Chapter 2. Methods

As previously noted, through the Federal WCRP and SWG legislation, DGIF was identified as the agency in Virginia with responsibility for development of the CWCS. The Department's Wildlife Diversity Division, under the leadership of its director David K. Whitehurst, was tasked with coordinating this project. Rebecca Wajda, assistant director of the Division, was selected as the CWCS Project Manager. Staffs within the Division developed an overall organizational framework and approach to completing the work that capitalized on existing expertise and partnerships, while providing considerable opportunity for others within and outside of the agency to participate in the project (Figure 2.1).

Critical to this process was the establishment of the Core Working Group (CWG), operating under the leadership of Kathy Graham, then Shelly Miller. This team was responsible for completing the tasks necessary to develop the CWCS. The CWG is composed of members of the Wildlife Diversity Division's Fish and Wildlife Information Services Section and includes:

- Kathleen Q. Graham, former FWIS/GIS Programs Manager
- Kendell D. Jenkins, GIS Specialist
- Shelly A. Miller, Wildlife Diversity Biologist
- David D. Morton, GIS Coordinator
- W. Adam Phelps, Wildlife Diversity Biologist
- Rebecca K. Wajda, Assistant Director, Wildlife Diversity Division
- Susan H. Watson, Research Specialist Senior

Karen K. Reay, VIMS, also participated in the Core Working Group while an employee of DGIF.

This group was responsible for developing strategies and processes to address the required elements, conducting the technical review and synthesis of information, creating the outputs needed to fulfill the requirements, and for coordinating the review, and modification as needed, with the experts and other committees working on the project. The CWG was also responsible for developing the draft CWCS document. The team met frequently (often weekly or bi-weekly) to assess project accomplishments, deliberate outstanding issues, and discuss approaches for completing work assignments.

The CWG also called on the expertise of other biologists within the Department's Fisheries, Wildlife, and Wildlife Diversity programs, as needed to help address project tasks. This Expanded Working Group was helpful in many of the technical aspects of the initiative, including the habitat assessment, and in the public outreach components.

2.1. Strategy Coordination

Much of the success of the Virginia CWCS is founded on the acceptance of it as a conservation plan for Virginia, not simply for DGIF. In that light, we recognized early the importance of involving key partners that manage significant land and water areas in Virginia or administer programs that significantly affect the conservation of SGCN and their habitats. Additionally, we recognized the value of this document and process having Agency-wide acceptance, and a need for all program areas to participate at some level in the development of the document.

The Department of Game and Inland Fisheries has five standing Taxonomic Advisory Committees (TACs) that are comprised of experts from academic institutions and agencies and organizations across the state. The Fish, Herpetofauna, Bird, Mussel, and Mammal TACs are chaired by Wildlife Diversity biologists from the DGIF Nongame and Endangered Wildlife Program. We also established an ad hoc Invertebrate TAC at the beginning of the CWCS project to help address issues related to invertebrates, excluding freshwater mussels. The TAC members include:

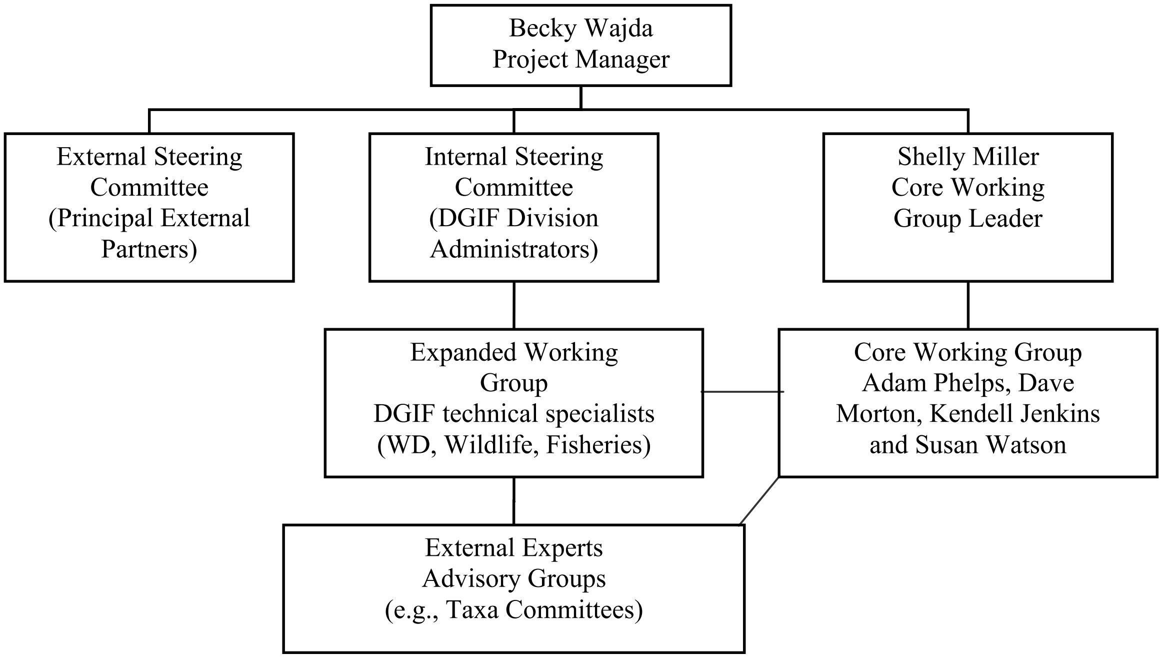

Figure 2.1. Virginia CWCS organizational structure.

Invertebrate TAC
Donald J. Schwab, Sr., DGIF, Co-chair [1]
Brian T. Watson, DGIF, Co-chair
Robert T. Dillon, Jr., Ph.D., College of Charleston
Richard L. Hoffman, Ph.D., VMNH
John R. Holsinger, Ph.D., ODU
Steven M. Roble, Ph.D., DCR-NH
William A. Shear, Ph.D., Hampden-Sydney College
Leonard A. Smock, Ph.D., VCU
Keith R. Tignor, VDACS
J. Reese Voshell, Jr., Ph.D., VPI&SU
Carl E. Williams, TN Wildlife Resources Agency

Mussel TAC
Brian T. Watson, DGIF, Chair
Braven B. Beaty, Ph.D., TNC
Shane D. Hanlon, USFWS
Richard L. Hoffman, Ph.D., VMNH
Jess W. Jones, VPI&SU
Richard J. Neves, Ph.D., VCFWRU
Michael J. Pinder, DGIF
Steven M. Roble, Ph.D., DCR-NH

Herpetofauna TAC
Donald J. Schwab, Sr., DGIF, Chair [1]
Robert S. Greenlee, DGIF
Joseph C. Mitchell, Ph.D., UR
Michael J. Pinder, DGIF
Steven M. Roble, Ph.D., DCR-NH
Paul W. Sattler, Ph.D., Liberty University
Alan H. Savitzky, Ph.D., ODU
Barbara A. C. Savitzky, Ph.D., CNU
Shelly A. Miller, DGIF, current acting Chair

Fish TAC
Michael J. Pinder, DGIF, Chair
Paul L. Angermeier, Ph.D., VCFWRU
Mark T. Kopeny, Ph.D., UVA
Stephen P. McIninch, Ph.D., VCU
Jack A. Musick, Ph.D., VIMS
Scott M. Smith, DGIF

Bird TAC
Jeffrey L. Cooper, DGIF, Co-chair
Michael D. Wilson, DGIF, Co-chair [2]
Ruth Boettcher, DGIF
Stephen W. Capel, DGIF
Roger B. Clapp, Smithsonian Institution
Chris Eberly, DoD PIF
Alix D. D. Fink, Ph.D., Longwood University
Teta Kain, VSO
Richard J. Reynolds, DGIF
Steven M. Roble, Ph.D., DCR-NH
Bryan D. Watts, Ph.D., CCB

Mammal TAC
Richard J. Reynolds, DGIF, Chair
A. Scott Bellows, ODU
Jack A. Cranford, Ph.D., VPI&SU
Michael L. Fies, DGIF
Christopher S. Hobson, DCR-NH
Dennis D. Martin, DGIF
Nancy D. Moncrief, Ph.D., VMNH
John F. Pagels, Ph.D., VCU
Robert K. Rose, Ph.D., ODU

[1] Donald J. Schwab, Sr. is currently employed by USFWS.
[2] Michael D. Wilson is currently employed by CCB.

These committees serve in an advisory capacity to DGIF, providing scientific and technical expertise to help guide the Department's conservation efforts. During the development of the CWCS, DGIF relied considerably on the TACs to implement and refine the preliminary technical analyses completed by the Core Working Group, and to provide best professional judgment regarding many of the required elements.

In 2002, VDGIF formalized its operational strategy for completing the development of the CWCS via the establishment of two working groups. The Internal Steering Committee (ISC) was established to provide leadership within the agency to the CWCS initiative. The members of the ISC are senior administrators across programs of the Department and include:

- James C. Adams, Capital Programs Director
- Major Gary M. (Mike) Bise, Assistant Director, Law Enforcement
- Frederick (Rick) A. Busch, Assistant Director, Wildlife
- Raymond T. Fernald, Manager, Nongame and Environmental Programs, Wildlife Diversity
- Virgil E. Kopf, Ph.D., Assistant Director, Administrative Services
- Fred D. Leckie, Jr., Assistant Director, Fisheries

The ISC was responsible for ensuring that DGIF's interests were addressed in the development and implementation of the CWCS, and that the CWG addressed the eight required elements appropriately in the development of the document. The ISC held monthly meetings to review the progress made; approve processes, procedures, and draft documents; and recommend actions or course corrections as warranted. The ISC also directed resources from individual organizational units within DGIF as needed to assist in CWCS activities.

The External Steering Committee (ESC) was established to maximize key partner participation in the development and subsequent implementation of the CWCS. The potential member agencies and organizations were identified by DGIF. We extended invitations to 15 agencies and organizations, including USFWS, USFS, DCR, DEQ, DOF, NPS, TNC, Ducks Unlimited, Virginia Audubon Council, VMRC, Virginia Department of Transportation, Western Virginia Land Trust, the Virginia Association of Planning District Commissions, Natural Resources Conservation Service, Virginia Department of Agriculture and Consumer Services. We asked the participating individuals be senior administrators or senior program staff in their respective agencies and organizations. At the completion of the development of the Virginia CWCS, the final member ESC list includes:

- L. Peter Boice, Team Leader (Conservation), U.S. Department of Defense
- C. Fair Brooks, III, State Chairman (through July 2004), Ducks Unlimited
- John Coe, CWCS Liaison, Virginia Audubon Council
- Dean P. Cumbia, Assistant Regional Forester, Virginia Department of Forestry
- M. Denise Doetzer, State Conservationist, Natural Resources Conservation Service
- Frank M. Fulgham, Jr., Program Manager, Office of Plant and Pest Services, Virginia Department of Agriculture and Consumer Services
- Carol Hardy, Ph.D., Forest Wildlife Biologist, George Washington and Jefferson National Forest, U.S. Forest Service
- Julie Hawkins, State Biologist, Natural Resources Conservation Service

- David A. Hurt, Project Manager, Western Virginia Land Trust
- Stephen J. Long, Assistant Environmental Division Administrator, Virginia Department of Transportation
- Karen A. Mayne, Virginia Field Office Director, U.S. Fish and Wildlife Service
- Joseph McCauley, Manager, Rappahannock River National Wildlife Refuge, U.S. Fish and Wildlife Service
- James M. McGowan, Planner, Accomack-Northampton Planning District Commission
- Gordon C. Olson, Natural Resources Branch Chief, Shenandoah National Park, National Park Service
- Nicole Rovner, Director of Government Relations, The Nature Conservancy-Virginia Office
- Thomas L. Smith, Natural Heritage Director, Virginia Department of Conservation and Recreation
- Jeffrey C. Southard, Chief of Planning and the Environment, Virginia Department of Transportation
- David K. Whitehurst, Wildlife Diversity Director, Virginia Department of Game and Inland Fisheries

We also want to recognize Greg Moser and John Myers, NRCS, Christopher Ludwig, DCR, and Carl Garrison, DOF, for their participation on the ESC during this project.

The ESC functioned as an advisory board, and was responsible for ensuring that resource conservation interests across the Commonwealth were addressed in the development and implementation of the CWCS. This committee also ensured that the CWG addressed the eight required elements appropriately in the development of the document. The ESC held quarterly facilitated meetings to review the progress made; endorse processes, procedures, and draft documents; and recommend actions or course corrections as warranted. The ESC also directed resources from their individual organizational units as needed to assist in CWCS activities. Importantly, many of the ESC members functioned as liaisons between DGIF and broader interests across the state. In addition, the ESC met on March 4, 2005 in a facilitated meeting by the VCU Center for Public Policy to identify the primary conservation needs affecting wildlife in Virginia and some specific actions to address those needs. These results are presented in Chapter 10.

2.2. Public Input and Involvement

Public participation is a critical aspect of the successful development of the Virginia CWCS. We utilized a variety of formats to create awareness about and to engage the public during the initiative.

2.2.1. Media Campaign

The Department has an excellent working relationship with media around the state. We used news releases and one-on-one interviews to promote the initiative. Additionally, we used media events associated with high-profile projects funded by SWG and WCRP grants to demonstrate the relationship between these efforts and the CWCS.

2.2.2. Public Outreach

Web Site

We recognized early the importance of a presence on the Internet and contracted with CMI at VPI&SU to develop and support a Web site separate from the DGIF site. This approach provided us with greater flexibility in the delivery of information via the Web, and allowed us to capitalize on technology resources available through the university that were not available to DGIF. The site (www.vawildlifestrategies.org) included information about the Virginia CWCS, operational approaches, our accomplishments of the required elements, and a feedback mechanism for individuals to submit comments about any aspect of the

Strategy. Information for the site was developed and updated by the Core Working Group and Project Manager. The web site is referenced in all materials and publications and is linked to directly from the DGIF official site.

