UNITED STATES OF AMERICA
DEPARTMENT OF AGRICULTURE
UNITED STATES FOREST SERVICE

Before the Regional Forester
Eastern Region

In re Appeal of the Decision Notice  
And Finding of No Significant Impact for the  
Upper Greenbrier North Project  
USDA Forest Service  
Greenbrier Ranger District  
Monongahela National Forest  
Pocahontas County  
West Virginia  

Appeal No. ________

FRIENDS OF BLACKWATER
Appellant

NOTICE OF APPEAL AND STATEMENT OF REASONS

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NOTICE OF APPEAL

Pursuant to 36 C.F.R. Part 215, the Friends of Blackwater (FOB) (Appellant) hereby again appeals the Decision Notice (DN) and Finding of No Significant Impact (FONSI) for the Upper Greenbrier North (UGN) Project on the Greenbrier Ranger District of the Monongahela National Forest (MNF), USDA Forest Service, in Pocahontas County, West Virginia. The Responsible Official is Jack Tribble, District Ranger for the Greenbrier Ranger District of the Monongahela National Forest who signed the decision on November 28, 2012. This appeal is timely under 36 C.F.R. § 215.15. having been filed within the 45 day appeal period that ends of January 14, 2013.

For the reasons explained below, the Decision Notice (DN) and Finding of No Significant Impact (FONSI) violate the National Environmental Policy Act (NEPA), the Administrative Procedures Act (APA), the Endangered Species Act (ESA), and Forest Service policy as set forth in the agency’s Handbook, Manual and other guidance.

The Appellant participates actively in management of the MNF. Appellant specifically participated in the public process surrounding the Upper Greenbrier North Project, including submitting comments during the scoping and 30-day comment periods and discussing the project at length with Forest Service and U.S. Fish and Wildlife Service (FWS) officials.

Friends of Blackwater (FOB) is a not-for-profit West Virginia membership organization devoted to preserving wilderness and wildlife; protecting West Virginia’s forests, parks, rivers, wild lands, unique habitats and endangered species; and fostering a West Virginia land preservation ethic. FOB has over 10,000 members and supporters. FOB also has a long-standing interest in the West Virginia northern flying squirrel, Glaucomys sabrinus fuscus. FOB has supported studies of the flying squirrel; staff of FOB has communicated with scientists from a number of states and Canada on the squirrel’s natural history and status and collected a large library of information of this squirrel. FOB also works to protect West Virginia’s endangered
bats both on and off the Monongahela National Forest. FOB has supplied information to the US Fish and Wildlife Service on little brown bat mortality as part of a request for a listing review for this species. We educate our 10,000 members and supporters about these issues through newsletters, our website and comments to the press.

Appellant’s members and supporters are very familiar with the Upper Greenbrier North Project area and with the Monongahela National Forest. Appellant’s members and supporters use and appreciate these lands for their scenic beauty and for hiking, camping, hunting, fishing, mountain biking, watching birds and viewing wildflowers and other flora and fauna, photography, spiritual renewal, and other outdoor recreational and educational activities. These lands are also valued for the role they play in water supply, flood control and other ecological functions that play out over the larger landscape. The Upper Greenbrier North Project appealed here would directly and significantly affect Appellant’s members and supporters because it would degrade all of these values and uses.
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STATEMENT OF REASONS

I. Introduction

The Upper Greenbrier North Project has suffered from the beginning from procedural mistakes which have resulted in a very confusing process, set of documents, project details, project acreage and a flawed and arbitrary and capricious decision. The public has not been given the opportunity for meaningful public involvement under NEPA. The lack of response to substantive comments at any stage of the process has been a part of this. So too was the decision not to engage in formal consultation with the FWS until after the 30-day comment period had closed, despite claims in the EA that this work had been done and despite the fact that much of the project would have a significant adverse effect on the listed species of bats both Indiana and Virginia bat eared, the West Virginia northern flying squirrel, a rare species being treated by the Forest Service as endangered.

Overall, site-specific locations, correct and accurate acreage numbers and the significance of impacts for UGN Project activities have not been disclosed, rendering the DN/FONSI arbitrary and capricious.

In the pages that follow we detail our specific concerns and the violations of law and policy that we believe the Forest Service has committed in reaching a final decision approving the Upper Greenbrier North Project including the current Upper Greenbrier North Decision Notice #2.

II. The Forest Service Must Prepare an Environmental Impact Statement to Address the Significance of Effects under NEPA

There is a thin line between dividing a large project up into smaller projects, and illegal segmentation under NEPA to avoid a determination of significant effect and the need to prepare an environmental impact statement (EIS). In the case of the UGN Project, we do not believe the recent decision issued to carry out the aquatic and road decommissioning aspects of the project lessen the overall significant impact of the project. We still believe that an EIS must be prepared for the remaining project elements. The concerns we described on this topic on pages 6-9 of our original appeal provide further details and still hold true.

Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA) (40 CFR Parts 1500-1508) contain a number of requirements to insures that federal agencies meet their obligations to comply with procedures and achieve the goals of the Act. The Code of Federal Regulations at 36 CFR 220 contains the Forest Service’s procedures for complying with both the NEPA and CEQ’s regulations. We believe the Forest
Service has failed to comply with a number of these requirements and is in violation of the NEPA. The various ways in which the agency has done so are detailed below.

**A. An EIS Should Have Been Prepared and Failing That Should Now Be Prepared**

We believe the agency should have prepared an EIS. Now that a Final EA has been prepared we believe it is clear that a FONSI should not have been issued and an EIS must be prepared.

Forest Service NEPA regulations at 36 CFR 220.6(c) state,

> “Scoping. If the responsible official determines, based on scoping, that it is uncertain whether the proposed action may have a significant effect on the environment, prepare an EA. If the responsible official determines, based on scoping, that the proposed action **may** have a significant environmental effect, prepare an EIS.”

We believe the responsible official should have determined after scoping, and certainly after the 30-day comment report was issued, that preparation of an EIS was warranted. This is based on Endangered Species Act (ESA) considerations, the size of the project area, the scale and intensity of the project activities, consideration of the significance factors under the CEQ regulations, and their role in defining the severity of impacts, the timeframe the agency identified to accomplish these activities and the overall cost for these activities when viewed through the lens of typical MNF budgets.

In order to determine “significance”, it is necessary to turn to the CEQ Regulations at 40 CFR 1508.27. Significance under NEPA requires consideration of both context and intensity. In the case of context, “significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole. Both short and long-term effects are relevant.” 40 CFR 1508.27(a). Intensity refers to the severity of the impact.

In the case of the UGN Project, at 69,600 acres, this project would be one of, if not the biggest project(s) ever on the MNF. Other aspects of the project speak to its significance in terms of context and intensity:

- At 69,600 national forest system (NFS) acres, this project area constitutes over 7½% of the entire MNF. The entire project area includes 85,400 acres.
- The UGN Project would occur across five 6th HUC level watersheds.
- Vegetation treatments are proposed in approximately 261 units across 25 different compartments.
- Commercial timber harvest in excess of tens of millions of board feet (mmbf) on thousands of acres is proposed. To further complicate matters, the estimated volume and the exact number of acres involved are with not disclosed at all or are inaccurately calculated as we discuss below.
> Herbicide treatments are proposed for thousands of acres, which are again incompletely calculated and disclosed...

> These projects are proposed to be carried out over a 10-12 year period, though given the lack of available federal funding and timing considerations for various activities, this timeline is likely to be much longer. (The Forest Service can’t possibly disclose impacts across this timeframe as required under NEPA, a topic discussed in more detail below.)

> The project would cost almost $24 million dollars, money unlikely to be appropriated to the Forest for this one project set even over the course of a number of years. (Exact budget figures are not available, as the Final EA does not reflect the actual alternative chosen, Modified 5; an issue which is also detailed below.)

The fact that the Forest didn’t even list the proposed activities in the EA itself, but instead disclosed them in a series of 8 Appendices in order to avoid confusion given the large number of actions, speaks volumes about the size and intensity of this project. Additional modifications have been added since the March 2012 Decision Notice which have not been made widely available to the public. We note too that Forest Service NEPA regulations at 36 CFR 220.7(b)(3)(iii) require that the MNF, “shall describe the impacts of the proposed action and any alternatives in terms of context and intensity as described in the definition of “significantly” at 40 CFR 1508.27” when preparing an EA. This does not appear to have been done, except belatedly, and we believe incorrectly, in the DN/FONSI.

Several other elements of the CEQ regulations under intensity come into play. 40 CFR 1508.27(b) lists ten factors that should be considered in evaluating intensity. Almost all of them pertain to the UGN Project and should have been considered and disclosed in evaluating the significance of the proposed action and whether to prepare an EIS. Their examination in the decision notice (DN), after considerable changes to the UGN Project in light of a number of these factors, circumvents NEPA requirements as they should have been carried out. Examination of a few of them is instructive.

(1) **Impacts that may be both beneficial and adverse.** A significant effect may exist even if the federal agency believes that on balance the effect will be beneficial.

This certainly applies to the UGN Project. The Forest Service is arguing that it can create a beneficial effect (increase in the red spruce vegetative component, improvement in stand conditions, etc.), while acknowledging activities to create this habitat will be adverse (an increase in stream sedimentation from forest roads and an increase in nonnative invasive species due to these same project activities).

(5) **The degree to which the possible effects on the human environment are highly uncertain or involve unique and unknown risks.**
A project of this size, scale, complexity and duration is new to this forest. As we discuss below, given Forest Service budgeting procedures and funding trends, the MNF is unlikely to be able to implement these project activities for many decades, let alone the 10 years they stipulate are needed. The effects of herbicide use across such an acreage are unknown and many of these herbicides have been found to have adverse effects on aquatic life.

(9) The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

The proposed activities may adversely affect the WVNFS, the Indiana bat and the Virginia big-eared bat and their habitats, as well as a number of regionally sensitive bats that are now candidates for listing. Had the Forest Service followed its own procedures under NEPA and the ESA, the agency would have identified the need for an EIS based on the adverse effect on flying squirrels and listed bats, would have initiated formal consultation with the FWS under the ESA and would have afforded the public the opportunity to provide meaningful comment by being able to read and analyze the FWS Biological Opinion which significantly influenced the decision made.

There also exists new information, which we detail below, wherein the FWS and bat experts have significantly raised the mortality figures for White Nose Syndrome (WNS) in bats, calling into question the analysis of cumulative effects in the UGN Project.

We believe the scope, scale and impacts of the proposed project are such that an environmental impact statement (EIS) should have been prepared. Given the information presented above and impacts described below, we believe the responsible official had the information necessary to determine that the proposed action may have a significant environmental effect at the conclusion of the scoping process. That the project then increased so much in size and scope between the end of scoping and the EA issuance makes this failure to prepare an EIS all the more problematic.

Forest Service regulations allow the agency to prepare an EA before preparing an EIS:

“An environmental assessment (EA) shall be prepared for proposals as described in §220.4(a) that are not categorically excluded from documentation (§220.6) and for which the need of an EIS has not been determined (§220.5).”

36 CFR 220.7(a)

Now that the Final EA has been completed (and does not actually reflect or analyze the decision made), we believe it is clear for the reasons stated in this appeal and the impacts
addressed below that a Finding of No Significant Impact (FONSI) should not have been issued and the need for an EIS has been determined and must be prepared.

B. The EA is No Substitute for an EIS

The MNF cannot argue that the EA because of its length is a substitute for an EIS. In fact, its length and complexity should have been a sign to Forest staff that they should have more thoroughly investigated the need for an EIS under 36 CFR 220.6(c). CEQ has instructed that “[i]n most cases…a lengthy EA indicates that an EIS is needed” because at minimum “it is extremely difficult to determine whether the proposal could have significant environmental effects.” Forty Most Asked Questions Concerning CEQ’s National Environmental Policy Act Regulations. “An EA and an EIS serve very different purposes” (Sierra Club, 769 F.2d at 875). The courts have in fact held that an EA cannot be accepted “as a substitute for an EIS” regardless of the “time, effort and analysis that went into [the EA’s] production.” Id. at 875 (emphasis in original). EAs help decision makers determine whether to prepare an EIS. Consistent with their different legal functions, there are much more stringent requirements on the preparation of EISs. We believe the Forest Service must prepare an EIS in this case.

C. The Timeframe of the Project Is Too Long under NEPA and Direct, Indirect and Cumulative Impacts Cannot Be Known or Disclosed

As we have discussed in many of our previous comments and our first appeal a project timeframe of ten years and more is too long. Too many critical elements can change in that amount of time, rendering the decision obsolete at best and damaging at worst. To use just two examples, threatened and endangered species can be found in the area, and overall climate and weather patterns (such as rising temperature and severe storm damage) can change, making project activities unwise.

CEQ also makes clear that analysis becomes stale over a much shorter period of time and must be conducted again.

“As a rule of thumb, if the proposal has not been implemented, or if the EIS concerns an ongoing program, EISs that are more than 5 years old should be carefully reexamined to determine if the criteria in Section 1509.2 compel preparation of an EIS supplement.

If an agency has made a substantial change in a proposed action that is relevant to environmental concerns, or if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed ... impacts, a supplemental EIS must be prepared for an old EIS so that the agency has the best possible information to make any necessary substantive changes in its decisions regarding the proposal.”

The courts have agreed with this view, as the litigation cited in our appeal details.

In the case of the UGN Project, an EIS has not even been prepared. The Forest is proposing to implement ten or more years of activities based on an environmental assessment (EA) that does not even include enough site-specific information to be able to determine exactly where all project activities would be carried out, let alone determine if that environmental analysis is sufficient to disclose the significance of effects. This must be corrected in both the UGN Project and other forest projects of similar proposed length to avoid future legal challenges to unimplemented forest projects that rest on out-of-date analysis.

The Forest Service is proposing a large number of activities that would take place over many years; in fact, too many years. This timeframe is far too long for the agency to adequately analyze and disclose the cumulative impacts of this project. The UGN Project EA states that the projects would take 10-12 years to implement and that many of the activities need to be staged in relationship to each other. The DN reveals a 10-year period is necessary. DN at 19. First of all, not enough information is provided to understand exactly what these staging needs would do to the implementation schedule. Secondly, as addressed in more detail below, the agency failed to take the “hard look” required under NEPA to adequately analyze or disclose whether a ten-year implementation schedule would even be possible in light of agency and Congressional budget procedures and budget history.

It is also clear from the project description that the MNF intends that this decision cover both stages of a shelterwood harvest despite the fact that these treatments are by their very nature a number of years apart. The Forest Service seems to describe this as 4-5 years (it’s a bit unclear) but our experience with the agency’s ability to finance and return for the second stage entry is that it could take many times that number before the agency finishes the second stage. Even leaving aside the shelterwood harvests, the sheer volume of timber harvest involved, and the preparatory activities described make it likely that a number of these sales wouldn’t even be proposed until well into the 10-12 year time period. Add in the fact that timber sales can legally be extended up to 10 years and the possibility exists that these project activities could still be being implemented two decades from now. That is longer than the fifteen year period covered by a Forest Plan, and far too long to adequately disclose effects.

Finally, the sheer scale and cost of the proposed project almost guarantees that the effects will be inadequately disclosed over the life of the project. There are many activities in the UGN Project which we support (road decommissioning and aquatic stream restoration), but given current federal budget constraints and the likely size of the budget on the MNF over the next 10-12 years we believe there is very little likelihood that the UGN Project would ever be implemented over that time period, or even one much longer. We also note that the costs of preparing NEPA and conducting field surveys have not been included in the project budget calculations. (This both understates the costs and removes the excuse that NEPA costs drive up project implementation.)
All of this results in the approval of activities many of which in the later stages of the project will almost certainly be based on stale scientific information and have adverse effects. The courts have found that, "Reliance on stale scientific evidence is sufficient to require re-examination of an EIS. Seattle Audubon Society v. Espy, 998 F.2d 699, 704-705 (9th Cir. 1993)." City of Carmel-by-the-Sea v. U.S. Dept. of Transportation, 95 F.3d 892, 900 (9th Cir. 1995). Lands Council v. Powell, 379 F.3d 738 (9th Cir. 2004), as amended (9th Cir. 01/24/2005) No. 03-35640 - 6-year-old species survey not good enough -- "stale habitat data" -- citing SAS.

As the CEQ has stated:

“As a rule of thumb, if the proposal has not been implemented, or if the EIS concerns an ongoing program, EISs that are more than 5 years old should be carefully reexamined to determine if the criteria in Section 1509.2 compel preparation of an EIS supplement.

If an agency has made a substantial change in a proposed action that is relevant to environmental concerns, or if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed ... impacts, a supplemental EIS must be prepared for an old EIS so that the agency has the best possible information to make any necessary substantive changes in its decisions regarding the proposal.”


Obviously, this is even more true of an EIS that is over 10 years old. See Oregon Natural Resources Council Action v. U.S. Forest Service, 445 F. Supp. 2d 1211, 1232 (D. Or. 2006) (finding this provision particularly applicable when dealing with EAs over ten years old, citing, inter alia, the CEQ language above); see also Portland Audubon Society v. Espy, 998 F.2d 699, 70304 (9th Cir. 1993) (overturning decision which "rests on stale scientific evidence”).

