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FINAL

ENVIRONMENTAL ASSESSMENT

GENETIC RESTORATION OF THE FLORIDA PANTHER

Extalopy

December 20, 1994

**U.S. Fish and Wildlife Service
Florida Panther Coordinator
117 Newins-Ziegler Hall, U.F.
Gainesville, FL 32611**



To: Allan Eibert *Tom Hogan*
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United States Department of the Interior

FISH AND WILDLIFE SERVICE
FLORIDA PANTHER COORDINATOR
117 NEWINS-ZIEGLER HALL, U.F.
GAINESVILLE, FLORIDA 32611-0307

MEMORANDUM

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DIRECTOR'S OFFICE
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DATE: January 12, 1995
TO: Attached Mailing List
FROM: Florida Panther Coordinator, FWS, Gainesville, FL
SUBJECT: Federal Register Notice - Genetic Restoration for the Florida Panther

Attached is a copy of the January 4, 1995, Federal Register Notice announcing the availability of a Final Environmental Assessment (Final EA) and a "Finding Of No Significant Impact" regarding genetic restoration and management of the Florida panther. If you have not received a copy of the Final EA and would like one, please let me know.

Dennis B. Jordan
Dennis B. Jordan

Enclosures

NOTE: Copy of EA enclosed.



United States Department of the Interior

FISH AND WILDLIFE SERVICE
FLORIDA PANTHER COORDINATOR
117 NEWINS-ZIEGLER HALL, U.F.
GAINESVILLE, FLORIDA 32611-0307

NOTE TO FPIC AGENCIES

COMPLETION OF THE FINAL ENVIRONMENTAL ASSESSMENT AND "FINDING OF NO SIGNIFICANT IMPACT" (SIGNED BY THE REGIONAL DIRECTOR ON DECEMBER 27, 1994) COMPLETES PREREQUISITE ACTIONS BY FWS. GFC INDICATES THAT IMPLEMENTATION OF GENETIC RESTORATION (RELEASE OF ANIMALS) WILL LIKELY OCCUR IN MARCH OR EARLY APRIL.

governments) should contact the State's Single Point of Contact (SPOC) as early as possible to alert them to the prospective application(s) and to receive any necessary instructions on the State's review process. For proposed projects serving more than one State, the applicant is advised to contact the SPOC of each affected State. A current listing of SPOCs is included in the application guidance materials. The SPOC should send any State review process recommendations directly to: Office of Review, Substance Abuse and Mental Health Services Administration, Rockwall II Building, Suite 630, 5600 Fishers Lane, Rockville, MD 20857.

The due date for State review process recommendations is no later than 60 days after the specified deadline date for the receipt of applications. The CSAT does not guarantee to accommodate or explain SPOC comments that are received after the 60-day cut-off.

Application guidance materials will specify if a particular FY 1995 activity described above is not subject to the provisions of Executive Order 12372.

Dated: December 28, 1994.

Richard Kopanda,

Acting Executive Officer, SAMHSA.

[FR Doc. 95-15 Filed 1-3-95; 8:45 am]

BILLING CODE 4162-20-U

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

Notice of Availability of a Final Environmental Assessment, and a Finding of No Significant Impact Regarding Genetic Restoration and Management for the Florida Panther

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of document availability and finding of no significant impact.

SUMMARY: The Fish and Wildlife Service (Service) announces completion of the Environmental Assessment regarding genetic restoration and management for the endangered Florida panther (*Felis concolor coryi*). Copies of the Environmental Assessment are available from the Service. The Service also announces a determination that the proposed genetic restoration and management program are not a major Federal action significantly affecting the quality of the human environment within the meaning of Section 102(2) (C) of the National Environmental Policy Act of 1969, as amended. The "Finding of No Significant Impact" is based on information contained in the final Environmental Assessment, the

approved Florida Panther Recovery Plan, the Plan for Genetic Restoration and Management of the Florida Panther, other pertinent scientific and technical data, and public comments received on the draft Environmental Assessment.

ADDRESSES: Copies of the Environmental Assessment are available from the U.S. Fish and Wildlife Service, Post Office Box 110450, Gainesville, Florida 32611-0450.

FOR FURTHER INFORMATION CONTACT: Dennis B. Jordan, Florida Panther Coordinator (see ADDRESSES section), telephone 904/392-1861.

SUPPLEMENTARY INFORMATION:

Background

Restoring endangered or threatened animals or plants to the point where they are again secure, self-sustaining members of their ecosystems is a primary goal of the Service's endangered species program. The Florida panther is one of the most endangered large mammals in the world. The panther formerly occupied a range comprising much of the southeastern United States. This range was contiguous with other populations of North American cougars (*Felis concolor* spp.). A single population estimated to number 30 to 50 adults represents the sole known remaining population in the wild. This population utilized approximately 2-3 million acres of habitat on public and privately owned lands in southern Florida. The biological circumstances of geographic isolation, habitat loss, population reductions, and associated inbreeding have resulted in significant loss of genetic variation and health of the population. The genetic variability and health of the panther must be restored for the taxon to survive even with adequate habitat preservation and other enhancement measures. Existing data indicate that the Florida panther will likely go extinct without actions to restore genetic health to the population.

Population declines and associated inbreeding in the Florida panther have resulted in significant losses in genetic variability and viability. The population exhibits multiple physiological abnormalities that are likely a consequence of recent close inbreeding. High incidences of maladaptive traits which include reproductive and medical abnormalities have been observed. Significant among these are: Cryptorchidism (50+ percent of male population), abnormal sperm (average 93.5 percent per ejaculate), and atrial septal defects (5 individuals within last 2 decades). Furthermore, the Florida panther has suffered from numerous

health problems and infectious disease that may be a consequence of a defective immune system.

The purpose of the proposed action is to implement a genetic restoration and management program designed to improve the genetic health, survivability and recovery potential of the Florida panther. The proposed program involves a strategy designed to restore lost historic gene flow into the panther from another *Felis concolor* subspecies.

As part of the development of the proposed action, the Service consulted with the Florida Panther Interagency Committee; numerous biologists, geneticists, scientists, and managers; and, received and reviewed written comments from the public. Based on the results of this review process, the Service has concluded that the proposed action (Alternative 2 of the subject Environmental Assessment—translocate a minimum number of wild non-Florida individuals into the wild population) provides the best overall opportunity to restore genetic health to the Florida panther.

Author

The primary author of this document is Mr. Dennis Jordan (see ADDRESSES section).

Authority

The authority for this action is the Endangered Species Act (16 U.S.C. 1532 *et seq.*).

Dated: December 27, 1994.

John T. Brown,

Acting Regional Director.

[FR Doc. 95-57 Filed 1-3-95; 8:45 am]

BILLING CODE 4310-65-M

National Park Service

National Register of Historic Places; Notification of Pending Nominations

Nominations for the following properties being considered for listing in the National Register were received by the National Park Service before December 24, 1994. Pursuant to § 60.13 of 36 CFR Part 60 written comments concerning the significance of these properties under the National Register criteria for evaluation may be forwarded to the National Register criteria for evaluation may be forwarded to the National Register, National Park Service, P.O. Box 37127, Washington, DC 20013-

FLORIDA PANTHER INTERAGENCY COMMITTEE ACTIVITIES MAILING LIST
January 12, 1995

AERIE, Attention: Jay Tischendorf, PO Bx 380, Ft. Collins, CO 80522
American Farmland Trust, Attention: Craig Evans, 1 Park Place, 621 NW 53rd St., Suite 240, Boca Raton, FL 33487
Archbold Biological Station, Attention: James N. Layne, Rt. 2, Bx 180, Lake Placid, FL 33852
Arkansas Game & Fish Commission, Attention: Steve N. Wilson, Director, 2 Natural Resources Dr., Little Rock, AR 72205
Big Cypress Nat'l Preserve, Attention: Wallace Hibbard, Superintendent, SR Bx 110, Ochopee, FL 33943
Big Cypress National Preserve, Attention: Buck Thackeray, SR Bx 110, Ochopee, FL 33943
Big Cypress Nat'l Preserve, Attention: Jim Snyder, SR Bx 110, Ochopee, FL 33943
Big Cypress National Preserve, Attention: Deborah Jansen, SR Bx 110, Ochopee, FL 33943
Bolgiano, Christina, Rt 1, Bx 331, Fulks Run, VA 22830
Canin Associates, Attention: Bill Bess, 500 Delaney Ave., Orlando, FL 32801
Conservation Breeding Specialist Group (IUCN/SSC), Attn: U.S. Seal, 12101 Johnny Cake Ridge Rd., Apple Valley, MN 55124
Christian, John I., 7755 134th Street, W., Apple Valley, MN 55124
Clark, James E., Refuge Reporter, Avocet Crossing, Millwood, VA 22646-0156
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Conway Conservation, Inc., Attention: Linda Duever, PO Bx 949, Micanopy, FL 32667-0949
Cooper, Victor, 810 N. Hyer Ave., Orlando, FL 32803
Coryi Foundation, Inc., Attention: Tim Mallow, 3715 Felda Street, Cocoa, FL 32926
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Davis, Linda, PO Box 3671, Lake City, FL 32056
Dees, Catherine, 854 SW 11th Court, Ft. Lauderdale, FL 33315
Defenders of Wildlife, Attention: Robert Dewey, 1101 14th St., NW, Suite 1400, Washington, D.C. 20005
Dept. of Wildlife & Range Sciences, Attention: Larry Harris, PO Box 110430, Gainesville, FL 32611-0430
Dept. of Wildlife & Range Sciences, Attention: Melvin E. Sunquist, PO Box 110430, Gainesville, FL 32611-0430
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Duffy, Joanne, Sand County South, Rt 1, Bx 661-B, High Springs, FL 32643
DuToit, Charlie, Tomoka Basin Geo-Park, 2099 N. Beach St., Ormond Beach, FL 32174
Eastern Puma Research Network, Attention: John Lutz, PO Bx 3562, Baltimore, MD 21214
Everglades Coalition, 666 Pennsylvania Ave., SE, 2nd Floor, Washington, D.C. 20003
Everglades National Park, Attention: Park Superintendent, 4001 State Rt. 9336, Homestead, FL 33034
Everglades National Park, S FL Res. Center, Attention: Oron L. Bass, 4001 State Rt. 9336, Homestead, FL 33034
Fakahatchee Strand State Pres., Attn: Park Manager, PO Bx 548, Copeland, FL 33926
Fergus, Charles, RD 2, 340 Mountain Rd., Port Matilda, PA 16870
Fla. Audubon Society, Attention: Charles Lee, 640 Hwy. 463, Suite. 200, Casselberry, FL 32707
Fla. Biodiversity Project, Attention: Brian Hunt, 1120 NW 1st Ave, Ft. Lauderdale, FL 33311
Fla. Defenders of the Environment, 2606 NW 6th St., Gainesville, FL 32609
Fla. Dept. of Envi. Protection, Attention: Virginia B. Wetherell, Secretary, 3900 Commonwealth Blvd., Tallahassee, FL 32303
Fla. Dept. of Envi. Protection, Attention: Jack Pons, 3900 Commonwealth Blvd., Tallahassee, FL 32303
Fla. Dept. of Envi. Prot., Bur. Sci. & Tech. Svs., Attn. Jim Stevenson, 3900 Commonwealth Blvd., MS 45, Tallahassee, FL 32303
Fla. Dept. of Envi. Protection, Div. Recreation & Parks, Attention: Ken Alvarez, 1843 S. Tamiami Trail, Osprey, FL 34229
Fla. DOT, Environmental Administration, Attention: Gary Evink, 605 Suwannee St., Tallahassee, FL 32304
Fla. Farm Bureau, Attention: Kevin Morgan, PO Bx 147030, Gainesville, FL 32614-7030
Fla. GFWFC, Attention: Dr. Allan L. Egbert, Exec. Dir., 620 S. Meridian St., Tallahassee, FL 32399-1600
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Fla. GFWFC, Wildlife Research Lab, Attention: Chris Belden, 4005 S. Main St., Gainesville, FL 32601
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Fla. Museum of Natural History, Attention: Laurie Wilkins, Museum Rd., Gainesville, FL 32611
Fla. State Clearinghouse, Intergovernmental Affairs Policy Unit-OPB, The Capitol, Rm 1603, Tallahassee, FL 32399-0001
Fla. Wildlife Federation, Attention: Manley Fuller, PO Bx 6870, Tallahassee, FL 32314-6870
Gallagher, Pete, PO Bx 7959, St. Petersburg, FL 33734
Georgia DNR, Wildlife Resources Div., Attention: David J. Waller, Director, 2070 US Hwy. 278 SE, Social Circle, GA 30278
Georgia DNR, Wildlife Resources Div., Attention: Joe Kurz, 2070 US Hwy. 278 SE, Social Circle, GA 30278
Georgia DNR, Wildlife Resources Div., Attention: Tip Hon, 1773-A Bowen's Mill Hwy., Fitzgerald, GA 31750
Humphrey, Stephen R., 330 Little Hall, UF, Gainesville, FL 32611

Jacksonville Zoological Gardens, Attention: Dale Tuttle, 8605 Zoo Rd., Jacksonville, FL 32218-5799
 Jensen, Holly, 11714 SW 89 Street, Gainesville, FL 32608-6289
 Land Use Chronicle, Attention: Alice L. Gustin, PO Box 468, Riverton, WY 82501
 Lindner, Geri, 6056 Barna Ave., Titusville, FL 32780
 Lowry Park Zoo, Attention: Lex Salisbury, 7530 North Blvd., Tampa, FL 33604
 Lowry Park Zoo, Attention: Pat Yarnot, 7530 North Blvd., Tampa, FL 33604
 Matthews, Arthur, 2507 Beechridge Rd., Raleigh, NC 27608-1433
 McBride, Roy, Box 725, Alpine, TX 39831
 McCracken, Donna, 718 SW 179th Ave., Micanopy, FL 32667
 McDonald, Dan, 285 Pelican Dr., Melbourne Beach, FL 32951
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 Miami Metrozoo, Attention: Bill Zeigler, 12400 SW 152nd St., Miami, FL 33177
 Mt. Lion Foundation, Attention: Kevin Hansen, PO Bx 1896, Sacramento, CA 95812
 National Audubon Society, Attention: Lawrence Thompson, 102 E. 4th Ave., Tallahassee, FL 32303
 National Park Service, Attention: Robert M. Baker, Regional Director, 75 Spring St., SW, Atlanta, GA 30303
 National Park Service, Attention: Suzette M. Kimball, Regional Chief Scientist, 75 Spring St., SW, Suite 1092, Atlanta, GA 30303
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 Ocala Star-Banner, Attention: Lucy Beebe, PO Bx 490, Ocala, FL 34478
 Office of the Governor, Environmental Policy, Attention: Rick Smith, The Capitol, Tallahassee, FL 32399-0001
 Rigerman, Alan, 17910 NW 84th Ave., Hialeah, FL 33015
 Ryan, Rory, Holland & Knoght, PO Bx 1526, Orlando, FL 32802
 Scherf, Brian, 1060 Tyler St., Hollywood, FL 33019
 Seminole Tribe of Florida, Attention: Jim Shore, 6073 Stirling Rd., Hollywood, FL 33024
 State Representative Bert Harris, 720 US Highway 27, South, Lake Placid, FL 33852
 Thacker, Roger, Div. of Animal Resources, Room H41A-MC, U. of Kentucky, Lexington, KY 40536
 The Florida Panther Project, Inc., Attention: Bill Samuels, PO Bx 19866, Sarasota, FL 34276
 The FL Times-Union/Jax. Jrn., Attention: Environmental Section, PO Bx 1949-F, Jacksonville, FL 32231
 The Fund for Animals, Attention: D.J. Schubert, 850 Sligo Ave., Suite LLZ, Silver Springs, MD 20910
 The Fund for Animals, Attention: Sidney Maddock, 850 Sligo Ave., Suite LLZ, Silver Springs, MD 20910
 The Humane Society of US, Attention: Allen T. Rotberg, 2100 L St., NW, Washington, D.C. 20037
 The Miami Herald, Attention: Heather Dewar, 1 Herald Plaza, Miami, FL 33132
 The Palm Beach Post, Attention: Betsy Aoki, 2751 S. Dixie Hwy., West Palm Beach, FL 33405
 The Palm Beach Post, Attention: Kirk Brown, PO Bx 24700, West Palm Beach, FL 33416-4700
 The Sierra Club, Attention: Judy Hancock, PO Bx 2436, Lake City, FL 32056
 The Sierra Club, Attention: Laurie MacDonald, 103 Wildwood Lane, St. Petersburg, FL 33705
 The St. Petersburg Times, Attention: Jeff Klinkenberg, PO Bx 1121, St. Petersburg, FL 33731-1121
 The St. Petersburg Times Bureau, Attention: Rick Bragg, 4911 14th St. W, #102, Bradenton, FL 34207-2479
 The Tampa Tribune, Attention: Booth Gunter, PO Bx 191, Tampa, FL 33601
 The Wilderness Society, Attention: Renata Russell, 4203 Ponce DeLon Blvd., Coral Gables, FL 33146
 Thomas, Carol, 912 Malone Dr., Orlando, FL 32810
 US Fish & Wildlife Service, Attention: Regional Director, 1875 Century Blvd., Atlanta, GA 30345
 US Fish & Wildlife Service, Ecological Services, Attention: Tom Olds, 1875 Century Blvd., Atlanta, GA 30345
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 USFWS Field Office, Attention: Field Supervisor, 6578 Dogwood View Parkway, Suite A, Jackson, MS 39213
 USFWS Field Office, Attention: Field Supervisor, PO Bx 2676, Vero Beach, FL 32960
 USFWS, FL Panther Nat'l Wildlife Refuge, Attention: Refuge Manager, 3860 Tollgate Blvd., Suite 30, Naples, FL 33942
 USFWS, Ecological Services, Attention: Andy Eller, 3860 Tollgate Blvd., Suite 37, Naples, FL 33942
 USFS, National Forest in FL, Supervisor, Woodcrest Office Park, 325 John Knox Rd., Suite F-100, Tallahassee, FL 32303-4107
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 White Oak Plantation, Attention: John Lukas, Rt. 3 Bx 226, Yulee, FL 32097
 Wildlife Rescue Inc., Attention: Bert Wahl, 127 W. Hiawatha, Tampa, FL 33604
 Wildt, David, Dept. of Animal Health, National Zoological Park, 3000 Connecticut Ave., Washington DC 20008
 World Wildlife Fund, Attention: Chris Williams, U.S. Land & Wildlife Program, 1250 24th St., NW, Washington, DC 20037-1175
 WTVJ TV, Attention: Nick Bogert, 316 N. Miami Ave., Miami, FL 33128

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II. PURPOSE OF AND NEED FOR ACTION

- A. **Proposed Action** - The proposed action is to develop and implement a genetic management strategy as deemed necessary to ensure the continued existence of the Florida panther.
- B. **Purpose** - The purpose of the proposed action is to improve the genetic health of the Florida panther which will greatly enhance opportunities for survival and recovery.
- C. **Need** - The Florida panther represents one of this Nation's most critically endangered animals -- presently consisting of a single population in south Florida estimated to number 30 to 50 adults.

The Florida panther's existence is severely threatened by both rapid and gradual extinction processes. Factors of concern include habitat loss and fragmentation, environmental contaminants, prey availability, human related disturbance and mortality, disease, and genetic erosion.

