An Analysis of Scientific Literature Related to the Florida Panther

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Abstract: We critically reviewed scientific literature on Florida panthers to identify strengths and weaknesses of existing research, and to recommend future analyses and research priorities. A quarter-century of research strongly supports many published conclusions, including that forests are important as daytime rest sites of panthers, that white-tailed deer and feral hogs are the most important panther prey, that the most important threats to panther persistence include limited habitat area and continued habitat loss and fragmentation, and that recovery of the panther depends most critically on establishing additional populations outside of south Florida. For about a century, loss of fitness due to erosion of genetic material was also a serious threat to the panther population. The genetic outcrossing program begun in 1995 seems to have remedied this problem for now; we recommend rigorously documenting this apparent success as a service to conservation science. Research on juvenile dispersal by Florida panthers ranks among the most detailed for any large carnivore species. Although panther numbers have been estimated only once and only in one study area, we believe that obtaining a rigorous estimate of population size would drain resources from more important research needs.

On the other hand, we also found poorly supported inferences. The conclusions that panthers prefer large forest patches and are reluctant to travel from forests are unreliable because the analyses excluded (without mention or rationale) a large fraction of the available data, ignored errors inherent in telemetry data, and did not rigorously compare used habitats to habitats available to the radio-tagged panthers. Re-analysis of existing data can address most issues related to habitat use. The conclusion that Everglades National Park and most of Big Cypress National Preserve are poor habitat for panthers is not scientifically supported; future performance of panthers in these areas will resolve this issue. Population Viability Analyses (PVA) conducted to date have used relatively inflexible software, and the most recent PVA used an unwarranted estimate of 80% annual survival of newborn panthers. We recommend analysis of existing data to estimate vital rates and variation in those rates.

Finally, some important aspects of research have received insufficient attention in recent years. Despite some early and meritorious experimental work on panther reintroduction, during the last decade progress has lagged on ecological and social research needed to reintroduce panthers outside of south Florida. Biomedical data have apparently been collected, but have not yet been analyzed to determine if mercury prevalence, and panther condition and reproduction, have continued to follow trends suggested a decade ago.

To guide the re-analysis of existing data on contentious issues (such as habitat preference), we recommend that stakeholders develop research protocols in a workshop setting. To address the longer-term issues of future research and monitoring, the Scientific Review Team recommends the creation of a Scientific Steering Committee that would be encouraged to communicate directly with the public, and to which researchers, agency employees, and other stakeholders would have direct access. As an appendix to this report, we provide an annotated bibliography of literature on the Florida panther.

ACKNOWLEDGMENTS

First and foremost we acknowledge the biologists and agency personnel who have worked to understand and conserve the Florida panther. Although some of their work is taken to task in this report, these people have fed mosquitoes and braved swamps, snakes, alligators, and endless meetings in the service of science and conservation. They are true panther experts—we have become experts only to the extent that we have peeked over their shoulders during the past year and a half. Their status as experts cannot be taken away by criticism, nor is our criticism intended to do so. The fact that panthers are better off now than they were 20 years ago is to their credit. Progress has not been perfect, but a great deal of the work has been of high quality, a fact which tends to get lost in a review like this.

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We thank all the researchers who responded candidly and helpfully to our requests for information; David Maehr and Darrell Land received a disproportionate share of queries and responded promptly and thoroughly. Scanning dozens of documents into pdf format and providing copies to the Scientific Review Team was a Herculean task, and we thank Darrell Land for his speed and good humor in attending to it. We thank Deborah Jansen and John Donahue for arranging a helicopter tour of panther habitat, Roy McBride for a field tour, and other staff of National Park Service and FWC for attending to the many logistical details of our visits. Justin Waskiewicz entered and edited data in the bibliographic database.

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INTRODUCTION

The U.S. Fish and Wildlife Service (USFWS) recently appointed a new Florida panther recovery team to revise the panther recovery plan. To support this revision and to assist the recovery team in setting priorities, USFWS and Florida Fish and Wildlife Conservation Commission (FWC) commissioned an independent critical review of literature related to ecology and management of the Florida panther. The four authors of this report were recruited to conduct the review.

The main objectives of this review are to identify strengths and weaknesses of existing data, previous analyses, and published interpretations of data and analyses related to the panther, and to recommend future analyses and research priorities. To support our review, we were asked to produce an annotated bibliography of all scientific publications, including unpublished reports, related to conservation and management of the Florida panther.

The 4 members of the Scientific Review Team (SRT) and their areas of expertise are Paul Beier (population ecology, conservation area design, wildlife response to habitat fragmentation, puma biology), Michael R. Vaughan (large carnivore ecology, population ecology and habitat selection), Michael J. Conroy (population ecology, statistics, and decision analysis), and Howard Quigley (carnivore ecology and conservation, landscape conservation applications, and field ecology). Although none of us is a geneticist, 3 of us (Beier, Quigley, Vaughan) have advised graduate theses on genetics of large mammals and are familiar with the literature in conservation genetics. Although one of us (Vaughan) has worked on large mammal reproductive physiology, none of us has expertise in veterinary science, epidemiology, comparative physiology, or pathology.

METHODS

The 4 members of the Scientific Review Team (SRT) met each other in Naples, Florida, on 29 April 2002. At that meeting, we also met several personnel from FWC, USFWS, and National Park Service (NPS) who are leading efforts on panther management and recovery. We learned about the history of management of the panther, and were provided with maps and copies of most of the literature in electronic format. None of the SRT members had prior knowledge of scientific controversies related to panther management. During the meeting we learned that there were disputes, but we were unaware of the nature of these disagreements.

The SRT classified the approximately 3,000 pages of published and unpublished papers on the panther into topical areas and assigned ourselves, in sub-teams of 2 persons, to review the literature in each subject area. About 20% of the papers straddled topical areas and were assigned to 2 or more sub-teams. Each of us read 1,500–2,000 pages of material in our 2 assigned subject areas by September 2002, at which time each pair of reviewers provided a list of 8–11 key papers in their topical area for the other SRT members to review. Thus, each paper was read by at least 2 of the 4 members of the SRT, and a considerable portion was read by all members. During this phase, SRT members carefully avoided making comments to each other, and avoided comments from other interested parties, so that each reviewer could independently evaluate the literature on its merits.

In appraising the literature, we did not take the attitude that Type I error must be avoided at all costs. Recognizing that managers need to act on the best available information, we instead evaluated whether the preponderance of evidence supported particular hypotheses, or which of several competing hypotheses was best supported by the evidence. In statistical analyses, we evaluated the strength of inference in terms of replication, whether exclusions of data were properly disclosed and discussed, adequacy of control or comparison groups (where appropriate), and appropriateness of the analysis. The overriding questions were "Is the information, as presented, reliable?" and "Should those responsible for recovery of the Florida panther use this information to make critical decisions that may affect Florida panther persistence?" The SRT operationally defined "reliable" as the condition of the data, analyses, models, or assumptions being capable of supporting inferences about the Florida panther, its population dynamics, biology, and habitats.

During 4–7 November 2002, the SRT again met in Naples, where for the first time we discussed our evaluations of the literature. Each of us approached the meeting with strong reactions to the literature, and concern that his opinion might not be shared by the rest of the SRT. In each subject area, however, there was a remarkable level of agreement about the strengths and weaknesses of the data and analyses. We also noted ambiguities in some of the papers, and started to develop a list of queries that we could send to particular authors to clarify these issues. On 5 November we took a half-day helicopter tour of panther habitat, courtesy of the National Park Service. During the last 2 days of the meeting, we continued our discussions, and made ourselves available for persons to express their opinions on scientific issues.

Either at or immediately after the November meeting, each SRT member shared their annotations and comments on each paper for collation into an annotated bibliography. We used ProCite® software to organize reviewer notes on the content and reviewer comments into a bibliographic database. During December 2002, we collated queries specific to each of several authors. We e-mailed queries to the respective authors and invited each author to attend an SRT meeting on 31 January 2003. Each author responded to their queries before the meeting, so that we could devote that meeting to matters of interpretation rather than matters of fact.

On 31 January 2003, the SRT met in Athens, Georgia. We separately interviewed each of the following persons: Oron L. Bass, R. Christopher Belden, E. Jane Comiskey, Mark W. Cunningham, John W. Kasbohm, E. Darrell Land, and David S. Maehr. Cunningham and Land participated by speaker phone from Florida; the others attended in person. After a discussion of scientific issues, we invited each interviewee to give us their perspective on any issues related to ecology and management of the panther.

This report is organized along the same topical themes we had used to organize the literature. All SRT members participated in writing each section, and this report reflects our consensus view. On 9 June 2003 the SRT submitted a draft to USFWS and FWC. The agencies distributed this draft to (a) six reviewers with no vested interest in the outcome of the report who were recruited by USFWS and FWC to provide detailed anonymous reviews and (b) members of the recovery team and the panther subteam of MERIT (Multi-species/Ecosystem Recovery Implementation Team) who were notified that they could submit comments directly to the SRT until 1 August 2003. The solicited reviews were returned to the agencies, which in turn provided the reviews to the SRT on 9 September 2003, maintaining reviewer anonymity. In producing this final report, the SRT considered both solicited reviews and all unsolicited comments received by 1 October 2003 (2 months after the deadline).

The June 2003 draft apparently circulated far beyond its intended audience. Because this final report differs substantially from the draft, we caution the public that neither the authors nor the agencies endorse the June draft, and that professional ethics requires that any draft circulated for review should be treated confidentially and destroyed after review.

The Literature Cited section of this document contains only those documents cited in the text of this report; it is not a complete list of all literature we reviewed. We list all literature reviewed in an annotated bibliography. The bibliography contains extended summaries of most papers, and the comments of SRT members on the major points and weaknesses in many papers.

HABITAT

During 1981–2003, a number of reports, popular articles, books or book chapters, and scientific papers were written about habitat use and habitat requirements of the Florida panther (*Puma concolor coryi*). Nonetheless, a comprehensive, scientifically defensible understanding of panther-habitat relationships has not emerged. In fact, the issue of panther habitat requirements is quite controversial. The controversy hinges primarily on whether the geographic areas in which data were collected match the areas to which inferences are made, and how habitat use data were collected, analyzed, and interpreted. In a series of papers (Maehr and Cox 1995; Maehr 1997*a,b*; Kerkhoff et al. 2000; Maehr et al. 2001), Dr. David Maehr and his colleagues drew conclusions about the relative importance of forests to panthers and the reluctance of panthers to use areas far from forest cover. Some of their conclusions were criticized, most vigorously by E. Jane Comiskey and colleagues, but also by other biologists and managers involved with Florida panther recovery, and even by some of Maehr's coauthors on the very papers from which the conclusions were drawn. Scientifically rigorous conclusions regarding Florida panther habitat requirements are critical because they affect land management decisions, particularly those decisions made in USFWS Section 7 consultations on land development and mitigation, where the "best available science" is the standard. Because the Endangered Species Act does not define "best available science" and nothing in case law suggests that it is synonymous with "published," "peer-reviewed," or "most recent" (Bean and Rowland 1997), it is important to carefully consider what conclusions are supported by the preponderance of evidence and meet our definition of "reliable" (above).

The Florida panther SRT recognized several issues, or areas of controversy, surrounding the scientific literature related to panther habitat requirements. These include, but are not limited to

- The use of daytime telemetry locations to depict 24-hour habitat use patterns;
- Selective use of telemetry locations to analyze panther habitat use data;
- Use of individual locations rather than individual panthers as the sampling unit;
- Currency of habitat maps used in analysis of telemetry data;
- Telemetry error and use of a point-to-pixel approach to plot telemetry locations;

- The distance from forest cover panthers are likely to travel;
- Panther home range size relative to percent forest cover within the home range;
- Big Cypress National Preserve and Everglades National Park as panther habitat;
- Analytical techniques used to analyze telemetry data;
- The peer-review process;
- Selection of reintroduction sites for establishing population(s) of panthers outside of south Florida.

Our evaluation of these issues is detailed below. Because the issues are interrelated, not all will be discussed individually.

About 75% of the habitat-related publications reviewed by the SRT were authored or coauthored by David Maehr, thus most of the following discussion focuses on the work of Dr. Maehr. It is critically important to note that the SRT strived to present an objective opinion of the literature with regard to its scientific rigor.

The most influential paper on panther habitat requirements was Maehr and Cox (1995), which identified the importance of forest types to panthers (previously reported in Maehr et al. 1991*a*), concluded that Florida panthers need large (mean = 20,816 ha) forested areas, reported that 96% of all locations occurred in or within 90 m of a forest type selected by panthers, found an inverse relationship between male panther home range size and percent forest in the home range, and implied that Everglades National Park (ENP) and Big Cypress National Preserve (BCNP) contained marginal habitat and may be avoided by panthers. This publication is repeatedly cited in subsequent manuscripts, authored or co-authored by Maehr, as evidence of the above ideas. For instance, Maehr and Meegan (2001) cited this paper in developing criteria for evaluating panther habitat for land management decisions. In other examples, Maehr denigrated ENP and BCNP as panther habitat (Maehr 1997*b*, Maehr et al. 2002*b*), modeled and provided guidelines for assessing panther habitat (Maehr and Meegan 2001, Maehr and Deason 2002, Meegan and Maehr 2002), and concluded that Florida panthers are forest obligates, while reinforcing the idea that panthers are reluctant to cross non-forested habitat greater than 90 m in width (Maehr et al. 2001).

In response to publications by Maehr and colleagues, Comiskey et al. (2002) challenged the validity of some of the conclusions drawn from these publications, alleging that Maehr and Cox (1995) based their analysis on a biased sample of the panther data available, and ignored location error, and that several of these papers incorrectly used daytime telemetry to make inferences about panther movements, including movements at night.

The SRT evaluated the scientific literature, spoke with several of the authors of the key habitat publications and reached the following conclusions.

Use of Daytime Telemetry Locations to Describe Habitat Use

Maehr et al. (1989*a*, 1990*a*) described nocturnal activities of 4 dams monitored 4,600 hours and 6 solitary panthers monitored for 130 hours. However, all other analyses are based on telemetry locations gathered primarily between 7 and 11 AM from a fixed-wing aircraft. This time window was selected because of unfavorable flying conditions at other times of the day (D. Land, personal communication). Thus, all analyses of available telemetry data, regardless of author, are restricted to daytime telemetry locations. However, Florida panthers apparently are most active at night (Maehr et al. 1990*a*), and daytime telemetry is insufficient to describe habitat use of animals that are most active at night (Beyer and Haufler 1994; Dickson et al., in press). In the opinion of the SRT, the use of daytime telemetry data should be limited to describing daytime panther habitat use patterns. Extrapolating daytime telemetry locations to describe 24-hour habitat use by Florida panthers is unjustified, and conclusions based on such extrapolation are unreliable. The SRT emphasizes that these data are useful for describing daytime habitat use patterns, identifying daytime bedding sites, documenting seasonal movements and dispersal, and outlining home ranges. Further, many of the publications that pushed these data beyond their limits (e.g., Maehr 1992, Maehr and Cox 1995, Kerkhoff et al. 2000) failed to mention that the data were collected in daylight hours only.

The SRT encourages acquisition and analysis of nighttime telemetry data to provide a more complete picture of Florida panther habitat use. These analyses may or may not change conclusions about what habitats are critical to Florida panthers, but until that analysis is done, the picture of Florida panther habitat use is incomplete.

Selective Use of Telemetry Locations

Between 1981 and 2002, more than 55,000 radio locations on more than 100 Florida panthers were recorded, yet most publications have not made full use of the locations available at the time of data analysis. The SRT discovered several unexplained examples of data sub-setting or selective use of data. For example, Maehr et al. (1991*a*) tracked 26 Florida panthers during 1985–1990, but without explanation, used only 9 of the 26 panthers (7,025 locations) to describe cover type use by panthers.

The most serious case of selective use of data occurred in the most influential paper on panther habitat use (Maehr and Cox 1995). In light of Maehr and Cox's study area map (their Figure 1), their reference to "14,548 locations" (in their Abstract and Methods sections), and their inferences about panther habitat throughout south Florida (e.g., their Figure 2), each SRT member initially assumed that all available data had been analyzed. However, the analysis had in fact excluded about 6,000 radio locations south of I-75 and east of SR-29. In a written response to an SRT inquiry, Maehr stated that the analysis had excluded data on 18 of 41 panthers because "…we viewed the southeastern area of occupied range as fundamentally different and not typical of preferred habitat." This exclusion probably created serious bias in their conclusions (see Importance of Forests to Panthers, below).

Alternatively, Dees et al. (2001) excluded panthers and locations from their analyses, but fully explained the reasons for excluding data. While there may be legitimate reasons to exclude data from certain analyses, it is incumbent upon the author(s) to explicitly state which data were and were not used, and to fully explain the reasons for excluding data.

Locations Versus Panthers as the Sampling Unit

Although it was not always clear from the description in the methods section of some publications, the analyses in at least two publications (Maehr and Cox 1995, Kerkhoff et al. 2000) used locations rather than panthers as the sampling unit to determine habitat use. The SRT believes this is an incorrect approach because a single panther with an abnormally large number of locations could bias the analysis. For example, suppose that a researcher had 54,750 locations on a single animal, and 5 locations for each of another 50 animals. A pooled analysis would be nothing more than the habitat selection of a single animal, because use by the other 50 animals would be swamped by the one animal with many locations. Although panther data are not this skewed, simple pooling makes sense only under the patently false assumption that animals with more locations are "better panthers" or "more representative panthers" than those with fewer locations.

In addition, inferential statistics from such a pseudoreplicated analysis are strongly biased toward "statistical significant" results (Hurlbert 1984). This problem is not remedied by having an equal number of locations per animal. The proper approach would be to calculate the habitat composition in the home range of each panther then average across panthers (Aebischer et al.

1993). The final answer may not change using this approach, but the analysis is defensible, whereas using the location (i.e., all locations from all panthers combined) as the sampling unit is indefensible.

Currency of Habitat Maps

Telemetry data have been collected for Florida panthers over a long time period (since 1981), but in some analyses of habitat use, the vegetation maps may not have been updated and ground-truthed to stay current with analyses of telemetry data. This could lead to erroneous conclusions about panther habitat use. For instance, what was a forest patch in 1985 may be an agricultural field in 1995. If this is not reflected on vegetation maps used in analyses of panther locations from 1995, then the wrong conclusions about habitat use may be drawn. The SRT has insufficient information to know to what degree this may be a problem, but recommends attention to this potential problem in future analyses.

Telemetry Error

No matter how good the telemetry tracking system, and how qualified the persons operating the tracking equipment, location error occurs in all telemetry studies; this error should be accounted for when analyzing location data (White and Garrott 1990). Almost all telemetry data from radio-marked Florida panthers were collected using aerial telemetry. White and Garrott (1990) noted that errors in excess of 0.5 km had been reported for aerial location estimates when the animal was not visually located. They further note that altitude above ground, air speed, location procedures, prevalence of landmarks, and investigator fatigue or discomfort affect aerial location accuracy.

Most papers that analyzed telemetry locations to determine habitat use and home range of Florida panthers noted that locations were gathered using aerial telemetry, and reported altitude and flight speed; however, only 3 publications estimated telemetry error. Belden et al. (1988) estimated error as 230 m, and Janis and Clark (2002) estimated a mean error of 176 m with 95% of locations within 489 m. Dees et al. (2001) estimated that telemetry error averaged 77 m with 95% of locations within 200 m. Maehr et al. (1991*a*) assumed (without explanation) that telemetry error was 100 m. The most influential paper on habitat use (Maehr and Cox 1995) did not provide any estimate of telemetry error, and implicitly assumed error was 0 m. These linear errors can be converted to aerial measurements (a circle of radius equal to the linear error displacement), yielding error estimates of 3 to 78 ha, corresponding to linear displacements of 100 to 500 m.

When locations are obtained by a system that is "blind" to the habitat map (e.g., triangulation), the main impact of telemetry error is to reduce the statistical power of analyses of habitat selection without adding bias (White and Garrott 1990). Although the impact on power and bias is less predictable when locations are assigned to habitat types by an observer, or when an observer in an airplane marks a location on a photograph or a map depicting vegetation, the SRT believes that failure to account for telemetry error probably did not have a large impact on analyses of selection of vegetation types by panthers. In analyses of habitat selection, accounting for telemetry error is simply a part of fully reporting results and the uncertainty surrounding them.

The SRT is more concerned about the impact of telemetry error on the claim by Maehr and Cox (1995, 1014) that "…96% of panther locations were within 90m of large forest patches." Here, an empirically based confidence interval is crucial to reflect the uncertainty in this estimate. Later, Maehr et al. (2001) and Maehr and Deason (2002) compounded this error when they incorrectly claimed that Maehr and Cox (1995) showed panthers were "reluctant to cross" non-forested areas greater than 90 m. Daytime locations do not indicate whether panthers cross non-forest areas at night. Indeed, Maehr et al. (1992) reported that an adult male panther north of the Caloosahatchee, in an area of fragmented forest, regularly crossed non-forest areas much larger than 90 m within his home range. Indeed, some forest fragments are probably smaller than the aerial error, with consequent ambiguity as to the correct classification of the animal location as to "forest" versus "non-forest" habitat.

Unfortunately, the 90-m distance has been proposed as a standard for computing mitigation for loss of panther habitat in land development projects. The SRT finds no empirical basis for the idea that panthers do not travel more than 90 m from forest cover, or that habitat patches farther than 90 m from forest cover are unlikely to be used by panthers. We recommend that use of these ideas be discontinued immediately.

Home Range

Belden et al. (1988), Maehr et al. (1991*a*), and Comiskey et al. (2002) reported home range size for male and female Florida panthers, and all agreed that males (435–650 km^2) and females (193–396 km^2) required relatively large areas to meet their needs. The SRT believes that all these estimates are reliable. Estimates of home range size are probably more sensitive to the statistical algorithm used (e.g., minimum convex polygon, adaptive kernel, fixed kernel) than to location error or daytime bias in locations. This is because home range algorithms vary greatly in how much of the landscape that lacks animal locations is considered part of the home range (White and Garrott 1990). In contrast, location error of ~200 m in the locations on the margin of a home range of 200 to 650 km^2 would change the estimate by <10% (for a 200-km^2 circular home range with 100% of errors in the centrifugal direction) or less (for home ranges >200 km^2, and the more likely scenario of offsetting errors).

Importance of Forests to Panthers

Maehr (1992), Maehr and Cox (1995), and Kerkhoff et al. (2000) concluded that panther home range size was inversely related to the amount of forest cover within the home range. Using fractal analysis, Kerkhoff et al. (2000) added that when the amount of forest cover within a home range drops below about 25%, "…the likelihood of intensive panther use declines dramatically," and because their study area contained only about 22% forest cover "…the region may be, from a panther-centered view, on the verge of collapse." Comiskey et al. (2002), on the other hand, also used fractal analysis, but failed to find a relationship between the amount of forest cover within a home range and home range size, and rejected the idea of a forest-centered view of panther habitat selection. Rather, they contended that the panther is a habitat generalist that occupies all natural habitats available.

Kerkhoff et al. (2000) used data collected in a 20,000-km^2 area of south Florida during 1981–1993 (41 individuals; 12,783 locations), whereas Comiskey et al. (2002) used data collected in a 25,000-km^2 area of south Florida during 1981 through mid-2000 (102 individuals; 49,889 locations). Comiskey et al. (2002) also used a subset of data (1981–1993, 18,118 locations, 52 panthers) in a fractal analysis for comparison with Kerkhoff et al. (2000).

The SRT was unable to find theoretical literature establishing that fractal analysis is appropriate for analysis of habitat selection, and we have several concerns about its use in this context. First, the approach ignores the identity of animals, and thus may suffer from the same problems as other analyses that treat the location rather than the animal as the unit of analysis. (In fractal analysis, the unit of analysis is a moving window of one of several specified widths, obscuring the relationship to panthers in a way that defies interpretation in terms of individual panthers.) Also, the central analogy used by Kerkhoff et al. (2000) to extend fractal analysis from a linear setting (e.g., measured length of a coastline as a function of ruler length) to the habitat setting (percent forest cover as a function of the size of rectangular window) seems intuitively incorrect. The 2-dimensional window within which forest area is measured is not analogous to a 1-dimensional ruler measuring coast length. Although coastline length will vary with ruler length, the mean percent forest cover should be independent of window size (although the variance should decrease as window size increases). Finally, all of the "plain English" interpretations of fractal analysis suggest that simpler analyses in the original metric would have yielded the same insights. We do not see the added value of using the original data to estimate the fractal dimension, *D*, and then back-translating to the original metric. For instance, to explain the relationship between panther locations and estimated *D*, Kerkhoff et al. (2000, Figure 7) referred to an illustration of the relationship between panther locations and forest cover; a simple analysis in terms of percent forest cover would have been more straightforward. Similarly, the hypothetical relationship illustrated in Figure 1 of Kerkhoff et al. is neither directly nor indirectly tested by fractal analysis, but could be directly tested by a simple correlation between home range size and amount of forest. We are unpersuaded that fractal analysis offers novel insights into panther habitat selection.

Comiskey et al. (2002) used GIS layers for vegetation that were not always concurrent with telemetry locations, and estimated home range using the Minimum Convex Polygon approach, which may include large areas of unused habitat in the home range. All the location data were diurnal locations, which should not be used to describe how panthers use habitat on a 24-hour basis. Despite these shortcomings, the SRT agreed that Comiskey et al. (2002) made a credible case that the relationship between panther home range size and amount of forest within the home range is weak, and convincingly showed that some panthers in the Everglades used home ranges that had less than 25% forest.

The most important defect of the analyses by Maehr and Cox (1995) is that habitat use by panthers in a heavily forested area (the area north of I-75 and west of SR-29) was contrasted with an available habitat area that extended 40 km beyond the polygon formed by all panther locations (apparently including panther locations otherwise excluded from the analysis). Thus the "available habitat" included some areas that were actually used by panthers in less forested areas south of I-75 and east of SR-29 (but excluded from the analysis) and some less-forested areas that lay up to 40 km outside of the panther's geographic range. This sort of analysis is biased toward a finding that panthers select forests.

Disregarding the fractal analysis, and the biased comparisons of Maehr and Cox (1995), there is reasonable evidence that forests are the most important habitat for diurnal locations of panthers. For instance, Table 2 of

Maehr and Cox (1995) presents percent composition of panther home ranges, and supports the importance of forests as diurnal habitat within the area north of I-75 and west of SR-29. These data are free of the bias mentioned above, in that panther locations are compared to the percents of each vegetation type within the home range of the same panther; these data also appropriately use the animal as the sampling unit. (Unfortunately, the analytic steps that produced Table 2 were not mentioned in the methods section, nor described anywhere except in the table caption.) Similarly, Table 4 in the draft Conservation Strategy (Florida Panther Subteam of MERIT 2002) convincingly illustrates the importance of forests as preferred diurnal locations for panthers.

Other analyses attempt to demonstrate the importance of forest based on apparently straightforward frequency distributions of patch sizes used by panthers. For instance, 75% (Maehr and Cox 1995) and 81% (Maehr and Meegan 2001) of panther locations were within forest patches larger than 500 ha. However, despite their apparent simplicity, these statistics by themselves say nothing about the preference for large forests because they were not compared to the frequency distribution of forest patches *available* to panthers. The fact that 19% to 25% of panther locations occurred in patches smaller than 500 ha could reflect either aversion, indifference, or preference for small patches—depending on the availability of small forest patches to each radio-tagged panther. This is an important issue because Maehr and Deason (2002) used this 500-ha minimum patch size as the *single most important factor* in their Panther Habitat Evaluation Model.

Panther scrapes, scats, tracks, and kill sites could shed light on nocturnal habitat use by panthers. The abstract of the paper by Comiskey et al. (2002) alluded to this potential, and indicated that the paper would include such analyses, but no quantitative data or analyses related to panther sign were presented in the paper.

The SRT strongly recommends the use of compositional analysis (Aebischer et al. 1993), or another statistically appropriate method, to compare the distributions of forest patch sizes available to panthers to those used by panthers. We also caution that such analyses should develop a frequency distribution of available patch sizes separately for each animal. An analysis using availability based on patch sizes pooled across animals would be misleading because it entails the assumption that a huge patch of forest (in Florida Panther National Wildlife Refuge, for example) is “available” to every panther (a panther in the Everglades, for example). The analysis should also consider the potential impact of location error.

Big Cypress National Preserve and Everglades National Park as Panther Habitat

Maehr et al. (2001) referred to public lands south of I-75 (i.e., ENP and most of BCNP) as population sinks for panthers because they do not meet the habitat requirements of the Panther Habitat Evaluation Model (PHEM). Maehr (1997*b*, 213) asserted that "the few panthers living in such marginal range are essentially the 'living dead' of the population." However, the PHEM relies substantially on 3 conclusions derived from Maehr and Cox (1995), namely (a) biased comparisons of used versus available habitat, (b) a 500-ha minimum size of forest patch, and (c) a 90-m distance from forest cover. As discussed above, these 3 conclusions are unsound.

In another line of reasoning, Maehr et al. (2002*a*) argued that 600,000 ha of National Park Service land in south Florida is marginal panther habitat because none of 27 subadult panthers captured during 1986–2000 began their dispersal to the southeast of their natal range, which was primarily in the core area north of I-75 and west of SR-29. They attribute lack of dispersal to the southeast to limited forest cover and low prey density. This argument may have merit, but dispersal movements were not described in sufficient detail to indicate if the dispersing animals ever visited these areas (i.e., if they could have assessed habitat conditions there).

Earlier, Bass and Maehr (1991) concluded that reproduction does not occur in unforested areas of ENP (a conclusion Bass no longer ascribes to; personal communication 31 January 2003). Comiskey et al.'s (2002) analyses did not support this conclusion, and reported that 1 male and 5 females occupied home ranges in ENP with <15% forest cover, and that reproduction occurred there.

The SRT recognizes that prior to release of Texas pumas into Florida in 1995, most of the panther population, including those that were radio collared and monitored, were in what was considered the core panther area north of I-75 and west of SR-29. Following release of the Texas animals, panthers occupied habitats south of this core area. Thus, conclusions about the habitat value of ENP and BCNP depend partly on whether a study used data from periods when the parks were and were not occupied by panthers. The SRT is not persuaded by the arguments that the 2 federally managed areas are poor panther habitat. On the other hand, the post-1995 population increase in these areas does not convince us that these areas will continue to support a dense panther population. Arguments over whether ENP and most of BCNP, or any other land outside the "core area," are suitable panther habitat will be resolved as we observe panther survival and reproduction in these areas in coming years.

The Peer-review Process

As the SRT reviewed the Florida panther habitat literature it became obvious that the paper by Maehr and Cox (1995) has been used to influence land management decisions involving Florida panthers, despite serious flaws. Particularly unsound conclusions of this paper (or conclusions later attributed to the paper by Maehr and colleagues) are that panthers are reluctant to use areas farther than 90 m from forest cover, that panthers require forest blocks >500 ha, and that panthers are forest obligates. These conclusions form the basis of a habitat model (Maehr and Deason 2002, Meegan and Maehr 2002) that might be used to evaluate and sanction development projects within panther range. Sadly, the peer-review process failed to prevent publication of these errors.

The peer-review process similarly failed to detect that later manuscripts inappropriately cited Maehr and Cox (1995) as supporting conclusions not stated therein—such as panthers being "reluctant to cross" 90 m of non-forest—perhaps because reviewers assumed Maehr would not misinterpret his own work. These examples illustrate the failure of the peer-review process to prevent publication of seriously flawed analyses and illustrate how the conclusions drawn from a flawed peer-reviewed paper can be accepted as fact by repeated citation and miscitation. The SRT questions the reliability of subsequent publications that uncritically rely on Maehr and Cox (1995) and cautions those responsible for the management and recovery of the Florida panther that the peer-review process can fail, at times seriously. At least 1 SRT member reviewed 1 or more of the papers involved in this particular example, and we emphasize that reviewers and editors share responsibility for the failures reported here. We earnestly hope our review will not create any new errors or reinforce other existing errors by failing to notice them.

Some persons have asked the SRT to subject Comiskey et al. (2002)—the paper which first raised these criticisms of Maehr and Cox (1995)—to similar scrutiny. In response, we note that (a) we do point out flaws in Comiskey et al. (2002); (b) these flaws do not invalidate the most important criticisms raised by Comiskey et al. (2002), namely that Maehr and Cox (1995) used a biased subset of the available data but failed to justify (or even report) their selective use of data, and that Maehr and Cox (1995) and subsequent publications made unsupportable inferences that panthers were reluctant to use or travel across non-forest habitats; (c) the paper by Comiskey et al. (2002) has not been widely cited and miscited, nor has it formed the basis for conservation policy.

Selection of Reintroduction Sites for Establishing Panthers Outside of South Florida

Maehr et al. (2002*a*) suggested that natural dispersal of panthers, abetted by habitat restoration and perhaps by translocation of females, may allow panthers to re-establish a breeding subpopulation north of the Caloosahatchee River. The SRT concurs that this is a reasonable possibility, and would significantly enhance panther recovery. However, recovery and delisting of the panther requires 3 viable populations within historic range (USFWS 1995, 1999). Because such populations are unlikely to occur via natural recolonization, reintroductions will almost certainly be required. FWC conducted well-designed experiments that will assist in the mechanics of reintroduction (Belden and Hagedorn 1993, Belden and McCown 1996). The collation and analysis of data on panther dispersal (Maehr et al. 2002*a*) also will be useful in planning reintroduction efforts. However, the SRT was dismayed that little substantive work has been done on identifying reintroduction sites and preparing for the social and political challenges involved in such an effort.

Jordan (1994) provided a start on this challenging issue. However, this document lacked several important elements, including a discussion of the biological links between each criterion and expected success of a reintroduction, a weighting scheme for criteria, sensitivity analysis of different weighting schemes, site boundaries based on something more meaningful than county lines, a discussion of opportunities to use education and other tools to alter social factors impeding public acceptance, GIS analysis of landscape connectivity and potential for population expansion (the report acknowledges the importance of connectivity, but ignores it anyway), and a more sophisticated road analysis (the report treats a 6-lane freeway the same as a public dirt road). Perhaps more important, Tasks 2, 3, 4, and 5 of the report had target dates between August 1994 and February 1996. As of late 2003, none of these tasks have been completed, and some may not have been started. The SRT's impression is that, as an agency, USFWS has not been strongly committed to the reintroduction effort. This impression was reinforced by several persons interviewed during our review. The SRT is aware that the USGS Southern Appalachian Science Center at the University of Tennessee is conducting some analyses that may constitute significant progress on this issue. We strongly urge USFWS to vigorously promote such research.

What the Data Support about Florida Panther–Habitat Relationships

Although the SRT questions some of the analyses and conclusions in papers on habitat selection, Dr. Maehr and others have provided a wealth of information that adds to our understanding of panther daytime habitat requirements, dispersal and movement patterns, daytime home range characteristics, and activity patterns. The following seems to be well established.

- Daytime home range characteristics (e.g., size, habitat types) are known and described. Forest cover, particularly hardwood hammocks, cypress swamps, saw palmetto, and hardwood swamps are important diurnal habitats (Belden et al. 1988; Maehr 1990*a*; Maehr et al. 1991*a*; Maehr 1992; Maehr and Cox 1995, Table 2; Kerkhoff et al. 2000; Comiskey et al. 2002).

- Panthers make extensive use of private lands, and habitat loss and fragmentation are among the most important threats to persistence of Florida panthers (Maehr 1990*b*, Maehr 1992, Roelke and Glass 1992).

- Panther habitat selection is related to prey availability (Dees et al. 2001).

- Juvenile dispersal (timing, distance, direction, habitat) is relatively well described (Maehr 1990*a*, Maehr et al. 2002*a*).

- Panthers use highway underpasses, which link habitats and reduce mortality due to highway collisions (Foster and Humphrey 1995; Shindle et al. 2001, Appendix VII).

Summary – Habitat Relations

Definition of habitat requirements of the Florida panther is one of the most contentious aspects of panther ecology. Most of the controversy revolves around conclusions drawn by David Maehr and colleagues regarding the relative importance of forest and forest cover to panthers. Maehr and colleagues concluded that Florida panthers are forest obligates, they strongly prefer large blocks (>500 km^2) of forest cover, they are reluctant to traverse areas greater than 90 m from forest cover, and they avoid areas lacking large forest tracts such as most of ENP and BCNP. Those with an opposing view argue that the data are insufficient to draw these conclusions because of the diurnal bias in telemetry locations and selective use of data by Maehr and colleagues. The SRT recognizes that selective use of data can be legitimate, but affirms that it is incumbent upon authors to divulge which data were deleted and why. The SRT agrees with the view that daytime telemetry is insufficient to describe a 24-hour pattern of habitat use by Florida panthers.

Although available data clearly indicate the importance of forests and forest cover to panthers, we find no basis for the ideas that panthers are reluctant to move greater than 90 m from forest cover, that panthers avoid forest patches smaller than 500 ha, or that BCNP and ENP do not provide useful habitat for panthers. Clearly, panthers use a variety of habitats and survive and reproduce in areas that do not meet the criteria of PHEM. In fact, we recommend that PHEM not be used to make land management decisions regarding Florida panthers. On a positive note, we recognize the value of the available data in describing daytime habitat requirements, determining home range attributes, and describing dispersal patterns. To our surprise, we find that, to date, no one has completely and properly analyzed available telemetry data nor, until recently, attempted to consistently obtain nocturnal locations.

Recommendations – Habitat Relations

The SRT recommends the following regarding Florida panther habitat relations.

1. Develop habitat models, using the best available data and accepted statistical approaches, which predict habitat occupancy as a function of vegetation, roads, patch size, and other attributes. These approaches should (a) be based on the full range of empirical data and not exclude outlying observations, particularly those that do not adhere to conventional wisdom about habitat suitability; (b) fully incorporate uncertainties in the data and statistical models, including telemetry location error and biases induced by incomplete sampling of activity patterns; (c) predict at appropriate scales of spatial and temporal resolution; and (d) explicitly incorporate alternative, plausible biological hypotheses as alternative statistical models. Evaluate these alternatives using information-theoretic approaches to develop predictive decision-supporting models. These analyses should use technique such as compositional analysis (Aebischer et al. 1993, Dickson and Beier 2002, Janis and Clark 2002) that use panthers, not panther locations, as sampling units, and should reflect selection at 2 levels (Johnson 1980), namely selection of home ranges within the geographic range and selection of locations to habitat available in the individual's home range.

2. Obtain and analyze data on nocturnal locations of panthers throughout their range to get a complete picture of panther habitat use.

3. Vigorously pursue efforts to identify at least 1 appropriate site for reintroducing panthers and re-establishing populations of panthers outside of south Florida. The analysis should include justification of the criteria used, sensitivity analysis of weighting schemes, GIS analysis of landscape connectivity and potential for population expansion, and rigorous consideration of roads and other factors.

4. Conduct research that would support the use of education and other tools to influence social factors that might impede public acceptance.

5. Conduct sensitivity analysis on any habitat model prior to using it to make decisions on management or land use. Each poorly estimated factor (such as panther aversion to roads) should be varied across the range of reasonable values for its impact on the map of predicted habitat, as well as priority assigned to various parcels. At a minimum, this would suggest future analyses to better estimate the important factors.

6. In the future, use radio telemetry to focus on specific unanswered research questions (e.g., nocturnal panther use of different sized patches of row crops and other types of agricultural land, areas at various distances from freeways, and areas at various distances from urban development, and fine-scale data on dispersal movements with respect to potential barriers) rather than to simply continue monitoring. Focusing on the research question will dictate the location of tagging efforts, the ages of animals tagged, types of radio tags deployed (GPS versus VHF), and types of analysis.

7. Until appropriate analyses are completed (Recommendation 1), cease using a 90-m distance from forest, minimum sizes of forest patches, and the Panther Habitat Evaluation Model in making decisions about habitat mitigation and acquisition. Ensure that future publications explicitly list the identities of panthers used in analyses and explain reasons for excluding portions of the available data.

PREY

Research has addressed the importance of prey selection, prey abundance, competition with other predators, and the effects of hunting, water levels, and weather on prey availability as factors affecting persistence of the Florida panther. While there is general agreement on which foods are important to Florida panthers, there is some disagreement on whether prey densities in some parts of panther range are sufficient to support a panther population, and uncertainty about the effects of hunting and habitat quality on the density and well being of the prey population. Although these issues do not appear contentious, this may reflect a paucity of sound data on prey abundance, distribution, and health.

Schortemeyer et al. (1991) presented a history of events since the early 1900s that have affected Florida panthers and their prey. Prior to the 1980s, there was no intentional management on public lands to increase prey for panthers. During the 1980s, actions were taken to reduce access to public lands, reduce hunting pressure and harvest on white-tailed deer (*Odocoileus virginianus*) and wild hogs (*Sus scrofa*), reduce the use of hunting dogs, and protect does and fawns. These initial efforts were not data based, but by the 1990s data were available and used to refine prey management strategies. Schortemeyer et al. (1991) outlined the positive effects of specific management initiatives, and concluded that (1) efforts to control wild hogs and armadillos (*Dasypus novemcinctus*), which were introduced for reasons unrelated to panther management, could negatively affect panthers; (2) higher prey densities may be achieved by improving habitat conditions; and (3) recreational hunting does not adversely affect deer behavior or numbers. In addition, they recommended further research concerning predator, prey, and human interactions.

Florida Panther Food Habits

The SRT found only 2 publications that described food habits of the Florida panther; both appeared to be based on solid data. Maehr et al. (1990*b*) described the food habits of Florida panthers in southwest Florida (Collier, Hendry, Lee, Glades, and Highland counties) based on 270 scats collected during 1977–1989 and 38 kill sites discovered during 1986–1989. Wild hogs dominated in estimated biomass consumed in the northern part of the study area, while white-tailed deer dominated in the southern part of the study area. Dalrymple and Bass (1996) examined 113 kill sites from 9 radio-collared panthers and 272 scats collected at kill sites and other random locations in ENP during 1984–1991. They concluded that white-tailed deer, which composed an estimated 78% biomass consumed, were the dominant prey species of Florida panthers. Marsh rabbits (*Sylvilagus palustris*) and raccoons (*Procyon lotor*) were secondary prey. In SRT discussions with state and federal biologists and land managers, the consensus was that white-tailed deer and wild hogs were the dominant prey species of Florida panthers, while rabbits, raccoons, armadillos, etc. were of secondary importance.

Both papers on food habits depended on examination of kill sites and scat samples. It apparently is not difficult to differentiate panther kills from kills of other potential predators (Shaw 1983, Johnson and Belden 1984). While the SRT recognizes that items dominant in the diet of Florida panthers vary over panther range, we believe the literature describing Florida panther food habits is reliable. We also note the existence of an unpublished data set on Florida panther food habits in the BCNP (Deborah Jansen, NPS, personal communication). The SRT encourages the analysis and publication of these data.

Impact of Hunting

Hunting of deer and other game species is a form of competition with panthers for what may be a limited resource. Hunting also disturbs land (e.g., vehicle tracks and hunting camps) and wildlife, including panthers and deer. While competition and disturbance have the potential to negatively impact panthers, the real issue is whether these potential impacts warrant management intervention. Several participants in a round table discussion of issues relative to Florida panther survival expressed concern over the impacts of recreational harvest of deer in panther range, and recommended more research on this issue (Branan 1986). In 1985, a panel was formed to make recommendations for deer management on Big Cypress National Preserve. They concluded that legal buck hunting did not affect herd productivity or rate of increase, and suggested that panther predation might focus on older does (Downing et al. 1986). The panel recommended reduced deer harvests and they encouraged managers to more carefully monitor deer and wild hog population trends. Steelman et al. (1999) reviewed regulation changes designed to reduce the harvest of deer and wild hogs on Big Cypress National Preserve and the impacts of those changes. In a 5-year study of radio-tagged deer on Bear Island, Land (1991, 1994*a*) reported poached deer (2) nearly equaled the legal harvest (3), and that hunters took about as many deer (5) as panthers did (4), but bobcats killed even more deer (10). Land (1991, 10) concluded, "Our data do not support contentions that hunting in Bear Island has adverse impacts upon the white-tailed deer population, and in particular, female deer. The deer herd provides a stable prey base for panthers and is not prone to wide fluctuations in survival patterns."

Janis and Clark (2002) found that panthers responded to human activity (i.e., hunting, ORV use), but suggested that hunting did not have a significant impact on energy intake or energy expenditure by panthers. They also found that kill rates by female panthers were trivially higher in the hunted area than in the non-hunted control area before, during, and after the hunting season. They reported that they had insufficient statistical power to make inferences about how hunting affected kill rates by male panthers.

The SRT finds these studies of hunting impacts inconclusive. The raw number of kills reported by Land (1991) suggests that hunters take about as many deer as panthers, a statistic that neither supports nor refutes the contention that deer hunting reduces panther fitness. Only Janis and Clark (2002) attempted to test whether hunting and harvest of deer affected fitness (predation rates) of Florida panthers, and their negative results are reasonably persuasive evidence that recreational hunting is benign. The study was not replicated (a single hunted area compared to a single non-hunted area), but their inferences were strengthened by their use of a split-plot design with before, during, and after hunting to test for effects based on the treatment-by-period interaction term. Nonetheless, panther kill rates (and other measures of fitness) on Bear Island might increase if hunting were halted. Another complication is that previous studies were conducted before the apparent surge in panther numbers since 1995. If panther numbers continue to increase, competition between hunters and panthers may also increase.

Thus, the SRT concludes that hunting probably has little impact on panther fitness, but that the issue is far from settled. We believe that steps to reduce hunt-related disturbance on Bear Island by closing deer camps and rehabilitating vehicle tracks probably benefit both deer and panthers on Bear Island. Additional studies could help determine the impacts of recreational hunting, and of particular hunting practices (e.g., use of hounds), on Florida panther predation rates in hunting areas throughout panther range with a larger panther population.

Relationships among Soil, Hydrology, Prey Density, and Panthers

The SRT found little to no quantitative data on prey densities. Belden and Hagedorn (1993) suggested that, for translocations, a density of 1 deer/36 ha could support a population of 50–60 panthers, but we found no specific information on prey densities required to support existing populations. Responding to a query from the SRT, Darrell Land (FWC) noted that "Spotlight surveys, track counts, and aerial surveys have all been used to monitor deer numbers, but their reliability as true estimators is very suspect." Cramer and Portier (2001, 56), who attempted to model panther movements in relation to some anthropomorphic and environmental variables, noted "The lack of specific deer density data on much of the study area makes this the weakest source of data."

McCown et al. (1991) collected 39 and 43 deer, respectively, from the Eastern Monument Unit (EMU) and Bear Island Unit (BIU) of Big Cypress National Preserve (BCNP) and concluded deer health and productivity were reduced in EMU by poor forage quality. In a more inclusive study (more years, larger sample), McCown (1991, 7), concluded that deer and panthers in the cypress-dominated habitats of the Corn Dance Unit of BCNP and the Fakahatchee Strand State Preserve were "…smaller, leaner, less thrifty, less productive and less numerous…" than in the Bear Island Unit of BCNP. Dees et al. (2001) used 1,940 telemetry locations collected during 1989–1998 to describe panther habitat use in relation to prescribed fires and suggested that panthers were attracted to burned areas less than 1 year old because deer were attracted there by the improved quality of the habitat. Roelke (1990) posited a north-south cline in which prey density, panther body mass, panther reproduction, and various measures of panther health all declined from north to south. This apparently corresponded to a shift from a diet of feral hogs and deer in the north to a diet of deer, raccoons, and armadillos in the south, and Roelke (1990) hypothesized that the small, more aquatic-based prey provided a vehicle for mercury poisoning of panthers. Fleming (1994) linked the quality of forage to soil quality, but presented no data on the quality of either soils or forage. Maehr et al. (2002*a*) analyzed dispersal movements of 27 panthers during 1986–2000 and argued that lack of panther dispersal to the southeast was due to limited forest cover and low prey densities in the Everglades area. All of these studies suggest that density of prey (mainly deer), and by implication, panther densities, are limited by vegetation and soil types, but they present remarkably little quantitative analysis of these relationships.

Land (1991) and Fleming (1994) found an inverse relationship between white-tailed deer fawn survival and water levels in BCNP and the Florida Everglades, respectively. Fawns had low survival when water levels were high, especially during the February fawning season, presumably because fawning areas were concentrated in areas easily exploited by predators. The 9-year study in the Everglades (Fleming 1994) suggested that seasonal flooding was an important positive factor, with intermediate hydroperiods (3–6 months of flooding) correlated with higher deer numbers than shorter or longer hydroperiods.

Maehr and Lacy (2002) expanded this idea by arguing that the demographic surge of panthers after genetic introgression was due to increased deer numbers, which were in turn due to several years of little flooding, and that deer and panther numbers can be expected to collapse during the next period of wet conditions. Their argument is supported only by a graph of deer numbers for 1 management unit, with no data suggesting a deer increase throughout panther range since 1995. Furthermore, the graph does not support their argument: 3 of the 6 high water events depicted in the graph were followed by deer increases, and most of the large year-to-year variation in deer numbers appears unrelated to hydrologic events. McBride (2001) noted, "The recent increases in deer and panther populations south of I-75 have taken place during what Big Cypress hydrologists describe as the wettest decade on record since the establishment of the Preserve (B. Sobczak [Big Cypress NP hydrologist], pers. comm.)." Thus, it is unclear to the SRT how recent changes in water levels may have affected deer populations and panther numbers.

Taken as a whole, these studies suggest important relationships among soil, vegetation, hydroperiod, prey density, and panther fitness. The SRT believes the time is ripe for a thorough analysis of these relationships, using some combination of existing data and new data. Detailed soil and vegetation maps probably exist in digital form, and some of the data sets used in previous papers (i.e., annual deer surveys in various game management units, data on panther health across occupied range, hydrologic data) have been expanded by another decade of research. Other data sets (i.e., panther diets) apparently have not been augmented during the last decade. Nonetheless, existing data may allow a rigorous investigation of at least some of these ideas.

