500), but there was more variability throughout the winter in Florida (Fig. 10). The overall density of wharf crabs was slightly higher in Florida than in Louisiana ($\bar{X}$ = 0.08 ± 0.02, N = 475 and $\bar{X}$ = 0.07 ± 0.01, N = 500, respectively), but the variability tended to be higher as well (Fig. 11). The two species of marsh clams not recorded in Texas were *Rangia spp.* in Louisiana and *Polymesoda spp.* in Florida (Table 2). Overall density of marsh clams was greater in Louisiana ($\bar{X}$ = 0.09 ± 0.01, N = 500) than in Florida (0.01 ± 0.004, N = 475) and so was variability throughout the winter (Fig. 12).

The horn snail was the only species found in both Texas and Florida and not in Louisiana (Table 2). Although the density of horn snails declined in Florida over the winter, until February (Fig. 13), overall mean density of horn snails in Florida ($\bar{X}$ = 2.36 ± 0.2, N = 475) was significantly greater (P < 0.001) than in Texas ($\bar{X}$ =0.02 ± 0.008, N = 500).

There was only one species found in both Texas and Louisiana, but not in Florida. *Succinia, spp.*, a terrestrial pulmonate snail, occurred in low densities sporadically throughout the winter in both sites (Table 2, Fig. 14). There was no difference between the two sites in

overall density of this species (Texas $\bar{X} = 0.01 \pm 0.005$, N = 500, Louisiana $\bar{X} = 0.01 \pm 0.006$, N = 500).

There were three species, which were found only in Louisiana plots: juvenile blue crabs, whirl snails, and ghost crabs (Table 2). Juvenile blue crabs were found underneath debris, which had washed onto the shore. They occurred in relatively low densities overall ($\bar{X} = 0.03 \pm 0.008$, N = 500) and were only recorded during the December survey (Fig. 15). Likewise, ghost crabs were detected only during November (Fig. 16), and their overall density was low ($\bar{X} = 0.002 \pm 0.002$, N = 500). The other species which was identified in plots was a terrestrial whirl snail, and it occurred regularly throughout the winter season (Fig. 17), but the overall density was low ($\bar{X} = 0.03 \pm 0.008$, N = 500).

WADING BIRDS

In Louisiana a total of 295 and 187 wading birds were observed during the two surveys, respectively, which represents 2.18 and 1.38 birds per km flown (Table 3). When combining the two surveys the number of wading birds observed was 1.78 per km flown overall. In Florida the total numbers of birds observed during 3 surveys were 414, 74, and 19, respectively. Overall, during the three surveys, the number of wading birds per km flown was 4.23 in Florida. In Louisiana the number of Great Egrets observed during the two surveys was 0.4 and 0.3 birds per km flown, while numbers of Tricolored Herons observed were 0.02 and 0.007 birds per km. In Florida, the number of Great Egrets observed per survey was 5.1, 0.3, and 0.2 birds per km flown. In comparison, the number of Great Egrets observed in Whooping Crane wintering areas in Texas has averaged 0.26 per km flown.

DISCUSSION

SITE SUITABILITY AS WINTERING SITES FOR WHOOPING CRANES

Previous assessments at a variety of locations along the Gulf of Mexico coast had resulted in the recommendation that Marsh Island Wildlife Refuge, Louisiana and Chassahowitzka National Wildlife Refuge, Florida be considered as potential sites for a possible introduction of a population of Whooping Cranes. It was decided that further research was needed to determine the availability of Whooping Crane food items throughout the entire winter season. Since whooping cranes are opportunistic feeders (Hunt and Slack 1989, Chavez-Ramirez 1996 and unpublished data), we attempted to determine abundance and density of adult blue crabs, as well as evaluating the presence and density of several species of mollusks, clams, and other crabs found in the coastal salt marshes. In addition, we utilized two wading birds (Great Egrets and Tricolored Herons), known to overlap extensively with cranes, as indicators of the extent of suitable Whooping Crane habitat.

BLUE CRABS

The single most important food item for wintering Whooping Cranes seems to be blue crabs (Hunt and Slack 1989, Chavez-Ramirez 1996); and both Louisiana and Florida had higher abundances of blue crabs than Texas during the winter of 1997-98. Although Louisiana had a higher overall mean abundance of blue crabs than Florida, the variability in abundance per month was less in Florida, particularly if November is excluded. During the month of November in Florida, crab traps were located throughout bay habitat, and no blue crabs were captured. After careful re-evaluation of the locations, we moved the traps into channels consisting of shallower water depths, which ran through the upper marsh areas. As indicated by Figure 4, thereafter, we consistently captured blue crabs.

The trend in crab abundance in Louisiana was highly variable with abundance relatively high early in the winter, but declining rapidly throughout the winter through January. In subsequent months, the abundance of blue crabs increased again. Given that crab abundance was negatively correlated to temperature in Louisiana, it may have been lower temperatures that caused this trend since temperatures were lower during the months of decline in crab abundance. This trend may, however, also reflect the change in water depths that occurred throughout the winter season in this area (D. Sherry pers. observ.).

In Louisiana during the winter months, storms from the north may blow the water out of the marsh, causing extremely low water levels during some days. The blue crabs may move out of the marsh in order to remain underwater and this would have reduced the number of crabs captured. A similar pattern, of lowered water levels due to northerns, has been observed at the Texas site, which has also correlated with low crab captures in traps (Chavez-Ramirez 1996). Contrary to the trends observed in Louisiana, in Florida dramatic changes in water levels were not noted during trapping dates (D. Sherry pers. observ.), and the variability of crab abundance was not as high. It is important to note that crab traps utilized were commercial traps and as such did not capture the smaller size classes (<6 cm) of crabs, although Whooping Cranes can consume crabs of all size classes (Chavez-Ramirez 1996).

MOLLUSK PRESENCE AND ABUNDANCE

Species of snails, clams and mollusks, which were identified within quadrats generally, occurred in the greatest densities in Florida. However, they also appeared to have greater variability throughout the winter season than those in Louisiana. Species which occurred in Louisiana were still at greater densities than those in Texas, suggesting that there are plenty of other prey items in addition to blue crabs at both potential sites. In Florida, coffee bean snails, horn snails and ribbed mussels seemed to have particularly high densities. Species which occurred in the highest densities in Louisiana included marsh periwinkles, olive snails, and to a

lesser extent marsh clams. Burrow densities were also highest overall in Florida, over two times that in Louisiana and three times that in Texas.

WADING BIRD SURVEYS

Florida had the highest number of Great Egrets per kilometer flown. In January there was a particularly high number of Great Egrets observed. During the other two surveys in Florida, the density of Great Egrets was much lower; however, it was still comparable to the density observed in Louisiana and greater than numbers previously recorded in Texas. The trend of reduced number of wading birds during the spring in coastal salt marshes has been previously reported in Texas (Chavez-Ramirez and Slack 1995). The decreased numbers of Great Egrets and overall numbers of wading birds may have been due to birds moving out of the area due to migratory activity or change in dispersion patterns due to movements to nesting sites located away from the coastal marshes.

The abundance and dispersion of wading birds, particularly Great Egrets, throughout both sites is indicative that large areas of suitable salt marsh (in relation to water depth and prey habitat) are present in both the Florida and Louisiana sites.

RECOMMENDATIONS

The overall data on blue crab abundance, and other potential invertebrate prey, suggest that both possible sites are suitable as wintering sites for Whooping Cranes, especially since both sites have considerably greater abundance and density of all items than the site in Texas where cranes currently overwinter. The abundance and dispersion of Great Egrets additionally supports the suitability of the two sites as having large areas of suitable marsh habitat in relation to water depth and aquatic prey habitat. Based on potential food sources, it is our opinion that both sites would meet the foraging needs of a flock of introduced Whooping Cranes. Therefore, it is suggested that the sites be considered equal in regards to food availability and that other factors

be considered in the process of selecting the ultimate location for introduction. Factors such as official (state) and unofficial support (conservation group, nearby landowners, and other stakeholders) should be given particular importance. Logistical considerations concerning the methodologies involved in the introduction should also be taken into account.

ACKNOWLEDGEMENTS

We are grateful to all that provided assistance and logistical support during all aspects of this project. The staff at Matagorda Island National Wildlife Refuge, TX, Marsh Island Wildlife Refuge and Game Preserve, LA , Chassahowitzka National Wildlife Refuge, FL, and St. Martins Marsh Aquatic Preserve, FL were extremely helpful and supportive of all our activities related to this project. C. Land, C. Westwood and S. Windels provided assistance in conducting field work.

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Table 1. Location, month and dates of visits to each of the sites.

Location	Month	Dates
Matagorda Island NWR, TX	November	13, 14, 15
Marsh Island WR, LA	November	18, 19, 20
Chass/St. Martin's, FL	November	24, 25, 26
Matagorda Island NWR, TX	December	2, 3, 4
Marsh Island WR, LA	December	15, 16, 17
Chass/St. Martin's, FL	December	10, 11, 12
Matagorda Island NWR, TX	January	6, 7, 8
Marsh Island WR, LA	January	27, 28, 29
Chass/St. Martin's, FL	January	20, 21, 22
Matagorda Island NWR, TX	February	4, 5, 6
Marsh Island WR, LA	February	10, 11, 12
Chass/St. Martin's, FL	February	17, 18, 19
Matagorda Island NWR, TX	March	2, 3, 4
Marsh Island WR, LA	March	24, 25, 26
Chass/St. Martin's, FL	March/April	30, 31, 1

Table 2. Mollusk and crab species identified in the quadrats and the location where they were identified.

SPECIES		LOCATION		
Scientific Name	Common Name	TX	LA	FL
Mollusks				
Melampus, spp.	Coffee Bean Snail	X	X	X
Cerithidea pliculosa	Horn Snail	X		X
Geukensia demisa	Ribbed Mussel		X	X
Rangia, spp.	Marsh Clam	X	X	
Neritina reclivata	Olive Nerite		X	
Polymesoda, spp.	Marsh Clam			X
Littorina, spp.	Marsh Periwinkle	X	X	X
Busycon, spp.	Whelk			X
Olivella, spp.	Olive Snail			X
Heliacus, spp.	Whirl Snail		X	
Succinia, spp.	Pulmonate Snail	X	X	
Crabs				
Callinectes sapidus	Blue Crab			
Sassarma, spp.	Wharf Crab		X	X
Uca, spp.	Fiddler Crab		X	X
Ocypoda, spp.	Ghost Crab		X	

Table 3. Wading birds observed during aerial surveys in Louisiana and Florida. Includes number of individuals observed, number of each species per kilometer; and total number of wading birds observed over entire transect.

Location	Date	Species	Number	Number/km
LOUISIANA	12/5/97	Great Egret	59	0.4
	12/5/97	Tricolored Heron	4	0.02
	12/5/97	Snowy Egret	81	0.6
	12/5/87	Roseate Spoonbill	72	0.5
	12/5/97	White Pelican	49	0.4
	12/5/97	Great Blue Herons	26	0.2
	12/5/97	Little Blue Heron	1	0.007
	12/5/97	Brown Pelican	3	0.02
Total Waders			**295**	
	2/13/98	Great Egret	42	0.3
	2/13/98	Tricolored Heron	1	0.007
	2/13/98	White Pelican	53	0.4
	2/13/98	Roseate Spoonbill	38	0.3
	2/13/98	Snowy Egret	31	0.2
	2/13/98	Great Blue Heron	19	0.1
	2/13/98	Brown Pelican	3	0.02
Total Waders			**187**	
FLORIDA	1/21/98	Great Egrets	307	5.1
	1/21/98	White Pelicans	49	0.8
	1/21/98	White Ibis	29	0.5
	1/21/98	Brown Pelican	18	0.3
	1/21/98	Great Blue Heron	10	0.2
	1/21/98	Unknown Blue	1	0.02
Total Waders			**414**	
	2/20/98	Great Egret	20	0.3
	2/20/98	Snowy Egret	30	0.5
	2/20/98	Brown Pelican	10	0.2
	2/20/98	Great Blue Heron	7	0.1
	2/20/98	White Pelican	7	0.1
Total Waders			**74**	
	4/1/98	Great Egret	11	0.2
	4/1/98	Brown Pelican	8	0.1
Total Waders			**19**	

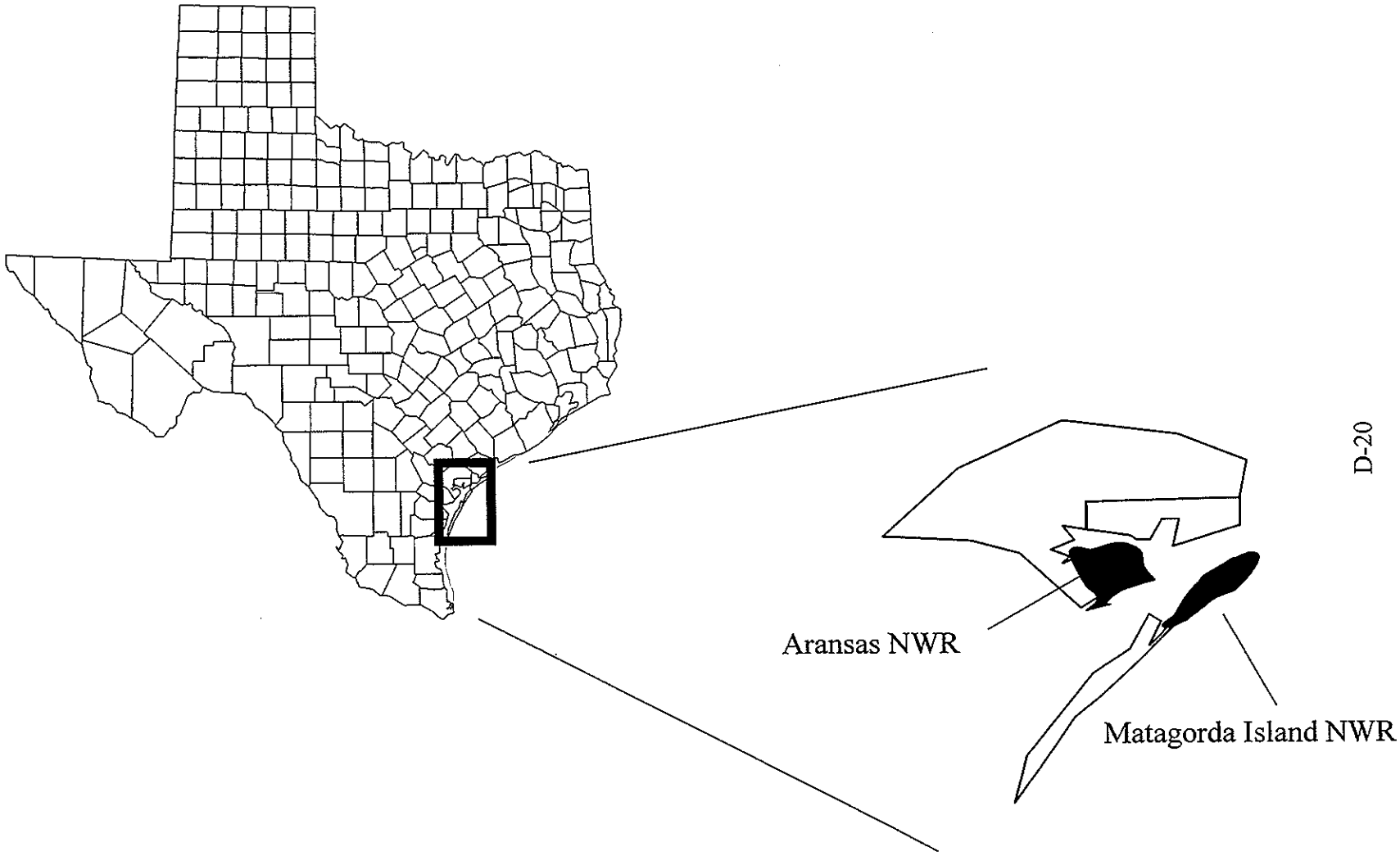

Fig 1. Current Whooping Crane wintering areas: Aransas National Wildlife Refuge and Matagorda Island National Wildlife Refuge.

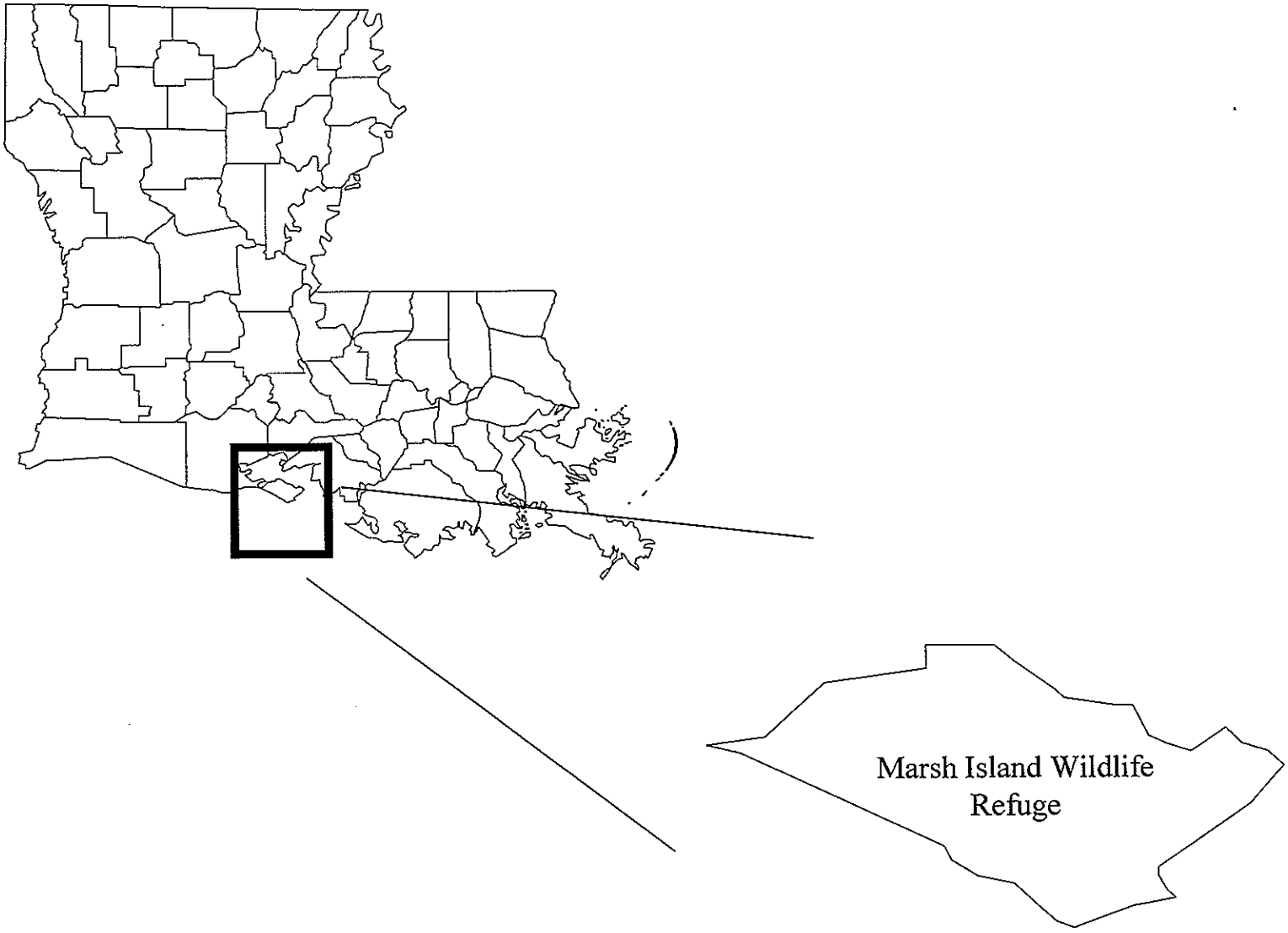

Fig 2. Potential Whooping Crane wintering area: Marsh Island Wildlife Refuge, LA.