Population viability analysis projections indicate that under existing demographic and genetic conditions the Florida panther will likely be extinct in only a few decades (24-63 years, Seal et al. 1992). Actual time to extinction could be accelerated significantly by the occurrence of a catastrophic population reducing event.

Extinction of the Florida panther can be avoided only if programs to expand the existing population (numbers and distribution), along with actions to enhance existing genetic conditions, are implemented and are successful. Programs to expand the population must include actions to preserve remaining habitats considered essential to meeting the needs of a self-sustaining population in south Florida and actions to reestablish populations and preserve habitats elsewhere within the panther's historic range. Measures to enhance genetic conditions must include actions to preserve existing genetic resources, restore diversity and viability, and manage for inbreeding problems. Consideration must be given to strategies designed to restore historic gene flow.

Lost Gene Flow - Literature indicates that gene exchange between the Florida panther (*Felis concolor coryi*) and other *F. concolor* subspecies occurred from the north through *F. c. cougar*, and from the west and northwest through *F. c. stanleyana* and *F. c. hippolestes* (Young and Goldman 1946).

This natural gene flow ceased at the time the Florida panther became geographically isolated, likely a century or longer ago. Isolation and accompanying population declines and inbreeding have resulted in the loss of vast amounts of the panther's historic genetic diversity and health. From a genetic standpoint, the present Florida panther population contains only a portion of the variability existing prior to isolation. Recent population viability analyses project that genetic heterozygosity is being lost at a rate of approximately 6% per generation (Seal et al. 1992). Low heterozygosity levels (0.019) indicate that the Florida panther is inbred and has lost approximately half of its genetic diversity (Roelke 1990).

Genetic Reduction - Based on results of genetic testing, which has been summarized in the following sentences from Roelke et al. (1993), surviving Florida panthers have experienced substantial inbreeding and concomitant loss of genetic diversity in their recent history. The level of mtDNA variation in the Florida panther is the lowest reported in any similarly studied feline population, including leopards, cheetahs, and other puma subspecies. Electrophoretic results indicated that the Florida panther had less variation than any other puma subspecies and is nearly as low as the level of allozyme variation reported in the two cheetah subspecies (Roelke et al. 1993). DNA fingerprint variation seen in the Florida panther is nearly as low as the extremely compromised genetic variation in Asiatic lions from the Gir Forest Sanctuary in India.

Genetic Health - The U.S. Fish and Wildlife Service (Service) is concerned that the overall genetic health of the Florida panther may now be at a point where the panther's continued existence is doubtful without a proactive genetic restoration program. This concern is supported by several physiological impairments displayed by the population which have been summarized below.

Spermatozoal Traits: Semen quality and endocrine and reproductive functions have been shown to be adversely affected in some inbred lines of several species, including mice, cats, 2 lion subspecies and cheetahs (Wildt 1994). Comparative reproductive analyses of seminal traits in five feline species, revealed that Florida panther males display some of the poorest seminal quality traits ever recorded for any felid species or subspecies (Barone et al., 1994). Total motile sperm per ejaculate in the Florida panther is 18-38 times lower than in other puma subspecies, 30-270 times lower than in other felids and 30 times lower than in the cheetah. Although cougars and other large felids tend to produce high proportions of morphologically abnormal

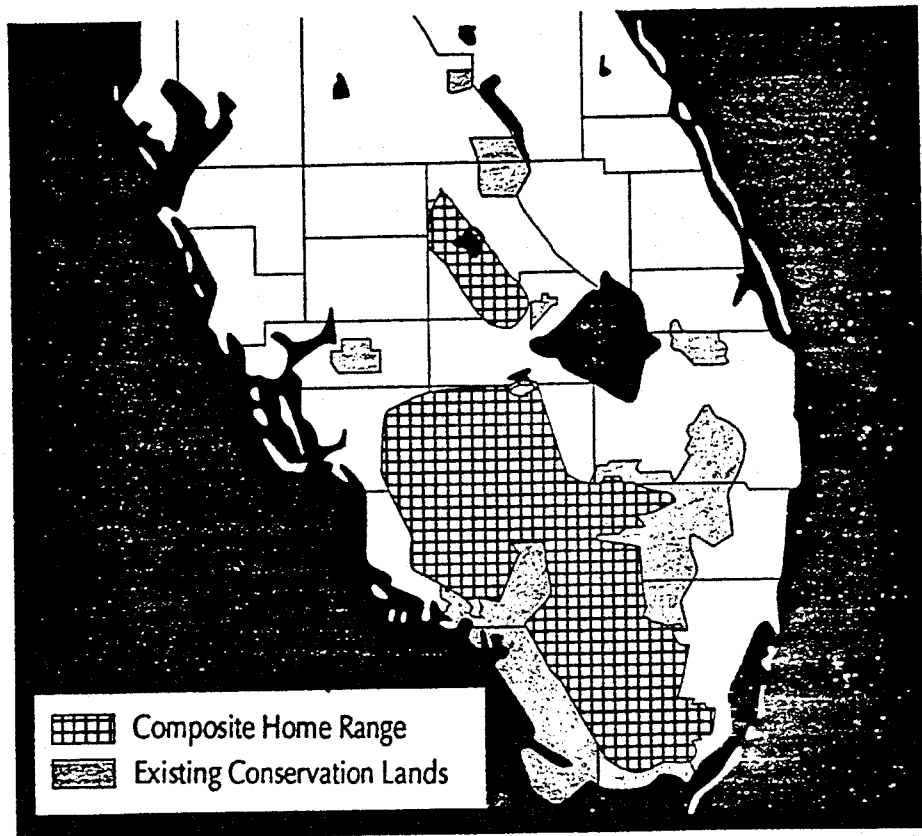
meaning only one testicle had not descended properly into the scrotum. This condition does not normally render the individual incapable of reproducing. However, from an overall population health and genetic standpoint it is of significant concern. This concern is magnified with the Florida panther because of the many other factors threatening panther survival. In 1992, concern over cryptorchidism heightened considerably when one of four newly captured males was determined to be bilaterally cryptorchid (neither testicle descended properly) and a second had a single, significantly smaller, descended testicle (Roelke and Glass 1992). Bilateral cryptorchid individuals are functionally sterile.

Congenital Heart Defects: Life threatening congenital heart defects have been observed in the population (Roelke and Glass 1992). Atrial septal defects (ASD), termed patent foramen ovale, have been found in 5 out of 55 documented Florida panther mortalities from 1972 through July 1994 (Roelke et al. 1993; Dunbar, personal communication, 1994). This defect may have contributed to death in 4 out of 5 of these cases. ASD has been observed in several species including human (ASD is the most common congenital heart defect in human adults) (Braunwald 1992), but has not previously been observed in cougars and only rarely in domestic cats (Bolton & Lui 1977). The etiology of ASD is not well understood, but certain cases in humans suggest an autosomal dominant mode of inheritance (Lynch et al. 1978; Mascia and Moller 1987). Heart murmurs have been detected in Florida panthers, sometimes at high frequencies (80%, compared with a frequency of occurrence of only approximately 4% with other cougar subspecies [Roelke et al. 1993]); however, the relationship between ASD and heart murmurs is not clear. Recently, hypo- and hyper- vitaminosis A have been ruled out as potential causes of cardiac abnormalities in Florida panthers (Dunbar 1994). The etiology of the cardiac defects is unknown, however, there may be a genetic explanation.

Additionally, some scientists now have concerns over what appears to be an inability of some, apparently "healthy" individuals, to overcome exposure to infectious agents that would normally not be expected to result in life threatening/terminal conditions; raising questions of possible immune deficiencies (Seal et al. 1992). The importance of population genetic diversity for loci involved in immune responses has been empirically demonstrated in several species (Roelke, et al. 1993). Through 1992, at least eight panther mortalities have been attributed to infectious pathogens, although no single agent has caused widespread mortality during the study period (Roelke et al. 1993).

centered around Collier and Hendry Counties. Radio-instrumented individuals have also utilized habitats in Broward, Dade, Glades, Highlands, Lee, Monroe, and Palm Beach Counties (Figure 1).

Figure 1. Area used by 43 radio-instrumented Florida panthers, 1981-1991.



Source: Florida Panther Habitat Preservation Plan - South Florida Population (FPIC 1993).

- E. **Recovery Thrusts** - The present Florida panther recovery program places emphases along three major thrusts: (1) actions to protect and enhance the existing wild population and associated habitats; (2) actions to protect and manage remaining genetic resources to preserve existing genetic health; and, (3) actions to develop population reestablishment technologies.
- F. **Intercrossing For Genetic Restoration** - Intercrossing, as used herein, refers to a mating between subspecies of the same taxonomic species and is a common, natural, and expected occurrence in nature wherever ranges are adjacent or overlap. The FWS is presently

some pesticides. Some of the chemicals which can cause these conditions are known to be present within the occupied range of the Florida panther (C. Facemire, USFWS, pers. comm. 1994). A summary of information on this subject to date and a proposed study design to investigate whether contaminants may cause or contribute to abnormalities which could affect recovery of the panther are presented in Enclosure II.

- J. **Scoping** - Scoping to address genetic issues related to the Florida panther started as early as January 1989, with a Population Viability Analysis workshop. In the fall of the same year, a second workshop was held to update the population viability analysis and develop a Species Survival Plan for the panther. In connection with the development of an Environmental Assessment to address the issue of establishing a captive population in 1990-91, a broad range of issues relating to genetic conditions and management options for the Florida panther received vast review, input and consideration. Additional workshops to specifically evaluate and address genetic conditions and issues for the panther, and to develop management recommendations were held in May 1991, October 1992 and September 1994. Genetic management considerations have ranged from actions deemed necessary to protect and maintain the Florida panther relying solely on genetic resources available in the wild population to strategies to enhance the panther's genetic health by restoring historic gene flow into the panther from other *Felis concolor* subspecies.

Specific to the development of this Environmental Assessment, the Florida Panther Interagency Committee, and its Technical Subcommittee reviewed and evaluated genetic information and considered potential courses of action regarding genetic management for the panther during a number of meetings. A notice of intent to prepare an Environmental Assessment addressing potential genetic management options for the Florida panther was published in the FEDERAL REGISTER August 17, 1993. The Notice invited input from the public, affected Federal, State, and local agencies and other interested parties on the scope of options and issues that should be addressed in this Environmental Assessment. Written comments received in response to the FEDERAL REGISTER Notice, as well as those received after the close of the specified comment period will be utilized in the decision-making process, and have been made a part of the official record.

program would be designed to restore genetic health that has been lost as a result of decades of isolation and inbreeding by renewing gene flow that historically occurred under natural conditions. The workshops in May 1991, October 1992 and September 1994 were held to give consideration to such a program and to develop concepts and strategies for implementation.

During the 1992 workshop nine genetic management scenarios for the panther were identified and evaluated. Details are provided in a workshop report titled: "Genetic Management Strategies and Population Viability of the Florida Panther", which is contained in this document as Enclosure III. Of the nine genetic management options evaluated in the subject report, five represent various ways to restore gene flow into the panther (options 2, 3, 4, 5, and 8). All five of these options would be expected to eventually accomplish the basic goal of restoring genetic health to the panther. Techniques utilized, levels of human involvement, support facilities and funding resources needed, and time intervals to achieve success would vary. Option 3 is considered the most direct, cost and time effective way to achieve improved genetic health for the wild population and is therefore, presented in this document as the preferred alternative (Alternative 2). For reasons outlined in the referenced report, options 1, 7 and 9 are not considered viable options in terms of programs likely to be successful in significantly improving the genetic health or ensuring the continued survival of the Florida panther. Option 6 of the referenced report is presented as Alternative 1 in this document.

The purpose of the September 1994 workshop was to develop a Genetic Restoration and Management Plan for the Florida panther. The results of this workshop are presented in Enclosure I.

It should be reemphasized that the importance of other panther recovery programs will in no way be de-emphasized with the implementation of a genetic management program. Genetic management is only one of many programs considered essential for survival and recovery of the panther. Actions to protect and enhance the existing wild population and its habitat must continue, as well as actions to reestablish the panther elsewhere within its historic range.

Alternative 1 - Continue Current Genetic Management Program (Status Quo) -- Under this alternative, emphasis would continue to be placed on actions to protect, preserve and manage genetic resources contained in the existing wild population (including captive panthers taken from the wild). This would essentially be carried out by continuing the program initiated in 1991, which is to establish and manage a large captive



Alternative 3 - Translocate Intercrossed Progeny Into The Wild

Population -- This alternative would follow the same basic plan of action as Alternative 2 except that intercross progeny (*Felis concolor coryi* x *Felis concolor* sp.) would be produced in captivity, conditioned and placed into the wild population.

Alternative 4 - Utilize Genetic Material From Other Captive Stock (*F.c. coryi* or *F.c. coryi* intercrosses) In The Genetic Restoration

Program -- Under this alternative, *Felis concolor coryi* or *F.c.c.* intercrossed genetic material that may presently be in captivity would be used in the genetic restoration program.

considered to have possibly played a role in the death of a female panther in 1991. The Service, in collaboration with the Florida Game and Fresh Water Fish Commission and others, is developing a study design to investigate and evaluate panther exposure to environmental contaminants and how exposure may cause or contribute to genetic or other abnormalities which could affect recovery (see Enclosure II).

Since 1981, 56 panthers have been captured, immobilized, radio-instrumented and monitored. As of August 15, 1994, 16 are radio-instrumented (7 males and 9 females). A great deal of biological information has been learned regarding the panther over the past 14 years. According to Maehr (1990a), from a demographic and behavioral perspective, panthers in southwest Florida exhibit characteristics typical of healthy, stable mountain lion populations elsewhere. He found that panthers in southwest Florida prefer uplands, especially hardwood hammocks and pine flatwoods over wetland forest cover. He observed that forested uplands cover a relatively small area of inhabited panther range but receive a disproportionately high level of use. He also found that daytime cover and female den sites usually are located in dense understory vegetation, typically saw palmetto. He reports that daybeds usually are relocated daily, while den sites are used for up to 2 months by female panthers and their litters from parturition to weaning.

Panther home range sizes in southwest Florida varied from 20 to 457 mi^2 and averaged 74 mi^2 for adult females and 215 mi^2 for adult males between 1985 and 1990 (Maehr 1990a). The author noted that home range shifts in adult females were the result of a home range vacancy and dispersal from a natal range. He observed that shifts in adult male home ranges were due to male deaths and home range establishment by an adjacent male. Maehr reported that mean dispersal distance for 6 males (mean age = 17.3 months) was 32 mi (range 14-50 mi), and was 10 mi for 1 female.

Florida panthers are essentially solitary except while females raise kittens and during mating or attempted mating. Maehr (1990a) observed that the most frequent interactions were between females and their kittens, followed by adult males and adult females, and adult males and subadult females. He also observed that panthers are usually greater than 1.2 miles apart.

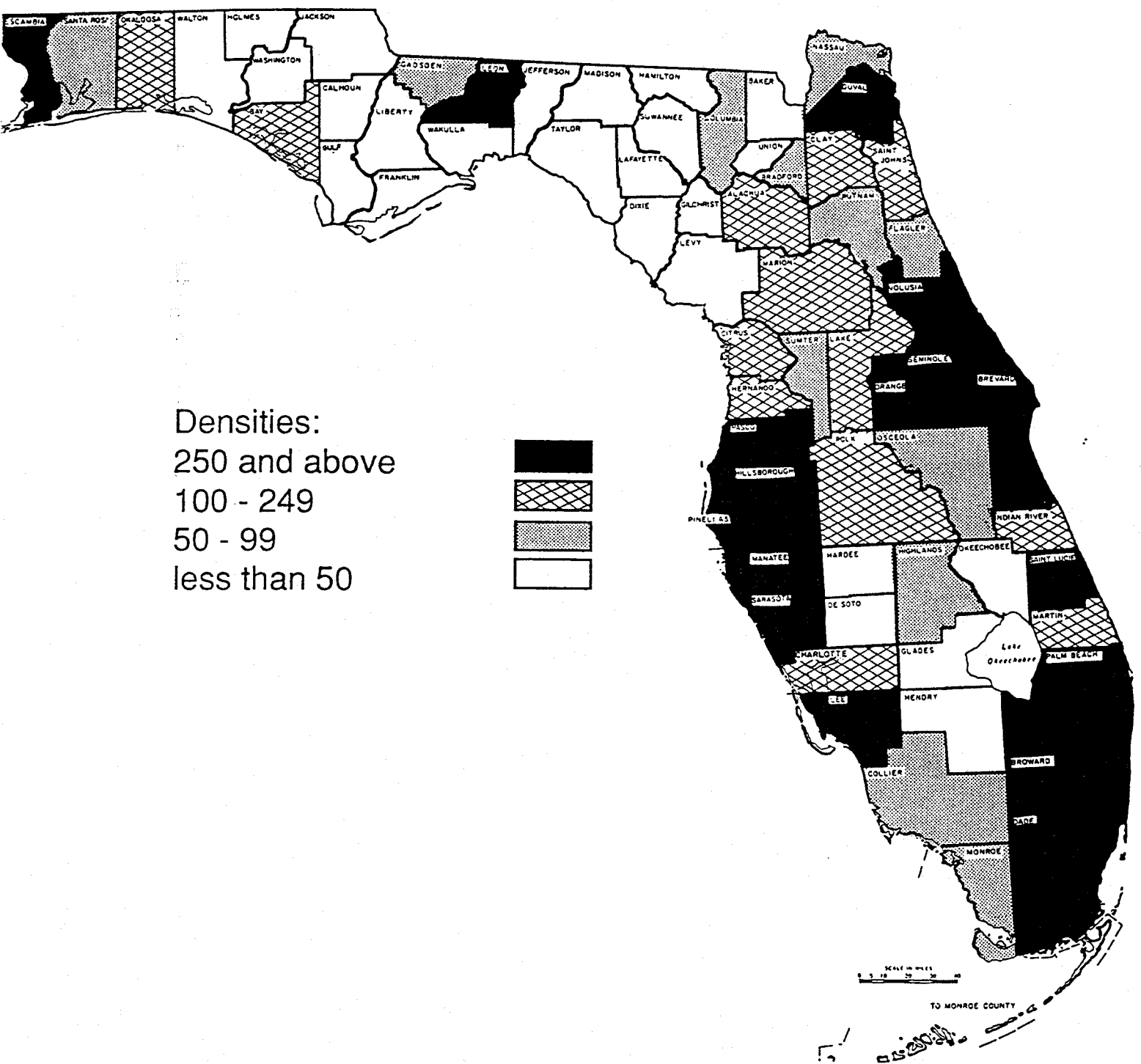
Since 1972, documented panther mortality has totalled over 55 animals (through July 1994). Since the development of the Florida Panther Viability Analysis and Species Survival Plan in 1989, only 3 of

Carolina and Tennessee. Habitat requirements of the panther would limit candidate sites to areas possessing large expanses of relatively undeveloped, forest-dominated habitats. Public lands could account for a significant component of some sites.

- B. Socioeconomic Factors** - The entire Region's economy is heavily dependent upon the tourist industry, which has contributed to the rapid growth of the area. Tourism is an important part of Florida's economy. Over 40.5 million visitors pumped \$30.8 million dollars into Florida's economy in 1992 (FDOC 1991). Clean air, a subtropical climate, and diverse recreational opportunities make the south Florida area extremely attractive to tourists, retirees, and year-round residents. The extensive natural resource amenities of south Florida have been widely advertised and marketed worldwide resulting in phenomenal growth, especially along the coasts. The population statewide, now over thirteen million, has doubled every 20 years since 1830 (Shermyen 1990). Fifty percent of the state's residents now live in south Florida.