Competition with Other Carnivores

Black bears (*Ursus americanus*), bobcats (*Lynx rufus*), and alligators (*Alligator mississippiensis*) are potential competitors with Florida panthers for prey. Maehr (1997*a*) concluded there was a low probability of competitive interactions among panthers, black bears, and bobcats because of different activity patterns and diet preferences. He further states that the diets of coyotes are more likely to overlap with all 3 carnivores than bears, bobcats, and panthers are to overlap with each other. Earlier, Maehr et al. (1989*b*) reported only 1 of 12 wild hogs released in occupied panther home ranges was taken by panthers, while other predators took 4 of 12 hogs. Also, Land (1991) reported 10 of 26 radio-collared deer (46%) that died during his study were taken by bobcats; bobcats and panthers combined accounted for 64% of the mortality. These results are conflicting, but suggest that competition for prey may be an important issue, and is fertile ground for investigation.

Summary – Prey Relationships

The Florida panther's main prey is white-tailed deer and wild hogs; however, there are few reports on prey densities. Data suggest that recreational hunting has little effect on prey numbers and thus is not detrimental to panther persistence; hunting does not seem to be an issue of concern. Competition between panthers and other predators for what may be a limited resource has not been explored, but is fertile ground for further research. Prey densities have been linked to hunting, soil types, hydrology, vegetation, and other environmental factors. Literature describing these relationships is, for the most part, inconclusive, and the issue is worthy of research effort.

Recommendations – Prey Relationships

The SRT recommends the following.

1. Develop a plan for determining the relationship among hydrology, soils, vegetation, abundance of prey (especially deer and hogs), habitat use by panthers, and panther fitness (population density, body mass, survival rates, reproduction). The results could provide meaningful estimates of desired minimum levels of prey in reintroduction sites, suggest whether intensive management of prey is warranted in any parts of currently occupied habitat, and influence management of wetlands in which water levels are controlled. We suspect that some of these analyses could be conducted with existing data sets. If existing data are lacking or in some way defective, we caution that this analysis may require sampling extensively across space and/or time, and thus would require a major commitment of resources. FWC and USFWS would need to weigh this against other important objectives.

2. Continue research in managing vegetation (control of exotics, use of fire) to enhance prey populations. This is not to suggest that management should focus on "farming prey." Rather, vegetation management should focus on broad ecosystem objectives, with prey enhancement among the benefits.

3. Assess the effect of competition by bobcats and other predators on the availability of deer and other prey for panthers.

GENETICS

There is no debate about the fact that the Florida panther had little genetic variation prior to the introduction of 8 female *P. c. stanleyana* from Texas into south Florida in March 1995 (Roelke et al. 1993*a*, Maehr 1998, Culver et al. 2000). Furthermore, both proponents (Seal 1991) and skeptics (Maehr 1998) of the introgression program agree that genetic restoration is insufficient for recovery of the panther, which cannot be considered recovered until it has a much larger geographic range, including range outside of south Florida. However, almost every other aspect of the role of genetics in conservation and management of the Florida panther is contentious.

Most management agencies and scientists believe that (a) the lack of genetic variation is a result of human overkill of panthers and their prey, and destroying panther habitat, with the most severe impacts occurring since about 1890; and (b) by 1994, this anthropogenic impoverishment of the genome presented an urgent threat to survival of the population. The counterargument starts with the idea that the Florida peninsula, which may have been narrower some 10,000 years ago, may have at least started the process of genetic divergence of south Florida panthers from other populations of *Puma concolor*, long before any human impacts (Maehr 1998, Wilkins 1994). A related idea is that the panther may have evolved some beneficial genetic adaptations, which should be conserved (Maehr 1998). Second, despite strong evidence of phenotypic abnormalities plausibly related to deleterious alleles (Roelke et al. 1993*a*), skeptics assert that the panther population is demographically vigorous and that these abnormalities thus have little practical consequence at the population level (Maehr and Caddick 1995; Maehr 1997*b*, 89).

The genetic restoration program also has come under criticism. Some have questioned whether the target of 20% genetic introgression is justified (Maehr 1998), and suggest that management agencies use genetic restoration as an excuse not to confront critical habitat issues (Maehr 1998, Maehr and Lacy 2002). They also worry about overachieving the target level of 20% introgression, which might swamp *coryi* genetic material or cause outbreeding depression (Maehr and Lacy 2002).

Genetic Variation of Florida Panthers

In a study of 31 puma populations throughout North and South America, *Puma concolor coryi* had the lowest value for each of 6 measures of variation in microsatellite loci (Culver et al. 2000). For most measures, *P. c. coryi* manifests one-half to one-eighth the variation of other populations. Similarly, Roelke et al. (1993*a*) reported that allozyme polymorphism at 41 loci was 4.9% for *P. c. coryi* compared to a range of 7.3% to 17.1% for 6 populations of western North American pumas, that average heterozygosity was 1.8% for *coryi* compared to 2.0% to 6.7% for the western populations, and that minisatellite variation ("DNA fingerprinting") was 85% lower in *P. c. coryi* than in western pumas.

Prior to the 1995 introgression program, there apparently was an infusion of non-*coryi* genes via release of at least 7 animals, including at least 3 females, from "Piper stock" into the Everglades during 1957–1967 (O'Brien et al. 1990). The Piper stock was comprised of captive *Puma concolor*, apparently dominated by genes of South American pumas, but including at least 1 Florida panther founder. Panthers were nearly extirpated east of Shark River Slough about 1990 (Bass and Maehr 1991), removing the animals that had the largest representation of Piper genes. Although the level of genetic admixture between these hybrids and panthers west of Shark River Slough was remarkably low (O'Brien et al. 1990), some introgressed genes remain in the panther population. For instance, Male #16, a probable carrier of Piper genes, was the probable sire of at least 2 litters with Texas dams.

According to Maehr (1998), "there is no debate about" the basic fact of low genetic variation in the Florida panther.

When Did Florida Panthers Lose Genetic Variation?

The strong preponderance of evidence suggests that Florida panthers lost half or more of their genetic variation since the 1890–1920 period. Culver et al. (2000) found that samples from 4 "ancient" (i.e., museum specimen) Florida panthers contained 6 microsatellite alleles that were absent from the 6 modern *coryi* samples they analyzed. The decline in microsatellite genetic variability was evident in polymorphism (50% in 4 ancient specimens, 20% in 6 modern samples), mean heterozygosity (42% declining to 5%), and mean number of alleles per locus (2.3 declining to 1.2). Similarly, the prevalence of cowlicks (a trait unrelated to fitness, but which is probably genetically controlled) increased from about 33% (2 of 6) during 1896–1898 to over 94% in modern specimens from southwest Florida (Wilkins et al. 1997). The most dramatic evidence that the loss of genetic material was not abating prior to the genetic restoration program was that cryptorchidism (which is almost certainly under genetic control) increased 4-fold during 1970–1992, a statistically significant increase despite small sample sizes (Roelke et al. 1993*a*).

Culver et al. (2000) had small sample sizes for Florida panthers (4–6 ancient specimens in each analysis, 6 modern specimens). Because the focus of Culver et al. (2000) was the entire Western Hemisphere, they did not offer any statistical analysis of these temporal changes. Nonetheless, these point estimates of temporal change suggest a striking loss of genetic material in recent decades.

In response to an inquiry from the Scientific Review Team about the "ancient" samples, Melanie Culver (University of Arizona, personal communication to P. Beier, November 2002) stated: "The 6 turn-of-the-century Florida panthers were mostly from the area where the type specimen was from, [namely] Sebastian, Florida. They were all from central, not southern Florida. The dates [of the 'ancient' samples] are 1890–1922, except 1 specimen from 1965 from the Florida Museum of Natural History. In retrospect, 1965 is more likely to be post-bottleneck and should not have been included with the other [ancient] specimens. The heterozygosity should probably be recalculated without the 1965 specimen.... I don't know how many other voucher museum specimens could be located. I tried to get all I could find and collected 12, of which only 6 yielded usable microsatellite DNA. The Harvard Museum would not let me sample the 'type' specimen."

In arguing that genetic divergence of Florida panthers may have started prior to modern human influences on the species, Wilkins (1994) and Maehr (1998) apparently were referring to panthers in south Florida, rather than the historic race *P. c. coryi*. The argument is that the peninsular nature of Florida (the authors state that the peninsula was narrower until sea level receded to its current level about 8,000 years before present) may have started the process of differentiation before the influence of Euro-Americans (Wilkins 1994). This geographic semi-isolation could have started the process of genetic divergence via the processes of genetic drift and isolation by distance. Maehr (1997*b*, 89) asserted that "mating between closely related individuals has always occurred more frequently in Florida than elsewhere in the species range." This divergence could then have been accelerated by selection for "traits that permit [the panther] to survive in the harsh south Florida landscape" (Maehr 1998, 181).

Empirical evidence supports the argument that peninsularity contributes to loss of genetic variability in pumas. Culver et al. (2000) reported that puma populations on Vancouver Island, the Olympic peninsula, and Florida were the only populations that showed a large proportion of monomorphic microsatellites (5 of 10 loci for Vancouver and Olympic, 8 of 10 for Florida). Further, the Olympic peninsula had a unique and fixed mutation in mitochondrial DNA. Finally, Ernest et al. (2003) present results consistent with modest reduction of puma genetic diversity in habitat peninsulas in California.

Nonetheless, the SRT believes that 8,000 years of life on a peninsula caused only a minor fraction of the genetic divergence of *coryi* from other pumas. First, the genetic evidence suggests that most variability was lost since 1890 and that erosion was continuing until the early 1990s (Roelke et al. 1993*a*, Culver et al. 2000). Second, analysis of museum skulls suggests that nineteenth century panthers in Florida resembled *P. c. coryi* in Louisiana more than they resembled contemporary *P. c. stanleyana* in Texas, suggesting considerable gene flow throughout the range of *P. c. coryi* through most of the nineteenth century (Wilkins et al. 1997). Finally, if genetic isolation of the Florida panther was a natural process driven by geography and abetted by local selection pressure, we would expect to see even stronger genetic effects on the pumas of Vancouver Island, which is an island rather than a peninsula, has only 35% of Florida's land area, and may be harsher than Florida in some respects (e.g., it lacks several species of small prey). But in fact, *P. c. vancouverensis* is 40% to 280% higher in each measure of microsatellite variation than *P. c. coryi* from Florida (Culver et al. 2000). We conclude that recent anthropogenic isolation and reduction of the *P. c. coryi* population probably caused most of the genetic erosion and divergence that was evident in Florida panthers by 1995.

Recommendations.—The SRT recommends a statistical analysis of the likelihood that the temporal changes in microsatellite diversity reported by Culver et al. (2000) could be the result of chance. Until the analyses are done, skeptics can continue to doubt the recent nature of these changes. Because no new sampling or laboratory procedures would be needed, the cost of this analysis would be negligible.

If the above analysis is statistically inconclusive, the SRT recommends additional analyses—using a larger sample of modern and pre-1960 samples—to address the temporal trends in genetic diversity. Tissue samples have been collected from many modern panthers uninfluenced by the recent introgression or Piper stock. We assume that these tissues have been appropriately stored by the Laboratory of Genomic Diversity (S. O'Brien, Fredericksburg, Maryland) and FWC, and would be available for analysis. It may be more difficult to increase the number of pre-1960 tissue samples, because Culver (personal communication, above) suggests that there may be only 12 museum specimens. However, another effort may extract usable DNA from the 6 museum specimens that did not yield DNA for Culver, and doubtless some persons possess skulls or hides from panthers killed circa 1900 that could also be sampled after careful screening for authenticity.

Evidence for Local Genetic Adaptation

There is no evidence for genetic fixation of locally adaptive genes that help the Florida panther thrive in the south Florida landscape, or in the larger range of *P. c. coryi*. Furthermore, unless the selection pressure for a particular trait was very strong, it is unlikely that such genes would have become fixed in *P. c. coryi* during the brief time (less than 10,000 years) since pumas apparently recolonized North America (Culver 2000). However, demonstrating such adaptations is difficult, and the lack of evidence should not be taken as rebutting their existence. Locally adaptive genes may exist. Because maintenance of genetic patterns at all scales is a basic goal of conservation biology (Noss and Cooperrider 1994), it is prudent to assume such genes do exist, and management should strive to conserve these genes in the population through continued monitoring of introgression level in this population. We discuss the "threat of outbreeding depression" (Maehr 1998) below.

The Impact of Decreased Genetic Variability on Panther Fitness

Maehr (1997*b*, 89) argued that the panther was adapted to a long history of inbreeding, and that "while features such as cowlicks, crooked tails, and cryptorchidism are probably manifestations of inbreeding, these traits do not appear to have disrupted the demography of the panther." Maehr correctly makes a meaningful distinction between inbreeding (loss of genetic material due to random mating effects in small populations) and inbreeding depression (loss of fitness due to fixation or near-fixation of deleterious genetic variants). We also agree with Maehr that cowlicks and crooked tails are unlikely to reduce fitness of panthers. Nonetheless, there is substantial evidence that genetic impoverishment was having a negative impact on panther fitness prior to genetic restoration in 1995.

Roelke et al. (1993*a*) discussed 4 abnormalities prevalent in the pre-introgression panther population that may be related to low genetic variability, namely cryptorchidism, low sperm quality, atrial septal defect, and opportunistic infections. Each of the 4 traits has been shown to be genetically determined in some species, and pedigree analysis (Roelke et al. 1993*a*) suggests that cryptorchidism is related to the level of inbreeding in individual panthers.

Although all large felids have low sperm quality, motile sperm per ejaculate in the Florida panther is 18–38 times lower than in other puma populations (Roelke et al. 1993*a*). Panther sperm had a 40% prevalence of acrosomal abnormality, which renders sperm unable to fertilize the ovum. Prior to genetic restoration, panthers had a greater frequency of malformed spermatozoa (94.3% per ejaculate) than any other puma population (Roelke et al. 1993*a*).

Cryptorchidism occurred in 56% of male panthers examined during 1978–1992 (Roelke et al. 1993*a*) and 49% of 49 male panthers during 1972–2001 (Mansfield and Land 2002), compared to 3.9% in other puma populations (Barone et al. 1994). Since 1972, there was a statistically significant increase in the rates of cryptorchidism in the panther population (Roelke et al. 1993*a*, Mansfield and Land 2002). Two males captured in 1992 were bilaterally cryptorchid and thus sterile, and cryptorchidism was associated with documented matings of close relatives (Roelke et al. 1993*a*, Figure 7). None of the progeny resulting from genetic restoration efforts has been cryptorchid (Mansfield and Land 2002).

Roelke et al. (1993*a*) also reported that atrial septal defect (ASD) or, *patent foramen ovale*, apparently caused deaths of 2 panthers (ages 2 and 5 years) and that a third panther failed to survive surgery to correct an ASD and a defective tricuspid valve. The link between this defect and genetics is less clear than for the reproductive abnormalities; environmental contaminants could also play a role. Roelke et al. (1993*a*) did not report the rate of occurrence of heart defects in necropsied panthers, but did report that heart murmurs consistent with, but not diagnostic of, ASD occurred in 80% of Florida panthers compared to 4% of other pumas. More recently, Cunningham et al. (1999) reported an 18% prevalence of atrial septal defect in necropsied panthers. This suggests that the true prevalence of ASD may be only one-fourth of the prevalence suggested by heart murmurs, in which case only about 1% of non-*coryi* pumas have ASD. Thus, even if necropsied panthers are a non-random sample of the panther population, this 18% rate on necropsy strongly suggests a high rate of ASD in Florida panthers.

Finally, low genetic variability may increase susceptibility of pumas to infectious disease and parasites. Roelke et al. (1993*a,b*) reported that the pathogen and parasite load was relatively high in Florida panthers. At least 1 agent (*Pseudomonas aeruginosa*, which caused 1 panther death) is unexpected except in hosts with disarmed immune systems. Mark Cunningham (telephone conversation with SRT, 31 January 2003) also reported that fungal infections (“ringworm”) were common in Florida panthers but absent in Texas-Florida hybrids, perhaps due to compromised immune systems of Florida panthers. Rigorous analysis is needed to explore this anecdotal trend.

In downplaying the impact of genetic impoverishment, Maehr (1997*b*, 1998) and Maehr and Caddick (1995) admit that most of these defects probably do have a genetic basis, but argue that they may have minor impact on *individual* fitness, and negligible impact on *population* fitness. Most of the arguments relating to individual fitness are speculative and less plausible than the presumption that heart defects, infections, and reproductive abnormalities lower the fitness of individual panthers. For example, bilateral cryptorchidism reduces fitness of the victim to zero, and reduces the fitness of neighboring panthers to the extent that the sterile male competes with them for resources. It is somewhat more plausible to argue that genetic defects could have minimal impact at the *population* level. The argument requires that the panther population has sufficient demographic vigor to maintain itself near carrying capacity, and that demographic performance is not impaired due to the presence of genetically impoverished panthers. To support this argument, Maehr and Caddick (1995) estimated kitten survival rate at 84% to 87%, and present a plot of the numbers of known births versus known deaths by year (their Figure 1). However, neither of these two lines of evidence is scientifically rigorous (see Demography section of this report). Finally, Maehr (1998) attempted to dismiss the evidence that genetic impoverishment reduces individual fitness by accusing Roelke et al. (1993*a*) of "a selective and biased approach." No such bias was evident to the SRT.

The lack of any supporting evidence does not disprove the hypothesis that inbreeding has no impact on panther demography. However, conceptual chains of causation (from genetic impoverishment to genetic defects to individual fitness to population fitness) favor the alternative hypothesis that genetic impoverishment decreases population fitness. The SRT believes that this conceptual linkage, along with the documentation of defects linked to genetic impoverishment, justified the decision to embark on genetic restoration. If Maehr's hypothesis is incorrect and had been adopted, risk of extinction would have continued to increase. If Maehr's hypothesis is correct, genetic restoration, by causing loss of some local adaptations, will probably make a positive growth rate somewhat less positive. This disparity in the consequences of potential error further justifies the decision for introgression.

The only conclusive test of Maehr's hypothesis would have been to decide not to embark on genetic restoration, and then to carefully document population trend; this test was rendered moot by the release of Texas pumas into south Florida in March 1995. The next-best opportunity to test the alternative hypotheses is to compare demographic performance (survival and reproduction) of contemporaneous, sympatric Florida panthers and Florida-Texas hybrids. Careful collection and rigorous analysis of the appropriate data constitute the SRT's main recommendation on this issue.

Preliminary evidence supports the hypothesis that genetic impoverishment had reduced panther fitness and that genetic restoration is increasing fitness. In addition to dramatic decreases in prevalence of abnormalities, kitten survival rate is 72% for hybrids compared to 52% for pure Florida panthers (Shindle et al. 2001), and opportunistic ringworm infections seem to be nonexistent in hybrids but common in pure panthers. Another striking line of evidence for the superiority of hybrids was inadvertently provided by Maehr and Lacy (2002), whose Figure 2 depicts changes in numbers of deer and panthers during the last 20 years. The figure shows a sizable irruption of deer in the late 1990s, with the hybrid panther population rapidly responding by approximately doubling in size. The figure also depicts a more prolonged and 3-fold larger increase in deer numbers during the late 1980s that pure Florida panthers failed to exploit, despite Maehr's consistent position that the panther population was demographically vigorous and showing all the signs of a population tracking its carrying capacity during those years.

Recommendations.—The SRT strongly recommends that managers aggressively collect field data on vital rates (litter size, kitten survival, subadult survival, adult survival) and important phenotypic traits related to fitness (cryptorchidism, atrial septal defects, opportunistic infections, sperm defects, body condition) of hybrid and pure Florida panthers during the few years that these animals can be reliably identified by pedigree analysis, and before the pure Florida panther blood line ceases to exist. These results should be analyzed promptly and published in a rigorous, peer-reviewed venue. By 2003 it is already impossible to know the pedigree of many panthers, so data already collected or soon to be collected will be the best opportunity to have a simultaneous comparison of the 2 genetic lines. The availability of 50%, 25%, and 0% introgressed hybrids gives us a brief window of time in which to definitively determine how genetics influences individual traits and vital rates in an analysis not confounded by extraneous spatial or temporal factors. Even if reliable genetic markers are developed (as we recommend), within 10 years it is likely that few if any "pure-bred Florida panthers" will exist to serve as a strong comparison to hybrid animals.

We believe that this analysis will confirm the hypothesis that genetic impoverishment was compromising demographic performance of the panther population. We adamantly reject the idea that, in light of the undeniable fact that genetic introgression is a fait accompli, there is no point in collecting such data. For decades, many scientists have doubted whether genetics is relevant to in situ conservation (Lande 1988, Caro and Laurenson 1994, Soulé and Mills 1998, Caughley 1994, Nash 2001). The first poster child for the role of genetics, the cheetah, has lost some of its credibility (Laurenson et al. 1995). A recent excellent analysis of butterfly extinction (Saccheri et al. 1998) showed that genetics, while important, was less important to extinction than other factors, and the lessons of this study are arguably of limited relevance to the species and landscapes typically managed for conservation. The story of decline and recovery of prairie chickens (Westemeier et al. 1998) is more persuasive and does incorporate measures of pre-bottleneck diversity (Bouzat et al. 1998), but is based on comparisons of populations before and after introgression, without measuring the genetic variability or the demographic performance of inbred and outbred *individuals*, or controlling for effects of place and time. The Florida panther story promises to be the most dramatic and conclusive example of the relevance of genetics to conservation—or it could be a striking example of the futility of genetic management. Future decisions of great importance to conservation deserve to be informed by the results of the panther introgression experiment. It would be derelict in the extreme to forgo the opportunity to rigorously address this issue.

Apart from any monitoring to compare panthers based on hybrid status, the SRT strongly recommends continued monitoring to document the prevalence of traits that might indicate a resurgence of inbreeding depression. Increased prevalence of traits such as cryptorchidism or congenital heart defects should promptly trigger consideration of additional introgression.

Many of the types of data we request have been collected since the report of Roelke et al. (1993*a*), but have not been analyzed or published. Additional data should be collected. Samples of convenience should be discouraged in favor of rigorous sampling designs. For instance, necropsies of animals found dead may overestimate the prevalence of disease; pathology screening of randomly captured live animals may yield less-biased estimates of some prevalence rates. (However, some conditions, such as atrial septal defect, are hard to confirm in live animals, even using modern echocardiography [Cunningham et al. 1999]). Doubtless, tissue samples have been and continue to be collected and stored that will allow researchers to quantify genotypes of individual animals. Such data should be used to determine the relationship between individual genetic impoverishment and phenotypic defects.

The Introgression Program

In its final Environmental Assessment of the planned introgression program, USFWS (1994) assumed that high and increasing levels of sperm abnormality, cryptorchidism, congenital heart defects, and immune deficiencies were caused by increased prevalence of deleterious alleles, and cited these trends as indicating the need for a genetic restoration program. Relying on Seal (1992, 1994), the service also reasoned that hybridization historically had occurred between *P. c. coryi* and parapatric populations, of which only *P. c. stanleyana* is extant, with Texas being the closest area known to have potential donors. Accordingly, animals from Texas populations of *P. c. stanleyana* were selected for release into the existing south Florida population. The decisions to use wild-caught females of about 2–3 years of age as gene donors, and to release them in vacant panther territories, were intended to minimize social disruption and the risk of animals leaving the release sites. Appropriate selection criteria and veterinary procedures were used to decrease the risk of introducing unwanted genes or diseases into the Florida population. The goal was to mimic historic gene flow, and not to replace or swamp the *P. c. coryi* gene pool.

In 1991 the USFWS (Jordan 1991) had decided against a genetic restoration program. At that time the service argued that genetic restoration should not proceed until after experiments on captive animals to determine whether outcrossing would reduce abnormal traits and whether outbreeding depression would occur. Although these experiments had not been done, or even initiated, the need for experiments on captive animals was not mentioned in the 1994 Environmental Assessment. The intervening analyses by Seal (1992, 1994 [both included as enclosures to the 1994 Environmental Assessment]) and the report of Roelke et al. (1993*a*) apparently had persuaded managers that the situation was more urgent than previously thought. The 1994 environmental analysis did call for careful monitoring to prevent swamping of *coryi* genes, and asserted that in such an emergency "all translocated individuals and their progeny could be removed at any time" (USFWS 1994, 44). Even without the benefit of hindsight, in 1994 it should have been obvious that within 1 or 2 decades, Texas progeny would include most of the population, and removing them would be tantamount to extinction.

The murkiest aspect of the program is the target of 20% introgression of non-*coryi* genes to be achieved in 1 release of 8 females in 1995 followed by 1 female per generation thereafter. The SRT searched in vain for an early explanation for these numbers. USFWS (1994) cited a September 1994 workshop (Seal 1994), which cited an October 1992 workshop (Seal 1992) as the source of these numbers. Seal (1992), however, simply stated the 20% target without explanation and credited the basic idea to Seal (1991). The 1991 paper did not give a quantitative target, but concluded that "further analyses will be needed to determine the optimal amount and rate of genetic introgression" (Seal 1991, 18).

Phil Hedrick, who later (1995) published a justification for the 20% target, was not cited or listed as a participant for the workshops summarized by Seal (1991, 1992), nor was he mentioned in the Environmental Assessment for the genetic restoration program (USFWS 1994). The SRT finds it rather startling that the selection of the 20% target may not have been justified prior to its adoption. Hedrick was listed as a participant in the September 1994 workshop (Seal 1994), but by that time the 20% target was 2 years old.

Maehr (1998, 182) asked, "is [genetic introgression] appropriate at this time, and is the number (about 20% of the estimated population) of relocated animals necessary?" Although the SRT agrees that the target may not have been explained in a timely fashion, Hedrick provided rigorous and persuasive arguments that a 20% level of introgression has <20% risk of causing the loss of any locally adapted allele, could eliminate highly deleterious alleles, and would greatly reduce (but probably not eliminate) moderately deleterious alleles (Hedrick 1995). The bulk of the effect would occur via the 20% introgression in the first generation, with smaller marginal returns from introgression of 1 individual per generation after the first generation. Hedrick concluded that gene flow after the first generation may not be needed to eliminate deleterious alleles, because selection will continue to do the work in the absence of continued introgression. However, assumptions about the effective population size of panthers strongly affect the expected outcomes.

Maehr (1998) challenged Hedrick's analysis, asserting that "the assumptions upon which Hedrick built his model were products of earlier workshops that based their conclusions on antiquated data," specifically referring to kitten survival rates. Maehr's criticism is unfounded, in that Hedrick's analysis made no assumptions about survival rates or any other field data on panthers (other than effective population size, for which appropriate caveats are given). To the contrary, Hedrick's analysis hinged entirely on numbers of introduced animals, strength of natural selection, level of dominance among alleles, and whether alleles are neutral, adaptive, or deleterious.

A pedigree analysis suggested that, as of December 1999, an introgression level of about 18–22% had been achieved (Land and Lacy 2000). Four of 8 Texas pumas were still alive at that time, and 5 of the 8 pumas had produced at least 36 descendants, of which 25 were probably still alive. The 5 reproducing females were equivalent to about 3 effective founders due to unequal representation of the Texas females in the population's gene pool.

Maehr and Lacy (2002) questioned Land and Lacy's analysis, pointing out that the true level of introgression may be much higher than 22%. The SRT agrees that this issue is not settled, in part because true effective population size, which contributes the denominator to any calculation based on pedigree analysis, is not known, and may never be known with sufficient certainty to calculate the level of introgression. This difficulty arises because effective population size differs widely from census population size in a way that defies any simple correction factor based on a species' life history (Waples 2002). Recently, Kerry Murphy, Melanie Culver, and Phil Hedrick used extensive telemetry combined with genetic paternity analysis to estimate the N_e/N ratio for pumas in Yellowstone National Park as 0.315 (Culver, personal communication; Murphy 1998). However, even if research on other populations confirms the generality of this ratio for pumas, its utility depends on an accurate census population size, which is lacking for Florida panthers.

Recommendations.—The SRT strongly recommends the prompt development of genetic markers to monitor the level of introgression in the Florida panther population. The rapid expansion of the population since introgression is rapidly making pedigree analysis useless as a measure of the degree of hybridization, and new tools are needed. If geneticists can identify genetic markers unique to the 5 Texas females that contributed genes to the Florida panther population, these markers would provide an efficient and accurate means of monitoring the trajectory of introgression. Seal (1994) made a similar recommendation, and suggested that mitochondrial DNA or microsatellites might provide ideal markers. Warren Johnson and colleagues (abstract titled "Preliminary Results of Florida Panther Genetic Analyses," Mountain Lion Workshop, Jackson, Wyoming, May 2003) have genotyped 175 samples at 23 microsatellite loci for the purposes of developing such markers, but the success of this effort was not described in the abstract. The SRT understands that such results may be forthcoming by early 2004.

We also recommend consulting with conservation geneticists, such as Phil Hedrick or Melanie Culver, about whether to continue to introduce additional Texas pumas per generation, and if so, what the rate of future introgression should be.

Certainly, any future introductions should avoid the claim that "all translocated individuals and their progeny could be removed at any time" (USFWS 1994, 44). We believe that the 1995 restoration was justifiable, but it, and any future introgression, should be viewed as an irreversible experiment, with appropriate up-front analysis of likely impacts.

Risk of Outbreeding Depression

In its Environmental Assessment (USFWS 1994), USFWS considered outbreeding depression an implausible outcome of the restoration program, citing the fact that the program simply seeks to emulate natural gene flow between parapatric populations. The service further noted that "outbreeding depression would be unprecedented for a cross between such closely related and recently diverged mammalian populations as the Florida and Texas *F. concolor*" (USFWS 1994, 44). The SRT concurs with this assessment, which is buttressed by 2 lines of evidence that became available since 1994. First, a rigorous analysis (Hedrick 1995) suggests a low risk of outbreeding depression from a genetic restoration program of this magnitude. Second, Culver et al. (2000) suggest that pumas recolonized North America only during the last 10,000 years, and that all putative North American subspecies probably should be subsumed into a single subspecies. Thus the divergence of these populations is probably far more recent than would have been guessed in 1994.

Nonetheless, the "threat of outbreeding depression" (Maehr 1998) should not be dismissed out of hand. Because maintenance of genetic patterns at all scales is a basic goal of conservation biology (Noss and Cooperrider 1994), it is prudent to assume that locally adaptive genes do exist, and management should strive not to eliminate these genes from the population.

Recommendation.—We recommend that a panel of geneticists consider the need for introducing additional Texas puma in the future. Because the genetic restoration program has been so successful, the marginal benefit of additional gene flow may no longer outweigh the marginal risk of outbreeding depression.

The Importance of Genetic Management in the Big Picture of Panther Conservation

Maehr (1997*b*, 1998), and Maehr and Lacy (2002) imply that genetic restoration is diverting attention from more critical issues of conserving habitat for Florida panthers and expanding panther range beyond south Florida. For instance, Maehr and Lacy (2002, 976) stated that "genetic restoration will have been only a stop-gap measure…unless the population can be increased to much larger size than can be supported in the present [occupied] habitat" and deplore "the apparent abandonment or indefinite postponement of plans to reintroduce the panther to other parts of its former range." Similarly, Maehr et al. (2001, 293) asserted that the recovery program "now targets a single solution, genetic restoration."

The SRT concurs that habitat conservation, and establishment of panthers outside of south Florida, are the most important elements of panther recovery and we advocate increased vigor in attacking these issues (See Habitat Relations above). However, we feel that it is unhelpful to frame the problem as genetic restoration versus habitat conservation and expansion. We note that proponents of restoration explicitly made statements similar to Maehr's at the outset of the restoration program. For instance, Seal (1991, 3, 17) warned against "creation of a false sense of management accomplishment and a masking of underlying environmental difficulties" and explicitly listed "securing and enhancing the wild population" as the first priority for conservation—with genetic restoration third. Proponents of introgression, and all recovery documents for the panther, explicitly consider genetic restoration a necessary, but not sufficient, recovery action.

Summary – Genetics

- Florida panthers lost half or more of their genetic variation since the 1890–1920 period as a result of isolation and reduction of the panther population by human activity.

- Coinciding with this loss of genetic variation, panthers experienced increased prevalence of cryptorchidism, acrosomal sperm defects, and atrial septal defects, and possibly increased prevalence of opportunistic infections. The rate of cryptorchidism increased over the 30 years prior to genetic introgression. All of these traits are plausibly related to increased prevalence or fixation of deleterious alleles.

- Since introgression, rates of these defects have dramatically decreased, hybrids seem to have substantially higher kitten survival than pure Florida panthers, and the hybrid population seems to exhibit greater demographic vigor. Aggressive, focused data collection is needed to confirm or refute these suggested patterns, and to provide guidance for future use of genetic management in conservation.

- The levels of introgression achieved are likely to remove deleterious effects of inbreeding with little or no risk of outbreeding depression. The genetic restoration program seems to have been a success. It has been an undeniably helpful step, and probably a necessary condition, for panther recovery.

- Genetic restoration is not sufficient as a strategy to conserve panthers in Florida. Both proponents and skeptics of the introgression program agree that the panther cannot be considered recovered until it has a much larger geographic range, including range outside of south Florida.

- During the period of genetic introgression, there has been little progress in implementing the 4 main steps to reintroduction recommended by Jordan (1994, each with target dates between August 1994 and February 1996). However, this lack of political will may be unrelated to any diversion of attention due to introgression efforts. We do not think it is helpful to argue that

USFWS and FWC have used the introgression program as an excuse to ignore the pressing need to expand the geographic range of the panther.

- At the time USFWS and FWC made the formal decision to embark on the introgression program, there was no justification for the target of 20% introgression. Hedrick (1995) provided strong justification after the fact.

- It is not clear whether the plan to continue (after the 1995 introgression via 8 female Texas pumas) to introduce 1 non-*coryi* individual per generation is needed. Because of the apparent success of the genetic restoration program, the marginal benefit of additional gene flow may no longer outweigh the marginal risk of outbreeding depression.

- Panthers in Everglades National Park function as a semi-isolated population that may occasionally require assisted dispersal (translocation of dispersal-aged animals) to maintain demographic and genetic viability.

Recommendations – Genetics

1. Aggressively collect, analyze, and publish data on vital rates (litter size, kitten survival, subadult survival, adult survival) and important phenotypic traits related to fitness (cryptorchidism, atrial septal defects, opportunistic infections, sperm defects, body condition) of hybrid and pure Florida panthers. Within a few years, it will be increasingly difficult to sort out the blood lines, and the data from 1995 to about 2004 will be the best opportunity to compare hybrid and pure Florida genetic lines at the same point in time. Such comparisons are needed to assess the success of the introgression program.

2. The importance of the above recommendation transcends the Florida panther. The management of Florida panther genetics will probably become the textbook example of the practical impact of genetic management for wild populations. This story is more relevant to conservation than the butterfly example of Saccheri et al. (1998), and has the potential to be better documented than the prairie-chicken example of Westemeier et al. 1998) or the controversial cheetah story (Caro and Laurenson 1994, Laurenson et al. 1995). Conservation science desperately needs, and

currently lacks, a well-documented, persuasive case study of the practical application of genetics in conservation of an endangered animal. This has the potential to be that example.

3. Apart from any monitoring to compare panthers based on hybrid status, continue monitoring the prevalence of traits that might indicate a resurgence of inbreeding depression. Increases in traits such as cryptorchidism or congenital heart defects should promptly trigger consideration of additional introgression.

4. Provide a rigorous estimate of the level of introgression achieved, including a range of plausible values, with an explicit discussion of the assumptions used in the calculations. Pedigree analysis is no longer useful as a measure of introgression (because Texas/Florida ancestry of panthers cannot be tracked with confidence and because total population size is unknown), and should be replaced with new genetic markers, probably based on mitochondrial or microsatellite DNA. Such markers will open the door to sophisticated analyses of the correlation between panther fitness and the degree of hybridization of individual animals.

5. Determine the statistical significance of the historical changes in microsatellite variation of *P. c. coryi* reported by Culver et al. (2000) to confirm the recentness of genetic erosion. Conduct additional analyses using a larger sample of modern and "ancient" samples and a larger set of markers, to address the temporal trends in genetic diversity, and to serve as a baseline for comparison to the genetics of post-introgression panthers.

6. Convene a small panel of conservation geneticists to evaluate the desired level of future introgression of non-*coryi* genes into Florida.

7. Because panthers in ENP are partially isolated by Shark River Slough, translocations should be considered whenever all breeding-age panthers are of the same sex for over a year, unless contraindicated by other factors. In most cases, release of only 1–2 animals of the limiting sex should be sufficient. The translocated animal could be from as far away as Texas, New Mexico, Wyoming, or Idaho if no dispersal-aged Florida animal is available.

DEMOGRAPHY

Our discussion about panther demography is organized by the demographic parameters or relationships that are fundamental to understanding and predicting panther dynamics. We especially focus on those areas where information is critical to managers in enabling the assessment of likely population outcomes under alternative recovery scenarios. We also discuss efforts to date directed toward viability modeling (PVA). For each parameter, factor, or approach, we view the results as "reliable" if the data, analyses, models, or assumptions are capable of supporting inferences about panther demography. We describe situations where the information is not reliable, for instance because data were inappropriately collected or analyzed, or functional relationships or assumptions are not supported. We make recommendations for each for improving the reliability of demographic information, particularly as regards applications to conservation decision-making.

We summarize what is known about each demographic parameter or functional relationship in relation to the study area, key citations, and methods used (Table 1). A more detailed commentary on each paper can be found in the annotated bibliography. Many of these studies dealt with more than one demographic parameter or issue; indeed, in some cases demography was not the main focus of the paper. Because the actual number of studies (versus papers) is relatively small, we have included all studies that related (directly or indirectly) to demography. We discuss the relative strengths and weaknesses of inferences from each study for each demographic parameter.

Abundance and Density

To our knowledge there are no reliable estimates of Florida panther abundance or density. This lack is perhaps unsurprising given the secretive nature of the species, which tends to render impracticable methods based on visual detection (e.g., direct counts, distance sampling), and the difficulty and expense of applying methods dependent on capture-recapture (Williams et al. 2002). To our knowledge, there has never been a statistically designed, range-wide sampling effort to estimate panther numbers. Range-wide estimates instead have depended on accumulating estimates from local studies, usually over non-overlapping time intervals, which by definition render such estimates suspect (Table 1). For example, "current verifiable population size" as reported in McBride (2000, 2001) consists of cumulative counts of radio-collared cats and sightings of uncollared cats over the various study areas in south Florida. However, it is not known over what period these observations were gathered, or whether some of cats counted therein have meanwhile exited the population via mortality (a possibility acknowledged by McBride 2001).

Table 1. Estimates of demographic parameters for Florida panthers.

Demographic parameter or relationship	Component	Mean or Mode (range)	Study area	Period	References	Methods used/comments
Abundance/density		D = 1/110 km^2 N = 46	South Florida ("core area")	1985–1990	Maehr et al. (1991*a*)	Estimate for "core area" based on radio telemetry
		N = 62	South Florida	2000	McBride (2000)	Cumulative counts of radio-collared panthers
		N=78	South Florida	2001	McBride (2001)	Cumulative counts of radio-collared panthers
Population growth		$\lambda > 1$	South Florida	10 years	Maehr and Caddick (1995)	Plots of "known births vs. known deaths"
		$\lambda > 1$	South Florida	1981–2001	McBride (2000, 2001)	Capture rates, counts of newly collared cats
Dispersal distance	Juvenile males	58.7 km (22–100)	South Florida	1986–2000	Maehr et al. (1991*a*)	Radio telemetry of juveniles
	Juvenile males	68.4 km	South Florida	1986–2000	Maehr et al. (2002*a*)	Radio telemetry of juveniles
	Juvenile females	20.3 km	South Florida	1986–2000	Maehr et al. (2002*a*)	Radio telemetry of juveniles
Home range size	All ages/sexes	(53–1183 km^2)	South Florida ("core area")	1985–1990	Maehr et al. (1991*a*)	Estimate for "core area" based on radio telemetry
	Resident males	519	South Florida ("core area")	1985–1990	Maehr et al. (1991*a*)	
	Resident females	103	South Florida ("core area")	1985–1990	Maehr et al. (1991*a*)	
Reproduction	Litter sizes	1.8 (1–4)	SW Florida	1993–1994	Land (1994*b*)	Litter counts of radio-marked females; probably biased low
		Mode =1 (1–3)	SW Florida	1995–2001	Shindle et al. (2001)	Radio telemetry
	Age at first reproduction	10.5 months–2 years	BCNP	1986–1987	Maehr et al. (1989*a*)	Radio telemetry from 9 to 26 months with litter (inferred that conception occurred at <20 months)
Survival	All ages	0.83 (0.69–1.00)	SW Florida	1987–1990	Maehr et al. (1991*b*)	Telemetry; Heisey-Fuller estimates (not stratified by age-sex)
		Frequency distribution of ages at death; no survivorship estimates computed)	SW Florida	1995–2001	Shindle et al. (2001)	Ages at death; evidently includes both radio collared and found, uncollared cats; concern here for discovery bias

Table 1. Continued.

Demographic parameter or relationship	Component	Mean or Mode (range)	Study area	Period	References	Methods used/comments
Survival (continued)	Kitten	0.959	SW Florida	1993–1994	Land (1994*b*)	Revisits to dens/litter counts (0–6 months); mixture of ages, biased
		0.84	South Florida	10 years (dates not specified)	Maehr and Caddick (1995)	Plots of "known births vs. known deaths"
	Birth to 6 months	0.62	SW Florida	1995–2001	Shindle et al. (2001)	Revisits to dens/ litter counts (0–6 months); mixture of ages, biased
	Juvenile	0.975	SW Florida	1995–2001	Shindle et al. (2001)	Telemetry; not adjusted for exposure days; includes Texas cougars; not clear if this is an annual or a periodic rate
	Juvenile	0.933	SW Florida	1993–1994	Land (1994*b*)	Radiotelemetry (6 months to 1 year)
Cause-specific mortality	All ages, sexes	Deaths listed by cause	SW Florida	1987–1990	Maehr et al. (1991*b*), Shindle et al. (2001, Appendix VII)	Telemetry; crude mortality estimates include non-radioed cats so biased toward auto collisions
	All ages	Rates not estimated	SW Florida	1988–1989	Maehr (1989)	Documentation of road kills of uncollared cats
		Listed percent of deaths by cause, rates not estimated	SW Florida	1995–2001	Shindle et al. (2001)	Radio telemetry
		Rates not estimated	South Florida	1978–1999	Taylor et al. (2002)	Carcass examination of collared and uncollared cats
Carrying capacity	All ages, sexes	Not directly estima -ted, inferred from home ranges and habitat preference	South Florida	1985–1990	Maehr et al. (1991*a*)	Radio telemetry; serious methodological questions about home range and habitat inferences

Table 1. Continued.

Demographic parameter or relationship	Component	Mean or Mode (range)	Study area	Period	References	Methods used/comments
Carrying capacity	All ages, sexes	Not directly estimated, inferred from home ranges, “frustrated dispersals”; authors conclude population was at carry capacity prior to Texas introductions	South Florida	1986–2000	Maehr et al. (2002*a*)	Radio telemetry; serious methodological questions about home range and habitat inferences
Functional relationship	Density-dependent dispersal	Positive relationship to density	South Florida	1986–2000	Maehr et al. (2002*a*)	Radio telemetry of juveniles
	Genetic introgression	20%	SW Florida	1995–2001	Shindle et al. (2001)	Extrapolation based on apparent reduction in kinked tails and cowlicks
Viability analysis	Probability of persistence over 100 years	0 to 1 (mode = 1) depending on assumptions	Florida	1999	Ellis et al. (1999), Maehr et al. (2002*b*)	VORTEX simulations
Reintroduction	Reintroduction (likelihood of success)	No formal estimates; success “likely” depending on assumptions and protocols	Florida	1991–1996	Jordan (1991, 1994), Belden and Hagedorn (1993), Belden and McCown (1996)	Review of candidate release sites; experimental releases of cougars

Although the estimate of Maehr et al. (1991*a*) of 1 panther/110 km^2 (Table 1), based on radio-telemetry observations, lacks a confidence interval or statistical underpinnings, it appears to be a reasonable approximation of panther density in the "core area" (as defined by Maehr et al. 1991*a*). However, this estimate cannot be extrapolated to other areas because it is not known whether densities elsewhere are the same as in the core area.

As far as the SRT can determine, the estimate by Maehr et al. (1991*a*) is the only reasonably rigorous estimate of the density of the panther population in south Florida. Nonetheless, the SRT does not believe that producing a rigorous estimate of population size (*N*) should necessarily be a high priority. One argument for a rigorous estimate of *N* is that assessing the level of genetic introgression depends critically on *N*, which forms the denominator of estimates based on pedigree. With no estimate of *N*, critics of introgression can argue that introgression may be as high as 45% (Maehr and Lacy 2002). Because introgression is now a fait accompli, this need may be less pressing. Genetic markers may provide a direct measure of introgression that does not depend on population size (see section on genetics).

There are two reasons that an estimate of *N* may not be needed. First, seat-of-the-pants estimates (minimum number known alive, new animals encountered per 10 days of capture effort, expansion and contraction of occupied range) are sufficient to persuade most reasonable observers that *N* was probably stable or slowly fluctuating below 70 animals during 1980–1995, and has grown rapidly since 1995. Second, estimates of per-capita age-specific fecundity and survival rates may provide a useful index of population status at much less expense than estimating *N*.

If reliable estimates of population size or density are deemed important, these must be based on a rigorous sampling design, collection of appropriate field data, and valid statistical analyses (Williams et al. 2002). For panthers, logistical considerations probably rule out methods based on direct counts, distance estimation, or conventional mark-recapture, the latter because recaptures are relatively infrequent. However, mark-recapture methods employing camera "trapping," analysis of DNA from hair samples, and other novel approaches could be used, together with conventional recaptures (physical and via radio telemetry). Such methods, if employed, should be based on a rigorous statistical sampling design and appropriate estimation models.

Population Growth Rates

Although, as noted above, reliable estimates of abundance are unavailable, the general trend in abundance appears to be fairly well-established. However, in the absence of either quantitative estimates of relative abundance or reliable projections from demographic estimates (below), more quantitative statements about rates of growth cannot be made. In particular, no reliable estimates of variability in λ are available; these estimates are essential components of PVA (see below).

The SRT cautions against the interpretation of graphical presentations of raw numbers of kittens produced compared to deaths of radio-tagged animals as indices to population growth, such as Shindle et al. (2001, Figure 4) and Maehr and Caddick (1995, Figure 1). First, it is not clear that these numbers relate to a common population base; they cannot, therefore, be interpreted as per-capita rates, nor for inferring growth rates. Second, these data are uncorrected for incomplete and heterogeneous detection in both data sources. Thus, the position of points in such a plot largely reflects researchers' ability to detect births and deaths, and may not be used to infer birth and death *rates* needed to calculate whether population growth rate is positive or negative. Such figures were misinterpreted by Maehr and Caddick (1995) as indicating a "positive growth rate"; this is an inappropriate analysis of population dynamics. Calculation of growth rate requires per-capita vital rates, which are not depicted in figures like these.

It is important to note that the entire body of evidence for demographic vigor of Florida panthers prior to genetic restoration hinges on this misinterpretation of Figure 1 of Maehr and Caddick (1995), plus their assertion that kitten survival rate exceeded 80% (discussed below). All subsequent arguments (Maehr 1998, Maehr and Lacy 2002) repeat and often overstate the 2 central claims of this paper, but offer no new supporting data or analysis.

Population Range and Dispersal

Much basic information exists, much of it highly relevant to management, regarding the historical and current distribution of panthers, and patterns of (and barriers to) dispersal (e.g., Belden 1989, Maehr et al. 2002*a*). Panther dispersal tends to be frustrated due to existing natural barriers (oceans and other large water bodies) and anthropogenic barriers (freeways, urban areas, large expanses of row crops and improved pasture). Recruitment of male dispersers into the breeding population is further frustrated by a lack of female panthers in areas north of the Caloosahatchee. Dispersing male panthers are able to find tenuous habitat linkages across the Caloosahatchee River, and dispersal to that region would doubtless be enhanced by habitat restoration. The study of panther dispersal (Maehr et al. 2002*a*) is one of a small handful of papers to provide meaningful insight into dispersal dynamics of *Puma concolor*.

There appears little doubt that panthers suffer from a highly constricted range relative to their historical distribution, and that significant natural and anthropogenic barriers exist to dispersal, range expansion, and, ultimately, population growth. Further research should focus on assessing specific factors that constrain or enhance dispersal, and in quantifying the uncertainty in the relative importance of these factors, particularly those potentially under management control.

Reproductive Rates

Although reliable per capita estimates of reproduction are generally not available for panthers, some aspects of panther recruitment are reasonably well-documented. Litter sizes range from 1 to 4 kittens, with modal values of 1–2 (Shindle et al. 2001, Land 1994*b*). However, there is no published frequency distribution of litter sizes for use in PVA. Shindle et al. (2001, Appendix IV) listed over 75 panther litters. Although this list does not indicate how long after birth the litters were handled, there may be sufficient data in FWC files to estimate litter size at birth, and variation in this parameter. Alternatively, estimates from closely related populations could be used to supplement this information. The work of Culver et al. (2000) suggests that pumas from Texas, Idaho, Wyoming, and New Mexico all have similar genetic distance with respect to the Florida population; intensive demographic studies have recently been completed in each of these states.