Decisions that rest on stale scientific information are one thing. In the case of the UGN Project, the agency is proposing from the beginning to create a project where the information will be known to be out of date halfway through the proposed implementation timeline. This is unacceptable under NEPA and must be corrected. Forest Service regulations and directives provide direction on what to do when new information becomes apparent. These regulations and directives do not contemplate starting out a project knowing that the analysis of effects will soon be invalid.

Questions of staleness are even more of a problem when relying on an EA that was never prepared to the rigor required of an EIS. We strongly urge the Forest Service to review the UGN Project based on a realistic assessment of their likely budget, timing considerations and what can reasonably be accomplished over a shorter time period than 10-12 years and recalibrate the
project proposal accordingly. A decision under NEPA can only be thought of as “ripe” when there is a reasonable expectation that the project can be implemented. Anything less certainly violates the letter and spirit of NEPA.

**D. The Range of Alternatives Is Inadequate: Adaptive Development of Alternatives Does Not Absolve the Forest of the Requirement for an Adequate Range of Alternatives**

While we appreciate the efforts the Forest has made to involve the public in the development of alternatives and to incorporate adaptive planning into its management approach, these efforts do not absolve the Forest of its responsibilities under NEPA to define and evaluate an adequate range of alternatives. The Corrected EA examined three alternatives: the No Action, Alternative 2 and Alternative 5. However, Alternative 2 was nothing more than an earlier version of Alternative 5. It was not even developed in enough detail to adequately disclose site-specific “on the ground” information and the impacts of proposed activities on those resources.

“...but Alternative 2 did not have quite the same level of on-the-ground information incorporated into its development as did Alternative 5, the Selected Alternative. This discrepancy is due to the fact that Alternative 5 evolved from Alternative 2 and therefore had the benefit of additional internal and external input and on-the-ground information as the ID Team went through the NEPA process.”

Decision Notice (DN) / Finding of No Significant Impact (FONSI), pg. 9

This would seem to indicate that Alternative 2 is not really a viable alternative as required under NEPA. The district ranger also signaled his intention to continue to this “single alternative” approach in future decisions. “I intend to follow this approach in any subsequent decisions that would implement Alternative 5 activities involving timber or spruce restoration.” DN/FONSI, pg. 10. The courts have held that 2 alternatives (the no action and one other) are not sufficient under NEPA. Future projects and decisions must include fully developed alternatives capable of being reasonably compared to each other.

**E. The Controversy Context Is Too Narrow**

The Forest Service has described the definition of controversy in its decision more narrowly than that prescribed by CEQ. CEQ regulations at 40 CFR § 1508.27 requires consideration of both context and intensity in determining significance under NEPA. Intensity refers to the severity of the impact and is further defined in detail. Element 4 at 40 CFR § 1508.27(b)(4) states, “The degree to which the effects on the quality of the human environment are likely to be highly controversial.”

The Forest Service in its UGN decision has narrowed this definition beyond that contemplated or required by CEQ.
“Controversy in this context refers to cases where there is substantial dispute as to the size, nature or effect of Federal action, rather than opposition to its adoption. None of the issues within the scope of the analysis are believed to be highly controversial within the scientific community.”

Decision Notice (DN) / Finding of No Significant Impact (FONSI), pg. 15.

First of all, as our comments and appeal of the UGN Project make clear, there is substantial dispute as to the size, nature and effect of the Project. At its simplest, the fact that the Appeal Reviewing (ARO) and Deciding Officers (ADO) agreed that it was difficult for the public to assess the accuracy of what was being proposed indicates a level of controversy as to the size, nature and effect. Secondly, the Forest Service has added a requirement “within the scientific community”, not required or defined by CEQ. This unnecessarily narrows the meaning of “controversy”. We do not believe this narrowed definition is supported by the courts. Thirdly top West Virginia northern flying squirrel (WVNFS) researchers do not agree that the restoration of red spruce is the key to protecting endangered squirrel habitat. Their challenge to this premise makes this project very controversial.

III. The Final Environmental Assessment (Final EA), DN and FONSI are Insufficient under NEPA, Rendering the Decision Arbitrary and Capricious

A. Many Site-Specific Details Are Either Unknown and/or Undisclosed

The UGN Project EA is not a programmatic document. Therefore, NEPA requires the site-specific analysis and disclosure of direct, indirect and cumulative impacts and their significance in order to determine if an EIS should be prepared. In the case of the Final EA, DN and FONSI there are substantial problems and inconsistencies with the documentation prepared such that it is almost impossible to understand exactly what is proposed and approved and where this is so. These problems cumulatively fail to adequately meet the requirements of NEPA and result in an arbitrary and capricious decision. Because Alternative 2 was not fully developed, many of the on-the-ground details were unknown and undisclosed. In addition, seemingly due to the sheer size of the project, many of the details for Alternative 5 were unknown and undisclosed, including in many instances, the exact location of site-specific activities. (See UGN DN at 9 for herbicide application amounts). Deciding after the decision where specific project activities will take place is unacceptable under NEPA. It calls into question the accuracy of the disclosure of effects, the assessment of the degree of significance, and cost figures prepared for the project. This must be corrected in future decisions.

Each of the problems is detailed below.

B. The Final EA Was Not Updated to Reflect the Decisions Being Made
The DN discloses, “Because my Selected Alternative includes changes from the Alternative 5 that was analyzed in the UGN EA, I want to be clear about the activities and modifications to Alternative 5 that will be implemented, and so they are described in detail below.” DN at 9. Unfortunately, the explanation that follows that statement is anything but clear as we discuss below.

Even more problematic, the Final EA was never updated to reflect the decision made. The Final EA is listed as having been written in March, 2012. With a March 5th decision date, and no external deadline keeping the Forest Service from ensuring the analysis was clearly and accurately presented, the details and any additional required analysis (see more on this below) for Alternative 5 Modified should have been disclosed in the Final EA. Without this data, the Final EA is rendered insufficient in disclosing the impacts of the project.

Two problems result. The first is the potential for significant error and violation of the Endangered Species Act (ESA). Should any Forest Service staff rely on the Final EA in setting up timber sale contracts, service contracts or other project elements, they will be using a document that still includes units that were dropped from the decision in order to protect the West Virginia northern flying squirrel (WVNFS or flying squirrel). This could result in harm or take of listed species well outside of the terms and conditions of the U.S. Fish and Wildlife Service (FWS) Biological Opinion issued in March of 2012, and well outside of any incidental take permit the agency has issued to the Forest Service. The chances of this egregious error happening are increased by the fact that the numerous appendices detailing all the project activities were never corrected and presented in the DN, so there exists no updated or corrected list. And the appendices and tables in the Final EA still include these dropped units.

Secondly, the fact that the Final EA was not updated to accurately present the details of the chosen alternative, Modified 5, means that the agency and the public must rely on the DN, and the DN alone, to understand just what measures would be carried forward and implemented. This problem continues in UGN Decision #2. This should be corrected in future decisions.

This also is an easy path to internal mistakes in project implementation by Forest staff. Forests often have trouble finding the Project Record and NEPA documents long after decisions are made. This occurs despite Federal Records requirements which should keep these important
records easily accessible. In the case of the UGN Project and other projects of similar length on
the MNF, ensuring that projects are implemented correctly according to the decision made
becomes almost impossible if the only record of the mitigation and design features required only
exists in an inaccurate EA document that must be reread to tease out the measures applicable to
the decision. A more efficient method would be to repeat the mitigation and design measures
that are part of the decision so that staff (and the public) can be assured of a complete list and the
ability to accurately track their accomplishment.

D. The Modified Alternative 5 and the Range of Analysis Conducted in the EA: The
Requirements of NEPA Have Not Been Met

The DN/FONSI explains that the Final EA was not updated to include the alternative selected
because “Many of the modifications to Alternative 5 were developed after consultation with the
U.S. Fish and Wildlife Service and U.S. Forest Service Research, and they were designed to
reduce the overall potential impacts to WVNFS or its habitat, as well as to soil and water
resources. Therefore, I find the effects of clarifying and modifying this alternative are within the
scope of the EA analysis and the predicted impacts of all the alternatives considered in detail.”
DN/FONSI at 7.

First of all, as we detail above, the effect of not updating the Final EA in light of all the
modifications to alternative 5 have resulted in a decision where there is no clear and
unambiguous listing of the exact project activities approved. The numerous math errors and
inconsistencies make it almost impossible to determine that the modified alternative is within the
scope of the EA analysis and the predicted impacts.

Secondly, NEPA requires site-specific analysis of the direct, indirect and cumulative impacts
of the proposed action and alternatives. Simply creating a range of impacts and saying that the
new alternative fits somewhere (as yet undetermined) within that range is insufficient.

The fundamental purpose of preparing an EA or EIS is to ensure that the agency and the
public are fully aware of the potential environmental impacts of a proposed action before the
agency decides how to proceed. Robertson v. Methow Valley Citizens Council, 490 U.S. 332,
349 (1989). An environmental document such as an EA or EIS must contain “sufficient
discussion of the relevant issues and opposing viewpoints to enable the decision maker to take a
‘hard look’ at the environmental factors, and to make a reasoned decision.” Izaak Walton

NEPA mandates that federal agencies take a “hard look at a decision’s environmental
consequences.” California v. Block, 690 F.2d 753, 761 (9th Cir. 1982). Specifically, an EA or
EIS must assess the direct, indirect, and cumulative environmental impacts of the proposed
action, performing an analysis commensurate with the scale of the action at issue. See, e.g., id.;
40 C.F.R. §§ 1502.2 (b), 1508.8. The EIS must “contain a reasonably thorough discussion of the significant aspects of the probable environmental consequences.” California v. Block, 690 F.2d 753, 761 (9th Cir. 1982). “General statements about ‘possible’ effects and ‘some risk’ do not constitute a ‘hard look’ absent a justification regarding why more definitive information could not be provided.” Neighbors of Cuddy Mt. v. United States Forest Serv., 137 F.3d 1372, 1380 (9th Cir. 1998).

In the case of the Upper Greenbrier North Project, the Forest Service failed to take the “hard look” required under NEPA and failed to adequately analyze and disclose the direct, indirect and cumulative effects of the Project. Playing catch-up by issuing small decisions with additional details fails to fix the problem. In the case of the economic analysis we do not believe the agency took the hard look required under NEPA and failed to analyze or disclose whether Forest Service budget procedures and funding even make the UGN Project possible as proposed. We examine this issue and others in more detail below.

E. The Response to Comments Must Be Made Public and Accompany the 30-Day Comment Report and the Final Decision/EA

As we discussed in our first appeal of the UGN Project, the Forest Service must complete and disclose to the public a “Response to Comments” section at each of the critical phases of the NEPA process. Though the Appeal Reviewing Officer (ARO) describes some sort of response document(s) in the Project Record (PR), no such documents were ever released to the public during the ongoing NEPA process for the project. To our knowledge, we can find no record that such materials were ever released to the general public, or that they are available now for public review on the Forest Service’s website. Again, as we discuss in our appeal, we believe case law points to the need to adequately respond to public comment and to disclose such response to the public.

The Forest Service notice-comment-appeal regulations provide that “The Responsible Official shall consider all substantive written and oral comments …” 36 CFR § 215.6(b)(1). And “At a minimum, an appeal must include the following: … (8) Why the appellant believes the Responsible Official’s decision failed to consider the substantive comments; …” 36 CFR § 215.14 (b).

In order to assure compliance with the requirements to “consider” comments, and if the public can base their appeal on the Forest Service’s failure to consider comments, it is only logical that the Forest Service must document in writing its consideration of comments. Without a record of the consideration of comments, administrative and judicial review of these requirements would be impossible rendering these requirements meaningless.

NEPA also requires federal agencies to respond to comments on NEPA documents. “An agency preparing a final environmental impact statement shall assess and consider comments both individually and collectively, and shall respond by one or more of the means listed below,
stating its response in the final statement. …” 40 CFR 1503.4(a). This section is addressed to EISs, but the CEQ regs are in fact applicable to EAs as well. “These regulations, unlike the predecessor guidelines, are not confined to sec. 102(2)(C) (environmental impact statements).” 40 CFR 1500.3.

In City of Davis v. Coleman, 521 F.2d 661 (9th Cir., 1975) the court said that in a statute requiring the social and environmental effects of projects be considered — “considered means to investigate and analyze; ‘consideration’ encompasses an affirmative duty to investigate and compile data, and a further duty to incorporate that data into a detailed reasoned analysis…”

Finally, independent of NEPA, the APA also requires agencies to adequately respond to all significant public comment as a “fundamental tenet of administrative law” NRDC v. EPA, 859 F.2d 156, 188 (D.C. Cir. 1988); see also ACLU v. FCC, 823 F.2d 1554, 1581 (D.C. Cir. 1987); Sierra Club v. EPA, 353 F.3d 976, 986 (D.C. Cir. 2004); Am. Iron & Steel Inst. V. EPA, 115 F.3d 979, 1005 (D.C. Cir. 1997). This principle ensures that agencies consider all material points raised by the public. NRDC, 859 F.2d at 188. Failure to respond to public comment can be grounds for invalidation of a decision as arbitrary and capricious. Id. A comment is “significant” when “if true, [it] raise[s] points relevant to the agency’s decision and which, if adopted, would require a change in an agency’s proposed rule.” Home Box Office Inc. v. FCC, 567 F.2d 9, 35, n.58 (D.C. Cir. 1977). The comment must “step over a threshold requirement of materiality” by explaining why the agency’s error is relevant and not “merely stat[ing] that a particular mistake was made.” Portland Cement Ass’n v. Ruckelshaus, 486 F2d 375, 394 (D.C.Cir. 1973).

As to why we believe the Responsible Official’s decision failed to consider the substantive comments; …” [36 CFR § 215.14 (b)], the UGN Final EA does not contain any responses to the comments submitted, unlike most other EAs in Region 9 and across the Forest Service. Nor did the 30-day comment EA contain any response to comments. While one can guess that our comments may have had an impact on the decision or actions taken (likely in pushing the agency to engage in formal consultation with the FWS under the ESA), the Forest Service has not in this case provided any evidence that our substantive comments were considered. This must be corrected.

IV. The Costs for the Project Do Not Appear to Have Been Corrected and Are Well in Excess of Forest Funding Likelihood

In our appeal and in discussions with Forest staff afterward, we reiterated our concerns that the project activities were of such size and cost that the UGN project activities were unlikely to be completed within the 5-year window NEPA allows before reanalysis of effects should take place, and were unlikely to be completed even within the 10-year window the Forest proposed for project completion. This over-assessment of what would be reasonably possible given time and budget restraints, does not appear to have been reexamined.
The revised decision details a project that will cost over $18.7M dollars over a ten-year period. This averages $1.9M per year in needed funding for this one project alone. Given past annual funding totals we do not believe it is reasonable to expect that the Forest will achieve this level of funding. We find no reason to believe it will be possible for the MNF to complete the UGN Project within ten years. Long before this time period ends, the Forest will need to reassess the environmental effects of these project elements and whether any conditions have changed sufficient to require changes or a halt to project elements. We continue to believe that the Forest must be more realistic in estimating how much the agency can accomplish given likely funding, and scale projects to stay within this range.

The Forest Service presented a number of cost and revenue projections in the Final EA, but failed to take the “hard look” required under NEPA. A “hard look” would have analyzed and disclosed a) the project activities and their costs in relation to the specific acres to be treated; b) the overall project timeline, FS budgeting procedures and history and the likelihood that the timeline could be met; and c) what that would do to project implementation, NEPA requirements for information that is not stale, the purpose and need for the project, and overall disclosure of the significance of cumulative impacts.

A “hard look” as required under NEPA demands that the agency calculate how far likely and predicted funding would go in accomplishing project activities and the length of the time period that would be necessary to complete the UGN Project. This is especially true in that the length of the UGN Project was one of the identified issues in the DN/FONSI and EA. Our knowledge of Forest Service budgeting is such that we fear the UGN Project would take far longer than even the ten years predicted, would cost more than predicted and would result in many of the timber harvest activities being completed and very little of the non-harvest activities. This would be especially troubling in that the agency acknowledges that the harvest activities have effects which the other activities are meant to mitigate (increased risk of NNIS spread, increased sedimentation into streams, decrease in quality of aquatic habitat, etc.).

Funding problems often result in local community unhappiness with the Forest Service’s lack of ability to get things done on the ground. Unfortunately, barriers to accomplishment often get blamed on appeals and litigation when funding is the real culprit. Given the limited funds, a hard look under NEPA would help to assess whether the UGN Project should be scaled back to a more reasonable size given time and funding constraints, and for those project elements that remain would serve to help the agency and area partners prioritize the most important work. The economic analysis must be revised.

V. The Analysis of the Impacts of the Upper Greenbrier North Project on Wildlife is Insufficient under the ESA and Violates NEPA
The Upper Greenbrier North Decision Notice and Finding of No Significant Impact #2 (111-28-12) states “Implementing the selected activities resulted in the following determination for species listed as threatened and endangered under the Endangered Species Act:

May affect and is “likely to adversely affect” the Indiana Bat. (UNG Decision Notice #2 pg. 19). The deciding officer states that this is no problem because the impacts were dealt with the USDA 2006 Biological Assessment and the Biological Opinion (USFWS 2006) in the seven year old Forest Planning Process that led to an ITP for the Indiana bat. This analysis is out of date as new information on serious negative impacts to bats on the Monongahela from White Nose Syndrome and energy development has come to light.