According to the 1990 census, five of the top ten fastest growing metropolitan areas in the nation; Naples, Fort Myers, Punta Gorda, Fort Pierce and West Palm Beach are located in south Florida. In 1987 there were 499,982 acres or 781 mi² of land designated as urban in southwest Florida. During the decade of the 1980's most southwest Florida counties experienced rapid human population growth. Collier County, which receives perhaps the greatest level of panther use of all counties, experienced a population growth in excess of 50 percent (Figure 2). Population densities in 1990 for the two most important counties in terms of recent panther use-levels remain relatively sparse at between 50-99/mi² for Collier County and less than 50/mi² for Hendry County (Figure 3). However, the Southwest Florida Regional Planning Council concludes that a doubling of the population in southwest Florida in the next 20 years as projected, will create a demand for an additional 292 mi² of urban land at today's housing densities (SWFRPC 1990). Southwest Florida's continued rapid population growth has the potential to magnify the loss of natural resources.

Figure 3.--Population Per Square Mile in Florida Counties, 1990



Note: The 1990 population counts are subject to possible adjustment for undercount or overcount by the U.S. Bureau of the Census.

Source: *Florida Population: Census Summary 1990*

counties, about 50 percent of the range is native and 50 percent is improved. Range acreage is steadily decreasing, primarily due to citrus development, but with some loss to urban development. Cattle range in southwest Florida decreased 11 percent from 1.5 million acres to 1.34 million acres between 1986 and 1990 (Townsend 1991). Florida ranks 10th in the United States for the total number of cows and calves. The majority of these cattle are raised on south Florida ranches. Though livestock are prevalent in south Florida, losses to panthers are rare (Maehr et al. 1990b).

Minerals - Mineral resources within the southwest Florida region include: sands, shells, marls, and clays (used in construction); differing grades of phosphatic sands and clays, limestones and Fuller's Earth; and, peats, petroleum and natural gas deposits (L. Zippay, FDEP, pers. comm. 1991). This area has proven important to the petroleum and gas industry, and is currently one of the few areas producing oil and gas in the state.

Oil and gas reserves are drilled in Collier, Lee and Hendry Counties. There are about 26 active wells, 100 abandoned wells, and 80 permitted, yet undrilled wells in the Sunniland Reef Trend Region. The potential for important oil deposits increases on a gradient from Palm Beach to Collier County.

Open-pit mining in south Florida is used to extract sand (27,362 acres), shell (80 acres), peat (49 acres), limerock (54,235 acres), and phosphate (426,000 acres)(L. Zippay, FDEP, pers. comm. 1991).

Rapid growth and lack of environmental safeguards prior to 1970 resulted in the loss or significant alteration of hundreds of thousands of acres of productive wetlands and upland habitats. Canal dredging, road construction, wetlands drainage, and destructive wildfires have markedly impacted viable interior wetlands in south Florida. The alteration of beneficial, pristine wetlands preceded much of the major growth era. Legal and illegal dredge and fill activities associated with modern road construction and urban and agricultural development have further affected water quality, water storage capacity, native landscapes, and the diversity, abundance, and distribution of regional wildlife.

Public lands comprise much of the panther's current occupied range (Figure 4). Public lands of primary importance in this region include the Big Cypress National Preserve (area B - approximately 600,000 acres), Everglades National Park (area A - approximately 1,000,000

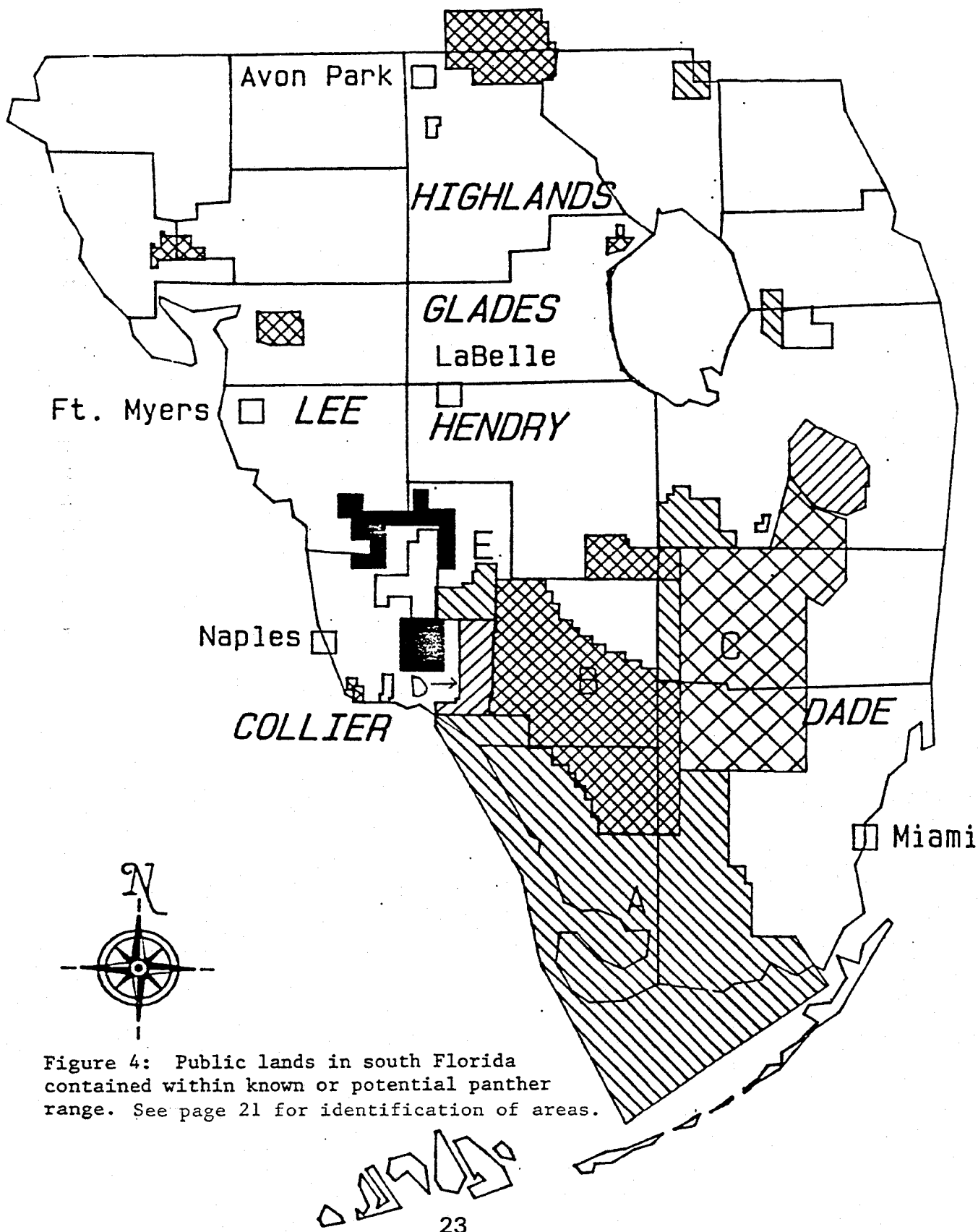


Figure 4: Public lands in south Florida contained within known or potential panther range. See page 21 for identification of areas.

Source: D. Maehr, Fla. Game & Fresh Water Fish Commission, Naples, FL

V. ENVIRONMENTAL CONSEQUENCES

This section discusses and evaluates potential impacts of each alternative on the biological and socioeconomic components of the area.

Alternative 1 - Continue Current Genetic Management Program

(Status Quo) -- Inaction does not appear to be a viable option. Without genetic intervention the wild population of Florida panthers is expected to become extinct within a few decades. Under this alternative, all available means would be utilized to work within the existing population, utilizing both wild and captive individuals, in an effort to buffer genetic erosion and provide security against extinction. Genetic management would be carried out through the captive breeding program, the exchange of individuals between the captive and wild population, and the translocation of individuals within the wild population. Genetic material from other *Felis concolor* subspecies would not be used.

- A. **Biological Impacts** -- A program of moving individuals in and out of captivity and between locations in southern Florida could help equalize the reproductive success of individuals (particularly males) and so increase the effective population size and delay loss of genetic variation. For example, dominant male #12 is probably over-represented genetically in the Florida panther population and, due to his relatedness with most of the females (daughters, grand-daughters, etc.), may be exacerbating the rate of inbreeding. Replacing this dominant male with a non-related peripheral male would provide an opportunity to introduce new genetic material and decrease the rate of inbreeding. If the removed dominant male's home range is allowed to fill naturally, there is a high probability that he will be successfully replaced by a local, peripheral male. On the other hand, if a peripheral male is moved from Big Cypress National Preserve (e.g., #42) or Everglades National Park (e.g., #16) into the vacant range, there is a good chance that the introduced male will home and not establish himself where he is needed. Also, the new male may be killed by intra-specific fighting, or he may kill other males or females. This option does less to correct genetic defects than introduced non-Florida genes. This option would allow demographic management but may not solve genetic problems.

Relying on captive breeding as the primary means of genetic management could face problems. The overall health and vigor of Florida panthers has been compromised by genetic defects and pathogens. Compared with individuals from outbred populations,

It is difficult to precisely describe *F. c. coryi* as it previously existed and thus design a profile upon which to base a restoration objective. The major differences observed in morphological and genetic traits between the Florida population and other populations of *Felis concolor* are likely due to the severe inbreeding and genetic bottleneck that has occurred in the Florida population. However, western populations of *Felis concolor* have not undergone inbreeding and genetic bottlenecks similar to that of the *F. c. coryi*. For these reasons, we assume that they appear today as they did at the time the Florida population became geographically isolated and thus are the best model for what *F. c. coryi* did look like previous to geographic isolation. Molecular genetic analysis indicate that western populations have levels of genetic diversity significantly higher than currently exist in the Florida population. Furthermore, there are low levels of genetic divergence among subspecies of *Felis concolor*. Therefore, western *Felis concolor* will be used as the model for genetic restoration of *F. c. coryi* and the objective is to restore levels of genetic diversity in the Florida population to the levels typical of western populations of *Felis concolor*.

The most practical method for restoring historical levels of genetic variability in the remaining population of Florida panthers and increasing the likelihood of its long-term survival is to translocate a limited number of wild non-Florida individuals into the south Florida population. The genetic restoration action addressed under this alternative would be intended to replicate the natural process of genetic exchange. The best source of lost genetic variation is in the Texas population (*Felis concolor stanleyana*), because it represents the geographically closest extant subspecies that historically interacted with the Florida population. Female Texas animals 2-4 years of age would be the most likely individuals for the translocation because they would be more prone to remain near release sites, less likely to have adverse impacts on the existing population, and more easily assimilated into the existing panther population.

- A. Biological Impacts -- Population declines and associated inbreeding in the Florida panther have resulted in significant losses in genetic variability and viability. The population exhibits multiple physiological abnormalities that are likely a consequence of recent close inbreeding. This inbreeding has resulted in a high incidence of maladaptive traits which include reproductive and medical abnormalities. Furthermore, the Florida panther has suffered from numerous health problems and infectious diseases that may be a consequence of a defective immune system. The goal of the genetic restoration is to reverse the consequences of inbreeding and monitor the reduction in frequency of the maladaptive traits.

depression. The proposed inter-crossing for genetic restoration would be between populations that are much more similar genetically, and would more recently have exchanged genes via natural migration, than were the subspecies that were crossed in the Piper stock that was subsequently released successfully into the Everglades. Outbreeding depression would be unprecedented for a cross between such closely related and recently diverged mammalian populations as the Florida and Texas *F. concolor*.

After the initial genetic restoration, any locally adapted gene would still persist at a frequency of about 80%, and a majority of the next generation would consist of animals that are homozygous for any Florida-adapted genes. Natural selection would further increase the frequency of non-Florida genes that were advantageous, and would keep low the frequency of any non-Florida genes that maybe maladaptive in the south Florida habitats. Ongoing gene flow at a rate of at least 1 new breeder recruited per generation (perhaps 2-4% of the breeding population) would over many generations lead to the replacement of locally adapted traits only if the selective advantage of the locally adapted trait over the non-local variant of the gene was less than the rate of immigration (2-4%). The low probability of loss of genetic traits that have a slight adaptive advantage in the Florida environment would likely be much more than offset by the substantial advantage gained by the reversal of the deleterious effects of inbreeding already seen in the populations.

Advantages of this approach include very low cost (individual could be kept in captivity for a minimal, mandatory quarantine period) and very low probability of disrupting the existing social organization of south Florida panthers. A disadvantage is that there would be less knowledge of medical history (compared with captive reared individuals) and the possibility of introducing a pathogen. This possibility is limited due to the health screening during the quarantine period.

Non-Florida animals, as well as offspring produced from non-Florida x Florida panther matings, will be radio-instrumented. This will allow monitoring of movements, survival, recruitment, and social interactions with other individuals and will allow animals to be recaptured quickly if needed for examination, removal, or to intercede in some other way.

Please refer to Enclosure I for additional information relative to this alternative.

- C. Conclusion -- This alternative provides the same benefits as alternative 2, but would take much longer and cost much more.

Alternative 4 - Utilize Genetic Material From Other Captive Stock (*F.c. coryi* or *F.c. coryi* intercrosses) In The Genetic Restoration Program

-- Under this Alternative, genetic material from captive animals with unknown and mixed ancestry (including "Piper Stock") would be introduced into the Florida panther population by directly releasing individuals into the population or by intercrossing in captivity and releasing the progeny into the population.

- A. Biological Impacts -- As referenced under Alternative 2 above, it has been determined that western *Felis concolor* would represent the most appropriate model for genetic restoration of *F. c. coryi* and objectives should be to restore levels of genetic diversity in the Florida population to levels typical of western populations of *Felis concolor*. The disadvantages of this alternative is that the source stock would be of unknown and mixed ancestry and may be partially adapted (behaviorally and/or genetically) to captivity and less adapted to survival in the wild than translocated individuals from the wild.
- B. Socioeconomic Impacts -- This alternative may provide for the long-term survival of the Florida panther. There is the possibility that an introduced captive-raised and conditioned animal might disperse into unwanted areas thus increasing the possibility of a panther/human interaction. A panther/human interaction would be greater with a captive-raised animal than a wild-caught non-Florida animal (Alternative 2) due to a greater association with humans during the rearing and conditioning process.
- C. Conclusion -- This alternative does not meet the objective of restoring levels of genetic diversity in the Florida population to the levels typical of western populations of *Felis concolor*. It also has a greater risk of not being successful due to the possible inability of the introduced animals to adapt to the wild.

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ENCLOSURE I

A PLAN FOR GENETIC RESTORATION AND MANAGEMENT OF THE FLORIDA PANTHER

A PLAN FOR GENETIC RESTORATION AND MANAGEMENT OF
THE FLORIDA PANTHER (*Felis concolor coryi*)

Report

Prepared by Workshop Participants

U. S. Seal, Editor

Sponsored by

Florida Game and Fresh Water Fish Commission

in Collaboration with

Conservation Breeding Specialist Group CBSG/SSC/IUCN

Hosted by

White Oak Conservation Center

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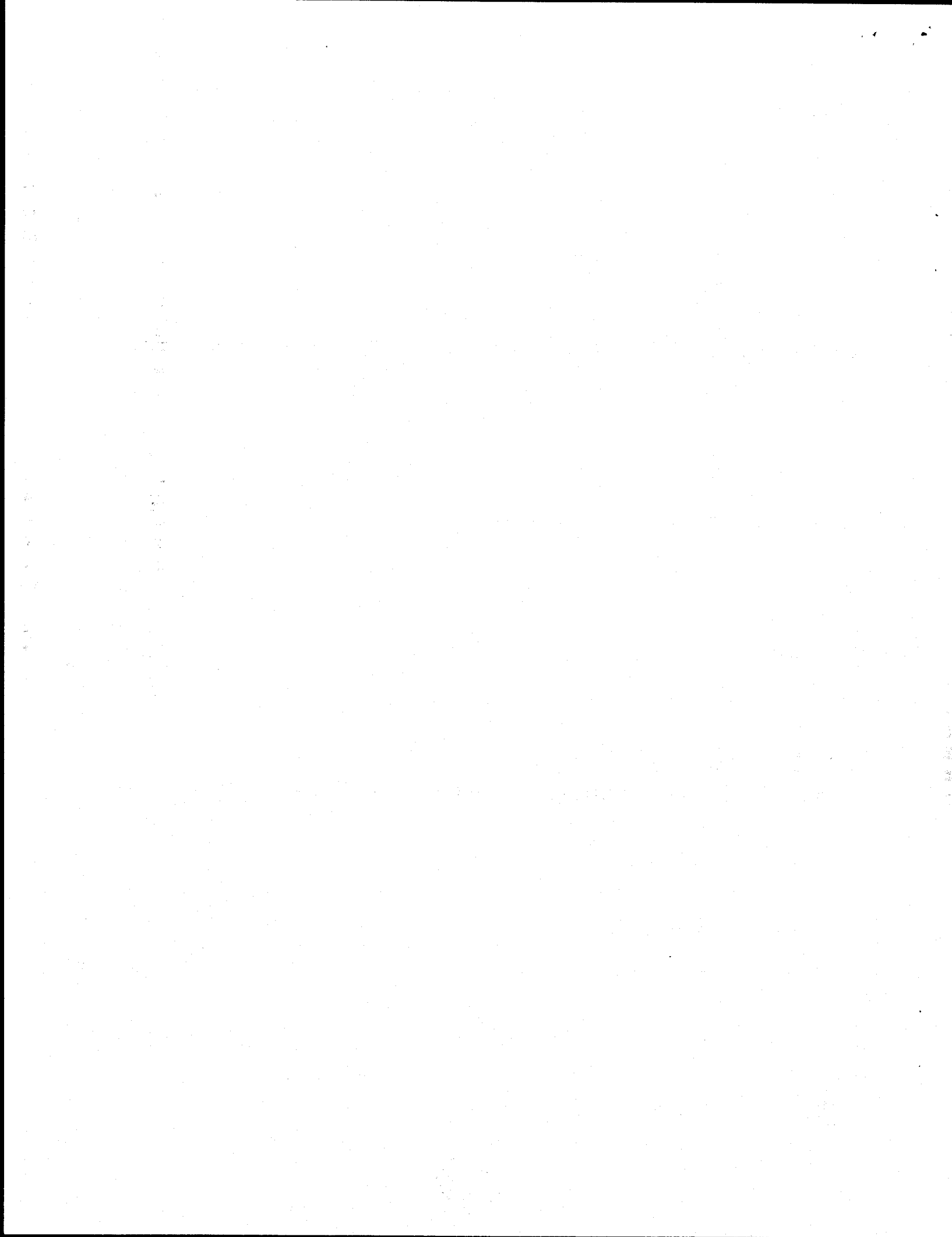


11-13 September 1994

Yulee, Florida

White Oak Conservation
Center





Executive Summary

The Florida panther (*Felis concolor coryi*) is one of the most endangered large mammals in the world. The biological circumstances of geographic isolation, habitat loss, resulting small population size and associated inbreeding have resulted in significant loss of genetic variability and health of the population. The genetic variability and health of the Florida population must be restored for the taxon to survive even with adequate habitat preservation and other enhancement measures. The Florida panther is a named subspecies of the cougar, *Felis concolor coryi*, that formerly occupied southeastern United States and was contiguous with other populations of the species but presently is restricted to a small relict population in southern Florida. The range of *F. c. coryi* was contiguous with that of the Texas cougar, *F. c. stanleyana*, prior to the twentieth century, and it is likely that genetic exchange occurred between these groups because there were no dispersal barriers between their ranges.

