

1 6 September 2005
2 Michael J. Conroy
3 School of Forest Resources,
4 University of Georgia
5 Athens GA 30602 USA
6 706-542-1167, FAX 706-542-8356; mconroy@uga.edu,
7

8 RH: Improving Science in Conservation · *Conroy et al.*
9

10 **IMPROVING THE USE OF SCIENCE IN CONSERVATION: LESSONS FROM**
11 **THE FLORIDA PANTHER**

12 MICHAEL J. CONROY,¹ US Geological Survey,, Georgia Cooperative Fish and Wildlife
13 Research Unit, Warnell School of Forest Resources, University of Georgia, Athens, GA 30602

14 PAUL BEIER, School of Forestry, Northern Arizona University, Flagstaff AZ 86011-5018

15 HOWARD QUIGLEY,² Global Carnivore Program, Wildlife Conservation Society, 2300 Southern
16 Boulevard, Bronx, NY 10460

17 MICHAEL R. VAUGHAN, US Geological Survey, Virginia Cooperative Fish and Wildlife
18 Research Unit, Department of Fisheries and Wildlife Science, Virginia Tech, Blacksburg, VA
19 24061-0321

20 **Abstract:** In a companion paper (Beier et al. 2006) we identified 2 sets of unreliable
21 inferences that may compromise efforts to conserve the Florida panther (*Puma concolor*
22 *coryi*). In spite of serious flaws in methodology and interpretation, these unreliable
23 conclusions have appeared in prominent, peer-refereed scientific journals and have been
24 repeatedly cited and mis-cited in support of panther conservation. Future editors and
25 referees may reduce these errors by insisting on adherence to an Introduction, Methods,
26 Results, and Discussion (IMRAD) format; checking improbable assertions attributed to

¹ Corresponding author e-mail: mconroy@uga.edu

² Present address: Beringia South, Box 147, Kelly, WY 83011, USA

27 earlier papers; and refusing to allow scientific inference in publication formats not subject
28 to scientific peer review (e.g., editorials). We urge conservation biologists to view science
29 as an adaptive process and to use the method of multiple working hypotheses (Chamberlin
30 1890) that are now a central feature of adaptive resource management (Walters 1986,
31 Williams et al. 2002). We advocate a workshop approach, similar to that used for analysis
32 of data for northern spotted owl (*Strix occidentalis*; Anderson et al. 1999), to deal with
33 scientific disagreement where, as in the case with panthers, stakeholders have entrenched
34 points of view. Finally, we recommend the creation of an independent Scientific Steering
35 Committee to address long-term issues of future research and monitoring of Florida
36 panthers.

37 **Key words:** endangered species, Florida panther, multiple working hypotheses, peer-
38 review, Puma concolor, recovery plans.

39
40 Wildlife biologists view themselves as the appropriate experts who decision makers
41 should consult on matters of wildlife conservation and management. The extent to which
42 such advice is reliable, and thus useful for decision making rests, in turn, on the degree to
43 which the advice is based on principles of good science (Murphy and Noon 1991, Nudds
44 and Morrison 1991). Like these authors and others (e.g., Romesburg 1981, Nichols 1991,
45 Sinclair 1991), we consider science to be a *process* for reliable (and thus repeatable)
46 inquiry and not merely an accumulation of facts. Thus, conclusions that are not supported
47 by good science are unreliable, even if they cannot be refuted and might eventually be
48 supported.

49 In the Endangered Species Act of 1973 (ESA 16 US Code 1531-1544), the principal

50 legal mechanism for endangered species recovery in the United States, scientific evidence
51 is required for listing decisions (Section 4), designation of critical habitat (Section 4), and
52 biological assessments of the impacts of proposed projects (Section 7). In addition to these
53 explicit references to science, the ESA clearly intended that scientific information and
54 scientific approaches be applied to management of listed species. This intent is apparent
55 from ESA's requirements for many scientific activities, including reporting to Congress on
56 the status of each listed species every 2 years (Section 4-f); monitoring recovered species
57 for 5 years (Section 4-g); using objective, measurable criteria to remove species from the
58 list (Section 4-f); determining whether proposed actions would jeopardize or otherwise
59 adversely affect a listed species (Section 7-a); reasonable and prudent mitigation and
60 enhancement measures for such projects (Section 7-g); quantifying the impact likely to
61 result from a permit to take individuals of listed species (Section 10-a); minimizing and
62 mitigating the impacts of any taking of listed species to the maximum extent possible
63 (Section 10-a); and prohibiting actions that would appreciably reduce the likelihood of
64 survival and recovery of listed species in the wild (Section 10-a). Finally, the Act
65 authorizes the U.S. Fish and Wildlife Service (USFWS) to procure the services of qualified
66 persons (typically scientists) to help develop and implement recovery plans (Section 4-f).
67 To encourage qualified persons to serve on recovery teams, the ESA explicitly exempts
68 them from the requirements of the Federal Advisory Committee Act. In 1994, the federal
69 agencies mandated independent peer-review of proposed listing decisions and draft
70 recovery plans (USFWS and National Marine Fisheries Service, Federal Register, July 1
71 1994)

72 In a companion paper (Beier et al. 2006) we identify 2 sets of unreliable inferences that

73 may compromise efforts to conserve the endangered Florida panther. In this paper, we
74 identify several ways that these inferences were published, with the result that science was
75 not effectively used for panthers. Our objectives are to: (1) suggest improvements to the
76 peer-review process to reduce the risk of publishing unreliable inferences, (2) emphasize
77 the importance of evaluating multiple working hypotheses rather than using research to
78 confirm favored hypotheses, (3) recommend an approach for analyzing data to support
79 conservation in an objective atmosphere devoid of the entrenched, personalized positions
80 of stakeholders, and (4) advocate engaging independent scientists in recovery activities
81 *between* recovery plan revisions so that scientific issues and controversies are promptly
82 addressed and recovery actions are rapidly adapted to new knowledge.