Panthers can reproduce before 2 years of age (e.g., Maehr et al. 1989*a*). It also appears that density, habitat conditions, and other factors may raise or lower this age. However, because only a few panthers have been monitored from birth to reproduction, there is no frequency distribution for first reproduction ages, nor is it clear how factors such as habitat influence this age. Because this parameter can be critical to population projection and PVA, reliable information on the range in values, and factors responsible for variation in the parameter, is important. Again, in the absence of adequate data for panthers, a frequency distribution for first age at reproduction could be inferred from data on closely related cougars.

Estimates are lacking on 2 other rates related to reproduction, namely percent of adult females breeding and inter-birth intervals. These rates are critically important in assessing population performance, and their absence precludes meaningful population projection and viability analysis. The SRT believes that appropriate data to estimate these rates exist from the last 2 decades of field research.

The SRT recommends that existing data be used to estimate frequency distributions for litter sizes and ages at first reproduction, percent of females breeding, and inter-birth interval. Suitable data to estimate these quantities may not exist; therefore, direct estimation of reproductive recruitment (e.g., via Jolly-Seber or other approaches [Williams et al. 2002]) should be considered. Where empirical estimates are impracticable, frequency distributions for these rates should be approximated from closely related populations. Finally, reproduction and its components are intrinsically variable, and emphasis must be placed on estimates of this variability and in separating statistical uncertainty from demographic and environmental variability in reproductive rates.

Survival Rates

No existing paper has published, nor has any PVA used reliable estimates of stage-specific survival rates for panthers, despite the fact that appropriate data exist from which to make such calculations (Maehr et al. 1991*b*, Land 1994*b*, Shindle et al. 2001). The estimate of 84% to 87% kitten survival (Maehr and Caddick 1995) is indefensible for several reasons. First, this estimate is described in 4 sentences within a 3-page editorial note that presented no underlying data, and thus is not scientifically supported. Moreover, it is higher than the 82% estimate for Florida panthers of all ages, mostly adults (Maehr et al. 1991*b*). It would be unprecedented in studies of vertebrates for the survival rate of juveniles to exceed adult survival rate. Finally, this estimate is contradicted by a more recent estimate of 52% for pure Florida panther kittens (Shindle et al. 2001, whose report included underlying data). Use of the Maehr and Caddick (1995) estimate of kitten survival in PVA cannot be supported.

Similarly, the age distribution of animals at death (e.g., Shindle et al. 2001, Figure 7) reflects survival rates only under restrictive assumptions about population growth rate and stability of age distribution over time (Williams et al. 2002, 337–342). Because such graphs tempt readers to naïve and probably incorrect estimates of survival rates, they should not be displayed in annual reports. Survival rates should be recalculated on basis of exposure days and actual age at the start of monitoring for each sex-age class (Williams et al. 2002, 343ff).

The SRT strongly recommends that survival and other vital rates be estimated rigorously, using approaches that are not highly dependent on an accurate estimate of the baseline population size. For example, radio-telemetry or mark-recapture estimates of survival, where the data are gathered under a rigorous sampling design, are far preferable to ratios based on crude mortality numbers divided by population estimates (Williams et al. 2002). Even if the mortality numbers are reliable (and they frequently are not), such estimates are highly sensitive to errors in the estimation of population size. In addition to these estimates, statistical comparisons, using data starting in 1995, should be made between the survival rates of progeny of released Texas pumas and pure Florida panthers.

Cause-specific Mortality

Although a list of lethal agents has been accumulated, it is for the most part impossible to assess these in terms of their relative demographic importance. This is so because many of these agents were discovered by post-mortem analysis of a small sample of panthers; in turn, many of these were discovered because of the nature of the mortality (e.g., road kill, Maehr et al. 1991*b*) or other non-random method of sampling. Because of these difficulties, currently available analyses cannot be used either to support or refute the importance of road mortality to panthers. Maehr et al. (1991*b*; N = 8 mortalities of radio-tagged panthers) and Shindle et al. (2001, Appendix VII; N = 59 mortalities of radio-tagged panthers) provide useful breakdowns on causes of mortality that are free of such bias, and suggest that vehicles cause 12% to 22% of panther deaths.

Even with radio telemetry, the cause of death is often ambiguous because of rapid deterioration of specimens if not discovered immediately, leaving post-mortem examination capable of determining only those causes leaving obvious physical evidence. For example, 22% of the mortalities of radio-tagged panthers reported by Shindle et al. (2001, Appendix VII) were of "unknown" causes—identical to the percentage of verified road-kills. Nonetheless, data available through telemetry (Shindle et al. 2001, Taylor et al. 2002) provide excellent information on cause-specific mortality. Statistical analyses must properly deal with nuances of telemetry or other data structures (e.g., staggered entry; censoring; and multiple, competing mortality risks). These data should be reanalyzed on the basis of exposure days to calculate annual cause-specific rates, which could then be used to analyze the population impact of various alternative scenarios of habitat management, reintroduction, or other intervention.

The SRT strongly recommends that existing data on radio-tagged panthers be properly analyzed to obtain cause-specific mortality (and, where possible, seasonal changes in these rates, differences among age-sex classes, etc.). Conclusions about cause-specific mortality based on samples of convenience should be avoided because such samples are biased with respect to probability of detection. This analysis is especially important given increasing road kill during the current population expansion.

Carrying Capacity

Carrying capacity is critically important to demography, extremely difficult to quantify, and likely varies over space and time. Assumptions about carrying capacity have great impact on population projections and PVA (see below), and it is essential that estimates of carrying capacity are based on the best possible biological information. Although there likely are behavioral, physiological, and other feedback mechanisms that limit panther population growth given infinite resources, most notions of carrying capacity for panther and other carnivores are linked to acres of habitat and biomass of prey. Thus, discussion of these topics earlier in this report is highly relevant to demography. To select but 1 example: differing assertions about the quality of habitats (some currently occupied by panthers and some not) potentially result in orders of magnitude difference in carrying capacity, both within the "core range" (Maehr et al. 1991*a*), as well as in portions of the former range into which panthers may either expand or be reintroduced.

The SRT recognizes that, without exorbitant effort, in practice it may be difficult or impossible to empirically estimate carrying capacity. We suggest, therefore, that population models of panther demography take into account uncertainty in this parameter, and err on the side of caution by including conservative estimates in demographic projections. On the other hand, information from prey densities, habitat quality, and panther energetics and behavior can be used to provide relative, if not absolute, measures of this parameter.

Functional Relationships

Little seems to be known about key functional relationships among demographic parameters, such as density dependence or inbreeding effects on demographic parameters. Assumptions about these relationships are in turn critically important in predicting demographic response under alternative conservation strategies. For instance, even assuming that there is a functional relationship between density and reproductive rates, the functional form and parameter values of that relationship are likely to be imperfectly known, if they are known at all. Thus, we could have a monotonically negative density relationship or an Allee effect (i.e., changing direction at very low density); in either case there are many choices for the function's shape. In turn, the results of population projections and PVA are highly sensitive to alternative functional forms (Runge and Johnson 2002). Unfortunately, canned programs such as VORTEX, RAMAS, etc. tend to gloss over this issue, typically providing either default (assumed) function forms and parameter values, a limited range of alternative functions, or both.

The SRT recommends research to investigate, and where possible to statistically estimate, critical functional relationships in panther demography. These would include estimating the effects of density and inbreeding on reproduction and survival rates. Given that such studies may be infeasible, the SRT recommends that the impacts of alternative functional relationships be thoroughly explored, via sensitivity analysis and simulation studies. PVA and other modeling exercises must take into account uncertainty in these relationships. The results of empirical, sensitivity, and simulation studies must be incorporated into viability analyses, particularly when these are part of decision making.

Population Projection and Viability Modeling

At least 3 “population viability analyses” (PVA) have been conducted for panthers, although these have not been independent, being based on overlapping data and many assumptions in common. The only major, published attempt to date to synthesize the panther demographic data and project viability was the result of a workshop involving agency biologists and university consultants (Ellis et al. 1999, Maehr et al. 2002*b*). In the workshop, analyses were conducted based on a range of data and expert opinions among 2 agency biologists, 2 university ecologists, and a population ecologist who was one of the developers of the computer model used, VORTEX (Lacy et al. 1995). Based on input estimates and assumptions, a “consensus” model emerged that predicted high (virtually 100%) probability of persistence for 100 years, although some individual estimates and assumptions resulted in the opposite conclusion (100% probability of extinction by 100 years). Leaving aside the unreasonable assumption of certainty about intrinsically uncertain events, parameter values used in these projections varied widely among experts, and in the degree to which the values were supported by data (survival rates seemed to be guesses or, if empirical, based on very small samples). Critical assumptions about functional form (e.g., density dependence, inbreeding effects) seem to have been based on model defaults, with little examination of credible alternatives. For instance, only the model developer initially invoked an assumption of inbreeding depression (using the model default for this), but this factor was deemed as important in the “consensus” model.

Modeling for conservation must always balance realism (dictating the incorporation of biological detail) with the need for models to be understandable, and capable of parameterization using field data (Conroy et al.

1995, Williams et al. 2002). Modeling for panthers must focus on issues that are relevant to panther life history, incorporating data-based estimates of parameters where available, information from congeners or informed opinion when not, and in both cases fully exploring the implications of uncertainty in these relationships via sensitivity analyses and statistical modeling (Burnham and Anderson 2002, Williams et al. 2002). On the other hand, models should not require the user to specify life history details that are unknown (or that cannot be addressed via sensitivity analysis). In particular, models that require a large number of arbitrary rules for behavior (as do some of the spatially explicit population models [Conroy et al. 1995]) or otherwise force a large number of arbitrary (and often critical) assumptions (as in VORTEX and RAMAS) should be avoided. Models should be built around a core of solid information about the species, which necessarily dictates models with relatively few parameters and simple structure. Again, however, uncertainty in model parameters and functional relationships *must* be taken into account via sensitivity analysis, regardless of the simplicity or complexity of the modeling approach.

Sensitivity analysis conducted by Maehr et al. (2002*b*) suggested that neither habitat trend nor continued genetic augmentation, nor interactions between them, influenced extinction risk. Unfortunately, they did not conduct sensitivity analysis for the largest changes in their model parameters compared to previous panther PVA, namely changing kitten survival from 0.50 to 0.80, changing carrying capacity K from 50 breeders to 70 breeders, and changing starting population size from 50 breeders to 60 breeders. Clearly, some combination of these changes caused extinction risk to plummet from 100% to about 0%. Understanding the sensitivity to these parameter changes is more important than the change in point estimate of extinction risk. Ellis et al. (1999, 65) summarize some sensitivity analysis related to kitten survival. In these, first-year survival rates from 0.4 to 0.8 were explored. These results suggest that kitten survival of less than 0.6 lead to negative growth rates and rapid extinction. Because uncertainty in this range is well within that expected either due to sampling variation alone, or to sampling variation in combination with demographic and environmental stochasticity, the SRT finds use of a point value of 0.8 in these PVAs unsupportable.

Although VORTEX and other canned procedures can reveal sensitivity to some parameter estimates, they are opaque on many other issues, especially those related to functional relationships. For instance, once the user is forced to select a mating system, the “polygynous” choice for panthers renders males demographically irrelevant. Clearly, this is an unrealistic oversimplification, but its impacts cannot be explored, except by comparing outputs to results using the even less-realistic “monogamous” choice. Similarly, the user can choose only among 2 or 3 caricatures of density-dependent relationships, and cannot gain a nuanced appreciation of how these important functional relationships influence extinction risk. The SRT recommends that any future PVA models should be built from scratch and explicitly consider parameter uncertainty, variation (demographic, environmental) in parameters, and uncertainty in key functional relationships such as density dependence and the effects of inbreeding.

The SRT also recommends that, to the extent possible, rigorous estimates of reproduction rates, survival rates, and variation in these rates, be incorporated into future PVA. Clearly, this calls for a re-analysis of data along the lines discussed earlier, particularly to adequately estimate age- and sex-specific survival rates and per-capita reproduction rates. The SRT also recommends that sensitivity analyses, first in the context of a simple stage-projection matrix or a stochastic PVA be conducted to examine variation in λ in response to ranges of values for key demographic factors, particularly those subject to great uncertainty (e.g., kitten survival rates, assumed inter-birth intervals). Sensitivity analyses should be extended to allow comparison of alternative recovery actions. For instance, proposed actions (e.g., highway underpasses) have presumed impacts (reduction of deaths from collisions). What do models predict about the impacts of the anticipated reduction in mortality on λ? Do differing assumptions about the modeled growth influence these predictions? Such an approach might allow a more quantitative assessment of the impact of highway mortality on panther. It should also allow managers to assess the relative value and cost effectiveness of management actions to reduce highway mortalities, compared with other possible actions (e.g., providing habitat connectivity north of the Caloosahatchee, a re-introduction in Arkansas, or other possible actions) that compete for dollars and attention. Thus, sensitivity analyses should be used not only to predict overall extinction risk, but more importantly to analyze alternative recovery actions, especially where these analyses may suggest a change in recommended management activities. Only after these basic sensitivity analyses are completely evaluated should more complex models be considered.

Ideally, model structure should incorporate alternative hypotheses about demographic response, including age structure and density dependence (including Allee effects). To the extent possible all parameters and functional relationships should be based on appropriate analysis of field data that takes into account both random errors (due to sampling) as well as systematic biases induced by flaws in design or data collection. Gould and Nichols (1998) discuss removal of sampling error from empirical data to estimate temporal variation. Where possible, data should be analyzed under alternative biological models, and measures of model uncertainty calculated for each. Where data are not available, ranges (or distributions) of parameter values should be based on studies from conspecifics. Population projections, viability analyses, and decisions based on these models, data, and assumptions must fully incorporate the range of uncertainty in each of these elements. Bayesian approaches, in which existing knowledge (including both statistical estimates and expert opinion) is incorporated in prior distributions, subject to updating as additional data become available, may be an ideal approach for integrating the various component of uncertainty.

The SRT discourages "consensus" approaches to input values for population modeling. These lead to a false sense of reliability, particularly if "consensus" was reached by force of argument, rather than weight of evidence. Rather, the data and opinions should be used as prior estimates (appropriately weighted) in a Bayesian or other approach. In general, there is a serious need to take into account the various sources of uncertainty in these projections, among them uncertainty in the input values and assumptions. Management alternatives could then be evaluated considering all these sources of uncertainty. This approach could also be used to evaluate the potential value (to decision making) of reducing various sources of uncertainty, for example, by further research or improved estimates.

Experimental Releases and Impact of Reintroductions

The success of experimental releases of Texas cougars into north Florida (Jordan 1991, 1994; Belden and Hagedorn 1993; Belden and McCown 1996) strongly suggest that reintroduction of panthers to vacant parts of historic range is biologically feasible. In addition, deliberate genetic introgression from cougars into the extant panther population appears to have dramatically stimulated population growth and reduced the prevalence of cats with characteristic signs of inbreeding depression (Shindle et al. 2001).

Experience with experimental releases (Belden and Hagedorn 1993, Belden and McCown 1996) suggests advantages and disadvantages of various combinations of the source (captive reared versus wild) and age-sex composition of the release stock. For instance, captive-raised animals seem to establish home ranges more quickly than wild-caught animals, but also are more likely to be involved in encounters with humans. Thus, reintroduction schemes might need to balance the advantages of more rapid establishment, with the disadvantage of more negative encounters with humans. A proposed, minimum release of 10 cats (likely more, depending on age-sex composition and source) seems reasonable, and takes into account the likelihood of both natural and human-induced mortality, including some deliberate persecution.

The optimal combination of wild versus captive-reared releases seems unknown, although it is reasonable to conjecture that releases of wild females are more critical than are those of males. In addition, the optimal sequence of release is unknown, but intelligent predictions can be made under alternate scenarios (e.g., releases of wild-caught males followed by several females into each male range; versus release of several females followed by a single, captive-reared male who would be removed once he had bred all the females; Belden and McCown 1996). While these "rules of thumb" may represent the best current information, it is important that the assumptions upon which these rules are based are subjected to testing. To that end, the SRT recommends that current information about the impacts of reintroduction and introgression, based on experimental releases to date, be summarized in the form of predictions (in conjunction with PVA; see above) as the basis for discriminating among alternative reintroduction schemes (numbers, composition, timing, location, etc.). When one or more alternative is selected, monitoring data should be collected so as to test these predictions, for example in an adaptive management framework (Walters 1986, Williams et al. 2002).

Finally, the SRT notes that south central Florida north of the Caloosahatchee River is part of the current geographic range of the panther, as evidenced by the regular occurrence of male panthers there. Thus, relocating panthers from south Florida into this area should not be considered reintroduction per se, but rather a within-range translocation. The distinction between "reintroduction" and "translocation" is of more than mere semantic importance, given the sensitivity of the reintroduction issue.

Summary – Demography

We reviewed studies that have dealt with the assessment of demographic parameters for Florida panther. We find that some aspects of panther demography are reasonably well understood. General patterns of population growth and dispersal, and certain components of reproduction, such as litter size and age at first reproduction, are fairly well known. Data are poor or do not exist for other components, such as interbirth interval and proportion of females reproducing. Data exist with which to estimate survival rates for kitten and adult panthers, but much of this data has not been properly analyzed, so that statistically defensible estimates of survival rates are not available. Likewise, much of the data on cause-specific mortality is inherently biased (e.g., based on incidental reports of highway mortality), but data exist (e.g., from radio telemetry) that has yet to be properly analyzed based on exposure-days to yield annual rates of cause-specific mortality. Population modeling (e.g., PVA) has principally employed "black box" models such as VORTEX and RAMAS that require unrealistically detailed demographic information and unverifiable (but critical) assumptions. Application of these models has emphasized "consensus" approaches that tend to obfuscate important uncertainties in demography.

Recommendations – Demography

The SRT makes the following specific recommendations regarding demography of Florida panthers.

1. Quantitatively assess factors that constrain or enhance dispersal. Quantify uncertainty in the importance of dispersal as a factor limiting panther populations.

2. Develop reliable estimates of per-capita reproduction rate and of critical components of recruitment, including estimated frequency of litter sizes, ages at first reproduction, inter-birth interval, and proportion of females breeding.

3. Use available data to compare survival of released Texas cougars and pure Florida panthers.

4. Develop reliable estimates of age- and sex-specific survival rates using methods such as Kaplan-Meier, Heisey-Fuller, or proportional hazard modeling that take into account exposure days. Emphasis should be on estimates based on radio telemetry or other mark-recapture approaches. Methods that rely on raw mortalities, age distribution, or other approaches that are heavily dependent on untested assumptions should be avoided.

5. Develop reliable estimates of cause-specific mortality rates based on radio-telemetry data. Avoid the use of raw mortality data that are heavily biased toward detection of certain mortality events (e.g., car collisions).

6. Quantifying critical functional relationships in demography, notably density-dependence and inbreeding effects. The inevitable uncertainty in these relationships must be taken into account in PVA or other modeling, via sensitivity analysis and simulation.

7. Develop population models that reflect (a) panther natural history and (b) do not require levels of detail about panther demography that are unknown (and largely unknowable). Explicitly address uncertainty about parameter estimates via sensitivity analyses,

simulations, and incorporation of uncertainty into decision-making models. Avoid the use of canned programs (e.g., VORTEX, RAMAS) that tend to obfuscate these sources of uncertainty. Use, to the extent possible, reliable estimates of reproduction rates, survival rates, and variations (distributions) in these rates.

8. Analyze data where possible under alternative biological/sampling models and use modern information- and decision-theoretic methods to account for "model uncertainty" in estimation and the application of models to conservation decision making.

9. Do not use "consensus" approaches for modeling that obfuscate uncertainty in parameters, assumptions, and functional forms.

10. Summarize current information about the impacts of reintroduction and introgression, based on experimental releases to date as predictions, testable under adaptive management (Walters 1986, Williams et al. 2002).

BIOMEDICAL

Descriptions of the new scientific field of conservation medicine read like an overview of Florida panther biomedical program needs and concerns. For instance, Ostfeld et al. (2002, 18) state, "Conservation medicine is…devoted to understanding the interactions among (1) human-induced and natural changes in climate, habitat structure, and land use; (2) pathogens, parasites, and pollutants; (3) biodiversity and health within animal communities; and (4) health of humans." Roelke (1990) listed similar emphases for the Florida panther recovery program. One of the most important aspects of conservation medicine, especially for species imperiled by human impacts, is monitoring through time (Munson and Karesh 2002). Important monitoring topics include biomagnification (or bioaccumulation) of pollutants in the environment, disease transmission and susceptibility, emerging and growing health issues as they relate to destruction and alteration of wild habitats, and the identification of sentinel species for tracking various health issues. Thus, biomedical research is an important field for wildlife conservation, particularly as it concerns Florida panthers. Consequently, Florida panther investigations can contribute to our understanding of this felid and its conservation, and contribute to wildlife conservation in general.

Less controversy and contradictory information appear in biomedical aspects of panther research than in some other issues examined by the SRT. Nonetheless, biomedical data are potentially important for the survival of the panther population, and biomedical monitoring requires consistent data collection. Thus, we gave special focus to consistency and completeness of biomedical information collected over the course of Florida panther recovery efforts. Early phases of biomedical research on the Florida panther recovery program included innovative, pioneering research. We seek to assure that biomedical aspects of the recovery program continue to supply meaningful data.

The SRT reviewed 21 peer-reviewed publications dealing specifically with biomedical topics, including reproductive characteristics, parasites, physical abnormalities, diseases, and toxins. In addition, we reviewed publications on related topics, such as genetics, artificial insemination, animal capture and handling, hormone disruptors, and population structure. We also requested data forms, protocols, and some specific databases for review. Our objective was to identify areas of Florida panther biomedical investigations requiring increased attention.

Physical Abnormalities

Several physiological abnormalities have been identified in Florida panthers. Many of these abnormalities have been implicated in mortalities and in reduced reproductive capabilities. Although in many cases the cause of these abnormalities cannot be proven in the wild, the SRT found that most researchers made reasonable inferences based on the preponderance of evidence.

Taylor et al. (2002) documented mortalities from an atrial septal heart defect, an aortic aneurysm, an esophageal tear, pleuritis, and a pyothorax, for a combined total of 5% of 73 panther mortalities. An additional 6 atrial septal heart defects were documented, 3 of which may have contributed to the deaths of the animals involved. Cunningham et al. (1999) reported 6 of 33 panthers necropsied between 1985 and 1998 displayed atrial septal defects. Taylor et al. (2002) believed that the cardiovascular defects were congenital anomalies, and that they were probably associated with inbreeding. However, there are few comparative data from other *Puma concolor* populations to determine the level of threat these may play in Florida panther populations compared to other wild populations of pumas. Kinked tails and cowlicks have also been reported in Florida panthers and are likely related to inbreeding.

Abnormal characteristics related to reproductive physiology are especially important in endangered species and have received much attention in Florida panther investigations. Cryptorchidism, testicular volume, and semen characteristics have been examined and are of particular concern due to direct effects on reproductive capabilities. As Roelke et al. (1993*a*) point out, these may be related to inbreeding and low genetic variability. There is no direct evidence of this; however, it is a plausible explanation given the correlation of such defects with inbreeding in other species, plus the observed increase in the occurrence of some traits with time in the Florida panther population. Reduction of such traits with genetic introgression would provide additional support for inbreeding as the cause of these abnormalities.

Cryptorchidism occurred in 56% of males examined from 1978 to 1992, and was increasing in prevalence (Roelke et al. 1993*a*, Figure 6) from 1970 to 1992. In addition, bilateral cryptorchidism has been documented (2 of 9 known living males in 1992). The lack of cryptorchidism in progeny from Texas pumas (as part of the genetic restoration program) indicates a potential that this characteristic is genetically based and not environmentally based (Mansfield and Land 2002) (see Genetics section above).

Although sperm quality is generally low in large felids, motile sperm per ejaculate in the Florida panther is 18–38 times lower than in other *Puma concolor* subspecies (Roelke et al. 1993*a*). The Florida panther also has a 40% prevalence of acrosomal abnormality, which renders sperm deficient in fertilization potential. They also have a significantly greater frequency of malformed spermatozoa (94.3% per ejaculate) than other puma subspecies (Roelke et al. 1993*a*).

Recommendations.—

1. Careful monitoring of physiological abnormalities correlated with inbreeding and depletion of genetic variability. Continued monitoring with the same intensity and vigilance during the genetic restoration period of panther recovery efforts will not only be important for this subspecies, but have the potential of being an exceptional contribution to our understanding of small populations overall.

2. Increased collaboration and studies comparing physiological traits of Florida panthers with those in other populations of *Puma concolor*.

Disease

Disease has not been considered a major mortality factor in the Florida panther (Maehr et al. 1991*b*, Taylor et al. 2002). Taylor et al. (2002) reported that 2% of panther mortality was due to disease, based on postmortem examinations of 73 panthers from 1978 to 1999. However, a wide array of pathogens (i.e., bacterial, viral, and parasitic diseases) or antibodies to pathogens have been documented in the Florida panther population, including feline calicivirus (FCV), feline panleukopenia virus (FPV), feline immunodeficiency virus (FIV)/puma lentivirus, feline enteric coronavirus/feline infectious peritonitis (FIP), rabies, pseudorabies, *Bartonella henselae*, and *Toxoplasma gondii* (Roelke 1990, Roelke et al. 1993*b*, Glass et al. 1994, Rotstein et al. 2000).

Roelke et al. (1993*b*, 36) indicated that "disease agents could contribute to the extinction of this endangered subspecies." There are 3 reasons to be concerned about disease, despite the apparently small documented impact of diseases on panthers. First, there are probably fewer than 100 non-juvenile panthers; thus, every mortality counts. Second, there is only one population. Although sloughs and highways are impediments, there is no absolute barrier that could prevent a disease from sweeping through the population. In this regard, no other management action would contribute more to conservation medicine of panthers than the establishment of a new population outside of south Florida. Finally, if immune responses have been compromised through the effects of inbreeding, the population may be more vulnerable. The genetic restoration program may be ameliorating this last risk.

Although the SRT found no fault with pathogen/parasite screening and analyses, we are concerned about the apparent lack of consistency in data collection over time, and the lack of regular annual reports and assessments of the findings. Such monitoring would provide timely identification of increases in pathogen effects and allow for actions and further analyses to resolve such outbreaks. From the literature provided to the SRT, it is unclear if this type of monitoring is taking place. Although monitoring intervals have been recommended for basic blood parameters (Dunbar et al. 1997), we were unable to determine if the same had been stated for monitoring disease and parasite contact in the Florida panther. For example, the 1998–2002 annual reports clearly list the hematological values and the serum antibody titer values for FIV, but it is unclear whether those values are available each year between 1993 (Roelke et al. 1993*b*) and 1998 (Land et al. 1999). We also note ongoing monitoring for some internal parasites such as helminthes (D. Land, personal communication) to determine correlations between parasite loads and environmental, physiological, or pedigree characteristics. Such study is of particular scientific and conservation value, especially considering the effects such parasites may have on panther health (c.f. Dunbar et al. 1994).

Recommendations.—

1. Continued screening for pathogens on a regular basis. This screening should include feline calicivirus (FCV), feline panleukopenia virus (FPV), feline immunodeficiency virus/puma lentivirus, feline enteric coronavirus/feline infectious peritonitis (FIP), rabies, pseudorabies, *Bartonella henselae*, and *Toxoplasma gondii*. Conduct regular reviews by a small panel of veterinary experts to evaluate data collected to date and suggest modifications to protocols and analyses. This review panel should include expertise in the area of felid clinical pathology.

2. Increased pursuit of samples from other populations of *Puma concolor* for comparison, or collaborators willing to use the same screening techniques for a comparative study.

Environmental Toxins

There are a number of reasons for concern about contaminants and their potential effects on the persistence of the Florida panther, not the least of which is the small population. Furthermore, part of the Florida panther population lives near the lower end of the Everglades hydrologic system, which is subject to pollution from urban, suburban, industrial, and agricultural land uses. Finally, as a top predator, the panther may be subject to bioaccumulation of toxins.

Panther tissues have been screened for a variety of toxins, including potential endocrine disruptors. In the early 1990s, serious concerns were raised about one toxin, mercury, which Roelke (1990) considered "a significant contaminant." Roelke documented high levels of mercury in blood and hair samples, and implicated mercury toxicosis in 3 panther deaths. Taking a more skeptical view of the evidence, Taylor et al. (2002) affirmed that no panther death has been documented as directly caused by mercury. Facemire et al. (1995, 84) stated "…environmental contaminants [including mercury] may be a major factor contributing to reproductive impairment" and they made a compelling case for the role of toxicants in sub-lethal effects in the Florida panther population, especially effects on male reproductive capability.

Sileo et al. (1997) initiated a study of endocrine disruptive chemicals and their association with congenital anomalies of the Florida panther. However, the results were incomplete, and the issue apparently has not been pursued vigorously.

Certainly the boldest scenario involving mercury was the "north-south health cline" in panthers posited by Roelke (1990). Roelke found panthers north of I-75, particularly on the private ranches east of Immokalee, the Florida Panther National Wildlife Refuge, Bear Island Unit of the Big Cypress National Preserve, and adjacent ranches were in excellent health and in better condition (body mass, reproduction) than those in the Everglades National Park or Fakahatchee Strand State Preserve. This cline was correlated with a southward decrease in the abundance of deer and hogs, and a southward increase in panther consumption of raccoons and alligators. These latter species are relatively high in the aquatic food chain, and thus could accumulate toxins that find their way into ground water. Consistent with this, Roelke et al. (1991) found high levels of mercury in raccoon tissues, again higher in the south than in the north. (Apparently, incinerators in the Miami metropolitan area could cause increased atmospheric mercury in the south.) Roelke et al. (1991) further stated that individual female panthers with high mercury levels tended to have lower reproductive success.

This apparent cline was based on relatively few panthers, and it is difficult to disentangle the cause-and-effect relationships when so many factors (i.e., prey abundance, prey consumption, mercury, body mass, reproduction) vary along the same gradient. Nonetheless, Roelke and colleagues assembled several consistent lines of evidence and painted a persuasive case for this cline, and for the role of mercury in the cline. The SRT was therefore surprised to find no publications since 1993 that either confirm or refute the patterns suggested by Roelke, despite the fact that another decade of tissues has been collected, and another decade of data on panther body mass and reproduction is available. Although some of the mercury assays have been reported (Taylor 1997), there have been no reports since 1997, and apparently no attempt to correlate mercury levels with panther fitness. Although Taylor et al. (2002) asserted that mercury "studies are underway," the recent report by Shindle et al. (2001) made no mention of it. D. Land and M. Cunningham (personal communications to SRT, 13 January 2003) indicated that tissues from 1997 onward have been stored, and mercury assays will be completed on them. They also indicated that mercury levels in panthers may have declined since 1991. Until existing data are analyzed, however, the SRT does not feel complacent about this issue.

The SRT believes that tissue samples and data now available would allow a fruitful re-examination of the association between mercury concentration levels and panther health and reproduction. Such analysis should consider all possible alternative explanations for any emergent patterns.

Recommendations.—

1. Continued, regular collection and analysis of panther tissue and blood for the presence of environmental toxins and pollutants, including mercury and potential endocrine disruptors (Sileo et al. 1997).

2. Thorough analysis of all existing data on geographic clines in toxins and panther health and reproduction. Such analyses must also include correlations between tissue levels of toxins and the fitness of individual panthers, rather than simple geographic correlations.

3. If the previous analyses suggest that mercury (or any other toxin) may still be a problem, research should identify the ultimate source of the mercury (toxins), and follow it through the food chain by sampling aquatic plants, invertebrates, and the vertebrate prey consumed by panthers.

Capture and Handling

One area of some additional interest by the SRT is the use of telazol, medetomadine, or a combination of either with the drug ketamine instead of straight ketamine for the immobilization of panthers in the field. The SRT is aware of the general advantages of telazol and medetomadine (Kreeger 1999) over the use of ketamine for general anesthesia; in fact, these advantages are succinctly articulated in the Biomedical Protocol. However, we also note the advantages straight ketamine has over either of these other drugs when the primary capture method is by treeing the target animal with the use of hounds. Despite the disadvantages of ketamine in many other situations, one important advantage of this drug is the retention of muscle tone, thus reducing the potential for the cat falling from the tree. We did not have and did not seek information about the percentage of cats that fell from trees during capture operations, but we also note the special arrangements for such occasions (i.e., the use of a "crash bag") to cushion the falling cat (McCown et al. 1990). In addition, we note the reduced amount of tiletamine hydrochloride/zolazopam hydrochloride with ketamine in situations where cats are treed high in the tree (Taylor et al. 1998), and the risk of orphaning kittens with extended anesthesia sometimes related to the use of ketamine. However, the preferred method for capture of treed cats would be to maintain the cat in the tree, climb the tree, and lower the cat safely to the ground with a rope. The chances of performing such a capture may be increased with the reduction or elimination of teletamine hydrochloride or zolazopam hydrochloride.

We note that kitten captures are not attempted until the age of 1 year or more, despite the fact that the technique has been used on other studies of *Puma concolor* for over a decade. Given the importance of kitten survival information in population models (see Demography section above), and the lack of a rigorous published estimate, collaring and marking kittens younger than 1 year of age may be warranted. However, this does present a set of additional risks that must be weighed against the potential gains in knowledge about this population.

Finally, we note that Taylor et al. (1998) and Sileo et al. (1997) mentioned loss of information due to incomplete record keeping and inadequate sample storage (i.e., autolysis), respectively. The SRT encourages increased diligence in collecting tissues, storing tissues and data forms, and backing up data.

Recommendations.—

1. A review of drugs and procedures used for immobilization and capture of Florida panthers, including detailed examination of related tradeoffs.

2. A review of kitten capture techniques and results in other field studies of *Puma concolor* and the potentials for investigations of the Florida panther.

3. Increased diligence in collecting tissues, storing tissues and data forms, and backing up data.

Recommendations – Biomedical Issues

1. FWC, NPS, and USFWS should conduct an immediate and thorough analysis of *existing* data on geographic clines in toxins, diseases, and panther health and reproduction. Such analyses must include correlations between tissue levels of toxins and the fitness of individual panthers, in addition to geographic correlations. The analyses should consider how the prevalence of abnormalities in panthers is correlated with, or interacts with, genetic status (heterozygosity, degree of hybridization with Texas pumas). It appears that considerable tissues and data have been warehoused for a decade. The marginal cost of the analyses would be small, and these analyses are sorely needed to guide future data collection.

2. As suggested by the results of the analyses recommended above, USFWS should collect and analyze panther tissue and blood for the presence of environmental toxins and pollutants, including mercury and potential endocrine disruptors (Sileo et al. 1997). If mercury may still be a problem, research should identify the ultimate source of the mercury and follow it through the food chain by sampling aquatic plants, invertebrates, and the vertebrate prey consumed by panthers. These results will be important not only for this subspecies but also for our understanding of how to conserve other small populations.

3. Panther researches should try to collaborate with puma researchers elsewhere to compare physiological traits, diseases, and contaminant loads of Florida panthers with those of other populations of *Puma concolor*.

4. A review of drugs used for immobilization and capture along with related tradeoffs.

5. A review of kitten capture techniques and results in other field studies of *Puma concolor* and the potentials for investigations of the Florida panther.

6. Increased diligence in collecting tissues, storing tissues and data forms, and backing up data.

MANAGEMENT RECOMMENDATIONS

At the request of the management agencies and several reviews of an earlier draft of this report, in this section the SRT attempts to:

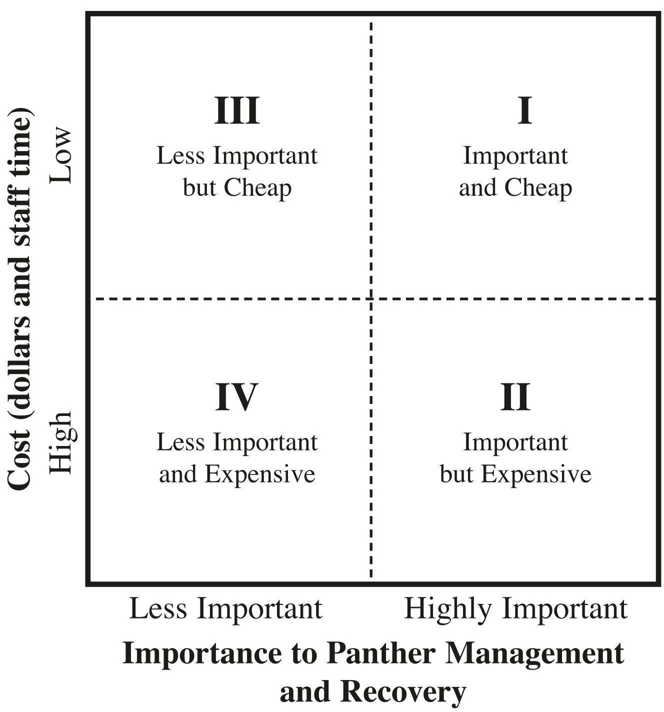
1. provide a prioritized list of recommendations;

2. suggest a process to encourage appropriate re-analyses of existing data, while respecting data ownership issues and publication ethics; and

3. suggest a process to ensure scientific rigor in the future for the panther research and monitoring program.

Prioritized List of Recommendations

Recommendations can be prioritized in terms of their importance to panther management and recovery and in terms of cost. Placing recommendations in a plane with respect to both factors (Figure below) may be more helpful than specifying priorities solely in terms of importance.



Activities in Quadrant I (cheap and important) probably would be completed first, and activities in Quadrant IV (expensive and less important) probably would be accomplished only when special opportunities arise (e.g., a donor is specifically interested in funding a particular activity in that quadrant). Although there is no simple way to prioritize between Quadrants II and III, our choice of number labels for these quadrants reflects our perception that, for the time being at least, Florida panthers command a lot of resources, and cost is less of a factor for this species than many other endangered species.

Below, with some trepidation, we place each of our recommendations into 1 of these 4 quadrants. Although we agonized over the order within each list, we urge the reader to attach less significance to that detail. We also caution that some activities will move between quadrants over time. For instance, an activity could move out of Quadrant IV because activities in Quadrants I–III have been completed, because costs decrease, or because priorities change in response to improved understanding or new threats. Finally, we caution that "less important" is not synonymous with "unimportant"; all proposed activities would help advance panther recovery.

I. Important activities that are cheap

- Until appropriate analyses are completed, cease using a 90-m distance from forest, minimum sizes of forest patches, and the Panther Habitat Evaluation Model in making decisions about habitat mitigation and acquisition.

- Ensure that future publications explicitly list the identities of panthers used in analyses and explain reasons for excluding portions of the available data.

- Convene **workshops to develop protocols and assign responsibilities for re-analyzing existing data**. This approach is outlined in the next major subsection of this report.

- Use existing data and knowledge to conduct population modeling that properly takes into account uncertainty in parameter estimates, functional forms, and other relationships, in making viability projections and assessing the possibly outcomes of alternative management scenarios.

- Establish a **Scientific Steering Committee**, as described in the last major subsection of this report.

- Use existing telemetry data to analyze selection with respect to vegetation type, roads and urbanization, and size and isolation of forest patches using an appropriate technique such as compositional analysis. Conduct analyses to compare panther home ranges to the geographic range of the Florida panther, and to compare locations within a home range to habitat available in that home range. Ideally, the protocols for this analysis would be developed in one of the workshops we recommend.

- Develop models to assist in making decisions on habitat acquisition and mitigation. Conduct sensitivity analysis prior to use.

- Convene a small working group of conservation geneticists to evaluate the desired level of future introgression of non-*coryi* genes into Florida.

- Because panthers in Everglades National Park are partially isolated by Shark River Slough, consider translocations into the park whenever all its breeding-age panthers are of the same sex for over a year, unless contraindicated by other factors.

- Use existing data to develop reliable estimates of litter size (and the frequency distribution of litter sizes), age at first reproduction, inter-birth interval, proportion of females breeding, and stage-specific and sex-specific survival rates. Ideally, the protocols for this analysis would be developed in one of the workshops we recommend.

II. Important activities that are expensive

- Conduct research to identify appropriate sites for reintroducing panthers and re-establishing populations outside of south Florida

- Conduct human dimensions research to identify and address social factors that might impede public acceptance of reintroduction.

- Collect field data to compare hybrid and pure Florida panthers with respect to important phenotypic traits related to fitness (cryptorchidism, atrial septal defects, opportunistic infections, sperm defects, body condition, litter size, stage-specific survival). This comparison is needed to assess the success of the introgression program and to serve as a well-documented case study for conservation science.

- Obtain and analyze nocturnal locations of panthers to ascertain how habitat use at night differs from diurnal habitat use.

- Apart from any monitoring to compare panthers based on hybrid status, continue monitoring to document the prevalence of traits that might indicate a resurgence of inbreeding depression.

- Develop a rigorous estimate of the level of introgression achieved, using new genetic markers (e.g., mitochondrial or microsatellite DNA). Such markers will open the door to sophisticated analyses of the correlation between panther fitness and the degree of hybridization of individual animals.

III. Less important activities that are cheap

- Develop and regularly update a plan to focus radio-telemetry efforts on specific unanswered research questions related to panther recovery rather than to simply continue monitoring "because we've always done it." Focusing on research questions will dictate the location of tagging efforts, the ages of animals tagged, types of radio tags deployed (GPS versus VHF), and types of analyses. This is a logical task for the Scientific Steering Committee.

- Determine the statistical significance of the historical (since circa 1900) changes in microsatellite variation of Florida panthers reported by Culver et al. (2000). Use a larger sample of modern and "ancient" (pre-1930) samples and a larger set of markers. This straightforward task could probably be achieved by a contract with Dr. Culver, and should not require a workshop to develop a protocol.

- Use improved estimates of vital rates (as recommended above) to develop and conduct sensitivity analysis on population models, avoiding the use of commercially available programs that obfuscate sources of uncertainty.

- Analyze existing data on geographic clines in toxins, diseases, and panther health and reproduction. Such analyses must include correlations between tissue levels of toxins and the fitness of individual panthers. The protocols for this analysis could be developed in one of the workshops we recommend, or, if data ownership resides entirely within FWC, that agency could either contract or conduct the analyses.

- Use existing data on radio-tagged animals to develop reliable estimates of cause-specific mortality rates.

- Consult a small group of veterinarians, physiologists, and persons with experience capturing pumas to evaluate drugs used for immobilization and capture, and the potential for safely capturing kittens.

IV. Less important activities that are expensive

- Determine the relationships among hydrology, soils, vegetation, abundance of prey (especially deer and hogs), habitat use by panthers, and panther fitness (population density, body mass, survival rates, reproduction). Some of these analyses could be conducted with existing data sets (at low cost), but if existing data are lacking or in some way defective, this becomes expensive.

- Continue research in managing vegetation (control of exotics, use of fire) to enhance prey populations.

- Assess the effect of other predators and human hunters on the availability of deer and other prey for panthers. As the panther population increases, this question may emerge as more important than at present.

- Quantitatively assess factors that constrain or enhance dispersal. Quantify uncertainty in the importance of dispersal as a factor limiting panther populations.

- Quantify critical functional relationships in demography, notably density-dependence and inbreeding effects.

- As suggested by the results of the analyses of existing data, collect and analyze panther tissue and blood for the presence of environmental toxins and pollutants, including mercury and potential endocrine disruptors. This would move into the important but expensive quadrant if analyses of existing data suggest that this is an important issue.

Protocols for Analysis of Existing Data

In its review, the SRT has identified several areas where the information or conclusions about panthers was deemed as not reliable, where we operationally defined "reliable" as the condition of the data, analyses, models, or assumptions being capable of supporting inferences about the Florida panther, its population dynamics, biology, and habitats. **The SRT recommends one or more workshops to develop protocols that would guide the re-analysis of existing data to correct identified areas of unreliability.** This workshop approach has helped resolve conflicts over interpretation of data, and ultimately over resource decisions, regarding the northern spotted owl (*Strix occidentalis*). As described by Anderson et al. (1999, 1050), the key to the approach is a protocol (essentially, a working agreement on procedures) for "conflict resolution when empirical data exist that bear directly on the potential resolution of the controversy." This protocol is developed in a workshop environment, which contains several features.

- It includes all groups that have both an interest and a potential contribution.
- Each participant has at least some data or analytical expertise.
- At least some participants (but not necessarily all) have no vested interest in the outcome.
- The main product of the workshop is a protocol—an agreement by all parties on the questions to be addressed, data to be analyzed, specific analysis methodologies, and methods for interpreting and reporting the results.
- Given that these rules are agreed to, arguments about the results must be confined to the agreed-upon bounds. Thus, for instance, having agreed on which data to include, no participant may reinterpret the results based on another data subset. Likewise, an invitee, having decided to absent him/herself at the outset, would not be allowed to (disruptively) reinsert themselves during the analysis and interpretation of the data.
- Conversely, though, any participating party would have the opportunity to challenge protocols and proposed methods at the outset, but this opportunity is lost once analyses begin.

- Agreement on protocols and methods can be reached in an amicable, consensus fashion when there is a great deal of respect and professionalism on the part of all. At least in the case of a workshop to set a protocol for re-analysis of data on habitat selection, the SRT recommends a professional facilitator to cut through agency or personal agendas and keep the process on track.

- Tentative agreement on authorship should precede analysis, with a recognition that order of authorship must be revisited after analyses are completed. Issues of data ownership must be respected, but no party should be allowed to "pull" their data from an analysis because they don't like the results.

- The process must be open and transparent.

- The process must be supported by the agencies and other stakeholders. This means not only financial support, but willingness to stand by the results, even if these run counter to agency or stakeholder positions.

We do not advocate that all steps proposed by Anderson et al. (1999) be followed. For instance, the information-theoretic approach advocated by the authors is probably not essential to the endeavor. The most useful first steps are to specify the question and to quantify uncertainty as objectively as possible, avoiding any attempt to "prevail" with any one scientific view. Then, and only then, can attention turn to considering the implications of scientific uncertainty to decision making, and ways that uncertainty can be reduced (but likely, never eliminated) through future research and monitoring.

We urge workshop participants to agree on clear and realistic timetables for conducting analyses, and to develop contingency plans in case of serious lack of timely progress. If dedicated but already-overworked persons volunteer to undertake certain analyses, their job expectations must be appropriately adjusted to allow them to succeed. Serious consideration should be given to the idea of contracting out some analyses.

The SRT recommends separate workshops for various topics, such as habitat selection and estimation of demographic rates. It may be possible to combine some topics into a single workshop or parts of an extended workshop.

In Table 2, we summarize the structure, format, and location of all the major databases currently maintained as part of Florida panther research and

Table 2. Locations of data collected on Florida panthers through September 2003. For examples and greater detail of data structure, see "Database files and sample data forms related to the Florida panther) (SRT document provided to Florida Fish and Wildlife Conservation Commission [FWC] and U.S. Fish and Wildlife Service [USFWS] 10 November 2003).

Type of data	Summary of information recorded	Format of storage	Location	Contact
Individual capture	Age, sex, mass, body measurements, tag number, radio-transmitter number, weather conditions, other capture information[a]	Paper records; about 50% have been scanned; plans for eventual Access database records	FWC, Naples	D. Land
Radio-telemetry encounter data	Location (UTM, latitude-longitude), date, time, activity, habitat, cat number, agency involved[b]	DBase files, updated annually	FWC, Naples[c]	D. Land
Biomedical records	Vital statistics, morphology, observed pathologies, fluids and drugs administered, reproductive status, tissue samples taken[d]	Recorded as part of capture record; paper records, some scanned, plans for eventual Access database	FWC, Naples	D. Land
	Results of diagnostic tests	Access database[e]	FWC, Gainesville	M. Cunningham
Genetic records	Sex, age, cat ID, birth, death, kinked tails, cowlicks, atrial septal defects, cryptorchidism, cleft spleens, suspected dams and sires	DBase files in SPARKS studbook program[f]	FWC, Naples	D. Land
	Analysis of dams and sires	Excel[g]	FWC	S. O'Brien
	Genotyping at 20–25 loci for all of panthers	Excel[g]	FWC	S. O'Brien
Habitat information associated with telemetry data	Taken as part of telemetry observations[h]	N/A	N/A	
Encounters and fate of panthers via methods other than telemetry	Observations of kittens with mothers	Paper records Field notes[i]	FWC, Naples	D. Land
	Evidence of uncollared panthers (track, scat, scrape, sighting, kill, photo), location, habitat, observer, and remarks	Paper records Field notes[i]	FWC, Naples	D. Land
Mortality reports and other encounters (e.g., roadkills) of marked or un-marked cats	Date; location; cause of death; ID, if marked; cause of death, if known	Paper forms[j] Dbase files	FWC, Naples	D. Land
	Vehicle collisions; cat ID, location, fate (i.e., death, injury)	Excel file[k]	FWC, Naples	D. Land

Table 2. Continued.

[a]Scanned copy of capture form included in "Database files and sample data forms related to the Florida panther."

[b]Copy of DBase files and format in "Database files and sample data forms related to the Florida panther." Some 2002–2003 panther locations from Big Cypress National Preserve (BCNP) may not have been shared with FWC and may only be held by BCNP.

[c]Copies of these data are "widely distributed" throughout the year (D. Land, personal communication).

[d]See capture form for a complete list of data collected.

[e]Database has current data but possibly not all historical samples. No linkage between this database and capture data, which are largely in not-retrievable form, or telemetry data, which are in dBase.

[f]Copy of ZIP file containing metadata can be found in "Database files and sample data forms related to the Florida panther." Data are maintained and kept current by D. Land.

[g]Plans exist to link these 2 Excel databases with the SPARKS stud data maintained by D. Land.

[h]No permanent records of classified imagery maintained by FWS; these are obtained from other state or federal agencies as needed.

[i]Copy of data form can be found in "Database files and sample data forms related to the Florida panther." No electronic data; some data are reported in sections of the annual report (e.g., Roy McBride's count of the number of panthers accounted for each year). Field notes maintained by individual researchers (no central repository).

[j]See "Database files and sample data forms related to the Florida panther" for copy of form. Dbase files "always current" (D. Land, personal communication).