The translocation of animals from the historically contiguous west Texas population into south Florida will restore genetic variation. The restored genetic variation will allow for more rapid adaptive evolution of the population, allowing for continued maintenance or improved demographic performance and stability, in contrast to the continued decline and instability that would be expected if the population becomes increasingly homogeneous and inbred. Thus, we would expect that genetic restoration will lead to an increase in reproductive performance and survival.

A workshop was convened by the Conservation Breeding Specialist Group of the SSC/IUCN at the request of the Florida Game and Fresh Water Fish Commission to assist in the formulation of a plan for the genetic restoration and management of the Florida population of *Felis concolor*. The meeting was hosted by the White Oak Conservation Center on 11-13 September 1994. Nineteen people participated in the workshop and contributed to the final document. This is the third workshop devoted to developing genetic management strategies for restoring genetic variation to small populations which have rapidly lost genetic heterozygosity and are suffering adverse effects ascribable to this genetic loss and inbreeding. The present workshop was devoted to the needs of the Florida panther program for a genetic restoration plan.

The level of introgression required to reverse the effects of inbreeding and genetic loss in the Florida population has been estimated at 20%, or 6 to 10 effectively breeding individuals, based on the estimated current population of 30 to 50 breeding adults (Seal et al. 1992). An initial release will be made of 8 non-pregnant young adult females from the Texas population. Supplemental additions will be utilized as needed to fully achieve and maintain desired restoration results. Maintaining restored genetic health of this population will require the occasional translocation of animals to achieve an immigration rate of at least one new breeder per generation into the small population in south Florida. This level of restored genetic exchange will prevent renewed inbreeding or continued loss of genetic variability from the Florida population. Implementation of this plan will require continuous monitoring and management to restore and maintain the genetic health of the population.

Objectives and Strategies

Objectives:

The objectives of the plan are to: 1) reduce occurrence of inbreeding; 2) restore genetic variability and vitality of offspring produced and recruited as breeders into a healthier, more resilient population of *F. c. coryi* and; 3) to resume the evolutionary adaptive potential of the South Florida population by restoring levels of genetic diversity to the levels typical of other subspecies of *Felis concolor* in western North America.

Strategies:

The current genetic diversity of western *Felis concolor* is most likely typical of the Florida population prior to its isolation and therefore will be used as the model for genetic restoration of *Felis c. coryi*. The Texas population of *Felis concolor* will serve as the source of genetic stock for translocation, since that population was historically contiguous with the Florida population.

The strategies to accomplish the objectives include 1) methods and locations for adding genetic variation to the Florida population, 2) selection and management of the animals to supply the genes, 3) monitoring of the genetic introgression and of its effects on the genetics and morphology of the resident Florida population, and 4) uses of the captive program for systematically measuring the effects of introgression and developing supporting methods for controlled reproduction.

1. Methods and Locations

- A. Direct translocation of non-Florida (western Texas) animals into suitable unoccupied territories or potential territories in south Florida is the primary approach selected to achieve genetic restoration.
- B. The potential translocation sites are in Everglades National Park (Long Pine Key), Big Cypress National Preserve (Loop Road, Turner River Unit), northern Fakahatchee Strand State Preserve, eastern Addition Lands and select private lands in Hendry County. These sites would allow the translocation of 8 female Texas animals that would have the potential to recruit and mate with Florida panther males.
- C. The level of introgression required to reverse the effects of inbreeding and genetic erosion is estimated at 20%, or 8 ± 2 individuals, based on the estimated current population of 30 to 50 breeding adults. The 8 introduced individuals need to produce at least 2 surviving offspring that recruit into the Florida population and mate with animals already in the Florida population. Since not all introduced individuals may survive and breed successfully, this part of the program will need to be monitored and continue until 8 introduced individuals do recruit and produce at least 2 offspring each which survive and breed in the population.

D. Maintaining restored genetic health of this population will require the occasional translocation of additional animals to achieve a recruitment rate of at least one new breeder per cougar generation into the small population in south Florida.

2. Selection and Management

A. Animals selected for translocation will be 2-4 year old, non-pregnant, females from widely distributed areas of the range of the source population, and without cowlicks, kinked tails, or cardiac abnormalities. Litter mates will not be selected. Otherwise, selection will not include other morphological or molecular criteria.

B. The threat of infectious disease in translocation programs is an issue of major concern because of the inherent risks involved with the introduction of pathogens into wild populations of naive animals. Conversely, introducing naive animals into populations harboring potential lethal organisms also has potential consequences. Therefore, animals selected for translocation will be quarantined to collect biomedical information for health screening of candidates prior to release.

3. Monitoring

A. The extent of introgression of Texas genes into the Florida population will be assessed by three different approaches: (1) pedigree analysis based on founder contributions from the Florida and Texas populations, (2) molecular genetic analysis of markers that show differentiation between the two populations, and (3) analysis of morphological characters that can differentiate between the populations and which may be associated with adaptation.

B. Demographic components of fitness will be monitored in the genetically restored Florida population and compared to data on the present and recent historical population. A comprehensive pedigree database (studbook) will be established for the Florida population. Pedigree analyses methods are seriously compromised when parentage is unknown. Uncertainties regarding parentage will be resolved when possible using such techniques as molecular genetics and behavioral observations.

4. Captive Population and Research

A. The role of the captive population will shift from one preserving subspecies variability to one consistent with current objectives for genetic restoration. Institutions holding Florida panthers in captivity will manage them in accordance with management, research, and educational objectives and needs identified in the genetic management plan and the Florida Panther Recovery Plan.

B. Actions will be undertaken to continue the development of artificial insemination (AI), so this technology can be utilized as may be appropriate to accomplish genetic restoration.

Introduction

The Florida panther (*Felis concolor coryi*) is one of the most endangered large mammals in the world. Geographic isolation, habitat loss, resulting small population size and associated inbreeding have resulted in significant loss of genetic variability and health of the population. Natural gene exchange that occurred historically between the Florida population and other contiguous populations of *Felis concolor* ceased to occur when the panther became geographically separated from other populations of the species. Gene flow occurs as individuals disperse among populations and breed. Just as dispersal is the natural mechanism for gene exchange and maintenance of genetic health within populations, those same dispersing breeders minimize the occurrence of inbreeding within populations. Inbreeding increases when dispersing breeders can no longer immigrate into the fragmented population, resulting in inbreeding depression, loss of genetic variation, declining health, reduced survivability, lower numbers and eventual extinction.

We now understand this scenario as part of the extinction process (Gilpin and Soulé 1986). It is this biological circumstance that perhaps most affects the health and survival of the Florida population. While other human related factors affect health of the panther's environment, we now understand that genetic variability and health of the Florida population must be restored for the taxon to survive even with adequate habitat preservation and other enhancement measures (Seal et al. 1992).

It is difficult to precisely describe *F. c. coryi* as it previously existed and thus design a profile upon which to base a restoration objective. The major differences observed in morphological and genetic traits between the Florida population and other populations of *Felis concolor* are likely due to the severe inbreeding and genetic bottleneck that has occurred in the Florida population (Seal et al. 1992). However, western populations of *Felis concolor* have not undergone inbreeding and genetic bottlenecks similar to that of *F. c. coryi* (Roelke et al. 1993). For these reasons, we assume that they appear today as they did at the time the Florida population became geographically isolated and are the best model for what *F. c. coryi* did look like previous to geographic isolation. Molecular genetic analysis indicate that western populations have levels of genetic diversity significantly higher than currently exist in the Florida population (Roelke et al 1993). Furthermore, there are low levels of genetic divergence among subspecies of *Felis concolor* (Roelke et al. 1993; O'Brien et al 1990). Therefore, we will use western *Felis concolor* as the model for genetic restoration of *F. c. coryi* and our objective is to restore levels of genetic diversity in the Florida population to the levels typical of western populations of *Felis concolor*.

This genetic restoration will be accomplished by reinstating gene flow from western populations into the Florida population by selectively translocating individual animals that can be recruited into the population as breeders. Such a management action seeks to mimic historic immigration into the population. The intent is not to replace, or swamp, the *F. c. coryi* gene pool with western *Felis concolor* genes. Rather, the intent is to reduce occurrence of inbreeding and restore genetic variability and vitality of offspring produced and recruited as breeders into

a healthier more resilient population of *F. c. coryi*. Furthermore, the enhanced genetic variation and gene flow will provide the necessary genetic material to restore the process of natural selection to the Florida population. Thus restoration is intended not only to resolve the current problems associated with loss of genetic variation, but also to restore evolutionary adaptive potential of the Florida population. Recovery of *F. c. coryi* will be greatly enhanced by such actions.

Direct translocation of non-Florida individuals into suitable unoccupied territories or potential territories in south Florida is the primary approach selected to achieve genetic restoration of that population. The primary reasons for selecting this approach are the immediacy of introducing selected genetic material into the wild population and the elimination of possible confounding factors that might be associated with the use of individuals produced in captivity. Two other processes that will have application and aid in the genetic restoration process are captive breeding and the use of artificial insemination (AI). AI technology presently is not developed as a reliable technique in *Felis concolor*. Actions will be undertaken to continue the development of AI so this technology can be utilized as may be appropriate to accomplish genetic restoration. The specific role of a captive program to assist the genetic restoration and management of the Florida panther has been redesigned consistent with objectives for genetic restoration of the wild population (see section on Captive Population below).

The level of introgression required to reverse the effects of inbreeding and genetic loss in the Florida population has been estimated at 20%, or 6 to 10 individuals, based on the estimated current population of 30 to 50 breeding adults (Seal et al. 1992). An initial release will be made of 8 non-pregnant, young adult females from the Texas population. Supplemental additions will be utilized as needed to fully achieve and maintain desired restoration results. Maintaining restored genetic health of this population will require the occasional translocation of animals to achieve an immigration rate of at least one new breeder per generation into the small population in south Florida. This level of restored genetic exchange will prevent renewed inbreeding or continued loss of genetic variability from the Florida population.

Translocation and Monitoring

The most practical method for restoring historical levels of genetic variability in the remaining population of Florida panthers and increasing the likelihood of its long-term survival is to translocate wild non-Florida individuals into the south Florida population. The most appropriate source of genetic variation for the south Florida population is in the Texas population (*Felis concolor stanleyana*) because the range of *F. c. coryi* prior to the twentieth century was contiguous with that of the Texas cougar, *F. c. stanleyana*, to the west and it is likely that genetic exchange occurred between these groups because there were no dispersal barriers between their ranges. Female Texas animals 2-4 years of age would be the best individuals for the translocation because they would be more prone to remain near release sites, less likely to have adverse impacts on the existing population, and more easily assimilated into the existing panther population.

Selection of Animals for Translocation

The animals captured for translocation generally will not be pre-selected to conform to any genetic type, as there is no way to determine which genes presently in the Texas population would be most adaptive in Florida. However, because some genetic traits (hair whorl or cowlick, kinked tail vertebrae, and atrial septal defect) that are at high frequency in Florida but low frequency elsewhere will be used as markers of the progress of genetic restoration, any Texas animals that show those traits will be rejected. Animals with a cowlick or kinked tail will be detected at the time of capture. Atrial septal defects in candidate animals will be detected during examination in quarantine. All genetic and morphological traits presently being monitored in the Florida panthers will be measured during quarantine to provide a baseline of data. The quarantine protocols for ensuring that the translocated animals do not transfer any contagious diseases into the Florida Panther population will be the same as presently used for Florida animals, except as may be noted in specific protocols.

Animals will be selected for translocation to maximize their probability of establishment into territories and subsequent breeding. Translocated animals will be non-pregnant, young females, 2 to 4 years old. Subsequent genetic comparison of the genetically restored Florida population to the source population for genetic exchange requires that the capture locality of each animal used for translocation be documented. Moreover, the animals chosen for translocation will not include any that are known or suspected to be closely related (siblings). Translocated animals will be selected, to the extent possible, from geographically diverse areas within the range of the Texas cougar.

Identifying Potential Release Sites

Existing telemetry data coupled with field observations of uncollared panther sign reveal several potential areas for release of translocated animals. These gaps, as well as areas that are vacant but recently supported female panthers are dispersed throughout the currently occupied range of the Florida population. It should be pointed out that release of Texas animals into south Florida is not intended to merely add more individuals to the population but to restore overall health and vitality of the population to a more natural level. Intrinsic limiting factors related to habitat quality and availability may already maintain panther numbers at or near maximum density or may be the cause for fluctuating or ephemeral populations in some areas such as Everglades National Park or the southern Big Cypress National Preserve (Bass and Maehr 1991). Releases of too many additional animals into an area of already limited resources may have destabilizing or other negative effects on these tenuous and apparently recent subpopulations.

The candidate translocation sites are in Everglades National Park (Long Pine Key), Big Cypress National Preserve (Loop Road, Turner River Unit), northern Fakahatchee Strand State Preserve, eastern Addition Lands and select private lands in Hendry County. These sites would allow the translocation of 8 female Texas animals that would have the potential of interacting with Florida panther males.

Monitoring and Evaluating Translocated Animals

Monitoring of the introduced Texas animals will be incorporated into the current schedule for monitoring Florida panthers. Introductions will be evaluated by comparing survival, movements and home range sizes of introduced animals with those of Florida panthers and documenting reproductive behavior, denning and kitten rearing.

All dens of Texas females will be visited within the first month of detection. Kittens will be examined, uniquely marked, blood and other tissue samples acquired as needed, and returned to the den. Kittens will be recaptured at approximately 6 months of age and radio-instrumented; standard morphological measurements and biomedical samples will be taken. Tissue sampling for genetic analyses will be of particular importance to document introgression of the Texas genetic material into the Florida population.

The goal is to have a balanced representation from each introduced Texas animal with at least 2 individuals from each Texas x Florida intercross recruited into the population. The kittens produced through matings of Texas females with Florida males would be expected to remain with their mother for 1.5 to 2 years. Female offspring often establish home ranges that overlap their mother or share a common boundary (Maehr et al. 1991). Translocated Texas females eventually may be removed to create a vacancy for recruitment of an F1 female into the Florida population. The F1 generation will be monitored as described above to document the success of their recruitment. Any removed animals may be relocated to another location within the south Florida study area, incorporated into the captive breeding program, used as an addition to concurrent panther re-establishment studies, or returned to Texas.

Monitors of Genetic Admixture

The extent of introgression of Texas genes into the Florida population (genetic admixture) will be assessed by three methods: pedigree analysis based on founder contributions from the Florida and Texas populations, analysis of molecular genetic markers that can differentiate between the two populations, and analysis of morphological characters that are differentiated between the populations and which may be associated with adaptation. Each of these methods has inherent power for quantifying genetic introgression in populations as well as limitations in interpretation. Their usefulness and specific advantages have been demonstrated in other species and offer an important measure of the quantity of genetic introgression.

Pedigree Analysis

Analysis of a population's pedigree can be used to monitor the genetic processes within populations (Lacy et al. 1994). If information on parentage is completely known, transmission of genes from one generation to the next can be tracked assuming each offspring receives 50% of its genes from each of its parents. This approach will be used to monitor the spread of *F. c. s.* genes in the *F. c. c.* population, document any further inbreeding, and help determine the genetic origins of traits that appear in the population. Pedigree data (sex, parentage) will be

combined with life-history data (data of birth, date of death, reproductive events) to allow genetic and demographic analyses.

A computerized pedigree database (studbook) will be established and maintained for the Florida population to record parentage, sex, date of birth, location, reproductive history, and date of death of every individual in the population. Any uncertainty in the data must be clearly identified in the database. The pedigree will be maintained in a centralized location and available in a standardized format (e.g., SPARKS) to facilitate management and analyses.

Pedigree analyses methods are seriously compromised when parentage is unknown. Uncertainties regarding parentage will be resolved when possible using such techniques as molecular genetics and behavioral observations.

Molecular Markers

Molecular markers of genetic variation have emerged in recent years as powerful estimators of the extent and character of population genetic variation and differentiation. By scoring a group of highly polymorphic genetic markers, it is possible to estimate the proportion of population genetic admixture following intercrossing, such as is proposed for the Florida panther. Initially a series of markers will be identified (nuclear and mitochondrial) that differentiate between the present day Florida population and the introduced Texas animals. These markers are not thought to reflect adaptive genetic differences, rather they would be useful primarily for discriminating the proportional genetic contributions of the two closely related populations. The biological materials required for identification will include specimens (blood samples and immortalized skin culture biopsies) of living Florida animals and Texas animals used for release and intercrossing.

Two categories of molecular genetic markers will be a priority for analysis: mitochondrial DNA genes and nuclear microsatellite (di-, tri-, and tetra-nucleotide repeat) loci. Mitochondrial genes are ideal because of their rapid genetic divergence, primarily maternal inheritance, lack of recombination, and ample genetic theory for interpreting patterns of variation. Microsatellites are ideal nuclear markers because there are a large number of loci known in cats, abundant genetic variation due to high mutation rate, and their PCR format assay makes them feasible to analyze with limited amounts of tissue. Other categories of genetic loci (minisatellite or VNTR, isozymes, Y-chromosome locus introns, MHC variation) may also be considered but would not constitute a first priority.

An estimate of the quantity of population genetic exchange can be calculated by quantifying the extent of variation attributable to Texas vs. Florida genetic markers in subsequent generations. They will reflect an overall estimate of admixture because the markers are not the genes subject to adaptation or selective pressure. The proportion of genes subject to adaptive pressures and that may have been retained from the Florida animals may be different and should

not be presumed identical to genetic marker frequencies. Sufficient polymorphic markers should be assayed to allow unambiguous genetic identification of each animal translocated from Texas and their offspring.

Morphological Characters

The Florida panther was originally described by Cory (1896) and named as a distinct subspecies by Bangs (1889). The original taxonomic description of *F. c. coryi* was based largely on geographical distribution and cranial morphology, specifically the occurrence of a distinctive broad frontal region of the skull with rather broad and highly arched nasals (Bangs 1989; Goldman, 1946). Belden (1986) reported two additional morphological characters consistently observed in Big Cypress Swamp panthers: a ridge or whorl of hairs similar to a cowlick on the mid-dorsal thorax and a 90 degree angle or kink in the posterior tail vertebrae. An analysis of 636 *F. concolor* specimens, including 35 Florida panthers, collected from 1896 to 1987, observed an 83% incidence of the cowlick in Florida panthers compared with 4.8% in other subspecies (Wilkens et al. in press). The kinked tail occurred in 100% of 18 examined specimens of Florida panther from Big Cypress Swamp for which post cranial skeletons were available (Belden, 1986; Wilkens et al., in press). The majority of these specimens postdate the demographic reduction of *F. c. coryi*. The tail kink and cowlick were likely less frequent in the historic outbred ancestors of *F. c. coryi*. Although tail kinks, cowlicks, and a shortened skull have been used in taxonomic descriptions of the Florida population, all of these characteristics may be consequences of inbreeding and consequently they should not be regarded as traits that should be deliberately preserved in future populations of Florida panthers.