83 **FOUR PATHS TO PUBLISHING UNRELIABLE INFERENCES – AND HOW**
84 **PEER-REVIEW CAN RESPOND TO THEM**

85 Two sets of unreliable inferences about panthers (Beier et al. 2006) made it through the
86 peer-review process via several routes (Table 1). Although authors bear the highest level of
87 responsibility for these inferences, it is useful to ask how the peer-review process could
88 help reduce the prevalence of these unfortunate events. We believe that the first 3 types of
89 problems typically are not what editors and referees look for; therefore, they deserve
90 increased attention. In contrast, referees usually detect inappropriate methods or inferences
91 within an otherwise well-constructed paper.

92 *1. Incorrectly Attributing Inferences to an Earlier Paper.*—In several instances,
93 previous work was inappropriately cited as the authority for assertions made in later papers
94 (Table 1, see also Beier et al. 2006). This sort of unreliable inference is the primary
95 responsibility of the authors because editors and referees cannot be expected to read each

96 cited work to determine if it was accurately interpreted. In these examples, referees
97 probably assumed that the authors would not misinterpret their own work, and thus they
98 were particularly unlikely to uncover the misattribution.

99 It is equally inappropriate to cite as fact claims made in editorials, essays, or other non-
100 rigorous sources (Table 1). The problem is particularly insidious when the original
101 inference appeared as an editorial note in a peer-refereed journal. In such cases, a referee
102 probably would not detect the problem because the entry in the Literature Cited section is
103 indistinguishable from the citation for a peer-refereed paper. A subtler problem arises in
104 citing inferences found in agency research reports, web sites maintained by researchers, or
105 news stories. Although many of these inferences are reliable, some of them use
106 inappropriate methods, describe methods or results in insufficient detail to evaluate
107 reliability of subsequent inferences, or fail to discuss discrepancies with previous work.
108 Authors considering whether to cite such works have a special responsibility to evaluate
109 these issues and provide appropriate caveats if the paper is cited.

110 Misattribution, especially when repeated in several papers, can make an unreliable
111 inference become accepted as fact in a way that snowballs over time and is resistant to
112 counter-evidence. Clearly, the best way to reduce the risk of these events is for authors to
113 scrupulously ensure that they accurately and honestly report inferences of earlier papers.
114 But we believe referees can help. Although they cannot check all inferences attributed to
115 previous literature, referees should make it a habit to verify the 1 or 2 most improbable
116 attributions to previous literature. For example, we believe that a referee familiar with
117 studies of large mammal habitat use and movements would have considered improbable
118 the Maehr and Deason (2002) assertion (attributed to Maehr and Cox 1995) that panthers

119 are reluctant to cross 90 m of non-forested habitat.

120 *2. Presenting Inferences within Papers Not Subject to Rigorous Peer Review.—*

121 Several papers with unreliable inferences (Table 1) either did not appear in peer-refereed
122 journals, or if they did, did not adhere to the standard IMRAD format (Day 1998). The
123 simple logic of IMRAD has endured and become dominant because it helps “the author
124 organize and write the manuscript, and provides an easy road map for editors, referees, and
125 ultimately readers to follow” in evaluating and reading the paper (Day 1998:7).

126 We urge authors to resist the urge to make scientific inferences outside of the system of
127 rigorous peer-review. Once published, such unreliable inferences can be intentionally or
128 unintentionally abused. Referees and editors of journals of record can reduce this problem
129 by being alert to attempts to insert scientific analyses and inferences into editorials, book
130 reviews, and essays (however, all original syntheses such as book chapters should be peer-
131 refereed). Such articles can and should be freewheeling and free of the IMRAD
132 straightjacket; conversely, we must keep these literary forms free of the analyses and
133 inferences that belong in peer-refereed, IMRAD papers.

134 *3. Presenting Inferences in the Discussion Section without Corresponding*

135 *Objectives, Methods, and Results.*—In a conventional IMRAD paper, the discussion makes
136 inferences from empirical results, which in turn were produced by clearly described
137 methods motivated by stated objectives. In contrast, a key paper on habitat use by panthers
138 presented inferences in the discussion section that bore no obvious connection to the
139 objectives, methods, and results presented earlier in the paper (Table 1). This made it
140 difficult for readers to critically evaluate whether the inference had strong, empirical
141 support or even to notice that the analysis had not been described in the paper.