The Virginia big eared bat (VEEB) is listed as may affect but is not likely to affect. The endangered VEEB is a canopy feeder whose year round caves are located within the 6 mile range of the UGB project area. Research on their use of the project area has not been fully disclosed. Timbering proposed in the UGN Decision Notice #2 will negatively impact these species. See sections below.

Impacts to the West Virginia northern flying squirrel by logging mature northern hardwoods adjacent to red spruce may negatively impact the West Virginia northern flying squirrel, a species treated as endangered by the Monongahela National Forest. See discussion below

The analysis of cumulative effects in the EA is flawed. NEPA requires that the Forest Service evaluate “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency [ ] or person undertakes such other actions.” 40 C.F.R. § 1508.7. The required “hard look” is missing in a few important instances.

A. Endangered Species Act (ESA) Background

The Supreme Court has explained:

The purposes of the [ESA] included the conservation of the species and of the ecosystems upon which they depend, and every agency of government is committed to see that those purposes are carried out. . . . [T]he agencies of Government can no longer plead that they can do nothing about it. They can, and they must. The law is clear. 119 Cong.Rec. 42913 (1973). (Emphasis added) . . . The plain intent of Congress in enacting this statute was to halt and reverse the trend toward species extinction, whatever the cost. This is reflected not only in the stated policies of the Act, but in literally every section of the statute. All persons, including federal agencies, are specifically instructed not to “take” endangered species, meaning that no one is “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect” such life forms. 16 U.S.C. §§ 1532(14), 1538(a)(1)(B) (1976 ed.). Agencies in particular are directed by §§ 2(c) and 3(2) of the Act to “use . . . all methods and procedures which are necessary” to preserve endangered
species. 16 U.S.C. §§ 1531(c), 1532(2) (1976 ed.) (emphasis added). In addition, the legislative history undergirding § 7 reveals an explicit congressional decision to require agencies to afford first priority to the declared national policy of saving endangered species. The pointed omission of the type of qualifying language previously included in endangered species legislation reveals a conscious decision by Congress to give endangered species priority over the “primary missions” of federal agencies.


**B. Indiana Bat Protections**


Thus the Court concludes that defendants are bound by the ESA and their own Forest Plan, to place the Indiana bat, an endangered species, at the top of its priority list. It will become apparent to the reader of this Opinion and Order that defendants have failed to comply with its affirmative duty by placing the sale of 199 acres worth of trees before the protection of an endangered species. _House_ at 1028.

The Court finds that protection of the Indiana bat’s habitat far outweighs the factors endorsed by the Forest Service. _Bensman_ at 1247. In both cases, the Forest Service argued that the proposed timber sales did not violate their duty to conserve and give top priority to the Indiana bat. The Forest Service argued they were complying with the ESA because they would preserve all known roost trees and leave most of the trees. Both courts, however, held that even if all known roosts are preserved and most trees are left, the timber sale would still harm the Indiana bats and this violated the duty to conserve the bats and improperly gave priority to logging over the Indiana bat.

Section 2 of the ESA states: “all Federal departments and agencies shall seek to conserve endangered and threatened species and shall use their authorities in furtherance of the purpose of this Act.” 16 USC § 1531(c). The ESA defines “conserve” as “mean to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary.” 16 USC § 1532(2).

**White Nose Syndrome: The New Threat**

White Nose Syndrome is a new disease threatening to wipe out huge numbers of bats in the United States which will have a huge cumulative effect on bat populations well into the future. When WNS was discovered in 2007, it was identified as a dire threat to the survival to all bats. For example, Indiana Bat Recovery Team member Dr. Virgil Brack wrote:

_The White Nose Syndrome (“WNS;” aka “White Death”) scares the hell out of us. It has the potential to be the single most devastating impact on bats in North_
America that we have seen in recorded history, with the possible exception of the settling of this land by Europeans and subsequent habitat destruction. It is possible that this could be to bats what the chestnut blight and Dutch elm disease were to well chestnut trees and elm trees.

As will be explained below, White Nose Syndrome (WNS) is threatening the survival of the Indiana bat. The US Fish and Wildlife Service’s National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats May 2011 identifies WNS as a serious threat to the survival of the Indiana bats. In response to WNS, the USFWS identifies “conservation measures” needed to assure the survival of the Indiana bats. The USFWS stated, “Until the threat of WNS has passed or has been mitigated, best practices are needed for the maintenance and recovery of bat populations of greatest conservation concern.” The USFWS identified “Protect or restore summer and winter habitat to ensure that quality habitat is available for bat populations before and after exposure to WNS” as one of the conservation measures/best practices. Therefore, this project would violate the Forest Service’s duty and highest priority to “protect * * * summer * * * habitat to ensure that quality habitat is available for bat populations before and after exposure to WNS.”

The Forest Service Must Consider New Information in Its Assessment of Impacts to Bats Affected by White Nose Syndrome

On January 17, 2012, the USFWS issued new Indiana bat population numbers and a press release explaining how White Nose Syndrome (WNS) has had much more devastating impacts than previously thought. As will be explained below, 70% of the Indiana bat population in the Northeast has been lost to WNS since 2007. This includes one state losing 99% of its Indiana bat population between 2009 and 2011. USFWS’s press release stated, “U.S. Fish and Wildlife Service biologists and partners estimate that at least 5.7 million to 6.7 million bats have now died from white-nose syndrome. Biologists expect the disease to continue to spread. White-nose syndrome (WNS) is decimating bat populations across eastern North America, with mortality rates reaching up to 100 percent at many sites.” (See the USFWS hosted blog at http://whitenosebats.wordpress.com/2012/02/14/estimating-mortality/) When the Forest Service prepared the EA and the updated EA for UGN it failed to take into account this estimate and its impact on the cumulative effects to bats.

The USFWS’s National WNS Plan identifies WNS as a serious threat to the survival of the Indiana bat and identifies “conservation measures” needed to assure the survival of the Indiana bats. The USFWS stated, “Until the threat of WNS has passed or has been mitigated, best practices are needed for the maintenance and recovery of bat populations of greatest conservation concern.” The USFWS identified “Protect or restore summer and winter habitat to ensure that quality habitat is available for bat populations before and after exposure to WNS” as one of the conservation measures/best practices needed for the survival of endangered bats. The UNG Decision Notice #2 has not taken these new facts into consideration.
In addition new research from the University of Wisconsin (Dec 2012) shows that the organism that causes deadly white-nose syndrome persists in caves long after it has killed the bats in those caves where it lives on in cave soils. This may force surviving bats to find new caves and change their foraging areas in order to survive. This discovery may make protection of foraging areas and unaffected bat caves more important than previously thought and has not been analyzed in the EA updated for the UGN Project and its timbering plans. (citation)

Information on WNS and its impacts on West Virginia bat populations is at least two years old and does not reflect current mortality numbers or population trends for the Indiana bat in the state. Major hibernacula for the Indiana bat such as Hellhole Cave, Schoolhouse Cave, Cornwell Cave, Big Springs Cave, and Cave Mountain Cave have all been infected by WNS as have their Indiana bat populations. This is very disturbing news and is not reflected in the EA updated for the UGN project.

New information concerning the impacts of white nose syndrome have not been considered is the Decision Notice for UGN or DN UGN #2. This new information requires that the Forest Service reinitiate ESA Section 7 consultation. See 50 C.F.R. § 402.16 (“Reinitiation of formal consultation is required . . . [i]f new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered. The much higher fatality rate cited above—more than five to six time higher than the agency believed when MNF staff prepared the EA—represents “new information” under the ESA, as well as “changed circumstances” under NEPA: “[W]here changed circumstances affect the factors relevant to the development and evaluation of alternatives, USFS ‘must account for such change in the alternatives it considers.’” Sierra Forest Legacy v. Rey, 577 F.3d 1015, 1021 (9th Cir. 2009), citing Natural Res. Def. Council v. U.S. Forest Serv., 421 F.3d 797, 813–14 (9th Cir.2005); see also Oregon Natural Res. Council Action v. U.S. Forest Serv., 445 F. Supp. 2d 1211, 1224 (D. Or. 2006) (same).

This new information on unprecedented Indiana bat mortality takes precedence over Tiering to the Forest Service Plan from 2006 which is out of date. Its protections for the Indiana bat are not sufficient. Moreover the RONI on white nose syndrome prepared by the Monongahela National Forest in 2009 is very much out of date and does not cover the current drastic situation. The Mon Forest Plan needs to be updated to reflect the new reality of White Nose Syndrome through a Section 7 ESA Consultation Process with The Fish and Wildlife Service. Following this programmatic process the Forest Service should reinitiate a site specific formal consultation under Section 7 of the ESA in order to determine the effect of its UGN decision on listed bats. As part of the site specific consultation the new Indiana bat survey protocols should be used, new surveys done and acoustic data already collected analyzed.

The Cumulative Impacts of Mortality of Indiana and other rare bats from WNS, industrial wind projects and gas drilling in the vicinity of the Monongahela National Forest Have Not Been Analyzed or Disclosed
One example: The fourth endangered Indiana bat to die at an eastern wind farm was found on Laurel Mountain in Barbour County in July, 2012 at AES’s Industrial wind project. This project is just south of the Big Springs Indiana bat hibernaculum on the Fernow Experimental Forest of the Monongahela National Forest. Four industrial wind farms have been built in West Virginia next to the Monongahela National Forest and more are planned. They are all expected to kill bats in large numbers including the Indiana bat over their life span. Another impact to endangered bats is drilling for natural gas on the Forest. One bat hibernaculum has been impacted and more may in the future be impacted by gas drilling on the Monongahela. Berry Energy’s gas well drilled through the Big Springs cave system (a major Indiana bat hibernaculum) in 2008 and 2009 on Monongahela National Forest Land. All of these factors must be considered together as part of the cumulative effects analysis. The cumulative effects of all these impacts should be analyzed in the EA but would be better done in an EIS.

**The Impacts to Indiana and Virginia big eared bats in the project area have not been sufficiently analyzed or disclosed**

The Forest Service is aware that Indiana bats have been found within the Project area and that part of the project area is within the 5 mile protected zone of the Indiana bat cave called the Izaac Walton Cave as well as the 6 mile zone for the Virginia big eared bat caves and foraging areas. In spite of this knowledge they have failed to complete mist net surveys for bats in the project area. The Forest Service has not had the caves within the project area surveyed for bats. The Monongahela has collected acoustic data on bats for since 2008 in parts of the project area (per. comm. FS biologist Shane Jones) and yet has not analyzed this bat sound information to see whether more endangered bats are using the project area. On January 9th the Fish and Wildlife Service announced in the Federal Register a new draft Indiana bat protocol with a strong emphasis on acoustic monitoring. (DRAFT REVISED RANGEWIDE INDIANA BAT SUMMER SURVEY GUIDELINES). This project should not move forward without analyzing their currently collected bat acoustic data and conducting new more complete surveys for listed bats that may use the project site.

**C. Continuing Concerns related impacts to the WV northern flying squirrel and WV’s Rare High Mountain Ecology and Lack of Monitoring**

**There are continuing concerns with logging in West Virginia northern flying squirrel (WVNFS) habitat and near squirrel capture sites. While the Forest Service purports to be treating the squirrel as a listed species and has said so in meetings with Friends of Blackwater its proposed actions do not support this contention. Logging whether under a non-commercial or commercial plan still disturbs the rare high mountain habitat of this Mon Forest “Management Indicator Species”.

We appreciate being able to meet with the Forest Service on October 29 to discuss Upper Greenbrier North and to see the most recent map of the project. We also appreciate the Forest’s Service willingness to further modify their timber plans to be more protective of this signature
species of West Virginia’s High Allegheny Mountains. In this meeting with the Service they claimed that both the northern hardwood forest and the red spruce forest type were both being protected (the WVNFS uses both). In fact the Forest Service is cutting northern hardwoods but not red spruce. This timbering degrades older growth forest characteristics that the squirrel depends on with no proof that timbering in this rare ecosystem will have any benefit for the squirrel. The proposed timbering delays the growth of middle age northern hardwoods into older growth so important to the shelter, food and travel routes for the squirrel. The Forest Service is conducting a huge experiment that may have very negative results for the squirrel. And how would one know the results … when the measure for success of the project is not squirrel population growth or recovery but an increase in red spruce! See Page 9 UGN #2

We view the Upper Greenbrier watershed and surrounding red spruce/northern hardwood forests as a sanctuary for the rare creatures of this high mountain ecosystem. It is also the viewshed for the Gaudineer Scenic Area which is a National Natural Landmark. Logging is inappropriate in the scenic area and in its viewshed. On the eastern edge of the project is another National Natural Landmark, Blister Swamp. This rare boreal wetland has many rare plants and may be negatively affected by timbering. The UGN Final EA fails to mention, analyze or take the required “hard look” at the impacts of the project on the Greenbrier crayfish, Cambarus smilax, recently found to exist in the UGN Project Area. See Cambarus (Puncticambarus) smilax, a new species of crayfish (Crustacea: Decapoda: Cambaridae) from the Greenbrier River basin of West Virginia, Zachary J. Loughman, Thomas P. Simon and Stuart A. Welsh, from Proceedings of the Biological Society of Washington, 124(2):99-111. 2011. This rare aquatic species is just one of many unusual fish and salamanders found in these watersheds which includes the hellbender (proposed for listing) and the candy darter. We believe that this timber project should not proceed as currently planned for all the reasons listed in this letter.
REQUEST FOR RELIEF

For the forgoing reasons, Appellant requests that the Forest Service:

1. Withdraw the Record of Decision for the Upper Greenbrier North Project.

2. If the Forest Service is determined to proceed with this project, Appellant requests that the agency prepare an Environmental Impact Statement to correct the inadequacies in the analysis discussed in the above Statement of Reasons, and provide legal notice and the opportunity for public review and comment under NEPA before making another decision on this project.

3. Appellants request that the MNF prepare the required Response to Comments in response to the substantive issues we have raised.

4. Appellant requests a stay of the Record of Decision for the duration of this appeal and for any other period appropriate under 36 C.F.R. § 215.

5. Appellant Requests that the Monongahela National Forest amend the Forest Plan to set new standards and guides for the Indiana bats due to the negative effects by white nose syndrome through a Section 7 consultation with the Fish and Wildlife Service. This must be completed before the site specific consultation for UGN which would be based on the amended Forest Plan and new bat surveys both acoustic and mist net surveys.
APPENDICES


II. Federal Register 1-9-13 Draft Protocol for Indiana bat Surveys Announcement of Request for Comments


IV. Weigl, Dr.Peter 2007 The Northern Flying Squirrel (Glaucomys Sabrinus): A Conservation Challenge

V. University of Wisconsin Study of Geomyces destructans the fungus that causes White Nose Syndromes found it surviving in bat cave soils when bats are absent. Research by Jeff Lorch and David Blehert.
APPENDICES

A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats

May 2011
Agency Representation in Plan Preparation

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Forest Service

U.S. Department of Defense
Department of the Army - Corps of Engineers

U.S. Department of the Interior
Bureau of Land Management
Fish and Wildlife Service
Geological Survey
National Park Service

St. Regis Mohawk Tribe

Association of Fish and Wildlife Agencies
Kentucky Department of Fish and Wildlife Resources
Missouri Department of Conservation
New York State Department of Environmental Conservation
Pennsylvania Game Commission
Vermont Department of Fish and Wildlife
Virginia Department of Game and Inland Fisheries
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I. INTRODUCTION
White-nose syndrome (WNS) is a disease responsible for unprecedented mortality in hibernating bats in the northeastern U.S. This previously unrecognized disease has spread very rapidly since its discovery in January 2007, and poses a considerable threat to hibernating bats throughout North America. As WNS spreads, the challenges for understanding and managing the disease continue to increase. Given the escalating complexity of these challenges, a highly coordinated effort is required for State, Federal, and Tribal wildlife agencies, and private partners to respond effectively to WNS and conserve species of bats. The plan proposed herein details the elements that are critical to the investigation and management of WNS, identifies key action items to address stated goals, and outlines the role(s) of agencies and entities involved in this continental effort.

Background
White-nose syndrome was first observed in four caves centered roughly 30 km west of Albany, New York, in the winter of 2006/2007. Photographs subsequently emerged of apparently affected bats in nearby Howes Cave, New York, taken during the previous winter, providing the earliest evidence of the disease. Counts at winter colonies of all 6 hibernating bat species in New York revealed that populations had been stable or increasing in recent decades, prior to the arrival of WNS. Whereas the effects of WNS appear to vary between species and winter hibernation sites (“hibernacula”), overall colony losses at the most closely monitored sites have reached 95 percent within 2 to 3 years of initial detection. As of April 2011, WNS has been detected in 6 of the 9 species of hibernating bats that occur in the affected region (Connecticut, Delaware, Indiana, Kentucky, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and the Canadian provinces: New Brunswick, Nova Scotia, Ontario, and Quebec). Species known to be susceptible to WNS thus far are the little brown bat (*Myotis lucifugus*), Indiana bat (*M. sodalis*), northern long-eared bat (*M. septentrionalis*), eastern small-footed bat (*M. leibii*), tricolored bat (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus*). Three additional bat species were found in 2010 that tested positive for the presence of *Geomyces destructans*, the fungus associated with WNS, but not with the pathological invasion of the skin that is characteristic of the disease. These bats, the gray bat (*M. grisescens*), the cave myotis (*M. velifer*), and the southeastern myotis (*M. austroriparius*), were found in Missouri, Oklahoma, and Virginia, respectively, and their discovery could portend the spread of WNS into new regions of the southeastern and western U.S., and beyond, in the near future. The disease appears to affect bats most during long torpor bouts characteristic of winter hibernation. Therefore, bat species that use hibernation as a strategy for surviving the winter months, collectively called the “cave bats,” are most notably affected. It is currently not known if WNS is causing mortality in bats that use torpor during winter but do not regularly occur in caves and mines, such as the so-called migratory “tree bats” (for example, silver-haired bats [*Lasionycteris noctivagans*], hoary bats [*Lasiurus cinereus*], eastern red bats [*Lasiurus borealis*]).
The rapid and widespread mortality associated with WNS is unprecedented in hibernating bats; moreover, epizootic disease outbreaks such as WNS have not previously been documented in bats. Like other top mammalian predators, such as polar bear (*Ursus marinus*), sea otter (*Enhydra lutris*), and gray wolf (*Canis lupus*), most of the affected bat species are long lived (~5 to 15 years or more); hibernating bats typically only have one offspring per year, and population growth depends on high rates of adult survival. Therefore, naturally low reproductive rates combined with the high mortality observed in populations with WNS will likely prevent affected bat populations from recovering quickly.