Morphological traits are an important component of the monitoring program for three reasons. First, perhaps more than any other kind of trait, morphology defines the essence of *Felis concolor*. The maintenance of species characteristics can be assessed by routinely recording morphological traits during population recovery. Thus, miniaturization for example, would be an undesirable consequence of genetic drift during recovery. Such evolution outside the normal limits of *Felis concolor* variation could be detected by monitoring body size. Second, some morphological traits may be adaptations to local conditions in Florida. Such traits should be monitored even though their status as adaptations may be questionable. Pelage color should be monitored, for example, because dark coloration is suspected to be an adaptation to environments such as are found in south Florida. Third, some morphological traits are reflections of inbreeding. Such traits (e.g., kinked tails, cowlicks or hair whorls) are likely to have recessive inheritance and should be monitored with the expectation that they will be masked by introgression (i.e., not be expressed in first generation intercrosses of Florida and Texas animals). Although recessive deleterious traits should not be expressed in first generation intercrosses, they probably will be expressed in later generations in a minority of intercross descendants. This decline in frequency of expression is a normal and desired result.

Monitoring morphological traits will allow the documentation of the combined effects of genetic exchange and adaptation to the Florida habitats via natural selection. Morphological traits

will be scored under four circumstances: (1) shortly after birth, (2) at approximately 6 months of age, when animals are under anesthesia while being fitted with radio-collars, (3) at each handling of the animals for other purposes, and (4) after death. Routine weight and other measurements will be made (body mass, body length, tail length, chest girth, neck girth, shoulder height, hind foot length, ear length) on kittens, young adults and at necropsy. Kinking of the tail, cowlicks and other unusual characteristics will also be scored. All wild and captive animals that die and can be recovered will be prepared as museum specimens (skin, skull and skeleton). Pelage characteristics and skull measurements (including bilateral asymmetries) will be recorded from such specimens.

Variation in most morphological traits is affected by environmental circumstances as well as inheritance. Although environmental contributions to variation within populations can sometimes be substantial, genetic effects are often the predominant influence on morphological traits (Mousseau and Roff 1987). The monitoring of morphological traits is based on the reasonable assumption that at least part of any differences detected may be genetic. Detailed studies of morphological inheritance in *Felis concolor* are not available; therefore, the possible inheritance of traits must be decided on a trait-by-trait basis by comparison with results for closely related species (e.g., domestic cat) or more distantly related vertebrates (e.g., hooved stock, humans). Thus, white flecking that has been observed on some *Felis concolor* hides is caused by tick scars and is almost certainly nongenetic. Conformational traits on the other hand (e.g., measurements of body parts) are usually highly heritable in domestic animals and so may be capable of rapid evolution in *Felis concolor*.

Each individual will be assigned a unique identification number that is used in all circumstances to insure that museum vouchers can be matched up with tissue samples, medical records, etc. Marking with passive integrated transponders may be the most infallible way to accomplish this identification. Such transponders will be injected into a body region (e.g., ear cartilage) that is permanently attached to the hide of the specimen. Ear tattooing is a good backup, but not a substitute for a transponder. In addition, site of origin and breeding history of the animal will be documented for each specimen. The site of origin for individual Texas animals that are used in translocations is especially critical because Texas populations may differ in genetic constitution, pathogen load, etc. The site of capture for each Texas animal will be established.

Monitoring of Maladaptive Traits

Population declines and associated inbreeding in the Florida panther have resulted in significant losses in genetic variability and viability. The population exhibits multiple physiological abnormalities that are likely a consequence of recent close inbreeding. This inbreeding has resulted in a high incidence of maladaptive traits which include reproductive and medical abnormalities. Furthermore, the Florida panther has suffered from numerous health problems and infectious diseases that may be a consequence of a defective immune system. The goal of the genetic restoration is to reverse the consequences of inbreeding and monitor the reduction in frequency of the maladaptive traits.

Maladaptive traits

1. Reproductive abnormalities

The occurrence of detrimental reproductive traits includes a high incidence of cryptorchidism, morphologically-abnormal sperm per ejaculate and malformed sperm acrosomes.

a. Cryptorchidism: Cryptorchidism is heritable and is suspected to result from a sex-limited recessive (or possible dominant) autosomal gene in several domestic species: dog, sheep, swine, and cat (Romagnoli, 1991; Burns & Fraser, 1964; Claxton & Yeates, 1972; McPhee & Buckley, 1934). Sixty-five percent of free-ranging Florida panthers of Big Cypress genetic lineage are cryptorchid, while there has been only 1 cryptorchid male of 7 males in the Everglades population (Dunbar, 1994). Cryptorchidism has not been observed in medical examinations of over 40 free-ranging cougars captured in Texas, Colorado, British Columbia, or Chile, and was observed in only two of more than 50 captive males, one in Chile and one in a US zoo (Roelke et al., 1993). Circulating testosterone concentrations were lower in male Florida panthers with only one descended testicle than in those with two, whereas testosterone levels in Florida panthers with two normally descended testicles were no different from males in other cougar populations (Barone et al., 1994). In addition, cryptorchid male Florida panthers tend to produce fewer motile sperm per ejaculate than normal males: 0.54×10^6 compared with 2.19×10^6 (Barone et al., 1994). A high incidence of cryptorchidism has been recently observed in the last two decades, a period in which there have been a number of documented matings between close relatives (Roelke et al., 1993). These observations document the rapid rise toward genetic fixation of a maladaptive genetic trait in a small population that continues to inbreed.

b. Spermatozoal Traits: Semen quality and endocrine and reproductive functions have been shown to be adversely affected in some inbred lines of several species, including mice, cats, 2 lion subspecies and cheetahs (Wildt et al., 1994). Comparative reproductive analyses of seminal traits in five feline species, revealed that Florida panther males display some of the poorest seminal quality traits ever recorded for any felid species or subspecies (Barone et al., 1994). Total motile sperm per ejaculate in Florida males is 18-38 times lower than in other cougars, 30-270 times lower than in other felids and 30 times lower than in the cheetah. Although cougars and other large felids tend to produce high proportions of morphologically abnormal sperm, the Florida panther has a significantly greater frequency of malformed spermatozoa (average 93.5% per ejaculate) than any other subspecies; particularly noteworthy was a 42% incidence of acrosomal defects, a trait that renders sperm deficient in fertilization potential (Barone et al., 1994).

2. Medical defects

a. Atrial septal defects (ASD): Atrial septal defects, termed patent foramen ovale, have been found in 5 out of 55 documented Florida panther mortalities from 1972 through July 1994 (Roelke et al., 1993; Dunbar, personal communication). This defect may have contributed to

death in 4 out of 5 of these cases. ASD has been observed in several species including humans (ASD is the most common congenital heart defect in human adults) (Braunwald, 1992), but has not previously been observed in cougars and only rarely in domestic cats (Bolton & Lui, 1977). The etiology of ASD is not well understood, but certain cases in humans suggest an autosomal dominant mode of inheritance (Lynch et al., 1978; Mascia et al., 1987). Heart murmurs have been detected in Florida panthers, sometimes at high frequencies; however, the relationship between ASD and heart murmurs is not clear. Recently, hypo- and hyper-vitaminosis A have been ruled out as potential causes of cardiac abnormalities in Florida panthers (Dunbar, 1994). The etiology of the cardiac defects is unknown, however, there may be a genetic explanation.

Assessment and Surveillance of Clinical Health and Reproductive Status

Health Screening and Quarantine of Candidates for Translocation

The threat of infectious disease in translocation programs is an issue of major concern because of the inherent risks involved with the introduction of pathogens into wild populations of naive animals (Wolff and Seal 1993). Conversely, introducing naive animals into populations harboring potential lethal organisms also has potential consequences. Therefore, biomedical information is needed for health screening of candidates prior to release. The following is a list of clinical health parameters and treatments that will be assessed during quarantine to select individuals for translocation.

1. Complete physical examination with emphasis on cardiac evaluation. Further cardiac assessment including ECG, chest radiography and ultrasonography will be performed if heart murmurs are detected.
2. Serum chemistry and hematological evaluation.
3. Evaluation for internal and external parasites.
4. Vaccinate and apply appropriate therapy to prevent introduction of pathogens and to ensure animal survival post-release.
5. Screen for various bacterial, viral, rickettsial and protozoal diseases that may include but not be limited to FIP, FIV, FeLV, panleukopenia, calicivirus, rhinotracheitis, rabies, brucellosis, and toxoplasmosis.

If future translocation programs include the release of males, a complete reproductive evaluation including semen analysis and sperm morphology assessment will be conducted.

Clinical Health and Reproductive Assessment of Captive and Free-ranging F. concolor in the

Restoration Program

Since the population of Florida panthers has suffered from numerous fatal infectious agents, the following is a partial list of clinical health and reproductive parameters and treatments that will be assessed in captive and free-ranging *F. concolor* including intercrosses.

1. Complete physical examination with emphasis on cardiac evaluation. Further cardiac assessment including ECG, chest radiography and ultrasonography may be performed if heart murmurs are detected.
2. Serum chemistry and hematological evaluation.
3. Evaluation for internal and external parasites.
4. Vaccinate and apply appropriate therapy to prevent introduction of pathogens and to ensure animal survival.
5. Screen for various bacterial, viral, rickettsial and protozoal diseases that may include but not be limited to FIP, FIV, FeLV, panleukopenia, calicivirus, rhinotracheitis, rabies, brucellosis, and toxoplasmosis.
6. Toxicological screen of fat and blood for heavy metals, organochlorines, PCBs and others.
7. Assess reproductive traits and semen quality in adults.
8. Nutritional screen (trace minerals and others).
9. Evaluation of metabolic parameters (T3, T4, cortisol, etc).
10. Evaluation of reproductive hormones (estradiol, testosterone, FSH, LH, etc.)
11. Evaluation of immune system function (i.e., CD4:CD8 lymphocyte ratio, etc.)
12. Evaluate causes of adult and kitten mortality through complete pathologic examination.

Monitoring Demographic and Fitness Parameters during Genetic Restoration

The existing Florida Panther population is threatened by demographic problems as well as genetic problems (for example, mortality rates are unacceptably high, and habitat is not sufficient to allow expansion of the population to a more stable size; Seal and Lacy 1989). The translocation of non-Florida animals into south Florida will restore genetic variation and,

therefore, may increase fecundity and survival. In addition, the restored genetic variation will allow for more rapid adaptive evolution of the population, allowing for maintained or improved demographic performance and stability, in contrast to the continued decline and instability that might be expected if the population becomes increasingly homogeneous and inbred. Thus, we would expect that genetic restoration will lead to an increase in reproductive performance and survivability.

Outbreeding depression, a possible negative consequence that could result from introgression, has been considered, but was rejected as an implausible outcome of the planned genetic restoration. For example, the outcrossed panthers in the Everglades subpopulation showed a reversal of some of the effects of inbreeding seen in the Big Cypress segment of the population (O'Brien et al. 1990), and showed no evidence of outbreeding depression. The proposed intercrossing for genetic restoration would be between populations that are much more similar genetically, and would more recently have exchanged genes via natural migration, than were the subspecies that were crossed in the Piper stock that was subsequently released successfully into the Everglades (Roelke et al. 1993). Outbreeding depression would be unprecedented for a cross between such closely related and recently diverged mammalian populations as the Florida and Texas *F. concolor*. It will be necessary to monitor demographic parameters of the intercrossed population to assure that damaging effects of the genetic restoration did not occur, and to document the likely beneficial effects of genetic restoration.

The planned genetic restoration consists of an initial introduction of sufficient animals so that approximately 20% of the breeders in the population will consist of migrants from the Texas population. This will be followed by further genetic management that results in at least 1 translocated animal recruiting into the breeding population per generation (about 6 years). This rate of genetic mixture would not be so great as to cause genetic swamping of locally adapted traits presently in the south Florida population. After the initial genetic restoration, any locally adapted gene would still persist at a frequency of about 80%, and a majority of the next generation would consist of animals that are homozygous for any Florida-adapted genes. Natural selection would further increase the frequency of non-Florida genes that were advantageous, and would keep low the frequency of any non-Florida genes that may be maladaptive in the south Florida habitats. Ongoing gene flow at a rate of at least 1 new breeder recruited per generation (perhaps 2-4% of the breeding population) would over many generations lead to the replacement of locally adapted traits only if the selective advantage of the locally adapted trait over the non-local variant of the gene was less than the rate of immigration (2-4%). The low probability of loss of genetic traits that have a slight adaptive advantage in the Florida environment would likely be much more than offset by the substantial advantage gained by the reversal of the deleterious effects of inbreeding already seen in the population.

The demographic components of fitness that will be monitored in the genetically restored Florida population are those that are being monitored presently and include:

- (1) proportion of the number of adult females producing litters each year,
- (2) average litter size,

- (3) average litter sex ratio,
- (4) kitten survival through 12 months,
- (5) subadult survival to reproductive age,
- (6) recruitment of adults into the population of territorial breeders,
- (7) age of first breeding,
- (8) annual adult survival.

These aspects of demography have been monitored for a number of years and they will be maintained in a studbook database, so that a baseline exists for comparison to the future genetically restored population.

Some of these demographic parameters may well improve following genetic restoration, as effects of previous inbreeding are reversed, and it is unlikely that any components of fitness would decrease as a result of the planned genetic management. In the unlikely event that the monitoring reveals a decrease in overall fitness in the inter-crossed progeny or their descendants, it would be important to examine the causes of the fitness depression and evaluate whether inter-crossed panthers should be removed from the wild population. Any outbreeding depression would be greatest in either the first or second generation of outcrossing. It would be possible at that time, if such did occur, to remove inter-crossed panthers from the wild population in south Florida. Even if some inter-crossed descendants remained in the wild, any decreased viability or fertility would eliminate genes that are poorly adapted to the Florida habitats within a few generations, and would lead to the evolution of new coadapted (and non-inbred) genomes. Thus, there is little risk that any maladaptive traits could "swamp" locally adapted traits or cause long-term damage to population viability.

The Role of the Captive Population in the Genetic Restoration of the Florida Panther

The implementation of a genetic restoration program for *Felis concolor coryi* will have a dramatic impact on the original aspects of the captive breeding program. The need to establish a large reservoir of identified *Felis concolor coryi* to maintain a specific level of genetic diversity as a safeguard from extinction will no longer be required (Seal et al. 1989.)

The role of the captive population will shift from one of preservation of the subspecies variability to one consistent with current objectives for genetic restoration. Institutions holding Florida panthers in captivity will manage them in accordance with management, research and educational objectives and needs identified in the genetic management plan and the Florida Panther Recovery Plan.

Production of Various Generation Types To Assess Intercross Effects

The number of individuals needed from various generational types (F_1 , F_2 , backcross) to assess fully the effect of intercrossing far exceeds the space presently available in the captive

population. A rough estimate is that 20-30 offspring are minimally needed for each generational type for adequate evaluation of the effects of intercrossing on, for example, survival rates. While these data can not be generated in the short term, they can be accumulated in time, at a rate compatible with the space available in the captive population. Initial strategies will be to produce 2-3 litters each of reciprocal F_1 (i.e., Texas female x Florida male and Florida female x Texas male) and backcross of F_1 to Florida parents (B_F), since these are the generational types most likely to occur first in the wild population. These intercrosses will provide enough initial data to detect problems that could significantly compromise the program (e.g., sterility). However, reciprocal F_2 and F_1 backcrossed to Texas parents (B_T) also will be produced to provide data for comparative purposes. The eventual goal is to increase the numbers in each generational type over time.

The primary objectives of the captive population will be:

1. Continue research on reproductive physiology, health and husbandry concerns.
2. Specific research on assisted reproduction to improve the reliability of AI techniques.
3. Assess results of introgression undertaken in captivity as previously outlined under Monitors of Genetic Admixture, Monitoring of Maladaptive Traits, Assessment and Surveillance of Clinical Health, and Monitoring Demographic and Fitness Parameters during Restoration.
4. Assess the impact of introgression in captivity on maternal behavior.
5. Continue development of techniques that improve the success rates of large carnivore release programs.
6. Production of F_1 animals for reintroduction into identified habitat for expansion of the species into its historical range outside south Florida when feasible and provide introgressed panthers to other institutions, when release is not feasible, for further research and public education needs.
7. Educate the public regarding panthers in Florida, their importance in the natural system and the recovery program.

Each *Felis concolor* in captivity that is part of this program will be evaluated as to health and reproductive fitness and assigned a specific role in the program. Production of F_1 cats will be based specifically on needs of genetic restoration. Offspring that do not have a specific role or have fulfilled their role in the genetic restoration program will be placed in accordance with each institutions animal disposition policy. A serious effort must be made to produce only introgressed offspring that have a specific role in the restoration program due to limited space in participating institutions.

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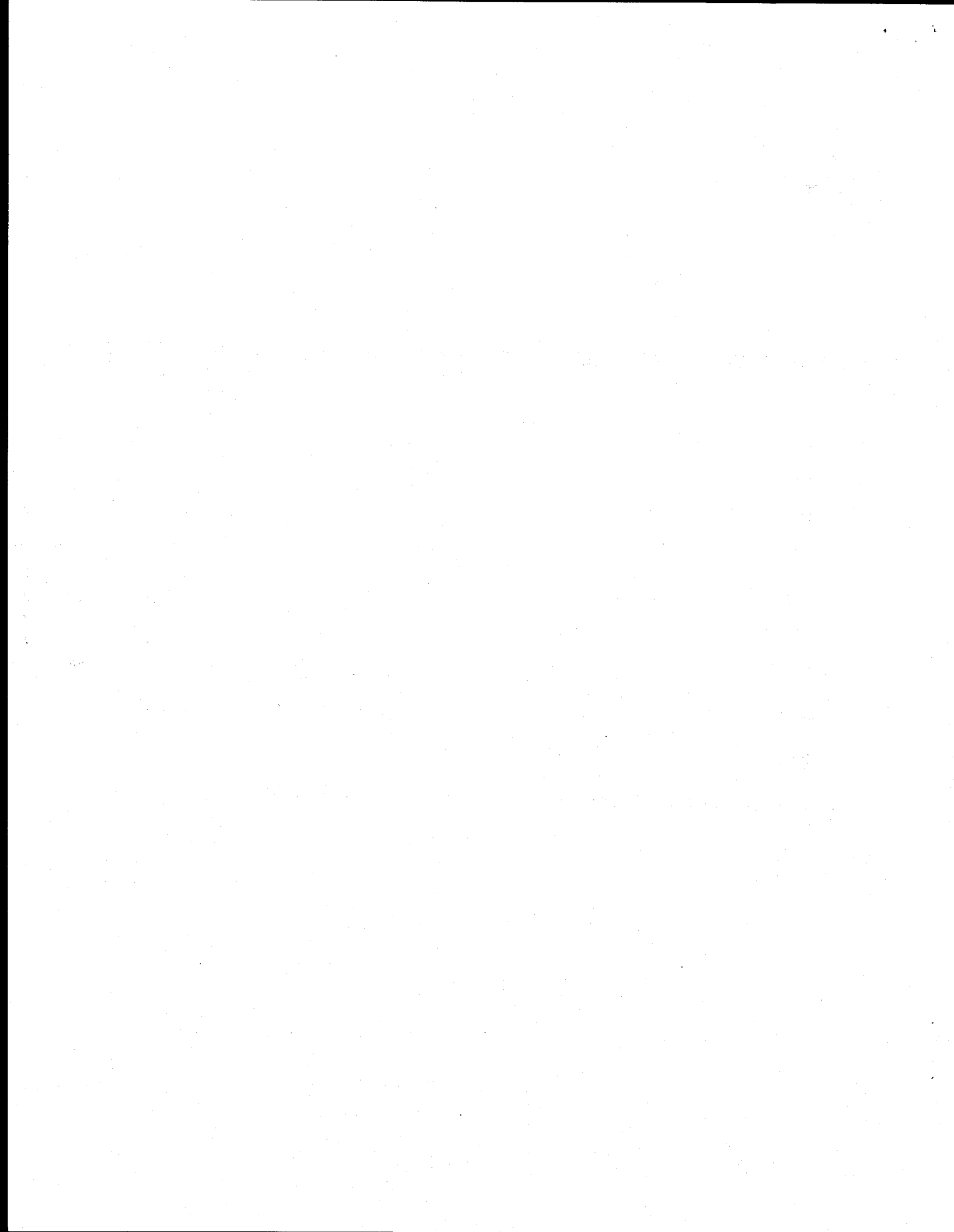
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Wildwood Park Zoo

14 September 1994

ENCLOSURE II

ENVIRONMENTAL CONTAMINANTS STUDY DESIGN



PROCEDURE:

A. **Methods and Materials:** Several groups of animals will be utilized during the course of this study. These include, but are not limited to:

- cougars to be introduced into the panther population;
- captive cougars;
- free-ranging cougars;
- captive panthers;
- free-ranging panthers;
- zoo animals;
- cougars from reference populations in West Texas/Northern Mexico, Bolivia/Paraguay and Central America (Belize);
- offspring of introduced cougars;
- offspring of free-ranging panthers; and
- captive-bred offspring.