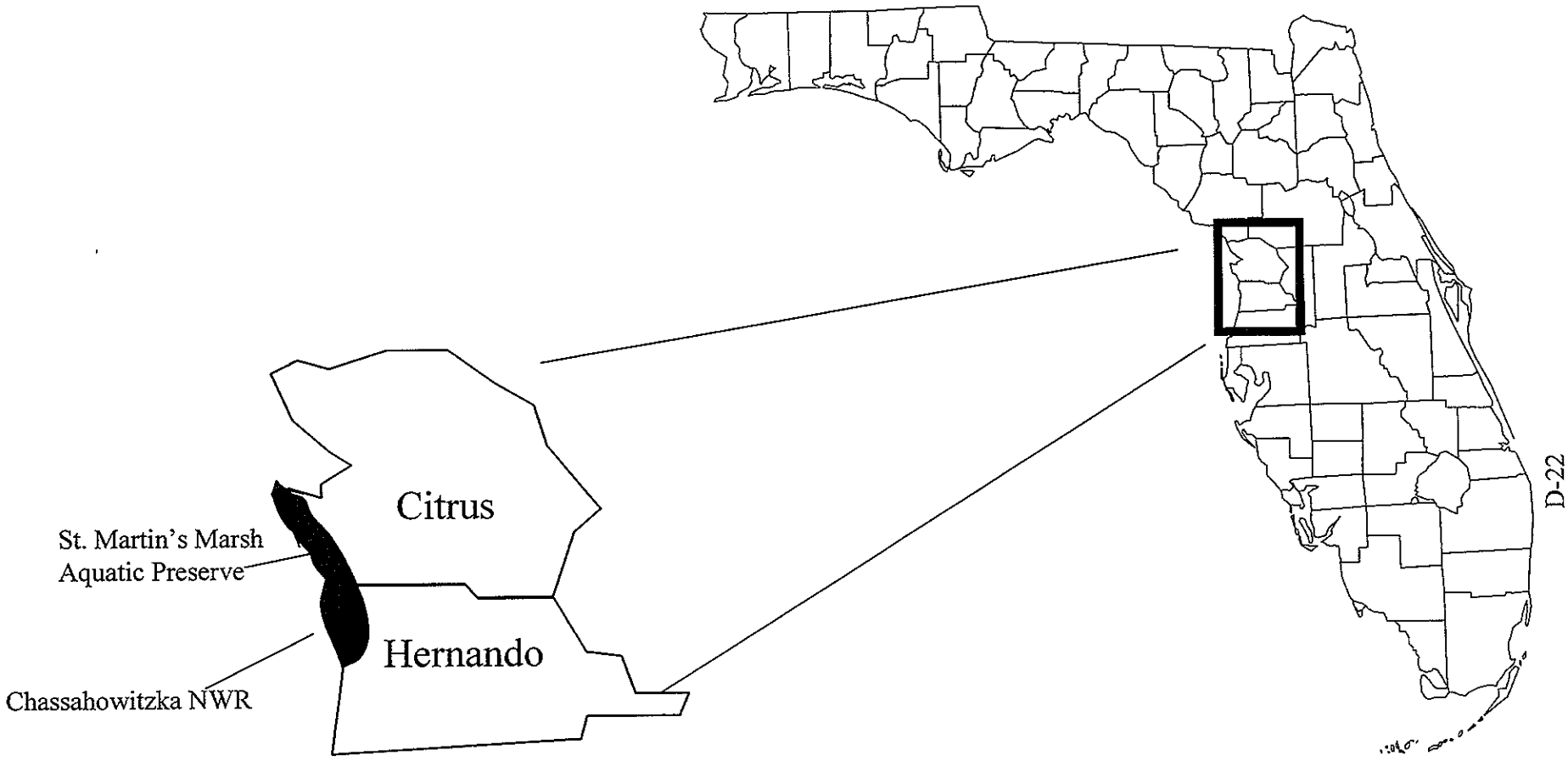

Fig 3. Potential Whooping Crane wintering area: Chassahowitzka National Wildlife Refuge and St. Martin's Marsh Aquatic Preserve, FL.

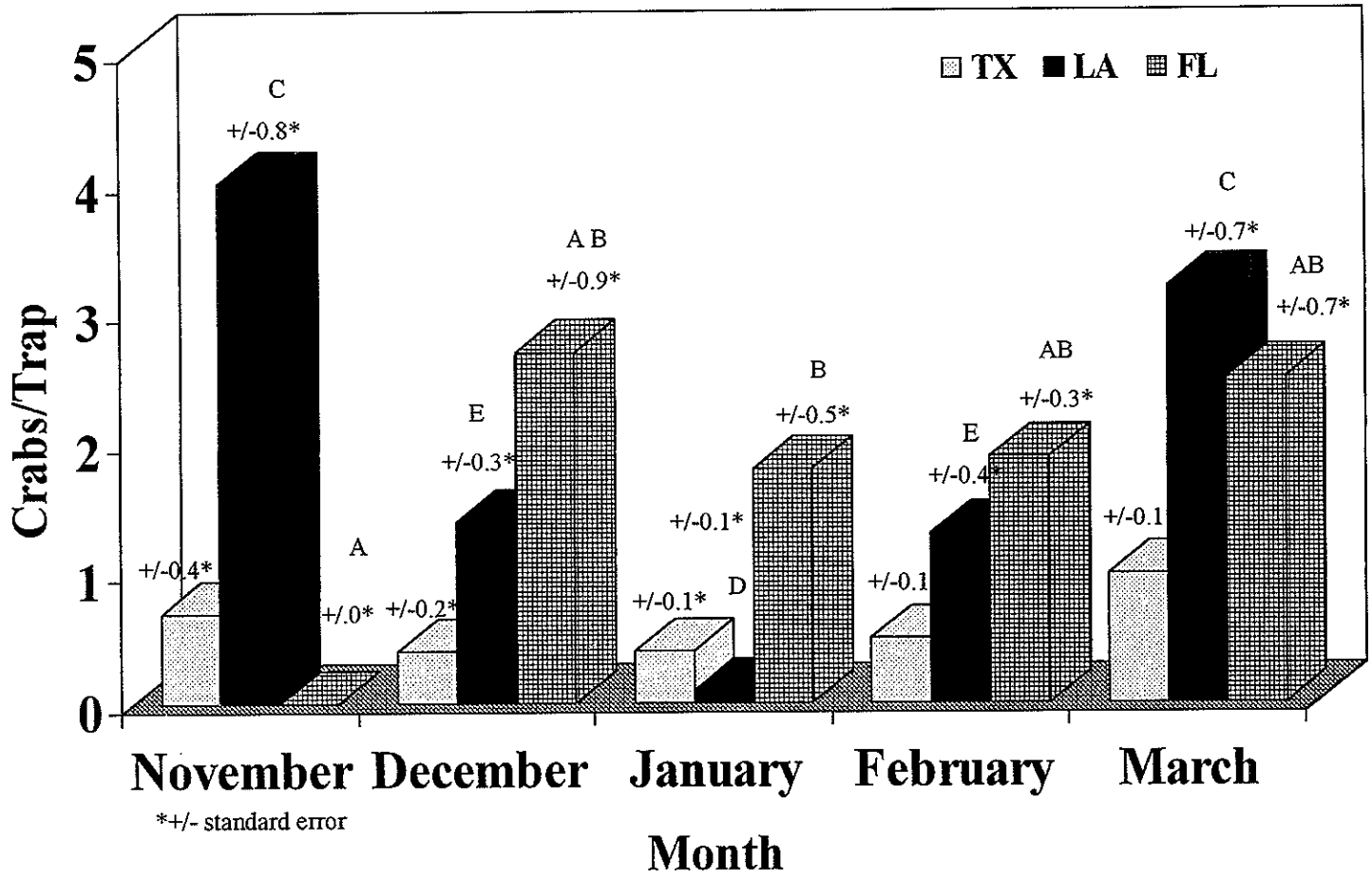

Fig 4. Abundance of blue crabs caught per trap during winter months of 1997-98 in Texas per month (n=20, except for November n=10), Louisiana (per month n=30, except for November n=28 and February n=18) and Florida (per month n=18). Bars with the same letter are not significantly different within sites.

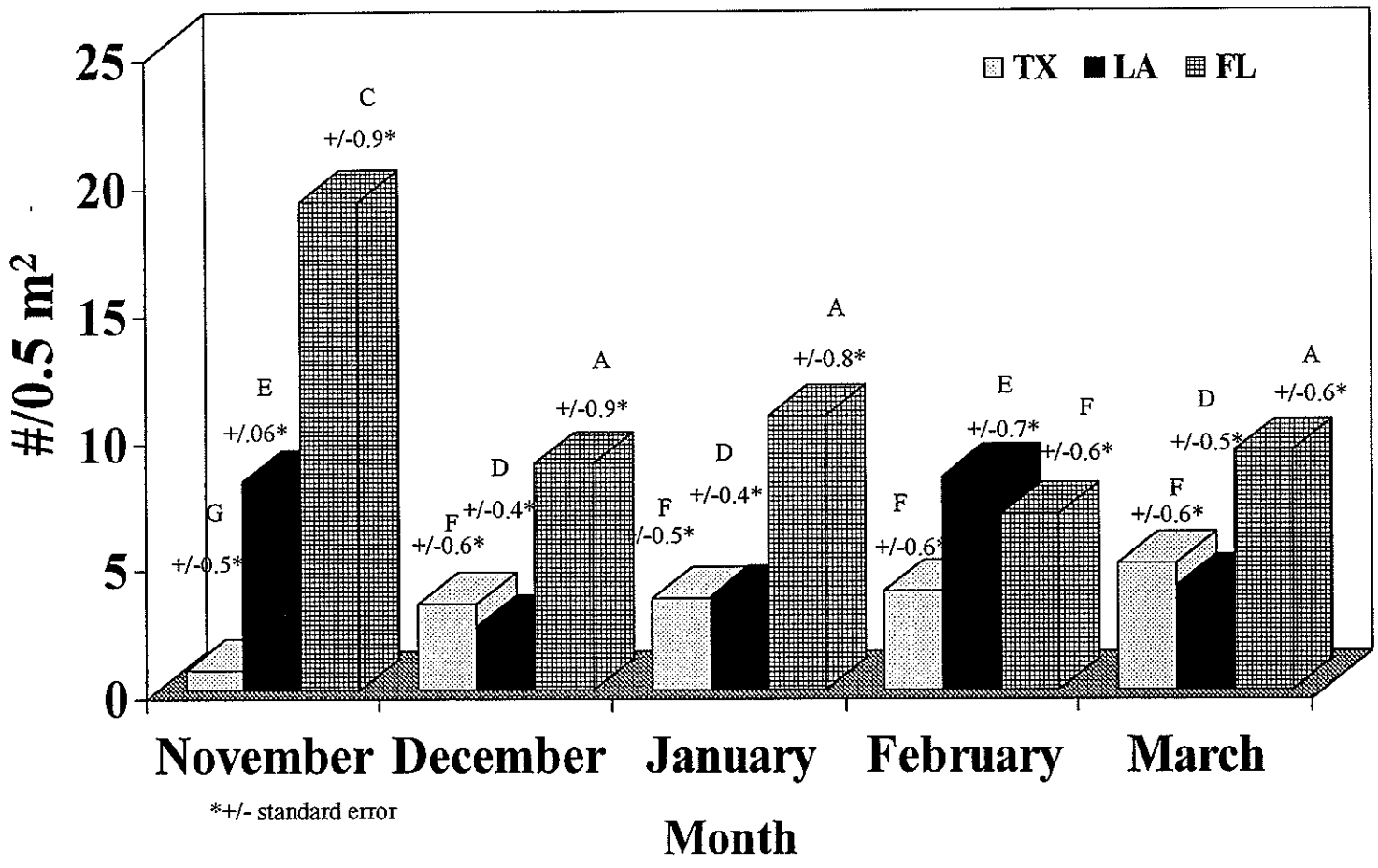

Fig 5. Density of burrows (#/0.5 m ^{2}) during winter months of 1997-98 in Texas, Louisiana and Florida per month (n=100, with the exception of Florida during December n=75). Bars with the same letter above them are not significantly different within sites.

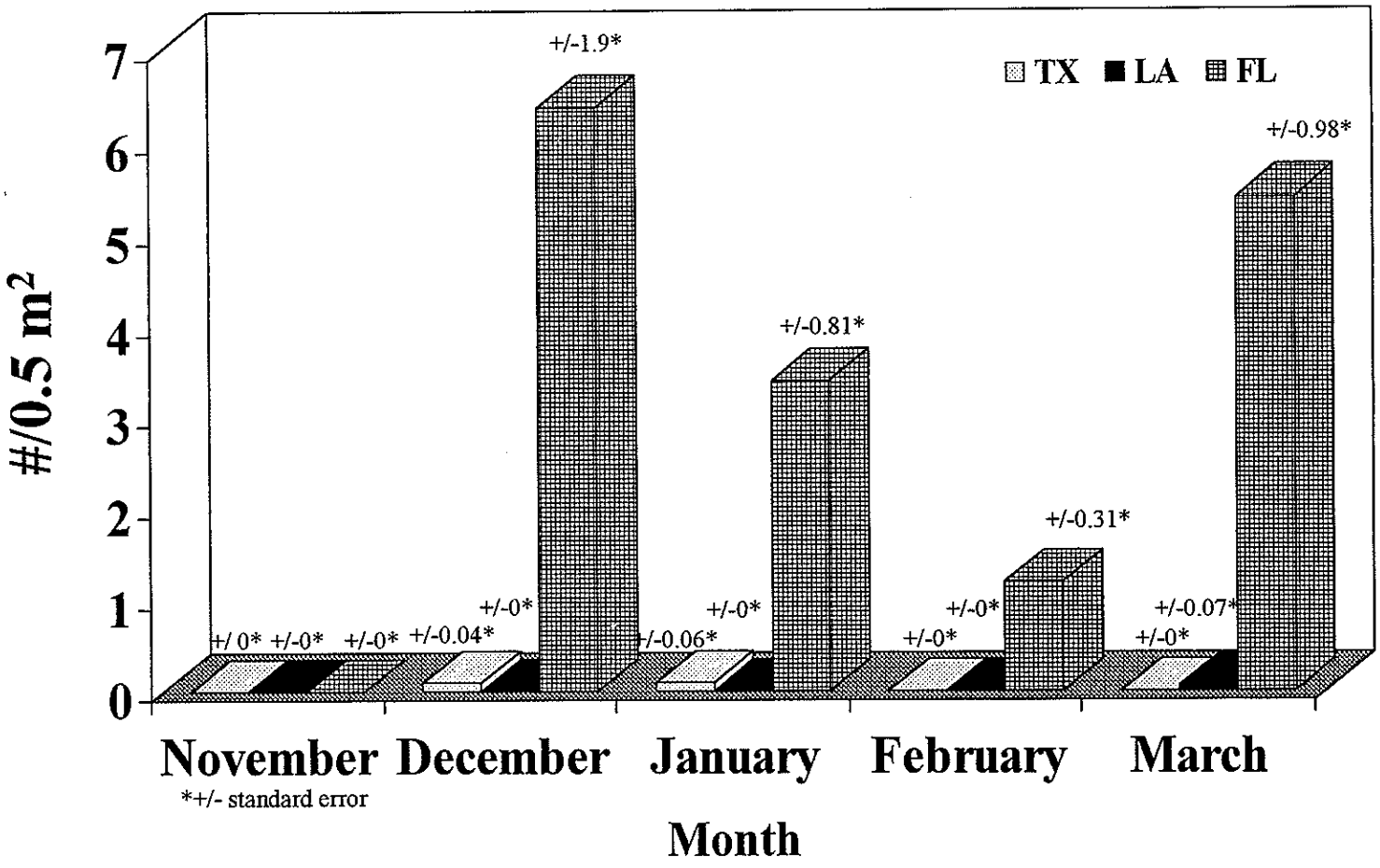

Fig 6. Density of Coffee Bean Snails (#/0.5 m ^{2}) during winter months of 1997-98 in Texas, Louisiana and Florida per month (n =100, with the exception of the Florida during December n=75).