Those involved in the peer review process can help reduce the prevalence of this problem in the literature. First, editors should insist that results be presented separately from discussion. Second, editors and referees must look for tight correspondence between objectives, methods, results, and discussion topics. A scientific paper should contain no method that is not related to a clearly stated objective, each result should correspond to a clearly described method, and each inference should relate to previously stated results. Authors, referees, readers, and conservation science are ill served by the lack of such tight correspondence. The IMRAD format helps authors and referees notice when the authors leap to an interpretation of results without first stating an objective to make this sort of inference, then describing the analytic methods, and then presenting the unvarnished results from which the inference can then be made.

One useful practice is for the referee to make a preliminary assessment of whether a paper should be published based solely on a careful reading of the Introduction and Methods sections (Armstrong 1997). If the paper has not raised important questions and described appropriate methods for each question in these initial sections, rejection or major revision will be required. If the objectives are important and the methods are clear and appropriate, the results (even if statistically non-significant) should be at least potentially publishable. This mental exercise will also sensitize the referee to upcoming results or inferences for which no proper groundwork was developed in the first part of the paper.

4. Flawed Methods or Inferences in a Paper Free of the Defects Listed Above.—

Some papers we reviewed that were free of the defects already mentioned, nevertheless contained technical flaws in methods that lead to erroneous inferences (Table 1). Although referees are generally alert to this type problem, editors can help reduce such flaws by

asking referees not to make decisions on acceptance or rejection but rather to see their role as making each paper as rigorous and reliable as possible (Armstrong 1997). If referees envision their names as co-authors on the paper, they would want to tell their colleagues how to make the paper as bullet-proof as possible. Likewise, referees would want to delete or qualify inferences that they would not want associated with their own scientific reputations. By clearly stating major concerns as changes needed to make the paper reliable and publishable, the referees will still provide editors the information they need. At the same time, referees will be encouraged to adopt a constructive tone in their review and will tend to focus on critical issues related to scientific reliability. Finally, because authors would perceive referees as allies rather than barriers to publication, the referees should feel less need for anonymity, a necessary condition for widespread acceptance of open review (next section).

Because of the specialized nature of some disciplines in conservation and management, referees often cannot evaluate whether certain methods are appropriate or whether the corresponding results are clearly presented and properly interpreted. In these cases, the referee should make a clear demand that someone with the appropriate expertise review the paper.

HOW EDITORS CAN ENCOURAGE BETTER PEER REVIEW

Greater Recognition and Accountability for Peer-reviewing.—Many of our recommendations call for increased effort on the part of referees and editors, most of whom are already overworked, and all of whom are under-rewarded for their labors. Although serving as an editor may bring prestige and can help scientists in promotion decisions, we think that referees are motivated mainly by love of science and a desire for

188 management and conservation decisions to be based on sound science. We are fortunate
189 that these motives have provided a peer-review system that works as well as it does. Good
190 referees are people whose habit of striving for quality in their own work leads them to
191 unselfishly help others do so.

192 We suggest 2 ways that journals can motivate referees to intensify their already-
193 laudable efforts. First, cognizant of the noble motives of referees, editors must show
194 referees that their effort has produced more reliable science. Whenever the referee has
195 raised significant concerns about a paper, the editor should send the revised manuscript to
196 the referees so they can evaluate whether the authors addressed those concerns or provided
197 convincing counter-arguments. In our experience as referees for journals, we have been
198 provided the opportunity to review the resubmitted manuscripts in <50% of the cases in
199 which we raised major concerns about the quality of the inferences. In some cases, we
200 have seen papers published in a form that did not address what we had seen as fatal flaws
201 during our reviews. Although the editor may have had good reason to set aside the
202 referee's concern, ignoring the referee in this way is the surest way to deflate the
203 enthusiasm of someone motivated by love of reliable scientific inference.

204 Second, journals can increase recognition for referees and assigning editors – and make
205 them more accountable – by publishing their names with each published paper. Although
206 this would eliminate referee anonymity, this may be acceptable if the process were
207 explained to the referees at the outset and applied only to papers that are eventually
208 accepted. We suggest listing these names on a separate line near the beginning or end of
209 the paper, rather than buried in the Acknowledgments section. Although such recognition
210 is small, the referee's contribution would be noted by readers working in closely-related

211 fields, and thus would add to the referees's stature among colleagues. The only recognition
212 offered by journals today (a list on the back pages of the last issue of the year) is nearly
213 invisible to print subscribers and unseen by those who obtain paper or electronic reprints.

214 Publishing names of referees may motivate them to avoid quick and careless reviews. A
215 referee whose name appears on the paper will feel responsible for its quality and will see
216 his or her role as an ally to the authors by trying to make the paper as publishable and
217 rigorous as possible. We further encourage journals to carefully consider – perhaps on an
218 experimental basis at first – moving to a system in which referees are required to sign their
219 reports. Godlee (2002) suggested such systems result in higher quality, more constructive
220 reviews with no adverse effects such as ruined careers or physical attacks on referees. By
221 making the best reviews accessible, journals can also let graduate students and other
222 potential new referees learn from the best of their colleagues.