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The following tasks are to be accomplished (the order in which they are presented does not necessarily imply relative priority for the task):

- all available archived sera, and sera from those groups or populations noted above will be analyzed for hormone activity; the specific hormones to be analyzed are estradiol-17 β , total estrogens, testosterone, progesterone (females only), T₃, and T₄. Sera will be collected from offspring at ages 6-8 months and 18-20 months; prior to reaching sexual maturity.
- whole blood from all animals noted above will be analyzed for mercury.
- lipid samples currently archived will be analyzed for organochlorine pesticides, endosulfan and polychlorinated biphenyls; muscle tissue biopsies from all adult females will be analyzed for these same analytes.
- histopathological examination of archived gonadal tissues from Florida panthers will be performed to determine whether any exogenous-estrogen-induced abnormalities may exist.
- immune response will be ascertained for all animals by utilizing three monitoring methods: 1) blood cell analyses; 2) mitogen stimulation procedures; and, 3) immune responsiveness to a viral vaccine.
- tissue biopsies will be collected annually from introduced female cougars and analyzed to determine build-up of contaminant load.
- sperm will be collected via electroejaculation from male offspring of introduced cougars at age 24-36 months.
- blood samples will be collected monthly for 12 months from captive females to determine the range of normal hormone levels during the annual cycle.

STUDY PROPOSAL

STUDY TITLE: Endocrine disrupting chemicals and reproductive impairment in the Florida panther.

STUDY OBJECTIVE(S):

DRAFT

- gather baseline data regarding hormone activity, contaminant levels and immune response in female Texas cougars prior to release into panther habitat
- determine normal hormone concentrations in both male and female adult panthers
- determine contaminant impacts on offspring of introduced female Texas cougars

BACKGROUND/JUSTIFICATION: The Florida panther (*Felis concolor coryi*; panther) population hangs precipitously near the edge of extinction. Only 30-50 free-ranging animals remain; primarily in the Big Cypress/Fakahatchee Strand area of southwest Florida. Several problems are prevalent in the population: most males are cryptorchid; sperm count is low; ejaculate volume is low; sperm motility is low; most spermatozoa are abnormal; several animals suffer from hyperthyroidism; and immune system impairment seems evident. It has long been the opinion of many involved that these problems are all traceable to inbreeding. However, most of the world's large cats are inbred and some of these symptoms (e.g., cryptorchidism) are not observed in other populations, or, if observed, are not of the same magnitude. At any rate, it has been proposed that the introduction of genetic diversity in the form of six to eight female Texas cougars (*F. c. stanleyana*; cougar) should improve the overall situation.

Preliminary investigation has shown that: 1) the panther is on the verge of extinction, with only 30 to 50 animals remaining; 2) the remaining panther habitat has been impacted by agricultural chemicals, many of which have been shown to disrupt the endocrine system; 3) the Florida panther is dependent upon an aquatic-based food chain with the raccoon as the major vector for exposure; 4) the panther has been exposed to a variety of potential endocrine-disrupting chemicals (some animals contain high levels of *p,p'*-DDE and PCBs in their body fat); 5) the population is affected by a suite of symptoms which, taken as a whole, appear to be unique to the panther; and, 6) all of the symptoms expressed by members of the population have been shown to result, in other species, from exposure to one or more of the chemicals present within the ecosystem. Thus, we believe that an alternative explanation for the maladies exhibited by the panther exists in the form of environmental contaminants.

Results: Results of this study will be prepared for publication in one or more refereed journals.

ROLES AND RESPONSIBILITIES:

Principal Investigators:

Dr. Charles F. Facemire, U.S. Fish and Wildlife Service, Atlanta, Georgia
Dr. Michael R. Dunbar, Florida Game and Fresh Water Fish Commission, Gainesville, Florida
Dr. Timothy S. Gross, BEECS Program, University of Florida, Gainesville, Florida

It is anticipated that the tasks outlined above will be accomplished by the following persons or organizations:

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- | | |
|-----------------------------|--|
| ● immunology | BEECS Laboratory, University of Florida |
| ● mercury analyses | U.S. Fish and Wildlife Service contract laboratory |
| ● hormone radioimmunoassays | BEECS Laboratory, University of Florida |
| ● histopathology | BEECS Laboratory, University of Florida |
| ● organic analyses | Mississippi State University analytical laboratory |
| ● wild animal capture | Roy McBride |
| ● sample collection | Roy McBride/Mike Dunbar, Florida GFWFC |

SCHEDULE: It is anticipated that the study will require 3-5 years (3 years for an initial investigation as outlined above; two additional years based on outcome). The study should be initiated prior to the release of the female cougars, or with sampling of offspring captured during the regular capture season in November 1994, depending on which event first transpires. Timing of future events will be dependent upon sampling opportunities.

OPERATIONAL COST ESTIMATE:

Supplies (\$1,500/yr x 3 yrs)	\$ 4,500
Other:	
Animal capture, sample collection, handling and shipping	
(West Texas/Northern Mexico - 10 adult males: \$ 4,000) (Bolivia/Paraguay - 10 adults: \$ 11,000) (Central America - 10 adults: \$ 9,000)	\$ 24,000
Graduate Student (University of Florida; \$20,000/yr x 3 yr)	\$ 60,000
Lab Technician (Florida GFWFC laboratory; \$18,000/yr x 3 yr)	\$ 54,000
Travel and other associated costs	\$ 9,000
Total Operational Cost	\$151,500

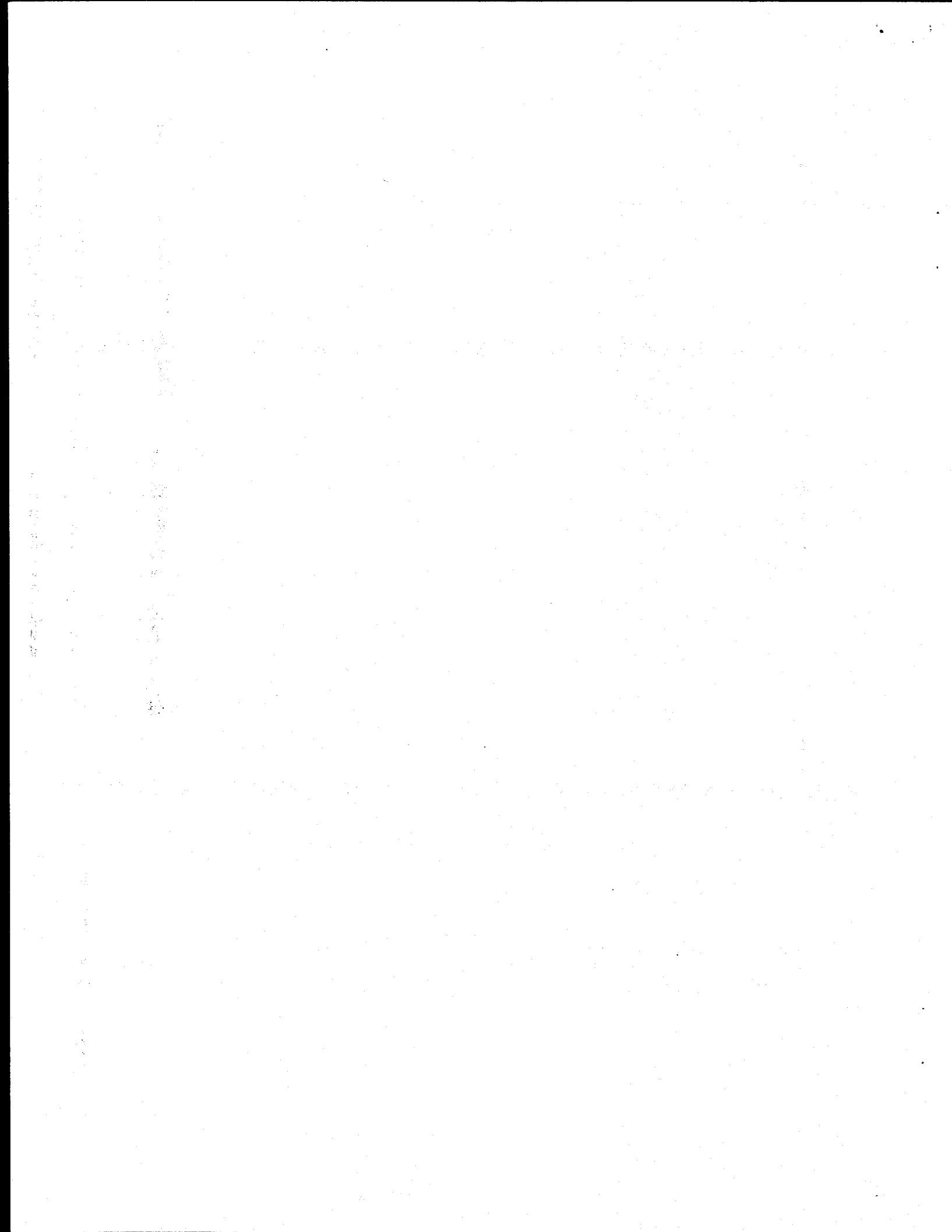
DRAFT**ANALYTICAL COST ESTIMATE:**

Inorganic (mercury) analyses (\$50 ea x 100 samples)	\$ 5,000
Organic (OCs, PCBs) analyses (\$700 ea x 85 samples)	\$ 59,500
Radioimmunoassays (\$37 ea x 200 samples)	\$ 7,400
Immunology (validation of methodology, testing of all animals)	\$ 15,000
Histopathology (\$25 ea x 30 samples)	\$ 750
Total Analytical	\$ 87,650

GRAND TOTAL (for first 3 years) **\$239,150**

ENCLOSURE III

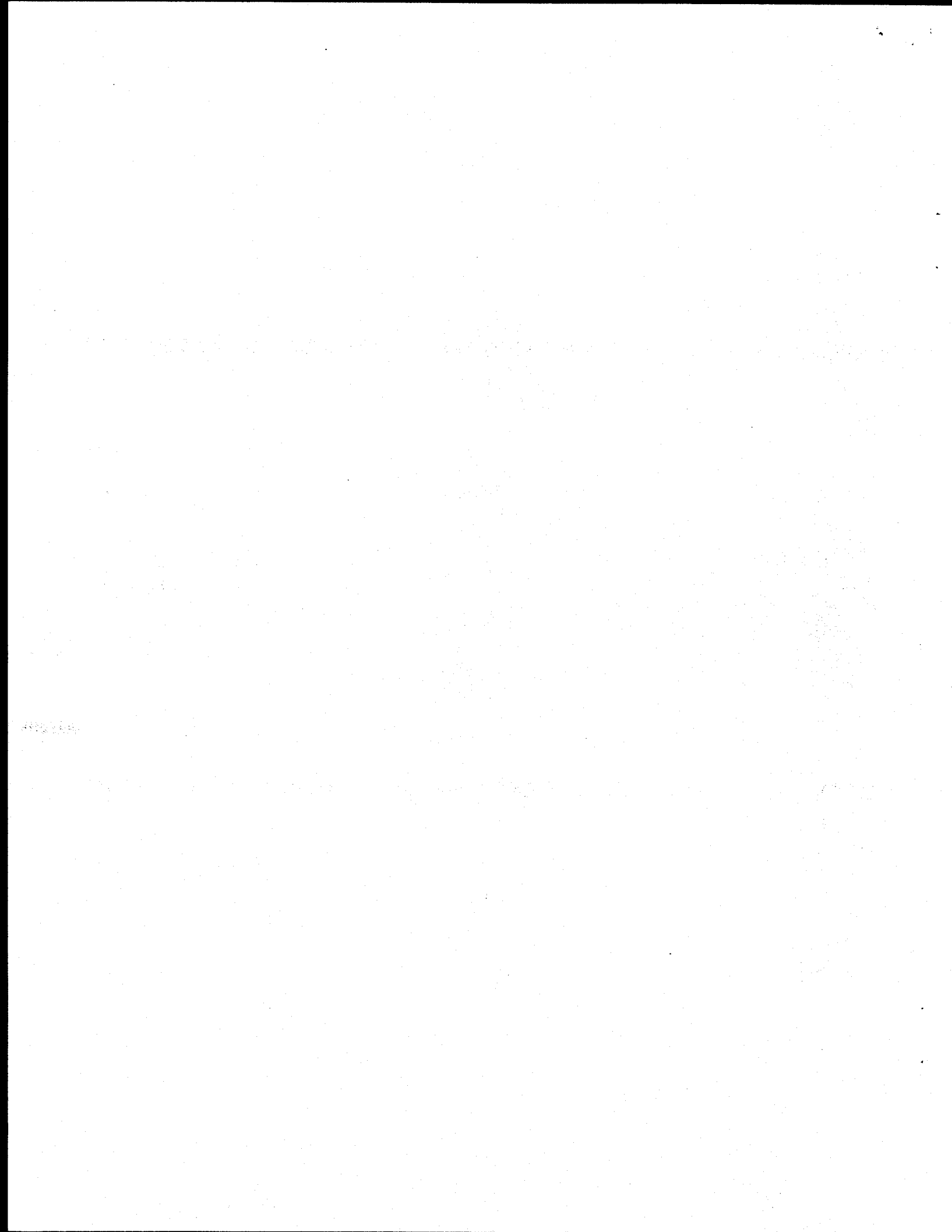
**GENETIC MANAGEMENT STRATEGIES AND POPULATION VIABILITY
OF THE
FLORIDA PANTHER**





**GENETIC MANAGEMENT STRATEGIES
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FLORIDA PANTHER**





**GENETIC MANAGEMENT STRATEGIES
AND POPULATION VIABILITY
OF THE**

**FLORIDA PANTHER
(Felis concolor coryi)**

REPORT OF A WORKSHOP

White Oak Plantation Conservation Center

**Yulee, Florida
21-22 October 1992**

Supported in part by USFWS Contract # 14-16-0004-92-983,

White Oak Conservation Center,

and CBSG/SSC/IUCN

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GENETIC MANAGEMENT STRATEGIES FOR THE FLORIDA PANTHER

Executive Summary

The Florida panther is one of the most critically endangered taxa in the United States. Population declines and associated inbreeding have resulted in significant losses in genetic variability and viability. Natural gene exchange existing historically between the Florida panther and other North American puma subspecies is no longer possible because of human induced isolation. Successful recovery of the Florida panther is doubtful without a reinstitution of lost gene flow.

The Florida Panther population was found to be at high risk of extinction over the next 25-40 years at the time of a population viability assessment in 1989 (Seal et al.). The analysis indicated that genetic heterozygosity would continue to be lost at the rate of about 6% per generation if the population was not increased in size. Substantial evidence for inbreeding depression was presented and led to the conclusion that the establishment and management of a captive population was the only way to preserve existing genetic viability. Delays, imposed by external events, prevented timely implementation of management actions to establish the captive population, rapidly expand the population, and secure full representation of the genetic diversity present in the population at that time.

Renewed concerns over reduced levels of genetic heterozygosity and the complete loss of historic gene flow patterns led to a workshop in 1991 to consider genetic augmentation as a tool in Florida panther recovery (Seal editor, 1991). General conditions and criteria for the use of genetic augmentation to ameliorate the adverse effects of inbreeding depression in a population were formulated in the workshop. These criteria were applied, at that workshop, to the Florida panther population with the determination that there was substantial evidence for inbreeding depression and that genetic augmentation should be undertaken.

The present Workshop was convened because of increasing evidence that the population displays multiple physiologic abnormalities that are likely a consequence of recent close inbreeding among the surviving individuals. Re-evaluation of the wild population viability indicates that it is continuing to decline genetically, remains at high risk of extinction, and that adverse effects of inbreeding are accumulating rapidly. It was the consensus of the Workshop participants that the reinstitution of historic gene flow between the Florida panther and adjoining Felis concolor subspecies, i.e., genetic augmentation, is needed to reverse these effects of inbreeding depression, that effective action needs to be taken quickly and that the amount of introgression required may reach 20%.

Eight alternative management scenarios for controlled introgression of genetic material from another population of Felis concolor were examined in terms of: accomplishing the biological objectives, evaluating population source of the individuals to be used for the intercrosses, accessibility of Florida panther and intercross animal, timing, availability of the requisite technology, and possible adverse effects on the individual animals. The scenarios given top priority were (1) direct introduction of animals into suitable unoccupied territories or potential territories, (2) AI of females brought into captivity for a brief period of time and then returned to the wild, and (3) breeding or AI of non-Florida animals in captivity with Florida panther males or their sperm. All 3 scenarios will need to be implemented in parallel given the time span required, the high incidence of abnormalities in the population, and the continued loss of animals from the wild population.

GENETIC MANAGEMENT STRATEGIES FOR THE FLORIDA PANTHER

Workshop Report

22 October 1992

Introduction

Historically, the Florida panther, *Felis concolor coryi*, ranged across much of the southeastern United States. Today, it is one of this nation's most critically endangered taxa. A single population in southern Florida, estimated to consist of 30 to 50 adults, is all that remains in the wild. Population declines and associated inbreeding have resulted in significant losses in genetic variability and viability. Natural gene exchange, existing historically with other populations of *F. c. coryi* and other *F. concolor* subspecies (Young and Goldman reported gene exchange between *F. c. coryi* and *F. c. cougar* to the north and to the west and northwest with *F. c. stanleyana* and *F. c. hipplestes*), is no longer possible because of isolation. Analysis of the present status of the endangered Florida panther (*Felis concolor coryi*) indicates that the population exhibits multiple physiologic abnormalities that are likely a consequence of recent close inbreeding among surviving individuals. To correct this serious and rapidly deteriorating situation, the consensus of the workshop was to immediately reinstate gene flow (or genetic augmentation) lost because of human caused isolation. The goal of the recommended genetic augmentation is to reverse the consequences of inbreeding as well as to reconstitute genetic variation that may have occurred naturally in Florida panthers when its former range and the ranges of adjacent subspecies were occupied.

