GAP ANALYSIS OF SPECIAL FEATURES: GENERAL DISCUSSION AND A CASE STUDY OF AMPHIBIANS AND MAMMALS OF WEST VIRGINIA'S CAVES

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Abstract

As part of the overall Gap Analysis mission to compile information in support of biodiversity maintenance, individual Gap projects may conduct analyses focusing on special features of states or regions. Special feature analysis may be used to capture location information for specialized or localized habitat features such as caves, springs, cliffs, certain tree species, etc. These special features may not normally be found in statewide land cover and habitat datasets but may be important factors in the distribution of certain wildlife species. In addition, the assignment of Gap management status (level of protection) may also be specifically tailored to the special features analyzed. A case study describing West Virginia Gap Analysis (WV-GAP) work on amphibians and mammals utilizing cave habitats will be presented. In addition to standard Gap Analysis methods, WV-GAP used existing datasets for cave locations and cave accessibility to determine the gap analysis status of cave species in the state. Additional examples of special features of interest will also be discussed.

Introduction

The recently completed West Virginia Gap Analysis Project (WV-GAP) is part of a larger nationwide effort supported by the Biological Resources section of the U.S. Geological Survey. A primary goal of the Gap Analysis program is to document and assess the distribution of elements of biological diversity, with a particular focus on terrestrial wildlife species and their habitats (Scott et al. 1993). The WV-GAP effort was conducted using national Gap Analysis Program standards. As with many other Gap projects, various portions of the WV-GAP project were expanded or revised in an effort to increase the overall utility of results and information generated.

In general, the Gap Analysis process includes the following steps:

- Map statewide land cover and general wildlife habitat using classified satellite imagery. Land cover categories should approximate the vegetation Alliance level (FGDC, 1997) for the purpose of mapping general wildlife species habitat types.
- Document wildlife habitat relationships for all native terrestrial vertebrates, associating species with mapped wildlife habitat types.
- Map the predicted distribution of terrestrial vertebrates using known range maps, expert knowledge, wildlife habitat relationships, and the statewide land cover and other mapped habitat variables.
- Compile a map of current land stewardship parcels (state parks, wildlife management areas, etc.) across the state, including a relative assessment of the degree of biodiversity conservation-related management objectives for each parcel.
- Conduct a Gap Analysis of the conservation status of wildlife species and habitat types by comparing the predicted distribution of each species/habitat type with the land stewardship conservation status within each species map of predicted distribution.

This paper focuses on a general discussion (with specific case study) of an approach to alleviate a commonly cited limitation of Gap Analysis. Although the examples presented are specific to data opportunities that were encountered in West Virginia, the methodologies used can provide useful examples for other regions.

Limitations of the Gap Analysis Process

A well-documented limitation of wildlife species habitat maps used in Gap Analysis is the difficulty in mapping specific wildlife habitat elements such as cliffs, rocky outcrops, snags, wetlands, riparian areas, springs, or caves. Statewide habitat maps generated from classified satellite imagery cannot adequately capture these features due to their size, complexity, or linear format. As a result, these features are not specifically mapped for Gap Analysis but are instead assumed to be adequately captured by their association with mapped land cover types. At large scales such as statewide Gap analysis, the assumption that the features are present (even though they are not mapped) may be made (Csuti and Crist (1998), Mayer and Laudenslayer 1988)). However, making this assumption may pose a problem for site-specific applications of GAP data and results. In some cases, Gap Analysis may best serve as a means of identifying those species that might require a fine filter mapping approach rather than the coarse filter of GAP (Davis et al., 1998).

Gap Analysis of Special Habitat Features

In some cases, additional mapping and analysis of special habitat features is a practical addition to a statewide Gap analysis project. Special habitat features such as snags, caves, particular tree species, water, wetlands, snags, easements, special shoreline features, karst topography or other special geological features may not be included in the overall statewide habitat map. However, some of these features may be captured in existing mapped datasets that can be very useful for a more focused Gap analysis process.

In previously completed state-level Gap analysis projects, at least three methods of incorporating special habitat features into Gap analysis have been utilized. These methods are discussed below, with a brief example of each:

(1) Special habitat features may be incorporated directly into statewide habitats map. One type of special habitat feature of importance to many animal species is riparian corridors along streams. Riparian corridors may be partially captured through satellite imagery, but additional mapping of these features using existing datasets such as US EPA River Reach data, USGS National Hydrography Dataset data, or USFWS National Wetlands Inventory data may be useful. Riparian areas may be modeled by buffering mapped surface water features using varying buffer distances according to stream order. This technique has been used by ID-GAP, WY-GAP, CO-GAP and others. In the case of WY-GAP and CO-GAP, the resulting mapped features were incorporated into the statewide wildlife habitat map layer for subsequent predicted distribution mapping of all species.

(2) Habitat features may be mapped independently of the statewide habitat map. In some cases it may not be feasible to incorporate separately mapped habitat features into a statewide habitat map. Instead, specially mapped features may constitute an independent habitat map to be used in predicting species distributions.