Later in the development of the CWCS, a draft of the document was posted on the web site with a tool for visitors to provide comment. These comments were reviewed by core team members, addressed as needed, and are provided in their entirety in Appendix P. Appendix P also contains comments on the draft document provided following the distribution of the draft through listservs and emails to partners.

E-mail Forum

Using listserver technology through our contract with CMI, we were able to leverage a considerable e-mail forum to provide periodic updates on the work accomplishments and upcoming opportunities. We used e-mail addresses derived from agency applications to help populate the list initially, and provided a tool on the site to facilitate individual subscription to the list.

Postcards/Mailers

We used postcards and other mailers to reach approximately 5,000 individuals across the state that have interacted with DGIF, but for whom we did not have e-mail addresses. These tools served to direct the recipient to the Web site for information about the initiative.

Public Presentations

We developed a "Top 50" list of agencies and organizations that we targeted for public presentations about the Virginia CWCS. We delivered presentations to numerous other agencies and organizations that requested our participation. We also made presentations to several professional societies at regional and national meetings including the Virginia Society of Ornithology, the Virginia Herpetological Society, the Organization of Fish and Wildlife Information Managers, and the Virginia Chapter and Southern Division of the American Fisheries Society.

2.2.3. Interactive Public Participation

We scheduled two sets of community meetings around the state to gather information directly from Virginians. Using comprehensive contact lists developed by DGIF's various programs, we invited more than 450 agencies and organizations to these meetings.

The first set of meetings was held in the fall of 2004 at 14 locations around Virginia. During each meeting, DGIF staff presented an overview of the Virginia CWCS. The bulk of the meeting was discussion between meeting participants, facilitated by the staff from the Center for Public Policy at Virginia Commonwealth University (CPP/VCU). During each meeting, participants were asked to provide input on what they thought was working well in Virginia with regard to wildlife and habitat conservation, and why it worked well; what they thought needed improvement in Virginia with regard to wildlife and habitat conservation, and how these improvements could be made; and threats to wildlife and habitats that the Commonwealth is facing and will be facing in the next decade and priorities for addressing those threats.

The second set of meetings was held in the spring of 2005 at eight locations around Virginia. During each meeting, DGIF staff presented an update on the status of the Virginia CWCS, including results of the fall community meetings and work of the TACs. The majority of the meeting time was discussion between meeting participants, facilitated by staff from the CPP/VCU. During each meeting, participants were asked to evaluate the threats and identify needed conservation actions.

Results from both sets of meeting were summarized by CPP/VCU and DGIF and are presented with in the Statewide Assessments and Results Section (Chapter 4). Comparisons were made between these data and the data acquired from the TACs, ESC, and other sources.

2.3. Selecting Species of Greatest Conservation Need

2.3.1. A Definition of "Wildlife"

Congress has mandated that the CWCS must give appropriate weight to "wildlife species of greatest conservation need." The definitions of both "wildlife" and "species of greatest conservation need" (SGCN) have been left to each state. We therefore needed to determine the species to be potentially included in Virginia's CWCS (i.e. define "wildlife"), then formulate from that list a subset considered to be of greatest conservation need in the context of the CWCS.

We had many options for determining which species would be considered as SGCN. Anthropogenically-introduced exotic species were immediately removed from consideration, as were all plant species. In addition, vagrant and accidental species were excluded, as were pelagic seabirds that occur off the Virginia coast but do not breed or winter within the terrestrial confines of the Commonwealth. Finally, all marine mammals, shellfish, and finfish were excluded from consideration. A management plan is currently under revision for marine mammals and sea turtles (original plan: Terwilliger and Musick 1995; revised plan: Boettcher and Fernald 2005), and we felt that it was redundant to consider these species in this context. However, the loggerhead sea turtle *Caretta caretta* is included in the CWCS as the only sea turtle that nests in Virginia. All marine species will be covered more thoroughly in the next iteration of the CWCS. However, we summarized many existing plans that have been developed for marine species in Virginia's waters (Section 4.2).

All animal species that use any terrestrial and/or freshwater habitats in the Commonwealth were considered in selecting the SGCN. This potential list included anadromous and catadromous fish, invertebrates, migrants, and all breeding or wintering species not specifically excluded above.

2.3.2. Identifying Species of Greatest Conservation Need (SGCN)

Once we determined which species would be considered for inclusion in the CWCS, we needed to identify SGCN. Again, we had many choices regarding how to proceed. One option was to repeat the symposium method conducted in Virginia in 1989, when compiling the first state endangered and threatened species list (Terwilliger 1991). In this process, expert taxonomic committees ranked all species within their area of expertise, using detailed survey forms considering various aspects of each species' life history, distribution, and threats. However, this method was extremely time-consuming, involving management of multiple meetings of multiple committees, with members from outside DGIF. Since the CWCS was to be submitted by 01 October 2005, and SGCN selection is only the first of many steps in the process, we felt that we did not have the time necessary to undertake this endeavor.

Simply adopting the list produced by the 1989 symposium was another option. However, because that status assessment was 13 years old when CWCS preparation was begun, and would be 16 years old by the time it was completed, we felt that too much new information existed to simply use this outdated list. Therefore, we decided that the best choice under these circumstances and constraints was to integrate existing information on conservation status from a range of organizations.

Our general process was to create a matrix of all included wildlife species in Virginia and their ranks on lists of conservation concern. We then prioritized each major taxonomic group into four tiers. These four tiers became a starting point for review by the Taxonomic Advisory Committees (TACs). Standing committees, arranged by taxonomic group, are maintained by DGIF. The TACs were established to provide input on taxonomy, conservation and other species issues. They have been consulted at various stages throughout the CWCS development process. The TACs are: Bird, Fish, Herpetofauna, Mammal, Mussel, and Invertebrate, the last of which included all non-mussel aquatic and terrestrial invertebrates.

The final list, reviewed and modified if necessary by the TACs, was then submitted for the approval of the ISC and ESC as the final list of SGCN for the CWCS. This method was faster than the original Virginia Endangered Species Symposium, because the experts had only to review and modify an existing list, rather than entirely creating the list.

The matrix was constructed using Microsoft® Access 2000 database management software (Microsoft 1999a). In the initial table, rows were species and each column was a list of conservation concern. At the intersection of each row and column, if the species appeared on a given list, then the rank it was given on that list was entered (see Table 2.1 for an example). Those species that had any rank on any list were then combined into a new table. This new table became the matrix that was manipulated in all further work, thus excluding those species that were absent from any conservation list.

Table 2.1. An example of the species matrix used in selecting SGCN. For clarity, not all species or columns are included. See Table 2.2 for clarification as to what lists and plans the columns represent. Due to space limitations, we have not included what each status abbreviation represents; see the individual references in Table 2.2 for each organization's methods and rankings.

Common Name	**Federal**	**State**	**DCR-NH Global**	**DCR-NH State**	**IUCN**	**CITES**	**PIF Breeding**	**Shorebirds**	**Waterbirds**	**NAS WatchList**
Piping plover	FT	ST	G3	S2	VU	(*NA*)	I	EH	(*NA*)	Red
Red-cockaded woodpecker	FE	SE	G3	S1	VU	(*NA*)	I	(*NA*)	(*NA*)	Red
Saltmarsh sharp-tailed sparrow	*(NA)*	SSC	(*NA*)	S1	NT	(*NA*)	I	(*NA*)	(*NA*)	Red
Bachman's sparrow	SOC	ST	G3	S1	NT	(*NA*)	I	(*NA*)	(*NA*)	Red
Appalachian Bewick's wren	SOC	SE	(*NA*)	S1	(*NA*)	(*NA*)	I	(*NA*)	(*NA*)	(*NA*)
Roseate tern	FE	SE	(*NA*)	SH	(*NA*)	(*NA*)	I	(*NA*)	H	(*NA*)
Henslow's sparrow	SOC	ST	(*NA*)	S1	(*NA*)	(*NA*)	I	(*NA*)	(*NA*)	Red
Black rail	SOC	NA	(*NA*)	S2	NT	(*NA*)	I	(*NA*)	(*NA*)	Red
Short-eared owl	(*NA*)	NA	(*NA*)	S1	(*NA*)	II	II	(*NA*)	(*NA*)	Yellow
Sedge wren	(*NA*)	SSC	(*NA*)	S1	(*NA*)	(*NA*)	I	(*NA*)	(*NA*)	(*NA*)
Bald eagle	FT	ST	(*NA*)	S2S3	(*NA*)	I	V	(*NA*)	(*NA*)	(*NA*)
Northern harrier	(*NA*)	SSC	(*NA*)	S1	(*NA*)	II	V	(*NA*)	(*NA*)	(*NA*)
Wilson's plover	(*NA*)	SE	(*NA*)	S1	(*NA*)	(*NA*)	I	H	(*NA*)	Yellow
Loggerhead shrike	(*NA*)	ST	(*NA*)	S2	(*NA*)	(*NA*)	II	(*NA*)	(*NA*)	(*NA*)
Cerulean warbler	SOC	(*NA*)	(*NA*)	S3S4	(*NA*)	(*NA*)	I	(*NA*)	(*NA*)	Red

Lists were selected for inclusion in the matrix based on two criteria: whether they were at least statewide in scope, and whether they added new information to the matrix. For instance, the Red List, maintained by IUCN, was one of the early lists added (Baillie et al. 2004). We then excluded the list of birds of conservation concern maintained by BirdLife International, because it is based on (and is wholly redundant of) the IUCN Red List. Geographically localized lists, such as TNC ecoregional plans and USFS National Forest plans, were omitted due to incomplete coverage of the state. They will be consulted during implementation of the CWCS.

After selecting which conservation lists would be included in the matrix (Table 2.2), we decided which rankings within each list would be included (Table 2.3). We included most ranks that were equivalent to "unknown status" or above. This essentially excluded only rankings equivalent to "secure."

Table 2.2. Lists of animals of conservation concern used in the production of Virginia's Species of Greatest Conservation Need.

Name	Reference	Taxonomic Group
DCR-NH	Roble 2003	All
State E & T	Terwilliger 1991	All
Federal ESA	USFWS 1999	All
Northeastern Greatest Concern	NESWDTC 1999	All
IUCN	Baillie et al. 2004	All
CITES	CITES 2003	All
NAS Watchlist	NAS 2003	Birds
PIF	PIF 2003	Birds
U.S. Shorebirds	Hunter et al. 2003; Clark and Niles et al. 2000	Shorebirds
N. American Waterbirds	Kushlan et al. 2002	Colonial waterbirds and marsh birds
AFS Crayfish	Taylor et al. 1996	Crayfish
AFS Mussels	Williams et al. 1993	Freshwater mussels
AFS Fishes	Warren et al. 2000	Freshwater fishes

Table 2.3. Established conservation lists, associated categories, and the tiering score assigned to each rank in the species selection matrix.

Conservation List	Categories	Tiering Score
USFWS Listed Species	Endangered	10
	Threatened	8
	Candidate	7
	Species of Concern (VA)	6
DGIF Listed Species	Endangered	10
	Threatened	8
	Special Concern	6
VDACS Proposed	Proposed State Endangered	7
	Proposed State Threatened	7
DCR-NH Rare Animals	G1, S1, SX, T1, GH, SH	10
	G2, S2, T2	8
	G3, S3, T3	6
	GU, SU	4
IUCN Red List	Critically Endangered	10
	Endangered	9
	Vulnerable	8
	Near Threatened	6
	Conservation-dependent	6
	Data Deficient	4
Northeastern Species of Greatest Concern	Yes	7
CITES	Appendix I	8
	Appendix II	6
	Appendix III	4
Audubon Society Watchlist	Red	10

Conservation List	Categories	Tiering Score
	Yellow	8
Partners in Flight	I	10
	II	8
	III	6
	IV	5
	V	4
U.S. Shorebird Conservation Plan	Extremely High Priority	10
	High Priority	8
	Moderate Priority	6
North American Waterbird	Highly Imperiled	10
	High Priority	8
	Moderate Priority	6
	Unknown Status	4
Crayfishes of the U.S. and Canada	Endangered	10
	Threatened	8
	Special Concern	6
Freshwater Mussels of the U.S. and Canada	Endangered and Endangered, Possibly Extinct	10
	Threatened	8
	Special Concern	6
Freshwater Fishes of the U.S. and Canada	Endangered and Endangered, Possibly Extinct	10
	Threatened	8
	Vulnerable	6

This preliminary matrix contained 1433 species in Virginia that occurred on at least one list of conservation concern. Because a single list of 1433 species does not provide adequate information regarding relative conservation need, we further prioritized this list. We began by splitting the species into groups based roughly on taxonomy. This was done for two reasons. First, it facilitated our expert review process. Secondly, some species groups have had more attention from conservation groups. For instance, in the "Birds" group are species that could potentially occur on PIF lists, the Audubon Watchlist, and in NAWCP. Therefore, when prioritizing species, we decided it would be appropriate to keep the taxa separated.

We further broke the grouped species lists into four tiers. Four tiers were selected to avoid a comparison with the "Endangered/Threatened" ranks that occur on both Federal and Virginia endangered species lists, along with the Virginia rank of "state special concern" and the similar "species of concern" rank issued by the USFWS Virginia Field Office. The tiers were not intended to mirror these ranks. We also felt that five tiers was a finer resolution than we could reasonably achieve with this method, and were concerned that a fifth tier would be immediately discounted as a very low conservation need, even though that may not be the case.

Our four tiers of imperilment are defined as follows:

> **Tier I**. Critical conservation need. Faces an extremely high risk of extinction or extirpation. Populations of these species are at critically low levels, face immediate threat(s), or occur within an extremely limited range. Intense and immediate management action is needed.
>
> **Tier II**. Very high conservation need. Has a high risk of extinction or extirpation. Populations of these species are at very low levels, face real threat(s), or occur within a very limited distribution. Immediate management is needed for stabilization and recovery.