White-nose syndrome was named for the visible presence of a white fungus around the muzzles, ears, and wing membranes of affected bats. Scientists recently identified a previously unknown species of cold-loving fungus (*G. destructans*) as a consistent pathogen causing skin infection in bats at affected sites. This fungus thrives in low temperatures (5-14º C; 40-55º F) and high levels of humidity (>90 %), conditions characteristic of many bat hibernacula. Pathologic findings thus far indicate that such fungal infections can be detected as early as October, and it is hypothesized that bats affected by WNS arouse from hibernation more frequently, and/or for longer periods than normal, and are prematurely expending the fat reserves they rely on for winter survival. Chronic disturbance of hibernating bats has been known to cause high rates of winter mortality through fat loss, and aberrant behaviors associated with WNS may cause bats to consume critical fat reserves prematurely during winter. Aberrant behaviors observed at sites affected by WNS include shifts of large numbers of bats in hibernacula to locations near the entrances or unusually cold areas; large numbers of bats dispersing during the day from hibernacula, even during mid-winter; a general unresponsiveness to human disturbance; and, on occasion, large numbers of fatalities, either inside the hibernacula, near the entrance, or in the immediate vicinity of the entrance. Additionally, recent hypotheses suggest that the characteristic wing pathology associated with WNS may cause death by disruption of important wing-dependent physiological functions, such as water balance, thermoregulation and mechanical function of the wing leading to dehydration, increased thirst-mediated arousals, increased heat loss, and inhibition of flight. Although evidence indicates that skin infection by *G. destructans* is the plausible primary cause of mortality associated with WNS, the exact processes by which skin infection leads to death remain undetermined, and it is unclear the extent to which other conditions may contribute to susceptibility of species or individuals to fungal infection and/or mortality.

For the purpose of implementing elements of this plan, WNS will be defined as Suspect when *G. destructans* DNA or characteristic conidia morphology is detected on bats in the absence of histopathologic evidence, or when field signs associated with WNS are observed in winter bat populations within a previously confirmed WNS affected state but diagnostic tests were either negative or not performed. WNS will be defined as Confirmed Positive upon histopathological characterization of skin invasion typical of *G. destructans* infection. Furthermore, a hibernaculum or area will be considered to be Infected if it is associated with bats that are either suspect or confirmed positive for WNS.

**Ecological Significance**

More than half of the 45 species of bats that occur in the U.S. rely on hibernation as a primary strategy for surviving the winter, when insect prey are not available. All four endangered species and subspecies of hibernating bats in the continental U.S. rely on undisturbed caves or mines for successful hibernation, and are at potential risk from WNS. Three of these species (Indiana, gray, and Virginia big-eared bat [*Corynorhinus townsendii virginianus*]) are currently within the affected area, and the remaining subspecies (Ozark big-eared bat [*C. t. ingens*]) will likely be at risk soon. Although the potential for WNS to continue to spread is currently unknown, the implications of its undermining the survival strategy of so many bat species are considerable. We are just beginning to appreciate the roles bats play in North American ecosystems, and the impact of WNS on bat populations has the potential to greatly impact ecosystem function. Considerable...
and abrupt reductions in predation pressure on insect populations, for example, could lead to increased numbers of insect pests resulting in damage to forests and agriculture, higher loads of environmental pesticides, and/or potential public health risks associated with zoonotic disease or chemical contact. As the major contributor of nutrients into many cave systems, mainly in the form of guano, bats are also an integral part of cave and karst ecosystems. The loss of bats could also, therefore, disrupt cave ecosystems and put many rare and unique cave fauna in jeopardy.

The Planning Process

Why a National Plan?
The mobility of bats, the rapid spread of WNS, the potential for human-assisted transmission, and the severity of the consequences make it imperative that a national effort on multiple scales be mounted to avert irreversible losses to bat populations, and associated ecological impacts, throughout North America. It is anticipated that WNS will continue spreading to surrounding states, and the potential exists for outbreaks due to human activities in states distant to the currently affected area.

State, Federal, and Tribal wildlife and land management agencies have statutory and regulatory authorities for managing trust wildlife species and their habitats. In exercising these authorities, agencies must comply with applicable laws. For example, Federal agencies must comply with the National Environmental Policy Act, the Endangered Species Act, and the Federal Cave Resources Protection Act, among other laws. Some of these laws provide alternative procedures to address emergency situations. The implementation of a national plan will assist State, Federal, and Tribal agencies, as well as local governments, in exercising their authorities for managing bats threatened by WNS and complying with all applicable laws. The implementation of a national plan will also help to standardize management practices, including disease surveillance and bat population monitoring, to ensure consistency in data collection and to facilitate the interpretation of results.

There is already a history of State-Federal collaboration in addressing the many challenges posed by WNS, which pre-date the formal requests for assistance made by State agents in the northeastern United States to the U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey (USGS) in the winter of 2007/2008. It is incumbent upon wildlife management agencies to advise and consult, as appropriate, with non-government organizations and those in the scientific community with appropriate expertise and authorities to assist in mitigating this threat. Further, this collaboration should extend internationally because the risk of WNS extends across borders and these insectivorous bats are a North American resource. A national plan will serve to facilitate this collaboration.

Origin and Intent of the Plan
In June 2008, an effort to formalize a coordinated approach for addressing WNS was initiated among Department of Interior, Department of Agriculture, Department of Defense (DoD), and State wildlife management agencies. More recently, a national plan steering committee was formed to ensure that Federal and State agencies coordinate and cooperate in the development and implementation of an effective national response to the disease. This plan is a product of the steering committee; it is a framework that outlines the actions necessary to coordinate Federal and State efforts and identifies actions in support of State, Federal, Tribal, and partner WNS management efforts. While the framework presented in this plan (the base plan) will mostly remain static, the implementation of the elements detailed herein is intended to be an adaptive process, requiring continual modification of assorted strategies and guidance as new information becomes available. Working groups will be responsible for developing and maintaining the various components of the action plans identified for each element of the national plan. The resulting implementation plan, because of its adaptive nature, will therefore be an evolving system rather than a static document.
**Implementing the Plan**

State and Tribal agencies will largely be responsible for implementing surveillance, population monitoring, and disease management programs at the local level, based on national guidance provided by the working groups. The primary Federal role will be to provide cross-border coordination and assistance with research, surveillance, disease management, diagnostic testing, communications, information dissemination, education, and funding for State WNS programs. Federal land management agencies such as the National Park Service, U.S. Forest Service, Bureau of Land Management, National Wildlife Refuge System (USFWS), and DoD also will provide guidance and policy for addressing WNS in relation to planning and managing Federal lands under their respective jurisdictions. Federal agencies will provide tools and financial assistance, when available, to States, and help develop standardized approaches to WNS control and mitigation.

While we have gained considerable knowledge regarding WNS and the presumed etiology, there are still large gaps in our understanding. Despite this, general principles of epidemiology, ecology, and conservation biology will continue to be applied, along with expert opinion, to inform the actions outlined in this plan. As our knowledge and understanding of WNS improves, plans will be modified and adapted accordingly to ensure that the best available science is applied to addressing this issue.

The development of coordinated, science-based, response plans, tiered from the national plan but tailored individually to meet the WNS-related needs of discrete State, Tribal, and Federal agencies, is also fundamental to the success of a national plan for managing WNS, and is encouraged. Ideally, such plans would consider the needs of all stakeholders and cover multiple jurisdictions, especially when jurisdictions share an affected population. Response plans should follow a standard outline of basic components that include objectives, management tools, management of contaminated environments, results monitoring, restoration plans, and budget. Response plans will form the basis for funding, public responsibility and accountability, and measuring results. Because such coordinated response plans may be difficult to prepare in a short time frame, a process for immediate funding for initial response for newly identified outbreaks should also be made available, as well as for preparation and education in currently unaffected areas.

WNS response plans will vary depending upon such factors as length of time the disease has been present, affected species, population density, location, resources, and human dynamics. States and other entities may use different strategies in response to different combinations of these factors. One of the key challenges is to learn as quickly as possible the safety and efficacy of control or disease mitigation strategies. As research knowledge provides new diagnostic, monitoring, and management tools, the challenge will be to continually adapt and improve WNS management strategies. Oversight committees will be convened as part of the implementation strategy, composed of representatives from State, Federal, and Tribal agencies, to assist with the coordinated execution of efforts to manage WNS at the national and local level. The organizational structure of the groups and committees engaged in the national response to WNS will be made available in the forthcoming implementation plan.

**II. WNS RESPONSE STRATEGY**

**Human Health Implications**

There is no evidence at this time that *G. destructans* is pathogenic to humans, therefore the direct human health risk from WNS appears to be low. Because *G. destructans* only grows at cool temperatures (5-20º C; 40-68° F), considerably lower than those of the human body, it is unlikely to cause infection in humans. No human illnesses to date have been associated with contact or exposure to WNS-infected bats or caves. Many WNS-infected bats exhibit unusual behavior and may be found in large numbers in locations not normally inhabited by bats; contact with bats, particularly in these settings, should be avoided since bats are potential sources for other human diseases including rabies, histoplasmosis, and ammonia
toxicity. People handling bats or entering their roosts should use safe work practices and personal protective equipment to minimize exposure to infectious or toxic agents. Additional research will be necessary to further explore potential human health risks associated with WNS.

**General Practices**

Our current understanding of the etiology of WNS is incomplete; however, *G. destructans*, the fungus known to cause the skin infection that is the hallmark of WNS, continues to be the common link among infected animals. Even in the face of incomplete information, general epidemiological principles must be used to inform the WNS investigation and response. To cite an historical, human health example, in the mid-1800s, germ theory was not widely accepted and diseases were believed to be caused by miasma, i.e., bad air. Applying modern principles of epidemiology to a major cholera epidemic in 19th century London, physician John Snow surmised that the source of the outbreak was, in fact, contaminated well water. Even though it would not be known until many years later that cholera is caused by a bacterium (*Vibrio cholerae*), disabling the contaminated well by simply removing the pump handle was enough to end the outbreak. Concerning a much more recent analogue to WNS, it took more than a decade to discover that the cause of the now-global amphibian disease chytridiomycosis was the exotic fungal pathogen, *Batrachochytrium dendrobatidis* (*Bd*). The institution of rigorous widespread precautions during the early years of the chytridiomycosis outbreak might have served to limit the spread of *Bd* and bought valuable time to institute conservation measures.

All available evidence indicates that WNS is caused by an infectious agent, and therefore can potentially be spread by all known modes of disease transmission, including direct contact, inhalation, ingestion, fomites (inanimate objects), and human or animal vectors. Wildlife diseases such as WNS spread rapidly when there is high prevalence of pathogen(s), efficient chains of transmission, abundant susceptible hosts, and/or environments that allow pathogen persistence without a host. Regardless of the nature of the infectious agent (fungus, bacterium, or virus), universal precautions should be implemented to reduce incidence of disease by both preventing infections and breaking chains of transmission. Research is underway to improve our understanding of what are believed to be the primary vectors for WNS, namely bat movement and contact with infected bats and environments. Adherence to the following actions/measures is considered to be prudent for combating the spread of WNS through human-assisted means, however, because humans are potentially capable of transmitting the disease great distances in a short amount of time. These recommendations can generally be applied in field situations with reasonable modifications and proper training:

1. Avoiding direct contact with bats, contaminated objects (fomites) or environments, and body fluids;
2. Wearing barriers (e.g., gloves, coveralls, etc.) when contact with bats is necessary or expected (single-use items are recommended);
3. Carefully handling, cleaning, and disinfecting all potentially contaminated fomites and vehicles between instances of contact with animals and/or movement between field locations;
4. Observing proper technique during sample collection for genetic or microbiological analyses (e.g., wing punch biopsies);
5. Promoting the concept that prevention of transmission requires constant personal surveillance;
6. Maintaining vigilance within the research, wildlife management, and caving communities;
7. Adhering to basic hygiene practices that are known to minimize the spread of infectious agents, as per the most current decontamination protocol for WNS;
8. Increasing public awareness and education.

Decontamination protocols specific to WNS have been developed and will continue to be revised to incorporate the best available information. All current protocols will be available at the WNS website maintained by USFWS, currently: [http://www.fws.gov/WhiteNoseSyndrome](http://www.fws.gov/WhiteNoseSyndrome).
Elements of the National Plan
The steering committee for the WNS national plan identified seven elements to be addressed by the plan; each will be administered by a working group responsible for the coordination of activities within that element. Working groups will be populated based on individual expertise and not on agency or organizational representation. Therefore, working groups will be open to qualified individuals, regardless of affiliation or nationality. Each working group will designate one leader who will oversee and coordinate the activities within that group. All working group leaders will also serve on an oversight team to coordinate activities and ensure communication between the working groups. This role is of particular importance given the complementary objectives of several groups and the need for collaboration to avoid duplicative efforts between elements.

The seven elements of the national plan are:

A. Communications
B. Data and Technical Information Management
C. Diagnostics
D. Disease Management
E. Epidemiological and Ecological Research
F. Disease Surveillance
G. Conservation and Recovery

A. Communications and Outreach Working Group: The purpose of this group is to develop and implement an effective plan for communicating information about
WNS to partners involved in the WNS investigation, to affected landowners and stakeholders, and to the public. The goals and actions outlined in this document provide the basis for a detailed national communications implementation plan.

B. Data and Technical Information Management Working Group: The purpose of this group is to provide a mechanism for making WNS information accessible in a timely fashion to all State, Tribal, and Federal agencies and others involved with the investigation and management of WNS. The primary goal of this group is to disseminate information about WNS by providing access to common scientific and technical information in a partner-based data system; working with States to create data standards that will allow interoperability with existing WNS data sets; providing researchers and wildlife managers with near real-time access to WNS data and other critical information; and, ultimately, integrating WNS data from State and Federal agencies and others into a more structured national database.

C. Diagnostics Working Group: The purpose of this group is to establish standards on how laboratories are to conduct and interpret WNS testing so that results are accurate and comparable between laboratories; identify current laboratory capacity for processing WNS samples and project the capacity needed to support effective WNS management programs; provide timely reporting of diagnostic results to resource agencies responsible for management decisions; and support WNS research.

D. Disease Management Working Group: The purpose of this group is to identify a range of alternatives and best practices to prevent the introduction of WNS into new areas, prevent or slow the spread of WNS to WNS-free sites within infected areas, and attain sufficient control of the disease in affected areas so that genetic and regional diversity and the potential for recovery to pre-WNS abundance is maintained; secure the future of bats while avoiding unacceptable risks to other cave-obligate biota and natural systems; and collaborate with public health officials to establish whether a human health threat is associated with WNS and determine a course of action if the WNS agent poses such a threat.

E. Epidemiological and Ecological Research Working Group: The purpose of this group is to identify critical ongoing research needs relating to the origin, transmission, pathogenesis, and impact of WNS on bats and the environment. Research to inform management actions will be a priority; therefore, approaches that recognize the synergy between research and management will be emphasized to maximize the potential to achieve optimal results.

F. Disease Surveillance Working Group: The purpose of this group is to develop standards for WNS surveillance in affected and non-affected areas, and describe best practices and techniques for surveillance strategies. The goal of this group is, therefore, to provide a framework for consistent, coordinated WNS surveillance, focusing on early detection of the expansion of WNS or newly established epicenters and providing data on the progression of WNS within an affected hibernating colony.

G. Conservation and Recovery Working Group: The purpose of this group is to develop standards for determining if and when to monitor populations of bat species that are affected by WNS or *G. destructans*; establish criteria for prioritizing conservation and management activities; and describe best practices and techniques for the recovery of bat populations of greatest conservation concern. Additionally, this group will provide guidance on collection of baseline data for areas still unaffected by WNS, such as conducting a statewide accounting of caves and mines.
III. ACTION PLANS

This section of the plan presents brief treatments for each plan element, providing additional background information and outlining the goals and currently defined actions of each working group. Element sections are divided into two components:

1. Overview
2. Goals and Action Items

A. Communications and Outreach:

A.1. Overview

A rapid and integrated internal and external flow of information is critical to addressing WNS. An organized national program of information dissemination about WNS and affected bat populations will enable those involved in the WNS research, monitoring, surveillance, management, and communication effort to work together. Providing the public with information about WNS and its effects builds public support and engagement for the effort. Mechanisms for information flow differ among audiences. The following goals and actions will guide the development of a communications plan that will facilitate information flow to three broad audiences:

1. The WNS investigative community (team) includes Federal and State agencies, Tribes, international government partners, and cooperating non-government research scientists, institutions, organizations, and individuals who are directly involved with WNS research, monitoring, surveillance, management, and communications.