223 *Journal Responsibility to Set the Record Straight.*—Journals should create
224 procedures to inform the scientific community about major errors in the papers they
225 publish. Publishing corrigenda in a later issue is a rather anemic effort that does not reduce
226 the prevalence with which discredited studies are favorably cited (Pfeiffer and Snodgrass
227 1990). Because many papers are now accessed via the publisher's web page, the on-line
228 version of journals should provide prominent links to commentaries, retractions, and
229 corrections of each paper. The on-line journal *Ecology and Society* has had such a format
230 for 8 years; perusal of their website demonstrates that this does not provoke a flood of
231 needless comments (see for example Kerkhoff et al. 2000, Marmorek and Peters 2001).
232 Journals should also consider allowing referees to add comments to the on-line articles,
233 indicating whether authors had satisfied the referees' requests for major changes to the

234 original submission.

235 *Science as an Adaptive Process.*— As we indicate in Beier et al. (2006), we
236 emphatically do *not* argue that the conclusions reached in the panther literature are wrong.
237 Indeed, we acknowledge that these conclusions may ultimately be supported by evidence.
238 We *do* contend that the process by which many of these conclusions were reached was
239 flawed (Table 1). Furthermore, we note that some studies that criticize these conclusions
240 may themselves be seriously flawed. However, such flaws in other studies would in no
241 way validate unsupported conclusions about panther biology (Table 1).

242 Regardless of who is ultimately right, managers usually must make decisions based
243 on the quantity and quality of the science they have *now*. We argue in the next section that
244 science would be best served by an approach based on multiple alternative hypotheses,
245 integrated into formal adaptive management (Walters 1986, Williams et al. 2002). This
246 approach provides a formal mechanism for decision making when knowledge is
247 imperfect—as it always will be—with incremental improvements in knowledge (and
248 therefore, decision making) occurring via adaptive feedback from monitoring and research.

249 **THE IMPORTANCE OF MULTIPLE WORKING HYPOTHESES IN RESEARCH**

250 More than a century ago Chamberlin (1890) warned against becoming too attached to a
251 favored hypothesis and advocated an alternative method based on multiple working
252 hypotheses. Similarly, Platt (1964) championed statistical testing of multiple working
253 hypotheses as a path to strong inference in biological sciences. There are many examples
254 of the method of multiple working hypotheses in ecology, including studies of factors
255 governing barnacle distribution in the intertidal zone (Miron et al. 1999), wetland loss in
256 the northern Gulf of Mexico (Turner 1997), and the phylogenetic origin of a metazoan

257 taxon (Collins 1998). Recent analyses have advocated or used multiple working
258 hypotheses in management contexts, including evaluating the success of restoration
259 experiments (Michener 1997), assessment of salmon stocks in Snake River basin
260 (Marmorek and Peters 2001), and the issuance of take permits (permits from USFWS
261 allowing activities that harm a listed species) under the Endangered Species Act
262 (Smallwood et al. 1999). In a particularly lucid example, Sinclair et al. (2000) summarize a
263 decade of experiments and observations that evaluate the level of support for 27
264 hypotheses about trophic interactions in a boreal ecosystem. The many studies summarized
265 by Sinclair et al. (2000) embody an approach that was markedly different than the series of
266 publications that re-asserted the importance of forests to Florida panthers in increasingly
267 strong language over time without new data or analyses.

268 In contrast to the studies cited above, many works we criticized (Table 1, Beier et al.
269 2006) seem to us to have in common the premature acceptance of single hypotheses. If
270 true, this phenomenon may have retarded advances in scientific conservation of Florida
271 panthers. Early research on panthers did suggest that panthers preferred forests to open
272 habitats (e.g., Belden et al. 1988, Maehr et al 1991a). At about the same time, Roelke
273 (1990) speculated that there could be a geographic health cline in panthers, with body
274 weight and physical condition declining and mercury contamination increasing from north
275 to south. This corresponded with a north-south decrease in the importance of deer as prey,
276 decrease in forest cover, and increase in the genetic contribution of South American pumas
277 (O'Brien et al. 1990). The geographic coincidence of so many clines precluded strong
278 inference about which factors were causes and which were effects, but they provided fertile
279 grounds for generating alternative hypotheses.

280 However, by the mid-1990s published work seemed focused on a single
281 hypothesis, namely that Florida panthers depended on forests for their existence (Maehr
282 1997), required large forest patches (Maehr and Cox 1995), and rarely traveled more than
283 90 m from forest edge (Maehr and Deason 2002). As we described (Beier et al. 2006),
284 selective use of data, biased analyses, and mis-citation of earlier work were used to support
285 these conclusions. This trend culminated in 2 papers that provided no new relevant data or
286 analyses (Maehr et al. 2001, Maehr and Meegan 2002), with the assertion that panthers
287 were forest obligates.

288 We provide 3 illustrations of the lack of alternative hypotheses in these papers. In the
289 first page of his book, Maehr (1997:xi) stated that the panther is, "hampered only by
290 limited space... [d]iseases, parasites, highways, hurricanes, inbreeding, and heavy
291 metals... [have not] impaired the panther's ability to live and reproduce." However, the
292 book did not provide an even-handed evaluation of these alternatives, but it simply
293 marshaled evidence for the importance of forests. Similarly, the second paragraph of the
294 Introduction in Maehr and Cox (1995:1009) started with the assumption that, "large
295 contiguous forested areas are required to sustain viable populations" – a curious starting
296 premise for a paper that has this same inference as its main conclusion. Finally, the
297 Introduction of Kerkhoff et al. (2000) started with the assumption that, "[f]orest cover is a
298 reasonable surrogate for useful habitat," and the paper proceeded to develop a model that
299 confirmed this assumption.