[k]Separate Excel database maintained for vehicle collisions. Also recorded on mortality data forms (See also "Database files and sample data forms related to the Florida panther").

monitoring. Although these data are all (more or less) centrally available (usually in the FWC office in Naples), only some are in digital form, and many of these are in different formats, are overlapping, or both. There appears to be interest in synthesizing some of these data into a common relational database (e.g., in Access or Oracle). We encourage this effort and believe it would enhance future analyses.

Scientific Steering Committee to Ensure Future Scientific Rigor

We rely on many of the lessons suggested in the monograph by Clark et al. (1994) in developing this recommendation. To address the longer-term issues of future research and monitoring, **the SRT recommends the creation of an independent Scientific Steering Committee (SSC)**.

Membership.—The SSC would be comprised of no more than 7 individuals from universities, agencies, professional scientific organizations, NGOs, or other bodies.

- The primary qualifications for membership should be strength of expertise with panthers or closely related species, or expertise with small population demography and genetics, or other technical areas relevant to the recovery process.

- No member may have current proprietary, legal, or contractual involvement with any aspect of Florida panther recovery.

- Each member should be appointed, either jointly or separately, by FWC and USFWS after the agencies have solicited nominations from professional organizations such as Society for Conservation Biology, The Wildlife Society, National Academy of Sciences, and American Society of Mammalogists. Appointments need not be restricted to these nominees.

- The head of the SSC should not be a member of FWC or USFWS.

- Any SSC member who is also an employee of FWC or USFWS should view their role not as representing their agency, but rather as promoting sound science in the service of panther recovery.

- Each member must commit to attend in person at least one SSC meeting per year. Over a two-year period, any member who does not participate in at least half of face-to-face meetings and at least two-thirds of virtual meetings (conference call or interactive television), should be considered as having resigned from the committee.

Mandate.—USFWS and FWC must set the SSC's objectives, and should clearly specify the Committee's mandate in letter(s) signed by the appropriate high-level persons in USFWS and FWC. Recognizing that USFWS and FWC cannot abrogate their responsibility to make decisions regarding endangered species, the SSC shall have no decision-making authority, but would be purely advisory. SRT recommends the following mandates.

- To provide advice on research priorities.
- To review and make recommendations on proposed study plans for research on the Florida panther.
- To call attention to needed scientific tasks, including those that agencies are not eager to undertake.
- To review and rank proposals submitted under any competitive Request For Proposals issued by FWC or USFWS for research related to the Florida panther.
- To review the results of research, monitoring, or other services provided by contractors to ensure that these results meet agency priorities and are technically sound.

Autonomy and Sunset Provisions.—The SRT is aware of previous entities (Florida Panther Interagency Committee and Florida Panther Technical Advisory Committee) that apparently no longer function. Although we are not aware of the extent to which these entities may have resembled the proposed SSC, we do not want to create an entity that will start out with promise and then quietly wither away when disagreements arise. Because the SSC may make recommendations that would be unpopular, its independence must be guaranteed. On the other hand, we do not wish to create another bureaucracy that outlives its utility, or that promotes the political agendas of a few members. To navigate between these two risks, we recommend the following procedures.

- Any decision to continue or disband the SSC should be made by an ad hoc advisory group in which FWC and USFWS each have one vote, with additional voting representatives from at least three professional organizations such as Society for Conservation

Biology, The Wildlife Society, National Academy of Sciences, and American Society of Mammalogists.

- At five-year intervals, or earlier at the request of USFWS or FWC, this ad hoc advisory group should be convened to determine if the SSC should remain in existence or if it is no longer useful.

- FWC and USFWS should support the SSC by providing meeting space in Florida and transportation costs for up to four SSC meetings per year. The decision to meet should reside with the SSC, and the management agencies should not be allowed to forbid an SSC meeting. The SRT believes that most of the committee's business could be conducted by telephone and e-mail and that face-to-face meetings may not be needed every quarter.

- The SSC should be encouraged to summarize important recommendations as written documents and to communicate directly with the public. This idea does not threaten the final decision-making authority of USFWS and FWC, but could signal when the agencies are choosing a course not recommended by the SSC.

- The Recovery Team, individual members of the Recovery Team, employees of state and federal agencies working on panther-related issues, and representatives of conservation NGOs should be encouraged to directly contact the SSC to suggest SSC attention to scientific issues, without having to route their request through a chain of command.

A decade ago, Ken Alvarez (1993, 171) grimly assessed panther recovery as follows: "And so it goes...the actors come and go; decisions are reversed, often without explanation; no one is in charge; the different agencies and factions pursue their separate objectives; motives are sometimes discernible and sometimes not; the recovery program is a case of strategic aversion and operational chaos, organized only to the extent that it can avoid any action deemed undesirable by its component factions, as they project an image of industry and purpose while consuming a perennial flow of revenue." The SRT does not know if this was an accurate assessment in 1993. We believe the situation is better than that today. We adamantly hope that the SSC and our other recommendations will help create a better future for the recovery program, and ultimately for the Florida panther.

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Taylor, S. K., E. D. Land, M. Lotz, M. Roelke-Parker, S. B. Citino, and D. Rotstein. 1998. Anesthesia of free-ranging Florida panthers (*Felis concolor coryi*), 1981–1998. Proceedings of American Association of Zoo Veterinarians 1998:page numbers??.

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Walters, C. J. 1986. Adaptive management of renewable resources. McMillan.

Waples, R. S. 2002. Definition and estimation of effective population size in the conservation of endangered species. Pages 147–168 *in* S. R. Beissinger and D. R. McCullough, editors. Population viability analysis. University of Chicago Press, Chicago, Illinois, USA.

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White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California, USA.

Wilkins, L. 1994. Practical cats: comparing coryi to other cougars: an analysis of variation in the Florida panther *Felis concolor coryi*. Pages 14–45 *in* D. B. Jordan, editor. Proceedings of the Florida panther conference. Florida Panther Interagency Committee, Gainesville, Florida, USA.

Wilkins, L., J. M. Arias-Reveron, B. Stith, M. E. Roelke, and R. C. Belden. 1997. The Florida panther (*Puma concolor coryi*): a morphological investigation of the subspecies with a comparison to other North and South American cougars. Bulletin of the Florida Museum of Natural History 40:221–269.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. Academic Press, San Diego, California, USA.

Appendix: An annotated bibliography of literature on the Florida panther, reviewed May 2002–October 2003. Note: When the word *Summary* appears, the Scientific Review Team either added to an existing summary or wrote a new summary. When the word *Abstract* appears, this is the abstract from the original paper without any additional notes from the review team. *Comments* contain opinions and reactions of the Scientific Review Team (P. Beier, M. Vaughan, M. Conroy, H. Quigley) and are often written in informal style. The following abbreviations are used throughout the appendix: F_1 = offspring from mating of TX female and FP male; F_2 = offspring from mating of 2 F_1 parents; FP = Florida panther with no genetic contribution from the 1995 release of Texas pumas (note that some of these may have non-*coryi* genes from previous releases and escapes); TX = 1 of the 8 female Texas pumas released into the FP population during March–July 1995.

Anonymous. 2002. Summary of the Florida Fish and Wildlife Conservation Commission's 2001–2002 panther capture season. Unpublished Report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Summary: During November 2001–April 2002, 8 panthers were recollared (to replace batteries or accommodate neck growth) and 6 new panthers were radio tagged, bringing the total radio-tagged population to 46 panthers (including 17 with Texas ancestry) and 3 TX; 10 of these collars are no longer functioning. Four of the new collars are GPS collars. Except for these GPS collars and 2 opportunistic deployments, there was no effort to deploy new VHF collars; in fact, 2 panthers treed incidental to other activities were not collared. The litters of 4 females were handled; 12 kittens were marked with subcutaneous transponders. Two panthers that suffered broken bones during the 2000-01 capture season were returned to the wild, where they displayed expected movement patterns. Four collared and 2 uncollared mortalities were documented. Three of the 4 collared were killed by male panthers, 2 uncollared cats were killed by unknown causes.

Comments: For the GPS collars, the number of locations per day and mode of downloading locations was not reported. The previous 2 annual reports on the capture season were written by McBride (2000, 2001), who expressed dissatisfaction with the number of failed collars and disagreement with some earlier published works.

Barone, M. A., M. E. Roelke, J. Howard, J. L. Brown, A. E. Anderson, and D. E. Wildt. 1994*a*. Reproductive characteristics of male Florida panthers: comparative studies from Florida, Texas, Colorado, Latin America, and North American zoos. Journal of Mammalogy 75:150–162.

Note: This report is reprinted in full in Jordan (1994*b*).

Abstract: Testicular volume, semen traits, and pituitary-gonadal hormones were measured in populations of *Felis concolor* from Florida, Texas, Colorado, Latin America, and North American zoos.

More Florida panthers (*Felis concolor coryi*) were unilaterally cryptorchid (one testicle not descended into the scrotum) than other populations (43.8 versus 3.9%, respectively). Florida panthers also had lower testicular and semen volumes, poorer sperm progressive motility, and more morphologically abnormal sperm, including a higher incidence of acrosomal defects and abnormal mitochondrial sheaths. Transmission electron microscopy revealed discontinuities in the acrosome, extraneous acrosomal material under the plasma membrane, and remnants of the golgi complex under the acrosome. No differences were detected in mean-circulating follicle-stimulating hormone, luteinizing hormone, and testosterone were similar between cryptorchid and noncryptorchid Florida panthers. Animals with *F. concolor coryi* ancestry were categorized on the basis of amount of genetic variation (low = type A; medium = type B; high = captive Piper stock). Compared to counterparts, type A Florida panthers had the lowest testicular volume and sperm motility ratings and were the only animals exhibiting unilateral cryptorchidism. These results demonstrate the existence of major morphological and physiological differences among populations of *F. concolor*, a finding potentially related to differences in genetic diversity.

Barone, M. A., D. E. Wildt, A. P. Byers, M. E. Roelke, C. M. Glass, and J. G. Howard. 1994*b*. Gonadotropin dose and timing of anesthesia for laparoscopic artificial insemination in the puma (*Felis concolor*). Journal of Reproduction and Fertility 101:103–108.

Note: This report is reprinted in full in Jordan (1994*b*).

Abstract: Ovarian response to equine chorionic gonadotrophin (eCG) and human chorionic gonadotrophin (hCG), the effect of timing of anaesthesia relative to hCG injection and the use of laparoscopic intrauterine artificial insemination were examined in the puma (*Felis concolor*). In Experiment 1, females were treated with 100 (N=6) or 200 (N=8) iu eCG (i.m.) followed 80h later by 100 iu hCG (i.m.) and were then anaesthetized 40–43 h after hCG injection for ovarian assessment. Although there was no difference (P>0.05) in the number of unovulated ovarian follicles, females treated with 200 iu eCG had more (P<0.05) corpora lutea per female and more corpora lutea as a percentage of the total number of ovarian structures. In Experiment 2, all females were treated with 200 iu eCG and 80h later with 100 iu hCG, and then anaesthetized either 31–39 h (Group A; N=8) or 41–50 h (Group B; N=6) after hCG injection for ovarian assessment. All Group B pumas ovulated compared with only three (37.5%) Group A females (P<0.05). Compared with Group A, Group B pumas had more corpora lutea per female, more corpora lutea as a percentage of the total number of ovarian structures, and fewer unovulated follicles (P<0.05). One of the nine post-ovulatory females laparoscopically inseminated in utero with 16 x 106 motile spermatozoa became pregnant and delivered a healthy cub. Administration of 200 iu eCG and 100 iu hCG followed by anaesthesia no earlier than 41 h after hCG treatment is most likely to result in ovulation in pumas, and laparoscopic artificial insemination can be used to produce pregnancy in this species.

Bass, O. L., and D. S. Maehr. 1991. Do recent panther deaths in Everglades National Park suggest an ephemeral population? National Geographic Research and Exploration 7:427.

Note: This appears as a 1-page sidebar within the longer paper by Maehr et al. (1991*a*).

Summary: The last 3 known females in Everglades National Park died recently. Mercury may have contributed to at least 2 of the deaths (citing Roelke unpublished data). Although in the future "surplus animals" from north of the park may occasionally recolonize the park, "reproduction does not appear to occur" in unforested habitats.

Comments: Sonny Bass (personal communication, 31 January 2003) no longer believes in his 1991 conclusion that panthers do not reproduce in the absence of forests.

Belden, R. C. 1978*a*. Florida panther investigation: a 1978 progress report. Pages 123–133 *in* R. R. Odum and L. Landers, editors. Proceedings of the Rare and Endangered Wildlife Symposium. Technical Bulletin WL4. Georgia Department of Natural Resources, Atlanta, Georgia, USA.

Summary: The Florida Game and Freshwater Fish Commission initiated a Florida panther investigation in October 1978 by establishing a Florida Panther Record Clearinghouse, investigating panther reports, and conducting special field searches. At least 1 panther population was found in the vicinity of the Fakahatchee Strand, Big Cypress Swamp, and Everglades National Park. Additional study is required to determine its geographic limits and to determine whether it contains the necessary number and age and sex structure for continued existence.

The major recommendation is that panther management rely only on confirmed sightings of panthers. Confirmation will generally be by the detection of physical sign. Many, if not most, reports of panthers cannot be substantiated by physical sign. Some of these may be valid, and the failure to detect sign may simply indicate an insufficient search effort. Probably the greatest value of the reports is in focusing sign searches in specific areas.

Belden, R. C. 1978*b*. How to recognize panther tracks. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 32:112–115.
Summary: Experience in investigating panther reports showed that most people, including wildlife biologists, cannot readily and accurately distinguish panther tracks from those of other species, particularly tracks from large dogs. Characteristics by which to identify panther tracks are presented.

Belden, R. C. 1986. Florida panther recovery plan implementation—a 1983 progress report. Pages 159–172 *in* S. D. Miller and D. D. Everett, editors. Cats of the world: biology, conservation, and management. National Wildlife Federation, Washington, D.C., USA, and Caesar Kleberg Wildlife Research Institute, Kingsville, Texas, USA.
Summary: The Florida Panther Recovery Team was appointed by the U.S. Fish and Wildlife Service in July 1976 to prepare and assist in coordinating the implementation of a recovery plan for the Florida panther. The step-down outline for the plan was completed in October 1976. The goal of the plan is to prevent extinction of the Florida panther and to re-establish viable populations in as much of the cat's former range as is feasible. Three objectives are identified to attain this goal: to find and maintain any existing populations of Florida panthers, to improve public opinion and behavior regarding the existence of Florida panthers, and to re-establish populations where feasible. In the past 7 years, progress has been made toward the accomplishment of these objectives. Activities include the operation of a Florida Panther Record Clearinghouse, investigating sighting reports, field searches for panther sign, radio-telemetry studies to determine movements and habitat preferences, food habits studies, public education programs, and evaluation of present regulations and land management policies.

Field data indicate that panthers avoided direct contact with humans, but seemed to be accustomed to continual noises from rock quarries, highways, and air traffic. All but 4 records of Florida panthers were from Lake Okeechobee south. None of these 4 were authenticated as Florida panther. Panthers tended to move toward wildfires and stayed around recent burns for several days. The key habitat for radio-tagged panthers was mixed swamp forests. The report identified the major reason for decline as the disappearance of wild habitats. Concern was also expressed about other subspecies of *F. concolor*, principally with respect to potential confusion with *F. c. coryi*.

Belden, R. C. 1989. The Florida panther. National Audubon Wildlife Report 1988–1989:515–532.

Summary: A description of panther characteristic—physical description and natural history, reproductive behavior, longevity and mortality factors, diseases and parasites, diet, habitat relationships, home range. The effects of disease are unknown; the principal disease is feline panleukopenia (85% prevalence and a presumed mortality factor for kittens). Twenty species of parasites were detected, but the population impact of these is unknown. The diet included deer, hogs, and raccoons.

The paper cites studies (later summarized with additional data by Roelke 1990) that showed positive relationship between body weight, and physiological parameters and reproductive success. There was an indication that areas with low prey densities (especially larger prey) may support panthers, but that reproduction is inhibited. Home range size was 168–190 miles^2 for adult males and 68–74 for adult females; large home ranges are needed to secure prey and because of social/reproductive behavior. Variability in home range size was attributed by the authors to differences in prey density, prey size, topography and foraging efficiency; however, it is not clear why the authors did not include panther density as a factor affecting home range size.

History—Early persecution, followed by later status as a game animal; protected under Endangered Species Act in 1967. Protection results in potential for conflict with recreation (hunting, vehicles). The recovery team was appointed in 1976, final recovery plan submitted in 1981, revised in 1987. The 3 major objectives of the plan are (1) identify, protect, and enhance panther habitat; (2) establish positive public opinion and support for management; (3) restablish populations where feasible. In 1983 the Florida Panther Tech Advisory Council advises Florida Game and Fresh Water Fish Commission on technical issues. In 1976 the Florida Panther Record Clearinghouse oversees collection and field investigation of panther reports.

Management—Highway mortality was reduced through implementation of speed zones, signs, brochures, special under/overpasses, fencing, shoulders. Increasing reproduction through increased food supply via hunting regulations. Other management actions include removal of illegal hunting camps, establishment of new refuge, captive breeding programs, and reintroduction.

Prognosis—Currently poor, high probability of extinction. This may be reversed by habitat conservation and other management actions, which in turn depend on public understanding and support.

Recommendations—(1) Interim steps for protection from traffic until highway modifications can be completed (1990); (2) comprehensive land management plan; (3) compromise on deer harvest on public areas; (4) control of residential and agricultural encroachment; (5) gather data on Florida panther demography, genetics, habitat selection, carrying capacity, and other biological parameters; evaluate the feasibility of reintroduction and habitat manipulation; (6) develop a system of marking and monitoring of captive lions.

Comments: A good summary of species biology and management as of 1989.

Belden, R. C., and D. J. Forrester. 1980. A specimen of *Felis concolor coryi* from Florida. Journal of Mammalogy 61:160–161.

Summary: The carcass of a 44-kg sub-adult male panther illegally killed in the Big Cypress Preserve was confiscated on 12 March 1978 in Homestead, Florida. The specimen was taken within the area in Collier and Dade counties for which there was evidence of their continued existence. Measurements are provided. The testes contained spermatogonia, but no spermatozoa were present. The stomach contained hair and bone from *Odocoileus virginianus* and *Dasypus novemcinctus*, and leaves of wax myrtle and bald cypress and an unidentified monocot. The skull, hide, and skeleton were deposited in the Florida State Museum (UF-1939).

Belden, R. C., and B. W. Hagedorn. 1993. Feasibility of translocating panthers into northern Florida. Journal of Wildlife Management 57:388–397.

Summary: Seven sterilized, radio-tagged, Texas pumas (3 males, 4 females, all adult except 1 yearling female) were released in northeast Florida and southeast Georgia as surrogates to evaluate the feasibility of translocating panthers to the area. The 12,400-km^2 area (parts of 5 Florida and 6 Georgia counties) was selected for its large size, abundance of deer and feral hogs, and low density of humans and roads. Pumas were released after 1 week in their release pens, then monitored 6 days a week (not on Sundays) during June 1988–April 1989. After 0.5 to 6 months of initial excursions (mostly westward), pumas established overlapping home ranges and normal feeding and ranging patterns until the hunting season. Home range was considered to be established when a panther restricted 95% of its movements to a predictable area for 3 months. Home ranges were along river drainages. The yearling female established a home range without preliminary excursions and used it for 5 months, but on the opening day of the gun hunting season ranged over a much wider area in an unpredictable pattern. One puma died of unknown causes 1 month after release. During hunting season, the other 6 pumas abandoned their home ranges, and 2 were killed (probably shot) by humans. Deer hunting was not curtailed during the study. Most hunters used dogs; some pumas also seemed to key in on bait stations created by hunters. Subsequent wandering into urban areas or livestock operations triggered early removal of the animals. Densities of hard-surfaced roads were 50% lower in home ranges than the mean for the study area, and pumas tended to avoid crossing the busier roads. The public was highly supportive of the possible reintroduction in this area. Though this remains the best of 3 possible reintroduction sites in Florida, the authors "cannot recommend the introduction of Florida panthers into northern Florida at this time."

A reestablishment area of >2,590 km^2, with a deer density >1 deer/36 ha should provide conditions capable of supporting 50 to 60 panthers (2–3/100 km^2). Human populations should be minimal within 64 km of release the release site. Cattle are not of major concern, but goats, sheep, and other small ungulates are vulnerable. The only areas in Florida beside the study area and south Florida that met these criteria were Kissimmee/St. Johns watersheds and Apalachicola National Forest and vicinity. Kissimmee/St. Johns may already have transient panthers, and Apalachicola National Forest has minimal buffering and intensive human use. The authors suggest, therefore, that the current study area is the best candidate for reintroductions. Animals should be released shortly after the close of the gun season to allow maximum time between hunting seasons to allow for home range establishment. Public education and resolution of damage complaints are essential. The authors suspect that stocking at higher densities may encourage normal social interactions and reduce excursions, and offset expected mortality. An initial stocking of 10–20 is recommended by the authors.

Comments: Ninety percent of locations were in hardwood swamps and pine flatwoods, but there is no information on habitat availability. The authors did not suggest an experimental release of animals to monitor their behavior in an area where use of dogs and bait stations is banned. Given the apparent impact of these hunting styles, this would have been a reasonable suggestion.

Belden, R. C., and J. W. McCown. 1996. Florida panther reintroduction feasibility study. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 72pp.

Summary: Pumas of Texas origin (11 females and 8 vasectomized males; 3,658 locations) were introduced (soft-release with 10–14 days in holding pens) into north Florida and monitored >3 days/week during February 1993–June 1995. Released animals included 10 wild-caught pumas released after translocation, 3 wild-caught animals held in captivity for 2–8 years before release, and 6 pumas born and raised in captivity. Ten animals were introduced in early 1993; the other 9 were introduced in mid-1994 to observe their interaction with the existing group. Fifteen pumas established 1 or more home ranges. Of the other 4, 2 wild-caught animals were killed 56 and 140 days post-release, and 2 captive-held pumas were removed 66 and 37 days after release. Seven pumas (3 dams with cubs) released in mid-1994 were assimilated into the captive population. Of the other 2, 1 wild-caught male dispersed from the population, and 1 female kitten was recaptured when she failed to follow her mother. Habitats were ranked as follows: forested wetlands > coniferous forest > hardwood forest = mixed forest >>> other (agriculture, urban). Compared to wild-caught animals, captive-raised animals tended to establish home ranges more quickly and closer to the release site and were more likely to be in association with other pumas. However, they were also more likely to be seen and caused most of the interactions with humans that created negative attitudes to the program. Captive-raised pumas were the only animals seen near houses. Seven pumas were involved in 8 depredation incidents (3 newborn calves, 2 exotic ungulates, 1 horse, 1 hog, and 1 housecat), and captive-raised males had the highest depredation rate. Males and females consorted regularly, and at least 3 (and as many as 5) litters were produced. Mortality was significantly higher for the wild-caught pumas. The fact that 2 captive-raised kittens failed to follow their dams on release may preclude releasing females with captive-raised young. Based on these results, a reintroduction strategy would be to release 4–5 wild-caught females (some could be released with kittens) into the target area. After they establish home ranges, a captive-raised male could be released only long enough to breed all receptive females, then removed. The release area would have to be 2,200–5,500 km^2 to harbor a viable population. Re-establishment of additional populations would be biologically feasible, but the economic, political, and social costs must also be considered. Although opinion surveys showed that over 70% of Florida residents, including those in this study area, supported reintroduction efforts even if they were in their county, many, perhaps most, of the rural residents closest to the release area were strongly opposed. The researchers met with "community leaders" (does not say who or how many) and hunt clubs in advance. They expressed concern about human safety, safety of pets and livestock, landowner rights, and impact on deer populations.

The local negative attitudes increased markedly during the study, and became increasingly vocal and organized. Clearly, educational efforts to address concerns would have to start early and continue well into a reintroduction effort.

The tables and appendices include maps of home ranges and movements, and individual histories of each animal. Movements of 3 individuals (Figure 2) to Savannah (Fig A15), Augusta (A16), and the Georgia-Alabama border (A28) are especially dramatic.

Comments: Obviously, sterilization procedures were not entirely successful. Starting with the proposed optimum strategy (release wild females, then a captive-bred male that would be recaptured after breeding), alternative schemes involving combinations of captive-raised and wild cougars could be treated as testable predictions (e.g., under adaptive management).

Belden, R. C., W. B. Frankenberger, R. T. McBride, and S. T. Schwikert. 1988. Panther habitat use in southern Florida. Journal of Wildlife Management 52:660–663.

Summary: Six Florida panthers were captured in southern Florida and radio located (daytime only, aerial homing) 1,630 times from February 1981 through August 1983 (30 months). Mean home area for the 4 males and 2 females was 435 ± 231 (SE) km^2 and 202 ± 141 km^2, respectively. "Tests with hidden transmitters indicated that locations were accurate to within 230 m." Mixed swamp forests and hammock forests were used more than expected based on the availability of these habitats within the panthers' home areas. Based on the availability of mixed swamp forests and hammock forests, the authors estimate that south Florida can support 30–40 panthers, with the major limiting factor being the availability of suitable habitat.

Comments: Sample size (6 panthers) was limited. The details of location error calculations are not provided, nor was the estimate of telemetry error incorporated into the analysis of habitat selection.

Branan, W. V., editor. 1986. Survival of the Florida panther. Florida Defenders of the Environment, Gainesville, Florida, USA. 67pp.

Note: Branan was editor. Most talks presented in conversational style or as a transcript of a presentation. A few synopses are summarized here.

Summary: • Alvarez: Some perspectives on strategy and survival prospects for the Florida panther. There are 12–13 panthers on public land, where hunting of panther prey should be curtailed, and at least 18 on private land, where no management occurs. The future is bleak unless prey density or area of safe habitat are increased; success is impossible solely on current public land. Alvarez made a number of bold statements without clear basis, and took a strong stand against "compromising." He called for research on the impact of hunting on puma prey and on deer populations in Everglades National Park. Agency resistance has prevented the implementation of several feasible recommendations.

- R. C. Belden: The number of panther sightings reported is a function of the number of people in an area and their activity patterns, not panther density or activity. The population in the Big Cypress/Everglades physiographic region includes about 30–50 animals. In this area, panthers have large home areas (range = 276–766 km^2 for males and 103–302 km^2 for females), and tend to select habitats that offer thick cover (mixed swamps and hammocks) in association with their primary prey (white-tailed deer). Individuals on occasion move as much as 30 km overnight or, at other times, stay in the same location for a week or more. Panthers frequently cross highways and swim canals or move from one tree-island to another.
- M. Roelke: Diseases such as feline panleukopenia and calcivirus, as well as hookworm have been documented. An inadequate prey base, diseases and parasites, and inbreeding (especially evident in male reproductive defects) may limit the population. Highway accidents, with continuously increasing traffic, kill many animals.
- Eisenberg: Taxonomic status. Lots of discussion about the genetic distinctness of *F. c. coryi*, subspecific designation, Endangered Species Act status, and the pros and cons of introducing genes from other cougar populations.

Recreational hunting and prey base. Discussion about carrying capacity (deer supply), maintaining deer at carrying capacity versus the logistic inflection point. The impact of recreational harvest on deer supply, panther kill.

- Miller and Hornocker: What next? Decisions about future have to be made based on best possible data. They recommend obtaining data on seasonal food habits; white-tailed deer productivity, abundance, survival, and habitat selection where deer overlap with panthers; and predator-prey interactions. They also call for an interagency panther committee and use of land use models to evaluate land use changes and options in south Florida.

Natural system management vs. habitat manipulation. There was an evolution of attitudes and polices through 1980s (National Park Service), from pre-1960s predator control, through "vignettes" in the 1960s and passive management in the 1970s, to the current policy, which is a mixture of passive and active intervention. The National Park Service prefers less intrusive approaches, but many systems are

highly disturbed and need protection and active management for restoration.

- Christian: "Conservation" includes all necessary measures to bring a species to the points where such approaches are no longer needed.

There is general agreement that food plots don't greatly increase deer populations, but do concentrate deer, which might favor panther kills.

- K. Alvarez: Private lands. Half or more of the existing Florida panther population inhabits privately owned lands, some of which are relatively large tracts. Others, such as South Golden Gate, consists of thousands of small lots. Many of the larger tracts are being converted to intensive agriculture. It is possible to save much of this land as panther habitat, but a plan must be formulated to identify upland tracts to be purchased. Regulatory agencies must coordinate with management agencies to preserve wetlands that would connect upland habitat blocks. Legislation is needed to establish special funding and staffing to expedite complex, small-parcel acquisition projects.
- Branan: Federal Agencies. Describes management plan for Big Cypress National Preserve and coordination with Panther Recovery Plan. The plan deals with hunting, off-road vehicle policy, and habitat management. "Post-conference discussion" included discussion as to whether, and how, Florida panther critical habitat can be identified. "First choice is to have the Florida panther in Florida, second to have panthers in Florida" (Branan).

Comments: Discussion of possible incentives for private landowners to protect panther habitat would be helpful.

Butt, M. T., D. Bowman, M. C. Barr, and M. E. Roelke. 1991. Iatrogenic transmission of *Cytauxzoon felis* from a Florida panther (*Felix concolor coryi*) to a domestic cat. Journal of Wildlife Diseases 27:342–347.

Abstract: A laboratory cat died 12 days after intraperitoneal inoculation of a 1 ml suspension containing 1.5 x 106 blood mononuclear cells from a Florida panther. Gross, histologic and ultrastructural investigations revealed the cause of death to be infection by *Cytauxzoon felis*, a protozoal parasite known to cause a rapidly fatal disease (cytauxzoonosis) in domestic cats. The bobcat has been identified as a natural host for *C. felis*; this report implicates the Florida panther as another possible host.

Comiskey, E. J. 1994. A spatially-explicit individual-based simulation model for Florida panther and white-tailed deer in the Everglades and Big Cypress landscapes. Pages 494–502 *in* D. B. Jordan, editor. Proceedings of the Florida Panther Conference, 1–3 November 1994, Ft. Myers, Florida, USA. 522pp.

Comiskey, E. J., O. L. Bass Jr., L. J. Gross, R. T. McBride, and R. Salinas. 2002. Panthers and forests in south Florida: an ecological perspective. Conservation Ecology 6(1):18. Available from <http://www.consecol.org/vol6/iss1/art18>.

Summary: The endangered Florida panther survives in an area of habitat diversity in southern Florida, occupying extensive home ranges that encompass a mosaic of habitats. Twenty-one years (1981–2000) of daytime monitoring via radio telemetry have provided substantial but incomplete information about panther ecology, mainly because this method fails to capture movement and habitat use between dusk and dawn, when panthers are most active. Broad characterizations of panther habitat suitability have nonetheless been derived from telemetry-based habitat selection studies, focusing on locations where daytime resting sites are often located. The resulting forest-centered view of panthers attributed their restricted distribution and absence of population growth in the mid-1990s to a scarcity of unfragmented forest for expansion. However, the authors assert that the panther population has doubled since the beginning of genetic restoration in 1995, increasing five-fold in public areas described as unsuitable based on forest criteria. They further assert that although the forest-centered view no longer explains panther distribution, it continues to shape management decisions and habitat conservation policies.

To address the absence of nighttime telemetry data, they considered circular areas around each daytime location with radius equal to mean distance between sequential locations (6.6 km for males, 3.2 km for females). The interval between successive locations is not stated, but the routine of 3 flights per week suggests an average of 2.3 days between locations. They also mention anecdotal information (e.g., tracks, scats, urine markers, and kill sites) from McBride's field observations indicating that during active hours panthers use non-forest habitat. The authors plot home range size against the amount of forest within each range, concluding that percent forest cover is a poor predictor of size, and that the expected decrease in home range size with increasing forest cover is not evident. They applied fractal analysis to characterize the relative density of forest cover associated with daytime locations and interpreted the results in terms of spatial landscape patterns. They conclude that the forest-centered view of panther habitat selection is based on an uncritical evaluation of telemetry data collected prior to the recent population expansion and on the unsupported assumption that day-bed habitats are representative of nighttime habitat use. They find that *P. concolor* in Florida, as elsewhere in their range, are habitat generalists, exploiting most available habitats for hunting, resting, mating, travel, denning, and dispersal. Their analysis confirms the idea that forested habitat with understory and prey are important to panthers. They find no support for the view that only the forested land within a habitat mosaic is potential panther habitat, or for the contention that only forested habitats are used by panthers within existing home ranges. They note that the forest-centered view of panther habitat quality has mischaracterized over 400,000 acres of public land in south Florida. They suggest a recovery paradigm based on maintaining the integrity of the system of overlapping home ranges that characterizes panther social structure and satisfies breeding requirements.

Comments: Contributions of this paper:

1. Figure 3 is a convincing argument against the idea that home range area decreases with increasing fraction of the home range in forest cover: 5 females and 1 male occupied home ranges in Everglades National Park (ENP) with <15% forest cover; the female home ranges in these treeless areas were quite small.
2. They provide a reasonable alternative explanation for the large home ranges of ENP panthers prior to 1995. Maehr had attributed this to low forest cover, but this paper points out that this may have been that the few animals were searching for mates. The small home ranges of panthers in these same areas since 1995 (when mates were available) suggest that low percent forest alone does not explain the former large home ranges.
3. The paper uses 49,889 radio-locations (102 individuals), and criticizes Kerkhoff et al. (2000) for using an undefined, but clearly much smaller subset of the data available, and Maehr and Cox (1995) for apparently using data on only 23 of the 36 animals for which data were available. The authors assert that Kerkhoff et al. (2000) and Maehr and Cox (1995) excluded 6,000 locations and 13 animals, specifically animals from fragmented habitats with less forest.
4. The claims about growth of the panther population are based on minimum number known alive from capture efforts, and may not reflect the actual population increase. However, it is indisputable that the population has increased markedly since introgression in 1995.

Defects of this paper:

1. Home range analysis was based on Minimum Convex Polygon, which can include large areas of unused habitat in the home range.
2. The GIS layers for vegetation date from the late 1990s, but most

panther locations were from late 1980s. During the interim, a lot of land was converted either to agriculture or to "improved pasture,"thus this analysis certainly mis-attributes some locations to non-forest habitat. It is impossible to know if this is a serious problem.

3. The paper was poorly organized, and the overly long Discussion section included both Methods (briefly described) and Results that were not reported in the sections with those titles. The abstract promised that the paper would use scats, tracks, and kill sites to elucidate daytime habitat use, but no quantitative analyses of these data were presented; instead they were qualitatively mentioned in the Discussion.

4. The fractal analysis, like that in Kerkhoff et al. (2000), is not intelligible. We see no value in either of the fractal analyses. Fractal analysis treats each panther location as an independent location; this fault would not be tolerated in conventional analyses but is not even mentioned by the fractal analysts. The fact that fractal analysis uses only windows centered on forest pixels (instead of all pixels) is probably necessary from a computational perspective, but is not explained, and seems to create an unavoidable bias toward a forest-centered view. The approach is convoluted and requires considerable work to interpret in terms of any tangible variables.

Cramer, P. C., and K. M. Portier. 2001. Modeling Florida panther movements in response to human attributes of the landscape and ecological settings. Ecological Modelling 140:51–80.

Summary: The model is an individually based, spatially explicit model created to assist in the introduction of panthers to northern Florida. A portion of the data generated from a feasibility study (introduction of Texas cougars into northern Florida [Belden and McCown 1996]), was used as the base for model development, calibration, sensitivity analysis, and validation. The study site was a 7,300-km^2 rural area in the Upper Suwannee River in northern Florida.

According to the authors, "Model output indicates locations in the study area with the highest potential for panther use, and predicts the consequences of human densities, roads, and future human growth on panther survival and utilization of the landscape." Model input included GIS data bases, deer densities based on 12 years of track counts ("The lack of specific deer density data on much of the study area makes this the weakest data source"), human density estimates, and a population of 7 panthers.

Results indicated that home range sizes were most sensitive to how panthers perceived the landscape, their place of reintroduction on the landscape, and gender-based rules. Panther interactions were dependent on perception distances. Model simulation results indicated locations along the Suwannee River where Florida panthers and humans would prefer to reside, both under 1990s landscape conditions and under 2 possible future scenarios that predicted future human development. Simulation results also indicated that panthers decreased use of hardwood hammocks and increased use of several other land cover types, were subjected to increased mortality on roads, and constricted their home ranges as human density and development increased.

The authors suggest that model results can be used to support conservation actions that restrict development in areas along rivers and identify landowners who own land panthers would most likely use.

"The strength of the model is its ability to predict where panthers move in the landscape, from accurately mimicking where reintroduction study cougars traveled, to predicting the most important landscape connections for wide ranging movements."

"Another limitation of the model is its inability to model 'smart' or 'dumb' behavior relating to how panthers make movement choices."

"Another limitation of the model is that it uses a population of seven panthers, which although dictated by computer limitations, restricts the ability of this research to make general conclusions for a larger population concerning panther behavior."

Comments: The model requires lots of decisions, which in turn requires lots of assumptions about panther behavior, etc. The model had many rules and few empirically based estimates; sensitivity analysis would have been helpful.

Culver, M., W. E. Johnson, J. Pecon-Slattery, and S. J. O'Brien. 2000. Genomic ancestry of the American puma (*Puma concolor*). Journal of Heredity 91:186–197.

Summary: The puma's range extends from Yukon to the Straits of Magellan. Until about 20,000 years BP, pumas shared North America with 3 other large felids that disappeared during the late Pleistocene extinctions, which probably also extirpated the puma from North America. Phylogenetic analysis of genomic DNA specimens from 315 pumas (148 wild, 113 captive, 54 museum specimens) of known geographic origin (3 mtDNA sequences and microsatellite genotypes based on 10 loci) indicates that current pumas exist as 6 subspecies or phylogeographic groups. The entire North American population (NA, based on 186 individuals from 15 previously named subspecies) belong to a single genetically homogeneous group and should be considered a single subspecies. The other 5 phylogeographic subspecies include 3 large and distinct units, eastern South America (ESA, roughly sub-Amazonian Brazil and Paraguay; this forms the ancestral home of puma), southern South America (SSA, roughly Chile and southern Argentina), and northern South America (NSA, most of the rest of South America). The other 2 proposed subspecies are probably hybrid zones: Central America (CA, roughly Costa Rica, Panama, and Nicaragua; an intergrade between NA and NSA) and central South America (CSA, roughly northern Argentina; an intergrade between ESA and SSA). The marked uniformity of mtDNA and a reduction in microsatellite allele size expansion indicates that North American pumas derive from a replacement and recolonization by a small number of founders about 10,000 years BP. These founders originated from a centrum of puma genetic diversity in eastern South American about 300,000 years ago.

Four nominal NA subspecies showed relatively low levels of microsatellite variation (modern *coryi*, *olympus*, the truly insular *vancouverensis*, and the apparently extinct *couguar*); however, samples sizes were low in each case (4, 4, 6, and 3, respectively). *Coryi* samples from 6 *coryi* museum specimens "dating to the turn of the 19th century" contained 6 microsatellite alleles that were absent from the 4 modern *coryi* samples. *Coryi*'s apparent decline in microsatellite genetic variability was evident in polymorphism (50% in 6 museum specimens, 20% in 4 modern samples), mean heterozygosity (42% declining to 5%), and average number of alleles per locus (2.3 declining to 1.2).

September 2002 personal communication from M. Culver to P. Beier: "The 6 turn of the century Florida panthers were mostly from the area where the type specimen was from, Sebastian, Florida (2 of the specimens I used were para-types). They were all central, not southern Florida. The dates are 1890–1922, except 1 specimen from 1965 from the Florida Museum of Natural History. In retrospect, 1965 is more likely to be post-bottleneck and should not have been included with the other specimens. The heterozygosity should probably be recalculated without the 1965 specimen.... I don't know how many other voucher museum specimens could be located. I tried to get all I could find and collected 12, of which only 6 worked. The Harvard Museum would not let me sample the 'type' specimen."

Comments: The most striking finding is that *coryi* loss of genetic variation probably occurred very recently. This dramatic change casts doubt on the idea that Florida's peninsularity created a naturally isolated population. The authors admit, however, that the small number of individuals sampled could have caused these results. It would certainly be useful to double the sample sizes of historic and modern individuals to statistically resolve this. Although Culver (personal communication, above) indicates that additional historical examples do not exist in museums, perhaps some families have panther skulls or hides from circa 1900 that could be sampled. Furthermore, perhaps another lab would be able to extract usable DNA from the 6 museum specimens that did not yield DNA for Culver.

Cunningham, M. W., M. R. Dunbar, C. D. Buergelt, B. Homer, M. Roelke-Parker, S. K. Taylor, R. King, S. B. Citino, and C. Glass. 1999. Atrial septal defects in the Florida panthers. Journal of Wildlife Diseases 35:519–530.

Abstract: Ostium secundum atrial septal defects (ASDs) were observed in six (3 M, 3 F) of 33 (20 M, 13 F) (18%) Florida panthers (*Puma concolor coryi*) necropsied by veterinary pathologists between 1985 and 1998. A seventh ASD was found in a female panther necropsied in the field and is included in the pathological description but not the prevalence of ASDs in Florida panthers. One panther (FP205) with severe ASD also had tricuspid valve dysplasia (TVD). Atrial septal defects and/or TVD are believed to have caused or contributed to the deaths of three (9%) Florida panthers in this study. Mean diameter ± SD of ASDs was 9.0 ± 4.7 mm (range 3 to 15 mm). Gross pathological changes attributed to ASDs/TVD in severely affected panthers (ASD ≥ 10 mm) (n = 4) included mild right ventricular dilatation (n = 3) and hypertrophy (n = 2), mild to severe right atrial dilatation (n = 2), interstitial and/or pleural fibrosis (n = 2), perivascular fibrosis (n = 1), and acute to chronic edema (n = 3). Twenty-six necropsied panthers were examined one or more times while living; medical records were retrospectively evaluated. Antemotem radiographic, electrocardiographic, and echocardiographic examinations were performed on two panthers with severe ASDs (FP20 and FP205). Thoracic radiographic abnormalities in both included right heart enlargement, and in FP205 (severe ASD and TVD), mild pulmonary overperfusion. Electrocardiographic examination of FP205 revealed a right ventricular hypertrophy pattern, while FP205 had a normal electrocardiogram. Echocardiographic examination of FP20 revealed marked right atrial dilatation; a bubble contrast study indicated regurgitation across the tricuspic valve. Echocardiographic abnormalities in FP20 included right atrial and ventricular dilatation, atrial septal drop-out, and severe tricuspid regurgitation; non-selective angiography revealed significant left to right shunting across the ASD.

All panthers with severe ASDs ausculted revealed significant left to right or left-sided grade I-V/VI murmurs loudest at the heart base. All male panthers with ASDs (n = 3) (100%) and 9 of 17 (53%) male panthers without ASDs in this study were cryptorchid.

Dalrymple, G. H., and O. L. Bass. 1996. The diet of the Florida panther in Everglades National Park, Florida. Bulletin of the Florida Museum of Natural History 39:173–193.

Summary: The authors examined the diet of Florida panthers in Everglades National Park (ENP) from 1984 to 1991 using data from 113 kill sites of 9 radio-collared panthers, and 272 scats found at kill sites and from free-ranging panthers. They used percent occurrence and percent frequency to evaluate food habits. Nine species were identified at kill sites and 14 species from scats. White-tailed deer (*Odocoileus virginianus*) was the most important prey species according to kill and scat analyses, composing 78% of estimated consumed biomass. In scat analysis, deer were the most common prey item (82% occurrence, 86% frequency in scats at kill sites; 39% occurrence, 43% frequency in scats at other sites; and 65% occurrence, 69% frequency in all scats). Most kills were of adult bucks (especially) and does. Mean time spent at kills was 3.86 days. Secondary prey species from scat analysis were marsh rabbits (*Sylvilagus palustris*) and raccoons (*Procyon lotor*). The diet of panthers in ENP was compared to that of panthers from southwestern Florida, including Big Cypress National Preserve. The estimated consumed biomass of white-tailed deer in ENP was nearly identical to the combined consumed biomass of deer and feral hogs from southwestern Florida.

Dees, C. S., J. D. Clark, and F. T. Van Manen. 2001. Florida panther habitat use in response to prescribed fire. Journal of Wildlife Management 65:141–147.

Summary: Managers at Florida Panther National Wildlife Refuge and adjacent Big Cypress National Preserve conduct annual prescribed burns in pine (*Pinus* sp.) as a cost-effective method of managing wildlife habitat. To determine if temporal and spatial relationships existed between prescribed fire and panther use of pine, the authors paired fire-event data from the refuge and the preserve with panther radio locations collected between 1989 and 1998 (1,940 locations on 26 individuals). Radio locations were collected between 0600 and 1000 hours, locations for panthers <1.5 years old and locations of denning panthers from 10 days prior to and 70 days following denning were excluded. The authors determined the time that had elapsed since burning had occurred in management units associated with the

radio locations, and generated a frequency distribution based on those times. This distribution was compared to an expected frequency distribution, based on random use relative to time since burning. Analysis revealed that panther use of burned pine habitats was greatest during the first year after a management unit was burned. Also, compositional analysis indicated that panthers were more likely to position their home ranges in areas that contained pine. The authors suggest that panthers were attracted to <1-year-old burns because of white-tailed deer (*Odocoileus virginianus*) and other prey responses to vegetation and structural changes caused by the prescribed fires. The strong selection for stands burned within 1 year is a persuasive indication that it is the burning in pine, rather than the pine per se, that most influenced habitat use. Before burning rotation lengths are reduced, however, managers should determine effects of shorter burning intervals on vegetation composition and evaluate the landscape-scale changes that would result.

Downing, R. L., L. K. Halls, R. L. Marchinton, and R. J. Warren. 1986. Deer management review panel. Final Report. Big Cypress National Preserve, Ochopee, Florida, USA. 20pp.
Summary: A panel was formed in 1985 to make recommendations on deer management on Big Cypress National Preserve because deer are an important prey species for Florida panthers, and deer were perceived to be in decline. The panel concluded that legal buck hunting did not affect herd productivity or rate of increase. The lack of older does in the population suggested they were the target of panther predation or that illegal hunting was responsible. The panel made several recommendations concerning deer management, more comprehensive data collection, and research priorities. The panel also suggested managing for feral hogs since they also are an important prey species. The panel's recommendations were designed to reduce deer harvest and more carefully monitor population trends.

Dunbar, M. R. 1994. Florida panther biomedical investigation. Final Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 81pp.
Note: This report is reprinted in full in Jordan (1994*b*).
Abstract: Veterinary medical management to reduce capture-associated mortality, provide medial care to promote health and increase survival, and to conduct biomedical research to further the understanding of disease, nutrition, and reproductive physiology continued as an integral part of the Florida panther (*Felis concolor coryi*) recovery. Since veterinary involvement began in 1983, 159

immobilizations involving 58 individuals have been accomplished with one mortality (0.63%) in 1983, possibly capture-related. This fiscal year resulted in re-collaring 9 panthers and the capture and radio-instrumentation of 2 newly captured panthers. In addition, 8 kittens were hand-caught, examined, and released at 3 den sites. A total of 22 kittens have been hand-caught during this four-year period. A range of 18 to 23 individual panthers have been monitored by telemetry during this 4-year period. Presently, 18 panthers (8 males, 10 females) are being monitored. the panther population estimate is 30 to 50 adults. Serologic evidence indicates that they were exposed to or were infected with several potentially pathogenic agents: feline calicivirus, feline panleukopenia virus, feline rhinotracheitis virus, feline enteric coronavirus/feline infectious peritonitis, feline immunodeficiency virus/puma lentivirus. However, panthers were serologically negative for *Brucella* sp., *Toxoplasma gondii*, feline leukemia virus, and pseudorabies virus. Twenty-one deaths were documented during this 4-year period. In fiscal year 93/94, 71% of the 7 deaths were due to road kills, 14% to intraspecific mortality, and 14% to bacterial infection. Panthers were positive for 2 trematodes, 2 cestodes, 6 nematodes, 1 acanthocephalan, and 1 protozoan. No major changes in endoparasite loads were found compared to previous studies of the Florida panther (Forrester et al. 1985). Two studies were initiated this fiscal year, one on vitamin A and one on estradiol levels in panthers. No vitamin A deficiency was found, although, vitamin A levels were correlated with several variables, including age and prey base. Apparently high estrogen levels in male panthers were suggestive of exposure to environmental estrogenic chemicals. There were no attempts to breed panthers in captivity during this period. One captive adult (#200) was euthanized this year due to a severe neurological disorder, leaving a total of 9 panthers currently in captivity.

Dunbar, M. R., G. S. McLaughin, D. M. Murphy, and M. W. Cunningham. 1994. Pathogenicity of the hookworm, *Ancylostoma pluridentatum*, in a Florida panther (*Felis concolor coryi*) kitten. Journal of Wildlife Diseases 30:548–551.

Abstract: We evaluated clinical signs and administered anthelmintic treatment to a wild-caught, captive Florida panther (*Felis concolor coryi*) kitten from Big Cypress National Preserve, Florida (USA) infected with the hookworm *Ancylostoma pluridentatum*. Clinical signs observed included poor body condition, lethargy, and below normal red blood cell numbers, hemoglobin concentration, and packed cell volume, and elevated eosinophil numbers. In addition, a

maximum of 936 *Ancylostoma* sp. eggs/g of feces were found on Day 11 of captivity. Following oral administration of 20 mg/kg pyrantel pamoate on Day 11, 26 *A. pluridentatum* were collected from the feces. Based on the resolution of clinical signs, cessation of egg shedding, and a return to normal hematologic values following anthelmintic treatment, we believe that infection with *A. pluridentatum* was the primary cause of the stressed conditions in the panther kitten.