The consequences of demographic contraction in the Florida panther are evident from a decade of field and biomedical monitoring. The Florida panther, reduced to less than 50 adult individuals in south Florida by human depredation and habitat depletion, display a remarkable array of genetic and physiologic impairments that pose a direct threat to survival. Relative to other puma subspecies the Florida panther has reduced genetic variation based upon mitochondrial DNA, allozyme and DNA fingerprint analyses, likely a result of genetic drift and close inbreeding caused by range and population contractions. Several cases of consanguineous matings have been documented directly in the surviving population.

Correlated with the genetic uniformity is the occurrence of several aberrant congenital defects including:

- 1) an average incidence of 95% morphologically-abnormal sperm per ejaculate (including a 41% incidence of malformed spermatozoal acrosomes), in contrast to

western or South American samples that have an incidence of 83% and 58% abnormal sperm respectively;

2) 71% cryptorchidism in living males (12 of 17) with 12% (2 of 17 living males) of these being bilateral and, thus, sterile;

3) emergence of fatal cardiac abnormalities.

Furthermore, the population has suffered from a score of pathological infectious agents that have been fatal in 8 panthers to date. These infections may be a consequence of a defective immune system compromised by inbreeding. Combined with the non-physiological perils that contribute to mortality (e.g. road kills, intra-specific aggression, mercury toxicity) and interacting stochastic effects that threaten the population (e.g. demographic fluctuations, genetic drift), the results indicate a precarious population at high risk for extinction. The cumulative results strongly indicate an imperative to manage more directly the residual genetic representation of the remaining population and support the reinstatement of gene flow with conspecific populations of puma.

In May 1991 a workshop was convened in Washington D. C. to consider "Genetic Management Considerations for Threatened Species with a Detailed Analysis of the Florida Panther". The report of that workshop (attached to this report) developed explicit criteria for considering genetic augmentation of an endangered population when inbreeding and associated consequences negatively affect population viability. These criteria were reexamined by the present group and applied to the available knowledge about the Florida panther. Our conclusion is that the Florida panther's status is sufficiently grave to recommend immediate implementation of a genetic augmentation program as outlined below.

A managed reinstitution of gene flow between *F. c. coryi* and a historic adjacent *F. concolor* subspecies would likely improve the genetic health and viability of the extant Florida panther gene pool. Although genetic augmentation is recommended and represents a management attempt to reconstitute the genetic variation that was once present in the ancestors of today's population, we emphasize that this measure does not address the need to identify and designate increased suitable panther habitat required to sustain a demographically viable population with a high confidence of persistence.

Sources and Levels of Genetic Augmentation

The primary goal of genetic augmentation for the Florida panther is the reduction in frequency of deleterious traits that can result from inbreeding by introducing genetic material from other *Felis concolor* populations. For such situations, the workshop on 'intercrossing' ("Genetic Management Considerations for Threatened Species with a

Detailed Consideration of the Florida Panther" 30-31 May 1991) recommended a small percentage of admixture of non-local genes in a single episode. The amount of genetic admixture should be sufficient for the target population to recover from the deleterious effects of inbreeding, but not so large as to swamp the local gene pool which may be adapted to local environmental conditions. A small admixture of non-local genetic material into a population suffering from inbreeding depression should permit natural selection to reduce the frequency of deleterious mutations over the course of several generations while maintaining local adaptations. The amount of admixture chosen for a given management program represents a tradeoff between rapid recovery from inbreeding effects and possible swamping of local adaptations. Because of the recent rapid increase in frequency of cryptorchidism and heart defects, and documented cases of close inbreeding in the wild Florida panther population, the panel members recommend immediate genetic augmentation of the population by introduction of 20% of the target population's genetic material from another puma population to rapidly reverse the deleterious effects of inbreeding within two or three generations.

A crucial part of the management strategy is that the initial genetic admixture should be monitored to track its spread through the Florida population to confirm recovery of intercrossed offspring from the proposed deleterious effects of past inbreeding, and to determine if and when further admixture is necessary.

A secondary, long-term goal of genetic augmentation is to maintain genetic variability in the Florida panther population at levels comparable to the historic panther population and to other *F. concolor* populations, to allow natural selection and adaption to environmental changes. After the initial augmentation, this can be accomplished by continued introduction from a non-Florida population of about one successful breeding individual every generation (generation time=6 yrs). Augmentation may also be considered or required for demographic purposes.

In a target population as small as the Florida panther, with 30 to 50 adult individuals, the primary goal can be met by introducing 6 to 10 unrelated, successful non-Florida individuals, or twice as many unrelated, successful F1 intercrosses between Florida stock and another population. One advantage of introducing a larger number of intercross individuals is that there is less risk that their genetic contribution will be completely lost from the population before integration by chance demographic events. Intercross individuals are also more likely to be adapted to local environmental conditions than non-Florida animals, if local adaptations exist.

To be genetically effective, individuals introduced into the target population must become part of the breeding pool. The behavior and social structure of panthers suggests that this may best be accomplished by introducing subadult intercross or non-Florida females (or as a second choice subadult males) into vacant territories. Another option is

artificial insemination of wild females by non-Florida or intercross males, if existing techniques can be refined.

There are six possible source populations for genetic augmentation of the Florida panther population:

1. Captive generic *F. concolor*'s of known ancestry.
2. Piper captive stock (intercrosses between Florida, South American and possibly other *F. concolor*'s).
3. "Everglades" panthers (intercrosses between early Piper stock and Florida panthers).
4. Wild Texas *F. concolor*'s.
5. Wild Western (non-Texas) *F. concolor*'s.
6. Central American or South American wild *F. concolor*'s.

Of these six possible source populations, captive stocks 1 and 2 have the disadvantage that they may be partially adapted (behaviorally and/or genetically) to captivity, and less adapted to the Florida habitat than any wild population. "Everglades" panthers are already part of the present wild panther population, but because of their intercross ancestry do not, at this time, experience the high frequency of cryptorchidism or heart defects characterizing the remaining Florida panthers. However, they do have a similarly high incidence of sperm abnormalities that may or may not improve upon intercrossing with other Florida panthers. If the overall Florida panther population were demographically stable, natural intercrossing with "Everglades" individuals might eventually reverse most or all of the deleterious characters in the Florida panther. But the small numbers of "Everglades" panthers, the fact that they have a high proportion of Florida panther genes, and their peripheral location in relation to the main Florida population suggest that it would take several generations for their genetic contribution to naturally spread through the Florida population and perhaps still achieve slight improvement at best. All of these considerations dictate that genetic augmentation of the Florida panther population should be conducted with genetic material from a separate wild population.

Because of the small amount of genetic differentiation among puma populations throughout their range, and the absence of barriers to intercrossing between puma populations, it probably does not make much difference which wild population is used for

genetic augmentation. However, a single wild puma population should be chosen for genetic augmentation of the Florida panther, and when the source population is determined, genetic studies on it should be conducted in conjunction with introduction and intercross efforts to characterize the introduced gene pool for monitoring and follow up studies.

Of the existing sources, wild Texas pumas formerly constituted part of a continuous range across which genetic material was likely exchanged with the Florida subspecies. For restoring the genetic fitness and natural pattern of genetic variation in the Florida panther, wild Texas pumas therefore appear to be the best source for genetic admixture. However, Texas puma populations sampled have also exhibited low genetic variation.

Possible Scenarios for Florida Panther Management With and Without Introgression.

The following is a list of management options that involve varying degrees of introgression. The list is ordered from the most drastic introgression (elimination and replacement of native stock) to the least drastic intervention (no action). The options are not mutually exclusive and some can be used in combination. For each option we have described some of the conspicuous advantages and disadvantages. All of the options that involve introgression (1-5) have the advantage that they would help the wild Florida population recover from inbreeding depression (i.e., lower the incidence of undescended testes, incompetent sperm, etc.). Such recovery would be immediate in the sense that intercrossed animals will not express its recessive genetic defects. The options that do not involve introgression (6-9) will not correct the genetic problems of the south Florida panther population but could have beneficial demographic effects.

1. Eliminate native stock and replace with non-Florida stock.

The present Florida panther population is genetically unique. This population is currently surviving and reproducing with apparent natural mortality and natality rates but showing signs of inbreeding depression. Elimination of this population would mean the extinction of a subspecies. Introduction of non-Florida individual may be met with high mortality due to dispersal and environmental factors. Finally, it is not necessary to institute a drastic plan of replacement when the current problems with genetic vitality can be more simply addressed through genetic augmentation.

2. Artificial insemination of south Florida females with sperm from non-Florida males.

This scenario includes the use of artificial insemination (AI) of free-living females to produce genetically-enhanced offspring in situ. Using frozen sperm from non-Florida males, this approach would rapidly place new genetic material into the wild population without disturbing the social structure of the free-living animals.

The greatest challenge associated with this scenario is the difficulty of manipulating females under field (uncontrolled) conditions. Timing of hormonal stimulation for the induction of estrus is critical to AI success. For this reason, the technique may require that females be removed from the wild for 30 days for the administration of hormones and AI, and released back into the wild immediately following inseminating. The disadvantage of this approach would be the unknowns associated with potential behavioral and physiological stress related to short-term captivity.

The reproductive biology techniques can be developed in conjunction with the captive breeding program. If field related problems preclude AI being used in the field, the technology could be useful in the captive breeding program and for the release or reintroduction of inseminated wild-caught or intercross females.

3. Translocation of wild non-Florida subspecies into south Florida.

The most expedient route for introducing genetic material into the south Florida panther population is to relocate individuals from another appropriate wild *F. concolor* population. The recommended action would involve capture of young (12-18 month old) non-Florida females and release (following only quarantine as necessary to assure that no diseases are carried) into vacant female Florida panther home ranges. Because female panthers are generally philopatric (do not disperse) and subadults are unattached to a home range, this sex and age class would be most likely to stay where released. In addition, introduced subadult females would be unlikely to interact aggressively with local residents. While subadult non-Florida males could also be used, the low frequency of male recruitment would probably delay the genetic contribution of these individuals for several years. Furthermore, the propensity for long distance dispersal by males increases the chances for mortality or travel to less desirable areas of panther range.

Advantages of this approach include very low cost (individual could be kept in captivity for a minimal, mandatory quarantine period) and very low probability of disrupting the existing social organization of south Florida panthers.

Disadvantages include less knowledge of medical history (compared with captive reared individuals) and a relatively slow incorporation of genetic benefits (compared with AI).

Offspring produced from non-Florida x Florida panther matings should be evaluated and radio-instrumented before they disperse in order to score key traits (e.g., incidence of cryptorchidism, heart murmurs, etc.) and to monitor survival and recruitment. Tissue samples should be collected at the first opportunity so that the progeny of these animals can be recognized by DNA fingerprints.

4. Release of captive-raised non-Florida *F. concolor*'s into south Florida.

This option differs from direct translocation of wild non-Florida subspecies (option 3) in that the source of animals will be captive-raised and conditioned non-Florida individuals. Variations using males versus females follow the same rationale suggested for Option 3.

An advantage of this approach is that the medical condition and history of released animals is better controlled and understood with little chance of introducing an unwanted pathogen into south Florida.

A possible disadvantage of this approach is that the adaptability of captive raised individuals to the wild is unknown and could influence success. The cost of raising (housing, feeding, etc.) individuals would be high.

5. Captive production and reintroduction of intercrossed panthers.

Florida panthers could be intercrossed with non-Florida individuals with the aim of reintroducing first-, second- or later- generation crosses to south Florida. Intercrosses may have a better chance of surviving and reproducing than non-Florida individuals. Furthermore, planned captive introgression may be more successful than simple propagation (option 6) in perpetuating south Florida panther genotypes. In particular, using non-Florida animals greatly expands the number of breeding options. For example, using non-Florida males as mates for Florida females circumvents the testicular and sperm problems that plague Florida males. Putting problems of breeding space and facilities aside, intercross production could also be used as an adjunct to captive propagation of Florida panthers. Reproductively competent male Florida panthers could be used to sire the litters of both Florida and non-Florida females. Under these or other scenarios involving intercrosses, a set of guidelines should be produced to steer the breeding program. Without guidelines and monitoring (e.g., with DNA fingerprints) a breeding program could produce animals of uncertain parentage.

6. Captive propagation of south Florida panthers without introgression.

The advantage of this option is that native genetic stock could be perpetuated for later reintroduction. Furthermore, the captive population could act as insurance against natural catastrophes or more gradual extinction of the wild population. Captive propagation does face problems. The overall health and vigor of Florida panthers has been compromised by genetic defects and pathogens. Compared with individuals from outbred populations, Florida panthers may prove to be difficult to breed in captivity. Secondly, the available stock in nature is currently limited to at most **two or three dozen** animals. Third, the panther that currently exists only partially resembles the historic population genetically and physiologically. Fourth, this option perpetuates the problem we have as a result of inbreeding depression. Finally, breeding facilities and space are currently limited and would have to be expanded. Optimistically, captivity may offer an opportunity to ameliorate the health problems of wild animals and to improve their breeding.

7. Shuffle animals between locations in south Florida.

Such a program could help equalize the reproductive success of individuals (particularly males) and so increase the effective population size and delay loss of genetic variation. For example, dominant male #12 is probably over-represented genetically in the Florida panther population and due to his relatedness with most of the females (daughters, grand-daughters, etc.) may be exacerbating the rate of inbreeding. Replacing this dominant male with a non-related peripheral male would provide an opportunity to introduce new genetic material and for a short time, decrease the rate of inbreeding. This dominant male and any other surplus males could be removed and used with non-Florida females to establish a new population in a reintroduction site. If the removed dominant male's home range is allowed to fill naturally, there is a high probability that he will be successfully replaced by a local, peripheral male. On the other hand, if a peripheral male is moved from Big Cypress National Preserve (e.g., #42) or Everglades National Park (e.g., #16) into the vacant range, there is a chance that the introduced male will home and not establish himself where he is needed. Also, the new male may be killed by intra-specific fighting, or he may kill other males or females. This option does less to correct genetic defects than introduced non-Florida genes. This option would allow demographic management but may not solve genetic problems.

8. Use surplus south Florida males and non-Florida females to found new populations in Reintroduction sites.

Under this option at least some Florida genotypes are perpetuated but in an intercrossed background. Young male panthers have limited options for dispersal and establishment in south Florida and several have been killed in intra-specific fighting. This option involves the removal of surplus male panthers in the south Florida population for translocation and reintroduction. This options assumes that males can be identified for translocation to sites that are unoccupied by panthers. Female non-Florida individuals would be placed into the reintroduction area with the males. This option would allow the opportunity for young male panthers to establish territories, breed with non-Florida individuals and produce intercross offspring.

9. Leave the Florida panthers where they are, without introgression.

Inaction does not appear to be a viable option. Without some sort of intervention the current wild population of Florida panthers is expected to become extinct within 25-50 years (see updated Population Viability Analysis below).

Reassessment of the Viability of the Florida Panther Population in the Absence of Further Intervention.

A. Data for Parameters of Population Viability Analysis

The 1989 Population Viability Analysis workshop concluded that the present population of Florida panthers was vulnerable to extinction within the next few decades, due to the combined effects of multiple sources of mortality and stochastic demographic and genetic instability. Since the 1989 workshop, additional data on mortality and reproduction have become available from the radio-collaring studies. These newer data have been incorporated into revised viability analyses, as described below. A more complete description of the bases of the estimates of population parameters and description of the simulation model are presented in the original PVA report (Seal et al. 1989).

1. Mortality

Mortality of radio-collared panthers has been somewhat lower than reported during the 1989 PVA workshop. Over the entire course of the radio-collaring studies (since 1981), 28 collared animals died during 1,444 animal-months of observation. This yields an annual mortality estimate of 21% (monthly mortality = $28/1444 = .0194$; monthly survival = $.9806$; annual survival = $(.9806)^{12} = .7906$; annual mortality = $.2094$). Because mortality was higher and samples sizes smaller during the early years of collaring, mortality was also estimated from data collected since 1/1/85. Between 1/1/85 and 6/30/92, 23 deaths occurred during 1,257 animal-months of observation, yielding an annual mortality of 20%. This estimate was used in the revised analyses. Animals were assumed to become post-reproductive and, hence, no longer capable of contributing to the population at age 12.

2. Reproduction and juvenile mortality

Data presented in the Florida Game Fresh Water Fish Commission annual medical reports indicate that approximately half of the litters observed or inferred to have been produced died at early ages. Among surviving litters, the mean litter size observed has been 1.9. However, data from known litters within the core study area indicate that, except for litters rapidly replaced, perhaps as few as 20% of litters die. In the Everglades National Park, three of six known litters were lost.

For the modelling analysis, we assumed a mean litter size of 2, distributed as 25% litters of one, 50% litters of two, and 25% litters of three. First year mortality was initially assumed to be 50%. To test the sensitivity of results to this uncertain parameter, scenarios were also examined with an assumption of 20% mortality of juveniles, as would occur if litters died when and only when the dam died (as adult mortality is 20%).

3. Age and frequency of breeding

Although some panthers have been observed to produce offspring by 2 years of age, it is not known whether this early age of breeding is typical or unusual. Analyses were conducted with breeding commencing either at 2 or at 3 years of age. Females were assumed to produce, on average, a litter every 24 months.

4. Breeding system

The population was assumed to be polygamous, with all adult females and half of the adult males in the breeding pool. The computer model assumes that the males within the breeding pool are reselected randomly each year.

5. Population size and carrying capacity

It is estimated that there is presently habitat in south Florida for about 50 adult panthers. If this habitat is saturated, then about 50 adults and about 25 young may exist in the population (Maehr et al. 1991). Some panther biologists have expressed concern that numbers might be lower. Analyses were conducted with either 30 or 50 initial animals (censuses prior to the breeding season) and with a habitat carrying capacity of 50.

6. Habitat loss

About 50% of the present panther habitat is on privately-owned lands, and an unknown fraction of that land is likely to be converted to uses that make it unsuitable for panthers in the coming few decades. Scenarios were assessed with no change in habitat, a 1% annual loss over 25 years (approximately 25% total loss), and a 2% annual loss over 25 years (approximately 50% total reduction in habitat).

7. Environmental variation

At this time, as in 1989, there are insufficient long-term data to allow estimating the annual fluctuations in birth and death rates that might be caused by variation in the environment. All modelling was conducted under the assumption that birth and death rates are subjected to no environmental variation. If environmental variation was substantial, it would further destabilize the population relative to the results presented here.

8. Effects of inbreeding

Although the deleterious effects of inbreeding appear to be impacting the panther population, it is not known, quantitatively, how severely inbreeding has reduced fitness, nor how it will further impact fitness if the panthers become even more inbred. Models were assessed under an assumption of no effect of further inbreeding, an assumption of 1 recessive lethal per present animal (a moderately low impact), or an assumption of 3 lethal equivalents (modelled as heterotic, rather than recessive, effects) per animal, as is typical of many other species of mammals.