300 Lack of alternative hypotheses can lead to study designs (selective use of data,
301 comparing used habitats to available habitats used by animals excluded from the analyses)
302 biased toward supporting the favored hypothesis. For instance, in response to an inquiry

303 from our Scientific Review Team (SRT) in late 2003, David Maehr stated that Maehr and
304 Cox (1995) had excluded data on 18 of 41 panthers because, "...we viewed the
305 southeastern area of occupied range as fundamentally different and not typical of preferred
306 habitat" (Beier et al. 2003b:3).

307 Unsupported inferences about panther demography (Beier et al. 2006) also may have
308 been motivated by a desire to support this same, prematurely-accepted idea that panthers
309 were limited only by habitat (forest) area. If the habitat-limitation hypothesis were true,
310 then genetic erosion was not an imminent threat in the early 1990s, and the genetic
311 restoration program of 1994-1995 was misguided.

312 Testing of competing hypotheses in wildlife science has been forcefully advocated by
313 Romesburg (1981), and it was further discussed by Sinclair (1991), Bauer (1994), and
314 Weiner (1995). As an alternative to null hypothesis testing, Burnham and Anderson (2002)
315 advocated an information-theoretic approach to evaluate which alternative models are best
316 supported by evidence (see also Guthery et al. 2001). Hilborn and Mangel (1997) and
317 Williams et al. (2002:24-27) show how information theory or Bayesian inference can be
318 used to explicitly place multiple working hypotheses in the context of adaptive
319 management (Walters 1986). We support the use of multiple hypotheses and believe
320 science and the Florida panther would have been better served had it been employed by
321 panther researchers.

322 **PROTOCOLS FOR RE-ANALYSIS OF DATA WHEN STAKEHOLDERS HAVE** 323 **ENTRENCHED DISAGREEMENTS**

324 We identified 2 sets of unreliable conclusions about panthers. Here, we suggest ways to
325 avoid the continuance or magnification of these and similar errors. Although science is not

326 about getting it right once and for all, it is about following protocols that tend, over time, to
327 discover and eliminate unreliable inferences (Romesburg 1981, 1991). Our single biggest
328 criticism of previous scientific research on panthers is that rigorous protocols sometimes
329 were not followed, and we are now paying the price in unreliable information.

330 Some scientists and managers have found constructive responses to previous
331 situations where information was lacking, unreliable, or contested, but where conservation
332 decisions nonetheless had to be made. We are most familiar with the example of the
333 northern spotted owl (*Strix occidentalis caurina*), an endangered species that favors old-
334 growth forested habitats of the Pacific Northwest (Gutiérrez 1996). As with panthers,
335 conservation decisions regarding owls are of interest to diverse local and regional
336 stakeholders. Much is known about basic biology, habitat affinity, and demographic
337 parameters of owls (Burnham et al. 1996, Gutiérrez 1996, Boyce et al. 2005). Nonetheless,
338 the issue is rife for contention, largely because of the huge stakes on both sides of the issue
339 of harvesting old-growth trees (Marcot and Thomas 1997). Perhaps compared to panthers,
340 the situation is scientifically more clear-cut. Nonetheless, even a relatively small degree of
341 scientific uncertainty surrounding, for example, about the degree to which owls are
342 dependent on old-growth forest, can be exploited by stakeholders, who sometimes demand
343 that opponents demonstrate scientific certitude. Although attractive in the legal realm, such
344 proof is impossible in science.

345 Instead, we suggest that scientific uncertainty regarding panthers be considered as
346 part of an adaptive approach to improved understanding and management. Ideally, this
347 approach would evolve to a formal adaptive management (Walters 1986, Williams et al.
348 2002), wherein decisions are made in the face of uncertainty, with feedback from

349 monitoring and research reducing uncertainty through time and thereby improving
350 management. It is essential to identify, and where possible correct, areas of unreliability
351 that can be agreed upon. One approach for doing this is the workshop format,
352 implemented by Anderson et al. (1999). The goals of a workshop for panthers would be
353 to: (1) develop protocols that would guide the re-analysis of existing data on habitat
354 selection and demography and (2) correct identified areas of unreliability. First, it is
355 important to establish protocols for evaluating data that are viewed as objective by all
356 parties. Parties must then agree on the specific questions to be addressed and methods to
357 quantify uncertainty as objectively as possible, avoiding any attempt to prevail with any 1
358 scientific view. Then, and only then, parties should consider the implications of scientific
359 uncertainty to decision making and ways that uncertainty can be reduced (but likely, never
360 eliminated) through future research and monitoring.