Tier III. High Conservation Need. Extinction or extirpation is possible. Populations of these species are in decline, have declined to low levels, or are restricted in range. Management action is needed to stabilize or increase populations.

Tier IV. Moderate Conservation Need. The species may be rare in parts of its range, particularly on the periphery. Populations of these species have demonstrated a declining trend or a declining trend is suspected which, if continued, is likely to qualify this species for a higher tier in the foreseeable future. Long-term planning is necessary to stabilize or increase populations.

To facilitate separation of the species into four tiers, an index of imperilment was created. We applied scores to each rank within the established lists. These scores range from 4 to 10, with 10 indicating most imperiled (Table 2.3). The intent was to create scores that were consistent across lists, and that provided information about the relative imperilment of each species within each list. These scores were then applied to the matrix, and a total score was developed for each species by summing the scores across all lists on which the species occurred.

Within each taxonomic group, potential scores were developed. This potential score reflects the total possible score if a species occurred at the highest level of every list on which it could occur. Within a single taxonomic group, there may be more than one potential score due to the methods used by list originators. Two groups that were especially complex were the birds and the aquatic mollusks. In the case of mollusks, the AFS mussel list includes mussels of conservation concern, but not snails or peaclams. Therefore, any snail in our mollusk matrix would have a potential score that is 10 points lower than a mussel.

Other complications existed that were not related to the taxonomic groupings. One major issue was that of the NESWDTC list (1999). On this list, those species that are already protected by ESA are excluded from consideration. This identifies species that are in need of conservation effort, but are not already protected. For example, the Atlantic sturgeon *Acipenser oxyrhynchus* is a species of concern as designated by the Virginia Field Office of USFWS, and could potentially be on the NESWDTC list, so the concomitant 7 points would be added to its potential score. However, the shortnose sturgeon *A. brevirostrum* is federally endangered, and therefore not considered for the NESWDTC list, so its potential score is 7 points lower than *A. oxyrhynchus*.

A relative index of imperilment was then calculated by dividing the total, or actual, score for each species by its potential score. This produces an index score for each species in the matrix. Within each taxonomic group, the species were sorted by index score.

Our next challenge was to determine the break points to determine the four tiers of imperilment. We used ESRI's ArcView® 3.2a software to determine natural breaks (ESRI 2000). ArcView's® default classification method is Jenks optimization algorithm (JOA). This method iteratively minimizes the sum of squares in each class, providing as the output the range to be included in each of a user-defined number of classes.

These tiers were then presented to the TACs for review. Each committee was charged with reviewing the tiers and recommending movements of species between tiers, addition of species to the list (with an indication of tier placement), or removal of species from a list, as they deemed appropriate. The reason for each change to the tiers was documented by the TACs, either in the form of literature citations, references to specific data, or, if neither was available, by indicating a specific ecological reason, in their best professional judgment. For example, eastern cougar *Puma concolor couguar* was placed by our process into Tier I. Mammal TAC then recommended that it be removed from the list, because it is extirpated from Virginia.

Possible reasons for movement of Species of Greatest Conservation Need between tiers include:

Promoting to Higher Tier/Adding to List
- Declining population trend
- Best remaining population is in Virginia
- Habitat loss
- Habitat fragmentation
- Competition with invasive species
- Environmental quality (pollution sensitivity)
- Exploitation by pet trade, collectors, others
- Relatively immobile
- Slow dispersal mechanism
- Other (specify)

Demoting to Lower Tier/Removing From List
- Increasing population trend
- Habitat restoration or zero loss
- Uncommon in Virginia, but common throughout rest of range
- Other (please specify)

The total list of SGCN was reduced through expert review from 1433 species in the draft list to 925 species. An average of only 2.2 species were added to each list, while an average of 48.6 were removed from each list. Most (82%) of those removed were from Tier IV. Sixty-six species were promoted to a higher tier, but 186 were demoted to a lower tier.

The expert-reviewed lists were provided to the ISC and ESC. Both committees approved the lists. The rest of the planning process (and this document) focuses on these species, their habitats, threats to them, and strategies to promote their conservation. The lists of species are detailed under the sections of this document describing each ecoregion and in total in Appendix A.

2.4. Habitat Assessment

2.4.1. Introduction and Background

The purpose of the habitat assessment was to provide structure to the strategy, information on all habitats, and detailed information on essential habitats of Tier I species. Our intent was to make the CWCS (particularly the habitat assessment) as spatially explicit as possible. Much of the analysis used GIS. ArcGIS® version 8.3 was the primary GIS software (ESRI 2004).

Although this strategy focuses on SGCN, it is important to evaluate habitat for all species. By taking a broad approach, we hope to proactively address habitat threats before more species become imperiled. This strategy presents a framework for evaluating all terrestrial and aquatic habitats in Virginia. Using GIS, we compiled many variables or factors that make up terrestrial and aquatic habitat. It is impossible to know or spatially represent all of the factors that together function as habitat for all species. However, we present spatial data that represent habitat factors that are generally recognized as important to many species, occur at a macro (between micro and landscape scale) or landscape scale, and can be mapped statewide. For the terrestrial section, no classification or logical grouping of these variables was completed. No single classification exists to describe habitat for all species across all taxa, and the creation of such classification system was beyond the scope of the CWCS. See Section 2.4.4 for the DGIF Aquatic Habitat Classification, which was used in mapping aquatic habitats.

Most of the effort within the habitat assessment has focused on compiling and consolidating information on the habitat needs of the Tier I species. Where possible, spatial data have been created showing areas of known and likely habitat important for these species. Data from both terrestrial and aquatic spatial habitat layers were used in the detailed mapping of Tier I species habitat. However, many other datasets were gathered or created, depending on the habitat requirements of individual species. These finer scale data were important for assessing habitat status, monitoring goals, and conservation priorities for our most imperiled species.

Much of what we know about a species' distribution, habitat and status comes from observation records. Two primary sources of species observation data are used through this document. These are DGIF's Collections database (DGIF 2004c) and DCR-NH's Natural Heritage Screening Coverage (DCR-NH 2005). Collections was developed by DGIF in 1991 to store information reported annually by researchers under Virginia's Scientific Collection Permit Program. It was expanded to include location data from technical reports, museum records, staff field activities, the agency's warm water stream survey and more detailed locations from a follow-up of BBA. In addition, DGIF has added records from other agency or individual's databases. Collections contains over 50,000 records consisting of over 220,000 species observations. White collections is a robust database, it is limited to reported observations and cannot feasibly represent all locations used by an individual species. DCR-NH's Natural Heritage Screening Coverage consists of several individual datasets. The Conservation Sites (including karst conservation sites, DCR-NH 2004b) dataset, provided the most detailed and current information on known species population and habitat. Conservation Sites was the dataset used within this strategy development. DCR-NH describes Conservation Sites as "…polygons built around one or more rare plant or animal, or significant natural community or geological feature. Sites are designed to include the element and, where possible, its associated habitat, and buffer or other adjacent land thought necessary for the element's conservation. For rare aquatic species we define Stream Conservation Units (SCUs), which identify stream reaches that contain aquatic natural heritage resources, including upstream and downstream buffer and tributaries associated with this reach. There are almost 2000 terrestrial and SCU site records in the Conservation Sites coverage; these sites encompass all viable, recently-verified element occurrences documented in our databases" (DCR-NH 2004b and DCR-NH 2005).

One of the early steps we took was to create a new database using Microsoft® Access (Microsoft 1999a), called Habitat Affinity (DGIF 2005). The idea behind this database was to take much of the information that exists in BOVA (DGIF 2004a), but to increase the information in it, and make it more easily queried. What began as a simple expansion of habitat information now includes information gathered throughout the CWCS process on habitat, distribution, and threats. Each of these aspects can be queried easily and extensively. While much of the information in Habitat Affinity relates to Tier I species, there is also extensive information on other tiered species. This database will continue to be populated and refined as part of the implementation of the CWCS (see Chapter 10 for details).

Clearly, managing habitat is how we manage most wildlife species. By presenting habitat information on several scales, from ecoregions to areas important for particular species, we hope to provide a flexible tool for guiding habitat management decisions.

2.4.2. Ecoregions

The broadest level of habitat delineation is the six ecoregions that divide Virginia. Woods et al. (1999) define ecoregions as "...areas of relative homogeneity in ecological systems and their components." There are several ecoregional classification systems. The systems created by Robert Bailey (USFS, Bailey 1995) and James Omernik (EPA, Woods et al. 1999) are two of the most popular. Because of its compatibility with planning units used by conservation partners, we chose Bailey's ecoregions (Bailey 1995). Within this ecoregional classification, the Section level was used to delineate our planning units. Section and Subsection levels are most appropriate for strategic planning at the state level (Cleland et al. 1997).

The most current and detailed digital delineation of Bailey's ecoregions was created at USFS Southern Research Station (Keys et al. 1995). However, these data represent Subsections. We manually edited these data to aggregate up to Sections (Figure 2.2). Continental-scale ecoregion GIS data (Bailey 1995) were used to guide the aggregation. The result was six Section level ecoregions: Middle Atlantic Coastal Plain, Southern Appalachian Piedmont, Blue Ridge Mountains, Northern Ridge and Valley, Northern Cumberland Mountains, and Southern Cumberland Mountains.

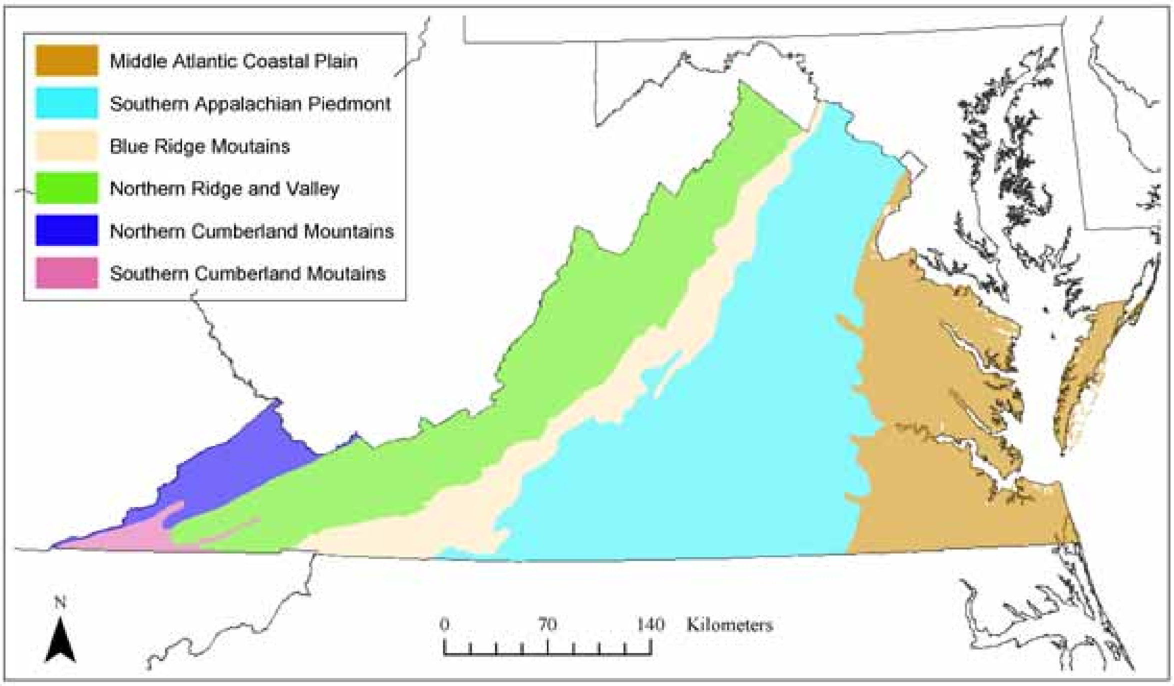

Figure *2.2.* Virginia's ecoregions based on Bailey's Sections (Keys et al. 1995).

2.4.3. Terrestrial Habitat

No terrestrial habitat classification system or single habitat map currently exists for Virginia. The Virginia Gap Analysis Project (VA-GAP) mapped land cover circa 1992 to model terrestrial vertebrate species distributions (Waldon et al. 2001). The intended scale of VA-GAP was broader than the needs of the CWCS, so VA-GAP land cover was not appropriate. Habitat, the place and conditions where an organism or population lives and grows, is multi-dimensional: A variety of factors influence whether or not an organism occurs, thrives, and survives in a given area. From microclimates to landscapes, different species of wildlife respond to factors at a wide range of scales. Because of the wide scope of "habitat" and the variety of SGCN, it is impossible to create a single map of habitat. Therefore, our approach was to gather or create geospatial layers that represent influences on the habitat of many wildlife species.

This group or library of spatial habitat variables was used in mapping habitats for some of the Tier I species, and provided information on habitat status at the state and ecoregional levels. It is intended that this series of data layers will be used as a flexible tool for mapping habitat, as well as forming the base of habitat classification system outlined in the future. The specific layers within this series include ecoregion, place, land cover, elevation, relative phenological index, slope, aspect, landform index, and moisture index.

2.4.3.1. Place

Place is a broad category that describes the basic physical environment. Place divides Virginia into estuarine/marine, submontane, montane, and high elevation (Figure 2.3). The main GIS data used to determine Place were elevation, slope, relative phenological index (RPI), and modified Chesapeake Bay salinity data. The RPI is a variable that incorporates elevation with geographic position (described below). Chesapeake Bay salinity data were from the Chesapeake Bay Program (CBP 2004a) and defined in the Chesapeake Bay Program's Analytical Segmentation Scheme (CBP 2004b). Salinity was split into four classes ordered by greatest to least salinity: polyhaline, mesohaline, oligolohaline, tidal fresh.

The definition of each area and geospatial methodology used to create the delineation is as follows:

Montane. "The zone in mountainous regions where the influence of altitude (vertical relief) results in local climatic regimes that are sufficiently different from those in the adjacent lowlands as to cause a complex vertical climate-vegetation-soil zonation; includes vegetation at the base of a mountain when it is different from lowland vegetation (FGDC 1997)."