Dunbar, M. R., P. Nol, and S. B. Linda. 1997. Hematologic and serum biochemical reference intervals for Florida panthers. Journal of Wildlife Diseases 33:783–789.

Abstract: Ninety-four blood samples were collected from 48 (29 males and 19 females) free-ranging Florida panthers (*Felis concolor coryi*) captured in southern Florida (USA) from 1983 to 1994 for routine hematological and serum biochemical analysis. Florida panthers in the northern portion of their range had significantly higher red blood cell (mean ± SD = 7.923 X 10^6 ± 0.854 X 106/μl), hemoglobin (12.53 ± 1.66 g/dl), and packed cell volume (36.97 ± 4.27%) values compared to those of panthers localized in more southern parts of Florida (7.148 X 10^6 ± 1.045 X 106/μl, 11.60 ± 1.62 g/dl, and 34.82 ± 5.99%, respectively). Adults had significantly higher mean serum total protein (7.50 ± 0.59 g/dl) and packed cell volume (36.90 ± 4.97%) values than juveniles (6.88 ± 0.49 g/dl and 34.54 ± 5.30%). However, mean serum albumin concentrations were significantly higher in juveniles (3.80 ± 0.26 g/dl) when compared to adult values (3.58 ± 0.26 g/dl). Mean serum calcium concentrations were significantly higher in juveniles (10.33 ± 0.39 mg/dl) than in adults (9.66 ± 0.45 mg/dl). Additionally, mean serum iron concentrations were significantly higher in those panthers of intergrade genetic stock compared to values in those of authentic genetic stock (105.6 ± 72.1 μg/dl versus 59.3 ± 19.7 μg/dl, respectively).

Dunbar, M. R., M. W. Cunningham, and S. T. Linda. 1999. Vitamin A concentrations in serum and liver from Florida panthers. Journal of Wildlife Diseases 35:171–177.

Abstract: Many of the anomalies and clinical signs afflicting the Florida panther (*Felis concolor coryi*) are suggestive of vitamin A deficiency. Our objectives in this study were to determine if a vitamin A deficiency exists in the free-ranging panther population and to determine if there are differences in vitamin A levels among various subgroups of free-ranging panthers. Retinol concentrations were used as an index to vitamin A concentrations and were determined in serum

and liver from free-ranging (serum, $n = 45$; liver, $n = 22$) and captive (serum, $n = 9$; liver, $n = 2$) juvenile and adult Florida panthers from southern peninsular Florida (USA), and in liver from free-ranging cougars (*F. concolor* subspp.) from Washington (USA) and Texas (USA) between November 1984 and March 1984. Combined juvenile (6- to 24-mo-old) and adult (>24-mo-old) free-ranging Florida panthers had mean ± SD serum retinol concentrations of 772.5 ± 229 pmol/ml. Adult free-ranging Florida panthers had mean liver retinol concentrations of 4794.5 ± 3747 nmol/g. Free-ranging nursing Florida panther kittens (age <1 mo) had mean serum retinol concentrations of 397.9 ± 69 pmol/ml. Among subgroups of free-ranging Florida panthers, females had higher concentrations of mean serum retinol concentrations than juveniles. Retinol concentrations in free-ranging Florida panthers did not differ significantly from those in captive panthers (liver and serum) or other free-ranging cougars (liver). Based on limited published values and our controls, a vitamin A deficiency could not be demonstrated in the Florida panther population nor were any subgroups or individuals considered deficient.

Ellis, S., R. C. Lacy, S. Kennedy-Stoskopf, D. E. Wildt, J. Shillcox, O. Byers, and U. S. Seal. 1999. Florida panther population and habitat viability assessment and genetics workshop report. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota, USA. 88pp.

Summary: In light of the ongoing, and apparently successful, program of genetic introgression and restoration using Texas pumas, this workshop was convened to conduct a population and habitat viability analysis (PHVA). A previous PHVA was conducted in 1989. The Introduction described the workshop as involving gathering information and deliberation about the major issues to list actions that will contribute to panther conservation. Modeling is mentioned as part of *The PHVA process* (p. 11), but it is not clear that any modeling occurred during the workshop. The process is described in somewhat vague terms: "[I]nformation contributed by…scientists,… landowners, and others all carry equal importance" (p. 11). Success is "an outcome where all participants coming to the workshop with different interests 'win'" (pp. 11–12). "Local solutions take priority" (p. 12). This workshop, held in Gainesville on 8–11 June 1999, had 31 participants, who divided themselves into 4 working groups that addressed 5 topics, namely, assessment of wild populations, health, genetics, captive populations, and modeling. There was no formal Methods section in the document. In comparing PHVAs from 1989 and 1992, they varied parameter values and assumptions including inbreeding depression, breeding age, maximum age, mean litter size, percent males breeding, mortality rates, "catastrophes," N_0 (initial abundance), K (carrying capacity), changes in K, removals, and releases.

A brief comparison of Vortex simulations in 1989 and 1992 (both predicted 100% extinction risk) to another Vortex PVA in 1999 (0% extinction risk) has since been published in expanded form (Maehr et al. 2002*b*). They recommended more effort in estimating kitten survival rates.

Workshop recommendations regarding the captive panther population seem to have been implemented at about the time of the workshop (Florida Panther Interagency Committee 1999). The workshop recommended 3 types of monitoring to evaluate the genetic restoration program; these are stated as monitoring goals in current reports from that program (Shindle et al. 2001). However, as of 2002 we lack reports on some planned analyses (e.g., contribution of Texas genes based on molecular analysis). Reasonable recommendations were made to continue to gather biomedical data on wild panthers. The participants were unable to recommend quantitative recovery criteria for inclusion in a revised recovery plan. Participants discussed concerns about unplanned genetic introgression from interactions between panthers and captive puma on the Seminole Indian Reservation (see McBride's Appendix IV in Shindle et al. 2000). There was considerable discussion whether the Texas females in Florida should be contracepted, removed, or left alone. Bob Lacy did an on-the-fly analysis—based simply on the numbers of known TX, F_1, and backcross animals on the ground, combined with a guess of 55 pure Florida panthers—that there were 18% TX genes at the time. The various subgroups provided several specific recommendations; most of those tasks were assigned to "field veterinarian," Darrell Land, Deborah Jansen, or Sonny Bass.

Comments: Page 58, Issue 1: Is this the highest priority? Much of this depends on uncertainty in parameters used in the Maehr et al. (2002*b*) model; some work is needed to describe a range of uncertainty in parameter values. Page 60, need more details here. Even with the parameters nailed down better—and that seems doubtful—there is the issue of the intrinsic (environmental, catastrophic) variability. Alternative functional relationships also do not seem to have been adequately considered. See, for instance, Runge and Johnson (2002) on the issue of functional form and extrapolation beyond the range of data used to estimate parameters. Substantial divergence in predictions under reasonable alternative models suggest the need to formally incorporate uncertainty into decision making (e.g., through

ARM). Issue 2: Again, though, the assumptions of the model (VORTEX) itself, functional forms of things like density dependence are critical. Have alternatives to these been considered, and are they being incorporated in evaluating PVA and in making decisions? Page 61, box 2: This information could be used to formally address uncertainty in these parameters for PVA analysis.

Evans, C. 1994. Improving cooperation between private landowners and government agencies to protect panther habitat. Pages 323–330 *in* D. B. Jordan, editor. Proceedings of the Florida Panther Conference, 1–3 November 1994, Ft. Myers, Florida, USA.

Summary: A plea to involve private landowners in the recovery plan as partners. Incentives can maintain habitat quality for panthers and keep land on the tax rolls. The annual cost of landowner incentives would be less per acre than annual management costs if the land were owned by the government for conservation purposes. An incentive program also avoids the purchase price and the problem that the largest landowners are not willing to sell. Specific proposals for a combination of incentives and constraints on land use are presented.

Facemire, C. F., T. S. Gross, and L. J. Guillette Jr. 1995. Reproductive impairment in the Florida panther: nature or nurture? Environmental Health Perspectives 103:79–86.

Abstract: Many of the remaining members of the endangered Florida panther (*Felis concolor coryi*) population suffer from one or more of a variety of physiological, reproductive, endocrine, and immune system defects including congenital heart defects, abnormal sperm, low sperm density, cryptorchidism, thyroid dysfunction, and possible immunosuppression. Mercury contamination, determined to be the cause of death of a female panther in 1989, was presented as the likely cause of thyroid dysfunction. As genetic diversity in the species was less than expected, all of the other abnormalities have been attributed to inbreeding. However, exposure to a variety of chemical compounds, especially those that have been identified as environmental endocrine disrupters (including mercury, *p.p'*-DDE, and polychlorinated biphenyls), has elicited all of the listed abnormalities in other species. A number of these contaminants are present in south Florida. An exposure pathway has been identified, and evidence presented in this paper, including the fact that there appears to be no significant difference between serum estradiol levels in males and females, suggests that many male panthers may have been demasculinized and feminized as a result of either prenatal of postnatal exposure. Thus, regardless of the effects of inbreeding,

current evidence seems to indicate that environmental contaminants may be a major factor contributing to reproductive impairment in the Florida panther population.

Fleming, D. M., J. Schortemeyer, and J. Ault. 1994. Distribution and abundance of white-tailed deer in the Florida Everglades. Pages 247–273 *in* D. B. Jordan, editor. Proceedings of the Florida Panther Conference, 1–3 November 1994, Ft. Myers, Florida, USA.

Abstract: The large size of white-tailed deer, their role as a major herbivore in the Everglades, as well as significant and well-publicized die-offs related to high water conditions, and their importance as a key prey base for the endangered Florida panther, have focused attention on the Everglades deer herd. However, no data are available on the relative distribution and abundance of deer in the Everglades in relation to systemwide landscape patterns and temporal characteristics. Objectives of this study, therefore, were to (1) document seasonal and annual changes in their relative distribution and abundance systemwide, (2) identify environmental correlates influencing the distribution and abundance patterns observed, with particular reference to hydrologic parameters, and (3) assess changes in deer distribution and abundance in response to intensive, regional water management regulation initiated in the early 1960s.

Systematic aerial surveys were conducted over the freshwater, interior wetlands of the system during the wet (August/September) and late dry season (May/June) months from 1985–1989 to document deer distribution and abundance. Annual productivity estimates (number of fetuses per adult doe) from harvested does in the northern Everglades and annual recruitment indices (number of 3+ month old fawns in population) for the entire study area were also obtained during this study period.

Highest average densities of deer observed occurred in wetlands characterized by seasonal water level fluctuation and intermediate hydroperiods. Estimated average breeding date occurred on 30 July, and ranged from 26 July to 1 August. Estimated breeding dates of individual deer (n = 69) ranged from 13 May to 10 September. Annual average productivity over the study period was 1.18 (n = 69) and ranged from 1.0–1.33. Annual productivity was related to average marsh water depths during the gestation period (September–January). Peak fawning was well synchronized with seasonal changes in the hydrologic regime and occurred during the middle of the dry season (February/March), at a time when numerous dry sites are normally available for fawning. Fawn survivorship was inversely related to average marsh water depths during the fawning season (January–May) of each study year in drainage basins with pronounced seasonal water level fluctuations. In such drainage basins, total numbers of deer fluctuated in relation to seasonal and annual changes in marsh water depths.

Comparison of deer herd population estimates from this study with those of previous studies conducted in the 1950s suggest that a major reduction in deer numbers within the northern Everglades has occurred. Environmental factors believed related to this decline, including wetland drainage and impoundment associated with intensive, regional water management practices initiated in the 1960s, are discussed along with critical hydrologic restoration elements.

Florida Panther Interagency Committee. 1999. Plan for management of captive held Florida panthers. Tallahassee, Florida, USA. 8pp.

Summary: The captive breeding program, approved in 1991, was never implemented. Of the 10 animals removed from the wild as kittens in 1991–1992, 2 have died, 2 were released back into the wild (where they died within 6 weeks), and 6 (3 males, 3 females) remain in captivity (2 in each of 3 facilities). One of the captive males is sterile; 4 individuals may be the only representatives of particular genetic lineages. There have been no attempts to breed any of the captives. In 1992, when it became apparent that the program probably would not proceed, a genetic restoration program was instituted instead, removing the original goal of the program. Options now are to release them back into the wild or maintain them in captivity. Because these animals may not survive in the wild after 8 years in captivity, they probably can best serve recovery by being mated, as soon as possible, to produce kittens that conserve genetic lineages for continued breeding, possible establishment of new populations, medical and reproductive research, and public education.

Comments: Release of progeny back into the existing population is not mentioned explicitly, but is alluded to *only* in the statement that the program could "meet specific demographic needs within the wild population." As of November 2002, the suggestion to mate them had not been implemented, and by this time the animals were probably too old to reproduce.

Florida Panther Subteam of the Multi-species/Ecosystem Recovery Implementation Team for South Florida. 2002. Landscape conservation strategy for the Florida panther in south Florida. U.S. Fish and Wildlife Service, South Florida Ecological Services Office, Vero Beach, Florida, USA.

Note: This was a draft report. Scientific Review Team (SRT) members were encouraged to send individual comments directly to U.S. Fish and Wildlife Service. Beier provided several pages of comments in spring 2003. As of November 2003, the SRT is not aware of whether a final draft has been published.

Forrester, D. J., J. A. Conti, and R. C. Belden. 1985. Parasites of the Florida panther (*Felis concolor coryi*). Proceedings of the Helminthological Society of Washington 52:95–97.
Abstract: Between 1978 and 1983 12 Florida panthers (*Felis concolor coryi* Bangs) were examined for parasites. Seven were examined at necropsy and the other five were live animals examined during capture operations. Findings included 1 species of protozoan, 2 trematodes, 3 cestodes, 7 nematodes, 6 ticks, and 1 flea. All panthers were infected with at least six species of parasites. Intensities varied from 263 to 10,094 parasites per animal. The two most prevalent and abundant parasites were the diplostomatid trematode *Alaria marcianae* (LRue, 1917) and the hookworm *Ancylostoma pluridentatum* (Alessandrini, 1905).

Foster, M. L., and S. R. Humphrey. 1995. Use of highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin 23:95–100.
Summary: Highway collisions account for 49% of documented panther mortality. This study was designed to determine if a combination of fencing and underpasses allowed movement across highways. The authors monitored 4 of 24 underpasses constructed on 64 km of I-75 for 2, 10, 14, and 16 months. They used digital event recorders and Trailmaster cameras. Photographs recorded 10 crossings by panthers, all by 2 individuals using 2 underpasses. Panthers crossed exclusively at night and crossed to get to part of their home range. Recommendations on underpass size are given.
Comments: Doubtless, roadkill is less than 49% of actual mortality.

Glass, C. M., R. G. McLean, J. B. Katz, D. S. Maehr, C. B. Cropp, L. J. Kirk, A. J. McKeirnan, and J. F. Evermann. 1994. Isolation of pseudorabies (Aujeszky's disease) virus from a Florida panther. Journal of Wildlife Diseases 30:180–184.
Abstract: Pseudorabies virus was isolated in cell culture from the brain tissue of a 3.5-year-old male Florida panther (*Felis concolor coryi*). The virus was not isolated from other tissues collected at necropsy. Based upon a nested polymerase chain reaction (pcr), the virus was determined to have the classical wild-type virulent genotype, glycoprotein I^+ (gI^+) and the thymidine kinase$^+$ (TK^+).

Greiner, E. C., M. E. Roelke, C. T. Atkinson, J. P. Dubey, and S. D. Wright. 1989. Sarcocystis species in muscles of free-ranging Florida panthers and cougars (*Felis concolor*). Journal of Wildlife Diseases 25:623–628.

Abstract: Sarcocysts of *Sarcocystis* sp. were found in the striated muscles from 11 of 14 wild Florida panthers and four of four cougars (two wild *stanleyana* and two captives of undetermined subspecies). The common occurrence of sarcocysts in muscles of top carnivores such as panthers and cougars is unexplained. This stage of the life cycle is normally confined to the muscles of the prey species. Because large felids are rarely preyed upon, it is unlikely that a species of *Sarcocystis* has evolved using large cats as intermediate hosts. Therefore, the presence of these sarcocysts might be an indication of immune compromise in these felids, enabling the atypical development of the sarcocysts.

Hedrick, P. W. 1995. Gene flow and genetic restoration: the Florida panther as a case study. Conservation Biology 9:996–1007.

Summary: Populations of some endangered species have become so small that they have lost genetic variation and appear to have become fixed for deleterious genetic variants. To avoid extinction from this genetic deterioration, individuals from related subspecies or populations may have to be introduced for genetic restoration (i.e., elimination of deleterious variants and recovery to a normal level of genetic variation).

The simplest predictions about allele frequencies after introduction assume no selection on loci. This paper considers the more complex situations of (1) the endangered population suffering from detrimental alleles that would be at a selective disadvantage to the introduced alleles and (2) the endangered population having alleles conferring local adaptation that should be favored but risk being swamped by introduced alleles. In case 1, both gene flow and selection act in concert, hastening the fixation of the new allele and elimination of the deleterious allele. In case 2, gene flow and selection operate in opposite directions, and the outcome depends on the level of selection and the level of dominance (which we can't control) and the level of introgression (which we can control). In small populations, genetic drift changes the deterministic outcomes of the above analysis into an array of different outcomes with different probabilities, readily amenable to mathematical analysis.

Seal (1994) recommended the translocation of Texas cougars into the free-ranging Florida panther population to achieve ~20% gene flow in the first generation of translocation and approximately 2–4%

in the generations thereafter. Hedrick's analysis in this paper suggests that this level of introgression has a low risk (<20%) of causing loss of any locally adapted allele, could result in elimination of highly deleterious alleles, and would greatly reduce (but probably not eliminate) moderately deleterious alleles. The bulk of the effect occurs via the 20% introgression in the first generation, with smaller marginal returns from 2.5% introgression per generation after the first generation. Assumptions about the effective population size of panthers can have a strong effect on the outcome. These conclusions hold for N_e of 40; at N_e of 20, there is somewhat greater risk of losing a locally adapted allele. Continuous gene flow after the first generation may not be needed to eliminate deleterious alleles (selection will continue to do the work in the absence of continued introgression). It is important to recognize that because adults do not have equal probability of being parents, N_e is probably considerably lower than the usual estimate of 30–50 adult panthers. If breeding is highly skewed, N_e could be as low as 10, and the actual impact of introducing, say 8 Texas females, could be much more than 20% introgression. Estimation of N_e is thus an urgent issue. Thus, unless the population of the free-ranging Florida panthers is very small, the planned translocation should result in genetic restoration of the Florida panther.

One new finding is that a locally adapted allele with a favorable effect (s) that is twice the level of introgression (m) may eventually be lost, an outcome most likely when dominance is low and N_e is low. Seal (1994) had predicted no loss of a favorable allele as long as $s > m$. However, terminating gene flow after 1 generation should eliminate this risk. This treatment ignores the effects of linkage disequilibrium ("genetic hitchhiking"), which could be significant, and of heterosis (heterozygote advantage or disadvantage), which is unlikely to be important.

Comments: This remarkably readable paper amply justified the target of 20% introgression. There is no indication, however, that the analyses in this paper were available to, or used by, Seal (1992) in setting this target. Hedrick's name was not included on the lists of participants in Seal (1991, 1992), nor in the U.S. Fish and Wildlife Service 1994 environmental analysis of the genetic restoration program. Hedrick did participate in Seal's 1994 workshop.

Hines, T. C., R. C. Belden, and M. E. Roelke. 1987. An overview of panther research and management in Florida. Pages 140–147 *in* Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium. Georgia Department of Natural Resources, Athens, Georgia, USA.

Abstract: This is a summary of Florida panther (*Felis concolor coryi*) research and management activities since 1976. Although some results are very preliminary, it appears that a viable but isolated population of panthers exists from Lake Okeechobee south in the Big Cypress/Everglades physiographic region. Some scattered documentation of animals exists outside this area but the significance of these animals is unclear. The threats that face the population include shrinking habitat, reduced prey base, disease and parasites, and possible reduced genetic diversity. Efforts are underway to subvert what appears to be a long term extinction process by identifying and mitigating threats wherever possible and by reintroducing panthers into formerly occupied range.

Janis, M. W., and J. D. Clark. 1999. The effects of recreational deer and hog hunting on the behavior of Florida panthers. Final Report Submitted to Big Cypress National Preserve, National Park Service, Ochopee, Florida, USA. 107pp.
Note: The main findings were published as Janis and Clark (2002).
Summary: This report is Michael Janis' M.S. thesis. See Janis and Clark (2002) for the published version of the main findings.

Janis, M. W., and J. D. Clark. 2002. Responses of Florida panthers to recreational deer and hog hunting. Journal of Wildlife Management 66:839–848.
Summary: The objectives of this study were (1) to test whether managed hunts affect panther activity rates, movement rates, predation success, home range dynamics, and habitat preferences; and (2) to assess whether public use of the addition lands would impact panthers that occur there. The design was a split plot (control/treatment) with repeated measures of 8 variables (activity rates, movement rates, predation success, home range size, home-range shifts, proximity to ORV trails, frequency of use of the Bear Island Unit, and habitat use). The study area was Florida Panther National Wildlife Refuge and Fakahatchee Strand State Preserve (control area); and Big Cypress National Preserve and addition lands (treatment). Data consisted of panther radio-locations collected since 1981 by the Florida Fish and Wildlife Conservation Commission and the National Park Service, which the authors augmented with radio locations and activity monitoring from 1994 to 1998. All telemetry locations (1981–1998) were daytime (0700–1100). The authors excluded data from females at dens or with cubs, and all non-adults. Included were only animals with >20% of their locations on public lands. There were a number of other exclusions, depending on the analysis.

Only 2 variables (proximity to ORV trails and use of Bear Island) were related to human activity. The other variables may have been influenced by environmental (e.g., temperature, water levels) factors. Panthers (3 males, 3 females) were located closer to ORV trails before hunting season than during or after hunting season. Eleven panthers (1989–1998) were used in the Bear Island Unit and refuge analysis. Control panthers used the refuge more after hunting season than before, while treatment panthers used Bear Island less during the hunting season than before or after hunting season. The decreased use of Bear Island is most likely a direct reaction to human activity and resulted in increased use of adjacent private lands. Future habitat loss on those private lands could exacerbate the negative consequences of this response by panthers.

This was the only study to examine how hunting may have affected panther fitness (kill rate as inferred from telemetry), and they found that female panthers had a slightly higher kill rate on Bear Island (hunted area) than in the control area. The data for males were so inconclusive that they did not even report mean kill rates for the 2 areas.

Comments: Despite the basic lack of replication (1 control area, 1 treatment area), this was the best study on this topic.

Johnson, M. K., and R. C. Belden. 1984. Differentiating mountain lion and bobcat scats. Journal of Wildlife Management 48:239–244.

Summary: Scat identification is essential to food habit studies to ensure that samples all come from the target species. There is overlap in scat and scrape dimensions for several species of felid, making visual identification difficult. This study's objective was to determine if thin-layer chromatographs of fecal bile acids can distinguish between mountain lion and bobcat scats. Scats from 10 captive bobcats and 10 captive lions, plus 144 scats collected in the field (including known bobcat and 24 lion) were numbered, but otherwise unidentified, and submitted for testing. Using thin-layer analysis alone, 64% of bobcat and 79% of mountain lion known scats were correctly identified, but 28 and 17%, respectively, were misidentified. When chemical analysis was used to confirm visual analysis, no misclassifications occurred, but only 50% of bobcat and 75% of mountain lion scats could then be identified. Field collected (unknown) scats were often (37%) too weathered to be analyzed chemically. Visual identification of scat, particularly when other sign, such as tracks at the collection site, is available, is likely more effective than chemical identification alone. When other sign is unavailable, visual identification is uncertain, or high accuracy is required, however, chemical analysis can be used to confirm that all samples are of the same species.

Johnson, W. E., D. Land, I. Mortenson, M. Roelke-Parker, and S. J. O'Brien. 2003. Preliminary results of Florida panther genetic analyses. Seventh Mountain Lion Workshop, Jackson, Wyoming, USA.

Note: Abstract only.

Abstract: Previous genetic analyses showed that Florida panthers (*Puma concolor coryi*) had the lowest genetic diversity among all North American puma, and subsequent modeling suggested that further declines could increase the probability of extinction. Currently, there are fewer than 100 panthers in south Florida. Although ongoing habitat conservation strategies may provide long-term stability for today's population extents, these same strategies are unlikely to allow the population to grow to 500 or more individuals, whereby genetic viability is more assured. As a result, a plan for Florida panther genetic restoration was created in 1994 and implementation began in the spring of 1995 with the release of 8 female Texas puma into areas occupied by panthers. Our objectives were to monitor the effectiveness of genetic restoration by developing an array of molecular genetic markers that characterized the status of current and past populations, to construct a pedigree among Florida panthers to follow inheritance patterns, to infer degrees of relatedness among individuals, and to help predict the future viability of the population. We have completed genotyping over 175 samples from Florida panthers at 23 microsatellite loci and these included individuals from canonical Florida panthers, the Everglades subpopulation (Piper stock), released Texas puma, crosses among all stocks, and captive animals of unknown ancestry from the early 1970s to the present. Genetic restoration has increased hetereozygocity within the population, but we have documented the loss of some panther matrilines. Certain morphological traits such as cryptorchidism, kinked tails, cowlicks, and atrial septal defects observed in canonical panthers are not present in the Texas puma descendants. We have identified several subgroups within our population and these subgroups seem to be partially the product of philopatric tendencies among dispersing female offspring. Male panthers may be physically and behaviorally capable of siring offspring earlier than suggested by radio-telemetry work and resident and resident males are not siring all litters with females within the respective males' home ranges. Intraspecific aggression, a common mortality agent for young male panthers, may not be removing panthers prior to producing offspring. Future monitoring should

ensure sampling across all panther subgroups in order to adequately estimate total population genetic characteristics.
Comments: The Scientific Review Team did not attend the Jackson meeting. It is not clear if they succeeded in developing genetic markers that will indicate degree of Texas-Florida hybridization.

Jordan, D. B. 1991. Final supplemental environmental assessment a proposal to establish a captive breeding population of Florida panthers. U.S. Fish and Wildlife Service, Florida Panther Recovery Coordinator's Office, University of Florida, Gainesville, Florida, USA. 136pp.
Note: This environmental assessment for the now-aborted captive breeding program is of limited utility unless the captive breeding option is resurrected. The1994 decision to embark on a genetic introgression program, and the rapid apparent success of that program since 1995, decreased the impetus for captive breeding.
Summary: This environmental assessment (EA) stressed the need for a captive population to insure *security* of the population (prevent immediate extinction), which is acknowledged to differ from *recovery* (a longer-term process). The alternatives considered included (1) no action; (2) translocation of Florida panthers within the range, to improve gene flow, and to unoccupied suitable habitats; (3) use kittens and select adults (those not reproducing in the wild and without captive offspring in the program) to establish a captive population (this was the preferred alternative); (4) use only kittens to establish a captive population; (5) use only adults and subadults to establish a captive population; (6) capture all panthers from the wild to establish a captive population; (7) genetic introgression from another puma subspecies.

For each alternative, the EA describes the probable impacts on the wild population, contribution of the alternative to maintaining *coryi* genes, how effectively it would prevent extinction, and socio-economic impacts. Alternative #2 could cause social disruption in the receiving subpopulation; could spread disease and, given the low genetic diversity throughout the range, might not improve genetic mixing as much as a captive breeding program. Alternative #4 would not protect as much genetic material as Alternative #3, which would also free up space and resources for subadults to join the wild breeding population. Alternative #5 would remove 30 to 80% of the wild adult population, making its extinction likely. Alternative #6 would guarantee the extinction of the wild population and is thus contrary to the primary goal of the recovery plan. Alternative #7 received the longest discussion. The EA affirms that the Endangered Species Act does permit this type of management (i.e., it would not cause the panther to become a non-listable entity). There is some uncertainty whether perceived genetic problems would be correctable by introgression. Although, theoretically, intercrossing could have negative effects (due to loss of local genetic adaptation) the EA argues that puma subspecies are weakly differentiated, "indicating a recent and shallow evolutionary separation of populations that formerly would have been connected by gene flow" and further notes that pumas are capable of long-distance dispersal. The EA advocates that planned introgression should be a part of panther management, but that this would not obviate the value of a captive breeding program. It further argues that evaluating genetic augmentation and the development of technology and strategy for such an effort "*can best be obtained and applied under captive conditions*" (emphasis in original). In particular, experiments with captive animals could allow a quantitative analysis of both the positive and negative benefits of crossing. Disruption of social structure, spread of disease or parasites, and creation of "a false sense of management accomplishment" (an excuse to ignore underlying habitat issues) are given as possible negative effects of Alternative #7. Finally, the EA argues that Alternative #7 would address only 1 of the 3 urgent problems that the proposed action seeks to address, those problems being low panther numbers, the single population, and genetic deterioration.

Comments: The last argument, that Alternative #7 would produce a "false sense of management accomplishment," applies with equal force to the preferred alternative. The idea that #7 would not address the urgent problem of low panther numbers apparently was probably (in retrospect in 2003) incorrect, as the population boomed after introgression.

The considerable discussion on Alternative #7 suggests that this option had strong proponents in 1991. Three years later, U.S. Fish and Wildlife Service (1994) picked #7 as the preferred action. It is worth keeping in mind that, as this EA pointed out in 1991, introgression will not address the critical issue of having a single, isolated panther population.

Page 3: The viability projections seem very debatable, especially given more recent and conflicting analyses.

Page 15: Capture of adults: perhaps the reasons they failed to reproduce in the wild would make them unsuitable for captive production?

Page 22, bottom: The authors suggest that information about 1 cat for each of 3 different programs provides information on each program. Obviously, this is unreplicated and anecdotal only.

Page 41: The conclusions about time to extinction are totally dependent on assumptions about inbreeding depression on demography.

Page 52: Alternative #4 was dismissed too quickly, solely on the unsupported notion that "all available" genetic material is needed.

Page 58, top: Why should captive propagation precede genetic translocation?

Page 2: The distinction between "security" and "recovery" is made repeatedly, but it is not entirely clear what the distinction really is. Presumably, these terms relate to "Priority 1 and 2" ("actions that must be taken to prevent extinction or an irreversible decline in the foreseeable future….or significant negative impact short term" and "Priority 3" ("actions that must be taken to provide full recovery") as defined on page 1.

Jordan, D. B. 1994*a*. Final preliminary analysis of some potential Florida panther population reestablishment sites. U.S. Fish and Wildlife Service, Atlanta, Georgia, USA. 107pp.

Summary: The title ("Final preliminary") makes more sense if you first read Enclosure 1 ("Preliminary analysis…" dated August 1993). The 1993 report summarized the results of a questionnaire sent to state wildlife agencies and federal offices within historic panther range, inviting respondents to nominate potential reintroduction sites for panthers. The 33 respondents nominated 24 sites. Respondents rated each site based on 10 criteria thought to be related to success of a reintroduced population. However, many of the criteria were estimated subjectively by the various respondents, other criteria were notoriously inaccurate (deer population density), and others may not have long-term relevance to success of a reintroduction (current hunting practices).

The 24 sites from 1993 were reduced (in most cases by combining sites and tweaking their boundaries) to 14 sites evaluated in this "final preliminary" analysis. The perimeter of each study area was based on county lines. The analysis used 4 criteria that are clearly important and that can be reliably estimated, namely square miles in the study area that meet the definition of rural, percentage of area in forest cover, number of housing units per square mile, and miles of public roads (paved and non-paved) per square mile. For an overall ranking, the 4 scores were equally weighted (a procedure acknowledged to be wrong, but as defensible as any other weighting). Interestingly, among an expanded group of 15 sites, the existing range of the panther would rank seventh overall, first (best) in road density, seventh in human population density, and fifteenth (worst) in forest cover.

At least 2 of the potential sites probably are at least partially outside the range of *coryi*.

The report recommends several sites that met all or most of the criteria. All sites were considered sufficient to support panther populations with minimal intervention, based on inferences from Florida telemetry studies. A scoring system was based on equal ranking of all factors. There were several recommendations including experimental reintroductions in high-ranked areas. The report included comments on a previous draft. Some of the investigators' comments opposed (or thought unworkable) the idea of compatibility of hunting with reintroductions. Others were opposed to some candidate sites because these are outside historical range of panthers (e.g., North Carolina), or out of concern for impacts on red wolves or livestock depredation. One comment-writer (Noss) thinks that 3 reintroduction sites are inadequate and will ultimately fail, and calls for reintroduction in all 24.

Comments: This seems to be a hurried effort. A more rigorous effort would include (a) discussion of the biological links between each criterion and expected success of a reintroduction and some weighting scheme for criteria, (b) sensitivity analysis of different weighting schemes, (c) a decision to exclude sites outside of *coryi* range, (d) drawing site boundaries on a basis more biologically meaningful than county lines, (e) a discussion of opportunities and limitations for using education and other tools to alter some of the social factors influencing public acceptance, (f) using a GIS to consider landscape connectivity to potential areas of population expansion (the report acknowledges importance of connectivity, but ignores it anyway), (g) a more sophisticated road analysis (the report treats a 6-lane freeway the same as a public dirt road). The report acknowledges that it took a very crude look at a very complex problem that should be vigorously pursued. This remains a critically important task, as the panther will never be secure as long as it is confined to south Florida. Of the tasks numbered 2–5 on page 10, each with target dates between August 1994 and February 1996, none have been completed as of November 2002. This is extreme foot-dragging. An effective NGO could sponsor a rigorous study that would help propel the process forward.

Jordan, D. B, editor. 1994*b*. Proceedings of the Florida panther conference, 1–3 November 1994, Ft. Myers, Florida, USA. 522pp.

Summary: This *proceedings* includes copies of many published papers, unpublished agency reports, or earlier drafts of papers that were later published elsewhere. It also contains a great many short talks that were transcribed, sometimes with the text and major figures and tables from the accompanying slide presentation. Most reports are followed by 1–2 pages of transcribed questions and answers. It also contains 2 scientific papers (meaning that a Methods section was present) that may not be available elsewhere, namely Comiskey (1994) and Fleming et al. (1994), and 1 substantial policy paper (Evans 1994). A single-authored early draft of Wilkins et al. (1997) is also printed here (pp. 14–41). A transcript of a video of interviews with Seminole Indians (pp. 6–12) offers insight into Seminole attitudes toward panthers (the Panther Clan is the largest clan on Big Cypress Seminole Indian Reservation).

Kautz, R. S. 2000. Ranking of strategic habitat conservation areas and lands needed for Florida black bear and Florida panther. Florida Forever Advisory Council. 13pp.

Summary: Cox et al. (1994) identified 4.8 million acres of Strategic Habitat Conservation Areas (SHCAs)—private lands that, if protected, would likely protect most of Florida's biodiversity. The Florida Forever program has purchased 0.8 million of these acres since 1994. No ranking of SHCAs has been previously attempted. This reports ranks SHCAs in terms of their value for 2 area-sensitive species, namely black bear and panther. There were 2 principal criteria: (1) degree of imperilment of species or natural communities for the proposed areas and (2) upland versus wetland dependence. Criteria for black bears and Florida panthers were considered separately and added to other criteria for Strategic Habitat Conservation Areas. The black bear prioritization occurred during a workshop.

The first draft of the panther prioritization was produced by Darrell Land under the assumptions that (1) as few as 200,000 acres might be acquired, (2) private land adjacent to protected core areas get priority, and (3) radio locations suggest habitats important to panthers. Randy Kautz tweaked the boundaries of Land's map and circulated the revised draft for review by 7 key persons. Ensuing discussions brought non-unanimous agreement to submit a compromise map (Figure 2) to the Florida Forever Advisory Council. In order of priority, the lands were (1) a linkage between Big Cypress National Preserve and Okaloacoochee Slough State Forest, a linkage between Florida Panther National Wildlife Refuge and Corkscrew Swamp Sanctuary, and private lands near Okaloacoochee Slough State Forest, totaling 269,00 acres; (2) parcels near Corkscrew Swamp Sanctuary, and habitats north and northeast of Okaloacoochee Slough State Forest that connect to Glades County, totaling 88,000 acres; and (3) 3 areas of disturbed lands (a) north of Corkscrew Swamp Sanctuary, (b) west of Florida Panther National Wildlife Refuge and north of Picayune Strand State Forest, and (c) southeast of Okaloacoochee Slough State Forest, totaling 76,000 acres. If all were acquired, they would increase protected panther habitat south of the Caloosahatchee River from the current 587,000 acres to 1.02 million acres.

The panther map was further refined by assigning a rank of 4 to all land contained in Cox's SHCA for panthers south of the Caloosahatchee River that were not in ranks 1–3, and a rank of 5 to such lands north of the Caloosahatchee. (Cox's panther SHCA included 810,000 acres of private land.) The rationale was that it is first necessary to secure occupied panther habitat south of the Caloosahatchee. Lands north of the river are nonetheless important as the only area into which the panther population is likely to expand on its own. This produced a final panther map (Figure 4).

The report also describes how a final composite priority map was produced by an unweighted overlay of 3 maps: the panther map, the black bear map, and a map reflecting habitat of 53 other wildlife species and 4 rare natural communities (map not shown, but described in tables). With this weighting scheme, bears and panthers were relatively well represented on the final map (Figure 5).

Comments: There was no formal analysis of how well the final map covered panther priorities 1 through 5. Obviously, however, the weighting scheme will produce a "panther-friendly" map.

The double ranking procedure seems confusing and arbitrary.

Kerkhoff, A. J., B. T. Milne, and D. S. Maehr. 2000. Toward a panther-centered view of the forests of south Florida. Conservation Ecology 4(1):1. Available from <http://www.consecol.org/vol4/iss1/art1>.

Summary: The authors used fractal geometry to analyze 12 years of panther telemetry data (February 1981–November 1993; 12,783 locations on 41 individuals) and remotely sensed forest cover. They used a scale-dependent notion of association and compared the density of forest cover associated with panther locations to that of the forest at large. The authors make no mention of the time of day telemetry locations were obtained, but note that a location was obtained for each panther on every flight (3 flights/week). They contend that anthropogenic habitat degradation and loss is the single largest threat to the Florida panther and make the assumption that forest cover = the best habitat. Study area is 20,000 km^2 of panther habitat in south Florida (22% of area is forested). They classify forest into 5 types, which they call "critical panther habitat" (hardwood hammocks, cypress swamps, hardwood swamp, pinelands, mixed hardwood pine). In the analysis the authors "…made no distinction between the five forest cover classes, nor between telemetry locations representing the 41 individual panthers, nor between those locations visited by panthers once and those visited many times" (i.e., 1 panther with many locations could bias the analysis). In the analysis they were trying to determine the amount of additional forest gained for an increase in area searched as the panther moved around its home range. They assumed that "…any forest point associated with even one panther location is in some sense "'good habitat'."

The following statements are found in the discussion.

- "When D drops below the threshold 1.8 (corresponding to about 25% forest cover…), the likelihood of intensive panther use declines dramatically."
- "The study area as a whole exhibits about 22% forest cover, implying that the region may be, from a panther-centered view, on the verge of collapse."
- "The fact that several plots exhibited D>1.8 but contained few, if any, panther locations suggests that, above the threshold, panthers respond to other environmental influences in addition to forest cover."
- "Where panthers do reside, they appear to select locally dense forest areas."
- "Taken as a whole, the conditional mapping results imply that panthers do indeed interact with forest cover at multiple scales…. Thus, management of the existing panther population cannot focus on large forest patches alone."

Finally, the authors conclude that "Panthers select densely forested habitat at multiple scales. The maintenance of forest cover is thus critical to the persistence of the subspecies."

The authors discuss landscape-scale management of the panther in light of their findings and propose a protocol for mapping forest cover with reference to the panther at multiple scales as a management tool for habitat assessment.

Comments: This paper suffers the same uninterpretability as the fractal analysis of Comiskey et al. (2002).

Lamm, M. G., M. E. Roelke, E. C. Greiner, and C. K. Steible. 1997. Microfilariae in the free-ranging Florida panther (*Felis concolor coryi*). Journal of the Helminthological Society of Washington 64:137–141.

Abstract: Blood samples from Florida panthers (*Felis concolor coryi*) collected from 1986 to 1993 during the months of December through May were screened for the presence of microfilariae (mff) by the Difil® filter test. Thirty-five of 47 (74.5%) panthers older than 2 yr of age were positive with microfilaremias ranging from 10 to 7,380 mff/ml of whole blood. No panthers that were 6 mo of age or less (*n* = 10) were microfilariae-positive, and only 20% of the panthers in the 1-yr class (*n* = 5) were positive. A representative number of microfilariae (*n* = 40) from each of 7 freshly collected positive blood samples was measured and morphological characteristics were noted. The average length of microfilariae processed by the modified Knott's technique was 320 μm. The finding of no significant difference ($P > 0.05$) between length measurements due to differences in head and tail shape leads us to believe that all microfilariae were of 1 species. Based on microfilarial length measurements, review of necropsy reports, and comparison with bobcat microfilariae, the most likely filarial species infecting the Florida panther is *Dirofilaria striata* (Molin, 1858).

Land, E. D. 1991. Big Cypress deer/panther relationships: deer mortality. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 30pp.

Note: This report is reprinted in full in Jordan (1994*b*, 218–242)

Summary: This study was designed to evaluate the causes and rates of deer mortality on the Bear Island Unit of Big Cypress National Preserve. Fifty-seven deer were radio collared. Data on home range and habitat use, activity patterns, fawning success, and doe/fawn survival are presented. Twenty-six of the deer died, 10 were taken by bobcats, 4 by Florida panthers, and 1 by an alligator. Four died of other natural causes, 5 were harvested (3 legally, 2 illegally), and 2 died of unknown causes. Bobcats accounted for 46% of the annual mortality of radio-collared deer. Bobcat and panthers combined accounted for 64% of annual deer mortality. There were no differences in survival rates among 3 intervals: summer (1 May–31 August), fall/hunting season (1 September–31 December), and spring (1 January–30 April). The average annual survival rate was 0.813 (95% CI 0.68–0.94), and 64% of the annual mortality was attributable to predation. Fawn mortality appeared to fluctuate with surface water levels (high water = high fawn mortality). In the low water years (1989 and 1990), apparent fawn mortality was 28% and 20%, compared to 55% and 47% in the high water years (1988 and 1991). These apparent fawn mortality rates are based on counts of fawns at heel (6+ weeks post birth) divided by an assumed 1.2 births per doe in each year. The hypothesis is that in high water, dams concentrate fawning in small upland areas, where predation risk is high. Hunting activities had little to no impact on does, either in number of illegal kills (2) or by causing does to leave the preserve (0). The population appeared to be stable with a net reproductive rate (R_0) of 0.97.

Although the time frame is never stated, the caption to Table 3 indicates that survivorship rates were calculated for radio-tagged deer May 1987–June 1991.

Comments: 1. The differences among years in apparent fawn mortality rates could reflect differences in numbers of births among years rather than mortality. Nonetheless, there clearly is some relationship between water and recruitment. This is reinforced by 9 years of data in the Everglades (Fleming et al. 1994).

2. Illegal hunter kill (2) was almost as large as the legal kill (3), and the hunting take (5 deer) was about as large as the panther take (4 deer). It is not clear how these raw numbers justify the conclusion that hunter kill has no impact on deer available for panthers. It seems just plain inconclusive. A few extra survivors could raise an R_0 of 0.97 to a number exceeding 1.

Land, E. D. 1994. Response of the wild Florida panther population to removals for captive breeding. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 12pp.

Note: This is one of a long series of annual reports on monitoring of radio-tagged panthers. During the early 1990s, these reports were titled to reflect their utility to the captive breeding program. Later, they have titles reflecting their utility to the genetic restoration program (e.g., Land et al. 1999 and Shindle et al. 2000, 2001). Several tables (cumulative litters since 1985, cumulative mortalities since 1978) reappear in each report. Unless errors were introduced along the way, the latest version of these tables should contain all previous information.

Summary: During July 1993–June 1994, 24 radio-collared panthers were monitored, and this report summarizes some of those results. Ten kittens (age 10 days to 8 months) were removed from the wild between February 1991 and August 1992 for a planned captive breeding program; they represented the progeny of 11 parents. This study was planned to evaluate response of the population to removal of those kittens. Date of capture, age and mass at capture, and parentage of removed kittens are listed in Table 1. Of the 7 females from which kittens were removed, 5 successfully reproduced afterwards. On average, the next litters of these 5 panthers was 10.4 months post removal. Of the other 2 panthers, one had poor reproductive history prior to removal, and the other may have reached reproductive senescence. All females continue to occupy their pre-removal home ranges. Because "recruitment balanced mortality" during the study period, they conclude that there were no adverse impacts to the population from the removal of 10 kittens.

Based on observations of litter sizes at 0 and 6 months, a survival rate of 0.959 was calculated.

Only 1 kitten died in a sample of 15 radio-instrumented kittens monitored from 6 months to 1 year, yielding a survival rate of 0.933 for the interval 6 to 12 months.

Comments: The comparison of known births to known deaths is meaningless, and should not be construed as indicating whether or not "recruitment balanced mortality." Conclusions about population trend require either complete accounts of births and deaths, or estimates of stage-specific (or age-specific) rates of fecundity and mortality.

The calculation of kitten survival rate as 0.959 is not a true survival rate estimate because it does not follow animals through time. Furthermore, none of the underlying data are presented. The report fails to state how many 0-month-old or 6-month-old litters were examined, the years over which they were examined, how litter size was determined for either age class, and the exact age at which litter size was estimated. The 0-month-old class, for instance, doubtless included a range of ages, from 0 days to 31 or more, and the result will be sensitive to these "rounding errors."

Both of the kitten survival calculations should be considered obsolete in light of the clearer estimate provided by Shindle et al. (2001), but a new analysis based on days of exposure would be superior to any estimates published as of November 2003.

The 0.933 estimate of survival from 6 to 12 months is better, in that the procedure of following individuals through time does represent a survival rate. Furthermore, dates and identities of kittens are presented. However, offspring of untagged dams may have a lower survival rate because they are not de-wormed and vaccinated.

Authors state that there is "no significant impact of removals on behavior and demography," but it is not clear how they reached this conclusion; the data seem inconclusive.

Land, E. D., and R. C. Lacy. 2000. Introgression level achieved through Florida panther genetic restoration. Endangered Species Update 17:99–103.

Summary: The plan to restore genetic diversity, initiated in 1995 with release of 8 female Texas puma, had a goal of 20% representation of Texas puma genes in the panther population. At the time of this analysis (apparently they used data through December 1999), 4 of 8 Texas pumas were still alive, and 5 of the 8 Texas pumas had produced at least 36 descendants, of which 25 were probably still alive. Based on pedigree, the panther population has 18–22% representation of Texas genes (15% to 16.8% if the Texas females are excluded). The

aging Texas females (8–9 years old) will not produce many more offspring. Factors that could influence the accuracy or interpretation of this estimate include (1) the unknown size of the total population, which is assumed to 70 for this calculation, (2) unequal representation among Texas females, more than 40% of Texas genes are derived from 1 female (TX 101, who was contracepted in 1998 and 1999, then died in March 2000) and much of the remaining from a second female; the 5 Texas pumas are equivalent to about 3 "effective founders"; (3) the fact that future breeding success may be related to ancestry. The plan includes future releases of non-local pumas to counter resumption of inbreeding and loss of genetic diversity.
Comments: The estimate of introgression level is directly and inversely related to the population size N, which forms the denominator of the estimate. Maehr and Lacy (2000) exploited this uncertainty to argue that "over 45%" of panthers "may" be Texas hybrids; this estimate requires an effective population size of 30 panthers, which was about half of the minimum number of adults known alive in 2000.

Land, E. D., D. S. Maehr, J. C. Roof, and J. W. McCown. 1993. Mortality patterns of female white-tailed deer in southwest Florida. Proceedings Annual Conference Southeast Association Fish and Wildlife Agencies 47:176–184.
Note: Same as Land (1991).
Summary: The information in this paper is the same as in Land 1991, except that 11, rather than 10 deer deaths are attributed to bobcats.

Land, E. D., D. R. Garman, and G. A. Holt. 1998*a*. Monitoring female Florida panthers via cellular telephone. Wildlife Society Bulletin 26:29–31.
Summary: A method to transmit signals from denning radio-collared female panthers via cellular phone is described. This allows researchers to know when the dam is away from the den, so that researchers can handle neonate kittens.

Land, E. D., S. K. Taylor, and M. Lotz. 1998*b*. Florida Panther Genetic Restoration and Management. Annual Report. Bureau of Wildlife Diversity Conservation, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA. 50pp.
Note: Most data in this report are presented in updated form in Shindle et al. (2001).

Land, E. D., M Lotz, D. B. Shindle, and S. K. Taylor. 1999. Florida panther genetic restoration and management. Annual Report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA. 63pp.

Summary: Most data in this report are repeated in Shindle (2001), with the exception of a map of known untagged panthers (p. 21), and a summary of the status of the kittens removed from the wild for captive breeding (pp. 22–23).

Land, D., M. Cunningham, M. Lotz, and D. Shindle. 2002. Florida panther genetic restoration and management, July 2001–June 2002. Unpublished Report. Bureau of Wildlife Diversity Conservation, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Abstract: Telemetry data were collected on 42 radiocollared Florida panthers (*Puma concolor coryi*) and 3 Texas cougars (*P. c. stanleyana*) in southern Florida during the reporting period. Five radiocollared panthers and 3 uncollared panthers died this past year. Male panthers FP96 and FP97 and female panther FP49 died of intraspecific aggression; male panther FP92 and female panther FP105 died of unknown causes. The three uncollared panthers were struck and killed by vehicles. Six new panthers were added to our radiocollared population this past capture season. Our current verifiable population count is 80 adult and subadult panthers and does not include kittens at dens. We documented 14 panther dens during the study period producing a total of 30 neonate kittens (13F, 17M). No Texas puma produced litters during the study period. All of these kittens were handled successfully at their dens, permanently marked with subcutaneous transponder chips, and skin biopsies taken. We have radiocollared a total of 112 panthers since 1981 and handled 136 neonate kittens at dens since 1992. Apparently, genetic introgression is reducing the occurrence of kinked tails, cowlicks, and cryptorchidism. Preliminary analysis indicate that the likely representation of Texas puma genes is on target with the originally proposed introgression level of 20%.