361 **INVOLVEMENT OF INDEPENDENT SCIENTISTS IN RECOVERY ACTIONS**

362 **OTHER THAN WRITING RECOVERY PLANS**

363 Our SRT was convened because a crisis simmered for several years until the agencies
364 realized they needed outside advice. Our review took nearly 2 years to complete; we
365 believe the panther would have been better served by continuous involvement of
366 independent scientists to address the scientific uncertainty, new scientific information, and
367 scientific controversies that are an inevitable part of recovering some endangered species.
368 Snyder and Snyder (2000) suggested that scientists and recovery teams spend less effort
369 writing recovery plans with detailed step-down outlines that are out-of-date as soon as they
370 are printed and more effort responding adaptively to current challenges. Recently, the
371 USFWS has moved toward the use of standing recovery teams, which may be able to

372 function as the scientific steering committee we advocate here.

373 In the spirit of suggestions by Snyder and Snyder (2000), and Clark et al. (1994), we
374 recommend the creation of an independent Scientific Steering Committee (SSC) to address
375 long-term issues of future research and monitoring of Florida panthers. Many of our
376 recommendations regarding this SSC would also help provide strong, independent
377 recovery teams. The SSC should be comprised of individuals from universities, agencies,
378 professional scientific organizations, non-government organizations (NGO), or other
379 stakeholder groups with an interest in conservation, management, and recovery of the
380 listed species. Members should not have current proprietary, legal, or contractual
381 involvement with any aspect of Florida panther recovery, and they should be an advisory
382 rather than decision-making body.

383 The SSC should be charged to: (1) provide advice on research priorities; (2) review and
384 make recommendations on proposed study plans for research; (3) call attention to needed
385 scientific tasks, including those that agencies are not eager to undertake; and (4) review
386 and rank proposals submitted under any competitive request. We recommend that
387 periodically an ad hoc advisory group constituted by 1 of the professional societies (e.g.,
388 The Wildlife Society, Society for Conservation Biology, National Academy of Science,
389 American Society of Mammalogists) be convened to determine if the SSC should remain
390 in existence, or if it is no longer useful. This ad hoc advisory group should also be
391 convened if there is a substantial demand by stakeholders for a change in membership of
392 the SSC.

393 Because the SSC may make recommendations that would be unpopular, its
394 independence must be guaranteed. The SSC should be encouraged to summarize important

395 recommendations as written documents and to communicate directly with the public. This
396 idea does not threaten the decision-making authority of the agencies, but it would allow the
397 SSC to signal when the agencies are choosing a course that is not recommended by the
398 SSC. The recovery team, individual members of the recovery team, employees of state and
399 federal agencies working on related issues, and representatives of conservation NGOs
400 should be encouraged to contact the SSC directly to suggest SSC attention to scientific
401 issues without having to route their request through a chain of command.

402 **MANAGEMENT IMPLICATIONS**

403 Modern wildlife management depends on wildlife scientists to provide reliable
404 knowledge. As Romesburg (1981:293) wrote, "Unreliable knowledge is the set of false
405 ideas that are mistaken for knowledge." To this we add that ideas that are based on
406 unsound methods or flawed logic are themselves unreliable, even if they are eventually
407 supported. Unreliable knowledge leads to poor management decisions and loss of
408 credibility to managers and scientists.

409 Managers accept peer-refereed publication as the gold standard of reliable
410 information. When unreliable knowledge appears in peer-refereed literature, professional
411 credibility is eroded. Our suggestions are offered in the spirit of continuing the
412 advancement of reliable knowledge for wildlife conservation, with hopes that this will
413 benefit the Florida panther and conservation science in general.

414 **ACKNOWLEDGMENTS**

415 Our work was funded by the Florida Panther Research and Management Trust Fund of
416 the Florida Fish and Wildlife Conservation Commission (FWC), USFWS, and the Georgia
417 and Virginia Cooperative Fish and Wildlife Research Units (FWS Interagency Agreement

1448-41910-02-N-0004, Research Work Order 74; Georgia Cooperative Fish and Wildlife Research Unit, Cooperative Agreement 1434-HQ-02-RU 1551). B. Millsap and J. Gore (FWC) and J. Kasbohm (USFWS) convened and supported our SRT review. We thank the many reviewers of the draft SRT report, and we thank M. J. Van den Avyle, D. R. Anderson, and an anonymous referee for critical and helpful comments. The Georgia Cooperative Fish and Wildlife Research Unit is jointly sponsored by the US Geological Survey (USGS), the University of Georgia, the Georgia Department of Natural Resources, and the Wildlife Management Institute. The Virginia Cooperative Fish and Wildlife Research Unit is jointly sponsored by USGS, Polytechnic Institute and State University, the Virginia Department of Game and Inland Fisheries, and the Wildlife Management Institute.

LITERATURE CITED

- ANDERSON, D. R., K. P. BURNHAM, A. B. FRANKLIN, R. J. GUTIERREZ, E. D. FORSMAN, R. G. ANTHONY, G. C. WHITE, AND T. M. SHENK. 1999. A protocol for conflict resolution in analyzing empirical data related to natural resources controversies. *Wildlife Society Bulletin* 27:1050-1058.
- ARMSTRONG, J. S. 1997. Peer review for journals: evidence on quality control, fairness, and innovation. *Science and Engineering Ethics* 3:63-84.
- BAUER, H. H. 1994. *Scientific literacy and the myth of the scientific method*. University of Illinois Press, Urbana, USA.
- BEIER, P., M. R. VAUGHAN, M. J. CONROY, AND H. QUIGLEY. 2005. Evaluating scientific inferences about the Florida Panther. *Journal of Wildlife Management*:in press.
- BELDEN, R. C., W. B. FRANKENBERGER, R. T. MCBRIDE, AND S. T. SCHWIKERT. 1988.