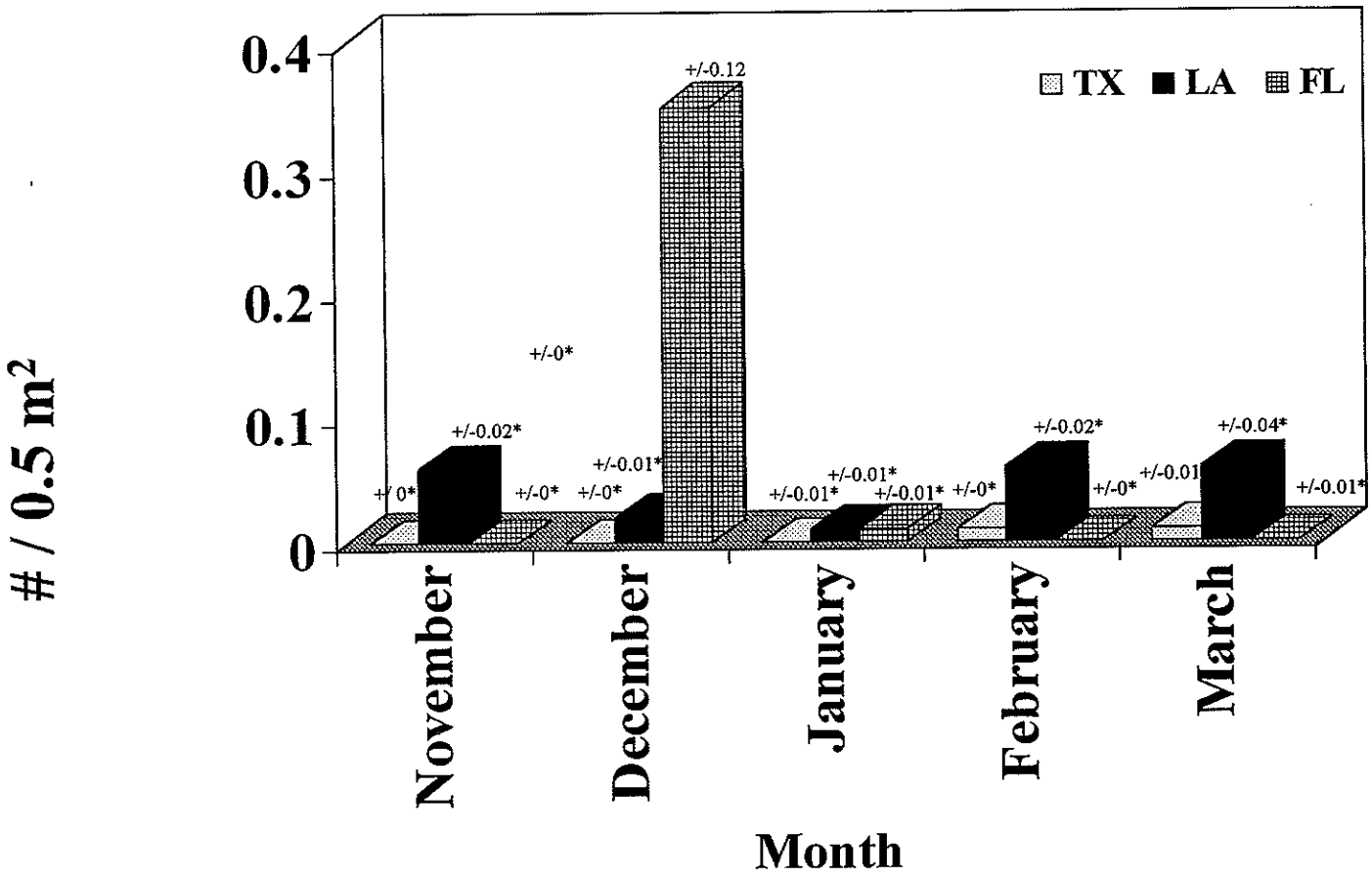

Fig 7. Density of Marsh Periwinkles (#/0.5 m ^{2}) during winter months of 1997-98 in Texas, Louisiana and Florida per month (n =100, with the exception of the Florida during December n=75).

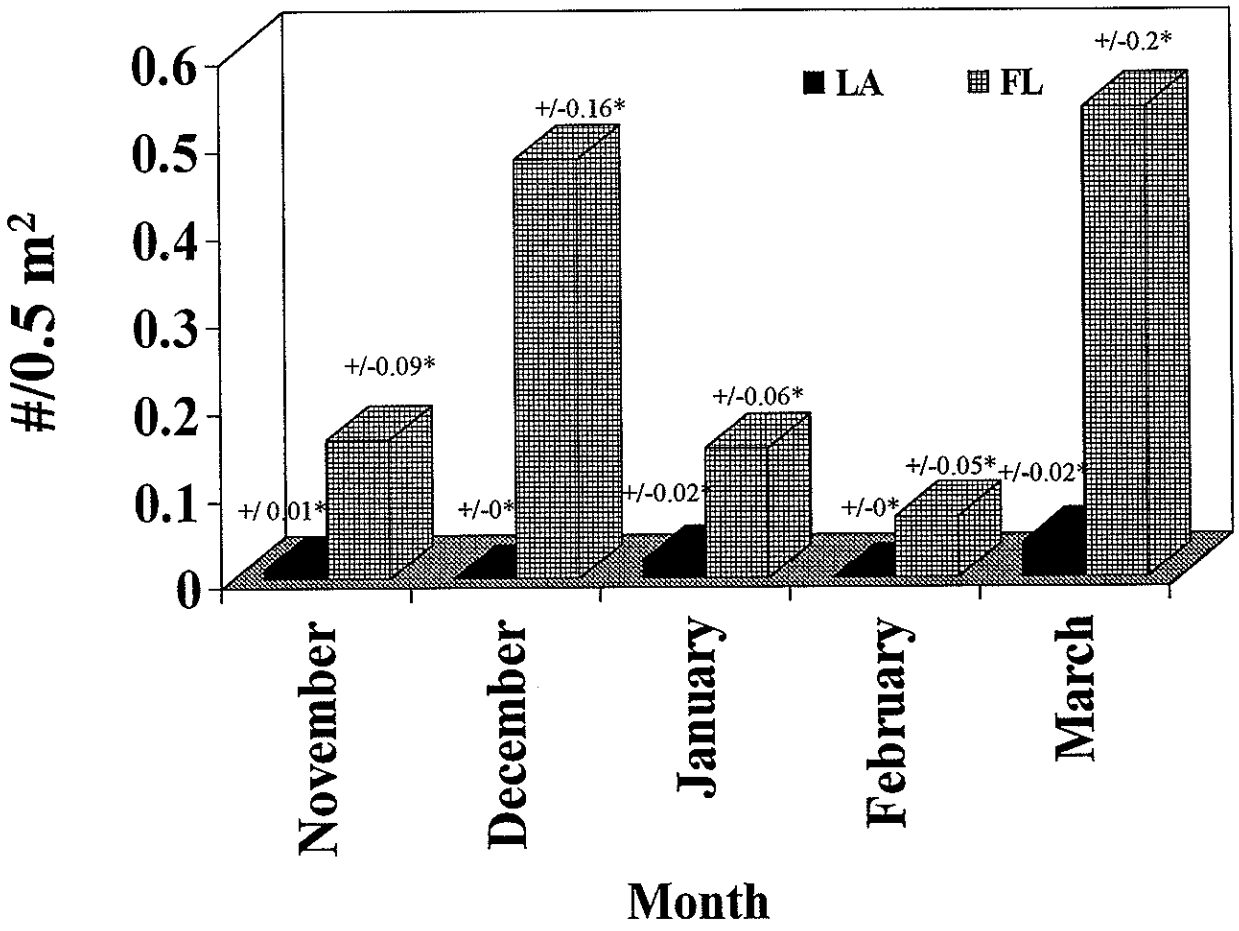

Fig 8. Density of Ribbed Mussels (#/0.5 m ^{2}) during winter months of 1997-98 in Louisiana and Florida per month (n =100, with the exception of the Florida during December n=75).

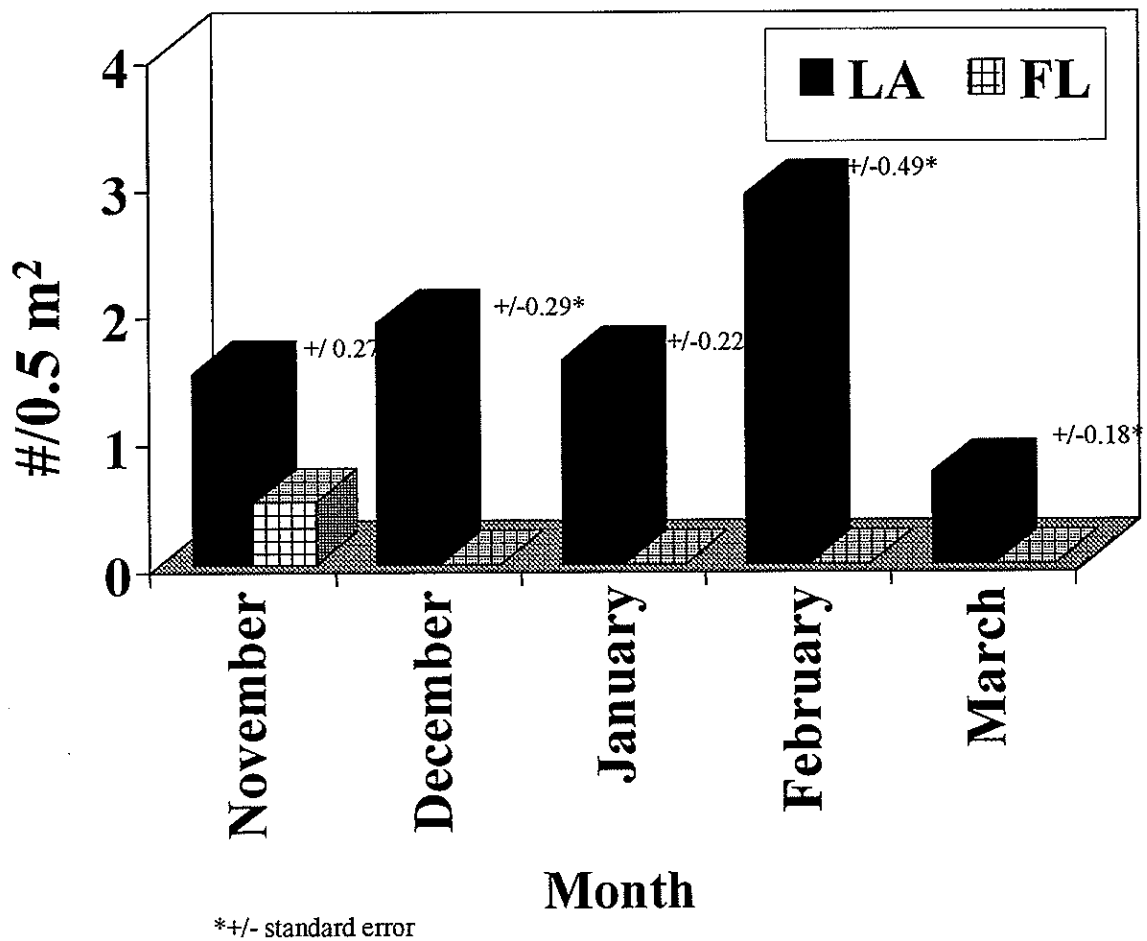

Fig 9. Density of Olive Snails (#/0.5 m ^{2}) during winter months of 1997-98 in Louisiana and Florida per month (n =100, with the exception of the Florida during December n=75). In Louisiana, the species is *Neritina reclivata*, in Florida it is *Olivella, spp*.

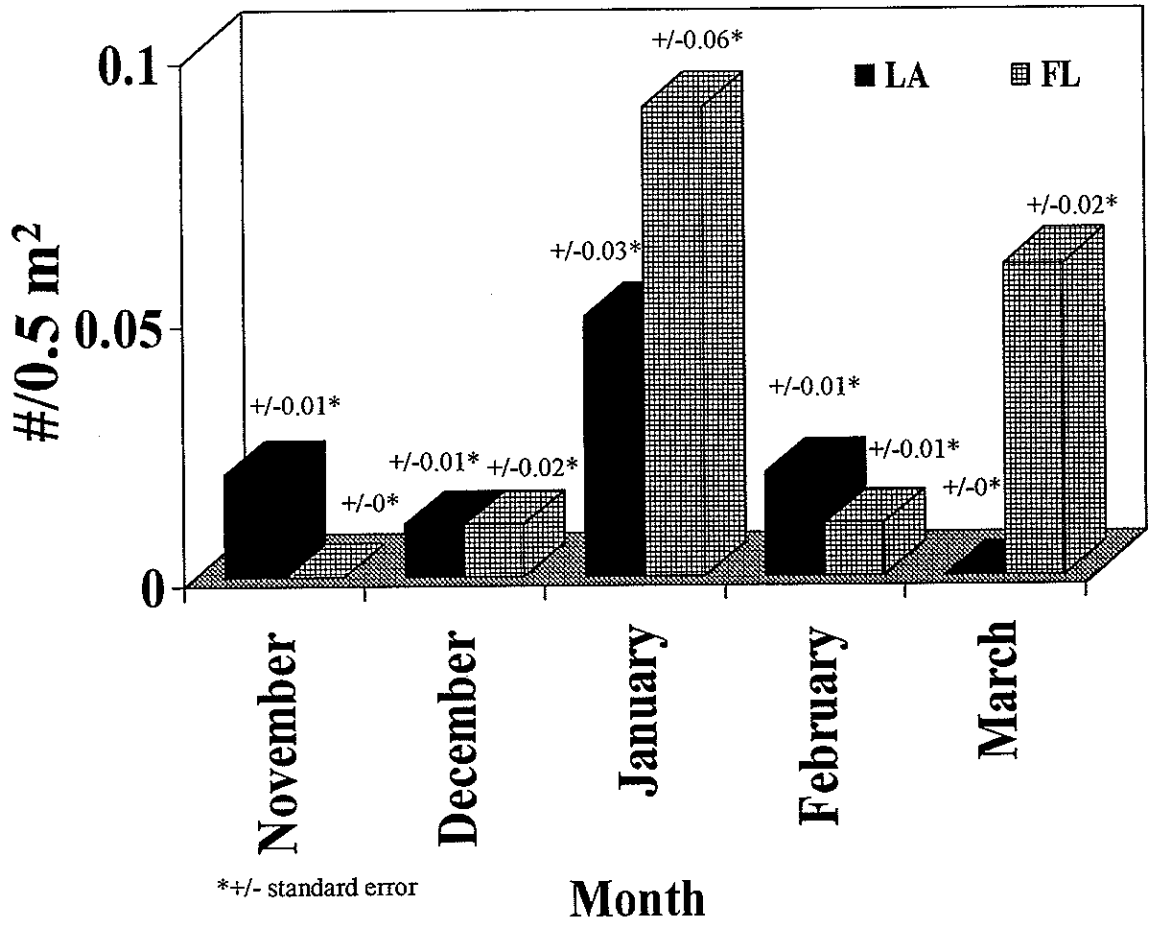

Fig 10. Density of Fiddler Crabs (#/0.5 m ^{2}) during winter months of 1997-98 in Louisiana and Florida per month (n =100, with the exception of the Florida during December n=75).

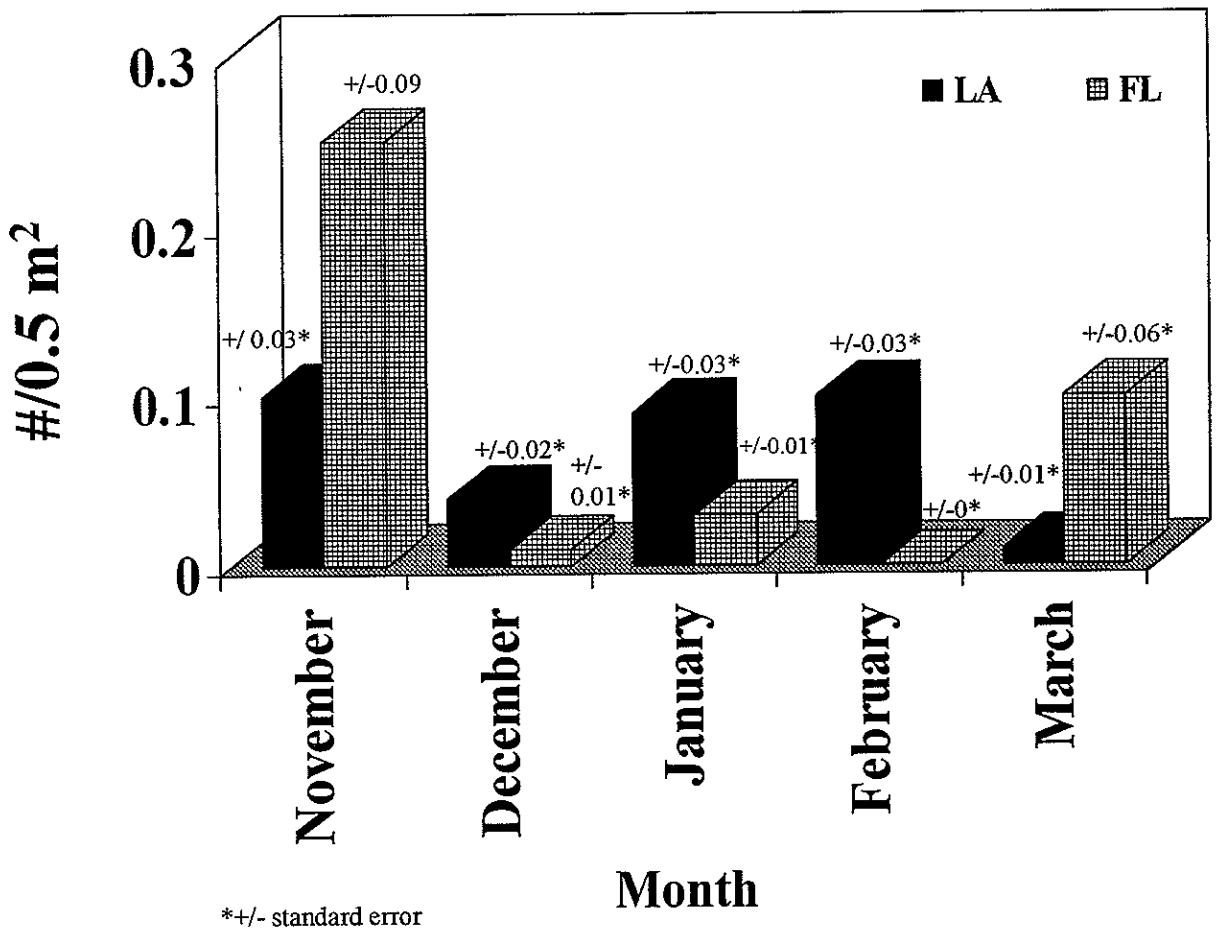

Fig 11. Density of Wharf Crabs (#/0.5 m ^{2}) during winter months of 1997-98 in Texas, Louisiana and Florida per month (n =100, with the exception of the Florida during December n=75).