Logan, T., A. C. Eller Jr., R. Morrell, D. Ruffner, and J. Sewell. 1993. Florida panther habitat conservation plan: south Florida population. Florida Panther Interagency Committee.

Summary: This document summarizes the status of the panther and its habitat, and provides the recommendations of the Florida Panther Interagency Committee. About 53% of the occupied range and 34% of radio locations occurred on private land. They recommended site-specific conservation strategies for 468,600 acres of habitat south of the Caloosahatchee River and 457,700 acres north of the river. Three million acres (72% publicly owned, but 31% of the private land already under active acquisition for reasons unrelated to panther recovery) should be considered for designation as critical habitat. A

full-time position in the U.S. Fish and Wildlife Service should be created to promote and coordinate implementation of this plan. Landowner incentives to preserve habitat should be designed and promoted. Existing authority (wetland regulations, Sections 7 and 9 of the Endangered Species Act, Florida Growth Management Act) should be used more effectively to protect panther habitat.

Lotz, M. A., E. D. Land, and K. G. Johnson. 1996. Evaluation of State Road 29 wildlife crossings. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 19pp.

Summary: Many species of wildlife use 2 undercrossing structures (inexpensive novel designs for 2-lane road) on SR-29 and 2 structures on I-75. Structures were large and relatively bright, with fencing to funnel animals toward the underpass. Over 1,000 photos were taken of <20 species of wildlife (panther, black bear, bobcats, deer, raccoons), domestic animals, and humans. Placement of the structures was determined by radio-telemetry data, locations of road-kills, and habitat characteristics (especially forest cover and alignment with bridges over the roadside canal). Panther use of the older I-75 crossings increased over time. At 1 structure monitored earlier by Foster and Humphrey (1995) there were 2 panther crossings in 16 months, compared to 11 crossings in 9 months at the same structure during this study. Thus, animals seem to learn to use the structures. At the time of writing, 3 radio-tagged panthers continued to cross SR-29 well north of the new structures, and additional structures should be built in that area. Panther use was strongly nocturnal, bobcat use less strongly nocturnal, and deer use was overwhelmingly during daylight (0700–1500). Both the bridge and box culvert undercrossings worked well. Wildlife use decreased when there was standing water in the structure; this could be corrected by better design or by re-grading after construction.

Comments: The crossings were used by only 4 panthers. The authors claimed that use increased over time, but supporting data for this is presented only for a few older crossing structures on I-75. For the newer structures the authors did not report any temporal trend and stated that use by panthers "will likely increase" over time.

Lotz, M. A., E. D. Land, and K. G. Johnson. 1997. Evaluation and use of precast wildlife crossings by Florida wildlife. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 51:311–318.

Summary: The authors studied use of less expensive pre-cast wildlife crossings from 27 March 1995–30 June 1996. They documented wildlife use of 2 pre-cast concrete wildlife crossings on State Road (SR) 29. Two additional crossings of a different design (double-bridge) were monitored on Interstate (I)-75 for comparison. Over 1,000 photographs were taken of >20 species of wildlife, domestic animals, and humans using those 4 wildlife crossings. Panthers and many other species of wildlife used both types of crossings.

Maehr, D. S. 1989. Florida panther road mortality prevention. Final Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 11pp.

Summary: Twelve of 16 panthers known to have been struck by motor vehicles since December 1979 died in the accidents. Three injured panthers were taken into captivity and survived under veterinary care, of which 2 could be returned to the wild (not stated if either *was* returned to the wild). Although the significance of highway mortality to the population is unknown, it is the most often documented source of mortality. Three radio-tagged panthers crossed SR-29 and SR-84 over 75 times during July 1988–June 1989. There was no seasonal pattern to panther crossings. Some crossing points seem to be traditional travel pathways for individual animals. Lower nighttime speed limits and increased law enforcement have not markedly reduced vehicle speeds.

Comments: Vehicle collisions are more likely to be detected or reported (and thus documented) than other sources of mortality for uncollared cats. No general conclusions about the importance of vehicular mortality are possible without a study using radio-tagged animals.

Maehr, D. S. 1990*a*. Florida panther movements, social organization, and habitat utilization. Final Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 165pp.

Summary: Analyses are of 6,845 radio locations of 24 panthers (≥3 locations/week/panther) in southwest Florida during January 1985–June 1990. Two other radio-tagged panthers (#33, #38) were followed by National Park Service, and their data were not analyzed in this paper. These 2 may have been included in Maehr et al. (1991*a*), which claimed 7,025 locations on 26 panthers. However, the analysis of selection for vegetation types is based on the same 9 panthers in both papers. This report provides additional tables on wet-season and dry-season use of vegetation types by the 9 panthers whose habitat selection is described in Maehr et al. (1991*a*). Almost all of the results in this report were reported either in Maehr et al. (1991*a*) or in the 6 publications appended to the report. These appendices (pp. 115–165) include Maehr (1990*b*), McCown et al. (1990), Roof and Maehr (1988), Maehr et al. (1989*a*), Maehr et al. (1990*a*), and Maehr et al. (1989*c*). Pages 11–22 give 1-paragraph summaries of the individual history of each panther, including known or suspected relationships to other panthers. The text of the report ends on page 44, which is followed by tables, figures (mostly home range maps), and appendices. Three sections of the paper may not be fully published elsewhere, they are as follows.

1) *Dispersal*. Dispersal was documented in 1 female and 6 male panthers; origin of 5 panthers (M10, F19, M29, M30, M34) was known, but 2 (M28, M33) were captured during dispersal. Mean dispersal distance for males (mean age 17.3 months) was 51.8 km (range 22–80 km), and was 16 km for the 1 female. Two dispersing subadult males were killed by resident adult males. Maehr et al. (2002*a*) reported on 27 dispersers from 1986 to 2000, presumably including these 7.

2) *Reaction to hunting and roads*. Panthers used Bear Island (the most heavily hunted part of the study area) significantly less during deer-hunting season than non-hunting season, probably due to disturbance of camping, hunting, and vehicle use. Adult female panthers avoided busy paved highways while males readily crossed them. Female panthers appeared to distribute themselves evenly through available habitat but did not include I-75 within their home ranges.

3. *Reproduction*. Thirteen natal dens of 6 female panthers were documented (including 1 in July 1990). Litter size after 2 months ranged from 1 to 4. Two older female panthers did not successfully reproduce during the reporting period. The youngest documented age at first reproduction was 18.5 months for female panthers and about 3 years for males.

Comments: No explanation is given for why the specific 9 panthers (5 females, 4 males) were used in analysis while the other 15 were excluded. On page 34, the discussion of mortality, and the recommendation to reduce mortality rates, would be more meaningful in the context of the impact on population dynamics: What is the marginal benefit of reducing an already low mortality rate?

Maehr, D. S. 1990*b*. The Florida panther and private lands. Conservation Biology 4:167–170.

Summary: This essay (no Methods or Results sections) argues that intensive efforts to protect Florida panther habitat on private lands are essential. The premise is that about half of the "presently-known occupied panther range in south Florida occurs on private lands" where agricultural and urban development are increasing rapidly.

None of the 17 panthers radio monitored 1985–1989 confined its movements to state and federal property. Panthers primarily using private lands are in better condition and more productive, perhaps partly due to better soils or beneficial management practices. Panther conservation strategies must go beyond traditional land acquisition by government and include economic incentive programs to preserve critical landscapes on private lands.
Comments: The collapse of southern subpopulations in the late 1980s (Bass and Maehr 1991), and the fact that most research in 1989 was confined to the area north of I-75 and west of SR29, mean that "presently known occupied" habitat in 1989 may not be indicative of the long-term distribution of panthers in south Florida.

Maehr, D. 1992*a*. Florida panther distribution and conservation strategy. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
Note: This paper is cited in the 2002 MERIT draft panther plan as documenting that home range size is related to habitat composition, and inversely related to habitat quality.
Summary: This paper relates habitat composition to intensity of panther use in south Florida. Tables 1 and 2 indicate that data from 13 male and 10 female panthers were considered. The paper emphasizes the importance of forested habitats (e.g., "This study, as well as Maehr et al. (1991*a*), were unanimous in identifying hardwood hammock as the most preferred habitat of Florida panthers" "Habitats avoided by panthers included agricultural, barren land, shrub and brush, and dry prairie"). The paper emphasizes the importance of private land in panther conservation and proposes incentives for landowners.
Comments: The paper does not state the identity of panthers used in analyses, numbers of locations per animal, nor that all telemetry locations were daytime locations. No statistical tests were performed on the data.

Maehr, D. S. 1992*b*. Florida panther (*Felis concolor coryi*). Pages 176–189 *in* S. R. Humphrey, editor. Rare and endangered biota of Florida. Volume I: Mammals. University Press of Florida, Gainesville, Florida, USA.
Summary: Article contains a description of the range and estimated abundance (30–50, an educated guess) of the Florida panther, documents causes of mortalities (notably car collisions), and speculates on demographic and genetic isolation (insularization at a distributional extreme, peninsular effect). Additional conservation issues are identified. Author identifies additional information required for conservation, including identification of habitat

requirements, effects of human activity, habitat requirements for prey, impact of competitors, genetic impacts, and potential release sites. Public education is also needed.

Comments: Similar to Belden (1989), this is a good summary of the state of knowledge as of 1992, written for the educated, conservation-minded reader.

Maehr, D. S. 1997*a*. The comparative ecology of bobcat, black bear, and Florida panther in south Florida. Bulletin of the Florida Museum of Natural History 40:1–176.

Summary: Comparisons of food habits, habitat use, and movements suggest a low probability of competitive interactions among these 3 carnivores in south Florida. All 3 species preferred upland forests but consumed different foods. Panthers manifest crepuscular activity while bears were mostly diurnal. Diet, movement, and reproduction varied seasonally for each species and among species. Subadults of all 3 species demonstrated extensive dispersal abilities, but only male black bears were documented to have crossed the Caloosahatchee River during the study period (1985–1994). Bobcat and bear occurred at higher densities than panthers, and thus may be less affected by anthropogenic landscape changes or sea level rise. Conversion of naturally patchy forests to other uses will increase the amounts of non-preferred habitats. Range expansion of coyote, which exhibit interference competition with bobcats, puma, and black bears elsewhere, may disrupt ecological relations among these 3 native species. Coyote diets in Florida may overlap the diets of the 3 natives by 38–64%.

Highest concentrations of black bears and panthers coincide with extensive forest, a landscape feature that accounts for only a small proportion of public lands. Because panther demography is typical of healthy populations, flexible reserve boundaries and collaboration with private landowners may be more useful than symptom-oriented practices such as genetic introgression.

Chapter 3, on habitat selection, reports percent composition (9 vegetation types) of annual home ranges of 5 adult male and 5 adult female panthers; some were followed multiple years (each reported separately in Table 3.4). Subadults and dispersers were excluded, but it is not clear if other adult animals were excluded. Habitat use was determined by the observer in the aircraft, not by vegetation maps in relation to UTM coordinates. The habitat use of these animals was compared to availability of habitats within a concave polygon that enclosed all resident home ranges (not clear if this included animals other than these 10 residents, but presumably it did). Table 3.8 reports mean percent habitat use by sex and season, but it it not clear how locations across years and animals were pooled. The numbers indicate highly disproportion use of pine flatwoods, hardwood hammock, and mixed swamp, and disproportionately low use of cypress swamp, fresh- and saltwater marsh, dry prairie, and agricultural land.

Comments: Habitat use is limited to daytime locations, and interpretation is made difficult by possible exclusion of some adult panthers and the possibility that the available habitat may have included habitat used by adult panthers excluded from the analysis.

This analysis differs from Maehr et al. (1991*a*), which (a) compared use versus availability within individual home ranges, and (b) used 9 animals.

Panther demography is not addressed in this paper.

Maehr, D. S. 1997*b*. The Florida panther: life and death of a vanishing carnivore. Island Press, Covelo, California, USA.

Summary: This book contains field stories and anecdotes, summaries of other reports and papers, but no previously unpublished data on panther ecology. The book emphasizes the importance of forest habitat, and suggests that as long as habitat containing some degree of forest cover is present, factors like deer and hog hunting, off-road vehicle use and other human disturbances, road kills, and inbreeding are relatively unimportant. The book acknowledges some limits to this idea. For example, intense human activity apparently does cause panthers to avoid Golden Gate Shores despite dominance of forest cover. One main message is that the recovery effort needs to involve the Seminole tribe, private landowners, the South Florida Water Management District, and the Army Corps of Engineers as the major players, with greatly reduced roles for the Florida Fish and Wildlife Conservation Commission (FWC) and National Park Service (NPS). He argues that because FWC owns no land, it is little more than an advisor; NPS owns more land than any other entity, but this land (except for Bear Island) is of so little value to panthers that it has little impact. With respect to the private landowners, page 210 states that "within core range or potential panther habitat, about a dozen ranches in south Florida hold the key…. In Collier and Hendry Counties, there may be as few as six." The book argues that incentives to private landowners are less costly than government purchase and subsequent management.

Comments: This book's dismissal of the value of National Park Service (NPS) land for panthers (p. 213: "the few panthers living in such marginal range are essentially the "living dead" of the population") contrasts sharply with the statement to the Scientific Review Team by some NPS personnel that Big Cypress National Preserve (BCNP) and Everglades National Park (ENP) are and always will be the only essential areas for panthers. The resurgence of panthers in BCNP and ENP since 1995 suggests that these lands can be an important landscape for panthers, at least at times. The value of these lands has varied temporally in the past, and future trends remain to be seen.

Even if the book is incorrect about the low value of NPS lands, it is certainly true that private lands are essential to security of this population, and that conserving these lands will require active support from water management districts, Seminoles, and private landowners.

Maehr, D. S. 1997*c*. The Florida panther and the Endangered Species Act of 1973. Environmental and Urban Issues 24:1–8.

Summary: The Florida panther can be taken as a case study for endangered species. It is (1) a subspecies of a secure and widely distributed species; (2) popular; (3) predisposed to endangered status because it is a wide-ranging, low-density animal; (4) there is enough information now to make sensible management decisions.

This essay argues that the root problem for the panther is a lack of space, and implies that management actions to restore genetic diversity divert attention from this most important issue. Recovery efforts are "short circuiting captive breeding" and introduction efforts and replacing them with "rushed and poorly controlled genetic introgression effort" in spite of "demographic indicators that suggest stability and the capability of panther population growth." "It has been noted repeatedly that forested habitat on private land is the key to the panther's future."

The paper questions why the U.S. Fish and Wildlife Service has not designated critical habitat for the species. Maehr argues that such designation would not have too harsh an impact on private land in critical habitat, and emphasizes opportunities to involve landowners as partners. It is not clear if the author is suggesting that landowners participate in the designation of critical habitat, or if he rather sees such collaboration as occurring after designation.

Comments: No new data are presented.

Maehr, D. S. 1998. The Florida panther in modern mythology. Natural Areas Journal 18:179–184.

Summary: This essay argues that recovery efforts have focused too much on reduced genetic variability, and should give greater consideration to landscape ecology. It presents an extended version of

the argument by Maehr and Caddick (1995) against the introgression program, and argues that the population is not on the verge of collapse, and that forest cover is the most important element in demographic performance. This paper also argues that because Florida is a peninsula, "a degree of isolation has existed since the end of the last ice age" and implies that this might account for most or all of the low genetic variation in panthers. The paper presents one anecdote (the anemic, dehydrated state of a single Texas hybrid kitten) to suggest that outbreeding depression may be occurring and argues that the introgression program is based only on "genetic theory, outdated information, and speculation." The most important conservation issue is to give the population "more habitat," primarily by maintaining connectivity and encouraging a population north of the Caloosahatchee River. The paper asserts that a connection to south central Florida could double or triple the population.
Comments: Except for the anecdote on poor vigor of 1 hybrid kitten, no new data are presented.

Culver et al. (2000) offer evidence that loss of genetic material occurred since 1900.

The paper offers no evidence for its claim that the introgression effort is based on "theory, outdated information, and speculation."

The estimate that a connection to south central Florida could double or triple the population seems to be based on the amount of forested habitat north of the Caloosahatchee, ignoring the habitat fragmentation and high road densities in that area. The MERIT subteam's draft Habitat Conservation Strategy (2002) suggested (without clear explanation) that central Florida would probably add 6–10 panthers to the population—certainly important, but far from a doubling or tripling. It would be useful to have a rigorous, well-explained estimate of how much population increase can be expected from a link to lands north of the Caloosahatchee.

Maehr, D. S., and G. B. Caddick. 1995. Demographics and genetic introgression in the Florida Panther. Conservation Biology 9:1295–1298.
Summary: This *Note* (lacking a Methods or Results section) argues against the need for the genetic introgression program initiated earlier in 1995 with the release of 8 female pumas from Texas. To support their position, the authors argue that the panther population is not suffering from demographic problems. They state that male reproductive abnormalities do not seem to have any demographic consequences, and make a similar assertion about cardiac abnormalities. They estimated juvenile survival rate in 5 sentences: "Known kitten production from 1985 through 1993 revealed a mean

litter size of 1.92 (*n* = 25 litters, range 1–4). Four neonate litters 14 days old or younger averaged 2.25 (range 1–3) and litters from 4 to 12 months of age averaged 1.89 (range 1–4). The differential between neonates and older kittens suggests a first-year survival rate of 0.84 (1.89/2.25 = 0.84). When only radio-collared kittens older than 4 months but less than 12 months are considered a survival rate of 0.87 is obtained (2 deaths out of 15)." This estimate later was used in a PVA by Maehr et al. (2002*b*).

As further evidence of demographic vigor, the authors present a graph (Figure 1) of number of births (y) versus number of deaths (x) for each of 9 years (1985–1993) and use the fact that 7 of 9 points lie above the diagonal to assert that "births have outpaced deaths" (p. 1295). On page 1297 they state, "The positive growth indicated in Figure 1, when combined with high juvenile and adult survival and an early age of first reproduction in females, portray a population that has the hypothetical potential for demographic stability and increase." They argue that lack of growth in the panther population is the result of limited space for dispersal.

They advocate incorporating introgression experiments within a captive breeding program, and following those results through the F_3 generation, before introducing non-*coryi* cats into the wild.

The paper concludes with a discussion of the risk of outbreeding depression. To support their argument that this risk is high, they point out that the Everglades National Park population, which winked out in 1991, contained non-*coryi* genes. No other empirical evidence for outbreeding risk is provided.

Comments: 1. The 2 estimates of kitten survival rate are not rigorous for 2 reasons. (a) The 84% estimate of kitten survival rate was not based on litters followed over time, but rather on litter sizes at 2 different ages. The 87% estimate does not suffer from this problem. (b) The value of 1.89 cubs per litter at age "12 months" actually included litters aged 4 months through 12 months, so clearly this should not be considered an annualized survival rate. This defect affects both the 84% and 87% estimates.

2. The authors fail to mention or discuss the fact that both of these estimates of kitten survival rate exceed the estimate by Maehr et al. (1991*b*) of 82% for panthers of all ages (presumably mostly adults). This is biologically implausible. Shindle et al. (2001) provide a more plausible estimate of 52% survival for pure Florida panther cubs.

3. The reference on page 1297 to "the positive growth rate indicated in Figure 1" is incorrect for several reasons. (a) This sample of convenience in no way represents a count of births or deaths in the

population. (b) Because "births" are not equivalent to "recruits," the graph says nothing about "growth rate." (c) Growth rate depends on *rates* of birth and death, not *numbers* of detected births and detected deaths.

4. The discussion of outbreeding depression is highly speculative.

Maehr, D. S., and J. A. Cox. 1995. Landscape features and panthers in Florida. Conservation Biology 9:1008–1019.

Dates: December 1985–December 1990

Animals: 23 individuals (10 females, 13 males)

Summary: The objectives of this paper were to provide data to help manage the landscape containing panthers, select private lands for acquisition or conservation, and to identify suitable reintroduction areas. The authors used a geographic information system (GIS) to document spatial associations of Florida panthers, land cover, and other geographical features. Panther radio locations (n = 14,548) occurred in hardwood hammock, mixed hardwood swamp, and cypress swamp in greater proportion than in randomly positioned points (n = 8,500). Panther radio locations occurred less frequently in agricultural, barren, and shrub and brush land cover. Panther home ranges consisted of a combination of preferred and avoided cover types, including freshwater marsh, cypress swamp, hardwood swamp, and agricultural land. These cover types accounted for 62% of the area in panther home ranges. Chi-square, regression, and discriminant function analyses were used to assess the potential importance of 20 landscape features. These panther locations were distinguished from random points with respect to 4 landscape variables: (1) the size of a contiguous patch of preferred land cover; (2) proximity to preferred land cover; (3) diversity of 3 preferred cover types within a window 120 X 120 m; and (4) the matrix within which preferred cover types occurred. Unexpectedly, none of the 8 variables related to road density distinguished panther locations from random points. Eighty-three percent of the panther locations and 81.9% of the random points were correctly classified based on a linear model constructed using these 4 variables. Large contiguous areas of preferred land-cover types were especially important; 96% of all panther locations occurred within 90 m of preferred land cover. The average preferred forest patch size that was used by these panthers was 20,816 ha, and a regression equation suggests that patches larger than 500 ha are important. Maps of panther habitat suitability were developed using coefficients derived from discriminant analysis. Large areas of suitable land cover that are heavily used by panthers occur on private ranches covering 3,606 km^2. Conservation of preferred habitat on these private lands is essential to maintaining a free-ranging population of panthers in southwest Florida.

Comments: This paper suffers from 3 major defects that cast a cloud over most of the results and conclusions.

1. The paper fails to mention or explain the exclusion of (a) about 6,000 of the 14,548 radio-locations, and (b) 18 of 41 panthers. The map (Figure 1) and the paper's description of the study area (p. 1009) and methods (p. 1010) suggest that data on all animals from the entire range of the panther were used in the study. The only clues that available data were excluded are (a) on page 1010, the authors refer to an "average of 382 locations for each of 23 panthers," which yields 8,786 locations, not 14,548; and (b) Panther locations were compared to 8500 random locations, a number which is close to 8,786 but not close to 14,548.

When the Scientific Review Team (SRT) queried Dr. Maehr about this issue, he responded that "To the best of my ability to reconstruct our approach on this paper, the animals used in the analysis were 08, 09, 10, 11, 12, 13, 17, 18, 19, 20, 24, 25, 26, 28, 29, 30, 31, 32, 34, 36, 37, 40, and 41. All of these animals were inhabitants of what we considered to be the panther population core north of I-75 and west of SR-29. Other animals (01, 02, 03, 04, 05, 06, 07, 14, 15, 16, 21, 22, 23, 27, 33, 35, 38, 39) were either collared for an insufficient period of time to be used, were monitored before our more regular data collection was instituted in 1986, or were primarily inhabitants of the Everglades region. I believe that even at this stage we viewed the southeastern area of occupied range as fundamentally different and not typical of preferred habitat."

2. Panther locations were compared to "available" habitat by randomly selecting 8,500 points from within an area that extended 40 km beyond all panther locations used in the analysis. This procedure (adding a 40-km band) means that many points south of I-75 were used in the analysis solely as *available* points, regardless of the fact that some of these points were in fact *used* by panthers during the period of study. Furthermore, the 40-km buffer doubtless included areas beyond the geographic range of the panther, such as water impoundments, urban areas, and expanses of row crops. Thus, the paper compared locations used by a subset of panthers to a set of "available" points that included areas beyond the known range of the panther as well as areas used by panthers excluded from the analysis.

3. The entire statistical analysis (except Table 2) is severely pseudoreplicated. Treating 14,600 (or 8,500) panther locations as statistically independent was inappropriate for the chi-square analysis,

the regression, and the discriminant function analysis. A proper statistical analysis, such as compositional analysis, would treat the animal as the sampling unit. The authors did acknowledge that their procedure was "biased" and advised the reader to pay more attention to the r-squared values than to the P-values. However, to the extent that animal selection was biased, the r-squared estimates will also be biased.

Other Comments:

1. Table 2 presents percent composition of panther home ranges, and correlates home range size with vegetation composition of the home range. This is a useful analysis that does not suffer from the fatal problems outlined above. Unfortunately, the Methods section does not mention this analysis (nor even the terms *home range* or *habitat composition*) so it is unclear how home range sizes or habitat compositions were calculated. In response to an SRT query, Dr. Maehr stated that habitat composition in this table is the percent of each home range that fell in each vegetation type in the GIS layer rather than the percents estimated by the observer in the aircraft. This seems an appropriate and unbiased approach.
2. The paper addresses error in radio locations with the statement (p. 1009) that an "analysis of location error conducted informally" showed that estimated locations "matched well" with actual locations. The analyses proceed to ignore such error; this is equivalent to assuming that location error was zero meters. However, location was earlier estimated by Belden et al. (1988) as 230 m, and was later estimated by Janis and Clark (2002) as 200–400 m.
3. In light of the fact that location error was implicitly treated as zero, the claim that "96% of panther locations were within 90 m of large forest patches" is unjustifiable.
4. Maehr et al. (2001) and Maehr and Deason (2002) mis-cite Maehr and Cox (1995) when they claim that Maehr and Cox (1995) showed that panthers are "reluctant to cross non-forested areas greater than 90m." This paper does not make such a claim; diurnal daybed locations would be a weak basis for inferences on what panthers might cross at night.
5. The authors stated that animals were monitored from fixed-wing aircraft at least 3 times per week, but failed to explicitly state that all locations were obtained during daylight hours, nor do they discuss the implications of this bias to their conclusions.
6. The idea that "patches larger than 500 ha are important for panther occupation" is based on an analysis that is presented solely in these 2 sentences in the Discussion section (without previous mention in the Methods section): "A linear regression of patch size showed that

panther occupancy became more likely in patch sizes greater than 500 ha, and only 25% of the panther locations occurred in patches smaller than 500 ha. These results suggest that patches of this general size may be needed for frequent panther occupation." Although this description is too terse to allow a full evaluation, the analysis is almost certainly fatally flawed. This regression, like other analyses in the paper, probably treated each location as an independent observation (severe psuedoreplication), and the regression result may reflect nothing more than the fact that large patches, like large quadrats, will inevitably contain more of whatever is being tallied. The fact that 25% of panther locations occurred in patches smaller than 500 ha could reflect either aversion, indifference, or preference for patches of that size, all depending on the availability of such patches to each radio-tagged panther. Unfortunately, the analysis failed to compare use and availability of patch sizes. This is an important point because Maehr and Deeson (2002), citing only these 2 sentences, use this 500-ha threshold as the basis for the single most important factor in their Panther Habitat Evaluation Model.

Maehr, D. S., and J. P. Deason. 2002. Wide ranging carnivores and development permits: constructing a multi-scale model to evaluate impacts on the Florida panther. Clean Technologies and Environmental Policy 3:398–406.

Summary: The paper starts with the correct premise that reviews of impacts to panther habitat "need to consider habitat issues that extend well beyond the project boundary…with the panther landscape in mind." The Panther Habitat Evaluation Model (PHEM) presented in this paper is a first guess at how to do this. The model ranks any patch of habitat based on

- Patch size: 25% weighting. Based on the report by Maehr and Cox (1995) that 75% of panther locations occurred in forest patches of >500 ha.
- Alpha Proximity: distance to the panther core area (west of US-29 and north of I-75): 20% weighting, with a score of 0.20 for land <10 km from core, 0.15 at 10–20 km, 0.10 at 20–30 km, 0.05 at 30–40 km, and 0 at >40 km.
- Gamma proximity: 5% weighting. Habitat patches bisected by >90 m of non-forest score 0, otherwise 0.05.
- Habitat (vegetation) type: 25% weighting, with scores for vegetation types based on Maehr's earlier work.
- Through-connectivity: 15% weighting. Assigned to parcels that connect 2 areas of occupied range.
- Connectivity from patches: 10% weighting, with a score of 0.025 for each cardinal direction from which a panther could move.

- Human use: a minus 5% score for areas <300 m from roads and cities and similar uses.

Comments: 1. The conceptual basis for the Gamma Proximity is indefensible. The paper justifies this 90-m limit as follows: "unforested habitats >90 m wide that separate forest patches can act as landscape filters that limit panther travel (Maehr and Cox 1995)." However, this claim was not made by and is not supported by Maehr and Cox (1995). Because gamma proximity is weighted only 5%, this may not have much impact on PHEM scores.

2. The "Patch Size" threshold of 500 ha is indefensible, being based solely on 2 sentences in Maehr and Cox (1995) that failed to show preference for larger forest patches. Although panthers may in fact prefer and even require large forest patches, until there is an analysis comparing patch sizes used and available to panthers, this patch size algorithm is speculation. Maehr and Cox reported that 25% of panther locations were in patches <500 ha; thus these smaller patches could be important if they comprise less than 25% of the panther home range. Because patch size is weighted 25%, this algorithm has a large impact on PHEM score.

3. Alpha proximity scores: It is not clear why otherwise suitable habitat is 20% less valuable because it is >50 km from the "panther core area." The paper refers only to Maehr's (1997*b*) book as the authority for the boundaries of the core area and the rationale for its importance. Although the paper does not reference specific page numbers, pages 210–215 of the 1997 book present a map of core area, and rhetorical arguments for its importance, but no rigorous and quantitative delineation of its boundaries.

4. The weighting of the factors is not unreasonable, but one could propose alternative weights that are equally reasonable. Before the model is used widely, there should be a sensitivity analysis, or at least several scenarios to illustrate how much or how little the conclusions would change as factor weights vary over reasonable ranges.

5. Conceptually, the additive nature of the model does not reflect the idea that a single factor could be limiting. Although not necessarily superior, a multiplicative model (like some habitat suitability models) might better reflect the limiting-factor approach. It would be good to consider the choice of an additive versus multiplicative model.

Maehr, D. S., and R. C. Lacy. 2002. In my opinion: avoiding the lurking pitfalls in Florida panther recovery. Wildlife Society Bulletin 30:971–978.

Summary: In this paper the authors challenge the proclaimed success of genetic management of the Florida panther population. The concerns outlined by the authors are (1) the introduction of 8 panthers from Texas may have resulted in overpopulation of panthers; (2) an unstable prey base may cause a collapse in panthers in the future; (3) genetic introgression may lead to swamping of Florida panther genes; and (4) satisfaction with success of the short-term responses of panthers to genetic management may distract from making progress in landscape planning and conservation. The authors present some data and some speculation to support their concerns (e.g., calculations that up to 45% of the Florida panthers may contain 25–75% Texas ancestry). The authors point out that there is no plan of action for dealing with introgression once it reaches 20%.

The paper argues that deer numbers periodically increase when there are several years without flooding. Figure 3 illustrates deer and panther numbers in Everglades from 1880–2030, with post-2001 deer numbers based on predicted water fluctuations. They argue that the TX panthers are exploiting a temporary surge in deer numbers, and "predict that the good reproduction of the last few years will soon be replaced by a decline to dangerously low numbers [of panthers]."

The authors believe successful panther recovery will not occur without 4 changes in management philosophy: (1) agencies must consider long-term environmental fluctuations as the key to regional panther carrying capacity (i.e., panther range in south Florida alone is insufficient to achieve recovery); (2) agencies should take action to prevent genetic swamping and maintain the genetic integrity of the Florida panther; (3) genetic management alone is not enough, land-saving actions must begin quickly; and (4) agencies should expand efforts to manage prey and landscape.

Comments: 1. Figure 2 is intended to show a link between deer numbers and high water events, but it fails in this regard. Three high water events were followed by deer increases and 3 were followed by deer decreases, and the authors present no statistical analysis or arguments to support their interpretation. Also, it is not clear whether these deep-water impoundments are in panther range. It is also unclear if deer-water relationships in an impoundment are the same as deer response to natural hydrologic events. Fleming et al. (1994) makes an excellent case that an intermediate hydrological regime is optimum and that flooding during the February fawning season is the critical factor suppressing fawn recruitment.

2. Figure 3 could be interpreted as illustrating that the introgressed Texas stock is superior to pure Florida panthers. According to this figure, the deer population boom in the 1980s was twice as high as the deer boom in the late 1990s. However, the pure panther population did not increase during this deer surge in the 1980s. In contrast, the hybrid Florida-Texas pumas increased dramatically during the much

smaller increase in deer in the late 1990s. This is contrary to the view that the population was demographically vigorous throughout this time.

3. The paper presents no data or citations to support their assertion that "several years without severe flooding" occurred since 1995 to create a surge in deer numbers.

Maehr. D. S., and R. P. Meegan. 2001. Corridors, landscape linkages, and conservation planning for the Florida panther: enhancing expansion potential for an endangered species. Unpublished report to Lee County, Florida, USA.

Study Area: 18 south Florida counties, especially Lee County

Dates: 1981–2000

Note: Substantially the same text appears as Meegan and Maehr (2002); please read summary and comments for that paper.

Comments: Florida panther range as mapped in Figure 1 does not include most of Okaloacoochee Slough State Forest or any of Corkscrew Swamp (each has >100 radio locations), and excludes substantial numbers of radio locations in Broward County and western Collier County. This error is trivial, as the geographic range of the panther apparently did not enter into any analysis.

Maehr, D. S. and C. T. Moore. 1992. Models of mass growth for 3 North American cougar populations. Journal of Wildlife Management 56:700–707.

Summary: Previous growth curves of cougars were based on data from diverse locations and rearing conditions, and made an implicit assumption of homogeneity of growth characteristics among collection sites. We compared body masses of wild cougars from populations in Florida (*F. c. coryi*), Nevada (*F. c. kaibabensis*), and California (*F. c. californica*). The authors modeled mass as a nonlinear Richards function of age for each sex and population demographic group. Groups were consistent with respect to estimated birth mass and location of the inflection point of the growth curve. Adult mass was greater ($P < 0.001$) in males than in females in all populations, and the size of the difference was similar among populations. Estimated adult masses of Florida and California cougars were not different ($P = 0.381$) from each other, but were less ($P < 0.001$) than that of adult Nevada cougars. Growth rate varied by population but not by sex; Nevada cougars grew fastest to adult mass. Cougar mass is too variable to serve alone as an indicator of age beyond 24 months. Failure to control for population-specific influences on growth may bias inferences about growth.

Maehr, D. S., J. C. Roof, E. D. Land, and J. W. McCown. 1989*a*. First reproduction of a panther (*Felis concolor coryi*) in southwestern Florida, U.S.A. Mammalia 53:129–131.

Summary: A radio-tagged female panther was monitored ≥3 days per week after exhibiting denning behavior on 15 May 1986 in the Bear Island Unit of the Big Cypress National Preserve, Collier County, Florida. Her 9-month-old female kitten was captured and radio collared on 9 February 1987. From capture through October 1988, she used a 97-km^2 home range completely contained within the boundaries of her mother's 239-km^2 home range, although she was infrequently in the same location as her mother. On 3 August 1988, when 26 months old, she was observed with 4 spotted 9- to 14-kg kittens that possessed characteristics of being approximately 20 weeks old. This corresponded with a mid-March birth date and indicated that she conceived before 20 months and gave birth before 2 years of age.
Comments: This is a useful observation; the authors correctly avoid any implication that this single observation could be used to parameterize age at first reproduction in PVA. The observation is consistent with ages at first reproduction used in the 1999 PVA workshop (1 to 3 years, mode = 2).

Maehr, D. S., J. C. Roof, E. D. Land, J. W. McCown, R. C. Belden, and W. B. Frankenberger. 1989*b*. Fates of wild hogs released into occupied Florida panther home ranges. Florida Field Naturalist 17:42–43.

Summary: This study examined the feasibility of wild hog introductions as a means of artificially augmenting the panther prey base south of Alligator Alley. Six castrated hogs were released 27 March 1987 in the Fakahatchee Strand State Preserve within 1 km of a radio-collared adult female panther. Another 6 hogs were released 28 March in the privately owned Golden Gate area south of Alligator Alley within 200 m of a radio-collared female panther and her 8-month-old male kitten. Only 1 of the 12 released hogs was killed by a panther. Other predators were implicated in the deaths of 4 other hogs, including black bears (2), alligator (1), and an unknown predator. The single panther kill occurred 117 days after release within 4 km of the release site. Because of small sample size, no strong inferences could be drawn.

Maehr, D. S., E. D. Land, J. C. Roof, and J. W. McCown. 1989*c*. Early maternal behavior in the Florida panther (*Felis concolor coryi*). American Midland Naturalist 122:34–43.

Summary: Intensive monitoring of 2 radio-collared dams from January 1985–December 1987 revealed behavior patterns associated with rearing of kittens. Reductions in home-range size immediately after parturition (by 80%) were followed by an increase in area used by one female and decreased area used by the other. Activity was highest between 1600 and 2400 hours, and absences from the den increased as kittens aged. Lower abundance of large prey may explain one female's larger home range size, more variable activity pattern, and poorer physical condition. Dens were characterized by slight depressions in the ground with a few panther hairs; the dams did not otherwise modify the sites. Both dens were in vegetation nearly impenetrable to humans.

Comments: These are interesting and useful observations on panther behavior. The speculation about reasons for differences in home range and physical condition are reasonable, but inconclusive in the absence of replication. Small sample size (2 individuals) may preclude extrapolation to the population at large.

Maehr, D. S., E. D. Land, J. C. Roof, and J. W. McCown. 1990*a*. Day beds, natal beds, and activity of Florida panthers. Proceedings of Annual Conference of Southeastern Fish and Wildlife Agencies 44:310–318.

Summary: Day rest sites (95 sites, 18 panthers, 178 locations) and natal dens (6) studied from January 1986 to August 1989 were dominated by dense vegetation. Saw palmetto (*Serenoa repens*) dominated 66% of daybed sites and 4 of 6 dens. Activity was measured as percent of minutes per hour during which pulse-rate changes associated with changes in head position. Activity peaked around sunrise and sunset for both denning females (4 dams, 4,600 hours during first 2 months postpartum) and solitary panthers (6 panthers, 130 hours), but solitary panthers exhibited greater extremes in activity and inactivity. The greatest variation in activity occurred at night. Nocturnal shifts in location of 20 km were not unusual, and the highest levels of activity occurred at night. The authors note, "these results indicate that hourly mean percent activity for all panthers follows a general 24-hour cycle of nocturnal activity, as well as a shorter 12-hour cycle of crepuscular activity." Females were most likely to be at the den during daylight (den arrivals centered around 0800 and departures around 2200) and spent about 50% of the denning period at the den. Dens were maintained for 47–56 days. Three dams made multiple dens within a 50-m radius. Day beds and den sites are important habitat features in panther management.

Comments: Daybed dimensions and vegetation descriptions were based on ocular estimates, not measurements. The most important aspect of this study is that the authors did 24-hour monitoring of radio-collared panthers. As of 2002, this, and the related 1989 report

on maternal behavior, appear to be the only reports based on non-daytime observations.

Maehr, D. S., R. C. Belden, E. D. Land, and L. Wilkins. 1990*b*. Food habits of panthers in southwest Florida. Journal of Wildlife Management 54:420–423.
Summary: The objective of this study was to determine food habits of panthers and to examine geographic (north and south of latitude 26°11'N) and temporal variation (wet vs. dry months) in their diet. Based on 38 kills (1986–1989) and frequency of occurrence in 270 scats (1977–1989), the diet of Florida panthers in southwest Florida (Collier, Hendry, Lee, Glades, and Highland counties) was dominated by wild hog (*Sus scrofa*), followed by white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and 9-banded armadillo (*Dasypus novemcinctus*). Diet did not vary between wet (June–December) and dry seasons. In an area of better soils (north of 26°11'N) estimated biomass was 59% hogs and 27% deer, compared to 23% and 43% in the south. While deer dominated in biomass in the south, raccoons dominated in terms of number consumed. The authors interpreted this as "panthers inhabiting an area of better soils consumed more large prey." Exotics (hogs and armadillos) were important in both areas; both have high fecundity and are probably easy prey for panthers.

Maehr, D. S., E. D. Land, and J. C. Roof. 1991*a*. Social ecology of Florida panthers. National Geographic Research and Exploration 7:414–431.
Note: Bass and Maehr (1991) is inserted as a 1-page box on p. 427.
Summary: The authors determined 7,025 locations on 26 radio-tagged panthers (adults: 8 males, 7 females; subadults: 2 males, 2 females; 7 kittens) over 5 years (December 1985–October 1990). They assumed locations (all from aerial homing) were accurate to 100 m. For each panther, vegetation types were ranked from 8 to 1 (most to least preferred) by the rank order of percent used minus percent of home range composition. Friedman's test was used to test for selection across panthers, and indicated a preference for 4 forest types (hardwood hammock > pine flats > cabbage palm = cypress swamp) over the 4 nonforest types (mixed swamp = thicket swamp = freshwater marsh = agriculture/disturbed). This analysis was based on data from 9 panthers (5 F, 4 M). No reason was given for excluding the other panthers. They state, but do not present data, that panther preferences did not differ between wet and dry seasons, that panthers did not respond measurably to changing water levels, and that deer did not have seasonal home range shifts. They acknowledge that

agricultural and other non-preferred vegetation types can support high deer densities, and thus may influence habitat quality for panthers. These results differ from Belden et al. (1988) because the previous study was further south where soils and vegetation differed.

One male and 1 female were recruited in the 5 years, during which 1 adult male and 2 adult females died. The 2 females were killed in intraspecific aggressions <3 months after the male died, likely a result of social disruption due to loss of that male. A sidebar emphasizes that the demographic stability of the population is good news. They calculated population density for an undefined subset of this study area for a 5-month period near the end of the study during which they had 17 instrumented panthers and evidence of 4 untagged animals assumed to be females. They multiplied this density estimate of 1 panther per 110 km^2 by the entire area occupied by instrumented panthers over the 5 years (5,040 km^2) to estimate N at 9 resident males, 28 resident females, and 9 transient males, excluding Everglades National Park, eastern Big Cypress National Preserve, and Highlands and Glades counties.

Home range size ranged from 53 to 1,183 km^2, averaging 519 km^2 (SD 130) for resident adult males (623 km^2 for transient males) and 193 km^2 (SD 98) for adult females (178 km^2 for subadult females), with extensive overlap among females and limited overlap among males. Dispersal data were sparse, but suggest that male dispersal is frustrated by limited habitat and connectivity. One male (>24 months old) died of rabies. Social interactions were consistent with other puma studies.

Comments: 1. Diurnal telemetry limits valid inferences about habitat use.

2. The paper does not explain the basis for selection of the 7,025 locations from the much larger available data set.

3. The assumption of <100 m radio-telemetry error based on aerial homing is unlikely even in flat terrain.

4. As of November 2002, this paper's estimate of 46 panthers in 5,040 km^2 of habitat is the only published population estimate for Florida panthers based on a substantial body of field data.

5. There are no clear statements about the relationship among (a) the "study area" (which, as defined in Figure 3, seems to include occupied range north of the Caloosahatchee River), (b) the area used to generate their density estimate of 1 panther per 110 km^2, and (c) the 5,040-km^2 area to which this density estimate was extrapolated. They do not justify the assumption that panther density is the same in area (b) and (c). They do not explicitly state whether areas excluded from (c) were used by the tagged or untagged panthers.

Maehr, D. S., E. D. Land, and M. E. Roelke. 1991*b*. Mortality patterns of panthers in southwest Florida. Proceedings of Annual Conference of Southeastern Fish and Wildlife Agencies 45:201–207.

Summary: Using the method of Heisey and Fuller (1985) and data from telemetered panthers during 1987–1990 (4 years), the mean mortality rate was 17.2%, which is similar to other non-hunted populations of pumas. A bar chart suggests crude annual mortality rates of 2/10, 3/10, 1/13, and 5/19 in the 4 consecutive years; they report a range of 0% to 31.4% (SE = 13.3%) in annual mortality rates. The total known deaths during 1980–1991 was dominated by road-kills (50%), but the obvious bias towards detecting road-kills makes this rather meaningless. The authors claim that the *rates* of highway mortality and other human-caused mortality are actually quite low. Among radio-tagged animals, 8 natural mortalities (6 due to intraspecific aggression, 1 involving a congenital heart defect, and 1 due to rabies) exceeded the 1 roadkill and 1 research-related death.

Comments: The estimates of survival depicted in the bar chart differ slightly from the reported mean and SD; this may have occurred because they used observations at monthly or smaller intervals, rather than the annual results in the bar chart, to calculate survival.

The paper is silent on the age and sex of the radio-tagged animals used to provide the estimate of 17% mortality, and on whether there were any differences among age or sex classes. Maehr and Caddick (1995) state that this 0.17 estimate was based on "37 panthers of all ages." This "37 panthers" differs from "34 panthers" on page 205 of this paper, but the paper used different subsets of data for different purposes.

Maehr, D. S., J. C. Roof, E. D. Land, J. W. McCown, and R. T. McBride. 1992. Home range characteristics of a panther in south central Florida. Florida Field Naturalist 20:97–102.

Summary: This 7-month study of a single adult male panther (57 kg, estimated age 3–4 years) west and northwest of Lake Okeechobee is of interest because the panther was "outside the core population, on land dominated by private ownership…[that] differs from the southern Florida population center…[in] greater human population and agricultural [use]." Relocations were all from aerial homing in daytime. The panther used a home range of 1,182 km^2 (MCP, 70 locations), preferred forested uplands (pine flatwoods and hardwood hammocks) (chi-square test, daytime locations, availability based on percents of vegetation types within MCP home range), and avoided unforested habitats for daybeds. His large home range may have been due to young age, lack of other resident panthers (at most 1), prevalence of avoided habitats (65% of home range was urban,

agriculture, and unforested), or habitat fragmentation. Given the configuration of land uses and cover types and his known daytime locations, the panther must have traveled extensively through unforested areas at night. The fact that the animal must have traveled through non-forest at night is not explicitly stated in this paper, but the point was made by Maehr and Meegan (2001, 14).

Comments: In this study area, where forest cover was highly fragmented and discontinuous, this panther regularly crossed non-forest habitats much wider than 90 m, contrary to the assertions of Maehr et al. (2001) and Maehr and Deason (2002).

Maehr, D. S., E. C. Greiner, J. E. Lanier, and D. Murphy. 1995. Notoedric mange in the Florida panther (*Felis concolor coryi*). Journal of Wildlife Diseases 31:251–254.

Summary: Notoedric mange (*Notoedres cati*) was found in a neonate Florida panther, and presumably its mother, on 22 June 1992 and 8 February 1993, respectively, in Collier County, Florida (USA). Both infestations were treated successfully with 0.2 mg/kg ivermectin. These are the first known cases of notoedric mange in the endangered Florida panther.

Maehr, D. S., T. S. Hoctor, and L. D. Harris. 2001. The Florida panther: a flagship for regional restoration. Pages 293–312 *in* D. S. Maehr, R. F. Noss, and J. L. Larkin, editors. Large mammal restoration. Island Press, Covelo, California, USA.

Summary: This paper is similar in tone and content to Maehr and Caddick (1995), Maehr (1997*c*), and Maehr (1998).

Comments: This paper contains several statements lacking supporting evidence or citation.

1. “Unlike conspecifics in western North America, the panther is an obligate forest creature.” The sole citation is Maehr (1997*b*), which does not seem to offer quantitative evidence for the statement.
2. “What once was a holistic approach...now targets a single solution, genetic restoration, as its recovery focus.” No citation is offered.
3. “Panthers seem reluctant to travel across unforested habitat that is greater than 90m in width... (Maehr and Cox 1995).” The earlier paper does not make this claim and offers no supporting data.

Maehr, D. S., E. D. Land, D. B. Shindle, O. L. Bass, and T. S. Hoctor. 2002*a*. Florida panther dispersal and conservation. Biological Conservation 106:187–197.

Summary: The authors used radio tracking to study dispersal of 18 male and 9 female juvenile panthers during 1986–2000. They gathered 3 radio locations per animal per week. Dispersal was defined as the first date that a juvenile panther was separated from its mother for 1 week.

Male dispersal (mean maximum distance 68 km) was longer than for females (mean 20 km), and may have been facilitated by high local densities. Male dispersal tended to be circular (mean effective distance 37 km), and was probably frustrated (meaning the animal failed to establish a breeding home range). Frustrated dispersal is attributed to lack of additional populations and limited colonization opportunities. The authors use this to argue for the need to establish additional panther populations outside of the south Florida range. None of the 17 eventual home ranges were southeast of the natal home range. The authors use this to argue that the Everglades area to the southeast is marginal habitat, largely due to limited forest cover and low prey density in the Everglades area: "These factors appear to limit dispersal into the southeastern-most part of panther range."

Females established home ranges <1 home-range width from their natal ranges. No females, but 37% of dispersing males died during dispersal. Fifty-eight percent of males were successful in establishing a home range, but none of the home ranges excluded closely related females. All females, but only 63% of males, established territories. Initiation of dispersal occurred at ~14 months of age and lasted 7–10 months. The relatively early dispersal age "may result from a population that has approached or reached carrying capacity." On average, panthers dispersed shorter distances than western pumas. In 20 years of research, 3 unprecedented long-distance male dispersal events, each involving crossing the Caloosahatchee River, occurred in recent years. The 3 river crossings (April 1998, May 1999, April 2000) apparently occurred within 1 small area, perhaps due to lack of night lighting and a revegetated rail grade leading to the area. A proposed conservation network encompassed 87% of the locations of the male who explored most extensively north of the Caloosahatchee River; the panther could be a useful flagship for this effort. These 3 extraordinary movements may be related to recent introduction of Texas panthers into the population. They argue that these movements are entirely a demographic effect of higher population density. Females have yet to colonize nearby vacant range; successful movement of females to these areas may require habitat restoration or translocation.