The montane delineation was obtain using RPI values between 22 and 45 days and RPI values between 17 and 22 when sites are on or near (within 200m) a slope of 10 degrees or greater.

Submontane. "An area where the influence of altitude (vertical relief) does not result in local climate regimes that are sufficiently different from the adjacent lowlands as to cause a complex vegetation-climate-soil zonation; generally includes the foothills of a mountain range; the lowland vegetation at the base of a mountain that displays vegetation zonation (FGDC 1997)."

All areas between montane and marine were identified as submontane.

High Elevation. Climatically cooler areas in Virginia containing northern vegetation communities. Vegetation communities include (DCR-NH 2004a): spruce/fir, Appalachian shrub and balds, northern hardwoods, high elevation bolder fields, high-elevation cove forest, northern red oak, high elevation outcrop barrens. DCR-NH defines high elevation as above 1070m elevation (DCR-NH 2004a).

A RPI threshold of 45 days and greater was used to define high elevation. This threshold was determined based on inclusion of known based on spruce/fir communities. Spruce/fir forests only occur in Virginia in high elevation.

Estuarine/Marine. Areas where salt water or other oceanic factors (sea spray or flooding) have the most impact on vegetative communities. This would include estuarine wetlands, marine tidal and non-tidal wetlands, beaches and overwash areas.

Areas within 500m of polyhaline water, or areas of 3m elevation or less and either within 2000m of polyhaline water, within 200m of mesohaline water, or within 60m of oligolohaline water were labeled estuarine/marine.

2.4.3.2. Land Cover

Land cover is from NLCD, which was classified from Landsat satellite Thematic Mapper (TM) imagery (USGS 1992). The land cover classes we used are similar to Anderson et al. (1976) and can be found in Appendix K.

Because of inaccuracies in some detailed categories of the NLCD (Vogelman et al. 2001) and due to thematic consistency, broad classes were aggregated for much of the CWCS. Land cover was aggregated to the broad categories of Water, Developed, Barren, Forest, Agriculture/Open, and Wetland. These categories form the basis for our habitat groups and subgroups described below. The specific aggregations of NLCD classes that we used are as follows:

Water- Open Water (11)
Developed- Low Intensity Residential (21), High Intensity Residential (22), Commercial/Industrial/Transportation (23), Urban/Recreational Grasses (85)
Barren- Bare Rock/Sand/Clay (31), Quarries/Strip Mines/Gravel Pits (32)
Forest- Deciduous Forest (41), Evergreen Forest (42), Mixed Forest (43)

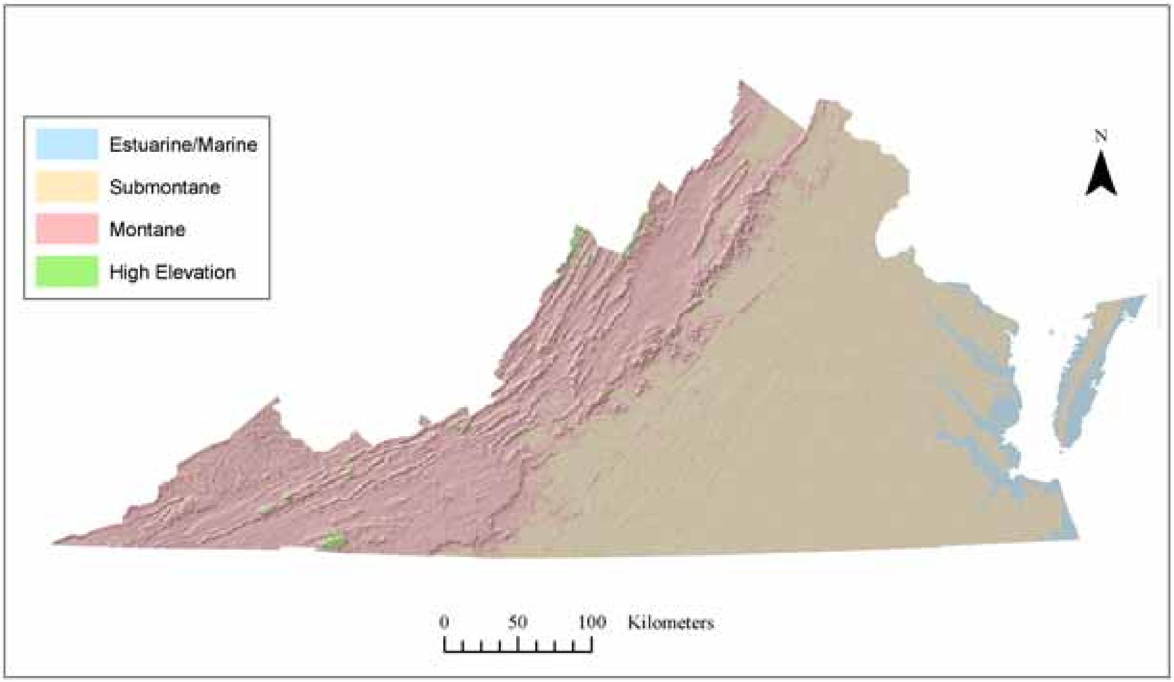

Figure 2.3. Place divides Virginia into Estuarine/Marine, Submontane, Montane, and High Elevation. Hillshading is shown to highlight the topography.

Agriculture/Open- Pasture/Hay (81), Row Crops (82), Transitional (33)
Wetland- Woody Wetlands (91), Emergent Herbaceous Wetlands (92)

See Anderson et al. (1976) or Appendix K for definitions of these codes.

Land cover changes daily. We hoped to be able to use data more current than 1992 in this iteration of the CWCS, and updates to the 1992 NLCD are in progress. The 2001 NLCD is only available for the eastern portion of Virginia (USGS 2001). There are some modifications to the land cover classification system for the 2001 version. However, the broad aggregated classes remain are very similar (USGS 2001). As more current land cover data becomes available, they will be incorporated into the library of spatial habitat variables. The NLCD datasets have a raster cell size of 30m.

2.4.3.3. Elevation

The USGS NED is the spatial elevation dataset used throughout the CWCS (USGS 2003). This dataset is a seamless raster product created from the best available digital elevation models, and has a raster cell size of approximately 30m (USGS 2003).

2.4.3.4. Relative Phenological Index

The Relative Phenological Index (RPI) integrates the geographic position with elevation. It is based on the fact that 1000m elevation in northern Virginia is not the same as 1000m elevation in southwestern Virginia. It uses Hopkins' bioclimatic law, which states that for every change of 122m elevation, one degree latitude, or four degrees longitude, phenological events are delayed four days (Hopkins 1938). Using this information, RPI shows the delay in phenological events from a base point measured in days. McCombs (1997) first used phenology in a spatial layer. The index in the CWCS is based on McCombs (1997), with the exception that the base for phenological events in Virginia is off the coast of Back Bay, in far southeastern Virginia. This data layer has a raster cell size of approximately 30m, but is more appropriately used at an ecoregional or broader scale.

2.4.3.5. Slope

Slope is the change in elevation in relation to the change in horizontal distance (rise divided by run). Slope was calculated using ESRI's Spatial Analyst in ArcGIS® (ESRI 2004). The NED (USGS 2003) was used as input. The output is measured in degrees. This data layer has a raster cell size of approximately 30m.

2.4.3.6. Aspect

Aspect is the compass direction that a hill faces. It is the steepest downslope direction in degrees (0-360). In Virginia, hillsides with north and northwestern aspects are cooler and moister than south and southeastern slopes. The aspect spatial layer was calculated using ESRI's Spatial Analyst in ArcGIS (ESRI 2004). The NED (USGS 2003) was used as input. This data layer has a raster cell size of approximately 30m.

2.4.3.7. Topographic Moisture Index (TMI)

Topographic Moisture Index (TMI) shows the influence of topography on local moisture regime: It is the relationship between the amount of water draining into an area compared to the amount draining out. It is based on the Moisture Index (Anderson and Merrill 1998). The equation is

$$\mathrm{Ln}[(\mathrm{flowaccumulation} + 1)/(\mathrm{slope} + 1)]$$

where flowaccumulation is the watershed or catchment area above a point calculated using ESRI's Arc/Info® flowaccumulation grid command (ESRI 2004). The result is an index in which higher positive numbers represent wetter areas, and lower negative numbers represent drier areas. This data layer has a raster cell size of approximately 30m.

2.4.3.8. Landform Index

Landform Index shows the topographic relationship of an area to its surroundings. This index shows the degree to which a site is topographically concave or convex. McCombs (1997) provides an excellent discussion of landform index. Landform index is the sum of distance-weighted elevation differences between a site and surrounding points (Anderson and Merrill 1998). Using an Arc Macro Language (AML) script (Evans 2002), landform index was created using methods outlined in McNab (1989, 1993). The search window was changed based on recommendations from McCombs (1997) to better fit Virginia's conditions (see McCombs 1997 for more details). The result is an index where higher positive numbers represent convex topography and lower negative numbers indicate concave areas. Landform index can be combined with slope to classify areas into slope classes (e.g. cliff, sideslope, ravine, cove, summit) (Anderson and Merrill 1998). This data layer has a raster cell size of approximately 30m.

2.4.4. Aquatic Habitat Classification

Over the past few years, DGIF has developed an aquatic habitat classification. The methods used in this classification follow the basic structure of TNC aquatic community classification and the Missouri Resource Assessment Program's Aquatic GAP study (Higgins et al. 1998; Higgins et al. 2005; Miller et al. 1998; MORAP 2005). The classification has been applied to riverine habitats only. There is currently no classification of lake habitats. There are only two natural lakes in Virginia, so the need for a classification system is not great. In addition, of the highest tiered species, only the blackbanded sunfish uses lentic habitats. However, lakes (both artificial and natural) are considered in the stream reach classification if they are connected to or are inline with a stream. Lakes and ponds can have a dramatic effect on water quality, temperature, flow regime, and faunal composition. Species composition can be altered by the change in the physical habitat and chemistry and through stocking efforts.

There were multiple goals of this effort. One was to provide a means to describe and catalog the diversity of stream habitats in Virginia. The second was to provide a dataset that can be used to describe species-habitat associations and predict species distributions at the stream reach level. These goals fit well with the objectives of the CWCS. Specifically, this classification was used to describe the known habitats of Tier I species and to map predicted distribution of the species, based on the range of these known attributes. This level of classification does not capture finer scale habitat attributes (i.e. pool/riffle/run composition, depth, specific substrate composition, etc.) that may be important to refine the predictive habitat maps. However, it is useful in determining general patterns in species distributions, and may indicate areas to survey for a species, or areas in which to promote habitat restoration. The stream reach classification was also used to group all SGCN into assemblages with similar patterns of habitat use.

This habitat classification is hierarchical and is based on an understanding of how habitat influences the composition and distribution of biological communities. It is based on four assumptions (Higgins et al. 1998):

1. Physiographic and climatic patterns influence the distribution of organisms, and can be used to predict the expected range of biological community types (Jackson and Harvey 1989; Tonn 1990; Maxwell et al. 1995; Angermeier and Winston 1998; Burnett et al. 1998).

2. The physical structure of aquatic habitats (or ecosystems) can be used to predict the distribution of aquatic communities (Gorman and Karr 1978; Schlosser 1982).

3. Aquatic habitats are continuous; however, generalizations about discrete patterns in habitat use can be made (Vannote et al. 1980; Schlosser 1982).

4. Using a nested classification system, (i.e. stream reach habitat types within Ecoregional Drainage Units (described below) within the large climate and physiographic zones), we can account for community diversity that is difficult to observe or to measure (taxonomic, genetic, or ecological) (Frissell et al. 1986; Angermeier and Schlosser 1995).

2.4.4.1. Ecoregional Drainage Units

The Ecoregional Drainage Unit (EDU) is a spatial representation of a variable described by Angermeier and Winston (1999). They found that physiography and drainage together described 27% of the variance in fish species composition. In addition, they found that fish community types described by the drainage-physiography combination were more distinct than those described by drainage or physiography alone. This concept has also been incorporated by TNC. However, they develop aggregations of 8-digit hydrologic units based on similarities in several variables including geology, flow characteristics, and topography (Smith et al. 2002).

Using 14 drainages (Figure 2.4) and six ecoregions (Mid-Atlantic Coastal Plain, Southern Appalachian Piedmont, Blue Ridge, Ridge and Valley, Northern Cumberland Mountains, and Southern Cumberland Mountains) (Figure 2.2), we have defined a total of 34 EDUs in Virginia (Figure 2.5). The drainages were developed by merging 14-digit hydrologic units developed by DCR (2004) into larger hydrologic units using the 8-digit USGS hydrologic unit boundaries and visual inspection of the DCR data layer. The EDU dataset was used in the CWCS to describe a layer of habitat classification within ecoregions, and as a unit of organization for the species of greatest conservation need and their habitats.