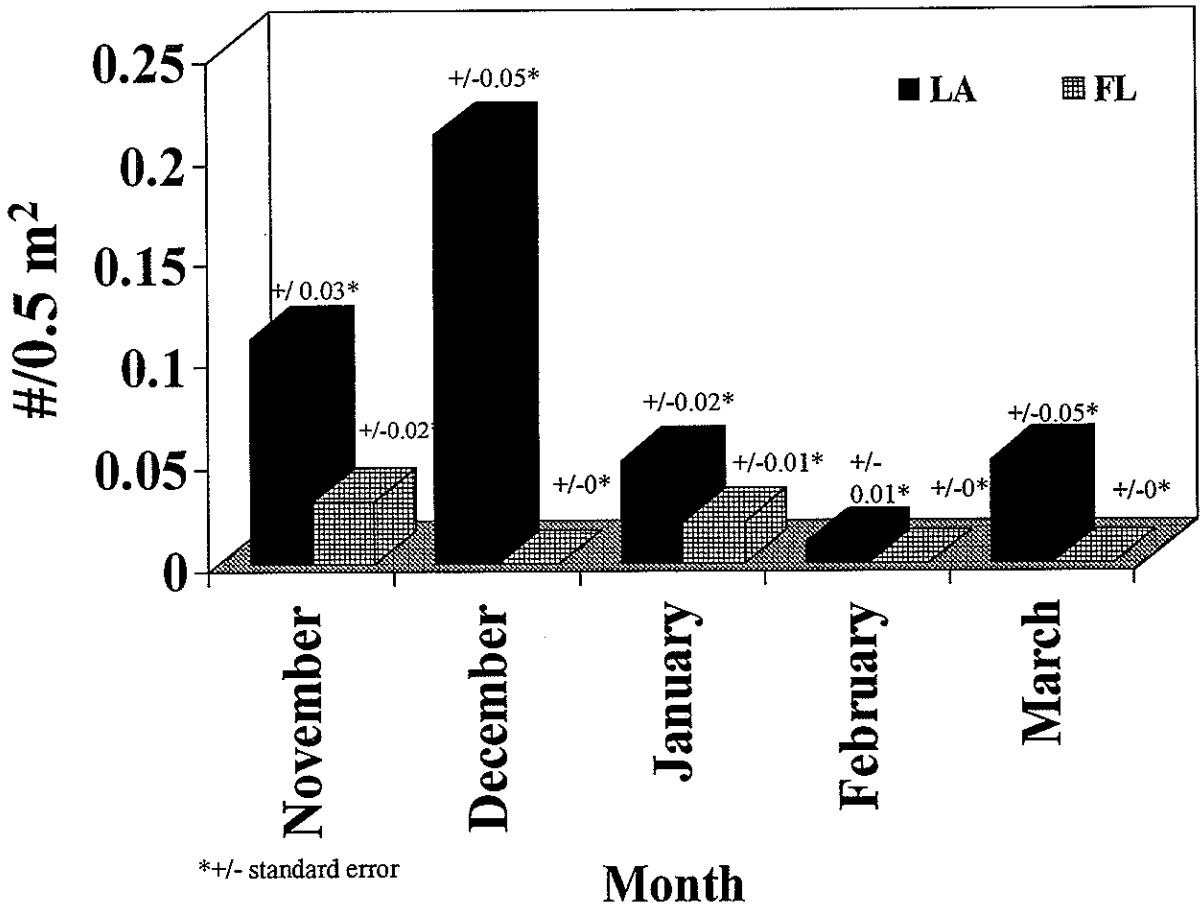

Fig 12. Density of Marsh Clams (#/0.5 m ^{2}) during winter months of 1997-98 in Texas, Louisiana and Florida per month (n=100, with the exception of the Florida during December n=75) In Louisiana, the species is *Rangia, spp.* in Florida it is *Polymesoda, spp.*

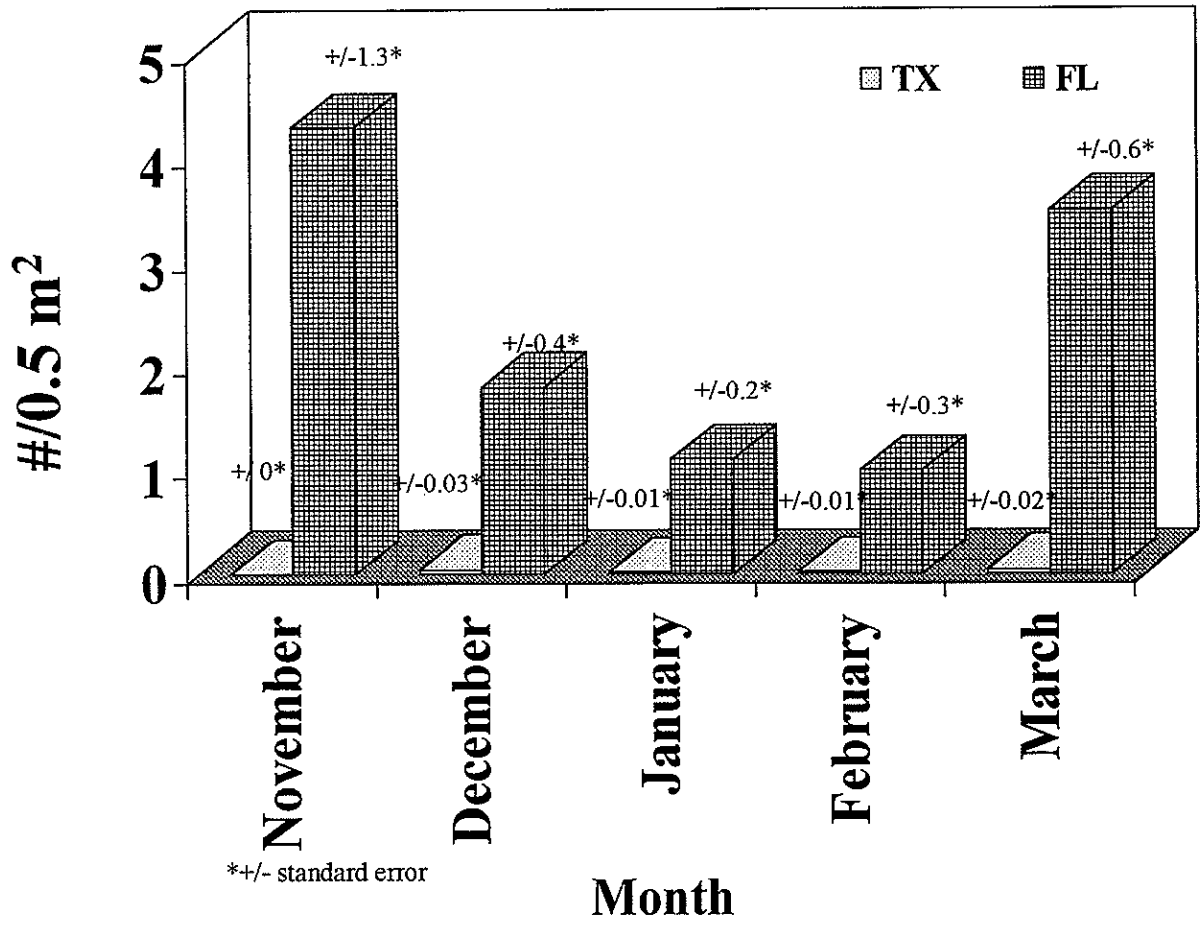

Fig 13. Density of Horn Snails (#/0.5 m^2) during winter months of 1997-98 in Texas and Florida per month (n =100, with the exception of the Florida during December n=75).

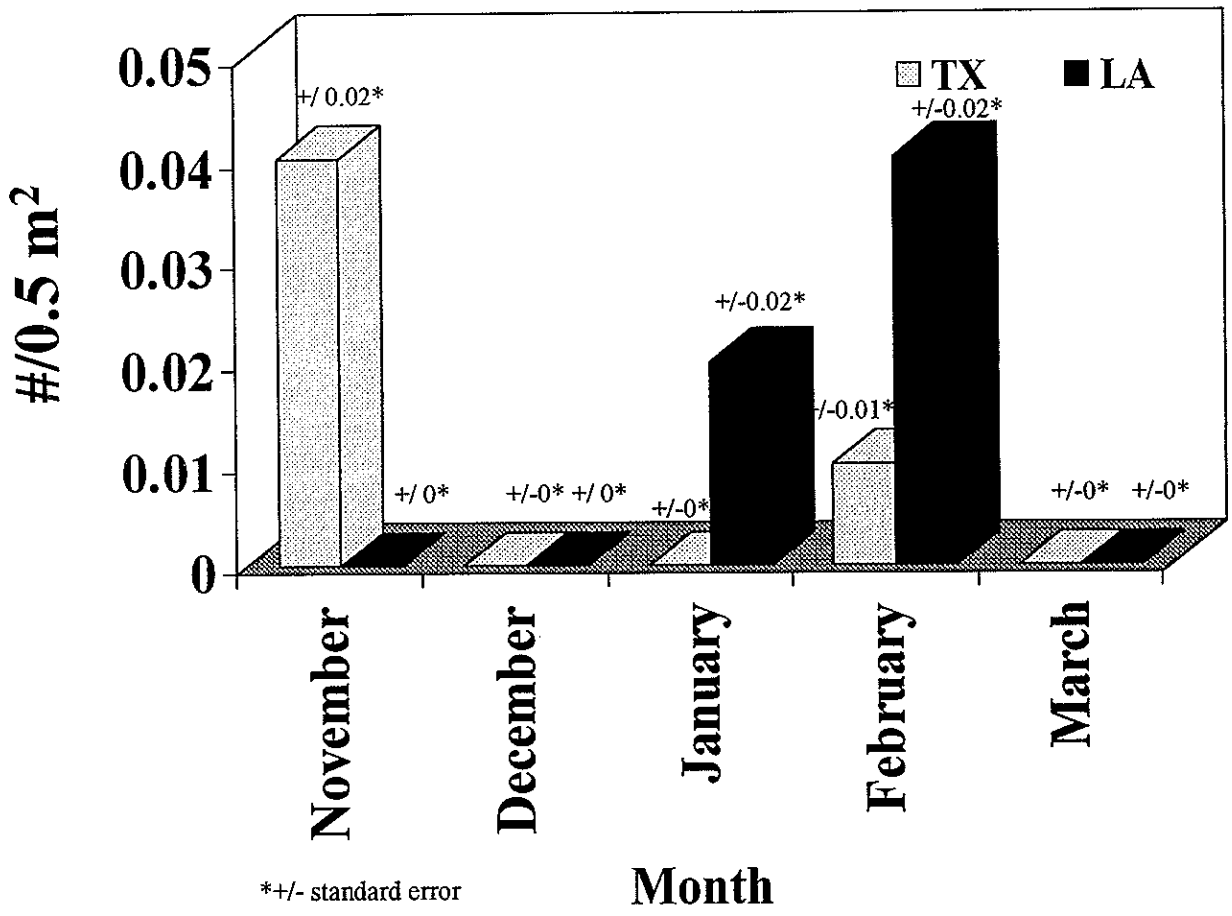

Fig 14. Density of *Succinia, spp.* (#/0.5 m ^{2}) during winter months of 1997-98 in Louisiana and Texas (n=100).

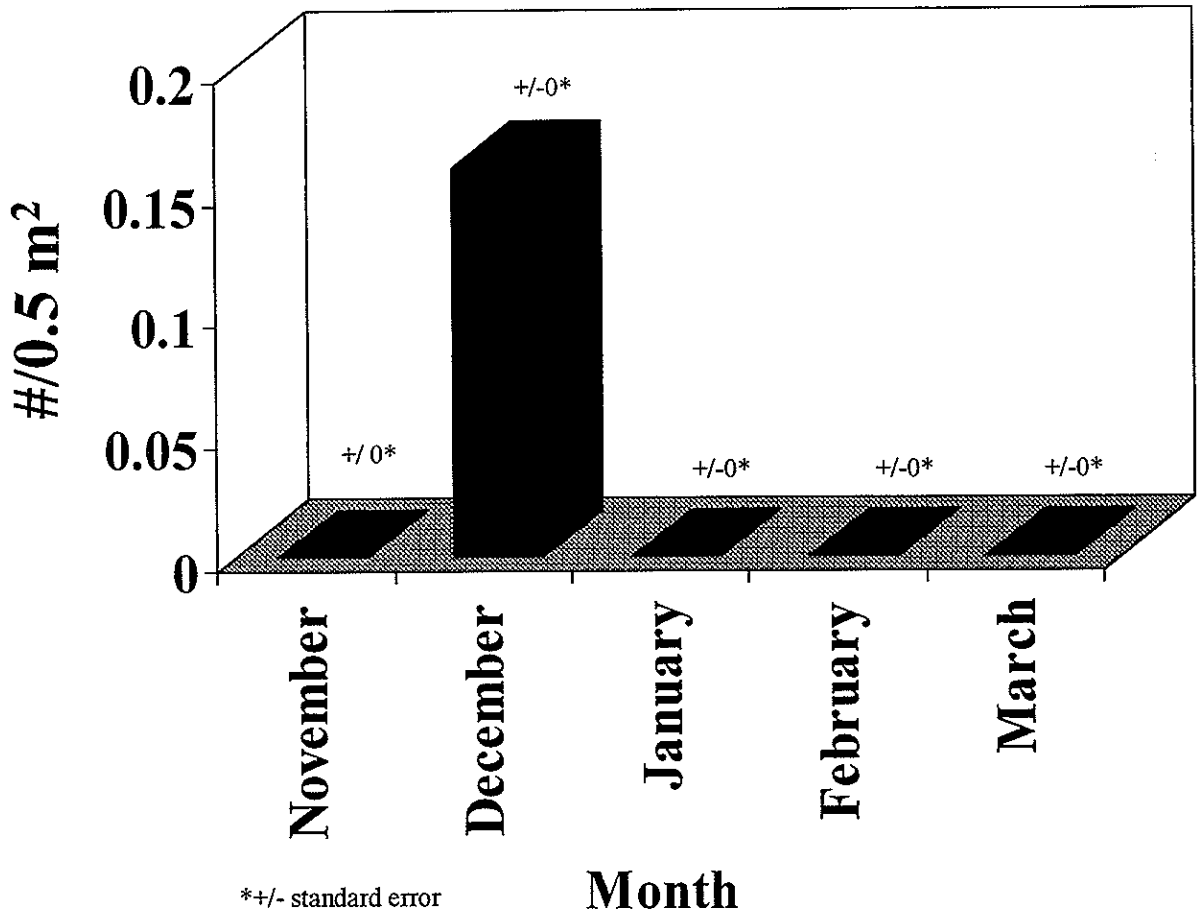

Fig 15. Density of juvenile Blue Crabs (#/0.5 m ^{2}) during winter months of 1997-98 in Louisiana per month (n =100).

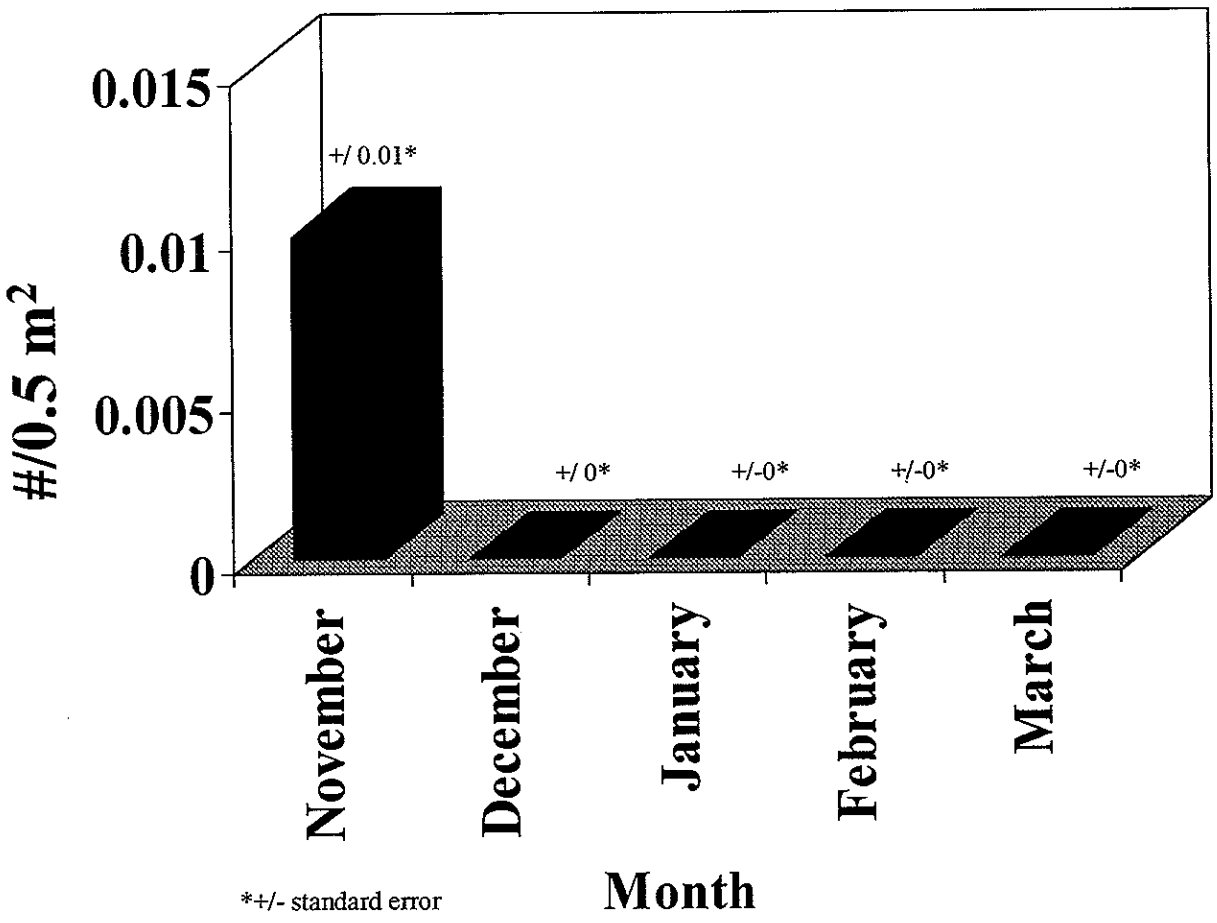

Fig 16. Density of Ghost Crabs (#/0.5 m ^{2}) during winter months of 1997-98 in Louisiana per month *(n*=100).