Comments: 1. The argument that lack of forest limits dispersal to the southeast is problematic because none the 9 dispersal movements illustrated in the paper show that the disperser ever explored southeast and left after finding it lacking in some respect. Unfortunately, 8 of these dispersal maps were mapped only in "UTM space," which makes it hard to evaluate what landscape feature(s) influenced direction of movement. The fact that "none of the 27 began their dispersal to the southeast" further suggests they never explored there. In response to a query from the Scientific Review Team on this issue, Maehr responded, "Other than those animals that were born in the southeastern reaches of occupied panther range, no panthers left the core to make explorations in the southeast. Even among those that originated in the southeast, very few made it far enough north or west to flirt with interactions among resident core animals. Although this may have changed recently as numbers have grown as a result of the reproductive jumpstart from Texas animals, during my years of intimate familiarity with the project, only 1 animal (male #33) made it into core range from the south (he subsequently died from rabies before he left any evidence of reproductive activity)."

2. It is not stated what fraction of male and female dispersers crossed one or more major highway. This would be useful information.

3. The argument that early dispersal reflects a population near carrying capacity is problematic, because these dispersals occurred over a 14-year period during which the population increased quite a bit, and during the early years, large areas south of the Caloosahatchee were not occupied.

4. The argument that recent movements of dispersing males north of the Caloosahatchee are entirely due to higher population density south of the river is problematic for 2 reasons: (a) Logan and Sweanor (2001) demonstrated that male dispersal in pumas is obligatory and density-independent; (b) Maehr has stressed in several papers that this population has been producing surplus juveniles (especially males) for years prior to genetic restoration.

Maehr, D. S., R. C. Lacy, E. D. Land, O. L. Bass Jr., and T. S. Hoctor. 2002*b*. Evolution of population viability assessments for the Florida panther: a multiperspective approach. Pages 284–311 *in* S. R. Beissinger and D. R. McCullough, editors. Population viability analysis. University of Chicago Press, Chicago, Illinois, USA.

Summary: The authors conducted a PVA and compared their results to 1989 and 1992 PVAs that predicted complete extinction. The authors claim to use "2 decades of long-term demographic research that minimizes speculation" (see comment 1, below). The 5 participants were Lacy (developer of VORTEX), state and federal biologists (Land, Bass), and university ecologists (Hoctor, Maehr); each independently provided inputs for VORTEX and used VORTEX to estimate extinction risk (see comment 2). These wildly divergent models produced divergent estimates of extinction risk. The agreement among 4 of the 5 estimates of extinction risk was due to drastically differing, but fortuitously offsetting, assumptions between modelers. They then developed a consensus model. The consensus analysis suggests 98% probability of persisting for 100 years. This result is more optimistic than the 1989 and 1992 estimates due to some combination of 4 factors. (1) Kitten mortality was simulated at 20% compared to 50% in earlier PVAs (see comment 3). (2) N_0 was set at 60 (instead of the earlier 50) and carrying capacity K at 70 (instead of the previous 50). (3) They assumed no loss of habitat, in contrast to the previous assumption of 1% annual loss. They justify this as follows: "A 20-year pattern of gradual population expansion noted by R. McBride [makes it] difficult to argue that there was a decreasing trend in the area of habitat used by panthers" (see comment 4). (4) The new simulations, unlike previous PVAs, included augmentation in the form of 2 females per decade.

They did some sensitivity analysis to help determine which factor(s) may have most influenced the expected extinction risk. These analyses showed that extinction risk did not increase by adding habitat loss (25% over a century) to the model nor by removing population augmentation, nor by both in concert (see comment 5). The consensus model predicted high extinction risk as time horizon increased to 500 years, at which time extinction risk rose to 80%. They argued that "Like the cheetah, the Florida panther exhibits genetic impoverishment without clear impacts on demographics" (p. 300) (see comment 6).

Comments: 1. The authors claim that their analysis used "2 decades of long-term demographic research that minimizes speculation." Presumably, these 2 decades started with radio telemetry in the early 1980s. This claim is inconsistent with statements claiming a "small ephemeral sink population in the Everglades" and "no evidence of growth in the 1990s." These statements (in the section on "Basic demographics") ignore 7 years of demographic data showing a marked range-wide surge in panther numbers after 1995.

2. Vortex provides a poor match to puma natural history. For example, once a polygynous mating system is chosen, males become demographically irrelevant. (However, males do remain relevant to modeling the loss of genetic variability.)

3. Changing kitten survival rate from 0.50 to 0.80 was a change for the worse compared to previous PVAs. Shindle et al. (2001) suggest that 0.52 is the best estimate for pure panther stock.

4. The authors decided that the PVA would assume no trend toward habitat loss, based on the fact that panthers recently reoccupied some areas that lacked panther sign in previous years. This argument

incorrectly equates habitat "used" (which may have increased during the 1980s and 1990s) to habitat *available* (which will almost certainly decrease in the future, and which the model reflects in the parameters *K* and *habitat trend*). Nonetheless, the incorrect assumption of no decline in carrying capacity *K* over time had little impact in their sensitivity analysis.

5. Their sensitivity analyses showed no sensitivity to the only 2 factors whose sensitivity was examined (habitat trend, augmentation by translocations). Thus, the low estimate for extinction risk must be due to changes in one or more of the other factors that the authors changed from previous PVAs, namely their higher estimates of kitten survival, starting population size, and carrying capacity. This begs for a sensitivity analysis of these factors. Nothing in the paper justifies the claim that previous PVAs were "overly pessimistic with regard to panther demographics" or that this paper's optimistic conclusions were "due primarily to the use of fewer guesses."

6. Their argument against introgression hinges entirely on the lack of a demonstrated proof that inbreeding caused a decline in panther demography, rather than on the basis of the most plausible interpretation of the data.

7. The coefficient for "lethal equivalents" (3.14) is the default value assumed by VORTEX. No explanation of this value is offered (either in the report or in the Vortex program documentation).

8. Maehr's book (1997*b*, 124) states that 4 of 15 adult female panthers did not produce kittens during the periods (up to 10 years) that they were radio-tagged. Although some of these could have been past reproductive age and others may have been monitored for too short a period of time to estimate percent of females breeding, these data do not seem to support their use of 50% of females breeding each year (equivalent to 100% of females breeding on a 2-year cycle).

Mansfield, K. G., and E. D. Land. 2002. Cryptorchidism in Florida panthers: prevalence, features, and influence of genetic restoration. Journal of Wildlife Diseases 38:693–698.

Note: D. Land (personal communication, November 2002): "None of the bilaterals have ever made it to adulthood.... I'll have to check, but my ever so faulty memory believes that they died of intraspecific aggression."

Abstract: The overall prevalence of cryptochidism in Florida panthers (*Puma concolor coryi*) from 1972–2001 was 49% (24/49), with a significant increase over time. The earliest age at which descent of both testicles was known to occur was 2 mo and the latest was 10–13 mo. Delayed testicular descent was documented in 23% (8/35) of juveniles examined. Most retained testicles were in the inguinal canal. There was no apparent difference in reproductive success between cryptorchid and normal panthers, although no bilaterally cryptorchid panthers were known to have sired litters. Cryptorchidism was thought to be a manifestation of inbreeding and was one of several factors that led to the development of a genetic restoration plan whereby eight female puma from Texas were released into the panther population in 1995. None of the progeny resulting from genetic restoration efforts has been cryptorchid. This report provides evidence that cryptorchidism in panthers is genetically rather than environmentally based, and demonstrates the utility of genetic restoration for eliminating certain deleterious traits that result from inbreeding.

McBride, R. T. 2000. Current panther distribution and habitat use: a review of field notes fall 1999–winter 2000. Report to Florida Panther Subteam of MERIT, U.S. Fish and Wildlife Service, Vero Beach, Florida, USA. 13pp.

Summary: During this season, 54 days were spent recapturing panthers whose transmitters had failed prematurely, 6 days were spent on scheduled transmitter replacement, 2 days marking kittens, and only 17 days collaring new cats. The most significant development is that the panther population south of I-75, which had declined to zero in 1990 (Bass and Maehr 1991), increased from 6 radio-tagged animals in the previous year to 14 radio-tagged animals (all Texas progeny) in 2000, with sign of an additional 7 panthers (age breakdown not given, this may include kittens). McBride points out that this surge, including production of 10 kittens, is at odds with Maehr's (1997*b*, 213) assertion that panthers in this "terrible panther habitat" are "the 'living dead' of the population." The author claims that Maehr's evidence suggesting habitat limitation and against managed introgression is not supportable.

The author suggests that low kitten survival rates and poor reproductive success of "pure" panthers is mainly responsible for the lack of population expansion prior to introgression.

The total population includes 41 tagged and an estimate (based on sign, not extrapolation) of 21 untagged panthers, including subadults but not kittens at the den site. The author believes that the population is at its highest point in 30 years.

On page 6, McBride states that "all male panthers which are products of outbreeding have both testicles fully developed." (Shindle et al. [2001] stated that this could not be assessed until sexual maturity.) McBride argues that the most important habitat to purchase and protect is the area generally south of County Road 846 from Immokalee east to Big Cypress Seminole Indian Reservation; the area is under rapid conversion to citrus, sugar cane, and pasture.

Comments: 1. McBride is displeased with the failure rate of collars. It is not clear whether the failure *rate* (as opposed to *number* of failures) has increased over time, nor whether this was due to a change in vendor.

2. It would be easy to create annual indices such as "new panthers captured during the first 10 days of effort capturing new animals" or "new panthers captured incidentally during first 10 days of attempts to recapture tagged animals." Although crude, such indices would be better than McBride's persuasive, but anecdotal, argument.

McBride, R. T. 2001. Current panther distribution, population trends, and habitat use: a review of field work fall 2000–winter 2001. Report to Florida Panther Subteam of MERIT, U.S. Fish and Wildlife Service, Vero Beach, Florida, USA. 24pp.

Note: The animals injured during capture were re-released in November 2001 and January 2002 (Anonymous 2002).

Summary: During fall 2000–winter 2001, 42 days were spent attempting to recapture 3 of the 10 panthers whose transmitters had failed prematurely, 20 days were spent on 10 scheduled transmitter replacements, 3 days marking kittens, and only 9 days collaring new cats. The team succeeded in capturing only 1 of the 3 top-priority animals with failed transmitters. Two panthers suffered broken legs during capture activities and are expected to be returned to the wild after convalescence in captivity (See note above). During this season, the one hundredth panther was captured.

Several lines of evidence suggest that the population is expanding. (1) Eleven untagged panthers were treed (8 of them were radio tagged after capture) during the attempts to replace failed transmitters. Such incidental captures were "rare" before 1995. (2) For the first time, a den (4 kittens) was recorded south of US-41. (3) Collars and sign suggest 78 adult and juvenile panthers (excluding kittens at den). This minimum number is 66 if you exclude the 10 failed transmitters and 2 convalescing animals. (4) Numbers of new captures per year has increased despite shorter capture seasons (9 seasons to capture the first 27 animals, only 2 seasons to capture the next 27). McBride believes that the genetic restoration program is directly responsible for the population increase.

McBride argued (pp. 6–8) that Maehr (1997*b*) overstated the importance of forests as prime panther habitat: (1) pumas outside Florida use treeless habitats (McBride gives no citations, nor quantitative description of the vegetation in those habitats); (2) panthers now occupy and reproduce in relatively unforested areas south of I-75; (3) cover for stalking and ambush is more important than trees per se, and the open wet prairies of south Florida offer such cover; (4) deer are abundant in these prairies and panther sign is common on the prairie margins; and (5) 5 paragraphs of anecdotes about panther use of these areas.

McBride also questions Maehr's estimate of 80% kitten survival, as capture rates do not support such a high number.

Comments: 1. McBride uses capture success rate as an index to abundance. His index is simply the numbers captured per year, which assumes identical effort each year. At a minimum, this index should be adjusted by actual measures of capture effort.

2. The limited data and analyses in the report neither support nor refute claims of forest habitat dependency.

McBride, R. 2002. Florida panther current verified population, distribution, and highlights of field work fall 2001–winter 2002. Report for Florida Panther Subteam of MERIT, U.S. Fish and Wildlife Service, Vero Beach, Florida, USA.

Summary: The current verified population is 80 panthers spread among Everglades National Park (ENP) (6 radio-tagged and 1 untagged panther), Big Cypress National Preserve (BCNP) south of US-41 (1, 2), BCNP north of US-41 and south of I-75 (11,8), BCNP north of I-75 and Big Cypress Seminole Reservation (11, 8), Fakahatchee Strand State Preserve and Picayune Strand State Forest (4, 3), Florida Panther National Wildlife Refuge and Catherine Island (7, 1), Okaloacoochee Slough and adjacent private land (5, 5), and outliers (1, 6). This includes 9 animals with failed collars for which sightings or tracks suggest they are alive, but excludes a few other failed collars.

A major section, "Across the Caloosahatchee," indicates a new effort to search for sign and evaluate the potential of this area to support panthers. The largest wildland area north of the Caloosahatchee (including private land) would probably support about 6–8 adult panthers. However, the largest *public* tract is smaller than the typical adult male home range. Slated development of a 30,000-acre ranchland could sever the connection between the 2 best parcels in this potential expansion area. There were 12 confirmed cases of sign, representing at least 6 individuals during February 1972–July 1989, no sign for 9 years, then 6 cases (representing 6 individuals) since April 1998. These last 6 cases included 3 radio-tagged animals (1 pure Florida panther and 2 Texas hybrids). This area has enormous prey density (1,865 hogs were trapped on a 60,000-acre site in 2001, compared to a harvest of 84 hogs on the 729,000-

acre BCNP). However, the area is badly fragmented, habitat patches are widely scattered and crisscrossed by busy highways that run between and within tracts. Of the 3 radio-tagged dispersers, 1 was road-killed here, and the other 2 may have been (1 radio quit, the other cat was found dead and decomposed).

Another section on Habitat Protection in South Florida points out that the Comprehensive Everglades Restoration Plan (CERP) is scheduling more water releases into Shark River Slough, which could further isolate ENP from the rest of the panther population.

Comments: The estimate of minimum number known alive is reasonably rigorous. Much of the rest of the report is reasonable, but anecdotal.

McCown, J. W. 1991. Big Cypress deer/panther relationships: deer herd health and reproduction. Final Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 75pp.

Note: This document is reprinted in full in Jordan (1994*b*, 197–217).

Abstract: White-tailed deer track counts, observations, and a fall collection of doe deer were utilized to compare deer herds inhabiting Florida panther habitat in the Bear Island (BI) and Corn Dance Units (CDU) of Big Cypress National Preserve (BCNP), Fakahatchee Strand State Preserve (FS), Florida Panther National Wildlife Refuge (PR) and Collier Enterprise (CE) lands. Necropsies were used to obtain standard body measurements, kidney fat indices (KFI's), amounts of fat on the tail, kidney, pericardiac lining and heart, abomasal parasite loads, inter-uterine fecundity and physical condition. Although the FS herd increased during the study, deer in FS, CDU, and PR were less numerous than deer in BI. Deer in FS and CDU had lower KFI's, tail fat and physical condition values than deer in BI, PR, and CE. Deer from FS and CDU had fecundity rates less than 1.0 fawns per adult female while females from other areas produced more than 1.0 fawns per adult female. There was an inverse relationship between physical condition and abomasal parasite counts.

McCown, J. W., D. S. Maehr, and J. Roboski. 1990. A portable cushion as a wildlife capture aid. Wildlife Society Bulletin 18:34–36.

Summary: A portable, inflatable cushion for catching treed cats to avoid injury during capture is described, which cost $600 (materials and labor) in 1988. Deployment and assembly require 15–20 minutes. During 18 captures of 13 panthers from January 1986 through November 1988, the cushion was deployed 14 times and falls were cushioned on 9 occasions; panthers were lowered by rope 5 times. Heights at which panthers treed varied from 4 to 17 m (mean = 7.7, SD = 3.3).

McCown, J. W., M. E. Roelke, D. J. Forrester, C. T. Moore, and J. C. Roboski. 1991. Physiological evaluation of 2 white-tailed deer herds in southern Florida. Proceedings of the Annual Conference of Southeastern Association Fish and Wildlife Agencies 45:81–90.

Summary: This study's objective was to document the influences of habitat quality on deer in panther occupied range. During 1984—1986 deer were spotlighted and collected in the Bear Island Unit (n = 43) and the Eastern Monument Unit (n = 39) of Big Cypress National Preserve. Eight physiological variables were measured. Results indicated that the health and productivity of Eastern Monument Unit deer were reduced by poor forage quality.

Comments: No mention of panthers in the study.

Meegan, R. P., and D. S. Maehr. 2002. Landscape conservation and regional planning for the Florida panther. Southeastern Naturalist 1:217–232.

Note: Substantially the same as Maehr and Meegan (2001). Figure 20 in the Maehr and Meegan version is of interest because it gives the dates and identities of radio locations in and near Lee County.

Summary: The authors develop a regional blueprint for landscape conservation and restoration to enhance panther dispersal, facilitate population expansion to the north, and be used as a tool for land use decisions. The study area included 18 south Florida counties (panther radio-locations occurred in 14 of the counties), with a special emphasis on Lee County, which provided financial support for the research.

A GIS analysis (30-m pixels) lies at the basis of the effort. The authors assert that >51,000 radio locations through June 2000 were used to characterize habitat use. The habitat model included several steps.

1) Identify all forest patches >500 ha, and smaller forest patches that lie <2 km from large forest, and "smaller patches that may facilitate dispersal movements." Forests were assumed (based almost entirely on Maehr and Cox 1995) to be especially important for panther occupancy. The finding by Maehr and Cox (1995) that forests >500 ha were used more often than smaller forests was the only cited justification for the 500-ha threshold.
2) This preliminary map of panther habitat (i.e., the forest patches) was expanded (buffered) by enlarging each polygon by 90 m because Maehr and Cox (1995) found 96% of day locations were <90 m from large forest.
3) The buffered polygons were decreased by buffers extending 90 m from urban areas. Beier's (1995) report that traveling

pumas avoided well-lit areas was the only citation used to justify the 90-m buffer.

4) The resulting polygons were decreased by buffers extending 500 m from major roads (roads with >5,000 vehicles/day). The sole justifications for this 500-m buffer are (a) a personal communication that "large mammals" (more specifically "black bears" in the 2001 draft of this paper) avoided areas within 500 m of roads and (b) a reference to Beier (1995, 1996) (see comment below).

Model outputs included frequency distributions of patch sizes and inter-patch distances, and maps that can be used to identify significant habitat areas in need of connectivity. Priority for protection should be for the largest forest-influenced patches and associated connective habitats.

A least-cost path analysis modeled natural dispersal-colonization events to predict the best location for landscape linkages. The northern part of the existing population core area was used as the source of simulated dispersers and Fisheating Creek (north of the Caloosahatchee River in Glades County) was used as the destination. This destination area was used by all 3 dispersing male panthers that recently crossed the Caloosahatchee, has supported panther recently, and is the core of recently protected wildlands in Glades County. Each 30-m pixel was given 1 of 4 resistance values:

1) Any cell in or <90 m from a forest cell (any size forest), unless <90 m from an urban cell;
2) Any cell outside the forested buffer whose land use was classed as agriculture, rangeland, or wetland;
3) Any cell outside the forested buffer with "other" non-urban land use; these are sometimes referred to as "industrial lands" (Figure 7 puts wetlands in class 3, not in class 2 as described in the text; the massive areas mapped in class 3 suggests that open water is class 3);
4) Impenetrable: urban cells plus a 90-m buffer.

The least-cost dispersal path passed by small areas of development and through 14 forest patches ranging in size from 2 to 20,218 ha before crossing the Caloosahatchee River. The model identified an optimal route that crossed the Caloosahatchee River within a 4-km stretch of river where 3 panther crossings occurred during 1998–2000. The gentle slopes and lack of human settlement and night lighting suggest that this is a critical landscape linkage. Examination of other possible paths on air photos and land-use maps suggests it may be the best linkage area. The dredging of the Caloosahatchee River and other landscape changes have increased the isolation of the current Florida panther population. Some restoration will be needed to facilitate colonization by females. Expansion of the population is important because the existing core area is too small to maintain the population.

An analysis of permitted, but unbuilt, projects in Lee County suggests that large-scale land protection must happen quickly. Over 4,300 ha of forest and 3,500 ha of additional potential habitat may be lost by 2020; these include 5 of the 6 forest patches >500 ha in Lee County. Forested areas of southeastern Lee County offer the best opportunity to expand panther habitat, especially if linkages to panther core habitat can be maintained or restored.

Comments: 1. In Step 1, there was no justification for the "<2-km" distance for including smaller patches, nor any more sophisticated way of recognizing the value of small forests. For example, a 2,000-ha landscape with 8 forest patches (each 100 ha in size) would apparently not qualify despite being 40% forest.

2. The 90-m buffer on forest patches (Step 2) is not well justified in light of fact that locations were determined by aerial homing, which has errors exceeding 200 m (Belden et al. 1988, Janis and Clark 2002). An error analysis should be used as part of the process of setting the buffer.

3. Similarly, the 90-m buffer on urban areas (Step 3) is reasonable, but not rigorous, given that Beier (1995) also noted puma use right up to the edge of dark urban areas. The model needs a sensitivity analysis to show if the impact of this assumption is trivial or important to the final map.

4. The 500-m road buffer is not reasonable or justified. The paper cites Beier (1995, 1996) to justify this 500-m buffer, but those papers made no statement that would justify calling all habitat within 500 m of a road "non-habitat" (Step 4 of model). Also, Maehr and Cox (1995) found no statistical aversion to roads. The 500-m buffer is unreasonably large. These buffers eliminated 241,000 ha of forest (p. 23). Again, a sensitivity analysis is needed to assess the impact of this unreasonable assumption.

5. A sensitivity analysis may significantly change the map of priority sites, especially as the 500-m road buffer is decreased to something more reasonable. Then again, perhaps the map would be the same.

6. The least-cost path analysis in ArcView assumes that a panther can "see" the destination and select the least resistant path. The authors acknowledge that a dispersing panther uses trial and error instead, and illustrate this in Figure 5. This simple model does not justify the claim (p. 15) that the model incorporates "behavioral rules that emerged from 2 decades of research."

7. The authors assert that >51,000 radio locations through June 2000 were used to characterize habitat use, but no new analyses of habitat use are presented, and the habitat-use part of the model appears to rely on earlier published reports, especially Maehr and Cox (1995). The only sentence that may represent a new result based on 51,000 radio locations is in the first paragraph of the results: "81% of panther locations were in forests over 500 ha in size." The more recent radio locations, however, were used to examine dispersal behavior.

National Wildlife Federation. 2001. Panther recovery and reintroduction workshop: summary of proceedings. White Oak Conservation Center, Yulee, Florida, 14–17 August 2001.

Summary: The objectives were to encourage the U.S. Fish and Wildlife Service to reintroduce Florida panthers into historic habitat, educate the public to prepare them to live with panthers, and build coalitions to make reintroductions a reality. The report contains lists of challenges, opportunities, and key steps needed to achieve these several goals.

O'Brien, S. J., and E. Mayr. 1991. Bureaucratic mischief: recognizing endangered species and subspecies. Science 251:1187–1188.

Note: Since this paper was published, federal and state policies have been changed to allow introduction of genetic variation into subspecies or populations that would have naturally exchanged genes prior to endangerment (Hedrick 1995).

Summary: An allozyme and mitochondrial DNA (mtDNA) analysis revealed 2 distinct genetic panther stocks in Florida, including 1 that resembled South American pumas, apparently due to the release of 7 animals from captive stock into the Everglades between 1957 and 1967. This otherwise beneficial infusion of additional genetic material is a problem in light of a ruling from the Solicitor's Office of Department of the Interior that hybrids between endangered species, subspecies, or populations cannot be protected under the United States Endangered Species Act (ESA) of 1973. This policy concluded that the protection of hybrids would jeopardize the continued existence of listed species. The current status of the Florida panther as endangered could be challenged or even revoked under such a strict interpretation of this policy. The authors cite the Biological Species Concept (BSC) definitions of species and subspecies and offer some guidelines for subspecies classification. They recommend that the Hybrid Policy of the ESA should not imperil the listing or protection of species with sympatric hybrid zones as long as the existence of the zones does not disintegrate the genetic organization of the species in contact. For subspecies and threatened populations, the policy should be dropped. Easement of this policy would offer the Florida panther continued protection since it clearly qualifies as a subspecies.

O'Brien, S. J., M. E. Roelke, N. Yuhki, K. W. Richards, W. E. Johnson, W. L. Franklin, A. E. Anderson Jr., O. L. Bass, R. C. Belden, and J. S. Martenson. 1990. Genetic introgression within the Florida panther *Felis concolor coryi*. National Geographic Research 6:485–494.

Summary: Field observations indicated the presence of 2 distinct morphological phenotypes that are stratified between 2 adjacent areas (Big Cypress, Everglades) despite the occurrence of periodic migration between them. In an analysis of 636 panthers specimens (35 from Florida) collected during 1896 and 1987, Florida panthers had an 83% incidence of cowlick compared to 4.8% for other subspecies. Kinked tail occurred in 100% of 18 Big Cyprus swamp panthers. In the last decade, 23/24 panthers collected in Big Cypress Swamp had the 2 morphological traits, while 10 collected in Everglades National Park did not. The authors examined 24 panthers from Big Cypress, 7 from Everglades, and 10 from the Piper captive stock. A comprehensive molecular genetic analysis using mitochondrial DNA and nuclear markers indicates the existence of 2 distinct genetic stocks concordant with the morphological phenotypes. One stock confined to Big Cypress is derived from the ancestors of *F. c. coryi*. A second stock, found largely in the Everglades, is descended primarily from pumas that evolved in South or Central America, but were introduced (probably by man) in the Florida habitat very recently. The probable source of the introduced genes ("Piper stock") was initiated in the early 1940s with a litter born to a Florida panther female, but was supplemented over the next years with other captive non-*coryi* animals. There were documented releases of 7 Piper animals, including 3 females, during 1957–1967. Because genetic variability in the few remaining authentic Florida panthers is extremely low, panthers may be benefiting from the introgression of genetic material. Shark River Slough probably acts as a filter to minimize gene flow between the 2 groups. The 2 stocks shared a common ancestor recently enough (~200,000 years) that there is no genetic rationale to avoid interbreeding the 2 lines. Furthermore, subspecies hybridization is common in natural puma populations.

Comments: If I interpreted Figure 4 correctly, the pattern of mtDNA haplotypes suggests relatively unidirectional flow from Everglades towards Big Cypress, but the authors do not mention this.

Olmsted, R. A., R. Langley, M. E. Roelke, R. M. Goeken, D. Adger-Johnson, J. P. Goff, J. P. Albert, C. Packer, M. K. Laurenson, T. M. Caro, L. Scheepers, D. E. Wildt, M. Bush, J. S. Martenson, and S. J. O'Brien. 1992. Worldwide prevalence of lentivirus infection in wild feline species: epidemiologic and phylogenetic aspects. Journal of Virology 66:6008–6018.

Summary: The natural occurrence of lentiviruses closely related to feline immunodeficiency virus (FIV) in nondomestic felids is shown here to be worldwide. Cross reactive antibodies to FIV were common in several free-ranging populations of large cats, including East African lions and cheetahs of the Serengeti and in puma throughout North America. Infectious puma lentivirus (PLV) was isolated from several Florida panthers. Sequence divergences suggest that transmission of FIV between felid species is infrequent. To date there have been no apparent immunological or pathological symptoms observed in infected free-ranging large cats. Because T-lymphocyte depletion has been observed in FIV-infected domestic cats, it seems important to monitor free-living infected animals for T-cell depletion.

Pritchard, P. C. H., editor. 1976. Proceedings of the Florida panther conference. Florida Audubon Society and Florida Game and Freshwater Fish Commission, Tallahassee, Florida, USA. 121pp.

Note: The participant list included 20 names. Most papers have been superceded by more recent work. The papers are listed below.

Summary: Layne, J. M., and M. N. McCauley (pp. 5–45). A biological overview of the Florida panther. (The many passages bemoaning lack of information demonstrate that 2 decades of research have filled many voids in our understanding.)

Kisling, V. N. (pp. 46–58). Captive propagation and study as an integral component of a field-captive management program for the Florida panther.

Henry, V. G. (pp. 59–77). The recovery plan concept of the Fish and Wildlife Service.

Belden, R. C., and L. E. Williams (pp. 78–98). Survival status of the Florida panther.

Baudy, R. E. (pp. 99–108). Breeding techniques for felines destined for release in the wild: recommendations for the Florida panther. (In the 1970s Baudy bought the Piper stock and produced over 100 animals of mixed *coryi* and western puma stock at his facility in Sumter County (Pritchard in Jordan (1994*b*, 333).

Vanas, J. (pp. 109–111). The Florida panther in the Big Cypress Swamp and the role of Everglades Wonder Gardens in past and future captive breeding programs. (Mostly a history of the Piper stock.)

Nowak, R. M. (pp. 112–113). Status survey of the southeastern puma. (Reprint from World Wildlife Fund Yearbook 1972-3.)

Nowak, R. M., and R. T. McBride (pp. 114–115). Status of the Florida panther. (Reprint from World Wildlife Fund Yearbook 1974-5.)

Nowak, R. M., and R. T. McBride (pp. 116–121). Status survey of the Florida panther. (Reprint from World Wildlife Fund Yearbook 1973-4.)

Roelke, M. E. 1990. Florida panther biomedical investigation. Final Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 175pp.

Note: There were annual performance reports by Roelke and various co-authors for each year during 1985–1989. Each report covered only 1 year, and we assume that this final report incorporates all previous ones.

Abstract: Veterinary medical management has improved the safety of Florida panther immobilizations. Since veterinary involvement began in January of 1983, 89 immobilizations involving 40 individuals have been accomplished with one possible capture mortality. The veterinary medical team has been involved in all Florida panther captures by the 2 agencies conducting panther research, the Florida Game and Fresh Water Fish Commission (GFC) and the National Park Service. The physical condition, body weight, reproductive status, and hematologic and serum values all indicate that the panthers utilizing land north of State Road 84, particularly the private ranches east of Immokalee, the Florida Panther National Wildlife Refuge, Bear Island Unit of the Big Cypress National Preserve (BCNP), and adjacent ranches were in excellent health and in better condition than those in the Everglades National Park (ENP) or Fakahatchee Strand State Preserve (FSSP). The north/south "health cline" in southwestern Florida appears to be associated with the type and abundance of prey taken. Nine panthers have been rescued and removed from the wild due to injuries or illness; 4 were successfully rehabilitated and released back to the wild, 3 did not survive because of the severity of their injuries or illness, and 2 are still receiving treatment in captivity or are permanent residents.

Serologic evidence from 51 different Florida panthers indicates that they were exposed to or are infected with several potentially pathogenic agents: feline panleukopenia virus (FPV) (65%), feline calicivirus (FCV) (43%), feline enteric corona virus/feline infectious peritonitis virus (23%), feline immunodeficiency virus (25.6%), rabies virus (26%), feline syncytia-forming virus (FeSFV) (33.3%), *Toxoplasma gondii* (8.0%) and *Brucella* sp. (2.4%). All were negative for pseudorabies virus (PRV), feline leukemia virus, and feline viral rhinotracheitis virus (FVRV). The prevalence of FPV was significantly higher in the FS/Big Cypress Swamp (BCS) ecosystem than in the ENP ($p<0.05$). However, there was no significant difference in prevalence of FCV by location ($p>0.05$). The significance of many of these agents in free-ranging panthers is yet to be determined, but an unvaccinated panther died of a raccoon rabies virus. We believe that this is the first documented case of rabies in a wild cougar. A serosurvey of bobcats (n=113) indicated that they have been exposed to FPV (44.2%), FCV (33%), FVRV (9.3%), and *Toxoplasma gondii* (7.1%). One hundred fifty-five other carnivores were tested for FPV antibodies, positive animals included otter (13.2%), raccoon (43.0%), and grey fox (8.3%). One hundred sixty-six non-panther carnivore sera were screened for PRV, and only raccoon (3 of 57) and black bear (2 of 20) were positive. *Cytauxzoon felis* was documented in both free-ranging Florida panthers and bobcats.

Mercury was identified as a significant contaminant in free-ranging panthers, particularly those living on the ENP and the FSSP. Mercury was strongly implicated in the death of one female panther in the ENP with a liver mercury level of 110 ppm (wet weight).

In vitro fertilization experiments produced 141 oocytes (eggs) from seven female cougars. Following insemination, ten cleaved embryos resulted, including one sired by a captive Florida panther. Transfer of the embryos to two recipient females did not result in any live births. Although the species as a whole has abundant genetic diversity (minimum of 11 of 41 loci are polymorphic based on allozyme analysis), *F. c. coryi* has fewer polymorphic loci (7.5%) and lower heterozygosity (0.019) than other wild subspecies examined. This result, coupled with abnormal male reproductive traits (>90% abnormal spermatozoa and 44.4% cryptorchidism), raises serious concern for the reproductive potential and genetic health of the subspecies. Mitochondrial DNA (mtDNA) analysis of 8 North American (NA) and 3 South American (SA) subspecies of puma indicates that two groups, or clades, can be discriminated a NA clade and a SA clade. The mtDNA study revealed that the Florida panther has two populations with differing maternal evolutionary histories: a BCS population largely descended from NA clade, and an ENP population that includes Central American (CA) or SA genes. This foreign genetic material may result from non-*coryi* cougar releases which occurred in the ENP between 1957–1967. The Florida panther may have benefited from this introgression of SA or CA genes in that the incidence of cryptorchidism is zero in males with ENP mtDNA as compared to 63% of the males with BCS mtDNA.

Only 10 of 23 pregnancies (43%) resulted in >1 offspring surviving beyond 6 months of age.

Comments: U.S. Fish and Wildlife Service (1994) cited the statistic that only 43% of pregnancies resulted in 6-month-old offspring to describe reproductive performance of Florida panthers. However, this statistic included 2 pregnancies documented on necropsy, and excluded 3 litters <4 months old that were alive at the time of writing. Thus, as many as 13 of 21 pregnancies (62%) could have resulted in 6-month-old offspring, and 43% is a pessimistic estimate.

Roelke, M. E., and C. M. Glass. 1992. Strategies for the management of the endangered Florida panther (*Felis concolor coryi*) in an ever shrinking habitat. Proceedings of the Joint Meeting of the American Association of Zoo Veterinarians and American Association of Wildlife Veterinarians 1992:38–43.

Summary: Habitat loss is the main threat to the subspecies, with only about half the range in federal or state ownership. Citrus acreage has grown by 400% in Collier and Hendry counties as the industry moves south to escape devastating freezes further north, converting thousands of acres of prime habitat. Large land acquisitions are in progress and planned. A huge block of public land in southeastern Florida is not occupied by panthers, perhaps due to low prey density, recreational traffic, lack of forest, poor soils, or environmental contaminants. Florida Panther National Wildlife Refuge, while only 1% of panther range, can be a valuable laboratory to determine if active management (control of human activity, vegetation, enhancement of prey populations) can improve capacity of land to support panthers. Their management strategies include reducing road mortality (speed limits, enforcement, undercrossings); rehabilitating injured or sick animals (4 of 8 have been returned to the wild); vaccination against rabies, panleukopenia, calicivirus, rhinotracheitis (at each handling); administration of de-worming medicine (at each handling); and captive breeding (9 animals in captivity, no reproduction yet).

Roelke, M. E., D. P. Schultz, C. F. Facemire, and S. F. Sundlof. 1991*a*. Mercury contamination in the free-ranging endangered Florida panther (*Felis concolor coryi*). Proceedings of the American Association of Zoo Veterinarians 1991:273–283.

Summary: Mercury was identified as an important contaminant in free-ranging panthers, raccoons, otters, and alligators but not bobcats in southern Florida. Those animals with relative high levels of mercury were found in the Shark River Slough of the Everglades

National Park, Water Conservation Area 3A, and adjacent wetlands. Mercury toxicosis may have been responsible for at least 1 panther death in the Everglades National Park and is strongly implicated in 2 others since 1989. There were significant differences in levels of mercury in panthers when compared by geographical locations and age. Average levels of mercury were greatest in panthers from the eastern portion of the range, particularly from the Shark River Slough area, and lowest values were noted in panthers from north of Alligator Alley. The mean liver mercury level of the younger group of panthers (less that 8 years old) living in the eastern range was significantly higher than that from the western range. When only the western group was considered, older animals had significantly higher liver mercury levels than did younger ones. The liver mercury burden was much higher among animals living in the Fakahatchee Strand State Preserve than the single older animal living north of that area. Females with elevated mercury had poorer reproductive success than those with low mercury levels. However, concomitant nutritional stress associated with their prey based probably also contributed to the poor reproductive performance of females in Fakahatchee Strand State Preserve, but apparently not in Everglades National Park. The most probable source of mercury contamination in panthers is via the food chain. The panthers north of Alligator Alley had the lowest levels of mercury and fed primarily on white-tailed deer and feral hogs. Although nothing is known about tissue mercury levels in the hog, mercury levels have been shown to be low in deer tissues from southern Florida. Panthers with elevated levels of mercury occur where they consume mercury-contaminated non-ungulate prey as part or all of their diet (raccoon is probably the primary source of mercury). Mercury levels in panthers living in the Fakahatchee Strand State Preserve have dropped significantly ($P < 0.01$) since fall of 1987 when land management actions were initiated to enhance deer density in that area. Chronic exposure to mercury, resulting in mortality and lowered reproductive success, may be a significant factor responsible for lower than expected population densities of panthers in large portions of their range and is likely contributing to the extinction of this endangered mammal.

Comments: 1. Comparisons among areas in Hg concentration are based on small sample sizes (in one case, a single cat) and thus generalizations to habitat differences are tenuous. The connection between Hg burden and reproductive failure is also tenuous. As noted in the article, when deer were in low densities or absent, females probably were nutritionally stressed, which is sufficient for explaining reproductive failure without invoking Hg contamination. Further, starvation may mobilize Hg stored in muscle. Under this view Hg might be a proximate cause of reproductive failure or depressed reproductive rates, but would not be the ultimate cause.

2. The Florida Fish and Wildlife Conservation Commission has continued to collect data on mercury since 1991, but as of 2002, they have not analyzed and interpreted changes over time, and tissues collected since 1997 have not even been analyzed for Hg. The annual veterinary reports show large year-to-year variation. The data in hand should be analyzed and given a thoughtful analysis to determine whether the hypotheses raised in this paper are supported.

Roelke, M. E., D. P. Schultz, C. F. Facemire, S. F. Sundlof, and H. E. Royals. 1991*b*. Mercury contamination in Florida panthers. Report to the Florida Panther Interagency Committee. 57pp.

Summary: Examination of a dead radio-collared female Florida panther (*Felis concolor coryi*) revealed relative high Hg concentration (110 ppm wet wt.) in the liver, comparable to levels found to be lethal in feral cats in Japan. Analysis hair and blood revealed Hg concentrations of 130 and 21 ppm, respectively. Tissue samples from 52 free-ranging panthers, mainly in the Big Cypress Swamp and Everglades ecosystems, were collected opportunistically from 1978 to 1991. Differences in Hg concentration occurred by location and age. Mean Hg level (25.8 ppm) for panthers <8 years old living in southeastern Florida was significantly higher ($p = 0.024$) than for panthers in southwestern Florida (0.304 ppm). Within the western group, older animals had higher Hg levels (14.6 ppm) than younger (0.304 ppm). Concentrations were particularly high among older animals living in the Fakahatchee Strand State Preserve (19–20 ppm). Patterns of distribution by location for hair and whole blood were similar. Reproductive success of females appears to be adversely affected by elevated Hg levels, with lower numbers of surviving kittens for females with whole blood Hg >0.5 ppm (mean = 0.167 kittens/female/year) compared to those with Hg <0.25 ppm (mean = 1.46 kittens/female/year). The most probable source of Hg contamination is via the food chain. Panthers with the highest Hg levels consumed the greatest amounts of nonungulate prey (raccoons, armadillos, rabbits, and alligators).

Comments: The evidence for spatial and age-specific variation, and a food chain mediation of Hg contamination, may not support the broad conclusions presented. Sample sizes for comparison were small; in one case a single cat was the basis of a comparison. No details are given as to the source of information about the details of prey consumption by individual cats. It seems doubtful, for instance, that the authors traced Hg levels of individual cats to that individual's prey consumption over a preceding time interval long enough to result in accumulation.

Roelke, M. E., J. S. Martenson, and S. J. O'Brien. 1993*a*. The consequences of demographic reduction and genetic depletion in the endangered Florida panther. Current Biology 3:340–350.

Dates: The paper reflects data collected through 1992

Note: This report is reprinted in full in Jordan (1994*b*, 423–433).

Summary: Florida panthers have low genetic diversity in each of 3 measures.

1) mtDNA of Florida panthers shows 2 highly divergent haplotypes: 1 centered on Big Cypress National Park that resembles other North American puma, and a second in Everglades National Park (ENP) that resembles South American puma and presumably resulted from Piper stock animals released during 1956–1966. The level of mtDNA variation in the pure panthers is the lowest reported in a felid, including leopards and cheetahs. The moderate level of kinked tails (9%) and cowlicks (27%) in ENP suggests that some mixing has occurred there.

2) Allozyme polymorphism at 41 loci was 4.9% for *coryi* compared to a range of 7.3% to 17.1% for 6 subspecies of western puma. Average heterozygosity was 1.8% for *coryi* compared to 2.0%–6.7% for the other 6 subspecies. The allozyme study supports the view that there has been a reduction in genetic diversity in the Florida panther, which is a consequence of inbreeding.

3) Minisatellite variation ("DNA fingerprinting") was 85% lower in *coryi* than in western pumas and 65% lower than Piper stock. This low level of DNA fingerprint variation supports the inference from mtDNA and allozyme findings that Florida panthers have experienced substantial inbreeding and concomitant loss of genetic diversity in recent history.

Panthers suffer from 3 physical abnormalities that may be related to low genetic variability.

1) Low sperm quality. Although all large felids have low sperm quality, motile sperm per ejaculate in the Florida panther is 18–38 times lower than in other puma subspecies. Florida panther sperm have a 40% incidence of acrosomal abnormality, which renders sperm deficient in fertilization potential. They also have a significantly greater frequency of malformed spermatozoa (94.3% per ejaculate) than any other puma subspecies.

2) Cryptorchidism occurred in 56% of males examined since 1978 compared to 0 of 40 free-ranging western and South American pumas;

this trait is known to be heritable in several domestic species. Figure 6 indicates a dramatic rise in this trait over time, with cryptorchidism in only 1 of 8 males born before 1980, compared to 11 of 17 males born after 1985. Eighty percent of males born after 1989 have the condition. Two of 9 known living males are bilaterally cryptorchid and sterile.

3) Atrial septal defect (ASD) or patent foramen ovale apparently caused death in 2 panthers (ages 2 and 5 years). A third panther underwent surgery to correct an ASD and defective tricuspid valve but failed to survive. The link between ASD and genetics is not clear; environmental contaminants could also play a role. Heart murmurs (which may not indicate ASD) occur in 80% of Florida panthers, compared to 4% of other pumas.

A pedigree chart (Figure 7) suggests that cryptorchidism is associated with documented matings of close relatives.

Finally, low genetic variability may increase susceptibility of Florida panthers to infectious disease and parasites. The pathogen/parasite load is relatively high in Florida panthers. At least 1 agent, *Pseudomonas aeruginosa*, which caused 1 panther death, is unexpected except in hosts with disarmed immune systems.

The authors conclude that the ecological and biomedical assessments of the population reveal a collection of interacting ecological, demographic, and genetic factors that threaten the survival of the Florida panther population. They further note, “The Florida panther provides a dramatic example of the process of human-caused population decline.”

Comments: 1. The bilateral cryptorchid (sterile) males would be a big problem if they fought with other males, copulated with females, and thus wasted reproductive potential of other animals in the population, but a smaller problem if they are just competing for prey. In that regard, Darrell Land (personal communication, November 2002) says that most bilaterals died young, often with bite marks, and that there is no suggestion that they are territorial or copulate with females.

2. All lines of evidence are mere correlations; there is no proof that any of these abnormalities are due to loss of genetic variability. However, the link between genetics and these traits is the most reasonable explanation. The rise of cryporchidism in recent decades is powerful circumstantial evidence. In general, this paper provides a compelling case that inbreeding was a serious problem for panthers.

Roelke, M. E., D. J. Forrester, E. R. Jacobsen, G. V. Kollias, F. W. Scott, M. C. Barr, J. F. Evermann, and E. C. Pirtle. 1993*b*. Seroprevalence of infectious disease agents in free-ranging Florida panthers (*Felis concolor coryi*). Journal of Wildlife Diseases 29:36–49.

Abstract: Serum samples obtained from 38 free-ranging Florida panthers in southern Florida, March 1978 through February 1991, were tested for antibodies against eight bacterial, parasitic, and viral disease agents. Sera were positive for antibodies against feline panleukopenia virus (FPV) (78%), feline calicivirus (56%), feline immunodeficiency virus/puma lentivirus (37%), feline enteric coronavirus/feline infectious peritonitis virus (19%), and *Toxoplasma gondii* (9%). All samples were seronegative for *Brucella* spp., feline rhinotracheitis virus, and pseudorabies virus. In addition, all the animals tested were negative for feline leukemia virus p27 antigen as determined by enzyme-linked immunosorbent assay. Feline panleukopenia virus was considered to be a potentially significant disease agent; FPV antibodies occurred in the highest prevalences in older age classes ($P = 0.096$). Because <50 animals remain in this relict population and the probable resultant depression of genetic diversity and lowered disease resistance, FPV or other disease agents could contribute to the extinction of this endangered subspecies.

Roof, J. C., and D. S. Maehr. 1988. Sign surveys for Florida's panthers on peripheral areas of their known range. Florida Field Naturalist 16:81–85.
Study Area: Fisheating Creek, Glades County, and Corkscrew Swamp, Collier County, Florida
Dates: April 1984–March 1987
Summary: This paper describes techniques used to look for panther sign in areas peripheral to panther distribution. A search method involving weekly surveys from an all-terrain cycle was preferred over pick-up truck surveys.

Rotstein, D. S., S. Taylor, J. Harvey, and J. Bean. 1999a. Hematologic effects of cytauxzoonosis in Florida panthers and Texas cougars in Florida. Journal of Wildlife Diseases 35:613–617.
Abstract: *Cytauxzoon felis* is a long-recognized hemoparasite of free-ranging Florida panthers (*Puma concolor coryi*), but its prevalence and effect on the population has not been assessed. Red blood cell indices and white blood cell counts were compared between infected and noninfected Florida panthers and Texas cougars (*Puma concolor stanleyana*) from 1983–1997 in Florida (USA). The prevalence of cytauxzoonosis for both populations was 39% (11/63) and 36% overall. Thirteen hematologic parameters were compared between *C. felis* positive and negative panthers and cougars. Florida panthers had significantly lower mean cell hemoglobin count (MCHC) and higher white blood cell (WBC), neutrophil, monocyte and eosinophil counts ($P \leq 0.05$) than Texas cougars. Infected Florida panthers had

significantly lower mean cell hemoglobin (MCH) and monocyte counts than infected Texas cougars. Although statistically significant difference were measured for hematologic parameters in *C. felis* positive panthers and cougars, biologically significant values were generally within expected reference ranges for healthy animals. Cytauxzoonosis does not appear to have a negative effect on the hematologic parameters of chronically infected panthers and cougars. Potential transient changes during initial infection were not evaluated.

Rotstein, D. S., R. Thomas, K. Helmick, S. Citino, S. Taylor, and M. Dunbar. 1999*b*. Dermatophyte infections in free-ranging Florida panthers (*Felis concolor coryi*). Journal of Zoo and Wildlife Medicine 30:281–284.
Abstract: Three free-ranging Florida panthers (*Felis concolor coryi*) were diagnosed with clinical dermatophytosis; two were infected with *Trichophyton mentagrophytes*, and one was infected with *Mycrosporum gypseum*. Two of these panthers were juvenile males that were diagnosed with focal to focally coalescing dermatophytosis; one caused by *M. gypseum* and the other by *T. mentagrophytes*. These animals were not treated, and clinical signs resolved spontaneously over 6 months. The third panther, an adult male from southern Florida, presented with a diffuse dermatophytosis due to *T. mentagrophytes* infection. Initially, the panther had alopecia, excoriations, ulcerations, and multifocal pyoderma of the head, ears, neck, rear limbs, and abdominal region that progressed to lichenification of the skin and loss of nails from two digits. When topical therapy applied in the field at 45-day intervals was ineffective in clearing the infection, the animal was placed in captivity for intensive oral therapy to prevent further development of dermal mycosis, loss of additional nails, and spread of infection to other panthers. The panther was treated orally with itraconazole (9.5 mg/kg) in the food s.i.d. for 6 weeks. After treatment, nail regrowth occurred but the multifocal areas of alopecia remained. The panther was released back into the wild after two skin biopsy cultures were negative for fungal growth. Temporary removal of a free-ranging animal of an endangered species from its habitat for systemic treatment of dermatophytosis requires consideration of factors such as age, reproductive potential, holding facilities, treatment regimen, and the potential for successful reintroduction of the animal.