2.4.4.2. Stream Reach Classification

The stream reach classification was the next level of the hierarchy applied. For the purposes of this classification, reaches were defined by confluences, recognizing that stream habitats are continuous and most breaks we apply are artificial and/or subjective. The dataset used to depict streams was the NHD (USGS and USEPA 1999). The complete NHD for Virginia is at a scale of 1:100,000; therefore, some valid perennial streams may be absent, and stream size could be underestimated. This scale poses some other challenges in defining species-habitat preferences and assigning species to reaches. Some Collections may be assigned coordinates for a stream found at the 1:24,000 scale; however, that stream may not be visible at

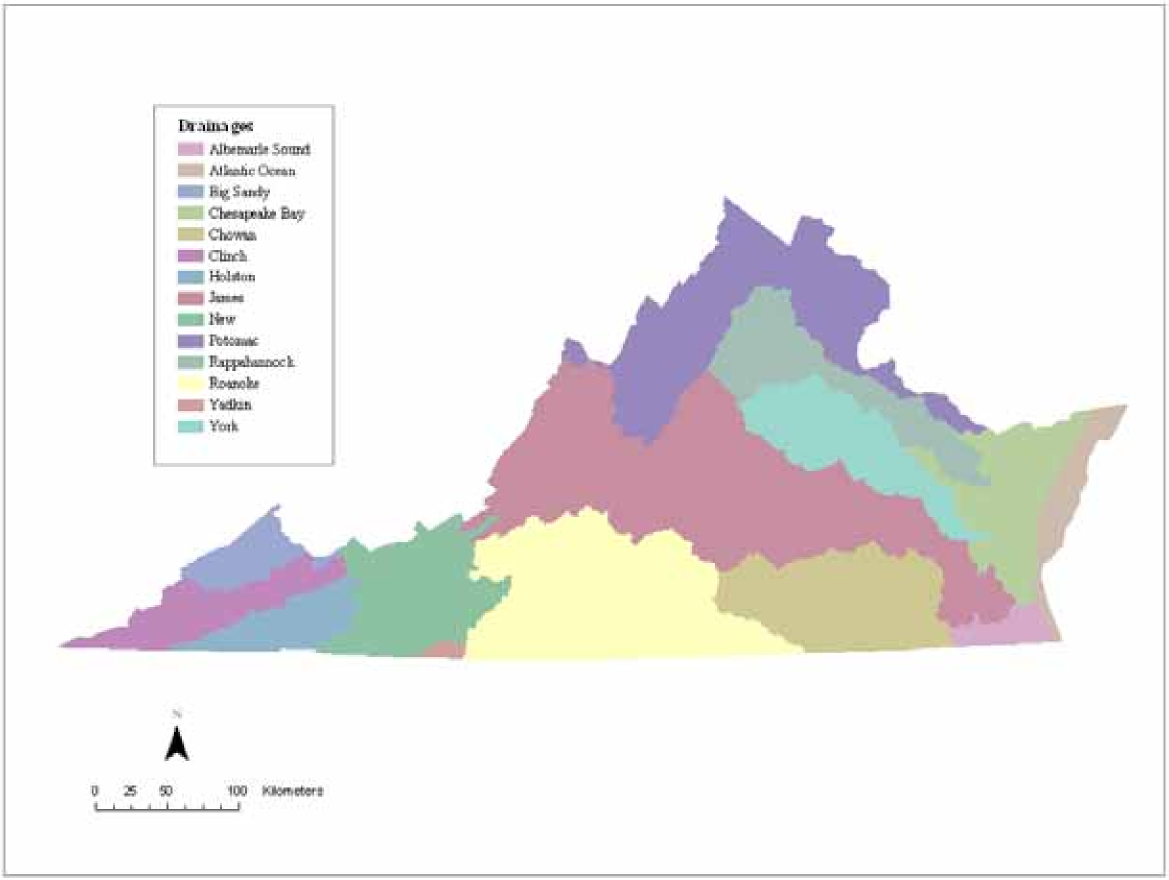

Figure 2.4. Drainage basins used in the development of the Ecoregional Drainage Units (DCR 2004).

the 1:100,000 scale and therefore that species may be assigned to an inaccurate stream reach. Unfortunately, the 1:24,000 scale hydrography was not complete for Virginia at the time of analysis.

We created an Aquatic GAP expert team at the start of the classification project (Table 2.4). The intent of the team was to provide input to the classification process that would help ensure that a useful product was developed. The attributes assigned to the reaches were identified through literature review and expert team input as biologically meaningful variables that are mappable using GIS. The attributes included size (link magnitude), connectivity (the link magnitude of the next downstream reach), gradient, reach elevation (as a surrogate for temperature), and dominant geology (carbonate, siliceous, argillaceous, etc.) (Table 2.5).

Table 2.4. Members of the Aquatic GAP expert team.

Name	Affiliation
Paul Angermeier	VCFWRU/VPI&SU
Richard Neves	VCFWRU/VPI&SU
Greg Garman	VCU
Chris Hobson	DCR-NH
Chris Ludwig	DCR-NH
Judy Dunscomb	TNC
John Copeland	DGIF
Scott Klopfer	CMI
Fred Benfield	VPI&SU
Mike Pinder	DGIF
Brian Watson	DGIF

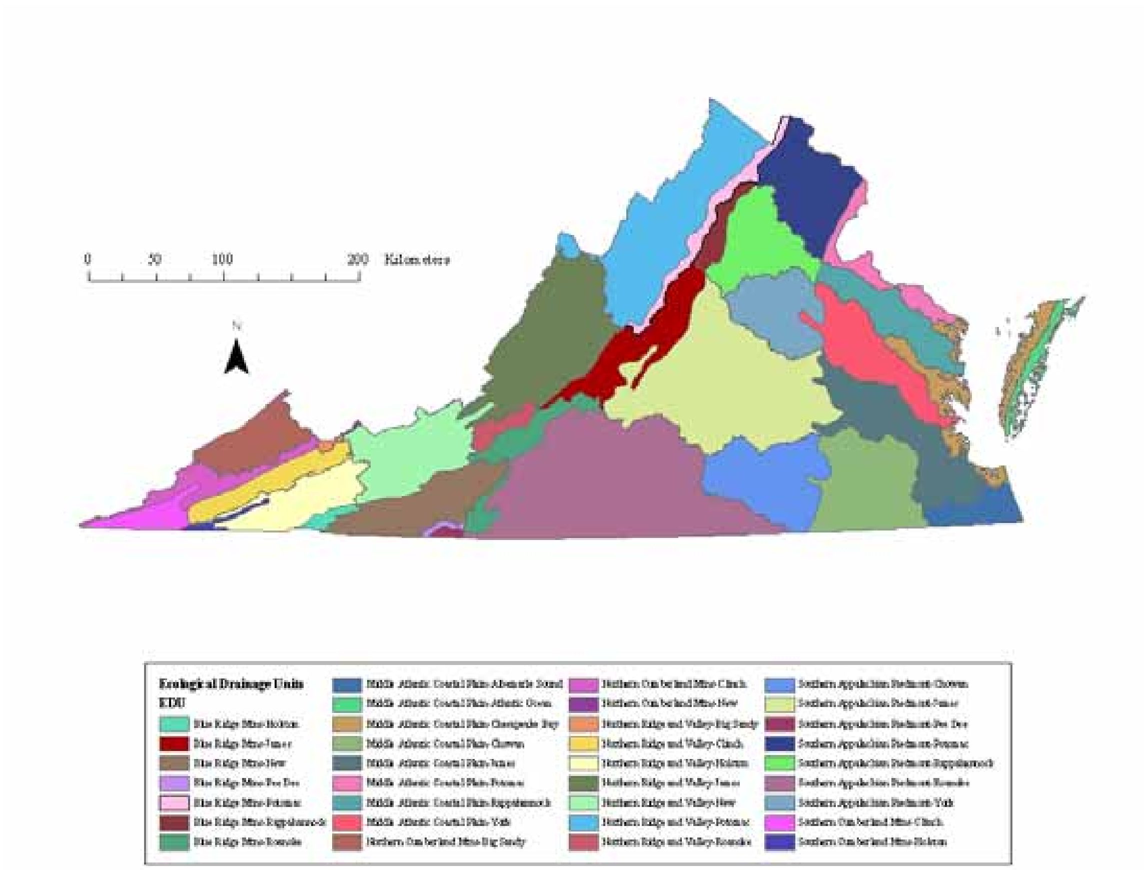

Figure 2.5. Ecoregional drainage units developed for the DGIF aquatic habitat classification hierarchy.

Prior to the attribution of these variables to the stream hydrography data layer (1:100,000 NHD), a series of steps were followed to prepare it for analysis. These steps were modified slightly from those developed by the Missouri Aquatic Gap Pilot Project (MORAP 2005). Unfortunately, all of the steps required to prepare and to attribute the NHD require the use of two different ESRI GIS products: ArcView® 3.x (ESRI 2002) and ArcMap® 8.3 (ESRI 2004). The most time-consuming portion of this effort is the review and iterative editing of disconnected and looping stream arcs. The disconnected reaches and loops must be addressed in order for the other automated steps to function properly. Another important step early in this process was the assignment of unique reach identifiers.

Table 2.5. Aquatic habitat attributes assigned to each reach.

Attribute	**Description**	**Data Source (if applicable)**
Strahler order	Commonly accepted definition of stream order; two first order streams join to form a second order stream; two second order streams join to form a third order stream, etc. Two streams of the same order must join for any increase in order.	NHD
Shreve order	Also known as link magnitude; calculated as the sum of the orders of the two upstream tributaries, therefore a second and first order stream join to form a third order stream.	NHD
Downstream order	The Strahler order of the next downstream segment in the network	NHD

Attribute	Description	Data Source (if applicable)
Downstream link	The Shreve order of the next downstream segment in the network	NHD
Gradient	The elevation at the upstream end of the reach subtracted by the elevation of the downstream end of the reach divided by the length of the reach; units are m/km	NHD, NED
Reach elevation	The average of the upstream node elevation and the downstream node elevation (in m)	NHD, NED
Proximate geology	The geological class through which >50% of the stream flows	NHD, USGS geology
Waterbody (wb_arc)	Indicates if the reach is the centerline of a lake or reservoir; other waterbody attributes included	NHD

Stream Size and Connectivity

Stream size was measured using both Strahler (1952) and Shreve (1967) orders. However, in this project more emphasis is being placed on Shreve order, or link magnitude. Strahler order is widely used, but is limited in that a large number of small streams may enter along the length of a reach adding significantly to the flow, width, and complexity of a reach without a change in order. Shreve order (link magnitude) overcomes this limitation. Link magnitude 1 is equivalent to Strahler's first order. After that, at every confluence, the link magnitudes of the two streams are added (Shreve 1967). Therefore, below the confluence of a link 2 and a link 3 stream, the reach is defined as having a link magnitude of 5.

Connectivity is being measured two ways. The first involves simply identifying if the reach is part of a lake or reservoir (centerline). A code identifying the waterbody is added to the attributes of the reach. This knowledge can be important in predicting species distributions. This step is an addition to the MORAP (2005) Missouri Pilot Project protocol. The second connectivity measurement involves identifying the link magnitude or Shreve order of the reach immediately downstream.

The application of both ordering techniques and downstream connectivity used automated tools developed by the MORAP (2005). The attribution of waterbody identifiers was not automated.

Gradient

Gradient was calculated as

$$(\text{upstream elevation} - \text{downstream elevation})/\text{reach length}$$

(units are m/km). The NED (30m pixels) was used to assign elevation to the upstream and downstream nodes of each reach. In our analyses, the gradient of some reaches was calculated as "0" or even a negative value. This is particularly common in the Coastal Plain ecoregion where there is less change in elevation across the landscape. We believe that the assignment of negative or zero slopes was largely a scale or data quality issue. A method was developed by MORAP (2005) to reduce this influence. They removed streams of link magnitude 1 and recalculated gradient along these new reaches defined at confluences of larger streams. This gradient calculation was then assigned to all of the reaches within that length. While this did reduce the number and magnitude of negative slopes, it did not eliminate the problem (Table 2.6).

Table 2.6. Gradient statistics for the James River before and after the gradient fix.

	Number of Arcs with Negative Gradient	**Minimum Gradient**	**Maximum Gradient**
Before fix	1991	-373	944
After fix	293	-23	125

Geology

Bedrock and surficial geology, including soils, strongly influence the water chemistry and hydrology of a stream. Dissolved calcium can be a limiting factor in the distribution of many aquatic organisms, mollusks and crayfish in particular. We have received a draft GIS dataset of the bedrock geology/lithology of Virginia (1:500,000) (Johnson et al. 2000). The USGS has created a summary classification of bedrock geology into rock type or lithology. The lithological classification incorporates information on mineral composition and grain size, and is meant to provide a level of data more appropriate for applications like biological modeling. Researchers at UVA have further summarized these into five classes: siliceous, argillaceous, felsic, mafic, and carbonate (Sullivan et al. 2002). Because their intent was to identify classes important to aquatic biota, we used these classifications and maintained a link to the original USGS data for any refinements. Each reach in the NHD was assigned an attribute of dominant geology using an automated tool developed by TNC (2000). This tool assigns an attribute from a polygon to a line based on the polygon containing the greatest proportion of the length of the line. While this can be helpful in describing proximate geology to a reach, it does not take into account the characteristics of the entire watershed, which may have a stronger effect on the reach than the immediate surrounding geology.

Temperature

Stream temperature has been identified as another important factor to predict species distributions. However, it is difficult to predict in a landscape scale classification. We have included reach elevation (in meters) as a surrogate attribute for temperature (USGS 2003). Attempts to assign temperature categories (cold vs. warm) based on some threshold of elevation proved difficult. It appeared that the threshold was different across watersheds and ecoregions. Therefore, the reach elevation value was included without added interpretation.

Stream Types

Once the reaches were attributed, we divided the continuous variables into meaningful categories. After some literature review and preliminary analyses of the data, the expert team was contacted again for comment. We recognize that there may be some differences among EDUs with respect to these categories and the range of values encountered. However, the expert team did not feel those differences were strong enough to warrant any further breakdown beyond statewide categories. We decided upon five categories for size, six categories for connectivity, and four categories for gradient (Table 2.7, Figures 2.6-2.8).

Table 2.7. Aquatic habitat classification categories used for continuous variables.