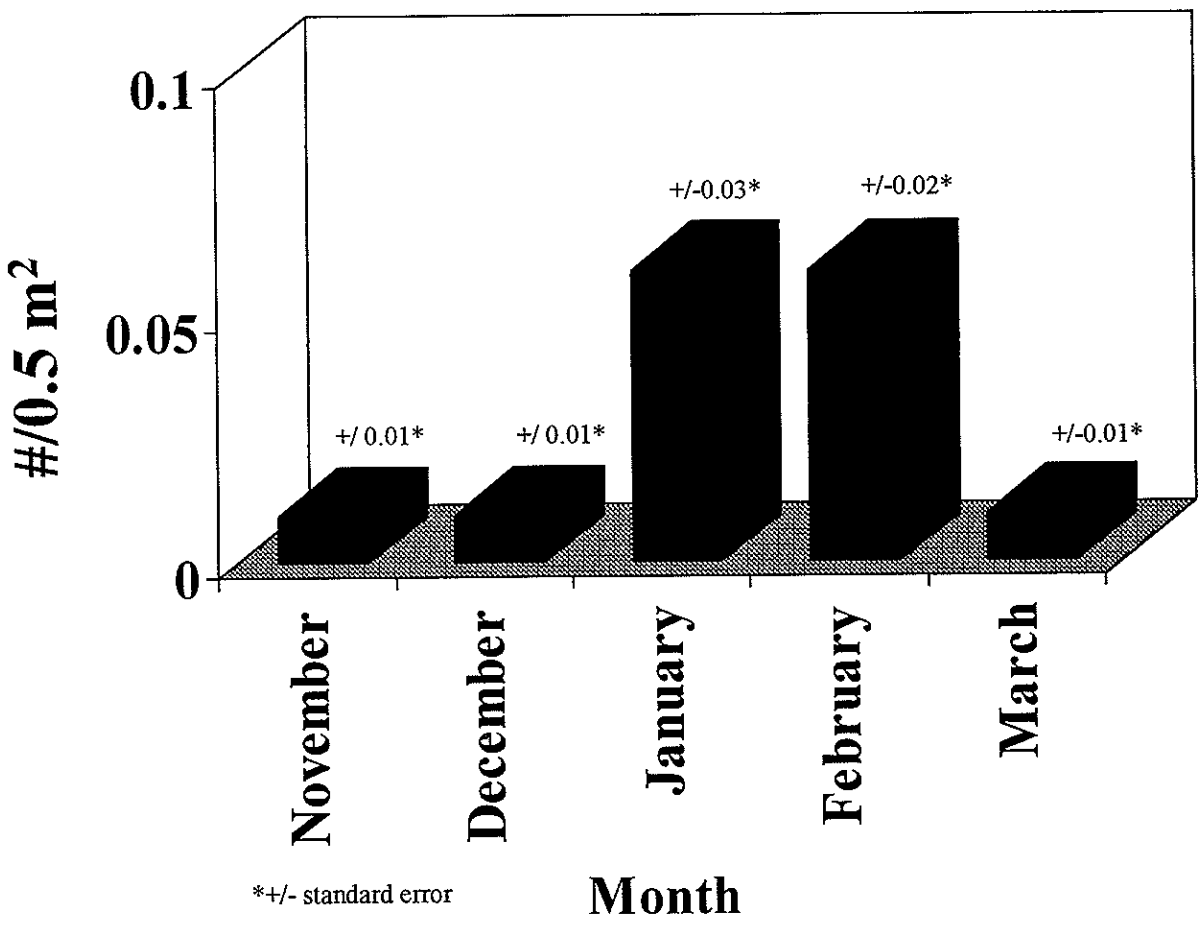

Fig 17. Density of Whirl Snails (#/0.5 m ^{2}) during winter months of 1997-98 in Louisiana per month (n =100).

APPENDIX E

Preliminary GIS Assessment Of Two Proposed Whooping Crane Migration Corridors

Preliminary GIS Assessment of Two Proposed Whooping Crane Migration Routes

22 July, 1997

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Introduction

A preliminary assessment of land cover and protected area coverage for buffer zones around the two proposed migration routes for an introduced migratory flock of whooping cranes was performed at a large-scale resolution. This analysis includes an examination of protected area coverage and land cover on two proposed migration corridors at several buffer sizes.

Methods

For this analysis, I obtained or generated three GIS data sets.

1) Managed Areas Database: A copy of the Managed Area Database (MAD) created by the Remote Sensing Research Unit, University of California Santa Barbara (McGhie 1996) was downloaded from their WWW site. This GIS database contains all types of managed areas existing in the conterminous United States, including land held by federal, state, tribal, and private agencies and organizations. MAD was developed at an approximate map scale of 1:2,000,000, with a Minimum Mapping Unit of about 100 hectares. A point coverage including areas that are smaller than this filter is available, but I only used the polygon coverage for this analysis, since it was area, not just quantity that I felt was most important.

2) Migration Routes: A map generated by Richard Urbanek provided the necessary baseline data for digitizing straight line proposed migration routes by using key landmarks on his map and the MAD. Both routes I analyzed began at the northern border of Agassiz National Wildlife Refuge (MN) since they are assumed to share a similar route until that point. The western route is simply defined as a straight line directly to Marsh Island Wildlife Refuge in Louisiana (~2100 km). The eastern route passes through Amsterdam Sloughs Wildlife Area (WI), Sandhill Wildlife Area (WI), Jasper-Pulaski FWA (IN) (approx.), Hiawassee Wildlife Refuge (TN) to Chassahowitzka National Wildlife Refuge (FL) (~2500 km) (Figure 1a). Each route was created as a separate ArcView 3.0 line shapefile.

3) Seasonal Land Cover AVHRR classification: A copy of the USGS North America Seasonal Land Cover (SLC) classification was downloaded from the EROS Data Center WWW site, imported into ERDAS Imagine image processing software, and converted to ARC/INFO GRID format for analysis. This data set has 1-km^2 nominal spatial resolution, and is based on 1-km^2 AVHRR (Advanced Very High Resolution Radiometer) data spanning April 1992 through March 1993. While several classifications of this AVHRR data set are available, the SLC was deemed most appropriate due to the high number of land cover classes (n = 205).

Data sets 1 and 2 were projected into Lambert Azimuthal Equal Area projection (the native SLC format) and then converted to 1-km^2 grids to match the native SLC projection and resolution before analysis. All subsequent query grids and masks had the same characteristics.

All analysis work was done in ESRI's Arcview GIS 3.0 using the Spatial Analyst extension and PC ARC/INFO 3.5. I ran no statistics to determine if observed differences are statistically significant. If needed these can be performed later.

For each route I performed the following analysis:

- *Buffer generation*: Using the Arcview GIS 3.0 Spatial Analyst, the Find Distance function was used to create a grid coverage that calculated linear distances from the migration route. Through the Map Query function, 4 separate buffer zone shapefiles were generated at distances of 50km, 75km, 100km, and 125km from the route (Figure 1b). This resulted in migration corridors with widths of double the buffer amount (100-250km). While the 250km corridor width was decided to be the widest corridor that whooping cranes might use, an analysis of different sized corridors up to that size was believed to be useful. Each buffer shapefile was converted to a grid. Through the use of a mask that allowed the route buffers to be clipped at roughly right angles to the ends of the straight line routes, the subsequent analysis was limited to the length of the route (rather than including buffers that extended in all directions from the end points). It should also be noted that large areas of open water (the Great Lakes, and the Gulf of Mexico) are excluded from all analyses (no MAD or SLC data). The area of the corridor was different for each route at each buffer distance because of length differences and masking:

Buffer Distance	**East Route**	**West Route**	**Ratio (E/W)**
50 km	244,238 km^2	213,025 km^2	1.15
75 km	362,150 km^2	318,745 km^2	1.14
100 km	478,490 km^2	424,074 km^2	1.13
125 km	592,374 km^2	529,078 km^2	1.12

For all analyses, both actual areas and percent of total buffer corridor area (to standardize comparisons) are presented in tables.

- *MAD query*: Using the Tabulate areas function, the MAD data set was queried to calculate area coverage by protected areas within each buffer. Area was reported by the field DESIGNATE, which defines the type of protected area designation (e.g., National Wildlife Refuge) (Figures 2 and 3).

- *SLC query*: Again, using the Tabulate areas function, the SLC data set was queried to calculate area coverage by land cover classes (a look-up table with these designations was linked to the coded grid coverage) within each buffer (Figures 4 and 5).

Results

MAD Query: The results of the MAD query, including a breakdown by 26 types of managed areas, is presented in Table 1. The general trend observed is that the eastern route has approximately double the land coverage in managed areas as the western route at every buffer distance (slightly less when comparing percent cover). The managed area types with the largest coverage include National Forests, State Forests, and Indian Reservations.

	Eastern Route				**Western Route**			
Buffer Distance:	*50km*	*75km*	*100km*	*125km*	*50km*	*75km*	*100km*	*125km*
Area km^2:	32,243	46,921	64,673	78,982	17,219	26,382	36,167	45,733
Percent of total:	13.2	13.0	13.5	13.3	8.1	8.3	8.5	8.6

SLC Query: Since the results of the SLC query could be analyzed an almost infinite number of ways, 3 such scenarios are presented which may be of interest for the examination of migration routes for whooping cranes. From 118 different land cover classes found within the routes (See Appendix for raw data on all classes), an analysis was performed on three major groups: Wetlands/Water (as a surrogate for possible stopover habitat), Cropland (as a potential food source), and Grasslands (as another potential stopover area). Distributions of these for these three aggregations are presented in Figures 6 and 7.

When examining the combined totals of five Wetland/Water designations (Table 2) and also for combined totals of 12 Grassland designations (Table 3), the western route appears to have more total area covered by these groups at every buffer distance. (Data for irrigated agriculture is also included in Table 2, but is approximately equal between routes). When looking at percent total calculations, the only significant difference appears in Grassland. For combined totals of 34 Cropland designations, the two routes appear to be very similar in both total area and percent of total (Table 4).

Discussion

The results of the MAD query can be taken at face value if it is determined that using ALL protected area designations to measure quality of a migration corridor is most appropriate. I provide the breakdown by type of managed area to allow inappropriate or ineffective managed area types to be removed from the analysis. It should be noted that some managed areas are not found in the data set (including Marsh Island WR), so the analysis may have some gaps, especially for smaller areas. However, a more complete data set of managed areas in the U.S is not available.

The SLC analysis is much more complicated as it is difficult to determine which groups best represent good stopover habitat for whooping cranes. Most designations suffer from a lack of specific definition, percentage cover indices for the components listed in the name, and overall reliability. AVHRR classifications such as this one have not proven to have high (> 50-70%) on-the-ground correlation in ground-truthing efforts, although newer algorithms show promise. Despite these limitations, it is still the best available universal data set for this large of an area at this scale.

Earlier discussions indicated that the 3 categorical breakdowns described above were most appropriate, but specific land cover classes were also provided to refine analysis if needed. Modifications of the analysis, by removing inappropriate designations, as in the MAD analysis, may be necessary. For example, the Water designation in Table 2 probably does not reflect area of whooping crane stopover habitat, but I felt it was an indication of potential appropriate shoreline habitats. Removal of this class results in a greater magnitude of difference between routes at all buffer differences. Most other designations in that table are vague representations of wetlands as well. Additionally, Grasslands in Table 3 may not all be potential stopover areas and Cropland comes in many forms (Table 4); it certainly needs some refinement to make a "best guess" of appropriate areas for feeding (e.g., croplands with wooded areas might need to be dropped).

Next steps

Given the scale of the required analysis, this was the best rapid option. Despite the limitations of the data, this analysis provides initial methods for quantitative assessment. More importantly, now that the data set is collected, it can be re-queried as necessary. New or revised analyses based upon the current data could be run in a relatively short time. Team members should look especially closely at the specific land cover classes or managed areas that should be excluded from the initial analysis for additional queries.

In addition to the MAD maps, figures depicting the distribution of aggregations of the three major SLC groups (Figures 6 and 7) used for land cover analysis are also included. These help illustrate the general distribution of these land cover types, and the areas in which none of these three major groups occur. This may help identify areas in which there may be some concern (i.e., inappropriate habitat composition or lack of protected areas of significant size) and where we may need to take a closer look.

A way that these queries may be refocused is to examine which AVHRR classes are represented in known suitable winter habitats or by looking at suitable stopover habitats in the current flyway. However, a preliminary examination of the two proposed winter sites revealed that the land cover classes were not too similar between the two; the only class they shared was Water. Extrapolating suitable stopover habitat from suitable winter habitat may be a stretch. Another option may be to look at the composition of the Aransas/Wood Buffalo migratory corridor to see how it compares with these two proposed routes, but there has been little time to run this analysis. This analysis may help identify important land cover characteristics of the flyway.

Literature Cited

McGhie, R. Gavin. 1996. Creation of a Comprehensive Managed Areas Spatial Database for the Conterminous United States: Summary Project Technical Report (NASA-NAGW-1743). NCGIA Technical Report 96-4. NCGIA, University of California Santa Barbara, California.

Table 1. Area Coverage by Managed Area Designations* in Buffered Corridors of Two Proposed Migratory Routes

	East Route				West Route			
Protected Area Type	50km	75km	100km	125km	50km	75km	100km	125km
Forest Preserve	189	189	189	189	0	0	0	0
Government Reservation	156	169	169	169	0	0	0	0
Indian Reservation	4639	5640	7244	9642	3604	4821	5923	6937
Military Reservation	364	704	1302	1863	189	437	903	1675
National Battlefield Park	0	18	18	18	8	8	8	8
National Forest	13849	19193	26864	34147	7909	12604	18063	21967
National Grassland	0	0	0	0	0	0	0	11
National Historic Park	0	0	107	149	0	0	0	0
National Lakeshore	54	54	54	54	0	0	0	0
National Military Park	0	0	0	17	0	0	17	17
National Monument	1	1	1	1	0	0	4	7
National Park	454	1115	1767	1990	27	27	27	27
National Reserve and Recreation Area	447	447	447	447	0	0	0	0
National Scenic River	613	866	1028	1203	486	572	572	572
National Scientific Reserve	16	16	16	16	0	0	0	0
National Wildlife Refuge	1019	1939	2813	3139	1085	1133	1303	1513
State Forest	9176	14729	20130	22692	1472	3264	4835	7815
State Memorial Park	0	0	0	0	2	2	2	2
State Natural Area	48	48	48	48	0	0	0	0
State Park	485	812	963	1121	396	560	617	730
State Park and Forest	43	79	79	79	0	0	0	0
Wild and Scenic River	420	623	1041	1401	2041	2954	3893	4452
Wilderness (Forest Service)	187	196	214	279	0	0	0	0
Wilderness (FWS)	21	21	21	78	0	0	0	0
Wilderness (USFS)	62	62	62	62	0	0	0	0
World Heritage Site	0	0	96	178	0	0	0	0
Total Area km^2:	32243	46921	64673	78982	17219	26382	36167	45733
Percent of total area:	13.2	13.0	13.5	13.3	8.1	8.3	8.5	8.6
Unclassified (EMPTY)	1012	1205	1399	1969	23	41	41	339

* Source: Managed Area Database created by NCGIA, University of California Santa Barbara, California 7/22/97

Table 2. Area Coverage by Wetland/Water Land Cover Designations* in Buffered Corridors of Two Proposed Migratory Routes

Land Cover Class	East Route				West Route			
	50km	75km	100km	125km	50km	75km	100km	125km
Cropland (Small Grains, Hay, Pasture) with Wetlands	192	274	322	387	1764	2631	3634	4384
Grassland with Woodland and Wetlands	0	3	21	48	657	884	1173	2345
Low Shrubs (Willow, Alder) and Wet Herbaceous	8	13	13	13	5	5	7	7
Mixed Wetlands; Herbaceous and Woody (Mangrove)	6	6	17	26	4	17	33	35
Water	5394	7847	9556	12239	3397	5797	8054	9605
Total Area km^2:	5600	8143	9929	12713	5827	9334	12901	16376
Percent of total area:	2.29	2.25	2.08	2.15	2.74	2.93	3.04	3.10
Irrigated Agriculture	0	0	0	0	0	1	1	1
Irrigated Agriculture	1	2	7	7	57	134	184	259
Irrigated Agriculture	89	127	151	160	10	10	11	11
Total Area km^2:	90	129	158	167	67	145	196	271
Percent of total area:	0.04	0.04	0.03	0.03	0.03	0.05	0.05	0.05

Table 3. Area Coverage by Grassland Land Cover Designations* in Buffered Corridors of Two Proposed Migratory Route

Land Cover Class	East Route				West Route			
	50km	75km	100km	125km	50km	75km	100km	125km
Grassland	2	5	7	10	0	0	3	4
Grassland	0	9	28	28	0	0	0	4
Grassland (Short Grass Prairie)	229	233	237	244	0	1	21	21
Grassland (Short mid Grass Prairie)	142	142	145	153	1	2	9	10
Grassland (Tall Grass Prairie)	13	16	22	26	108	223	356	656
Grassland (Warm Season Grasses)	966	1074	1140	1186	29	102	209	276
Grassland with Cropland	72	96	198	269	0	0	0	0
Grassland with Cropland	0	0	0	0	67	142	276	333
Grassland with Cropland (Small Grains)	0	0	0	0	1	10	57	78
Grassland with Cropland (Small Grains, Pasture)	65	68	76	81	53	95	121	141
Grassland with Woodland and Wetlands	0	3	21	48	657	884	1173	2345
Grassland/Woodland (Oak) Mosaic with Cropland	565	692	810	1079	2136	3759	5776	8790
Total Area km^2:	2054	2338	2684	3124	3052	5218	8001	12658
Percent of total area:	0.84	0.65	0.56	0.53	1.43	1.64	1.89	2.39

* USGS Seasonal Land Cover AVHRR Classification

Table 4. Area Coverage by Cropland Land Cover Designations* in Buffered Corridors of Two Proposed Migratory Routes