WV-GAP used this approach to more accurately model the distributions of wetland or riparian-dependent species by developing a separate, highly detailed land cover map focused on wetland, riparian, and surface water features. Predicted distributions for approximately half of West Virginia's reptile and amphibian species were modeled using this wetland/riparian features map substituted for the standard WV-GAP habitat map. Species that required the use of the wetland/riparian model were determined from the WV-GAP species habitat relationship database. The alternative habitat map made it possible for WV-GAP to more accurately predict the occurrence of wetland/riparian herptile species than remaining herptile species (average site-specific accuracy of 74% for the wetland/riparian species vs. an average of 65% for other species) (Strager and Yuill 2002).

(3) Habitat features may be used in a supplemental species-level gap analysis for given wildlife species. In some specialized cases, special habitat features may be mapped and analyzed for gaps in protection in addition to the standard gap analysis of predicted distribution.

For the "special features" analysis of predicted species distributions, ME-GAP chose to incorporate work specific to four species of interest in Maine, including White-tailed deer *(Odocoileus virginianus*). An important aspect of deer habitat in Maine is deer wintering areas. Wintering areas had been previously mapped for portions of Maine by a state agency. ME-GAP then analyzed the locations of current deer wintering areas, organized townships, wildlife management districts, and potential winter cover areas. Findings suggested that sufficient winter cover for deer may be lacking in certain portions of Maine, a contributing factor in lower population density.

WV-GAP conducted an additional gap analysis on species utilizing cave habitats in West Virginia. This analysis is presented in more detail below.

Example: Gap Analysis of Species Utilizing Cave Habitats by WV-GAP

WV-GAP chose to analyze the degree of protection of cave habitats in the state, in addition to analysis of standard predicted species distribution maps. Eight species of amphibians and 16 species of mammals were listed as associated with cave habitats in the WV-GAP Wildlife-Habitat Relationship database. Species using cave habitats may be merely occasional or opportunistic users of these habitats, or their distribution may be extremely limited to areas containing cave habitats. In an extreme case, the West Virginia spring salamander (*Gyrinophilus subterraneus*) is only found in one particular cave in the state. One of the mammals, the federally endangered Townsend's big-eared bat (*Corynorhinus townsendii)*, is only associated with caves in the database (no other habitat association exists).

WV-GAP was fortunate to have access to digital database of cave locations provided by the West Virginia Natural Heritage Program (WVNHP). Other special habitats mapped by WV-GAP included shale barrens (also provided by WVNHP) and springs. Cave locations were found from information contained in Davies (1965) and data from the NHP. Cave locations were mapped from coordinates for single points, usually located at cave entrances. Some caves may have more than one physical entrance, but in most cases only one point per cave was mapped. Since cave point locations are approximate and may not show all cave entrances, no attempt was made to incorporate the caves into the WV-GAP land cover map.

Caves were attributed with stewardship information including name of managing entity (or owner if applicable), level of access provided to cave, and Gap land stewardship management status codes (Table 1). Stewardship codes range from 1 to 4, with 1 offering the highest degree of biodiversity protection, and 4 the least. Stewardship information was obtained from data maintained and published by the D.C. Grotto chapter of the National Speleological Society in their "Virginia Area Region Limited Access Caves" listings. Caves not listed were classified with Gap stewardship status of 4 (lowest biodiversity protection).

Figure 5-1. Locations of 532 mapped caves (triangles) within West Virginia's ecological subsections.

Management status was assigned to caves based on the degree of public access provided to the cave entrance(s). Many cave entrances occur on private lands that may frequently change hands. Certain caves may have gates or other structures designed to limit human access while still allowing use of the cave by animals such as bats. A limited number of caves in West Virginia have highly limited access and have been permanently or seasonally closed by The Nature Conservancy or federal and state agencies. Other caves may be closed to human access due to landowner's desire to prevent trespassing, physical blockage of the cave entrance, or other safety concerns.

Table 1. Gap stewardship status, number of caves, cave stewardship, and level of cave access assigned to caves mapped for WV-GAP analyses.

Gap Status	Number of Caves	Stewardship	Cave Access
1	6	Federal, State, or TNC	Permanently closed
2	16	Federal, State, or TNC	Seasonally closed
2	3	TNC, private	Limited to conservation/study
2	4	Private or other owner	Permanently closed
3	18	Private or other owner	Access denied by owner or access physically blocked
3	1	Private or other owner, including commercial	Access limited for other reasons (commercial)
4	484	Unknown/other *	Unknown

* - Caves may be located on Forest Service or other managed lands, but they were not attributed according to surface land ownership unless specifically listed in DC Grotto listing.