Category	**Range of Values**
Size	Link magnitude
Large river	> 999
Small river	200 – 999
Large stream	50 – 199
Stream	3 – 49
Headwater	1 and 2
Connectivity	Downstream link magnitude
Connected to large river	> 999
Connected to small river	200 – 999

Category	**Range of Values**
Connected to large stream	50 – 199
Connected to stream	3 – 49
Connected to headwater	2
Disconnected	Null and [Disconn] field=1
Gradient	Rise over run (m/km)
Very low	</= 4
Low	4 – 15
Moderate	15 – 40
High	> 40

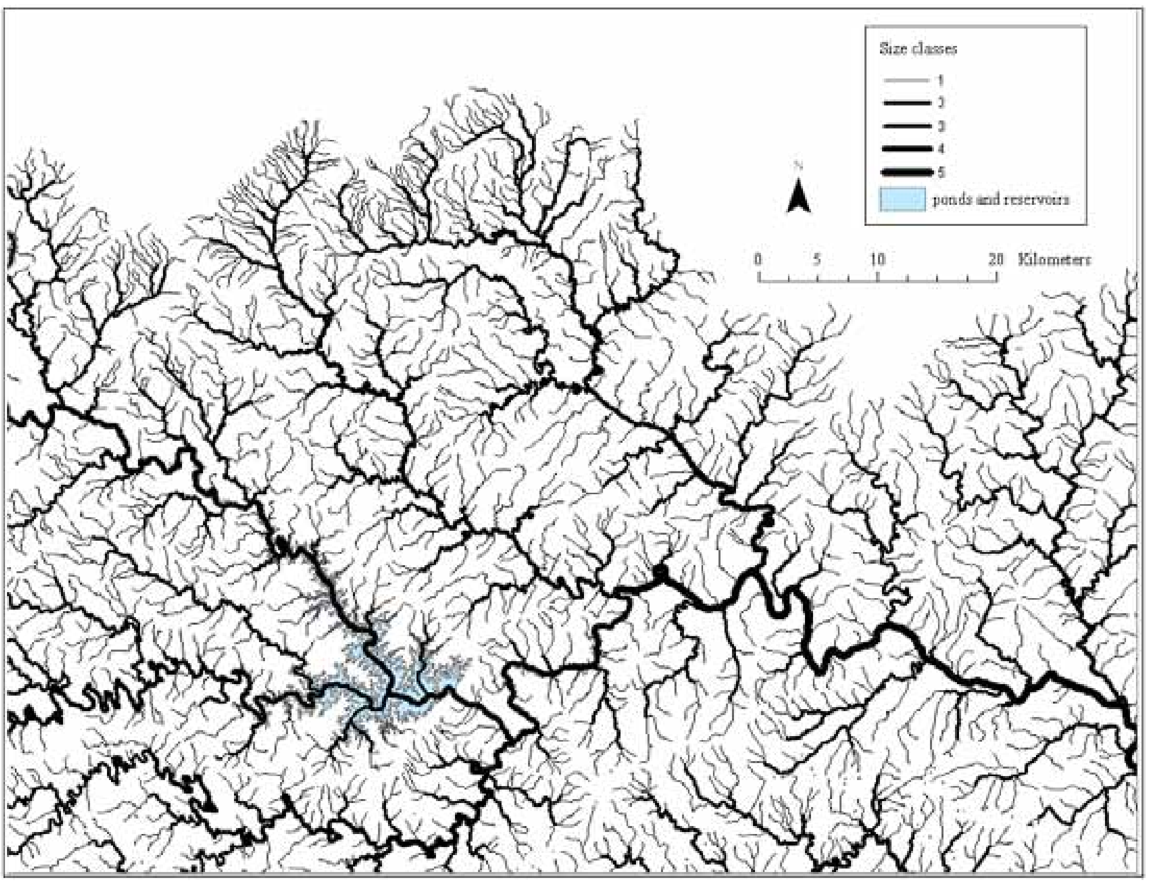

Figure 2.6. Size classes assigned to streams in a section of the Roanoke River drainage.

To develop stream types, the categorized attributes of size, connectivity, and gradient were combined. Whether the stream represented the centerline of a lake or other waterbody was also indicated. Therefore, there are 230 possible streams types, though some do not occur in Virginia (e.g., high gradient large rivers). Proximate geology was not included at this time because the relationship with the reach and confounding effects of watershed geology are not easily separated. This typing allows for a description of habitat diversity at several scales. Even within a small section of a watershed like the Roanoke, 32 stream reach types can be found (Figure 2.9).

There are three USGS HUCs for which classification was not completed in time for use in this project. These are the Albemarle-Chowan (03010205), the Great Wicomico-Piankatank (02080102), and the Lynnhaven-Poquoson (02080108). The Albemarle-Chowan is in far southeastern Virginia and includes

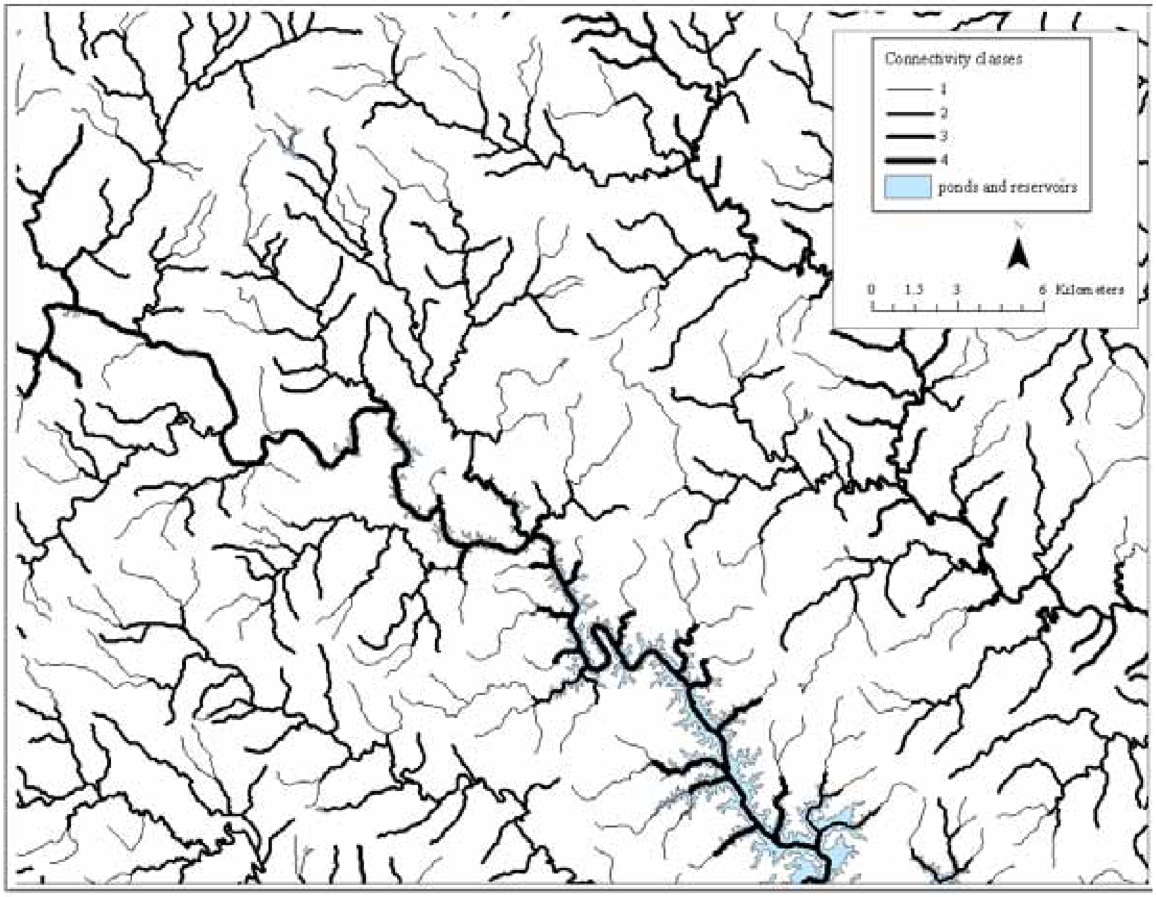

Figure 2.7. Connectivity classes assigned to reaches in a section of the Roanoke drainage.

Lake Drummond. The hydrology in this area is highly modified with abundant canals and ditches, as well as natural wetlands. Therefore, the flow direction is difficult to ascertain and the automated tools used in other sections of the state could not be used. The other two HUCs both encompass small tributaries of the Chesapeake Bay. The structure of the HUCs is such that they contain more than one tributary of the Bay, meaning there were multiple pour points, or connections, to the Bay within each HUC. As with the altered hydrology, this situation makes use of the automated tools difficult. These HUCs will most likely have to be classified manually.

Species-Habitat Relationships

A database of species collection records is maintained by DGIF (Collections, DGIF 2004c). Many of these records come to DGIF through the scientific collection permitting process. Using ArcMap®, records from Collections were connected to the attributed reaches, allowing for remote characterization of the species' habitats (Figure 2.10). We recognize that some Collections records may not have been assigned to the correct reach because of scale issues or other errors within either dataset. All Tier I species reach assignments were reviewed for obvious errors; however, a thorough review of all reach assignments was not possible in the timeframe of this project. This should be completed if more advanced modeling is undertaken.

Once the connections were complete, we exported the data to Microsoft Excel® 2000 spreadsheets and pulled out the reaches for each species (Microsoft 1999b). The attributes of these reaches were then examined for patterns in size, connectivity, gradient, reach elevation, and whether it was a waterbody. We also looked for possible differences between drainages if a species was found in more than one. See Section

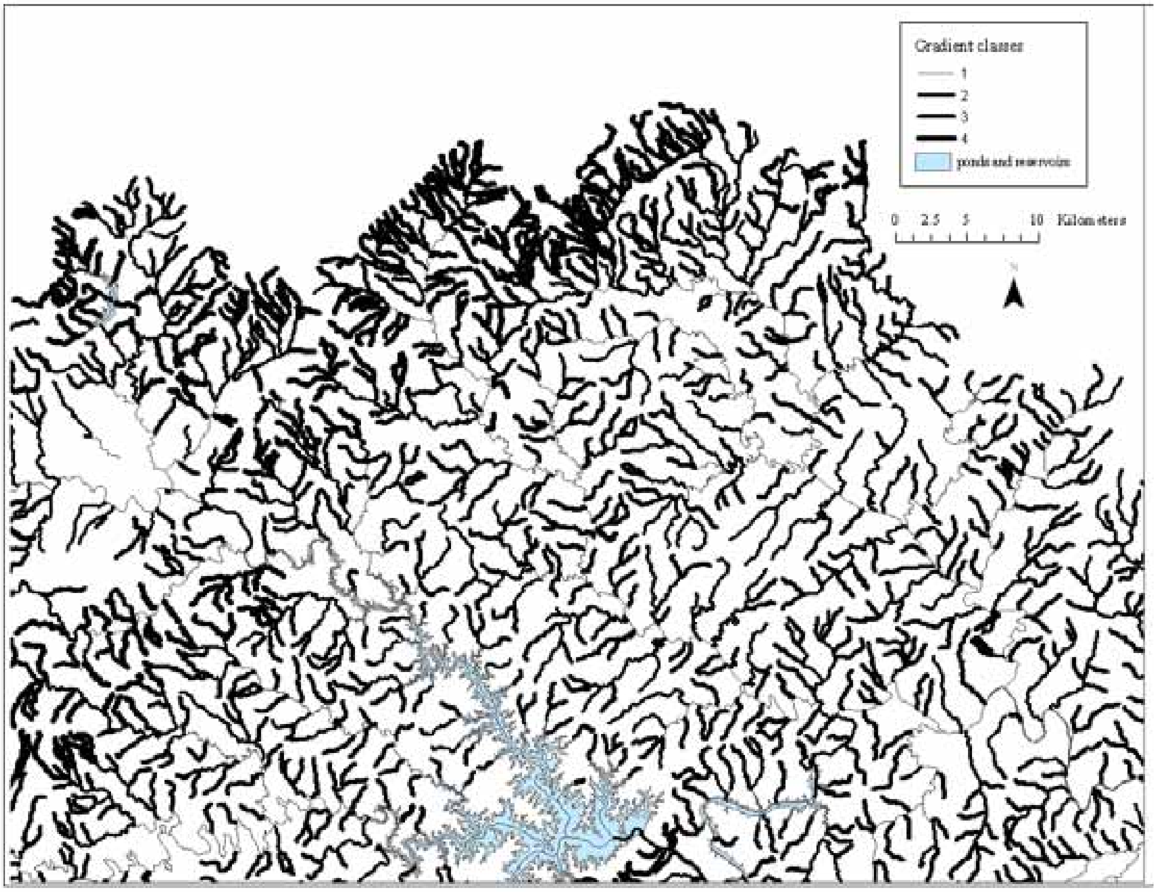

Figure 2.8. Gradient classes assigned to reaches in a section of the Roanoke drainage.

2.4.6 for discussion regarding the use of these data in producing known and predicted maps for the species of critical conservation need.

For all species, we looked at the range and frequency of types used by each within each EDU. Then we placed the species into a habitat group comprised of one of more stream reach types. In many instances, types were combined if the patterns suggested they should be. For example, several species in an EDU occurred in types 221, 231, and 331. These were combined into the habitat group, very low gradient small to large streams. A species was placed into a group if more than 60% of the reaches used by that species were within that group and no one type made up more than 20% of the remainder. We indicated for each species in a group the percentage of reach records for that species in this habitat group, the number of DGIF classification types in which the species occurred, and the number of occurrences if fewer than 10. The data used for this analysis may be biased as habitats are not sampled equally. Many more small to large streams are sampled than large rivers or even headwaters. We may also be missing habitats used by the species during different life stages or seasons. Therefore, more specific sampling regimes may be needed to truly characterize the habitat requirements of these species.