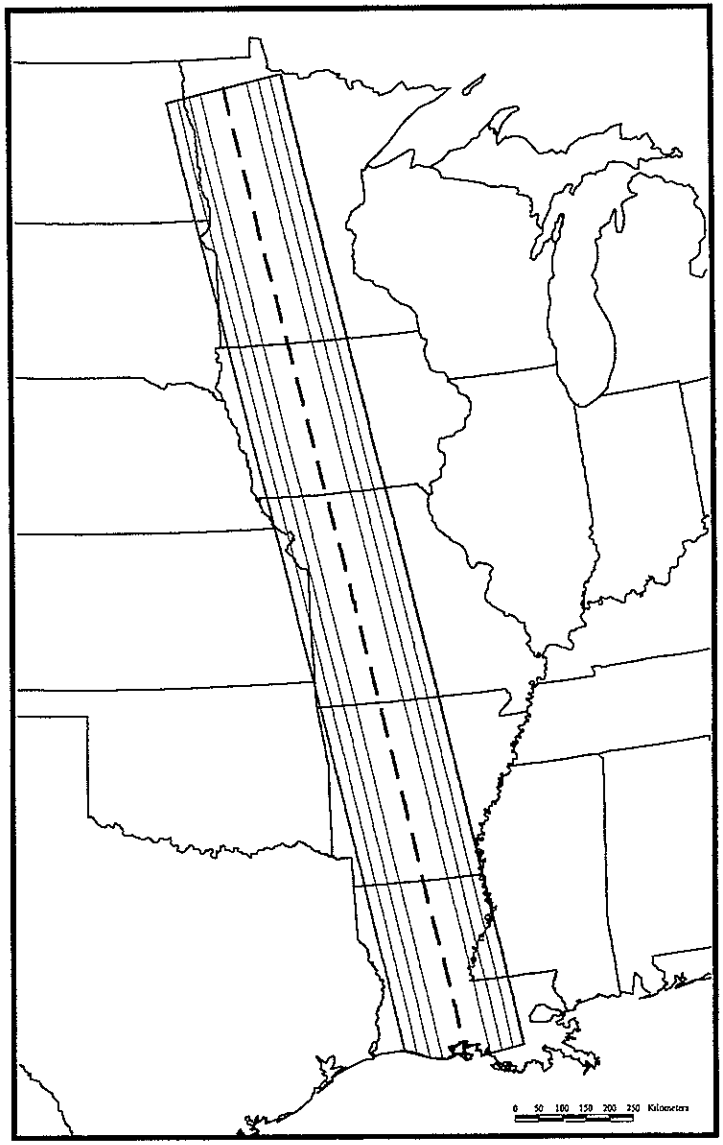
Land Cover Class	East Route				West Route			
	50km	75km	100km	125km	50km	75km	100km	125km
Cropland (Corn and Other Row Crops, Forage Crops)	9088	12368	15109	17082	0	6	6	45
Cropland (Corn and Soybeans)	2	2	25	214	41220	61474	82207	102174
Cropland (Corn and Soybeans)	24112	36740	49339	62528	1315	2126	4195	6825
Cropland (Corn and Soybeans)	62	119	283	524	547	660	782	816
Cropland (Corn, Cotton, Sorghum, Pasture)/Grassland Mosaic	0	0	0	0	2	30	102	166
Cropland (Corn, Small Grains)/Deciduous Forest (Oak, Hickory) Mosaic	174	237	333	558	4542	7466	10727	15972
Cropland (Corn, Sorghum, Small Grains)/Grassland Mosaic	0	0	0	0	40	72	86	118
Cropland (Corn, Soybeans, Alfalfa)/Woodlands Mosaic	14141	18578	21791	24652	20	47	98	258
Cropland (Corn, Soybeans, Cotton, Rice) with Woodlands	10299	15442	21531	27240	13182	18412	23551	28829
Cropland (Corn, Soybeans, Pasture)/Woodland (Maple, Elm) Mosaic	18507	28845	39194	47321	0	0	21	44
Cropland (Corn, Soybeans, Pasture)/Woodland (Oak, Hickory) Mosaic	8744	12733	15652	20087	6307	10801	15964	21247
Cropland (Cotton, Soybeans, Rice)	6315	8649	10123	11714	2817	4541	5632	6477
Cropland (Cultivated Grasses) with Savanna	15	15	15	17	5	7	8	12
Cropland (Cultivated Grasses) with Woodland	1	2	2	2	0	0	0	0
Cropland (Mixed Row Crops) with Woodland	1867	3116	4920	6694	24927	36034	45127	52414
Cropland (Pasture)/Grassland Mosaic	8135	11932	15849	18942	100	156	194	237
Cropland (Row Crops, Small Grains)/Grassland Mosaic	1482	2456	3799	5394	8683	11812	14849	17413
Cropland (Small Grains) with Grasslands	0	0	0	0	0	0	4	4
Cropland (Small Grains, Hay, Pasture) with Wetlands	192	274	322	387	1764	2631	3634	4384
Cropland (Small Grains, Pasture) with Deciduous Woodlands	166	200	254	312	263	967	1802	3007
Cropland (Small Grains, Pasture)/Grassland Mosaic	310	725	1372	2454	1774	2761	4609	6668
Cropland (Small Grains, Row Crops)	50	68	104	381	598	1488	2166	3170
Cropland (Small Grains, Row Crops)/Grassland	2	2	2	7	39	94	127	191
Cropland (Sugar Cane)	77	98	98	115	0	0	0	0
Cropland (Truck Crops) with Deciduous Woodlands (Oak)	144	186	269	320	0	0	13	18
Cropland (Winter Wheat)	0	0	0	0	20	35	47	56
Cropland with Grassland	2	2	2	2	0	0	0	0
Cropland with Savanna	0	0	0	0	45	45	45	68
Cropland(corn, Cotton, Soybeans)/Evergreen Needleleaf Forest (Slash Pine) Mosaic	4897	7172	9801	11814	77	112	199	266
Cropland, Woodland, Urban Mosaic	2136	2501	2730	2991	310	521	879	1109
Cropland/Deciduous Forest (Aspen) Mosaic	7623	10787	13868	16047	10208	14157	17896	20221
Cropland/Grassland	0	0	0	0	0	0	0	0
Cropland/Woodland	4	14	20	20	12	15	22	31
Cropland/Woodland (Maple, Beech, Birch) Mosaic	25645	35800	46985	58298	11420	17235	22877	30135
Total Area km^2:	144192	209063	273792	336117	130237	193705	257869	322375
Percent of total area:	59.0	57.7	57.2	56.7	61.1	60.8	60.8	60.9

* USGS Seasonal Land Cover AVHRR Classification

7/22/97

Figure 1: Buffered corridors for two proposed whooping crane migration routes.

West Route



East Route

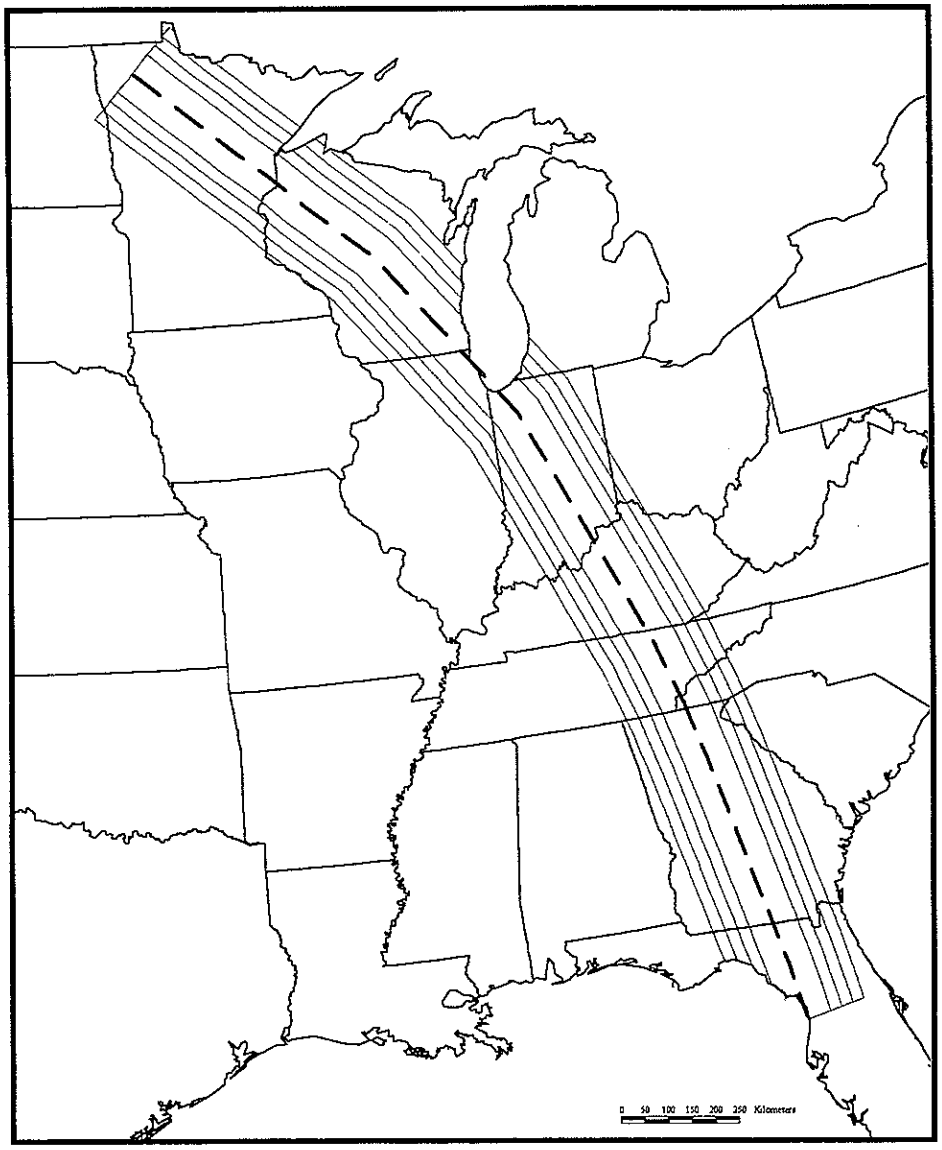
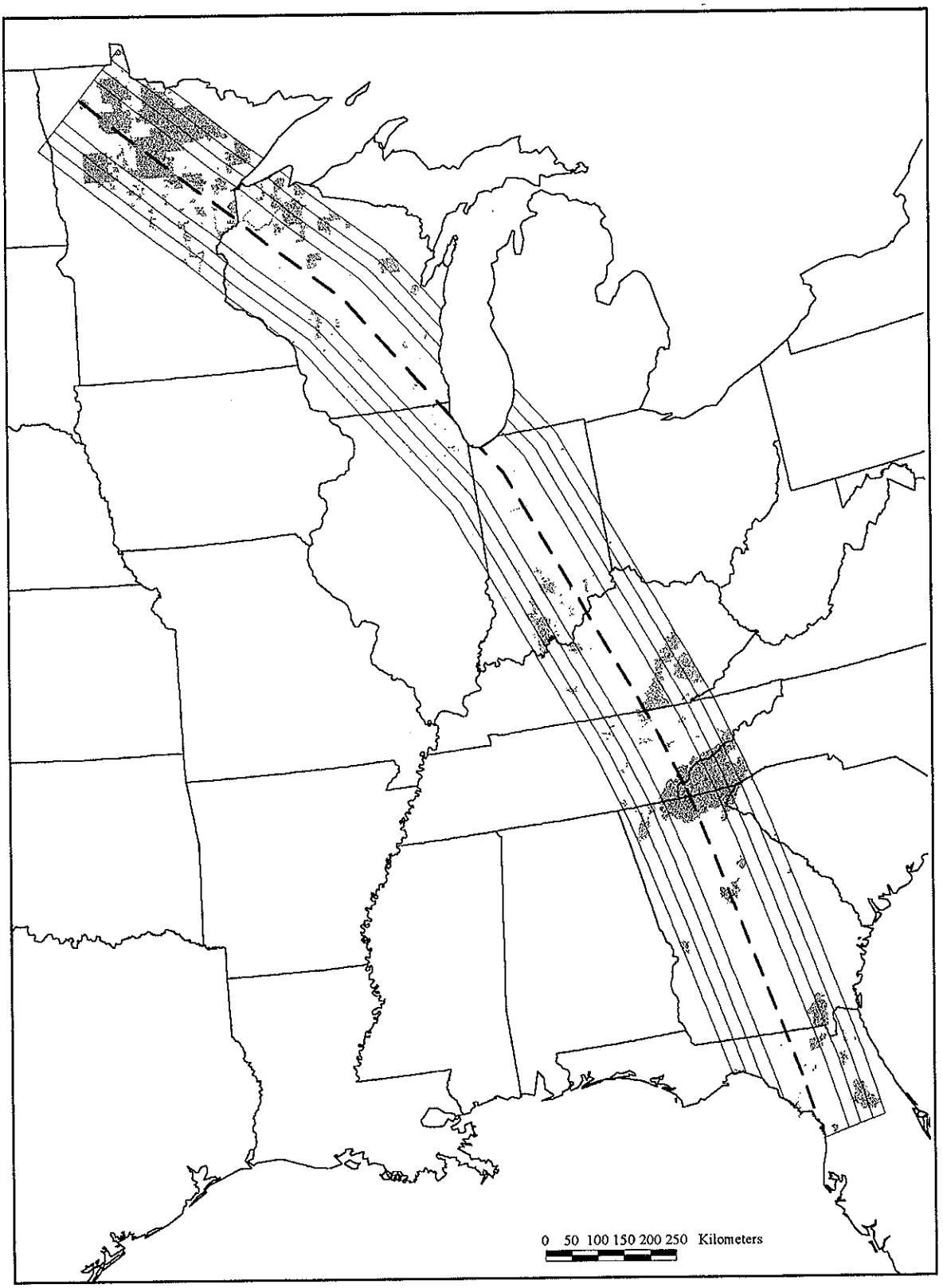
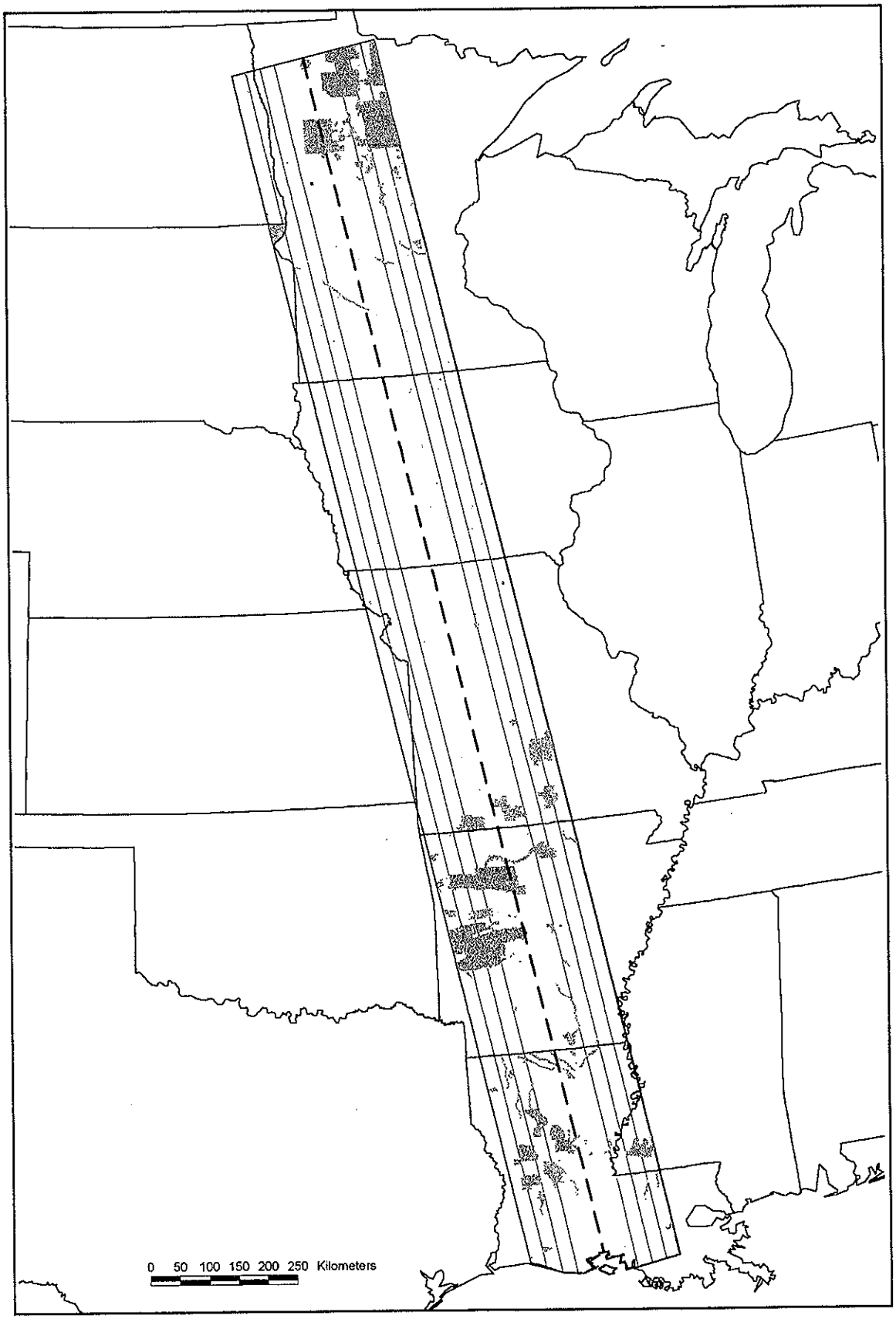


Figure 2. Managed area coverage for buffered corridors of the east route.