For each wildlife species utilizing caves, we determined the approximate number of caves the species may use in West Virginia by intersecting the cave locations with hexagons of occurrence (general range) for that species. It is important to keep in mind that this is likely an over-generalization of cave habitat use: most of these species are not restricted to caves alone, and may only use caves occasionally or seasonally. There are many other caves in the state that are not included in this analysis since they were not included in our mapping efforts.

A special note should be made that cave locations and descriptions of cave access may be frequently considered as sensitive information by both cavers and private landowners, similar to the locations of nests of endangered bird species etc. From our experience, special precaution is recommended when describing or distributing these data to others. As a result, the WV-GAP cave database is not generally distributed with other data layers used or created by WV-GAP.

Results

Species utilizing caves in West Virginia include some of the rarest species known from the state (as indicated by TNC, Federal, and State status) as well as very common species such as striped skunk (*Mephitis mephitis)* and raccoon (*Procyon lotor.)* Twenty-nine (5.45%) of the 532 mapped caves in West Virginia have management status 1 or 2 and can be assumed to be reasonably well protected for species conservation purposes. Many of the bat species in Table 2 have at least 5.45% of their cave habitat protected in status 1 or 2, and two of the rarest species (Townsend's and Rafinesque's big-eared bats) have even greater amounts of cave habitat protected – up to 20%. The cave habitats for cave salamander (*Eurycea lucifuga*), Cumberland Plateau salamander (*Plethodon kentucki),* and spring salamander (*Gyrinophilus porphyriticus*) are less protected than most species,

due to the fact that the distribution of these species includes areas outside the Allegheny mountain region of the state. Most of the protected caves in West Virginia lie in or near the Monongahela National Forest or in the eastern panhandle of the state.

Table 2. Gap analysis for species utilizing cave habitats. Total caves indicates number of caves species may be found in (see text), status 1&2 indicates number of these caves within management status 1 or 2.

	Rankings				Habitat		
Common Name	TNC	Federal	State	USFS	Total Caves	Status 1&2	%
Amphibians							
Jefferson's salamander	G5	.	S3	.	274	14	5.11
Slimy salamander	G5	.	.	.	491	26	5.30
Wehrle's salamander	G5	.	.	.	362	20	5.52
Kentucky salamander	G4	.	S2	.	2	0	0.00
Spring salamander	G5	.	.	.	16	420	3.81
West Virginia spring salamander	G1Q	.	S1	.	1	1	100.00
Cave salamander	G5	.	S3	.	269	4	1.49
Long-tailed salamander	G5	.	.	.	491	25	5.09
Mammals							
Little brown bat	G5	.	.	.	532	29	5.45
Indiana bat	G2	LE	S1	.	498	26	5.22
Small-footed bat	G3	.	S2S3	Sensitive	520	29	5.58
Northern long-eared bat	G4	.	S2	.	532	29	5.45
Silver-haired bat	G5	.	S2	.	481	26	5.41
Eastern pipistrelle	G5	.	.	.	532	29	5.45
Big brown bat	G5	.	.	.	532	29	5.45
Townsend's big-eared bat	G4	LE	S2	.	164	21	12.80
Rafinesque's big-eared bat	G3G4	.	S1	.	64	13	20.31
Allegheny woodrat	G3G4	.	S3	Sensitive	45	4	8.89
Coyote	G5	.	.	.	287	26	9.06
Black bear	G5	.	.	.	145	5	3.45
Raccoon	G5	.	.	.	532	29	5.45
Spotted skunk	G5	.	.	.	168	21	12.50
Striped skunk	G5	.	.	.	532	29	5.45
Bobcat	G5	.	.	.	510	29	5.69
TOTAL					532	29	5.45

For most of the rare bat species utilizing West Virginia's caves, a great deal of work has already been done to map their distribution more accurately and to protect sensitive caves during winter months (hibernacula) and breeding season (maternity caves). Results of

Gap Analysis need to be interpreted taking into account additional expert knowledge. In one example, most significant caves used by the Indiana myotis (*Myotis sodalis*) are already protected or have restricted access, even though Gap Analysis (table 2) indicates that only 5.22% of the caves within this species range are protected (in status 1 or 2). According to the WVNHP, up to 94% of the world's population of this species uses a total of 13 caves, and over 90% of the West Virginia population is found in just one single cave. While many of the bat species listed in Table 2 have benefited from conservation management, other sensitive species such as the salamanders may be of additional interest to wildlife managers.

Conclusion

Gap Analysis involves comparison of predicted species distributions with existing land stewardship parcels and management objectives (Scott et al., 1993). The overall result includes an assessment of each species' conservation status, primarily based on the amount (and percentage) of a species' predicted distribution that lies within lands managed for biodiversity conservation. This information can assist managers in identifying 'gaps' in conservation planning for states and regions. Gap Analysis may be limited by the ability to map and analyze the conservation status of special habitat features or species-specific habitat elements such as deer wintering areas or caves. Analysis of such special features can help improve the overall utility of state Gap project results, even if Gap is used only as an initial screening tool to identify additional habitat mapping requirements and other data needs.

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