B. Population Viability Analysis Results

Each scenario described above was examined by simulating 250 populations with the population viability analysis program VORTEX (Lacy, in press). The following tables present the population fates projected 25 years, 50 years, 100 years, and 200 years into the future. The input parameters that varied among scenarios are described at the top of the tables and in the first four columns. The six tables show the results for three levels of inbreeding depression with either 50% or 20% juvenile mortality. Inbreeding depression (Inbreeding depression) was set at 0, at 1 recessive lethal per individual, or at 3 lethal equivalents. Initial population size (N_0) was set at 30 or 50 (just prior to the breeding season). Carrying capacity (K) was assumed to remain stable, decrease at 1% annually, or decrease at 2% annually for 25 years. First breeding by both sexes was assumed to occur at 2 years or at 3 years of age.

The mean and standard deviation of the exponential growth rate (r) observed in the simulated populations, prior to any carrying capacity truncation each year are given in the next two columns of each table. The probability of extinction (PE), mean size (N_t) and standard deviation in size of those simulated populations not yet extinct, and the mean proportion still remaining of the initial expected heterozygosity (H) or gene diversity are presented at 25 year, 50 year, 100 year, and 200 year intervals. The median time to

extinction (TE) for those scenarios in which at least 50% of the simulated population went extinct is given in the last column of each table. Because of rounding, scenario results occasionally show a mean size and heterozygosity of remaining populations when the (rounded off) probability of extinction is displayed as 100%. These are cases in which the probability of extinction was 99.6% (249 out of 250 simulations).

The expected deterministic population growth rate (r) for the scenarios, calculated from standard life table analysis of birth and death rates, assuming no fluctuations in annual rates, is given at the bottom of each table.

C. Discussion

The revised population viability analyses project that the population is both demographically and genetically unstable, and is likely to become extinct within about 24 to 63 years if juvenile mortality is 50%. The effects of higher survival, but lower litter size, estimated from current data relative to the earlier analyses, are approximately offsetting, and the results presented here do not lead to substantially different conclusions than those that arose from the 1989 population viability analysis. Population biology parameters estimated from field research do not ensure a self-sustaining population. The time and certainty of extinction varies under the various scenarios analyzed, but all suggest that the population will be highly vulnerable to extinction if genetic, habitat, and demographic conditions cannot be improved.

If juvenile mortality is as low as is adult mortality (20%), the population would show, on average, positive population growth, but it is still subjected to inbreeding depression and random demographic effects that can cause extinctions. In particular, if the effects of inbreeding on juvenile mortality are similar to the median effects seen in other mammalian species (Ralls et al., 1988), the joint and synergistic effects of demographic fluctuations and inbreeding virtually always drive the simulated populations to extinction.

Although there is a possibility of population survival under the scenarios that assume weak or no impact of inbreeding and 20% juvenile mortality, the population was projected to become highly inbred (beyond the inbreeding that has already occurred) within a few generations. Those simulated populations which did survive contained little genetic variation, generally at levels expected after about four to nine generations of brother-sister or parent-offspring matings (about 32% and 8% of present genetic variation, respectively). However, the much greater and longer stability of the simulated populations when there is low juvenile mortality and no effects of inbreeding indicates that if genetic problems can be avoided through managed introduction of genetically divergent stock and continued movement of genetic material, and if juvenile mortality can

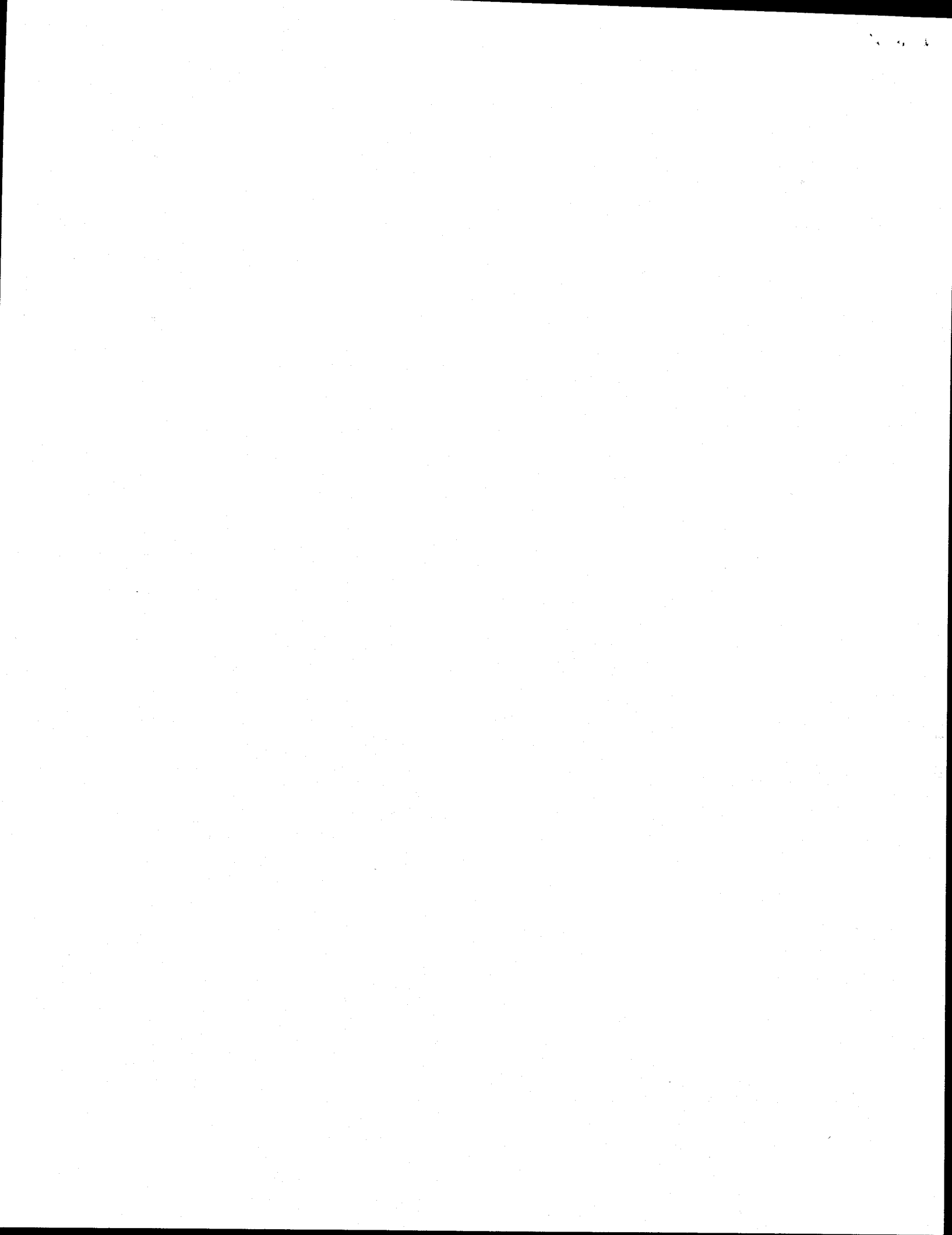
be kept low, the south Florida population of panthers can be a demographic "source" population as a component of a metapopulation of panthers, rather than the "sink" that is projected if inbreeding effects accumulate or if juvenile mortality is about 50%.

D. Literature cited

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Florida panther population viability without further intervention: No inbreeding effects, 50% juvenile mortality																						
Inbr. depr.	N _e	Change in K: 25 yrs	1st breed	Growth:r		25 yr results				50 yr results				100 yr results				200 yr results				TH E
				mean	SD	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	
None	30	-2%/yr	2	-.042	.204	14	17	7	76	55	12	7	51	92	12	7	22	100	4	0	0	47
			3	-.082	.223	34	10	6	72	92	9	6	53	100	--	--	--	100	--	--	--	30
		-1%/yr	2	-.039	.199	11	19	10	76	48	18	10	58	85	16	11	37	98	22	5	30	53
			3	-.081	.226	34	11	7	70	87	9	7	50	100	5	0	18	100	--	--	--	31
		None	2	-.040	.193	16	22	12	78	46	18	12	60	85	20	13	35	99	15	3	4	53
			3	-.083	.225	38	11	6	72	87	9	6	55	100	--	--	--	100	--	--	--	29
	50	-2%/yr	2	-.040	.200	5	18	7	81	46	13	7	56	86	13	7	25	100	--	--	--	53
			3	-.083	.201	22	12	7	79	84	9	6	53	100	--	--	--	100	--	--	--	35
		-1%/yr	2	-.039	.186	6	22	10	82	44	17	10	59	82	19	10	31	97	17	9	17	56
			3	-.080	.210	18	13	8	78	81	10	7	57	99	6	1	22	100	--	--	--	35
		None	2	-.035	.178	3	26	13	83	31	21	13	67	76	21	12	41	95	23	18	21	63
			3	-.079	.208	18	14	8	79	80	9	6	58	100	--	--	--	100	--	--	--	38

Note: deterministic r (from life table) = -.018 with breeding at 2, r = -.056 with breeding at 3.



Florida panther population viability without further intervention: No inbreeding effects, 50% juvenile mortality																						
Inbr. depr.	N _e	Change in K: 25 yrs	1st breed	Growth:r		25 yr results				50 yr results				100 yr results				200 yr results				TH E
				mean	SD	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	
None	30	-2%/yr	2	-.042	.204	14	17	7	76	55	12	7	51	92	12	7	22	100	4	0	0	47
			3	-.082	.223	34	10	6	72	92	9	6	53	100	--	--	--	100	--	--	--	30
		-1%/yr	2	-.039	.199	11	19	10	76	48	18	10	58	85	16	11	37	98	22	5	30	53
			3	-.081	.226	34	11	7	70	87	9	7	50	100	5	0	18	100	--	--	--	31
		None	2	-.040	.193	16	22	12	78	46	18	12	60	85	20	13	35	99	15	3	4	53
			3	-.083	.225	38	11	6	72	87	9	6	55	100	--	--	--	100	--	--	--	29
	50	-2%/yr	2	-.040	.200	5	18	7	81	46	13	7	56	86	13	7	25	100	--	--	--	53
			3	-.083	.201	22	12	7	79	84	9	6	53	100	--	--	--	100	--	--	--	35
		-1%/yr	2	-.039	.186	6	22	10	82	44	17	10	59	82	19	10	31	97	17	9	17	56
			3	-.080	.210	18	13	8	78	81	10	7	57	99	6	1	22	100	--	--	--	35
		None	2	-.035	.178	3	26	13	83	31	21	13	67	76	21	12	41	95	23	18	21	63
			3	-.079	.208	18	14	8	79	80	9	6	58	100	--	--	--	100	--	--	--	38

Note: deterministic r (from life table) = -.018 with breeding at 2, r = -.056 with breeding at 3.

Florida panther population viability without further intervention: 3 lethal equivalents, 50% juvenile mortality																						
Inbr. depr.	N _e	Change in K: 25 yrs	1st breed	Growth: r		25 yr results				50 yr results				100 yr results				200 yr results				TE
				mean	SD	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	
3 H	30	-2%/yr	2	-.077	.207	25	13	7	76	92	5	3	54	100	--	--	--	100	--	--	--	33
			3	-.108	.227	53	8	5	72	99	5	2	35	100	--	--	--	100	--	--	--	24
		-1%/yr	2	-.080	.213	26	13	8	76	91	7	4	56	100	--	--	--	100	--	--	--	32
			3	-.104	.225	53	8	5	72	98	3	1	33	100	--	--	--	100	--	--	--	25
		None	2	-.079	.215	19	15	11	75	86	8	6	54	100	--	--	--	100	--	--	--	35
			3	-.102	.227	51	8	5	73	100	2	0	38	100	--	--	--	100	--	--	--	25
	50	-2%/yr	2	-.073	.199	8	15	7	80	82	7	4	59	100	--	--	--	100	--	--	--	39
			3	-.102	.213	28	10	6	77	98	4	3	51	100	--	--	--	100	--	--	--	31
		-1%/yr	2	-.069	.194	3	19	9	82	71	9	6	58	100	--	--	--	100	--	--	--	44
			3	-.100	.209	27	11	6	78	98	5	6	56	100	--	--	--	100	--	--	--	31
		None	2	-.073	.194	7	20	12	82	75	10	7	62	100	--	--	--	100	--	--	--	40
			3	-.100	.216	26	11	6	77	95	5	2	46	100	--	--	--	100	--	--	--	31

Note: deterministic r (from life table) = -.018 with breeding at 2, r = -.056 with breeding at 3.

Florida panther population viability without further intervention: 1 recessive lethal, 50% juvenile mortality																						
Inbr. depr.	N _e	Change in K: 25 yrs	1st breed	Growth:r		25 yr results				50 yr results				100 yr results				200 yr results				TE
				mean	SD	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	
1 L	30	-2%/yr	2	-.050	.204	14	15	7	77	61	12	6	54	96	12	7	7	100	--	--	--	42
			3	-.085	.223	38	9	6	73	93	8	7	55	100	--	--	--	100	--	--	--	28
		-1%/yr	2	-.049	.201	20	18	10	78	62	15	9	56	92	16	10	32	100	5	0	0	42
			3	-.091	.226	44	9	6	70	93	8	5	52	100	4	0	22	100	--	--	--	27
		None	2	-.047	.198	18	19	11	78	56	16	12	56	89	17	11	36	99	18	14	22	46
			3	-.091	.226	42	10	6	73	93	11	8	47	100	--	--	--	100	--	--	--	28
	50	-2%/yr	2	-.046	.196	7	17	7	82	55	13	7	61	94	13	7	29	100	25	0	0	47
			3	-.087	.207	22	12	6	79	88	7	4	53	100	--	--	--	100	--	--	--	34
		-1%/yr	2	-.049	.194	5	21	10	83	50	15	9	62	93	15	9	31	100	--	--	--	50
			3	-.085	.208	17	13	8	80	85	9	7	60	100	3	0	44	100	--	--	--	35
		None	2	-.044	.185	5	24	13	84	43	20	13	68	87	20	14	42	99	13	6	0	58
			3	-.088	.213	20	12	8	79	82	8	5	55	100	--	--	--	100	--	--	--	34

Note: deterministic r (from life table) = -.018 with breeding at 2, r = -.056 with breeding at 3.

Florida panther population viability without further intervention: No inbreeding effects, 20% juvenile mortality																						
Inbr. depr.	N _e	Change in K: 25 yrs	1st breed	Growth: r		25 yr results				50 yr results				100 yr results				200 yr results				TE
				mean	SD	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	
None	30	-2%/yr	2	.063	.163	0	25	3	82	3	22	5	61	14	21	5	35	32	22	5	9	--
			3	.001	.189	4	23	5	81	18	17	7	62	58	18	7	34	87	17	7	14	85
		-1%/yr	2	.069	.128	0	36	4	84	1	34	5	70	2	34	5	48	5	34	5	21	--
			3	.006	.160	2	31	8	84	12	28	9	69	31	26	10	49	63	26	10	24	149
		None	2	.072	.109	0	48	5	85	0	47	5	75	0	48	4	57	1	48	5	34	--
			3	.011	.136	2	38	12	84	8	39	12	74	20	38	12	55	41	39	11	35	--
	50	-2%/yr	2	.062	.161	0	25	3	82	1	22	5	63	12	23	5	36	28	22	5	13	--
			3	.005	.185	1	23	4	84	19	18	7	65	52	17	7	39	84	17	7	14	98
		-1%/yr	2	.068	.129	0	36	4	85	1	35	5	71	4	34	5	51	8	34	5	25	--
			3	.008	.155	1	31	8	86	9	28	9	72	30	27	9	47	58	27	10	21	173
		None	2	.072	.108	0	48	4	87	0	48	5	77	0	48	5	59	1	47	6	38	--
			3	.014	.131	0	40	10	88	3	37	13	76	15	39	12	58	29	39	12	32	--

Note: deterministic r (from life table) = .081 with breeding at 2, r = .023 with breeding at 3.

Florida panther population viability without further intervention: 3 lethal equivalents, 20% juvenile mortality																						
Inbr. depr.	N _e	Change in K: 25 yrs	1st breed	Growth: r		25 yr results				50 yr results				100 yr results				200 yr results				TE
				mean	SD	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	
3 H	30	-2%/yr	2	-.010	.191	0	24	4	83	18	14	7	59	98	7	5	38	100	--	--	--	65
			3	-.037	.199	4	20	6	82	48	11	6	60	99	3	0	47	100	--	--	--	51
	-1%/yr	2	-.009	.177	0	34	6	85	6	26	9	70	79	10	8	39	100	--	--	--	85	
		3	-.040	.192	6	26	10	83	37	15	9	66	98	5	1	14	100	--	--	--	56	
	None	2	-.008	.166	1	45	8	86	4	37	12	75	54	18	12	53	100	--	--	--	98	
		3	-.039	.189	2	30	14	83	32	22	13	71	94	8	3	52	100	--	--	--	64	
	50	-2%/yr	2	-.005	.192	0	24	4	83	18	15	7	64	98	6	5	30	100	--	--	--	66
			3	-.036	.196	0	21	5	85	41	11	6	61	100	2	0	38	100	--	--	--	53
	-1%/yr	2	-.008	.175	0	34	6	86	4	24	10	72	80	10	8	45	100	--	--	--	83	
		3	-.037	.186	0	28	9	86	22	17	10	70	98	5	3	46	100	--	--	--	63	
	None	2	-.006	.162	0	46	6	88	1	41	10	77	42	21	13	53	100	12	0	22	108	
		3	-.035	.175	1	36	12	88	14	23	13	74	91	8	5	48	100	--	--	--	71	

Note: deterministic F (from life table) = .081 with breeding at 2, F = .023 with breeding at 3.

Florida panther population viability without further intervention: 1 Lethal recessive, 20% juvenile mortality																						
Inbr. depr.	N _e	Change in K: 25 yrs	1st breed	Growth: r		25 yr results				50 yr results				100 yr results				200 yr results				TE
				mean	SD	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	PE	N _e	SD	H	
1 L	30	-2%/yr	2	.054	.166	0	24	4	83	5	22	5	63	20	21	6	28	40	22	5	8	--
			3	-.003	.192	2	21	6	83	22	17	7	63	58	16	7	28	89	18	6	9	87
		-1%/yr	2	.065	.130	0	36	5	85	1	34	6	71	3	34	5	41	8	35	5	16	--
			3	-.001	.170	2	29	10	84	17	25	10	71	46	24	11	42	75	24	11	11	105
		None	2	.068	.110	0	47	7	87	0	47	5	76	0	47	7	55	1	48	5	25	--
			3	.006	.145	4	36	13	85	14	35	13	74	34	35	13	52	52	42	10	23	190
	50	-2%/yr	2	.056	.167	0	25	3	84	9	21	5	63	24	21	5	33	44	21	5	9	--
			3	-.006	.190	0	22	5	85	19	15	7	62	69	17	7	36	91	20	6	13	71
		-1%/yr	2	.066	.128	0	36	4	86	0	33	6	72	3	34	6	46	7	34	5	18	--
			3	.003	.161	0	31	8	87	10	25	9	73	35	25	10	42	65	27	9	15	141
		None	2	.068	.108	0	48	5	88	0	47	5	78	1	47	5	55	2	48	5	29	--
			3	.006	.139	0	38	12	88	8	36	13	77	27	36	13	55	46	36	14	25	--

Note: deterministic r (from life table) = .081 with breeding at 2, r = .023 with breeding at 3.

Appendices

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