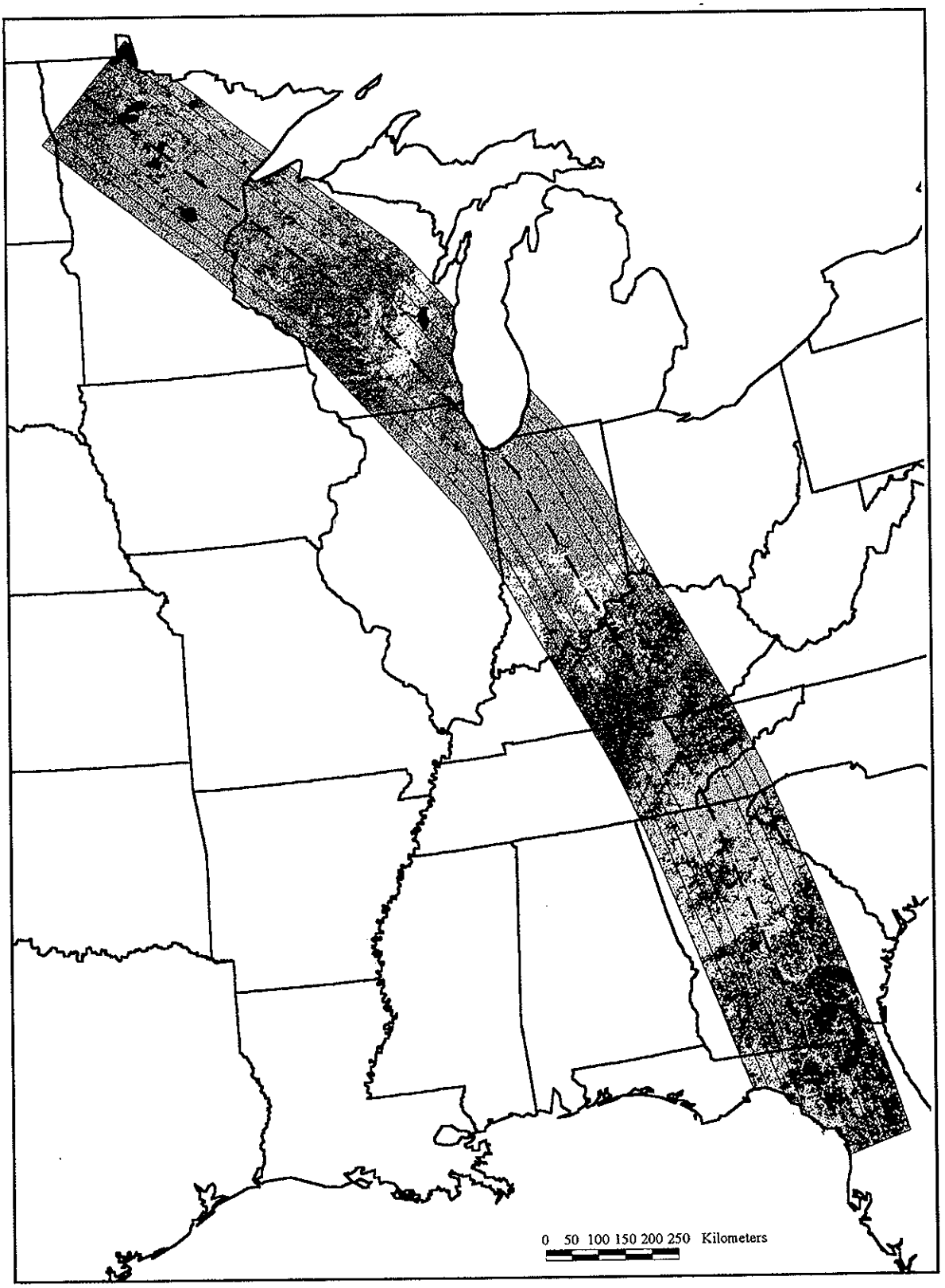
Managed Areas derived from: McGhie, R. Gavin. 1996. Creation of a Comprehensive Managed Areas Spatial Database for the Conterminous United States: Summary Project Technical Report (NASA-NAGW-1743). NCGIA Technical Report 96-4. NCGIA, University of California Santa Barbara, California.

Figure 3. Managed area coverage for buffered corridors of the west route.



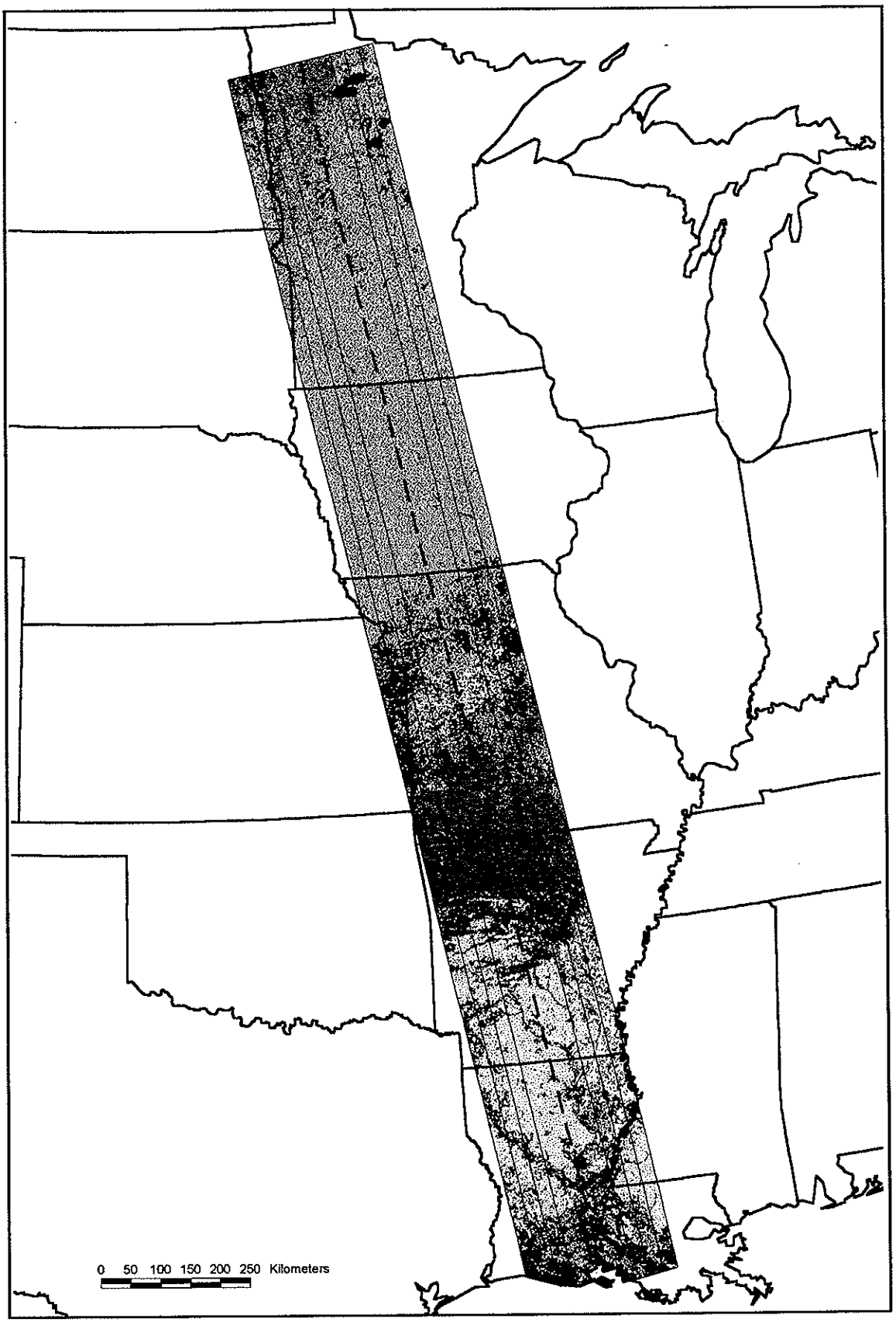
Managed Areas derived from: McGhie, R. Gavin. 1996. Creation of a Comprehensive Managed Areas Spatial Database for the Conterminous United States: Summary Project Technical Report (NASA-NAGW-1743). NCGIA Technical Report 96-4. NCGIA, University of California Santa Barbara, California.

Figure 4. USGS seasonal land cover classification for buffered corridors of the east route.



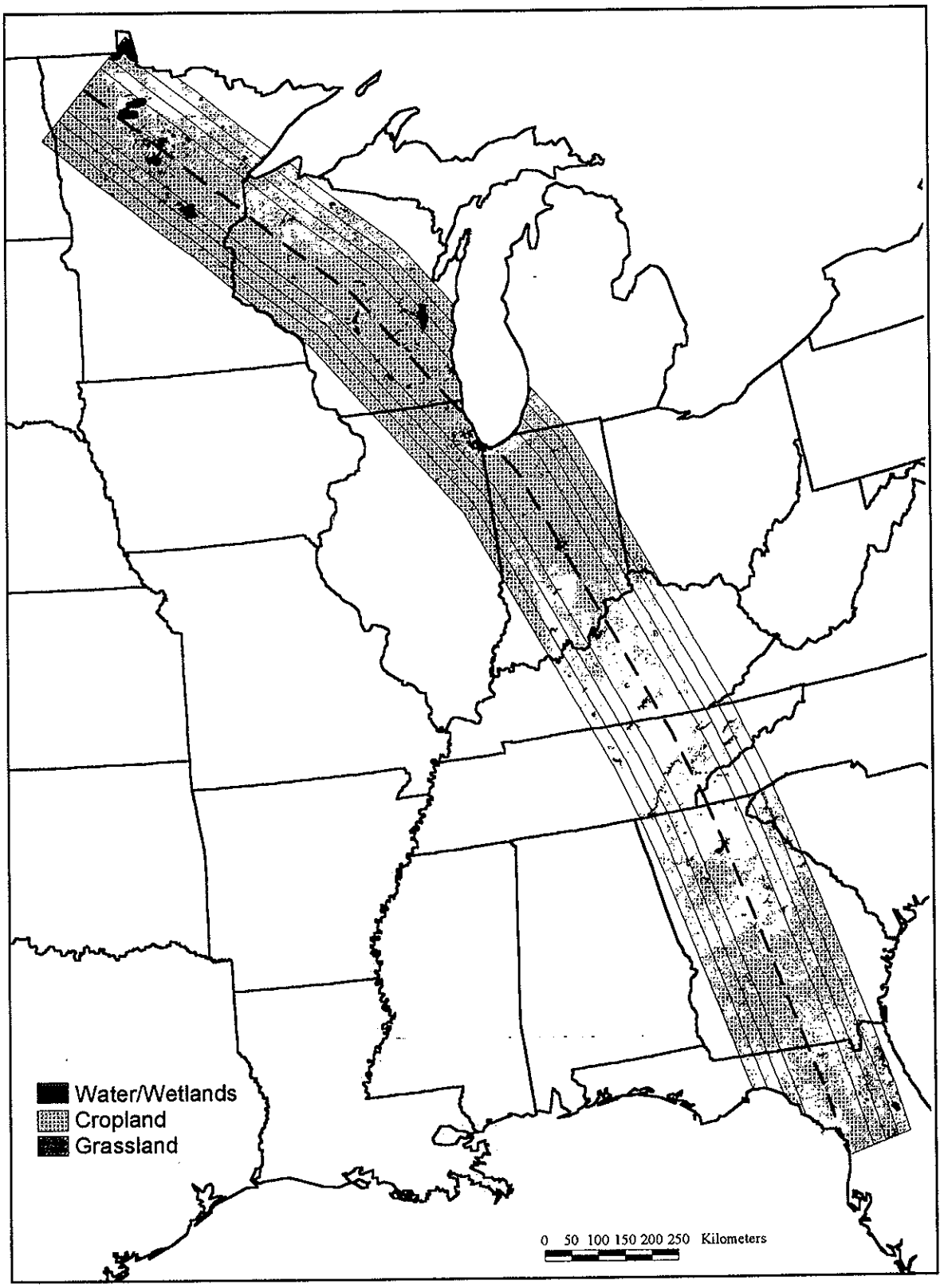
Source: The USGS North America Seasonal Land Cover classification has 1-km2 nominal spatial resolution, and is based on 1-km2 AVHRR (Advanced Very High Resolution Radiometer) data spanning April 1992 through March 1993.

Figure 5. USGS seasonal land cover classification for buffered corridors of the west route.



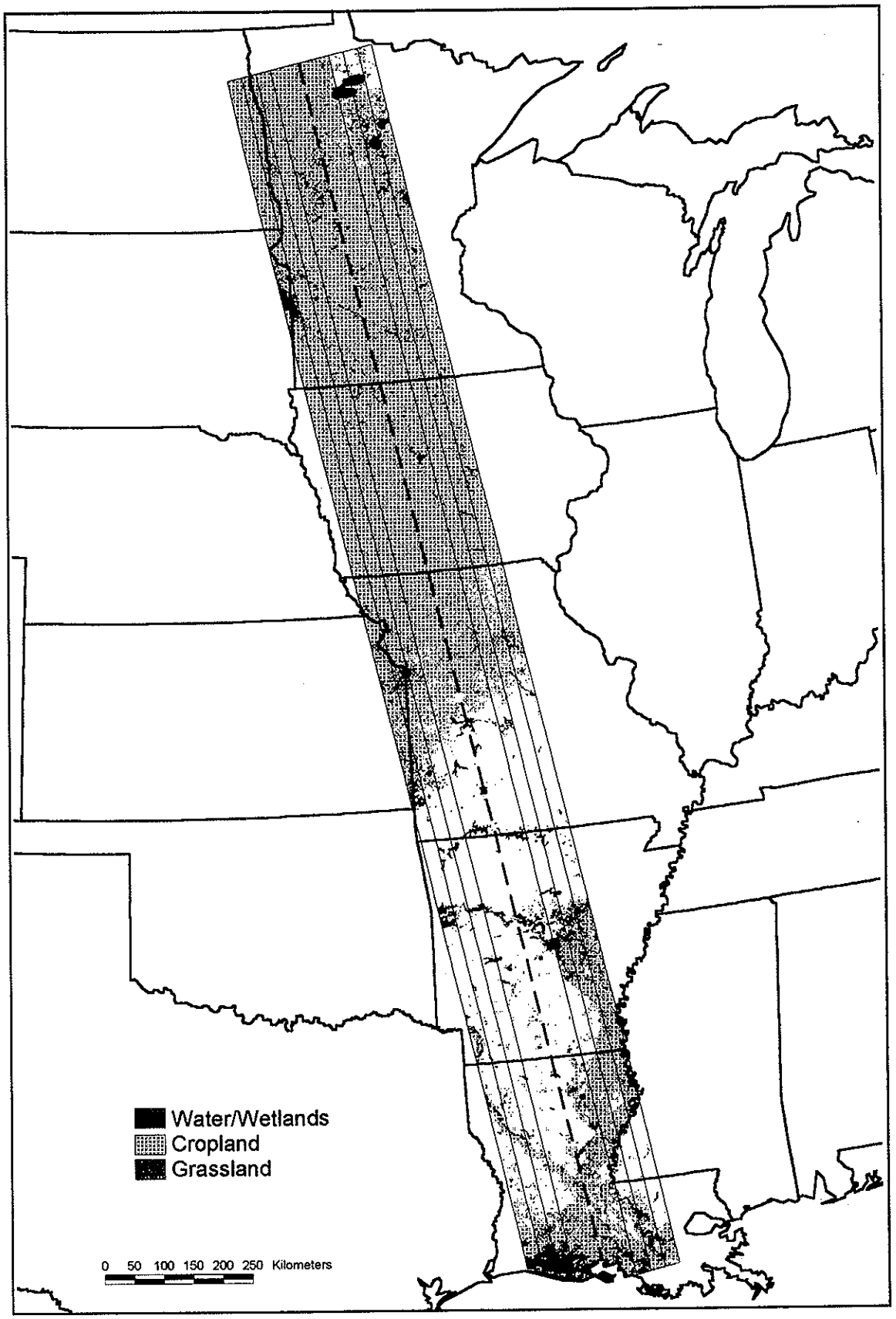
Source: The USGS North America Seasonal Land Cover classification has 1-km2 nominal spatial resolution, and is based on 1-km2 AVHRR (Advanced Very High Resolution Radiometer) data spanning April 1992 through March 1993.

Figure 6. Consolidated USGS seasonal land cover classes for buffered corridors of the east route.



Source: The USGS North America Seasonal Land Cover classification has 1-km2 nominal spatial resolution, and is based on 1-km2 AVHRR (Advanced Very High Resolution Radiometer) data spanning April 1992 through March 1993.

Figure 7. Consolidated USGS seasonal land cover classes for buffered corridors of the west route.



Source: The USGS North America Seasonal Land Cover classification has 1-km2 nominal spatial resolution, and is based on 1-km2 AVHRR (Advanced Very High Resolution Radiometer) data spanning April 1992 through March 1993.