2. Internal audiences include employees of Federal and State agencies, Tribes, and international government partners not directly involved with the WNS investigation.

3. External audiences include non-government research scientists and institutions, non-government organizations, elected officials (State and Federal), private land managers, decision-makers, private industry, relevant stakeholders, news media, and the public.

A.2. Goals and Action Items

Goal 1: Communicate research, monitoring, surveillance, management, and conservation activities among the WNS investigative team to facilitate an effective response to WNS.

Actions: (1) Finalize an organizational chart to ensure that coordination and flow of communication are clearly defined among the WNS investigative team.

(2) Designate points of contact for each working group identified in the organizational chart to work with the WNS investigative team on a broad range of communications issues, including when and how proprietary data would be shared among team members.

(3) Develop a communications toolbox for the WNS investigative team.

(4) Communicate about activities and distribute products to the WNS investigative team in a timely manner.

(5) Develop tools for public reporting and commentary to inform the WNS investigative team.

(6) Maintain a centralized list of relevant literature in coordination with all working groups.

Goal 2: Communicate about WNS as an unprecedented wildlife disease event resulting in devastating consequences, spreading at an alarming rate, and with no obvious means of curtailment.

Actions: (1) Disseminate information that is responsive to a broad range of frequently asked questions regarding WNS.

(2) Create, deliver, and update products that can be customized to convey key information about WNS and the actions being taken to respond to it.
Goal 3: Communicate about the importance of bats to people, ecosystems, biodiversity, and economies.

**Actions:**
1. Disseminate information that is responsive to a broad range of frequently asked questions regarding the importance of bats.
2. Create, deliver, and update products that can be customized to convey the key information about the importance of bats.

Goal 4: Communicate about the efforts of the partner agencies and organizations involved in the WNS investigation to control and manage WNS.

**Actions:**
1. Disseminate information that is responsive to a broad range of frequently asked questions about the collaborative effort to control and manage WNS.
2. Create, deliver, and update products that can be customized to convey key information about the collaborative effort to control and manage WNS.
3. Distribute the recommended practices and procedures to minimize the spread of WNS to all audiences.
4. Publish contact information for key WNS investigation team members and State/Federal WNS points of contact.

B. Data and Technical Information Management:

B.1. Overview

Management and dissemination of scientific and technical information is critical to States, Federal agencies, Tribes, and other groups involved in the investigation and management of WNS. Although these entities will collect important data for their own use, there will be significant opportunities for resource sharing as well as assistance for data management and transfer, allowing analyses to be conducted on a continental basis. The creation of uniform standards for data collection and transfer will facilitate research and management of WNS. A unified system will allow economies of scale for the proposed activities to be undertaken at a national level. A strategy to effectively incorporate national data standards with existing local data systems and newly developing systems will enhance efficiency and the effectiveness of data management at multiple scales. Further, data and information from all parties will be securely handled to assure appropriate intellectual property rights and confidentiality, as required by the Federal Cave Resource Protection Act and other authorities.

A secure, Internet-based WNS database will be established to effectively accomplish the efforts outlined in this plan. The WNS database(s) will be designed to provide timely access to biological data and geospatial information specific to the investigation and monitoring of WNS. Planning for the implementation of an initial stage of such a database, with focus on cataloging all available bat specimens, is currently underway with the USGS Fort Collins Science Center. This database will be modified as needed and when resources are available. The majority of data to be incorporated in the WNS database will be provided by State and Federal agency biologists, with additional information coming from private and academic partners. The database is intended to explicitly support researchers and managers in addressing WNS data needs, and will allow State and Federal agencies, Tribes, and the public to obtain near real-time data on WNS.

B.2. Goals and Action Items

**Goal 1:** Provide a database system that can be used by all State, Federal, and Tribal agencies, and serve as a central repository for nationwide analyses and specific projects.

**Actions:**
1. Establish or utilize an existing robust database that can accommodate test results as well as monitoring and surveillance data from State, Federal, and Tribal agencies.
2. Develop a data import system to allow State and Federal agencies to enter their current and archival data.
(3) Develop data collection and management standards in cooperation with State and Federal agencies.
(4) Develop a certification and quality control system.
(5) Provide States with a system for tracking WNS samples from collection through laboratory testing.
(6) Create data-sharing agreements that will allow inter-operability with existing WNS data and among stakeholders, while providing confidentiality of data to data providers as needed.

Goal 2: Integrate WNS data from State, Tribal, and Federal agencies, land managers, and other sources into a centralized system.

Actions: (1) Conduct a thorough literature review focusing on WNS.
(2) Assemble information on biology and management of bats and other wildlife species at risk for developing WNS.
(3) Collect and assemble State, Federal, and other pertinent bat and WNS-related data.
(4) Create a Web-based system that will integrate information collected above.
(5) Catalog and provide internet links to WNS information resources maintained by Federal, State, and non-government organizations, including scientific libraries.

C. Diagnostics:

C.1. Overview
Accurate, reliable diagnosis of the presence of G. destructans and WNS in bats is a foundation for sound, effective disease management decisions by resource agencies. This requires laboratory capacity sufficient to run a meaningful number of standardized assays relative to the sampled population, in a useful timeframe. Primary diagnostic priorities include detecting WNS in new species, new states, and at biologically significant sites that may harbor threatened or endangered bat species or experience significant human visitation. Secondary diagnostic priorities include supporting research and surveillance at previously confirmed WNS-positive locations. Group membership should consist of representatives from Federal, State, academic, and/or private laboratories with a minimum of BSL-2 (biosafety level) status demonstrating a willingness to test samples and report WNS status results, following established, peer-reviewed methods endorsed by the network of WNS diagnostic laboratories.

C.2. Goals and Action Items

Goal 1: Develop consensus standards for WNS testing and interpretation.
Action: Make WNS diagnostic assays available through peer-reviewed publications, protocol summaries, workshops/conferences, and on-site training. This information would be available internationally. Communication among participating laboratories assures consistent assay application, interpretation, and diagnoses.

Goal 2: Establish sufficient laboratory testing capacity.
Actions: (1) Assess laboratories currently involved in WNS diagnostics for sample processing capacity by the various assay methods (histology, PCR, fungal culture, light microscopy).
(2) Survey resource agencies for their projected short-term and long-term WNS diagnostic needs.
(3) Assist agencies in identifying suitable diagnostic laboratories to help meet their disease-management needs.
(4) Assess funding requirements based on the projected diagnostic needs of resource agencies.

Goal 3: Assure quality of sample submissions and comparable results among participating diagnostic laboratories.
Actions: (1) Provide training and/or descriptions of ideal sample quality and storage requirements needed for the available WNS assays to resource agencies for distribution to field biologists to ensure
suitable sample submissions for diagnostic evaluation.
(2) Provide case definitions for suspected and confirmed cases of WNS, and classification criteria of contaminated hibernacula.

Goal 4: Assist with timely reporting of WNS testing results to inform the appropriate resource management agencies for release to the broader WNS community.

Action: Work with the Data and Technical Information Management Group to develop a secure, centralized database for tracking sample results and disease progression.

Goal 5: Support WNS research such as epidemiology, treatment/management options, improved diagnostic assay development, etc.

Actions: (1) Critically review current knowledge of WNS diagnosis to identify knowledge gaps and research needs.
(2) Prioritize diagnostic research needs to fill identified knowledge gaps and determine funding requirements.
(3) Help coordinate laboratory assistance with federally and state-funded WNS research projects requiring sample testing, and ensure that sufficient funding is allocated to support participating laboratories beyond their primary diagnostic priorities.

D. Disease Management:

D.1. Overview

Disease management is composed of three complementary goals: to identify and implement science-based management actions to slow the expansion of WNS in order to delay, for as long as possible, the impacts of the disease reaching unaffected regions of the continent; to develop and employ interventional strategies to the disease that will ensure the perpetuation of susceptible bat species, and that will provide the best opportunities for their recovery to pre-WNS numbers in affected regions; and to ensure that implemented actions will not be detrimental to bat populations or have unacceptable effects on the ecosystems in which they are found. This work is in its infancy and most of the questions critical to its success have not yet been resolved. There are, as yet, no proven applications that address any of the challenges presented below, and it is unclear whether the objectives detailed below are obtainable. This group will assist State, Federal, and Tribal agencies in determining the goals of management actions taken and the most feasible management tools that can be applied.

Monitoring the effectiveness of management actions will be critical to achieving the goals outlined below. Successful coordination and monitoring of all management actions will maximize our potential to learn from them and allow managers to employ adaptive management principles to refine research and management priorities. It will be important to develop and/or maintain the necessary capacity within State agencies to support the implementation of these disease management objectives.

D.2. Goals and Action Items

Goal 1: Critically review current knowledge of WNS disease management to identify knowledge gaps and research needs.

Actions: (1) Solicit expert review of previous and current research projects and identify knowledge gaps.
(2) Identify priority research questions and capacity not currently being addressed in the investigation of WNS, including human dimensions.
(3) Identify high-priority laboratory and field activities needed to support research priorities.

Goal 2: Reduce the risk of WNS transmission by humans.

Actions: (1) Identify the mechanisms for WNS transmission by humans to
environment to bats.  

(2) Provide guidance on regulation or restriction of human actions that are likely to pose a risk for spreading WNS.

(a) Develop standards for restricting use of potentially contaminated gear (both caving and bat research) at unaffected sites or regions.
(b) Manage cave access to minimize transmission risk.
(c) Work with cave owners to implement operating guidelines for commercial caves.
(d) Modify mist netting and harp trapping protocol/techniques.
(e) Investigate the potential risks of commercial trafficking of bat guano to the spread of WNS.

(3) Develop, implement, and where possible, enforce decontamination/disinfection protocols to guard against human-assisted transmission of WNS to new sites or animals.

Goal 3: Reduce inter-/intra-specific transmission and disease spread.  

**Actions:** (1) Investigate bat-to-bat transmission of WNS.

(a) Identify prevalence/distribution of infected animals within hibernacula/clusters.
(b) Develop techniques for identifying infected animals (photo/thermography).
(c) Determine effectiveness of in situ management actions (e.g., removal of infected and adjacent individuals, temporary barriers to infected substrates, etc.).
(d) Investigate the potential for tree bats to serve as carriers of G. destructans.

Goal 4: Reduce environmental transmission to and from bats.  

**Actions:** (1) Investigate WNS transmission from environment-to-bat.

(2) Develop environmental decontamination techniques.

Goal 5: Eliminate *G. destructans* from infected individuals.  

**Actions:** (1) Investigate means of *G. destructans* control that are effective and safe for the bats.

(a) Identify chemical control treatments for *G. destructans*.
(b) Identify biological control treatments for *G. destructans*.
(c) Identify effective environmental manipulations to reduce or eliminate *G. destructans* from affected bats or sites.
(d) Identify effective bat exclusion/inclusion of infected sites/uninfected sites.

(2) Reduce disturbance-related mortality associated with disease management activities.

Goal 6: Identify and limit adverse ecological impacts of management actions, including decontamination techniques, to acceptable limits.  

**Actions:** (1) When appropriate, research the need for, conduct, and/or support human dimensions inquiries to define acceptable limits for ecological impacts.

(2) Monitor management action outcomes and use adaptive management iterations to improve results, in light of potential ecosystem impacts.

E. Epidemiological and Ecological Research  

E.1. Overview  

Although State, Federal, academic, and non-government organization researchers have worked collaboratively to increase understanding of WNS since its discovery, there are significant knowledge gaps regarding the fundamental dynamics and ecology of this disease. These gaps impede the development of plans to control and mitigate the disease, because effective management requires an understanding of the interactions among the disease, its host(s), and the environment. This
This section identifies priority research areas in which progress must be made in order to better understand and respond to the threat of WNS. Key to managing this disease will be the guiding principle that research must primarily address management needs, and that basic research results should be applied to adaptive management decisions.

Research is still needed on relevant aspects of bat ecology and behavior, diagnostic methods, etiology, pathology, epidemiology of the disease, presence and persistence of the causative agent in the environment, risks posed to other species and environments, genetics of cave fungi, host immune response, limits of pathogen survival, mode of mortality, bat population structure, and differential susceptibility. This research will be conducted through partnerships among academic entities, non-government organizations, and State and Federal agencies. New information may shift priorities and reveal new areas of investigation. Therefore, an effective process for coordinating research is also required.

E.2. Goals and Action Items

Goal 1: Critically review current knowledge of epidemiology and ecology of WNS to identify knowledge gaps and research needs.

*Actions:* (1) Solicit expert review of previous and current research projects and identify knowledge gaps.
(2) Identify priority research questions and capacity not currently being addressed in the investigation of WNS.
(3) Identify high-priority laboratory and field activities needed to support research priorities.

Goal 2: Establish disease etiology.

*Actions:* (1) Investigate the role of *G. destructans* as the likely primary causal agent of WNS, and increase our understanding of other potential contributing factors.
(2) Investigate the origins and evolution of *G. destructans*.
(3) Continue to consider evidence for other potential synergistic, predisposing, and/or causative agents for the suite of WNS signs observed in bats.

Goal 3: Enhance understanding of WNS pathogenesis.

*Actions:* (1) Investigate the life cycle of *G. destructans*, including optimum environmental growth/viability conditions.
(2) Identify the mechanisms of transmission and infection of *G. destructans*.
(3) Investigate species differences in pathogenesis and susceptibility.
(4) Investigate whether other animal taxa are associated with WNS epidemiology.

Goal 4: Understand interactions of pathogen, host ecology, and environment.

*Actions:* (1) Obtain basic epidemiological information (e.g., distribution, prevalence, incidence, case-fatality rates).
(2) Investigate critical control points in WNS dynamics.
(3) Collect baseline information on species presence, population sizes, and hibernacula in unaffected areas.
(4) Collect information on other biota at affected and unaffected hibernacula.
(5) Continue long-term monitoring efforts in affected areas to identify changes over time in disease infection, mortality, and population demography.
(6) Design and implement studies to identify and parameterize variables for disease models of transmission routes and rates, as well as species-specific infection, mortality, and carrier rates, and the impact(s) of bat density and species composition.
(7) Identify and employ appropriate disease models to evaluate and predict the spread and impact of WNS.
Goal 5: Evaluate the ecological and economic consequences of WNS.

Action: Assess the ecological impacts that result from the dramatic loss of insectivorous bat populations, with an emphasis on impacts to forestry, agriculture, public health, and cave ecosystems.

F. Disease Surveillance:

F.1. Overview
Individual States will likely have different priorities and capabilities due to their geographic location, the bat species present, land ownership, and the influence of other local factors; however, the coordination of agency disease surveillance efforts will be necessary to effectively combat WNS. These efforts will focus primarily on the detection of WNS in bats. The overarching goal of this group is to provide a framework for consistent, coordinated WNS surveillance, focusing on early detection of the expansion of WNS or newly established epicenters and providing data on the progression of WNS within an affected hibernating colony. Given the critical role that States will play in WNS surveillance, it is necessary to ensure that State agencies have the capacity to implement a surveillance plan.

F.2. Goals and Action Items
Goal: Create a coordinated disease surveillance program nationwide that identifies and minimizes disturbance to bats and potential transmission risks while still enhancing early detection.

Actions: (1) Develop and provide recommendations for coordinated disease surveillance.
(a) In known WNS-affected areas, bat populations should
be monitored to assess disease progression and effects of management actions.
(b) In areas outside the WNS-affected region, surveillance should provide early detection of WNS, expansion from affected areas, and new foci of WNS.
(c) In all areas, surveillance should provide early detection of WNS in threatened and endangered and previously unaffected species.

(2) Develop effective surveillance strategies based on disease risk and assist with implementation.
(a) Provide guidance for prioritizing sites.
(b) Determine appropriate sampling frames and sample sizes required to meet surveillance objectives.
(3) Integrate surveillance efforts with those of other WNS working groups.

G. Conservation and Recovery (of Affected Bat Species):

G.1. Overview
Populations of several species of bats are declining because of WNS. Because species affected by WNS range across State and international boundaries, conservation and recovery efforts need to be closely coordinated to be effective.

Monitoring WNS-affected bat populations is necessary to determine which species may be at risk of local extirpations and extinction due to WNS, and where conservation and management activities would be most effective. Coordination will be critical to this effort as dramatic losses from WNS, and possibly other sources, can rapidly affect the conservation status of impacted populations. Population monitoring differs from WNS surveillance in that it concerns the status of entire species or genetically important populations, rather than the distribution and dynamics of the disease.

Until the threat of WNS has passed or has been mitigated, best practices are needed for the maintenance and recovery of bat populations of greatest conservation concern.

G.2. Goals and Action Items
Goal 1: Develop and validate rapid-assessment monitoring plans to determine differences in susceptibility among species, and identify which species are most vulnerable to extinction due to WNS.
Actions: (1) Seek consensus on feasible monitoring techniques and protocols that will gauge impacts of WNS on bat species.
(2) Develop and implement monitoring plans to establish the degree to which different species of bats are vulnerable to WNS.
(3) Establish best practices for population monitoring on a range-wide scale for species of greatest conservation concern.