Rotstein, D. S., S. K. Taylor, G. D. Bossart, and D. Miller. 2000*a*. Dissecting thoracoabdominal aortic aneurysm in a free-ranging Florida panther (*Felis concolor coryi*). Journal of Zoo and Wildlife Medicine 31:208–210.
Abstract: A 12-yr-old female free-ranging Florida panther (*Felis*

concolor coryi) was found dead in good flesh. The panther had a ruptured thoracoabdominal aneurysm and 0.5 L of unclotted blood in its thorax. Intimal plaques 6.0 X 3.0 X 3.0 cm and 4.0 X 3.0 X 1.0 cm were present in the thoracic and abdominal aorta extending below the bifurcation of the renal arteries. Histologic examination revealed necrohemorrhagic aortitis with a mixed inflammatory infiltrate of lymphocytes, macrophages, and neutrophils. Death was almost certainly due to exsanguination and hypovolemic shock secondary to the ruptured aneurysm, and the aortitis with the resultant aneurysm may have been secondary to an infectious or a toxic process. This is the first reported death of a free-ranging mammal from a ruptured aortic aneurysm.

Rotstein, D. S., S. K. Taylor, J. Bradley, and E. B. Breitschwerdt. 2000*b*. Prevalence of *Bartonella henselae* antibody in Florida panthers. Journal of Wildlife Diseases 36:157–160.

Abstract: Serum samples from 28 free-ranging Florida panthers (*Puma concolor coryi*) and seven mountain lions from Texas (*P. concolor stanleyana*) living in south Florida (USA) between 1997 and 1998 were tested for antibodies to *Bartonella henselae*. Twenty percent (7/35) of the samples were reactive to *B. henselae* antisera with a subspecies prevalence of 18% (5/28) for Florida panthers and 28% (2/7) for cougars from Texas (USA). There was no significant sex related difference in infection rates among the Florida panthers. Antibody prevalence was higher in panthers <2-yr of age (40%) compared to panthers >2-yr (13%). Compared to studies of antibody prevalence in mountain lions (*P. concolor*) from California (USA), overall seroprevalence was lower as was prevalence in panthers >2-yr-old. However, the seroprevalence in animals <2-yr from southern Florida was similar to prevalences reported in mountain lions of domestic felids in California.

Rotstein, D. S., S. K. Taylor, A. Birkenhauer, M. E. Roelke-Parker, and B. L. Homer. 2002. Retrospective study of proliferative papillary fulvitis in Florida panthers. Journal of Wildlife Diseases 38:115–123.

Abstract: Proliferative, papillary vulvitis was identified in 16 of 34 (47%) free-ranging and captive female Florida panthers (*Puma concolor coryi*) monitored over a period from 1983–98. Gross lesions were characterized by extensive papilliferous proliferation in the mucosa of the vestibulum vaginae. Within lesions, the mean length and width of vestibular papillae were 1.07 ± 0.39 mm (CV = 36%) and 0.55 ± 0.11 mm (CV = 20%) respectively. Histologically, three to 12 layers of non-cornified stratified squamous epithelium with various degrees of basal cell spongiosis and rete ridge formation covered fibrous papillae. Mixed leukocytic mucosal inflammation also was observed. Infectious organisms were not observed, and immunohistochemical testing for the presence of papillomavirus antigens in specimens from seven panthers was negative. Lesions in nearly all of the panthers were first observed during a six-year period (1986–92), with one each in 1983, 1996 and 1998. There were no significant differences between the number of females having litters, the number of litters between age-matched and interval-matched females, and the interval between litters among lesion positive and lesion negative females over the 15-yr period. The severity of lesions did not appear to differ between parous and nulliparous free-ranging lesion-positive females. The cause of proliferative vulvitis remains unknown. However, the lesion did not appear to have a significant effect on reproduction.

Schortemeyer, J. L., D. S. Maehr, J. W. McCown, E. D. Land, and P. D. Manor. 1991. Prey management for the Florida panther: a unique role for wildlife managers. Transactions of the North American Wildlife and Natural Resources Conference 56:512–526.

Summary: This is a history of events between the early 1900s and the present that affected panthers and prey. It includes a history of regulation changes, land purchases, etc. Some conclusions and recommendations include the following.

- Two important prey species (wild hogs and armadillos) are exotics that became established as a result of actions unrelated to Florida panthers. Efforts to control or eliminate either species from currently occupied range could have adverse impacts on the panther. In addition, stocking, especially wild hogs, could enhance game abundance, especially in areas where low prey density is a problem for the panther.
- Loss of habitat due to urban and agricultural development has been widespread. The most important conservation action yet has been the protection of >1,000,000 ha of contiguous habitat in the Everglades and Big Cypress Preserve. Most of the landscape in the Everglades/Big Cypress areas, although very important to panthers, is not prime habitat for the panther or its prey (Maehr 1990*a*). New management strategies and incentives must be developed to ensure that private lands will continue to provide important habitat for panthers and their prey.
- In the last decade, initial management action was regulatory and aimed at minimizing perceived adverse impacts of recreational hunting on both prey and predator. These actions, combined with the

existing conservative bucks-only harvest strategy, have minimized the potential adverse impacts of overharvesting deer and hog.

- Higher prey densities may be achieved by improving habitat conditions; increasing forage quantity and quality has the greatest potential in the Big Cypress area. Prescribed fire, currently used mostly to prevent catastrophic wildfires, can also improve habitat conditions for wildlife, but burning programs should be designed for these specific purposes. Burns should be conducted on fire-tolerant areas on a 2- to 5-year rotation, depending upon fuel type and site conditions. Burn compartments should be less than 2,500 ha and annual partial compartment burns or rotating burns should be employed when possible to increase habitat heterogeneity. For deer and/or hogs, food plots, clearings, and feeders have been effective management tools in local situations. Disturbed sites, particularly those invaded by willows, have produced good forage for deer. Establishment of mast-producing species, including oak and palms, on disturbed sites can significantly increase mast production in selected areas.
- Although recreational hunting may not adversely impact deer behavior or deer numbers, radio-tracking data suggest that panthers may alter use patterns in response to human hunting activity. Recent regulation changes including designated trails, reduced quotas, and shortened seasons may reduce these impacts. However, because the cause and effect relationships between panther and human behaviors have not been established, additional research concerning predator, prey, and human interactions would be valuable.

Seal, U. S. 1991. Genetic management considerations for threatened species with a detailed analysis of the Florida panther. Report to U.S. Fish and Wildlife Service. Conservation Breeding Specialists Group, Apple Valley, Minnesota, USA. 20pp.

Note: A report of a workshop held 30–31 May 1991 in Washington, D.C. In 1991, the Conservation Breeding Specialists Group was the *Captive* Breeding Specialists Group; we use the newer name for the sake of consistency with the modern one.

Summary: This is a report of a workshop held in Washington, D.C., in May 1991. It outlines the steps necessary for genetic augmentation of a population on the verge of extinction. It outlines the consequences of an ill-conceived translocation or genetic augmentation, and gives guidelines of when augmentation is necessary (e.g., demographic and genetic threats). It notes that the level of gene flow in an augmentation to counteract inbreeding depression should be 2–5% of the total genetic material in the target population. The paper then applies the criteria for augmentation to the Florida panther population by asking and answering 7 pertinent questions. The paper concludes that the Florida panther population meets all the criteria for augmentation and provides a strategy for incorporating intercrossing (augmentation) into the recovery of the Florida panther. The paper suggests that recovery should proceed through 3 levels of interventive management (done simultaneously): (1) ongoing attempts to secure and enhance the wild population must continue, 2) use of the captive population for genetic back-up and translocation to re-establish populations in other parts of former range, and 3) intercrossing experiments. They suggest that intercrossing be done in captivity rather than release panthers in the wild.

This report concluded that "further analyses will be needed to determine the optimal amount and rate of genetic introgression."

Comments: Seal's next panther publication (Seal 1992) reports the target of 20% introgression without reporting on the "further analysis" called for in this 1991 report. Phil Hedrick, who analyzed this target thoroughly in a 1995 paper, was not listed as a participant at this conference.

Seal, U. S. 1992. Genetic conservation and management of the Florida panther (*Felis concolor coryi*). Report to U.S. Fish Wildlife Service. Conservation Breeding Specialist Group, Apple Valley, Minnesota, USA. 27pp.

Note: This can probably be most easily accessed as Enclosure III in U.S. Fish and Wildlife Service (1994). It is the report of a workshop held 21–22 October 1992 in Yulee, Florida.

Summary: The document considers 9 options for panther management, with a brief (typically 1 paragraph) analysis of each option. The more feasible and useful options are discussed in more detail in U.S. Fish and Wildlife Service (1994). The workshop also considered the option of capturing Florida panther females for artificial insemination with sperm of non-Florida males, and returning them to the wild to bear young. Because hormonal stimulation is needed to induce estrus and conception, the females would probably need to be held for 30 days. This could create behavioral problems and induce physiological stress, and the artificial insemination techniques would have to be developed using existing captive animals. The workshop gave top priority to 3 of the scenarios, namely introducing non-Florida pumas into the Florida population, artificial insemination of Florida panther females (above), and artificial insemination of non-Florida females with Florida panther sperm.

The workshop also updated Seal and Lacy's (1989) PVA using Vortex with some revised estimates of vital rates. The estimate of adult mortality was decreased from 0.25 to 0.20 based on survival of radio-tagged panthers. Kitten mortality was modeled at 0.50 and 0.20. Simulations were run with N_0 of 30 and 50, with $K = N_0$. Habitat loss was simulated at 1% and 2% per year for the first 25 years of the 100-year simulation period. The model assumed that each female bred every 24 months, no environmental variation, and either 1 lethal recessive allele or 3 lethal heterotic alleles per animal. The main difference from the 1989 PVA was that with an 80% kitten survival rate (same as adult survival, and highly improbable), the mean r was positive, and extinction risk was low in most simulations. With 3 lethal equivalents and 80% kitten survival, mean r was negative, and extinction risk was <7% at 25 years, <49% at 50 years, and >42% at 100 years (with greatly increased risk when assumed age at first reproduction increases from 2 years to 3, or when K is 30 instead of 50).
Comments: 1. There are few citations to support the assertions in the document.
2. Seal (1994) cites this document as giving reasons why genetic restoration is needed, even if habitat issues are addressed, and **as the source of the introgression target of 20%**. However, this 1992 document simply states, without explanation, that "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." That is 100% of the discussion of the target; this same paragraph refers the basic approach to Seal (1991). It is truly remarkable that the genetic restoration program was initiated using a target that was not justified until after the releases. That later justification (Hedrick 1995) is quite persuasive. Hedrick's name, however, is not included in the list of participants at this workshop.

Seal, U. S. 1994. A plan for genetic restoration and management of the Florida panther (*Felis concolor coryi*). Conservation Breeding Specialist Group, Apple Valley, Minnesota, USA. 24pp.
Note: This can probably be most easily accessed as Enclosure I in U.S. Fish and Wildlife Service (1994).
Summary: The objectives of the plan are (1) to reduce inbreeding in the Florida panther population, (2) to restore genetic vitality/variability to offspring and recruit them to the population, and (3) to resume the evolutionary adaptive potential to the population by adding genetic diversity. This paper gives a detailed outline of implementation steps needed to achieve 20% level of introgression of genetic material in the panther population. The 20% target is a starting point in this paper, is

not justified, but simply cited as coming from Seal (1992). Selected animals should be from Texas (closest extant pumas that would historically have interacted with *coryi*); should be free of kinked tails, cowlicks, and atrial septal defects; and should be females 2 to 4 years of age. The animals should be selected to maximize expected geographic and familial diversity. Releases should be in vacant territories to minimize destabilizing the existing social structure. There should be 3 types of monitoring for progress toward the 20% target: pedigree analysis, molecular markers (mtDNA and microsatellite loci), and morphological characters (size, coloration, and other traits that could represent local adaptation, as well as neutral traits [kinked tails and cowlicks], and heritable maladaptive traits [atrial septal defects, cryptorchidism, and semen quality]). Animals to be released should undergo a thorough medical screening to avoid introducing infectious disease. The monitoring program should include thorough medical evaluations for both FP and TX-FP crosses (a detailed list, with no end date for this intense monitoring), and demographic performance (% females breeding, litter size, kitten survival, kitten sex ratio, recruitment of breeders, age of first breeding, adult survival) of FP and TX lineages. Demographic rates should improve in the outbred lineages. Outbreeding depression is unlikely; Texas panthers are genetically much closer to FP than the Piper stock. After the initial release of 6–10 females (assuming a population of 30 to 50 FP), additional releases of about 1 animal per generation (6 years) will probably be needed. With the new program, the original goal of the captive breeding program (selective breeding of FP to preserve the subspecies from extinction) will be lost, and captive animals should now be managed to assess the impact of genetic restoration on maternal behavior and other traits, and other goals supporting recovery.

Seal, U. S., and R. C. Lacy. 1989. Florida panther population viability analysis. Report to U.S. Fish and Wildlife Service. Captive Breeding Specialist Group, Apple Valley, Minnesota, USA.
Note: Not reviewed by the Scientific Review Team.
Abstract: The objective of this plan is to prevent the certain extinction of the Florida panther and to provide for its recovery in the wild through the establishment of 130 breeding animals in a combination of wild and captive populations by the year 2000 and increasing to 500 breeding age panthers by the year 2010. Implementation of the captive population recommendations in this plan are contingent upon the continuation and, in some cases expansion, of the existing capture and tracking program. The current wild population is estimated at 30–

50 animals. The recommendations in this plan call for: 1) immediate initiation of a captive breeding program as called for in the approved recovery plan dated June 22, 1987; 2) continuation and expansion of management and monitoring of the wild population; 3) continuation and expansion of the reintroduction program and 4) continuation and expansion of the habitat conservation program. The purpose of the captive breeding program is to place in captivity representative individuals from the wild population which would be selectively bred to expand their numbers. This population would serve to enhance the genetic and demographic structure of the Florida panther in captivity and serve as a source of individuals which may be used in prescribed management interventions of the wild population, as well as serve as a source of stock for re-establishment of the panther into its historic range. The captive breeding program would take from the wild 4 adults, and 6 kittens in 1990 and 1 pair of older animals (adults or juveniles) and 6 kittens per year through 1992. The purpose is to obtain genetic representation from each of the known remaining potential founder animals. There are estimated to be 19 potential founder lineages represented in the living wild population. Requirements for additional animals (l pair of older animals and 2–4 kittens per year for 3 years may be needed) in future years (l993–l995) would depend on whether there is sufficient representation of this wild founder stock in the captive population. The captive populations would be managed cooperatively through the Captive Breeding Specialist Group of the IUCN, the participating zoos and the Florida Panther Interagency Committee (FPIC). A SSP working group comprised of biologists from these organizations would work under the leadership of the Technical Subcommittee of the FPIC. All activities would be conducted through the oversight of the FPIC consistent with the approved recovery plan and species survival plan. This approach will allow us to evaluate experimentally the results of the program without an irretrievable commitment of the wild population. An annual meeting would be held to review the past year's results and plan the next year's activities including selection of individual animals for the captive program. This plan will require an initial investment of $50,000 above existing expenditures by the involved agencies. In addition, it will be necessary to construct an expanded conditioning facility at White Oak Plantation over the next 3 years which would cost approximately $200,000. In addition, it is recommended that additional research be funded over the next 5 years to enhance the captive breeding program including: development of reproductive technology to reduce the need for future removals of animals from the wild (Wildt proposal, $136,000 total for 2 years) and

2) genetic investigations to determine lineages of the Florida Panther (O'Brien proposal, $140,000 total for 2 years). The funding of these research proposals is not considered to be a prerequisite to the captive breeding program but could increase its effectiveness in the future. Finally, the participating zoos contribution would be approximately $l,000,000 in facilities and $500,000 per year in operating costs towards the captive breeding program. This major contribution to the public interest should be fully recognized. The result of this investment would be to prevent the certain extinction of the Florida panther and provide for its recovery. Once the objective of 500 breeding adults is achieved, consideration would be given to removing the species from the Endangered Species list. It should be clearly understood that this plan represents a biological compromise that maintains the existing wild population while developing a captive population to ensure long term survival of the taxon. There is a clear biological tradeoff involved. If *all* the Florida panthers were removed from the wild immediately then there would be less of a loss of genetic diversity because most of the remaining founders would be protected. Our proposed strategy would capture animals at a slower rate over a 3- to 6-year period and it is likely that mortality of some founders would occur during this time. This loss would be minimal but clearly represents a loss of genetic diversity that could be preserved if all animals were taken immediately. The consensus of the SSP working group members and the Technical Subcommittee was that the more conservative incremental strategy was an experimental approach that would provide safeguards to the wild population and allow ongoing evaluation during removal. This consensus on strategy was based on the: 1) ability to protect habitat through regulatory provisions would be compromised by removal of all animals; 2) opportunities to learn more about developmental, social, and behavioral aspects of panther biology that will be important to successful reintroduction would be lost; 3) learned behavioral features, potentially critical to survival in the wild, would be compromised or lost.

Shindle, D., D. Land, K. Charlton, and R. McBride. 2000. Florida panther genetic restoration. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA. 94pp.

Note: This report is largely superceded by the 2001 report. Tables 1 through 5 give blood chemistry and antibody titers for animals captured during July 1999–June 2000 (not included in the 2001 report). Appendix IX was published by Land and Lacy (2000). The most interesting unique reports in this volume are included in the summary.

Summary: Maps of dispersal movements of 2 panthers are presented on pages 54–55.

Appendix IV, by Roy McBride, "Captive pumas on the Big Cypress Seminole Reservation." Since 1996 there were ≥3 incidents involving ≥14 escapes on non-FP pumas from pens on the 2,200-acre Billie Swamp Safari. Pumas are kept in 3 smaller pens within the larger facility. In 1997, a male non-FP puma was on the loose for 7 months, and probably bred with >1 female Florida panther. In June 1999, 3 adult and 4 young pumas escaped, of which 1 young puma was not recovered (and may have died). In September 1999, 6 pumas escaped and 1 female remained at large for >4 months. In June 2000, a castrated male went missing; if he escaped, he may pose a risk to human safety. The report did not state how long captive puma have been held at this facility or at the 3,300-acre Big Cypress Hunting Adventures (also on the Big Cypress Seminole Indian Reservation). Thus, there probably were other escapes before 1997.

Shindle, D., D. Land, M. Cunningham, and M. Lotz. 2001. Florida panther genetic restoration. Annual Report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA. 102pp.

Summary: This report contains maps of locations with minimum convex polygon home ranges, maps of dispersal movements, and other telemetry data for 45 radio-tagged Florida panthers (FP) and 4 Texas cougars (TX) for the year July 2000–June 2001. Home range size for adult panthers was 151 km^2 (females, N = 19) and 423 km^2 (males, N = 10).

Four tagged FP and 1 TX died, and 7 untagged FP were killed by vehicles. Twelve animals were newly radio tagged. Eight FP and 1 TX dens produced 23 neonates, all of which were marked with subcutaneous transponder chips, and had skin biopsies taken. Two of the introduced females reached the goal of recruiting 2 offspring into the population; both females were contracepted (TX 101 in 1998 and TX 107 in 2000). As of 30 June 2001, all 17 FPxTX progeny have been given transponders, and 10 of the 12 old enough for collars have been collared. All known F_2 and backcross progeny have also been marked with transponders.

Genetic introgression has reduced occurrence of kinked tails and cowlicks; 0 of 17 F_1s had kinked tails compared to 26 of 49 FP neonates in the same years. Similarly, 0 of 7 F_2 progeny and 3 of 15 backcrosses had kinked tails. Presence of cowlicks cannot be assessed until ~6 months of age. Cryptorchidism and sperm abnormalities are not evident until sexual maturity, and atrial septal defect cannot be diagnosed in neonates (necropsy provides a definitive diagnosis). Thus, it will take a decade to assess the most hoped-for benefits of genetic restoration. The representation of Texas genes approximates the target level of 20%.

A detailed summary of the year's capture activities (Table 1) is followed by the biomedical details of the year's captured animals, including blood chemistry (Tables 4–7), antibodies to diseases (Table 8, p. 41), semen characteristics (Table 9, p. 42), prevalence of kinked tails in kittens (Tables 10, 12), and this year's mortalities (Appendix V).

In the last year, 6 of 23 (26%) captures of adults or juveniles resulted in moderate to severe injuries (including 2 broken legs requiring removal of animals from the wild; not yet re-released), all related to use of hounds and treeing. The Texas puma and progeny were more likely than Florida panthers to jump after being treed ($P = 0.0037$), thus increasing injuries compared to earlier years.

Florida panthers had larger mean litter sizes (2.4) than Texas pumas (1.5) (see Tables 11 and 12). However, the second generation of backcrosses had a mean litter size or 2.9 (10 litters) and no sex bias (15F:16M). FP litters were male-biased (19F:29M) in contrast to female-biased Texas F_1 litters (12F:5M) since October 1995.

Table 14 gave litter size at birth and at 6 months for "select" FP and Texas puma descendants, including backcrosses. Fourteen litters of pure FP averaged 2.35 kittens per litter and 52% survival to 6 months, compared to 11 litters with Texas ancestry that averaged 2.27 kittens and 68% survival. The kitten survival rates were not statistically different ($P = 0.28$).

There is a wealth of long-term data, such as the following.

- Appendix I: Status of all tagged panthers since 1981 (sex, capture date, estimated age at capture, death date, general use area).
- All injuries related to capture since 1990 (Table 3).
- Prevalence of kinked tails in neonates since October 1995 (Table 11).
- All progeny with TX genes since 1985 (Tables 12, 13) with a summary for 3 generations (Appendix III).
- Vegetation and UTM of all den sites since 1985 (Appendix IV).
- Litter size at birth and 6 months for FP and TX lineages for "select" animals (Table 14).
- Survival from age of 4–14 months to independence for FP and TX lineages for litters born to tagged females since 1985 (Table 15). (This can and should be used to estimate mean monthly survival rate during this period. Because age at capture was usually 8–10 months and varied from 4–14 months, it would not be valid to use these data to estimate "survival from 6 months to independence," except in a careful pseudo staggered-entry design.)

- All known mortalities and injuries since 1972 listed by cause of death, including locations of road injuries, and including non-tagged animals (Appendix VI). Fifty-nine panthers are known to have died since 1981, 38% from intra-specific aggression. Survivorship curves show that male panthers have a much steeper decline than females in the first 6 years of life.

An analysis of road injuries and deaths (Appendix VII). Vehicles killed 12 panthers in zones with low speed limits (designed to protect panthers) since the zones were established in 1985. The authors note that there is a misconception that vehicular collisions account for most panther mortalities, but this is the result of sampling bias because uncollared panther mortalities are found only if the death is human-induced. Panthers have also been killed in at least 2 low-speed collisions. There have been no fatalities on the 40 miles of highway served by structures designed to let panthers pass under the road. Due to the expense of such structures, they should be built only where there is a good prospect for continued protection of the surrounding landscape.

Comments: 1. The caption in Table 1 indicates that it reflects “select” panther litters. Darrell Land (personal communication to Scientific Review Team, 3 December 2002) stated that “The select list includes ALL the litters we handled shortly after birth and had subsequent counts at 6 months-of-age. There are obviously other litters we handled but we did not have the follow-up information and therefore those were excluded.” This indicates that there is no deliberate bias involved. However, it also means that there may be an unintended bias IF those litters that cannot be assessed at 6 months are less likely to have survived than those that could be verified at 6 months. This seems likely, because it is impossible to “prove a negative” (i.e., you can’t get a count of a litter if you can’t even confirm that any of the litter has survived). This would suggest that the true kitten survival rates is lower than the calculated rate; the bias should apply equally to both TX and FP litters.

2. The 0.72-kitten survival rate for TX progeny may not be statistically higher than the 0.52 rate for FP, but it may well be biologically significant. Certainly this is the most rigorous estimate yet published for panthers. This estimate still suffers from “rounding errors” (i.e., treating an unstated range of ages as “6 months old” and another unstated range of ages as “at birth”).

3. Figure 3 shows that 2-year-old females produced as many litters as any other age class. Although this is not a calculation of age at first reproduction, it suggests $\omega = 2$. Compared to a ω of 3, this will substantially decrease extinction risk in any PVA (e.g., see Seal 1992).

4. Figure 4 is a bar chart that compares numbers of kittens produced versus known panther deaths; the same figure has appeared in each annual FWC reports for several years. This chart is meaningless, like Figure 1 in Maehr and Caddick (1995), and tells us nothing about lambda. This sort of chart does not belong in a scientific report.
5. Appendix I contains most of the data needed to calculate sex-specific survival rates for adults. Such a calculation should be done to update the estimate in Maehr et al. (1991*b*). The authors provide a "survival curve" in Figure 7, but it is not equivalent to a true survival rate estimate calculated by following fates of individual animals over time. Figure 7 should be deleted from future scientific reports and replaced by an actual calculation of age-specific survival rates based on radio-tagged animals.
6. As usual, the habitat use data reflect only diurnal locations.
7. McBride (personal communication, November 2002) asserts that the kitten survival rate for TX panthers is biased because it includes a litter of #66 (an F_1 TX hybrid), whose litter probably died because she was translocated to a new area during her pregnancy. If her failed litter is excluded, the TX survival rate would be higher than 72%. McBride's assertion seems to be supported by Land et al. (1998*b*) who report that #66 was moved "for management purposes to vacant range on 16 July 1998.... She had 3 kittens (1F, 2M) estimated to be 12 days old when handled at the den on October 2, 1998." Her backdated conception date would have been about 2 weeks before translocation, which means she would have had about 2.5 months to learn her new home range before parturition. This unfamiliarity plausibly could have contributed to the early death of her kittens.

Sileo, L., M. Dunbar, and M. McCollum. 1997. Occurrence of selected endocrine disruptive chemicals and their association with congenital anomalies of the Florida panther. Annual Performance Report. U.S. Geological Survey, Madison, Wisconsin, USA. 19pp.
Abstract: Thirty-four heparinized whole blood or serum samples from both normal and cryptorchid male Florida panthers (*Felis concolor coryi*) and dams of both normal and cryptorchid males are presently being analyzed for the presence of selected organochlorines, including polychlorinated biphenyls and other chemicals that may be endocrine disruptive. Hormone determinations for 89 serum samples representing 14 normal and 16 cryptorchid male panthers were completed. The serum estrogen and testosterone concentrations were found to be considerably lower than previously published values reported for Florida panthers. The serum concentrations of estradiol and testosterone for male Florida panthers are consistent with those in

other wild felids. Testicular tissues from seven panthers were examined histopathologically. However, severe autolysis precluded reliable interpretations of most samples. Interpretation of test results of chemical concentrations that may be founding Florida panthers and testing of hormone concentrations in selected female Florida panthers will be conducted next fiscal year if funding is available.
Comments: There was no conclusive histopathology; contaminant survey work is delayed. Apparently the funding for this work was not continued, so there was no follow-up work.

Smith, T. R., and O. L. Bass. 1994. Landscape, white-tailed deer, and the distribution of Florida panthers in the Everglades. Pages 693–707 *in* S. Davis and J. Ogden, editors. Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida, USA.
Dates: December 1986–October 1989
Summary: In this paper, the authors used radio-telemetry data (daytime only; 1–3 hours after dawn) on 6 (3 adult females; 2 subadult females, 1 subadult male) panthers and satellite imagery of Everglades National Park (ENP) to determine the effects of landscape on panther distribution. Data on white-tailed deer also were examined to see if prey numbers and distribution affect panther distribution. Panthers used upland forest more than expected and open wetlands less than expected. Deer were not randomly distributed. The authors conclude that (1) the distribution of panthers is limited by availability of prey, availability of hunting cover, and/or human interference; (2) the acquisition of large prey explained the dichotomy observed between the distribution of breeding and non-breeding female panthers; (3) the availability of edge between upland forests and open prairie determines the breeding density of panthers in the Everglades; (4) it is unlikely that the carrying capacity of ENP for panthers can be increased by management; and (5) protection of undeveloped lands outside ENP, which are suitable panther habitat, may be the best strategy for panther management in the eastern Everglades.

Steelman, H. G., J. A. Bozzo, and J. L. Schortemeyer. 1999. Big Cypress National Preserve deer and hog annual report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA. 86pp.
Abstract: Prior to the 1990-91 season the National Park Service (NPS) and the Game and Fresh Water Fish Commission (GFC) agreed to several regulation changes on the Big Cypress National Preserve (BCNP) with the proviso that additional changes be held to a minimum for a period of five years. No significant rule changes were made for the 1998-99 hunting season. During previous years

regulatory changes have been implemented on BCNP either to reduce white-tailed deer (*Odocoileus virginianus*) and wild hog (*Sus scrofa*) harvest or to reduce recreational pressure on the area.

Hunting pressure during the 1998-99 Big Cypress season (17, 485 man-days) increased 21% from 1997-98 (14,410 man-days) and was 31% more than the prior 5-year average (13,306 man-days). Hunting pressure increased on all units compared to last years levels. Big Cypress had a record checked deer harvest (346) for Archery, Muzzleloading Gun and General Gun seasons combined and was 27.7% above the previous record (271, 1996). Archery (21), Muzzleloading season harvest 982) and General Gun seasons (243) were above the prior five-year average (18, 54 and 151 respectively). Deer harvest increased in all units compared to last year. Checked hog harvest for all seasons was 147, and decreased in all units except Corn Dance. Total checked hog harvest for the 1998-99 season was 28% less than 1997-98 season (188), but was within 3.0% of the 5-year average (151). Hunter success (game checked/man-day) was 0.029 which is comparable to the previous 5-year average (0.028).

White-tailed deer physical characteristics were similar to values recorded since implementation of the 5-inch antler rule in 1986-87. Mean dressed weight (72 lbs) was 6.9% lower than last years mean of 77 lbs. Mean antler beam circumference (5.79 cm) decreased by 21.8% over last year (7.4 cm). Mean antler beam length (21.8 cm) decreased 21.3% over las year (27.7 cm). Mean spread was 19.5 and mean number of points was 3.85.

Wild hog physical characteristics exceeded or were in the upper range of recorded values. Mean dressed weight (82 lbs) and shoulder height (67 cm) for hogs were in the upper range of recorded values. Mean dressed weight (82 lbs) was 7.9% greater than the 15-year mean of 76 lbs. Mean shoulder height (67 cm) increased 6.3% from the 15-year mean (63 cm). Mean body length (124 cm) is equal to the second highest on record.

Taylor, S. K. 1997. Florida panther biomedical investigations July 1996–June 1997. Annual Performance Report. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA. 26pp.

Summary: Initial radio-instrumentation was conducted on 4 Florida panthers (*Felis concolor coryi*); 3 had been handled as kittens at the dens, while 1 was previously unknown. Six panthers and 5 Texas cougars (*F. c. stanleyana*) were captured for routine replacement of radio collars; 1 panther was recollared after her radio collar had prematurely stopped transmitting 5 years ago. Seven litters, totaling

15 kittens (8 females and 7 males), were handled at the dens of 3 panthers and 3 cougars during this reporting period. Fourteen of the kittens appeared healthy, while 1 kitten was developmentally behind and weighed 50% less than his 3 siblings. Juvenile female panther 61 was captured to replace an intermittently malfunctioning radio collar and found to be severely emaciated, dehydrated, and anemic, and to have hind limb weakness and a facial cellulitis with bite wounds. This animal was placed in captivity for medical treatment and is expected to be released back to the wild. Florida panther 51, a male, had mycotic dermatitis and was placed in captivity for aggressive therapeutic treatment. The mycotic infection resolved and partial nail regrowth occurred, however his fur did not regrow. A visual examination conducted 3 months post release indicated that this panther appears to be able to survive in the wild. During this reporting period, 1 free-ranging panther died from a septicemia that resulted from bite wounds to all 4 legs. Two panthers that had been reintroduced into the wild after 5 years in captivity also died. Investigations are ongoing into the etiology that caused the severe hemorrhagic pneumonia that appeared toxic in nature. Biomedical studies on free-ranging panthers included mercury levels and infectious disease testing. Panther mercury concentrations in whole blood ranged from 0.019 to 0.42 ppm and in hair from 0.44 to 18 ppm. In vaccinated panthers, serum antibody titers for feline panleukopenia ranged from 50 to > 10,000, feline viral rhinotracheitis from < 2 to 12, and feline calicivirus from < 2 to 3,072. In nonvaccinated panthers, serum antibody titers for feline panleukopenia virus ranged from < 10 to > 5,000, feline rhinotracheitis virus were all < 2 , and feline calicivirus were all < 2. One panther is positive for feline immunodeficiency virus, while no panthers are positive for feline infectious peritonitis or feline leukemia virus. *Cytauxzoon* sp. was found in 8 (34%) panther blood samples. Internal parasites included *Alaria* sp., *Ancylostoma* spp., and *Spirometra* sp. Of the 7 panthers placed in permanent captivity in 1992, 6 continue to be healthy. Florida panther 21, who has been in captivity since 1988, is now 12 years old and has declining visual capabilities and hind limb trembling. Mercury concentrations in individual panthers fluctuated greatly from year to year (1991–1997).

Comments: There are certainly enough data by now (2003) to determine if there is any correlation between Hg and reproduction, and to revisit the geographic patterns in Hg concentration, health, and reproductions reported by Roelke et al. (1991*a*,*b*).

Taylor, S. K., E. D. Land, M. Lotz, M. Roelke-Parker, S. B. Citino, and D. Rotstein. 1998. Anesthesia of free-ranging Florida panthers (*Felis concolor coryi*), 1981–1998. Proceedings of American Association of Zoo Veterinarians 1998:26–29.

Abstract: The Florida panther (Puma concolor coryi) is one of the most endangered mammals in the world. The free-ranging population is estimated to be between 30–50 adult animals. Historically, this species of mountain lion ranged from eastern Texas or western Louisiana and the lower Mississippi River Valley east through the southeastern United States, including Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida and parts of Tennessee and South Carolina. Up until 1966, they were hunted to protect livestock and for sport. South Florida landscape has under gone significant changes including habitat loss from human development, changes in land use to housing and citrus groves, fragmentation by roads, and introduction of exotic plants and animals. The Florida Game & Fresh Water Fish Commission began studying the panther in 1972 and it was listed by the United States Fish & Wildlife Service as an endangered species in 1981. Panthers are now only known to inhabit south Florida and a subset of the population has been studied using radio telemetry since 1981.

Between 1981 and 1998, 72 panthers have been anesthetized multiple times (1–10 times per cat) for a total of 183 capture events. Panthers have ranged from 6-mo- to 16-yr-old. Direct or indirect capture related mortality has occurred in 3 (0.016%) of the 183 captures. These mortalities included: A cat that died less than 8 min after being darted and was most likely a result of either a negative anesthetic reaction or a dose miscalculation; A cat died of cellulitus and toxemia which resulted from a dart that penetrated the abdomen; And a cat that died approximately 3 days post handling but was too autolytic to evaluate further.

The field capture event involved a core capture team composed of a hounds man, veterinarian, and two biologists. The first phase involved the hound man who, with two to six hounds, located the felid scent and pursued the panther until it “treed.” Actual chases were relatively short and usually ranged from 5–10 min. The second phase involved rapidly assessing the cat’s physical condition, determining the appropriate anesthetic drugs and dose, and the preparation of a 3-cc dart with 1.5 x 30mm uncollared needle. A CO_2 powered rifle with scope (Teleinject, Saugus, California USA) was used to deliver most darts. The third phase usually involved catching the anaesthetized panther in a net as it fell from the tree. If the fall distance was greater than about 5 m, a portable wildlife cushion was used. Occasionally an

anaesthetized cat would remain in the tree and a biologist had to climb up and lower the cat to the ground with a rope. The fourth phase involved biomedical monitoring and research and involved: Physical examination and collection of blood, hair, feces, urine, and external parasites; Full thickness skin punch biopsies were taken. Panthers were vaccinated for rabies, panleukopenia, calicivirus and rhinopneumonitis. Anthelmintics were usually administered. Panthers may also have received long acting penicillin, vitamins, and iron. Intravenous and/or subcutaneous saline was usually administered. Panthers were then fitted with radio collars (Telonics, Inc., Mesa, Arizona USA). These collars are equipped with both an activity switch and a mortality sensor. The cats were usually monitored 3 days/wk through aerial telemetry. For additional permanent identification the cat's ears were tattooed and a subcutaneous transponder chip was implanted. Body measurements were taken and the animal was weighed. Special studies such as semen evaluation by electro ejaculation may periodically have been conducted. Handling time to complete these tasks has ranged from 12min–3hr.

Since 1982, anesthesia on the panthers has been conducted by one biologist and eight veterinarians. Not all records have complete information and the brand of the specific drug may not have been listed. Anesthetic drugs used in free-ranging Florida panthers have included acepromazine (10 mg/ml), ketamine (100 mg/ml or 200 mg/ml) (Ketaset, Fort Dodge Laboratories, Inc., Fort Dodge, Iowa USA), tiletamine hydrochloride/zolazopam hydrochloride (100 mg/ml) (Telazol, Fort Dodge Laboratories Inc., Fort Dodge, Iowa USA), diazepam (5 mg/ml), midazolam (5mg/ml) (Versed Roche Laboratories, Mutley, New Jersey USA), and xylanzine hydrochloride (100 mg/ml). Drugs were reconstituted with sterile water as necessary.

Taylor, S. K., C. D. Buergelt, M. E. Roelke-Parker, B. L. Homer, and D. S. Rotstein. 2002. Causes of mortality of free-ranging Florida panthers. Journal of Wildlife Diseases 38:107–114.

Summary: Between 1978 and 1999, 73 wild panther carcasses, including 47 radio-collared animals, were examined. Of the 47 radio-tagged animals, the main causes of death were intraspecific aggression (41%), vehicular trauma (19%), research activities (4% of deaths, 1% of 183 capture events), infectious disease (4%), and undetermined (21%). Atrial septal heart defect, aortic aneurysm, esophageal tear, pleuritis, and pyothorax each accounted for 1 death (each 2% of tagged animals). Eighty percent of road-kills occurred during the winter tourist season (October–April). Of 19 deaths due to intraspecific aggression, 79% occurred during August–February and

16 cats (84%) were males. Of these males, 14 (88%) were either <3 or >8 years old; most were probably fighting to establish or retain territory. Kills by a conspecifics followed 2 bite patterns: a bite to the head in which the canine penetrated to the brain or multiple bite wounds to distal limbs with became infected and led to septicemia and death within 7–10 days. Intraspecific aggression accounted for 79% of kills. The paper claims to report the first case of rabies in a wild puma.

Six of 33 (18%) captive and wild panthers necropsied during 1985–1998 had atrial septal defects, which killed 1 animal and may have contributed to 3 other deaths. Although the methods simply state that toxicology tests were conducted "as appropriate," the paper asserts that "there has never been a documented case of mercury toxicosis directly causing mortality" of a panther.

The fact that roadkills included 16 untagged and 9 tagged panthers suggests that the uncollared population "may be larger than the collared population."

The paper reports percentages of untagged animals found dead of various causes, but the obvious bias (finding road-kills along a road) renders these numbers meaningless and not worth stating here.

Comments: 1. Although the paper documents the first case of rabies in a wild puma by testing the puma, on 16 August 1994 an apparently rabid puma attacked a human and dog in Mendocino County, California, and the dog developed rabies after an appropriate incubation period. Also, 2 persons lightly injured by a puma near San Jose, California, in 1909 died 2 weeks later of rabies-like symptoms.

2. The idea of using road kills of tagged and untagged panthers as a sort of population index is an intriguing idea. However, summing across 12 years certainly complicates this line of reasoning, as the size of the radio-tagged population and the untagged population both changed over this time.

3. The paper makes no attempt to estimate cause-specific mortality rates. This could only be done for radio-tagged animals, given that vehicle mortality is the most likely detected mortality source for untagged cats. There are sufficient data by 2003 that cause-specific mortality rates can and should be calculated.

U.S. Fish and Wildlife Service. 1994. Final environmental assessment: genetic restoration of the Florida panther. Atlanta, Georgia, USA. 112pp.

Summary: The intent of the proposed action "is to improve genetic conditions and population health…. It is not an action to merely '*add numbers*' to the population" (emphasis in original). High levels of sperm abnormality, cryptorchidism, and congenital heart defects (each of which is presumed to be linked to fixation or increased prevalence of deleterious alleles) indicate the need for action. The environmental assessment (EA) considered 4 alternatives.

1) Continue current program, including building a captive population of >200 Florida panthers by 2010. (The 1991 EA estimated startup cost of $1,000,000 and $500,000/year in operation costs, with costs borne by the 4 institutions housing the captives). The 4 captive facilities have a total capacity for 15–20 Florida panthers; conditioning captives for release can cost $30,000/panther. Further, since 1991 the U.S. Fish and Wildlife Service has become increasingly concerned that maintaining genetic diversity (the best captive breeding can do) may not avert extinction: an increase of genetic diversity seems warranted. The EA projects that this alternative would lead to "gradual decline" and "eventual extinction" of the wild population (p. 38).

2) Proposed action: translocate 8 young-adult female Texas puma into the wild population, a level expected to bring 20% Texas genes into the population. This would be followed by 1 new Texas breeder per generation. Possible short-term negative impacts are intraspecific aggression and social disruption (minimized by placing young females in vacant territories), disease transmission (minimized by quarantine and screening). The most serious long-term impacts could be swamping of *coryi* genes (to be minimized by monitoring to achieve 20% goal) or outbreeding depression (implausible based on genetic theory and historical contact between these 2 subspecies). If outbreeding depression were to occur, "all translocated individuals and their progeny could be removed at any time." The expected outcome is that genetic diversity should increase, incidence of reproductive and medical abnormalities should decrease, and overall fitness should improve; these benefits should start to occur within a year (p. 44).

3) Translocate 16 F_1 or 32 F_2 progeny into the wild. This would cost more, and there may not be enough wild habitat for this many animals. This would have the same potential impacts as the proposed action, but the potential for social disruption and aggression would be much greater. Costs would increase by about $500,000.

4) Use some Piper stock animals (*coryi* crosses with South American puma) within Alternative 3. This would have similar impacts to Alternative 3, plus the potential of introducing genetic material that would be less appropriate.

The document describes the socioeconomic setting in some detail, including growth of human population, the projected conversion of 292 $miles^2$ from rural to urban use in the coming 20 years, the conversion of over 100,000 acres in south Florida to citrus during the previous 8 years (about two-thirds was previously cleared rangeland, one-third native habitat) following the loss of 435,000 acres of citrus in north Florida to freezes in 1983, 1985, and 1989, potential for future conversion to citrus and row crops, and mineral extraction.

There are 3 appendices, of which Enclosure I is Seal (1994), and Enclosure III is Seal (1992). Enclosure II is a 3-page draft proposal (by C. E. Facemire, M. R. Dunbar, and T. S. Gross) to study endocrine-disrupting chemicals as a possible cause of reproductive impairment of panthers. The proposal states that agricultural chemicals impact panther habitat, that the raccoon is an important vector that could concentrate these chemicals before consumption by panthers, and that these chemicals have been shown (in other species) to cause each of the symptoms exhibited by panthers. Thus environmental contaminants are "an alternative explanation for the maladies exhibited by the panther."

Comments: 1. Jordan (1991) had argued that experiments on captive animals were needed to determine whether outcrossing would reduce such abnormalities and not cause outbreeding depression, and this was his main argument against proceeding with a genetic restoration program in the wild at that time. By 1994, these experiments had not been done; nonetheless, genetic restoration had become the preferred alternative, and the captive experiments are not mentioned in this 1994 document.

2. There is no discussion of, or attempt to justify, the target of 20% introgression. All indications are that Hedrick (1995) provided the first analysis of this target; this analysis apparently occurred after the releases were started. The paper makes no reference to Hedrick's work.

3. The assertion that "all translocated individuals and their progeny could be removed at any time" is incorrect. Within 2–5 years, it would be impossible to remove the progeny without causing extinction of the population.

4. It is not clear why the proposed action does not include any captive population. In 1991, captive breeding had been considered critical for maintaining genetic diversity, and as an essential adjunct to any future introgression effort like that now proposed. Cost was probably a factor, but the option of pursuing Alternative #2 along with a scaled-back Alternative #1 was not discussed.

U.S. Fish and Wildlife Service. 1995. Second revision Florida panther recovery plan. Atlanta, Georgia, USA. 69pp.

Summary: This revision was written to make a single change to the

1987 plan, namely the addition of the genetic restoration program to the recovery plan, and to update the implementation schedule (Part III). The entire narrative section (including literature cited) is unchanged from the 1987 version.

U.S. Fish and Wildlife Service. 1999. South Florida multi-species recovery plan. Atlanta, Georgia, USA.
Note: This document by MERIT (Multi-species/Ecosystem Recovery Implementation Team) contains a 33-page section on the panther.

U.S. Fish and Wildlife Service and Florida Panther Recovery Team. 1981. Florida Panther Recovery Plan. Atlanta, Georgia, USA. 32pp.
Abstract: The Florida Panther Recovery Team was appointed by the U.S. Fish and Wildlife Service in July 1976 to prepare and assist in coordinating the implementation of a recovery plan. Consistently documented evidence of the animal's presence was available only from the Fakahatchee Strand, Big Cypress National Preserve, Everglades National Park, and Collier-Seminole State Park in Collier, Dade, and Monroe Counties, Florida. The recovery objective was to prevent extinction and reestablish viable populations of the Florida panther in as much of the former range as feasible. The plan is outlined and steps which are necessary to complete the recovery objective are delineated. An implementation schedule is provided which lists priority actions necessary to prevent extinction, maintain population status, and other actions necessary for full recovery of the species. It was deemed vital that the Department of Natural Resources acquire the remaining acres of the Fakahatchee Strand and adjacent prairies and cypress forests to insure a unified management strategy and provide an extremely important permanent corridor of natural habitat between the Fakahatchee Strand, the Big Cypress National Preserve, and the Everglades National Park. It was recommended that hunting be discontinued in the Fakahatchee Strand and that portion of the Big Cypress National Preserve where panthers were presently known to occur.

Wehinger, K. A., M. E. Roelke, and E. C. Greiner. 1995. Ixodid ticks from Florida panthers and bobcats in Florida. Journal of Wildlife Diseases 31:480–485.
Abstract: Ixodid ticks were present in all 189 samples examined from 53 Florida panthers (*Felis concolor coryi*, 104 collections) and 85 bobcats (*Felis rufus floridana*) in Florida (USA) between 1974 and 1991. We identified 3,251 ticks from panthers and 918 from bobcats. Specimens of *Dermacentor variabilis*, *Ixodes scapularis*, *I. affinis*,

Amblyomma maculatum, and *A. americanum* were present on 49, 39, 17, seven, and two of the 53 Florida panthers, respectively, and comprised 36%, 55%, 7%, 1%, and <1% of the 3,251 ticks collected from panthers. *Ixodes scapularis*, *D. variabilis*, and *I. affinis* were present on 61, 56, and 11 of the 85 bobcats respectively, and comprised 58%, 39%, and 2% of the 919 ticks collected. *Amblyomma americanum* and *A. maculatum* were found infrequently and comprised <1% of the total ticks collected from bobcats. Only adult ticks were found on the cats, except for one *D. variabilis* nymph and three *A. americanum* nymphs that were found on bobcats.

The most common tick (*I. scapularis*) also commonly infests white-tailed deer and wild hogs. It is possible that some of these were transmitted via prey.

Comments: This study did not address health/survival implications of tick infestation.

Wilkins, L. 1994. Practical cats: comparing coryi to other cougars: an analysis of variation in the Florida panther *Felis concolor coryi*. Pages 14–45 *in* D. B. Jordan, editor. Proceedings of the Florida Panther Conference. Florida Panther Interagency Committee, Gainesville, Florida, USA.

Note: This report was later published as Wilkins et al. (1997).

Summary: Wilkins used museum specimens to compare puma races on the basis of pelage color, whorls (cowlicks), and cranial measurements, and used data on live-captured animals to analyze frequency of kinked tails. The pelage of *coryi* is darker than *stanleyana* and other inland western populations of North America. Whorls occurred in *coryi* at 3 times the frequency of any other subspecies; frequency currently exceeds 90% outside the Everglades. Frequency of cowlicks apparently increased since 1896–1898, when Bangs found no whorl in 4 of 6 specimens. The analysis of "cranial profile" was complex and did not indicate a conclusive trend among subspecies. However, in canonical space, "cranial proportions" of *coryi* had almost no overlap with western puma or Everglades animals (presumably Piper stock). Historical and recent *coryi* are indistinguishable in cranial proportions. Although historic Louisiana samples resembled *coryi*, cranial proportions of animals killed in Louisiana and Arkansas since 1970 suggest they were dispersing *stanleyana* rather than relict *coryi*. Given the lack of permanent geographic barriers between the Everglades and Big Cypress (Shark River Slough has been crossed by radio-tagged animals when water level is low), it is remarkable that the dichotomy between the 2 areas has persisted for 30 years. Prevalence of kinked tails was analyzed from live captures only; frequency in *coryi* was 8 times that of western puma. Wilkins speculated that the peninsular nature of Florida (which she asserted was narrower until sea level receded to its current level about 8,000 BP) may have started the process of differentiation before the influence of Euro-Americans.

Comments: Wilkins' speculation that peninsularity may have started genetic differentiation several thousand years ago is countered by (a) evidence that puma reoccupied all of North America <10,000 years ago (Culver et al. 2000), (b) the fact that historic Louisiana samples were morphologically similar to *coryi* (this paper), and (c) the fact that most genetic heterozygosity was lost from Florida panthers since 1922 (Culver et al. 2000). Furthermore, increased incidence of cowlicks (this paper) and deleterious phenotypic traits (Roelke, several papers) since 1890–1920 suggests a greatly accelerated rate of genetic differentiation in modern times.

Wilkins, L., J. M. Arias-Reveron, B. Stith, M. E. Roelke, and R. C. Belden. 1997. The Florida panther (*Puma concolor coryi*): a morphological investigation of the subspecies with a comparison to other North and South American cougars. Bulletin of the Florida Museum of Natural History 40:221–269.

Note: An earlier version of this report, with only Wilkins as author, is printed in Jordan (1994*b*). See the entry for Wilkins (1994) for the Scientific Review Team's summary and comments.

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