- 441 Panther habitat use in southern Florida. *Journal of Wildlife Management* 52:660-663.
- 442 BOYCE, M. S., L. L. IRWIN, AND R. BARKER. 2005. Demographic meta-analysis:
443 synthesizing vital rates for spotted owls. *Journal of Applied Ecology* 42:38-49.
- 444 BURNHAM, K. P., D. R. ANDERSON, AND G. C. WHITE. 1996. Meta-analysis of vital rates
445 of the Northern Spotted Owl. Pages 92-101 *in* E. D. Forsman, S. DeStefano, M. G.
446 Raphael, and R. J. Gutiérrez, editors. *Demography of the Northern Spotted Owl*.
447 *Studies in Avian Biology* 17.
- 448 _____, and _____. 2002. *Model selection and multimodel inference*. Springer, New
449 York, New York, USA.
- 450 CHAMBERLIN, T. C. 1890. The method of multiple working hypotheses. *Science* (old
451 series) 15:92ff. Reprinted in *Science* (1965) 148:754-759.
- 452 CLARK, T. W., R. P. READING, AND A. L. CLARKE. 1994. *Endangered species recovery:*
453 *finding the lessons, improving the process*. Island Press, Covelo, California, USA.
- 454 COLLINS, A. G. 1998. *Proceedings of the National Academy of Sciences USA* 95:15458-
455 15463.
- 456 DAY, R. A. 1998. *How to write and publish and scientific paper*. Oryx Press, Phoenix,
457 Arizona, USA.
- 458 GODLEE, F. 2002. Making reviewers visible. *Journal of the American Medical Association*
459 287:2762-2765.
- 460 GUTHERY, F. S., J. J. LUSK, AND M. J. PETERSON. 2001. The fall of the null hypothesis:
461 liabilities and opportunities. *Journal of Wildlife Management* 65:379-384.
- 462 GUTIÉRREZ, R. J. 1996. Biology and distribution of the northern spotted owl. Pages 2-5 *in*
463 E. D. Forsman, S. DeStefano, M. G. Raphael, and R. J. Gutiérrez, editors. *Demography*

- 464 of the northern spotted owl. *Studies in Avian Biology* 17.
- 465 HILBORN, R., AND M. MANGEL. 1997. *The ecological detective: confronting models with*
466 *data*. Princeton University Press, Princeton, New Jersey, USA.
- 467 KERKHOFF, A. B., B. T. MILNE, AND D. S. MAEHR. 2000. Toward a panther-centered view
468 of the forests of south Florida. *Ecology and Society* 4:1 <
469 <http://www.ecologyandsociety.org/vol4/iss1/art1/>>. Accessed 2005 14 August.
- 470 MAEHR, D. S., E. D. LAND, AND J. C. ROOF. 1991a. Social ecology of Florida panthers.
471 *National Geographic Research and Exploration* 7:414–431.
- 472 _____, AND G. B. CADDICK. 1995. Demographics and genetic introgression in the Florida
473 panther. *Conservation Biology* 9:1295–1298.
- 474 _____, AND J. A. COX. 1995. Landscape features and panthers in Florida. *Conservation*
475 *Biology* 9:1008–1019.
- 476 _____. 1997. *The Florida panther: life and death of a vanishing carnivore*. Island Press,
477 Covelo, California, USA.
- 478 _____, AND J. P. DEASON. 2002. Wide ranging carnivores and development permits:
479 constructing a multi-scale model to evaluate impacts on the Florida panther. *Clean*
480 *Technologies and Environmental Policy* 3:398–406.
- 481 _____, R. C. LACY, E. D. LAND, O. L. BASS JR., AND T. S. HOCTOR. 2002. Evolution of
482 population viability assessments for the Florida panther: a multiperspective approach.
483 Pages 284–311 in S. R. Beissinger and D. R. McCullough, editors. *Population viability*
484 *analysis*. University of Chicago Press, Chicago, Illinois, USA.
- 485 MARCOT, B. G., AND J. W. THOMAS. 1997. Of spotted owls, old growth, and new policies: a
486 history since the interagency scientific committee report. General Technical Report.