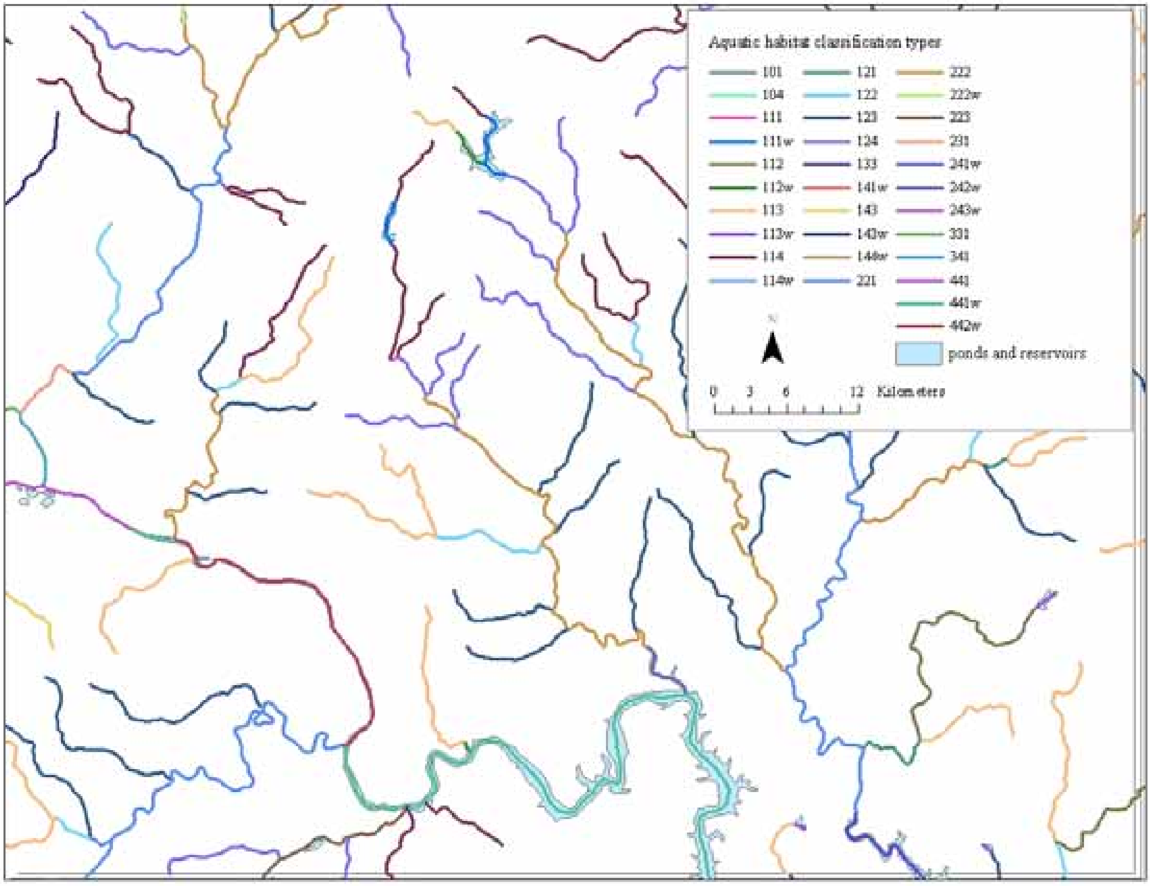

Figure 2.9. The aquatic classification types assigned to the reaches in a section of the Roanoke drainage.

2.4.5. Terrestrial Habitat Groupings

In choosing terrestrial habitat groupings, two concerns needed to be addressed. The first concern is that we needed to choose habitat groupings that are precise enough to be useful to managers. The second concern is that we preferred to use habitat groupings that are general enough to allow us to map them reliably. For example, simply using "Forest" would not meet the first need, since many different types of forest exist, each of which contain their own biological attributes. However, using "Beech-Maple" would not meet the second need, since it is difficult or impossible to identify such a precise habitat within our present datasets.

To meet both of these needs, we chose the terrestrial habitat types discussed in Sections 2.4.5.1-5. Our hope is that, by combining our habitat groupings with ecoregions and the Place variable (Section 2.4.3.1), enough resolution is provided to land managers.

Within each group of habitats, a group of species labeled "generalists" is often listed. Generalists are species that, within that ecoregion and Place, occur in all of the subtypes within that habitat type. For example, a forest generalist would occur in deciduous, coniferous, and mixed forests. If a species occurs in more than one but not all of the subtypes, it is listed individually within each of the subtypes in which it occurs.

Within each ecoregion, Tier I – IV species appear in tables by major habitat groupings, then by subtypes. For each species, a short textual description of specific habitat needs is provided as well. For instance, within the Coastal Plain Forest, brown-headed nuthatch *Sitta pusilla* is listed in the "Coniferous" table (Table 5.7). However, this species requires a specific type of Coastal Plain coniferous forest, so the "Special Habitat Needs" column indicates that this species needs pine savannah.

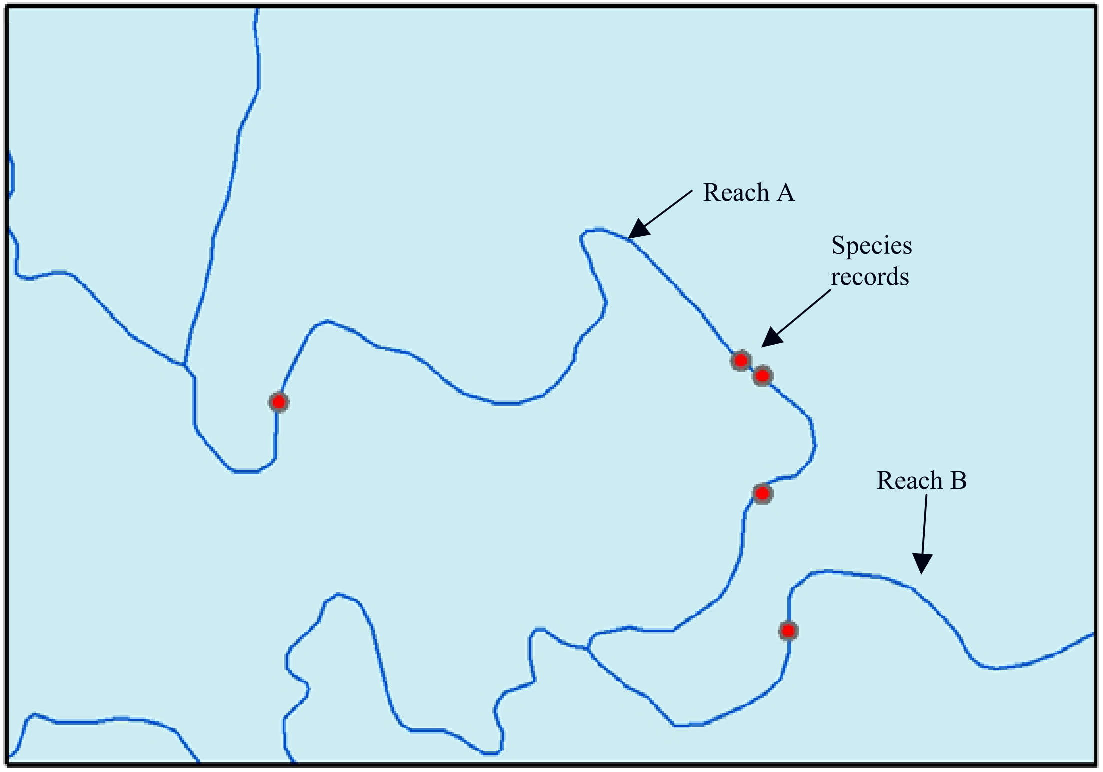

Figure 2.10. Connection of Collections records to the attributed reaches (DGIF 2004c).

Some habitat types have received special consideration due to their importance to tiered species, or due to their unique interactions (or lack thereof) with surrounding habitats. For instance, caves are considered their own habitat type, without consideration of the surrounding upland cover, even though some species may use both the cave and the surrounding matrix.

Vernal pools also received special consideration. While we recognize that vernal pools are crucial to the life cycles of many organisms, we chose to associate these species with the upland matrix with which they are associated during most of the year. We then indicate within the "Special Habitat Needs" for Tier I – IV, and within the Life History Summary for Tier I species, when a species needs vernal pools within their primary habitat. We feel that this more realistically (and usefully) indicates the habitat needs for these organisms.

2.4.5.1. Forest Habitat Subtypes

Forest occurs throughout Virginia, in every ecoregion and in every Place. It has been divided into three subtypes. The "Forest" habitat type includes periodically-flooded bottomland forest, but not semi-permanent to permanent forested wetlands (see Section 2.4.5.3, "Forested Wetlands"). In terms of age, "Forest" includes areas that contain trees that are predominantly larger than saplings, while areas of newly regenerating forest (sapling or younger) are included in the "Scrub Open" subtype (Section 2.4.5.2).

Deciduous Forest

The "Deciduous Forest" subtype includes forested areas that are predominantly hardwoods, though some conifers may be present.

Coniferous Forest

The "Coniferous Forest" subtype includes forested areas that are predominantly conifers (pines in most of Virginia), though some hardwoods may be present.

Mixed Forest

The "Mixed Forest" subtype includes forested areas that are fairly equally divided between conifers and hardwoods. This is a very common habitat type in Virginia, as hardwoods have invaded many areas that were historically fire-maintained pine forests.

2.4.5.2. Open Vegetated Habitat Subtypes

Open Vegetated

This subtype refers primarily to grassland, including native grassland, pastures, and highly managed grasslands, such as extensive mowed areas at airports. These areas contain little to no woody vegetation; any such vegetation is widely scattered across the habitat.

Open Scrub

This subtype refers primarily to regenerating old fields and clearcuts. The main vegetation is tall grasses and forbs with a significant shrubby and/or woody component. If this refers to a regenerating clearcut, most trees within the habitat are no larger than sapling-sized.

2.4.5.3. Wetland Habitat Subtypes

Emergent

"Emergent Wetland" refers to wetlands with a significant component of vegetative cover, such as cattails, sedges, or rushes. There may be some small, widely scattered trees or shrubs or open water.

Forested

"Forested Wetland" refers to wetlands that are largely forested. They may contains some small open patches. This generally does not include patches of forest that are only occasionally flooded, but rather semi-permanent to permanent wetlands with predominantly forest cover.

2.4.5.4. Barren Habitat Subtypes

Beach

"Beach" in Virginia is largely relegated to the Coastal Plain, in terms of its use by tiered species. This could also include similar adjacent habitats, such as tidal mudflats.

Balds

"Balds" refers to rocky balds, since grassy balds are included in the "Open Vegetated" subtype and heath balds are in the "Open Scrub" subtype. This is a rare habitat type in Virginia, occurring only in the mountainous areas of western Virginia.

Developed

Developed areas are a subtype of Barren habitats. Many tiered species occur secondarily within developed areas, especially residential areas.

Other Barren

A wide variety of habitats are considered within the "Other Barren" subtype, most of which are very specific and widely scattered. These include sand pits, quarries, and other unvegetated habitats.

2.4.5.5. Subterranean Habitat Subtypes

We have not used a "Subterranean Generalist" subtype. All species occur in one or both of the following subtypes.

Cave

Organisms that utilize caves during a significant portion of their lives are included in this habitat subtype. Some of these species, such as Indiana myotis *Myotis sodalis*, only spend part of their lives in caves, while others (including many invertebrates) are cave-obligate throughout their lives. This subtype includes species without regard as to whether they are terrestrial or aquatic within the cave.

Groundwater

Virginia is home to a group of apparently rare groundwater-obligate, or phreatic, invertebrates. Some of these species also have been found in caves; where that is the case, those species are listed in both subtypes.

2.4.6. Mapping Habitat for Tier I Species

One requirement of the CWCS is to describe the locations of key habitats essential for SGCN. First, we determined what the "essential" habitats are for these species. Then, we attempted to spatially depict where in the state those habitats occur. While we planned to map only what is "essential habitat," in most cases, we were not able to be that specific. As will be explained in more detail, we were limited by available data and in some cases, basic life history information. This resulted in mapping known occurrences and areas considered potential habitat that ideally included, but were not limited to, what is "essential." Because there are such a large number of SGCN (925 total), it was not feasible to carry out this process for all species. Thus, we only attempted to describe in detail and map habitats for the ninety-three species of critical conservation need, or Tier I species.

We defined "essential habitat" as "habitat features critical for a species' viability." This may include any or all stages in a species' life cycle. Habitats were considered essential only if they were more than occasionally used and not merely preferred habitat. For habitat limited species, the limiting factors would be considered essential. As will be described in more detail, habitat characteristics may or may not be able to be mapped.

We outlined a general process for identifying and mapping habitat for the Tier I species. The steps in this process included: compiling a habitat narrative, translating the narrative into spatial data, sending this information to expert reviewers, editing species' models based on review and mapping the habitat. This was a dynamic process so the steps were not necessarily followed in a linear fashion, and often multiple iterations occurred.

The essential habitat narrative for each species was based on expert knowledge, scientific literature, NatureServe Explorer Online Encyclopedia (NatureServe 2004) and BOVA (DGIF 2004b). The habitat narratives were as specific as possible, focusing on habitat characteristics determined to be critical to each species. Where possible, we translated this habitat description into spatial data, and specific data layers and parameters were assigned. The data layers used in this process include the following:

- USGS National Land Cover Dataset (NLCD), based on classification of Landsat TM imagery at 30m resolution (USGS 1992)
- NLCD, based on Landsat 5 and 7 data at 30m resolution (USGS 2001)

- USFS Continuous Inventory of Stand Condition (CISC) timber stands, with data digitized from USGS 1:24,000 7.5-minute series quad maps (USFS 2002)
- Southern Appalachian Assessment (SAA) spruce-fir areas digitized at 1:24,000 scale (SAMAB 1996)
- USGS National Elevation Dataset (NED) at approximately 30m resolution (USGS 2003)
- USFWS National Wetlands Inventory (NWI), data for which is continuously updated, and metadata for which varies by quad; scale ranges from 1:24,000 to 1:63,360 (USFWS 1995).
- Tidal Marsh Inventory, data collected through site visits using aerial photography for assistance and digitized at a 1:24,000 scale (CCRM 1992).