Appendix: Area Coverage (km^2) by USGS Seasonal Land Cover AVHRR Classes

	USGS Seasonal Land Cover Class (several have the same name, different map codes)	East 50 km	East 75km	East 100km	East 125km	West 50km	West 75km	West 100km	West 125km
1	Black Spruce, Tamarack, Lichen Woodland	0	0	0	1	2	2	4	5
2	Cropland (Corn and Other Row Crops, Forage Crops)	9088	12368	15109	17082	0	6	6	45
3	Cropland (Corn and Soybeans)	2	2	25	214	41220	61474	82207	102174
4	Cropland (Corn and Soybeans)	24112	36740	49339	62528	1315	2126	4195	6825
5	Cropland (Corn and Soybeans)	62	119	283	524	547	660	782	816
6	Cropland (Corn, Cotton, Sorghum, Pasture)/Grassland Mosaic	0	0	0	0	2	30	102	166
7	Cropland (Corn, Small Grains)/Deciduous Forest (Oak, Hickory) Mosaic	174	237	333	558	4542	7466	10727	15972
8	Cropland (Corn, Sorghum, Small Grains)/Grassland Mosaic	0	0	0	0	40	72	86	118
9	Cropland (Corn, Soybeans, Alfalfa)/Woodlands Mosaic	14141	18578	21791	24652	20	47	98	258
10	Cropland (Corn, Soybeans, Cotton, Rice) with Woodlands	10299	15442	21531	27240	13182	18412	23551	28829
11	Cropland (Corn, Soybeans, Pasture)/Woodland (Maple, Elm) Mosaic	18507	28845	39194	47321	0	0	21	44
12	Cropland (Corn, Soybeans, Pasture)/Woodland (Oak, Hickory) Mosaic	8744	12733	15652	20087	6307	10801	15984	21247
13	Cropland (Cotton, Soybeans, Rice)	6315	8649	10123	11714	2817	4541	5632	6477
14	Cropland (Cultivated Grasses) with Savanna	15	15	15	17	5	7	8	12
15	Cropland (Cultivated Grasses) with Woodland	1	2	2	2	0	0	0	0
16	Cropland (Mixed Row Crops) with Woodland	1867	3116	4920	6694	24927	36034	45127	52414
17	Cropland (Pasture)/Grassland Mosaic	8135	11932	15849	18942	100	156	194	237
18	Cropland (Row Crops, Small Grains)/Grassland Mosaic	1482	2456	3799	5394	8683	11812	14849	17413
19	Cropland (Small Grains) with Grasslands	0	0	0	0	0	0	4	4
20	Cropland (Small Grains, Hay, Pasture) with Wetlands	192	274	322	387	1764	2631	3634	4384
21	Cropland (Small Grains, Pasture) with Deciduous Woodlands	166	200	254	312	263	967	1802	3007
22	Cropland (Small Grains, Pasture)/Grassland Mosaic	310	725	1372	2454	1774	2761	4609	6668
23	Cropland (Small Grains, Row Crops)	50	68	104	381	598	1488	2166	3170
24	Cropland (Small Grains, Row Crops)/Grassland	2	2	2	7	39	94	127	191
25	Cropland (Sugar Cane)	77	98	98	115	0	0	0	0
26	Cropland (Truck Crops) with Deciduous Woodlands (Oak)	144	186	269	320	0	0	13	18
27	Cropland (Winter Wheat)	0	0	0	0	20	35	47	56
28	Cropland with Grassland	2	2	2	2	0	0	0	0
29	Cropland with Savanna	0	0	0	0	45	45	45	68
30	Cropland(corn, Cotton, Soybeans)/Evergreen Needleleaf Forest (Slash Pine) Mosaic	4897	7172	9801	11814	77	112	199	266
31	Cropland, Woodland, Urban Mosaic	2136	2501	2730	2991	310	521	879	1109
32	Cropland/Deciduous Forest (Aspen) Mosaic	7623	10787	13868	16047	10208	14157	17896	20221
33	Cropland/Grassland	0	0	0	0	0	0	0	0
34	Cropland/Woodland	4	14	20	20	12	15	22	31
35	Cropland/Woodland (Maple, Beech, Birch) Mosaic	25645	35800	46985	58298	11420	17235	22877	30135
36	Deciduous Dry Forest with Savanna Patches	6	7	7	9	61	129	212	235
37	Deciduous Forest (Aspen, Birch, Balsam Poplar) with Black and White Spruce	0	8	17	41	39	39	39	39
38	Deciduous Forest (Maple, Beech, Birch) with Cropland (Pasture, Hay)	7	8	12	12	3	16	17	17
39	Deciduous Forest (Maple, Beech, Birch, Oak, Hickory) with Pasture	7402	12710	19229	23436	3782	5622	7516	9800
40	Deciduous Forest (Oak, Hickory, Sweet Gum, Southern Pines) with Cropland and Pasture	23536	36556	50024	63751	39748	58303	76971	93317
41	Deciduous Tropical Dryland Woodland	0	1	2	4	20	45	101	208
42	Deciduous Woodlands (Aspen)/Shrublands (Mountain Mahogany)	50	76	95	96	9	42	61	68
43	Degraded Tropical Forest	17	39	51	54	0	0	0	1
44	Degraded Tropical Forest	0	4	9	9	0	0	0	0
45	Desert Shrubland/Grassland (Creosote, Saltbush, Mesquite, Sand Sage)	6	6	6	6	0	0	0	0
46	Evergreen Broadleaf Tropical Forest	6	17	22	23	0	0	0	0
47	Evergreen Needleleaf Forest (Balsam Fir, Black Spruce, White Spruce)	7	19	31	35	0	2	4	7
48	Evergreen Needleleaf Forest (Douglas Fir, Lodgepole Pine, Larch, Western Red Cedar)	0	0	0	0	0	0	0	0
49	Evergreen Needleleaf Forest (Loblolly, Slash Pine) with Hardwoods (Gum, Cypress)	30053	44489	58371	71829	30592	44953	57259	68534
50	Evergreen Needleleaf Forest (Longleaf, Slash Pine)	4202	6931	9083	11708	50	238	463	894
51	Evergreen Needleleaf Forest (Pine Species)	0	4	4	4	0	0	0	0
52	Evergreen Needleleaf Forest (Ponderosa Pine, Douglas Fir, Western Red Cedar)	531	1200	1508	1790	26	160	438	746
53	Evergreen Needleleaf Forest and Woodland (Black and White Spruce)	62	91	132	148	9	12	20	25
54	Grassland	2	5	7	10	0	0	3	4
55	Grassland	0	9	28	28	0	0	0	4
56	Grassland (Short Grass Prairie)	229	233	237	244	0	1	21	21
57	Grassland (Short mid Grass Prairie)	142	142	145	153	1	2	9	10
58	Grassland (Tall Grass Prairie)	13	16	22	26	108	223	356	656
59	Grassland (Warm Season Grasses)	966	1074	1140	1186	29	102	209	276
60	Grassland with Cropland	72	96	198	269	0	0	0	0

Appendix: Area Coverage (km^2) by USGS Seasonal Land Cover AVHRR Classes

	USGS Seasonal Land Cover Class (several have the same name, different map codes)	East 50 km	East 75km	East 100km	East 125km	West 50km	West 75km	West 100km	West 125km
61	Grassland with Cropland	0	0	0	0	67	142	276	333
62	Grassland with Cropland (Small Grains)	0	0	0	0	1	10	57	78
63	Grassland with Cropland (Small Grains, Pasture)	65	68	76	81	53	95	121	141
64	Grassland with Woodland and Wetlands	0	3	21	48	657	884	1173	2345
65	Grassland/Cropland (Wheat, Corn) Mosaic	0	0	0	0	0	0	0	0
66	Grassland/Woodland (Oak) Mosaic with Cropland	565	692	810	1079	2136	3759	5776	8790
67	Herbaceous Arctic Tundra	4	4	4	4	0	0	0	0
68	Irrigated Agriculture	0	0	0	0	0	1	1	1
69	Irrigated Agriculture	1	2	7	7	57	134	184	259
70	Irrigated Agriculture	89	127	151	160	10	10	11	11
71	Low Shrubs (Willow, Alder) and Wet Herbaceous	8	13	13	13	5	5	7	7
72	Mixed Boreal Forest (Aspen, Birch, Spruce, Pine)	81	373	629	1180	17	98	197	401
73	Mixed Forest (Aspen, Birch, Spruce, Balsam Fir)	835	1650	2268	2512	208	643	1000	1343
74	Mixed Forest (Aspen, Birch, White Spruce, Black Spruce)	0	0	0	0	0	0	1	1
75	Mixed Forest (Aspen, Maple, Oak, Jack Pine, Red Pine, Spruce)	295	1046	1951	2860	143	315	494	986
76	Mixed Forest (Balsam Fir, Jack Pine, Black and White Spruce, Jack Pine, Aspen, Birch)	253	374	478	512	7	33	52	63
77	Mixed Forest (Black and White Spruce, Aspen, Birch)	83	206	271	299	13	75	156	226
78	Mixed Forest (Oak, Pine Species)	14342	19524	23794	28619	635	1238	2067	3136
79	Mixed Forest (Pine and Oak)	0	0	0	0	0	0	0	0
80	Mixed Forest (Pine and Oak)	0	0	0	0	0	0	2	2
81	Mixed Forest (Pine, Oak)	17	22	22	31	4	7	13	13
82	Mixed Rangeland (Big Sage, Rabbitbrush, Needlegrass)	126	126	126	126	0	0	0	0
83	Mixed Rangeland (Grassland and Shrubland)	21	42	43	49	0	0	4	5
84	Mixed Rangeland (Grassland, Shrubland) with Crops, Fallow	9	28	46	50	7	19	33	62
85	Mixed Rangeland (Grassland/Shrubland)	23	32	42	66	2	7	31	37
86	Mixed Rangeland (Saltbush, Sand Sage, Rabbitbrush)	0	0	1	1	0	0	0	0
87	Mixed Rangeland (Shrubs and Grasses)	0	0	0	0	2	2	5	6
88	Mixed Wetlands; Herbaceous and Woody (Mangrove)	6	6	17	26	4	17	33	35
89	Needleleaf Boreal Forest (Black and White Spruce, Aspen, Birch)	115	138	147	152	0	6	6	9
90	Needleleaf Boreal Forest (Black and White Spruce, Tamarack, Aspen)	58	82	90	112	0	0	2	2
91	Needleleaf Forest (Douglas Fir, Spruce, Western Red Cedar)	1	1	1	2	9	12	25	32
92	Needleleaf Forest (Englemann Spruce, Lodgepole Pine, Douglas Fir)	0	0	1	1	28	29	30	30
93	Needleleaf Forest (Hemlock, Spruce, Douglas Fir)	0	0	0	0	1	1	7	8
94	Needleleaf Forest (Ponderosa Pine)	1	29	35	36	144	226	259	290
95	Needleleaf Forest (Red Pine, Jack Pine, Spruce, Aspen, Birch, Tamarack)	1907	3670	5719	7467	169	585	955	1674
96	Needleleaf Forest (Sitka Spruce, Western Hemlock)	0	0	0	0	2	11	19	23
97	Needleleaf Forest (Spruce, Jack Pine, Aspen, Birch, Tamarack)	402	592	766	875	16	79	105	146
98	Needleleaf Forest (Western Hemlock, Sitka Spruce, Douglas Fir)	7	15	19	21	85	131	143	148
99	Needleleaf Forest (Western Red Cedar, Lodgepole Pine, Douglas Fir, Larch, Ponderosa Pine)	0	0	0	0	11	18	24	27
100	Northern Mixed Forest (Maple, Beech, Birch, Pine)	7757	12102	16571	22052	268	499	783	1108
101	Open Black Spruce with Balsam Fir, Aspen, Birch	4	14	24	25	8	8	8	8
102	Open Evergreen Needleleaf Forest (Ponderosa Pine)	152	341	433	481	67	127	214	256
103	Open Needleleaf Forest (Ponderosa Pine and Lodgepole Pine)	16	21	22	23	15	23	29	35
104	Open Needleleaf Forest (Spruce) with Aspen	1	1	1	1	0	0	0	0
105	Pine and Juniper Forest and Woodland	0	0	0	0	0	0	0	1
106	Pinyon-Juniper Woodland	0	1	1	1	0	0	1	1
107	Ponderosa Pine and Pinyon Juniper Woodland	31	71	71	73	0	1	6	6
108	Ponderosa, Lodgepole Pine Forest	13	14	17	19	5	5	10	12
109	Savanna	0	0	0	0	50	87	112	126
110	Semi-Deciduous Dry Forest	0	3	11	12	0	0	0	0
111	Semi-Deciduous Tropical Forest	0	0	0	0	0	1	1	2
112	Sparsely Vegetated Desert Shrublands	29	29	29	29	0	0	0	0
113	Spruce and Pine Forest	1	3	3	6	0	1	1	1
114	Spruce Forest	0	1	3	4	0	1	1	1
115	Spruce Woodlands with Low/Tall Shrubs	0	1	2	2	0	0	0	0
116	Tall/Low Shrubs, Tundra, Spruce	6	8	12	13	0	1	6	6
117	Tropical Broadleaf Forest	0	0	0	1	1	1	1	1
118	Water	5394	7847	9556	12239	3397	5797	8054	9605

APPENDIX F

Site Selection Issue Paper

SITE SELECTION ISSUE PAPER

Background

It is a generally-accepted maxim of conservation biology that plants and animals should not be introduced into areas outside of their natural historical range (Kleiman 1989, Falk & Olwell 1992, Tudge 1992). Further, the few hard data that exist on the factors that contribute to success and failure of animal reintroduction efforts clearly indicate that reintroductions should occur in the core of a species' historical range as opposed to the periphery or outside of that historical range. For example, where success is defined as the establishment of a self-sustaining population, Griffith et al. (1989) present the following data (p.478):

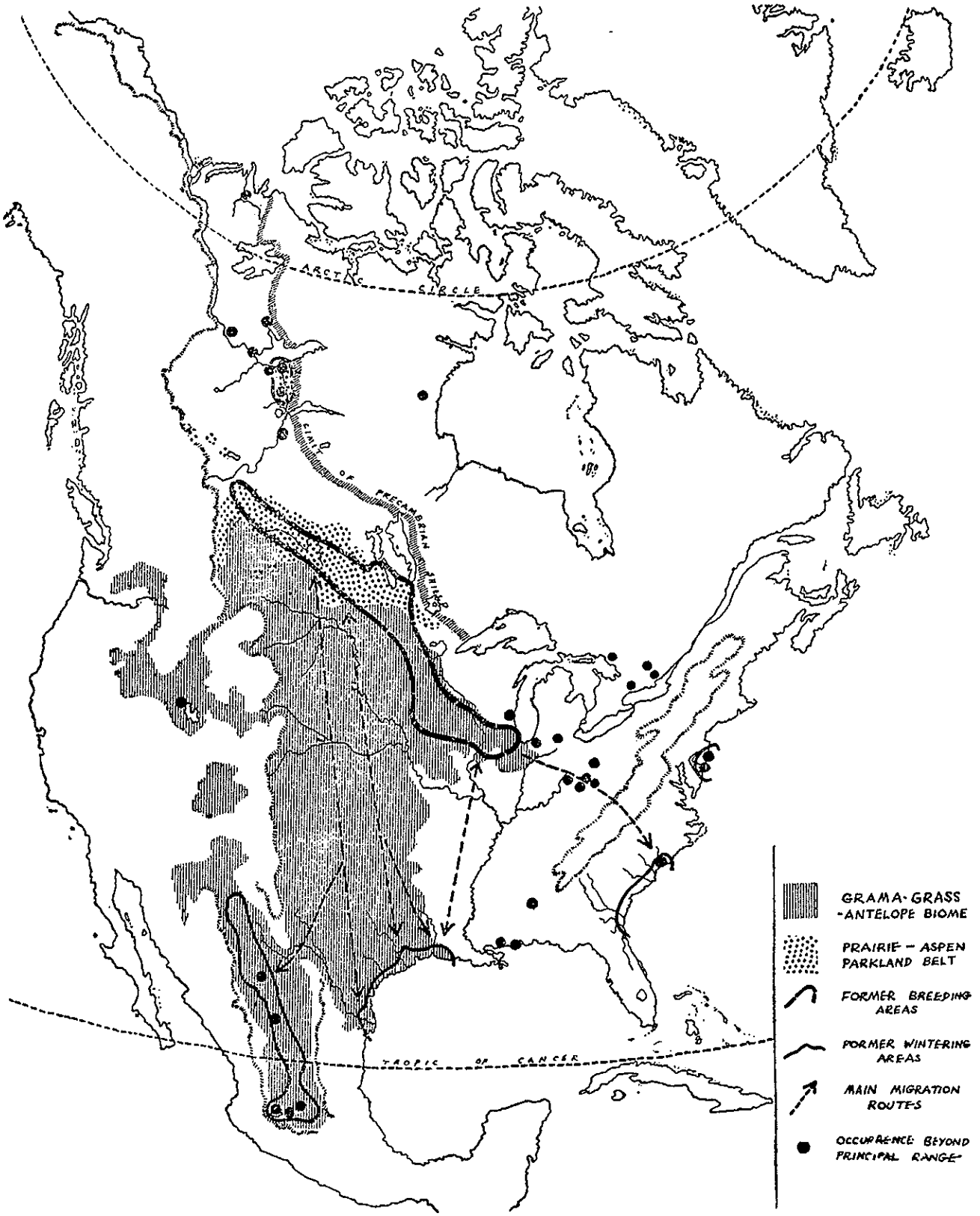
Location of Release	Number of Releases	Success (%)
Core of Historic Range	133	76
Periphery or Outside	54	48

Historical Range of the Whooping Crane

Allen (1952) presented the most complete data set on the historical range of the whooping crane. He cited almost all the records cited by previous authors (e.g., Howell 1924, Bent 1926, Oberholser 1938, Forbush 1939, Sprunt & Chamberlain 1949), and he cited many more records than any one previous author. Most discussions of the whooping crane's historical range since Allen (1952) have either accepted Allen's presentation in full or have drawn principally on Allen's data (e.g., Walkinshaw 1973, Johnsgard 1983, Edwards et al. 1994, U.S. Fish and Wildlife Service 1994, Lewis 1995).

One intriguing aspect of Allen's presentation is that his visual depiction of the historical range of the whooping crane was more liberal in its inclusion of data than his written analysis (Is a picture worth more or less than a thousand words?). Allen's range map (see following page) showed former wintering areas on the Atlantic seaboard and a migration route from Illinois and Indiana southeasterly across the Appalachian mountains to the southeast coastal wintering area. The written text in Allen's report was much more conservative. He discounted numerous historical references as doubtful or inaccurate, and he noted that a number of previous authors confused whooping cranes with other species (e.g., Audubon) or simply made things up (e.g., "Nuttall's treatment of the distribution of the Whooper is as imaginary as his description of their habits." -- Allen 1952, p. 11). Further, he described the cross-Appalachian migration route as ". . . such conjecture as we wish to indulge in . . ." (p. 98). When he looked at the record critically, Allen concluded:

> On the record, there are only six occurrence locations on the Atlantic seaboard and three others for the entire region east of the Ohio and Mississippi Rivers. (Allen 1952, p. 65).



The Original Range of *Grus americana* in Recent Times Related to Major Habitats.

When he looked at individual occurrence records that he felt were credible by state, he derived the following totals for documented sightings between 1722 and 1948 for the Atlantic seaboard and Gulf Coast states (p. 41):

State	Total	Last Record
TX	117*	Current * does not include Aransas area
LA	57	1950
GA	2	1723
NJ	2	1857
AL	1	1899
FL	1	1723
MS	1	1902
SC	1	1850

Although Allen's map allowed for the possibility of including the east coast of the U.S. in the total original range of the whooping crane (rather than the locus of a few casual or accidental sightings), the bulk of his analysis supports his opening description of "the original winter range" as ". . . high grasslands in Mexico and central Texas, coastal lagoons and beaches in Texas and tall grass prairie, sea-rim and brackish coastal marshes in Louisiana . . ." (Allen 1952 p.1). Further, it seems fairly certain that no whooping crane scholar would argue that the core of the historical wintering range encompassed any significant territory east of the Mississippi River.

Implications

If one were to be guided by the maxim of reintroducing species only in the core of their historical range, it would seem that U.S. wintering sites east of the Mississippi River and west of the Rocky Mountains would be ruled out. However, there is another reintroduction principle that might lead to different conclusions. That is the principle of not endangering the current natural wild population by intermingling introduced birds that might bring with them diseases to which the natural wild birds were not sufficiently immune or survival handicaps from captive rearing that could reduce the natural wild flock's productivity if reintroduced birds pair up with naturally wild birds, etc. As Chivers describes the problem:

> Because of differences between populations and their experiences, either the residents or the re-introductants might lack immunity to the diseases of the other group, with devastating consequences. (Chivers 1991 p. 93).

After studying introduced whooping cranes that have been released in Florida, Spalding et al. (1996) note the following:

> In spite of attempts to introduce relatively parasite and disease free individuals, it appears that a number of helminth parasites were introduced. (p. 48)

Finally, Kleiman (1989) concludes:

> The survival of the wild population of an endangered species should never be jeopardized to reintroduce captives, unless the wild population's future existence depends entirely on the release. (p. 155)

Questions To Consider

Before selecting possible wintering sites and migration routes for a new introduced population of whooping cranes, the following questions should be considered:

1. Are there possible wintering sites and migration routes that would be located in the core of the historical range, but would also minimize the chances of intermingling with the Aransas/Wood Buffalo population (AWP)?

2. If the answer to 1. is YES, should any other areas be seriously considered?

3. If the answer to 1. is NO, which principle should receive priority consideration in our site selection: site location in the core of the historical range, or separation from the AWP?

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