Goal 2: Establish criteria for prioritizing conservation activities
Actions: (1) Develop criteria for determining which species affected by WNS warrant conservation action, which may include identifying proportions of populations affected or thresholds of population size at which conservation actions should be taken.
(2) Develop contingency plans for adapting conservation actions if populations of greatest conservation concern decline and approach the threshold of population viability (e.g., extirpation or extinction).

Goal 3: Determine best practices for maintaining and recovering populations
Actions: (1) Develop techniques and protocols for assessing and mitigating the population effects of WNS.
(2) Prioritize monitoring and recovery efforts based on analysis of
species vulnerability (E.2., Goal 3).

(3) Determine the feasibility and role for captive management for species of conservation concern. These actions could include translocation, temporary captivity, propagation, and cryopreservation.

(4) Protect or restore summer and winter habitat to ensure that quality habitat is available for bat populations before and after exposure to WNS.

(5) Should proven environmental treatments for WNS become available, establish methods for restoring hibernation sites to provide refuge for surviving and non-affected individuals.

(6) Identify previously occupied hibernacula and suitable but previously unused sites that warrant continued protection for bat recovery, and clearly identify a means of justifying such protection.

(7) Mitigate anthropogenic sources of mortality that have additional detrimental influences on bat populations.

Goal 4: Research most effective methods for monitoring, conserving, and recovering affected populations.

Actions: 

(1) Establish and maintain a list of prioritized research needs and work closely with other working groups to see that high-priority needs are communicated and/or addressed.

(2) Regularly assess monitoring, conservation, and recovery practices in light of new research findings, and refine when appropriate.
WNS National Plan Writing Team
Jeremy Coleman, Chair...... U.S. Fish and Wildlife Service
Anne Ballmann .................. U.S. Geological Survey
Les Benedict ..................... St. Regis Mohawk Tribe
Eric Britzke ..................... U.S. Army Corps of Engineers
Kevin Castle ..................... National Park Service
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II. **Federal Register 1-9-13 Draft Protocol for Indiana bat Surveys Announcement of Request for Comments**
Endangered and Threatened Wildlife and Plants; Draft Revised Indiana Bat Summer Survey Guidelines

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of availability; request for comments.

SUMMARY: We, the U.S. Fish and Wildlife Service (USFWS), announce the availability of our draft revised summer survey guidelines for the Indiana bat (Myotis sodalis) for public review and comment. The Indiana bat is federally listed as endangered under the Endangered Species Act of 1973, as amended (Act). The draft guidelines were prepared by representatives of the U.S. Department of Agriculture’s Forest Service, U.S. Department of Defense’s Army Corps of Engineers, U.S. Department of the Interior’s Geological Survey and USFWS, Kentucky Department of Fish and Wildlife Resources, New York State Department of Environmental Conservation, and the Indiana Department of Natural Resources. We request review and comment on our guidelines—along with acoustic identification software testing criteria our 2013 contingency plan—from local, State, and Federal agencies and the public.

DATES: Comments on the draft guidelines must be received on or before February 8, 2013.

ADDRESSES: Obtaining Documents: The draft survey guidelines, acoustic identification software testing criteria, and 2013 contingency plan are available at http://www.fws.gov/midwest/Endangered/mammals/inba/inbasummersurveyguidance.html. The documents are also available by request, by U.S. mail from the U.S. Fish and Wildlife Service, Ecological Services Field Office, 620 South Walker Street, Bloomington, IN 47403–2121; or by phone at 812–334–4261, x1216.

Submitting Comments: If you wish to comment on the documents, you may submit your comments in writing by any one of the following methods:

• U.S. mail: U.S. Fish and Wildlife Service, 620 South Walker Street, Bloomington, IN 47403–2121;
• Hand-delivery: Field Supervisor at the above U.S. mail address;
• Email: indiana_bat@fws.gov; or
• Fax: 812–334–4273. Include “Indiana Bat Summer Survey Guidelines” in the subject line of the facsimile transmittal.

DEPARTMENT OF THE INTERIOR

Background

The Act (16 U.S.C. 1531 et seq.) prohibits activities with endangered and threatened species unless a Federal permit allows such activity. Along with our implementing regulations in the Code of Federal Regulations (CFR) at 50 CFR 17, the Act provides for permits, and requires that we invite public comment before issuing these permits.

A permit granted by us under section 10(a)(1)(A) of the Act authorizes applicants to conduct activities with U.S. endangered or threatened species for scientific purposes, enhancement of propagation or survival, or interstate commerce (the latter only in the event that it facilitates scientific purposes or enhancement of propagation or survival). Our regulations implementing section 10(a)(1)(A) for these permits are found at 50 CFR 17.22 for endangered wildlife species, 50 CFR 17.32 for threatened wildlife species, 50 CFR 17.62 for endangered plant species, and 50 CFR 17.72 for threatened plant species.

Applications Available for Review and Comment

We invite local, State, and Federal agencies, and the public to comment on the following applications. Please refer to the appropriate permit number (e.g., Permit No. TE–123456) in the subject line of the message.

• U.S. Mail: Kris Olsen, Permit Coordinator, Ecological Services, U.S. Fish and Wildlife Service, P.O. Box 25486–DFC, Denver, CO 80225.
• In-Person Drop-off, Viewing, or Pickup: Call (303) 236–4256 to make an appointment during regular business hours at 134 Union Blvd., Suite 645, Lakewood, CO 80228.

FOR FURTHER INFORMATION CONTACT: Kris Olsen, Permit Coordinator Ecological Services, (303) 236–4256 (phone); permitsR6ES@fws.gov (email).

SUPPLEMENTARY INFORMATION:

Public Availability of Comments

All comments and materials we receive in response to this request will be available for public inspection, by appointment, during normal business hours at the address listed in the ADDRESSES section of this notice.

Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

Authority: We provide this notice under section 10 of the Act (16 U.S.C. 1531 et seq.)

Dated: January 2, 2013.

Michael G. Thabault, Assistant Regional Director, Mountain-Prairie Region.

[FR Doc. 2013–00133 Filed 1–8–13; 8:45 am]

BILLING CODE 4310–55–P
Background

The Indiana bat was originally listed as in danger of extinction under the Endangered Species Preservation Act of 1966. Summer survey guidelines (mist-netting protocols) were first developed for the species in the early 1990s and the USFWS provided revised mist-netting guidelines in our 2007 Draft Revised Recovery Plan. The USFWS recently convened a group of State and Federal agency representatives to revise existing survey guidelines. We solicited peer review through the bat working groups across the range of the Indiana bat between February and March 2012 and received comments from 57 individuals. Based upon comments received and the results of pilot testing of the survey guidelines at known Indiana bat maternity colonies in the summer of 2012, we offer the revised guidelines for public review and comment.

In addition to soliciting comments on draft survey guidelines for determining presence or probable absence of Indiana bats in the summer, we request comment on our proposed approach and criteria for testing the accuracy and suitability of available acoustic identification software programs. Only programs that pass our suitability test would be approved by the USFWS for official survey use. Our goal is to incorporate comments and finalize the draft survey guidelines and testing criteria in time for implementation in the 2013 field season. However, should no USFWS-approved software programs be concurrently available, we propose to follow an intermediary contingency plan. The draft survey guidelines, draft acoustic identification software testing criteria, and 2013 contingency plan, with instructions for commenting, are available on the Internet (see ADDRESSES).

Request for Public Comments

We invite written comments on (1) the draft survey guidelines, (2) the acoustic identification software testing criteria, and (3) the 2013 contingency plan. Substantive comments may or may not result in changes to the USFWS guidance document. Please include sufficient information with your comments to allow us to verify any scientific or commercial information you include.

While all comments we receive will be considered in developing final documents, we encourage commenters to focus on those portions of the guidelines that have been revised, particularly those topics noted above that address peer-review comments.

All comments received by the date specified in DATES will be considered in preparing final documents. Methods of submitting comments are in ADDRESSES.

Public Availability of Comments

Responses to individual commenters will not be provided; however, we will provide the comments we receive and a summary of how we addressed substantive comments in a frequently asked questions document on the Web site listed above. If you submit comments or information by email to indiana_bat@fws.gov, your entire submission—including any personal identifying information—will be posted on the Web site. If your submission is made by hard copy that includes personal identifying information, you may request at the top of your document that we withhold this information from public review. However, we cannot guarantee that we will be able to do so. We will post all hard copy and email submissions on the Web site listed above in ADDRESSES.

Comments and materials we receive will be available on our Web site; however, individuals without internet access may request an appointment to inspect the comments during normal business hours at our office in Bloomington, Indiana (see ADDRESSES).

Authority

The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.).

Dated: January 2, 2013.

Lynn M. Lewis,
Assistant Regional Director, Ecological Services, Midwest Region.

[FR Doc. 2013–00213 Filed 1–8–13; 8:45 am]
IV.  Weigl, Dr. Peter 2007 The Northern Flying Squirrel (Glaucomys Sabrinus): A Conservation Challenge
THE NORTHERN FLYING SQUIRREL
(GLAUCOMYS SABRINUS): A CONSERVATION CHALLENGE

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The northern flying squirrel (Glaucomys sabrinus) has an extensive range in North America, inhabiting boreal, coniferous, and mixed forests of the northern United States and Canada and the slopes of the mountains of the east and west. Most undisturbed northern populations are apparently thriving, but those in the southern mountains are considered disjunct relics occupying declining remnants of suitable habitat. It is clear that range contraction in the past has been associated with climate and vegetation change in the Pleistocene and the large-scale timber harvests of the early 20th century and that today a significant threat comes from forest practices and development. However, the major problem in dealing with conservation of this species is understanding its complex ecological position in its regional communities and the subtle as well as obvious influences of human activities. Thus, to preserve this species over its extensive range one will have to consider its various roles as a biological opportunist, an important prey item, a disperser of mycorrhizae, a potential victim of biological warfare, and a small, secretive glider especially vulnerable to anthropogenic and possible climatic changes in the size, arrangement, and quality of its home forests.

Key words: conservation, Glaucomys, heterothermy, northern flying squirrel, Strongyloides, truffles

The ability to develop an effective conservation strategy for a vulnerable species presupposes that one knows enough about the animal’s biology and the potential threats in its environment to create a meaningful protection plan. In the case of the northern flying squirrel (Glaucomys sabrinus), both the acquisition of adequate data and their interpretation have been a challenge. Although concern for this species over much of its range in North America has stimulated a great number of studies over the past 20 years after a long period of limited interest, the listing of some populations as endangered fueled an intense search for that “magic” factor or formula that might explain its biology, guarantee its survival, and eliminate its interference with the human exploitation of its home forests. We still have much to learn. As a participant in a symposium held at the annual meeting of the American Society of Mammalogists in June 2006, I was asked to address the broad problem of flying squirrel conservation. Although this topic may be approached in a number of ways, I have chosen to attempt to provide an overview—with pertinent background and examples—of 2 interacting components of this conservation issue: the particular or salient ecological factors potentially critical to species survival; and those human activities, past and present, contributing to the species’ vulnerability. I am looking for common denominators—factors important to varying degrees over the wide range and diverse habitats occupied by this species as well as special, regional threats, and I wish to raise questions about current ideas and assumptions. I maintain that in the field of northern flying squirrel conservation there may be no simple solutions but instead, within some common denominator of basic biology, an array of problems and possible management strategies dictated by regional variation in squirrel ecology and in the kinds of human influences.

With some chagrin I have recently realized that I started my studies of flying squirrels as a graduate student 43 years ago. Thus, I have decided to approach the topic partially from a personal point of view, stressing my own experiences as well as findings documented in the literature and derived from discussions with other researchers. Although my studies have included many other vertebrates over the years, I have been repeatedly drawn back to flying squirrel investigations as interesting questions and concerns have arisen. Along with a few other workers, I have become a “marked man,” because, over the past 25 years, inquiries have poured in from federal and state agencies, conservancies, consulting firms, and various business concerns. Everyone wants definitive information on flying squirrels in order to preserve rare or endangered squirrel populations, to find a rationale to protect threats to parks and especially significant forests, or to provide justifications for logging, road building, or development in or near the species’ habitat. I would argue that the predicament of the northern
flying squirrel is often too complicated and subtle for the pat answers these people request. Thus, I hope I can be forgiven for using my own experiences in the southern Appalachians as a starting point for a broad but not a definitive discussion of the species, linking these findings to much of the other North American research.

**BACKGROUND**

The northern flying squirrel is not uniformly threatened over its wide range across the boreal forests of North America and the montane and mixed forests of the south-trending mountains of the east and west (Wells-Gosling and Heaney 1984). Except in areas under heavy settlement and large-scale clear-cutting, this species is holding its own rather well in much of the northern part of its range. Its vulnerability is most pronounced in the mountain areas at the southern margins of its range—the southern Appalachians, Sierra Nevada, and Rocky Mountains.

It is quite clear from historical studies of climate and vegetation that the species has experienced a number of range contractions in the past (Arbogast 1999, 2007; Arbogast et al. 2005; Weigl 1968). During times of glacial advance in the Pleistocene, boreal forests repeatedly extended as broad southern peninsulas along the eastern and western mountains and even down the Mississippi Valley (Davis 1976; Delcourt and Delcourt 1981, 1987). One can assume, based on a few fossil records, that the northern flying squirrel then occupied a much larger southern range. The retreat of the glaciers starting 18,000 years ago would have confined squirrels to narrower strips of land and isolated massifs along the Appalachians and western mountains, but much of its remaining habitat was probably quite adequate. Then, in the late 19th and early 20th century the catastrophic clear-cut logging of Appalachian forests took place. Huge areas were denuded and burned over a short period of time—a process repeated in the west somewhat later (Loeb et al. 2000). From what we can surmise from species’ habitat requirements this was a critical time of range contraction, disjunction, and probably population extinction in the mountains. However, it is unlikely that the public or even the biologists of the time were at all aware of the plight of the flying squirrels. Many of the subspecies considered endangered or rare today were unknown. Hall (see Hall and Kelson 1959) described *Glaucomys sabrinus lucifugus* of Utah in 1934, Miller (1936) described *G. s. fuscus* of West Virginia in 1936, and Handley (1953) described *G. s. coloratus* of North Carolina and Tennessee in 1953. Although some populations from the west were described in the 1890s, many subspecies remained undiscovered until well into the 20th century (Hall and Kelson 1959; Howell 1918).

Starting in the early 1980s the northern flying squirrel became the object of intensive research, but much of this work concentrated on the more abundant and widely distributed northwestern forms, whereas the rare, relict, often inaccessible populations of the mountain ridges to the south received only limited attention in spite of the listing of some subspecies as endangered in 1985 (Weigl et al. 1999). Fortunately, recent studies have provided much more background information, and the pace of research has accelerated. However, we still have much to learn about the peculiarities of the ecology of this species and both the obvious and subtle effects of human activity. And that is why conservation of this species is such a challenge.

**NORTHERN FLYING SQUIRREL ECOLOGY**

**General**

In the simplest terms one can describe the northern flying squirrel as a small, nocturnal, nonhibernating, gliding tree squirrel that occupies boreal conifer and mixed forests and uses both tree cavities and dreys for nesting (Smith 2007; Wells-Gosling and Heaney 1984). Contrary to suggestions that this squirrel is a narrow, boreal specialist, the northern flying squirrel is best described as a behaviorally plastic opportunistic, capable of adjusting its biology to wide range of conditions. For example, it is quite capable of occupying deciduous and lower-elevation woodlands of the east and west, not just the spruce, fir, and other conifer forests usually cited in the literature (B. S. Arbogast, pers. comm.; Weigl et al. 2002; Weigl and Osgood 1974). Faced with cold temperatures, turbulent weather, and short periods of food limitation, the squirrel can become heterothermic, dropping its body temperature several degrees without becoming torpid (Bowen 1992). This enables it to wait out short intervals of bad weather and make the most of its body energy reserves. Unlike most squirrels, it does not depend on seeds and nuts, even when these are available (Brink 1965; Brink and Dean 1966; Hall 1991; Mitchell 2001; Thysell et al. 1997), but, although occasionally using mast, generally subsists on fungi, lichens, buds, berries, staminate cones, and animal material, none of which it appears to store. Even its reproductive biology is rather flexible. Although the squirrel commonly produces a litter in early spring, in some areas energy availability and condition of females lead either to reproductive failure or delay, with litters being observed late into the summer and even into October or December (Raphael 1984; Weigl et al. 1999; Witt 1991, 1992). Thus, compared to the smaller southern flying squirrel (*G. volans*) and most other North American tree squirrels, *G. sabrinus* possesses some unusual ecological characteristics, in keeping with the diversity of environmental conditions it must survive.

What salient features of the ecology of the northern flying squirrel need to be considered in developing conservation measures? Our knowledge of the species is still quite fragmentary, because relatively few long-term studies have been conducted (Carey et al. 1999; Cotton and Parker 2000a, 2000b; Fryxell et al. 1998; Lehmkuhl et al. 2006; Ransome and Sullivan 2002; Smith and Person 2007; Weigl et al. 1999). Most studies have been of short duration, confined to warmer months, or limited to surveys. Long-term, year-round investigations are rare. In addition, once some populations were listed as endangered in 1985 in the Appalachians and others were deemed vulnerable because of habitat modifications in the west, researchers avidly attempted to acquire and interpret new data in a quest for unitary and perhaps overly simple strategies.
to preserve these squirrels. Because the extensive literature on the genetics, biogeography, and ecology have been largely reviewed by Arborgast (2007) and Smith (2007) in this issue, I will concentrate on aspects of the squirrel’s biology that appear essential to conservation of the species and then raise questions about the current state of our knowledge and interpretations. Some of my comments will be based on the literature, some on personal experiences.