- 487 PNW-GTR-408. U.S. Department of Agriculture, Forest Service, Pacific Northwest
488 Station, Portland, Oregon, USA.
- 489 MARMOREK, D., AND C. PETERS. 2001. Finding a PATH toward scientific collaboration:
490 insights from the Columbia River Basin. *Ecology and society* 5 (2): 8. <
491 <http://www.ecologyandsociety.org/vol5/iss2/art8/> >. Accessed 2005 14 August.
- 492 MICHENER, W. K. 1997. Quantitatively evaluating restoration experiments: research design,
493 statistical analysis, and data management considerations. *Restoration Ecology* 5:324-
494 337.
- 495 MIRON, G., B. BOUDREAU, AND E. BOURGET. 1999. Intertidal barnacle distribution: a case
496 study using multiple working hypotheses. *Marine Ecology Progress Series* 189:205-
497 219.
- 498 MURPHY, D. D., AND B. R. NOON. 1991. Coping with uncertainty in wildlife biology.
499 *Journal of Wildlife Management* 55:773-782.
- 500 NICHOLS, J. D. 1991. Science, population ecology, and the management of the American
501 black duck. *Journal of Wildlife Management* 55:790-799.
- 502 NUDDS, T. D., AND M. L. MORRISON. 1991. Ten years after "Reliable Knowledge": are we
503 gaining? *Journal of Wildlife Management* 55:757-760.
- 504 O'BRIEN, S. J., M. E. ROELKE, N. YUHKI, K. W. RICHARDS, W. E. JOHNSON, W. L.
505 FRANKLIN, A. E. ANDERSON JR., O. L. BASS, R. C. BELDEN, AND J. S. MARTENSON.
506 1990. Genetic introgression within the Florida panther *Felis concolor coryi*. *National*
507 *Geographic Research* 6:485-494.
- 508 PFEIFER, M. P., AND G. L. SNODGRASS. 1990. The continued use of retracted, invalid
509 scientific literature. *Journal of the American Medical Association* 263:1420-1423.

- 510 PLATT, J. R. 1964. Strong inference. *Science* 146:347-353.
- 511 ROELKE, M. E. 1990. Florida panther biomedical investigation. Final Performance
512 Report. Florida Game and Fresh Water Fish Commission, Tallahassee, USA.
- 513 ROMESBURG, H. C. 1981. Wildlife science: gaining reliable knowledge. *Journal of Wildlife*
514 *Management* 45:293-313.
- 515 _____. 1991. On improving the natural resources and environmental sciences. *Journal of*
516 *Wildlife Management* 55:744-756.
- 517 SINCLAIR, A. R. E. 1991. Science and the practice of wildlife management. *Journal of*
518 *Wildlife Management* 55:767-773.
- 519 _____, C. J. KREBS, J. M. FRYXELL, R. TURKINGTON, S. BOUTIN, R. BOONSTRA, P.
520 SECCOMBE-HETT, P. LUNDBERG, AND L. OKSANEN. 2000. Testing hypotheses of trophic
521 level interactions: a boreal forest ecosystem. *Oikos* 89:313-328.
- 522 SMALLWOOD, K. S., J. BEYEA, AND M. L. MORRISON. 1999. Using the best scientific data
523 for endangered species conservation. *Environmental Management* 24:421-435.
- 524 SNYDER, N. F. R., AND H. SNYDER. 2000. *The California condor*. Academic Press, San
525 Diego, California, USA.
- 526 TURNER, R. E. 1997. Wetland loss in the northern Gulf of Mexico: multiple working
527 hypotheses. *Estuaries* 20:1-13.
- 528 WALTERS, C. J. 1986. *Adaptive management of renewable resources*. MacMillan Press,
529 New York, New York, USA.
- 530 WEINER, J. 1995. On the practice of ecology. *Journal of Ecology* 83:153-158.
- 531 WILLIAMS, B. K., J. D. NICHOLS, AND M. J. CONROY. 2002. *Analysis and management of*
532 *animal populations*. Academic Press, San Diego, California, USA.

533 Table 1. Types of unreliable inferences identified by the authors in a review of scientific literature supporting Florida panther
 534 conservation, and recommendations for how these may be reduced by editors and referees..

Type of unreliable inference	Example related to the Florida panther	How editors or referees can reduce this problem
1. Incorrectly attributing an inference to an earlier paper, or citing a non-IMRAD ^a paper as if it were rigorously peer-reviewed.	Maehr and Deason (2002) wrongly cited Maehr and Cox (1995) as demonstrating that panthers were "reluctant to cross" 90 m of non-forest. The population viability analysis by Maehr et al. (2002) used estimates of kitten survival provided in an editorial by Maehr and Caddick (1995).	Within the manuscript, identify 1 or 2 improbable attributions to previous literature; verify whether the attribution is justified.
2. Making inferences (that may later be abused) within editorials or other non-IMRAD papers.	Demographic inferences in Maehr and Caddick (1995).	Do not allow authors to insert scientific inferences into editorials, book reviews, and essays. Insist that scientific inferences be presented in IMRAD

3. Presenting inferences in the

Discussion section of an IMRAD paper that: (1) were unrelated to the paper's stated objectives, (2) used methods not described in the Methods section, or (3) lacked relevant material in the Results section.

Inferences by Maehr and Cox (1995) that panthers need large forest patches.

format.

Strict adherence to IMRAD format with 1:1:1:1 correspondence among objectives, methods, results, and inferences.

4. Flawed methods or inferences in an otherwise well-constructed IMRAD paper.

Maehr and Cox (1995) ignored location error in stating that 91% of panther locations were within 90 m of forest cover.

Reviewers should insist on additional review by persons with expertise the reviewer lacks.

Editors should not ask reviewers for recommendations on whether to publish the paper. Instead, they should ask reviewers to specify the steps needed to

make the paper publishable.

Journals should publish names of

Associate Editor and reviewers for each

paper that is accepted and published.

^a The format of Introduction, Methods, Results, and Discussion in scientific papers.