Habitat

In reviewing the voluminous literature on the habitats utilized by northern flying squirrels, one cannot help but be impressed by certain common features as well as some regional variations that perhaps reinforce this perceived “common denominator” (Waters and Zabel 1995; see Smith 2007). Northern flying squirrels generally occupy boreal or north temperate conifer, mixed conifer-hardwood, and northern hardwood forests, as found in the northern United States and Canada, at various elevations of mountain regions, and in some narrow valleys subject to cold air drainage. These habitats support old-growth forest, communities with old-growth elements, or younger woodlands usually contiguous with such forest. Such areas are usually cool and moist, have cold winters, and possess a well-developed canopy, substantial ground cover, quantities of wet, dead, and downed wood, and often organic substrates. These conditions favor an abundance of snags, cavities, witches brooms, trees festooned with lichens and moss, and a diverse array of buds, berries, seeds, and fungi. In drier sites in the west, squirrels appear to select riparian areas where these cooler and wetter conditions prevail, and where there is easy access to drinking water (Meyer et al. 2005, 2007).

In fact, Carey (1989, 1995) observed differences in population densities in Washington and Oregon that might be associated with moisture conditions in various forest types. Although one can point out variations in this “typical” habitat description, it is clear that the northern flying squirrel is versatile enough to prosper in a wide range of forest types as long as the above conditions occur in enough favorable patches and enough habitat is left undisturbed.

Although G. sabrinus may be a habitat opportunist and readily uses a diversity of potentially suitable forests, habitat is a major conservation problem, exacerbated by various controversial approaches to forest management. The ongoing harvest of old-growth forest, its replacement with plantations or regenerating stands, and the increasing fragmentation of much of the remaining habitat has alarmed some biologists concerned about this and other rare animal species (see Smith 2007). When rare species are declared endangered, as in the case of the northern flying squirrel, then economic forces exert tremendous pressure on researchers to develop definitive management plans that will protect the rare organisms, but also allow a return to timber harvest and development. Such is the case in Alaska (Smith and Person 2007) where the size, quality, and connectedness of planned reserves is an issue, in the Pacific Northwest where the debate over the importance of old growth versus successional forests to rare species has raged for years (Carey 1989, 1995; Lehmkuhl et al. 2006; Waters and Zabel 1995; Witt 1992; but see Ransome and Sullivan 1997, 2002, 2004; Rosenberg and Anthony 1992), and in the Sierra Nevada where thinning, fire, and harvesting may limit the size and quality of squirrel habitat (Meyer et al. 2005; Meyer and North 2005). Another example comes from the Appalachians where the currently endangered subspecies G. s. fuscus of West Virginia is a candidate for delisting. In the Appalachians northern flying squirrels are commonly found in older forests of spruce (Picea rubens), fir (Abies fraseri), beech (Fagus grandifolia), sugar maple (Acer saccharum), and yellow birch (Betula alleghaniensis), especially in the ecotones between conifers and hardwoods. However, throughout the east from Nova Scotia, Canada (Lavers 2004), to southern North Carolina (Weigl et al. 2002) the species is known to occupy hardwood habitats without spruce and fir. An array of studies have documented the squirrel’s habitat diversity (Ford et al. 2004; Menzel et al. 2006; Payne et al. 1989; Stihler et al. 1987; United States Department of the Interior, Fish and Wildlife Service 2006; Urban 1988) pointing out the importance of hardwood and mixed forest habitats. G. sabrinus of West Virginia is more abundant and its populations more continuous than in most parts of the east. Many of the squirrels are caught in forests in which spruce is present, and this tree species supports one of the fungal genera (Elaphomyces) eaten by the squirrel (Loeb et al. 2000). Therefore, the United States Fish and Wildlife Service has decided that if forests containing spruce are protected in the national forests, the flying squirrel’s preservation is insured, and it can be delisted, not to the “threatened” level but taken off the critical list entirely. The problems with this approach are many. First, it is not clear if there is any direct causality between the presence of flying squirrels and spruce. Both animal and plant may be responding independently to the same boreal conditions. Squirrels may nest in spruces occasionally and use them as one of many food sources, but there is no proof of any obligate relationship. Second, in more than 40 years of trapping and nestbox checking in various Appalachian habitats, I almost never captured animals in extensive, pure conifer stands, although telemetry revealed that they sporadically used them. Third, such a course of action fails to sufficiently protect the northern hardwood areas often used by G. sabrinus. Finally, the quality and connectedness of the proposed spruce-containing reserves, now and in the future, need careful study, especially in a region where timber harvest is an important part of the local economy. My main point is that economic pressures may at times influence how ecological information is interpreted resulting in overly simplistic solutions to a conservation and political issue.

Foods

One of the especially significant aspects of northern flying squirrel ecology and conservation is the direct link between the squirrel, its diet, and the perpetuation of its forest habitats. Years ago, McKeever (1960) noted high levels of fungi in the guts of California animals, and in 1965 I discovered that North Carolina squirrels were consuming large quantities of fungi and the staminate cones of fir (Weigl 1968). Subsequently, research
in the Pacific Northwest documented the dependence of northern flying squirrels on the fruiting bodies of hypogeous, mycorrhizal fungi (truffles—Carey et al. 2002; Fogel and Trappe 1978; Lehmkuhl et al. 2004; Maser and Maser 1998; Maser et al. 1978, 1985, 1986; Meyer and North 2005; North et al. 1997; Pyare and Longland 2001b). The hyphae of these underground fungi form associations with tree roots, greatly increasing their surface area for the absorption of water and minerals at a small energy cost to the tree. Many tree species grow poorly or not at all without mycorrhizae. But spore dispersal to new seedlings and older trees is a problem for an underground fungus. Based on our study of the northern flying squirrel and another truffle eater, the fox squirrel (Sciurus niger—Weigl et al. 1989), and the work of Zabel and Waters (1997) and Pyare and Longland (2001a), the following scenario has taken shape. The truffle produces a fruiting body that gives off a chemical signal on ripening; this causes a squirrel to avidly excavate and devour the fungus (Secrest 1990). However, although the squirrel obtains energy and certain minerals (e.g., sodium and phosphorous) from these truffles, it is unable to digest the fungal spores, which are then dropped over the landscape for days or weeks afterward (Ganroth 1988). The resulting inoculation of young trees and spread of the fungus may thus have a marked impact on the perpetuation of the forest habitat on which the squirrel depends. Although G. sabrinus is not the only mycophagist in its home forest, it is one of the most mobile and spends much time on the ground during foraging (Bird and McLenaghan 2005; Loeb et al. 2000; Mitchell 2001; Zabel and Waters 1997). In any case, because of these food habits and their positive effect on the trees of its habitats, conservation of this species assumes a greater dimension and significance. In fact, many of the habitat models for G. sabrinus are now implicitly based on recognition of this squirrel, tree, and fungus symbiosis (Ford et al. 2004; Menzel et al. 2006; Odom et al. 2001; see Smith 2007).

Given the above account of the use of hypogeous fungi, it is important to link these and other foods to certain environmental factors. Truffles are the fruiting bodies of mycorrhizal fungi and appear to be most abundant in association with larger and older living trees, especially in moist, organic soils. The time course of fungal inoculation, growth, and maturation of sporocarps may vary in different forests, but old-growth conditions may be optimal. Epigeous fungi and lichens, which also are important foods, depend on abundance of dead wood and extensive tree surface areas, respectively, and, once again, cool, wet conditions. Although lichens and animal material such as insects and carrion may help support squirrels in the winter when most other foods are unavailable, some researchers also have found evidence for winter truffle use in habitats with frozen ground. Hackett and Pagels (2003) and Smith (2007) have data on the use of underground nests, but no one has reported underground foraging in winter. The other plant materials making up the squirrels diet—staminate cones, berries, beechnuts, and some seeds—are reflective of a preference for boreal habitats and old-growth conditions but also are indicative of an opportunistic species that is not limited to truffles and that might utilize additional foods.

Demographic Considerations

In spite of the spectacular increase in northern flying squirrel studies, we have surprisingly little information on the species’ life history and population biology. Most studies have been dedicated to particular questions such as home range, relative density, foods, and habitat associations. Longer-term studies (e.g., Carey et al. 1999; Fryxell et al. 1998; Smith et al. 2004, 2005; Smith and Nichols 2003; Weigl et al. 1999) have begun to fill in some gaps in our knowledge, but we know very little about most population parameters and long-term temporal and spatial trends.

Smith and Person 2007 have recently reviewed much of the demography of the species and raised questions about the distribution and stability of populations. The picture of G. sabrinus that is developing is of a relatively long-lived (4–7 years) species with a low reproductive rate for a small mammal. In the western part of the range of G. sabrinus, flying squirrels appear to be more abundant than in the east and more continuous in their distribution within the old-growth forests that they commonly occupy. However, most workers report lower densities in managed or successional stands. In the east, populations often occur in distinct patches, often kilometers away from other groups in spite of what seems to be suitable intervening habitat (Weigl et al. 1999, 2002). Also in the east, population size appears to be highly variable. In some years, squirrels will be abundant in an area; in other years the populations are low or nonexistent. Have the animals died out or moved? No answer is available, but population fluctuations have been noted by other researchers (Fryxell et al. 1998). In spite of the meager data from recaptures, it is clear that at least some of the squirrels missing in intervening sampling sessions show up again months or years later (Weigl et al. 1999).

Examination of telemetry data from throughout North America suggests that home-range size is associated with habitat quality and food resources (Smith 2007). Home ranges from 2 to 60 ha have been reported. Our own work and that of others have revealed that squirrels have relatively small core home ranges (3–15 ha) that vary somewhat with sex and season, but that many individuals will display bouts of extensive linear travel, in some cases more than a kilometer, that involve both outward movement and return (Menzel et al. 2006; Weigl et al. 1999). There is some evidence that this long-distance travel is associated with a search for foods and possibly mates (Weigl et al. 1999). Such forays may affect home-range estimates if data are taken at wide time intervals. The important question here relates to the use of space by the species. If populations in a locality can fluctuate widely in numbers, have a distinctly patchy distribution in fairly uniform forest, and consist of individuals that can cover spectacular distances, it is possible that northern flying squirrels may use and thus require much larger expanses of suitable habitat than is commonly acknowledged if they are going to survive in many parts of their range. Both habitat size and connectedness assume great significance under these conditions.

Smith and Person 2007 have recently provided an intriguing example of space use that may partially relate to the preceding
discussion. Working in Alaska in undisturbed habitat, they investigated populations in prime old-growth forest and adjacent groups in a wet, mixed muskeg and forest landscape. Examination of the demographic data suggested that there was a dynamic source–sink situation governing these populations. The muskeg areas were not maintaining viable squirrel populations in a steady state, but were the beneficiary of constant migration of animals from the better forest habitats. To what extent high mobility, source–sink conditions, and metapopulation distributions of squirrels are a common phenomenon is unknown, but this may be worth investigating in areas with old-growth forest adjacent to human-modified habitats. The squirrel populations reported from cutover and regenerating areas may be more variable because they are not self-perpetuating. Certainly the status of populations in West Virginia, the Sierra Nevada, and parts of the Pacific Northwest should be evaluated with this possibility in mind.

Other Species of Animals

The fate of northern flying squirrels may be closely linked to the presence of other animal species—predators, competitors, and parasites—that are in turn often of particular concern to wildlife biologists and conservationists.

Predators.—Smith (2007), Carey et al. (1992), and Weigl et al. (1999) have described some of the potential predators of the flying squirrel, but 2 in particular may be of interest in different parts of the range. Over the past 20 years it has become clear that the northern spotted owl (Strix occidentalis), an endangered and much celebrated species of western forests, is especially dependent on the northern flying squirrel as a prey item (Carey et al. 1992). The owl seems to thrive in extensive old-growth forests or in habitats with old-growth elements where the squirrels are most abundant (Carey 1995; Carey et al. 1999). The size and condition of the habitat ideal for supporting both the flying squirrel and the owl have been the focus of ferocious debate (Carey et al. 1992; Ransome and Sullivan 2002; Rosenberg and Anthony 1992). Old-growth forests in the west are becoming smaller in size and increasingly fragmented, but often are viewed as the economic salvation for a timber industry that is worried about an endangered species restricting the exploitation of remaining tracts. For the squirrel the issue of habitat quality, size, and connectedness is of great importance and has been the focus of several studies. Conservation of squirrel and owl thus seems inextricably linked, but doubtless shall remain a source of intense political and economic controversy.

In the eastern United States another rare animal is periodically associated with the issue of protection of G. sabrinus. Every few years, wildlife biologists consider the reintroduction of the fisher (Martes pennanti) to the southern Appalachians; this species was known to exist in the region in the recent past. In most areas fishers can probably coexist with northern flying squirrels without problems. But in small habitat islands of the southern Appalachians with few squirrels and limited alternate prey items, a predator such as the fisher might kill off these relict populations. Although there have been no introductions of fishers in areas with isolated flying squirrel populations, this idea resurfaces frequently (R. Powell, pers. comm.) and will require the careful attention of wildlife agencies in the region.

Competitors.—Smith et al. (2004, 2007) have suggested that the biology of G. sabrinus in the Pacific Northwest may be different from that in Alaska and the east because of the abundance of other small mammals in western forests. This diversity of sympatric rodents might then produce a greater degree of den-site and food specialization in response to direct and diffuse competition. In reality, we have little information on resource competition between northern flying squirrels and other mammals. Although red squirrels (Tamiasciurus hudsonicus) and Douglas squirrels (T. douglasii) are often mentioned as possible competitors, there is not much evidence of any severe interaction. Flying squirrels may pilfer food from red squirrel middens and the 2 species may both use cavities for nesting sites and fungi for food, but the very different overall diets of these squirrels and their nocturnal–diurnal activity separation may minimize interactions, especially in good habitat. In many years of trapping both species, I was always surprised to find that the best years for capturing northern flying squirrels also were the best for red squirrels.

The southern flying squirrel (G. volans) often has been considered a major competitor (Weigl 1968, 1978). Both species are nocturnal gliders that use tree cavities for dens and both may consume fungi, insects, and plant parts. Although experimental studies suggested that G. volans was the more active and aggressive in interactions, especially around nests (Weigl 1978), habitat preferences, diets, and climatic tolerances of the 2 species (Bowen 1992; Bowman et al. 2005) suggest only limited competition. In fact, except in the north, the 2 species usually show limited and unstable sympathy. Thus, except for the diffuse interactions suggested by Smith et al. (2005) in the west, and a few instances of resource overlap, there is little evidence that competition per se is a significant factor in the conservation of the northern flying squirrel.

Parasites.—A particularly intricate relationship between squirrel ecology and conservation grew out of some unusual discoveries in the southern Appalachians. In the 1960s I had set out to study the interaction of G. sabrinus and G. volans in the Appalachians as a model system for evaluating aspects of competition theory (Weigl 1968). Northern flying squirrels were exceedingly rare, but after several months of trapping I eventually captured enough for the experimental parts of my study. Colonies of both species were then housed in large outdoor aviaries in North Carolina. The 1st spring saw the demise of almost all of the G. sabrinus except those kept in the laboratory, whereas the G. volans seemed to thrive in an adjacent cage. With the help of 2 veterinarians and a former zoo pathologist, I narrowed down the cause of this massive die-off to an infection by the nematode Strongyloides robustus. S. robustus has a life cycle like that of the famous hookworms (Necator and Ancylostoma); embryonated eggs released with animal feces hatch and develop into infective larvae in the substrate; these penetrate the skin of a host, are carried to the lungs where they break through to the lumen, are swallowed, and finally lodge in the intestine doing marked physical and nutritional damage (Weigl 1968; Weigl et al. 1999). The...
parasite is most common in warmer climates where it has been reported to cause marked pathology in wild species (Davidson 1975). Once the cause of the affliction of the captive G. sabrinus was determined, other wild populations of squirrels were checked. All of the captive G. volans in my colony were parasitized (and were probably the source of the infection in the G. sabrinus), but had suffered no ill effects. In fact, all populations of G. volans studied in subsequent years carried this parasite. On the other hand, S. robustus could not be found in any of the G. sabrinus captured on the Appalachian peaks during the remaining years of the study. In the 1980s the federal listing of the Appalachian subspecies G. s. coloratus prompted a new 5-year study of the northern flying squirrel over a wide area of the North Carolina and Tennessee mountains. G. volans now also appeared intermittently in some of the capture sites of G. sabrinus, although there was never any stable sympatry of the 2 species (Weigl et al. 1999). G. sabrinus now supported varying intensities of parasite infection, and in the summer months there appeared to be some correlation between parasite loads and the condition of the animals (Weigl et al. 1999). We eventually cultured the parasite through its life cycle in the laboratory and determined its cold sensitivity (Wetzel and Weigl 1994) and its ability to be transferred by contact with contaminated nest material or soil substrates. Based on all the data to-date and some additional studies by Pauli et al. (2004) and Sparks (2005), I would suggest the following scenario. The cold, high-elevation or northern forests occupied by G. sabrinus only intermittently can support S. robustus because of the sensitivity of the infective larvae to cold. When G. sabrinus moves down into the more climatically moderate forests at lower elevations or when infected G. volans invade the upper slopes during the summer months along paths of human-modified habitat, the 2 species come into contact, especially by using the same tree cavities or feeding areas (Hackett and Pagels 2003), and S. robustus is then transferred. Even if the northern flying squirrels are not killed by the parasite, its effects may be sufficiently debilitating to put the species at a disadvantage.

It is interesting that only in the colder parts of the range of G. volans—the Great Lakes area, northern New England, Ontario, and Nova Scotia—does one get reports of some degree of sympatry of the 2 flying squirrel species (J. Bowman, pers. comm.; Lavers 2004; Pauli et al. 2004). Why then doesn’t G. volans take over the high-elevation refuges or northern habitats of G. sabrinus? The answer probably lies in sensitivity to cold of G. volans, its dependence on stored nuts and seeds for winter survival (Bowman et al. 2005; Doby 1984), and the virtual absence of these resources in most habitats of G. sabrinus. In summary, G. volans may possess a kind of biological weapon that at least in the southern and central part of its range, can prevent the persistence and spread of G. sabrinus (Barbehenn 1969; Haldane 1949; Hatcher et al. 2006; Price et al. 1988; P. D. Weigl, in litt.). It has been argued recently that the loss of genetic heterogeneity in the increasingly isolated, high-elevation populations of G. sabrinus of the east may make the species even more susceptible to parasite and other infections (Sparks 2005). What will happen if warming climatic conditions favor invasion of higher peaks and northern habitats by G. volans is thus an open question in considerations of species persistence.

Genetics

In many parts of the range of the northern flying squirrel, one can reasonably argue that the species is an island inhabitant, subject to most of the constraints that affect other such populations (Brown 1971, 1978; MacArthur and Wilson 1967). Whether occupying real islands off the coast of Alaska; widely scattered habitats of the San Jacinto, Sierra Nevada, Rocky Mountains, and perhaps the Black Hills; or the upper elevations of the southern Appalachians, the species often occurs in small, disjunct populations, relics of broader ranges in the late Pleistocene. The genetics of these populations have received intensive study over the last 10 years (Arbogast 1999, 2007; Arbogast et al. 2005; Bidlack and Cook 2001; Browne et al. 1999; Sparks 2005; Wartell 2005; A. Wartell, in litt.). Genetic structuring, private alleles, and loss of heterozygosity have been detected in many populations, most likely as a result of reduced population size, isolation, inbreeding, bottlenecks, and other drift effects. Although inbreeding tolerance and the replacement of alleles in time by mutation (Sparks 2005) might alleviate the plight of some groups, the loss of genetic diversity is usually seen as a potential threat, especially in changing environments. The persistence of reasonably large and interconnected populations thus appears to be critical to the species survival, and that means sufficiently large habitat reserves and the maintenance of forested corridors. Such a conservation solution might work if the environmental status quo can be maintained. However, in the face of continued forest destruction, drought cycles, El Niño effects, and the still largely unknown impacts of global climate change, the reduction of available habitat and of corridors could well spell the regional demise of this species from both a loss of genetic variability and the loss of viable places to live.

The Impact of Human Activity

Habitat Size and Quality

So far I have emphasized some of the complexities of northern flying squirrel ecology and its implications for species conservation. However, it is clear that the really major threats to these squirrel’s persistence come from human activities, especially in areas of small disjunct populations such as those on islands or at the southern extension of the range. Clearcutting, development, or anything that destroys extensive tracts of habitat will have obvious harmful effects. The size of the remaining forest habitat and its condition then becomes critical to survival. One has only to fly over parts of the Rocky Mountains, Sierra Nevada, and Cascades or along the Appalachians to appreciate the scope of forest destruction and roadway construction in national and privately owned forests. And landscape modification is not the only concern. Successional and regenerating communities require considerable time to develop into habitats of sufficient quality to support flying squirrels. Using demographic models, Smith and
Person (2007) have questioned the adequacy of the size of planned reserves in Alaska; Carey and others (Carey 1995; Carey et al. 1999) have provided evidence that the 2nd-growth landscapes of the Pacific Northwest do not always have the same capacity as old growth for supporting flying squirrels. In the Sierra Nevada, thinning and controlled burning may have adverse impacts on the canopy and organic material on the ground, respectively. Finally, some 2nd-growth stands may well appear to support healthy densities of squirrels, but, in reality, are population sinks for migrants from neighboring old-growth habitats and thus may not permanently maintain viable populations (Smith and Person 2007). Only long-term studies can provide the conclusive data on the suitability of these special or successional areas. The small disjunct squirrel populations of the central and southern Appalachians appear particularly vulnerable to any further modification or reduction of their habitats.

Given the above problem of loss of quality habitat, one needs to recognize 2 major forces that can aggravate this threat. One is economic and political—the demand for forest products and recreation venues, for local and regional employment, and for tax revenues and investment returns. These factors are of overwhelming significance, but are beyond the scope of this paper. The other force—climate change—is more intangible. A warming climate could cause the retreat of some tree species and communities to higher latitudes and cause the substantial reduction or elimination of boreal communities on mountains. Change in the composition and the position of communities might be especially dire in areas already modified by other human influences. Thus, the persistence of northern flying squirrels in the already-disturbed forests of West Virginia could be more tenuous than many have thought during a period of global warming. In addition to modifying community composition and distribution, climate change may have another major impact. A recent paper by Westerling et al. (2006) has documented a link between progressive climate warming and changes in the phenology, desiccation, and fire frequency in western forests. Thus, climatic warming may not only cause modifications of forest distributions, but also their complete annihilation by fire. It is likely that the desiccation observed by Westerling et al. (2006) would also have a marked impact on the moisture-requiring staple foods (fungi and lichens) of flying squirrels.

**Habitat Connectedness**

Along with habitat size and quality, habitat connectedness assumes an important role in species preservation. The extent of unsuitable terrain between high-quality habitat and the absence of wooded corridors could be major factors in regional survival. Frequently, the greater the reduction of contiguous forest, the wider the barriers to dispersal. Such fragmentation of flying squirrel distributions could destroy the viability of metapopulation-structured groups of squirrels, and the resulting small isolates then would be susceptible to the genetic problems mentioned earlier.

The impact of barriers on movements of flying squirrels needs further study, especially the effects of the proliferation of roadways through quality habitats. One example of barrier effects comes from the southern Appalachians. A 3-year study of an extravagant economic development scheme in the North Carolina–Tennessee mountains called the Cherohala Skyway revealed such unexpected impacts (Weigl et al. 2002). Clearly, a 2-lane scenic road removes a quantity of habitat, but, of greater significance, it also can act as a barrier to dispersal to different parts of the forest. Although *G. sabrinus* is an able glider and is known to cover distances along the ground, it is unable to cross wide, exposed roadways, especially the kind of blast-and-fill rights-of-way commonly cut into the sides of mountains. In 2 years of telemetry and trapping, no squirrel was observed to have crossed the Cherohala Skyway. The resulting range fragmentation may doom this southernmost population. In addition to barrier formation, there are 2 more-subtle impacts from a roadway. One impact was detected in the winter when snow permitted the identification of mammals moving on or along the roadway. It was obvious that various predators—bobcats, coyotes, and foxes—used the roadway as patrol routes when hunting and might easily catch any small mammals on the road. Hawks and owls also hunted over the road. Thus, one can easily see that such a right-of-way is both a physical barrier and a site of increased mortality. Another effect of roadways or similar corridors is the modification of adjacent vegetation or other habitat conditions in ways that favor the invasion of potential predators, competitors, or pathogens. In the case of *G. sabrinus*, strips of oak, cherry, and other hardwood species in disturbed areas along roadways provide foods for *G. volans* and favor its invasion of high-elevation habitats, and the transfer of *Strongyloides* to *G. sabrinus*. Thus, linear disturbances of a certain width and severity are a potential source of species fragmentation and possibly increased deleterious species interactions. The impact of roads, systems of ski trails, ridge-top wind farms, recreational vistas, and other types of habitat subdivision need careful evaluation in the future—much more then they have received to-date.

**Pathogens, Pests, Pollutants, and People**

Another anthropogenic factor threatening northern flying squirrels is the introduction of plant pathogens, insect pests, and industrial contaminants into squirrel habitats. In the southern Appalachians, the high-elevation conifer forests have been decimated by an adelgid insect (*Adelges piceae*) that kills Fraser fir (*Abies fraseri*), a valuable timber and Christmas tree species and a source of food and habitat for northern flying squirrels (Amman 1966; Amman and Speers 1965). The staminate cones of fir and spruce are important foods for flying squirrels in the spring when they are eaten in vast quantities. Interestingly, both field and experimental studies suggest that the essential oils from these foods suppress gut parasites such as *Strongyloides* (Weigl et al. 1999). The loss of Fraser fir then would remove a source of food (truffles, staminate cones, and possibly seed), den sites, and a possible natural medicine. In any case the adelgid killing firs, a new adelgid now destroying hemlocks, the impact of pine bark beetles in some parts of the
west, and the effect of acid precipitation on vegetation and soils all represent potential threats to flying squirrels.

The last intrusion mentioned in the heading of this section of the text—people—usually goes unmentioned. One of the major effects of building of roads through prime habitat is the provision of access to lands for private and commercial development. The state or federal government builds a road, and nearby landowners demand the right to connect in order to develop their forest property. During an era of explosive interest in living in natural environments or in 2nd-home ownership, the demand for newly accessible forest land is intense and is often fueled by the economic aspirations of neighboring municipalities. A short trip on the Blue Ridge Parkway in the Appalachians reveals the result of this process. The end result is the loss and fragmentation of habitat and possibly a loss of flying squirrels. Thus, the inclusion of people as a factor along with pathogens, pests, and pollutants may indeed be appropriate.

**SUMMARY**

In the past 25 years the northern flying squirrel has come under increasing scrutiny as new studies have been initiated, papers published, and various agencies alerted to its status and ecological significance. Because of physical, logistical, and economic difficulties associated with long-term research in remote and often rugged areas, our knowledge of this species is still fragmentary, especially in the southern Rocky Mountains, parts of the Sierra Nevada, the Black Hills, and the northeastern United States. Enough is known now to form a picture of the species’ ecology and those aspects of its biology that may affect its preservation. In 2 cases, the northern flying squirrel makes a positive contribution to the forests it occupies. Throughout its range its use and dispersal of mycorrhizal fungi—both hypogeous and epigeous—make it an integral part of a squirrel–fungus–tree mutualism that may well help maintain the very forests needed for its survival. In the northwestern United States and western Canada, the flying squirrel is a critical food item for the endangered spotted owl. Thus, if its habitat is protected and the squirrel is permitted to flourish, the owl has a greater probability of survival.

In spite of the fact that the northern flying squirrel is something of an ecological opportunist, versatile enough to occupy several forest types, consume a number of foods, and reproduce when conditions permit, certain of its characteristics potentially increase its vulnerability. Its dependence on fungi and lichens during much of the year confine it to a certain array of old-growth, boreal forests with cool, moist climates and abundant dead wood and organic soils. The phenology of fungi, particularly the locality and timing of sporocarp production, may require the exploitation of a multitude of widely spaced, ephemeral patches and thus the use at times of extensive home ranges or reliance on long-distance travel. In short, the area needed to support these animals may be larger than our short-term telemetry studies have indicated. And although its diet and tolerance of cold conditions facilitate survival in habitats with severe climates, the low caloric density of much of its diet may be a factor in its relatively low metabolic and reproductive rates (McNab 1986).

The influence of other animals in the environment of the northern flying squirrel needs further study. In no part of its undisturbed range does it seem adversely affected by predators or competitors. Perhaps only in human-modified areas do these markedly assume importance. In the southern and central parts of the eastern United States the possibility that the nematode *S. robustus*, carried by the southern flying squirrel, harms the northern species is unresolved. However, the obvious ability of northern flying squirrels to occupy lowland, deciduous habitats in the absence of the smaller species, their confinement to high elevations when *G. volans* is present, and the instability of populations in contact zones argue for some kind of interaction. In Ontario, Nova Scotia, and northern Pennsylvania, the 2 species have been found in the same nest boxes (J. Bowman, pers. comm.; A. Lauers, pers. comm.; M. Steele, pers. comm.), but these are areas that are climatically unfavorable for the parasite. Thus, in part of the range of the northern flying squirrel a parasite-mediated interaction may be operating. Clearly more research on this topic is needed.

Although there is abundant evidence of the effect of small population size and isolation on the genetic diversity of northern flying squirrel populations, there is at present no evidence of a direct link between loss of genetic diversity and survival. The isolation of populations may occur naturally because of climatic responses of forest communities, but, more likely today, it is caused—or least aggravated—by human activity. We may never know when genetic impoverishment is a major or just a contributing factor to a population’s disappearance.

All of the above ecological aspects of the biology of the northern flying squirrel may have varying effects on the perpetuation of populations in different parts of the range. When one adds the human component, the probability of survival can change spectacularly. Human influences on habitat size, quality, and connectedness are most likely the main threats to the species throughout its range. These critical factors in turn are the products not only of direct habitat destruction and modification, but indirect effects such introduced pathogens, pests, and contaminants and the slow, inexorable pressure of climate change. Survival of the species *G. sabrinus* is certainly critically dependent on an understanding of the species’ ecology, but, even more important, an awareness of the impact of human activity on this ecology throughout its range.

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LITERATURE CITED


Special Feature Editor was Barbara H. Blake.
V. University of Wisconsin Study of Geomyces destructans the fungus that causes White Nose Syndromes found it surviving in bat cave soils when bats are absent. Research by Jeff Lorch and David Blehert.
Bad news for bats: deadly fungus persists in caves
Dec. 14, 2012

by David Tenenbaum

Researchers have found that the organism that causes deadly white-nose syndrome persists in caves long after it has killed the bats in those caves. A study just published in Applied and Environmental Microbiology shows that the fungus can survive in soil for months, even years, after the bats have departed.

A biologist takes samples from a cave in an early attempt to determine the cause of the deadly white-nose syndrome in hibernating bats. New research indicates the fungus causing the disease persists in caves long after the bats it afflicted have died.

Photo: USGS National Wildlife Health Center

This is not good news for the bat population, says lead author Jeff Lorch, a research associate in the Department of Forest and Wildlife Ecology at the University of Wisconsin-Madison.

"We have found that caves and mines, which remain cool year-round, can serve as reservoirs for the fungus, so bats entering previously infected sites may contract white-nose syndrome from that environment. This represents an important and adverse transmission route."

"This certainly presents additional challenges," adds David Blehert, a microbiologist at the U.S. Geological Survey National Wildlife Health Center in Madison, who also led the study. "It's important that we have completed this foundational work that further implicates the environment in the ecology of this infectious disease. We can now collectively move forward to address this problem."
The fungus cannot grow at warm temperatures, so scientists have long wondered how it survived over the summer. The new study sheds light on this mystery, proving that the fungus can survive over the summer in the cool soil of the caves and mines where bats hibernate.

The researchers analyzed soil samples collected during the summer (when bats were absent) from 14 caves and mines in which bats had been observed with white-nose syndrome, and they found viable samples of the fungus, called Geomyces destructans.

White-nose syndrome has killed millions of bats in at least seven species since it was first detected in North America in 2006. From an epicenter in New York state, it has spread into New England, West Virginia, Missouri and Canada north of Michigan's Upper Peninsula. The disease has not yet appeared in Wisconsin.

Although the new study did not assess how effectively the soil-borne samples could cause disease in bats, they probably can, says Lorch. "Other studies, along with some of our current work, show that isolates we have found in North America are genetically identical, so there is no reason to think the fungus found in the soil would be less virulent. However, it would require additional experimentation to confirm that."

The study reveals the challenges involved in repopulating caves after bats have been wiped out by white-nose syndrome, says Lorch. "A lot of people were wondering whether the bats would eventually recolonize caves they had disappeared from due to the disease. It now appears as though this may be a challenge for susceptible bats because the pathogen is living in the soil."

The results also support current disease management recommendations to limit access to caves, Lorch adds. "Some of the states have put restrictions on entry into caves or require those entering to decontaminate gear and clothing to prevent transmission. We cultured the fungus from 200 milligrams of soil, and that amount could easily be transported in the tread of a boot. So even if a cave does not have bats, there is still a risk that people going in could spread the fungus."
Based upon analysis of samples from 55 bat hibernation sites, the scientists also found that the fungus was present in caves and mines where the disease had been found, but not in disease-free sites. Therefore, this study supports other ongoing work indicating that G. destructans is probably not native to North America but rather was introduced from Europe.

Still to be determined is why a few bats survive white-nose syndrome. "We have documented the recovery of some bats, and we might speculate that this has to do with the environmental conditions in which the bats chose to hibernate," says Blehert, who is also an honorary associate in the UW-Madison School of Veterinary Medicine. When bats hibernate at near-freezing conditions, fungal growth is much slower than at temperatures just a few degrees warmer, and it could be that the survivors have the habit of hibernating in colder conditions.

This might be good news for the bats, Blehert adds, because if inherited, this behavior could eventually protect some American bats from the fatal fungus.