Along with habitat variables, precise range information was compiled. For terrestrial species we defined a species' range based on county distributions included in BOVA (DGIF 2004a). For aquatic species, range was based on known or likely distribution within DCR's14-digit hydrologic units (DCR 2004) using Collections (DGIF 2004c). In addition to the above information, expert opinion was also considered when determining range for both terrestrial and aquatic species. Next, the data layers and parameters representing the habitat description, along with range, sources used and any questions or notes pertinent to that species and/or its habitat were compiled into an information sheet. Each species/information sheet was reviewed by an individual chosen by the chair of each TAC as the regional expert for that species. These reviewers, often more than one person for each species, were usually on a TAC (see Appendix E for a list of experts). Any changes by the reviewers were returned to us.

Following the expert review, we mapped the potential habitat to the best of our abilities using the range information, data layers and habitat parameters. As an example, for a species that is limited to deciduous forests above 900m, the model parameters included areas that had cell values equivalent to deciduous forest in NLCD and all values greater than 900m in NED. Parameters for aquatic species in most cases were limited to variables from the DGIF Aquatic Habitat Classification as described previously in Section 2.4.4.2. We used stream reach attributes associated with known stream habitats to extrapolate and map potential stream reaches. For instance, for a species found in reaches with a link magnitude less than ten, and an elevation less than 100m, these attributes were used to identify other potential reaches within a species' distribution.

The habitat mapping was done within a GIS. In most cases GIS projects were created, analyzed and displayed in ArcMap® 8.3 (ESRI 2004). In a few cases ArcView® 3.3 was more appropriate because of available software extensions (ESRI 2002).

We mapped potential habitat where it was appropriate and possible for each species. Species' habitats were not mapped if not enough was known about its habitat, or if its habitat needs were too specific or too general to be mapped with existing datasets. Examples where habitat characteristics could not be mapped included requirements for a particular species of plant, or ephemeral stages of habitat succession. It is not possible to map certain plant species because the data layers available are at a coarser level of detail. For instance, using satellite derived NLCD data, forested areas can be identified, but not particular tree species. Similarly, identifying specific early stages of succession would require more detail, and more frequent updates of data, because of the ephemeral nature of this habitat. Accuracy and availability of data were limiting factors, since it was not feasible to perform fieldwork to collect new data. Likewise, if species had no specific requirements, their habitat could not be depicted. In these cases, only species' confirmed locations were depicted. Similarly, for aquatic species where only a few collection records or confirmed reaches were available, we did not attempt to locate potential reaches (we displayed confirmed reaches only).

We supplemented our information to this point with DCR-NH's Natural Heritage Screening Coverage (DCR-NH 2004b, 2005). These data include information on rare, threatened, or endangered plant and animal species, unique or exemplary natural communities, and significant geologic formations. The coverage consists of Conservation Sites, including Stream Conservation Units and Karst Conservation Sites. The Conservation Sites displayed are polygons built around the species and, where possible, its associated habitat and buffer or other adjacent land thought necessary for conservation. The Stream Conservation Units (SCUs) identify the stream reaches that contain the species, including upstream and downstream buffer and tributaries associated with this reach. We also included Karst Conservation Sites representing regions of karst topography for the Tier I species that are found in caves. Each significant karst feature is buffered with a 3km radius. It is important to note that Conservation Sites may represent more than one species. This is different than our potential habitat which was designed to show the extent of habitat for only the species in question. For our species maps, we included DCR-NH data if they supplied additional location and/or habitat information to the species maps. More specifically, if the DCR-NH data was spatially redundant with our potential habitat we did not included it. Along these lines, in some cases, we were instructed by DCR-NH not to display sites for a particular species because the boundaries were drawn primarily for other species.

Species' habitats were mapped across their range unless we had documentation that specified otherwise; that is, if it was known that a species had disjunct populations or should otherwise be considered separately, the habitat was mapped accordingly. The data displayed in the species' habitat maps include points, lines and/or polygons. For terrestrial species, confirmed habitat which is based on Collections (DGIF 2004c) is shown as points, while potential habitat is displayed as polygons. For aquatic species, since collections have been assigned to reaches, confirmed habitat and potential habitat are both displayed as lines representing the reaches. Confirmed reaches indicate that somewhere in that stretch of water (in between confluences) that species has been found. Potential reaches are selected based on the characteristics of that reach, with no documented usage by the species. For both terrestrial and aquatic species, confirmed areas or locations do not necessarily represent current usage of the areas by species. Data may be several years old, which is frequently the case with species that are not often surveyed for or are hard to find. The outcome of the species' habitat mapping process includes one or many shapefiles for each species. Maps showing these confirmed and potential (where available) habitats are displayed in the results chapters for each ecoregion along with a brief description of the map contents. The specific details on the potential habitat selection can be found in Appendix D.

To highlight geographic areas of conservation importance, demonstrating one possible application of these data, we overlaid all available potential and confirmed habitat layers for all Tier I species in one map. Where potential habitat was mapped for a species, we displayed only potential and not confirmed habitat. However, in situations where both types of habitat were mapped, but some confirmed locations were outside of the area of potential habitat, then those confirmed locations were also included. This prevented coinciding potential and confirmed habitat from misrepresenting and double counting habitat presence in an area. For species for which we could not map potential habitat, but had confirmed areas, those areas were included. Overlaying these habitats allowed areas that could potentially contain multiple Tier 1 species to stand out as areas of greater significance. In addition, combining these habitat data for all Tier I species highlights habitat patterns evident within or across ecoregions. It is important to emphasize that any area with potential to support a Tier 1 species should be a priority for conservation. Areas with a higher co-occurrence of Tier 1 species' potential habitat however, may represent areas of extraordinary conservation opportunities. These maps are included at the end of each ecoregional chapter with a statewide map in the final chapter.

2.4.7. Assessing Relative Condition of Habitat

We present information on relative habitat condition at several levels.

2.4.7.1. Ecoregion

Within each Ecoregion, the amount of land cover is presented (USGS 1992, 2001). The land cover categories are discussed above in section 2.4.3.2. The amount of land within an ecoregion in a protected area is also presented. This is the area of a property within the DCR-NH Conservation Lands Database (DCR-NH 2003). Parcels within this dataset are assumed to have some conservation value. These lands may be owned by a federal, state, or local government, non-profit organization, or private citizen. Most of the privately-owned properties are lands under a conservation easement. Because this dataset includes everything from county parks to National Wildlife Refuges, there is wide variation in the priority placed on species and habitat conservation among parcels. However, the area within the Conservation Lands Database provides an indication of the amount of conservation protection in an ecoregion.

The proportion of land cover types, within protected areas, are also presented. The proportion of land cover types within an ecoregion can be compared against the proportion of land cover types represented in protected lands. These comparisons may reveal land cover or habitat types that are underrepresented in current Conservation Lands.

Ecological Drainage Unit

Many researchers have noted the cumulative and proximate effects of land use on aquatic systems (Richards et al. 1996; Roth et al. 1996; Wang et al. 1997). Agricultural land use can result in increased sediment loads, altered hydrology, pesticide and herbicide runoff, increased nutrients, temperature increases, and bank destabilization. Urban and suburban development can lead to all of the same impacts as agriculture with varying relative inputs. Increased urban development can also increase the likelihood of spills from road crossings, habitat fragmentation, and direct habitat manipulation. For these reasons, we calculated the percent agricultural and developed land use within each EDU using NLCD (USGS 1992, 2001). This analysis does not take into account the location of that land use type within the EDU. There is some controversy over whether the immediate land use or upstream watershed land use is more important in determining water and habitat quality. Because of the number of species and the time frame in which we were working, we did not have the time to address these issues for each species or habitat type. Our calculations simply identify the relative contribution of these land use types to the land cover of the EDU.

<u>2.4.7.2. Tier I species Relative Habitat Condition</u>

Information on relative habitat condition for each Tier I species is presented from several sources. Methodology differed between terrestrial and aquatic species.

Terrestrial Relative Habitat Condition

For terrestrial species, information on the number of locations from Collections (DGIF 2004c) or Conservation Sites (DCR-NH 2005), the area of potential habitat (if possible), the relative protectedness of locations and/or habitat area, and the quality of habitat locations are presented. This information was not available for all species.

The number of locations from Collections (DGIF 2004c) or Conservation Sites (DCR-NH 2005) provides an indication of the amount of known habitat. However, the number of locations is also a function of effort in observing species and their habitats and/or the species themselves. Some species have many more known habitat locations due to a large number of research projects, broader monitoring efforts, high interest, greater movement or visibility. For other species, information on their habitat may not have been sought. When available, potential habitat provides the best information on the amount of habitat available.

The amount of habitat protected or "protectedness" provides information on how vulnerable habitat may be to conversion. To assess protectedness, we again used DCR Conservation Lands Database (DCR 2003). Where possible, the area of potential habitat was calculated by clipping the potential habitat layer by Conservation Lands. If potential habitat was not available, the number of locations within Conservation Lands was presented.

Under the *Life History Summary* sections of each terrestrial vertebrate species, statewide protectedness is reported from VA-GAP (DGIF 2004a). VA-GAP used a much broader scale representation of habitat than our essential habitat used within this strategy. Within VA-GAP, habitat was based on county range and basic land cover. Conservation Lands (DCR 2003) was again used to assess protectedness. Because of the gross scale of VA-GAP habitat and statewide scope of analysis, it is not appropriate to use below range-wide assessments. In many cases, the reported statewide protectedness relates more to the amount of land protected within a species' range rather than the amount of actual species-specific habitat protected.

The quality of habitat is difficult to assess. When appropriate, we have reported on habitat quality through literature, TACs, or other observations. Information from Conservation Sites (DCR-NH 2004b) was also used to assess habitat quality. Each Conservation Site is made-up of one or more Element Occurrences (EO). Individual EOs are not presented in maps of species habitat or locations. Each EO has an associated rank; this rank is an estimate of viability or persistence (NatureServe 2002). The ranking is based on size (area of occurrence and population number), condition, and landscape context. Using these categories, DCR-NH biologists rate an EO using the letter code (Table 2.8).

Table 2.8. Element Occurrence ranks from NatureServe (2002).

EO Rank	Description
A	Excellent estimated viability
B	Good estimated viability
C	Fair estimated viability
D	Poor estimated viability
E	Extant – not assessed
H	Historical
X	Extirpated

Element Occurrences with 'H' or 'X' rankings were not used in this strategy. Only 'A'- 'D' rankings were assessed as part of relative habitat condition. Sites can be assigned a single letter code or a range of ranks (e.g. 'AC'). For more information on this ranking process, see NatureServe (2002). The assumption was made that occurrence viability is directly related to habitat quality. Therefore, we present a summary of these ranking within the Relative Habitat Condition sections. The number of excellent, good, fair, and poor EOs are presented in each ecoregion for each Tier I species.

Aquatic Relative Habitat Condition

The relative condition of aquatic habitats was assessed using data from the DEQ/DCR integrated 303d/305b report (2004). The percentage of riverine habitat in each EDU that was listed as impaired was calculated using GIS (ArcMap® 8.3, ESRI 2004). For each EDU, the length of impaired stream was divided by the total length of stream to estimate the percent of available riverine habitat listed as impaired. For Tier I species, it was noted if a large amount of known habitat for each species was within or downstream of impaired waters.

2.5. Assessing Threats, Trends, and Conservation Actions

We took a three-pronged approach to assessing stresses to species and habitats and developing conservation actions: gathering and analyzing expert opinion, reviewing available literature, and analyzing spatial and temporal trends in human population growth. This is in addition to the public input sessions described in Section 2.2.3. The team relied heavily on Salafsky et al. (2003) to develop a spreadsheet that allowed the experts to identify stresses and stressors and rank their severity and scope by species. The lists of stresses (Table 2.9) and stressors (Table 2.10) were compiled from Salafsky et al. (2003) and Richter et al. (1997). During TAC meetings, additional stresses were occasionally identified and added to the list. We defined "stress" as "any human activity or process that is causing the destruction, degradation, or impairment of biodiversity and natural processes."

2.5.1. Expert Opinion

The original intent was to have the TACs provide information for each species of greatest conservation need regarding stresses and sources of stresses, a number of statistics for each stress/source combination, conservation actions to address the stresses, needed monitoring and research projects, and conservation goals. This approach worked well for a taxonomic group with a small number of species like the mammals, where each of the 24 species was reviewed within a seven-hour meeting. However, for larger groups like the fishes (97 species) and the freshwater mussels (62 species), reviewing individual species became unmanageable. In addition, species within the same drainage or habitat type often had the same, or similar, stresses. Therefore, for all taxonomic groups other than the mammals, species were reviewed by groups developed around habitat needs or watershed distribution. A list of species by drainage (aquatic species) or habitat type (terrestrial species) was sent to each TAC prior to their meeting, allowing them to recommend adjustments to the species grouped in each habitat type or drainage.

The necessary information for each species or species group was provided by the TACs. Each TAC met in person to accomplish this task with the exception of the Invertebrate TAC. Each member of the Invertebrate TAC is a specialist in a different subset of species, so little is accomplished together that could not be accomplished individually. During the meeting, the CWG member(s) facilitating the meeting asked the following questions about each species or group of species.

- What are the top stresses and sources of stress to this species or habitat group (from the lists provided, Tables 2.9-2.10)?
- What is the scope of each stress, as far as the percent of the species' population or habitat affected (Table 2.11)?
- What is the severity of each stress (Table 2.11)?
- What conservation actions and/or monitoring and research needs are needed to address this stress, or are needed to protect these species from further decline?

Due to time constraints with most TACs, only limited information was collected regarding conservation goals. If appropriate, they also provided specific comments about a species. For example, the wood turtle *Clemmys insculpta* is affected by many stresses identified for its habitat group; however, the experts also indicated that it is affected by pet trade collection, which does not affect the rest of the group.

Table 2.9. Possible stresses on species and habitats (from Salafsky et al. (2003) and Richter et al. (1997)).

Habitat Stresses	Aquatic Stresses
Air temperature changes	Channel or shoreline alteration
Air quality changes	Dissolved oxygen regime alteration
Fire: manipulation of timing or frequency	Hydrologic regime alteration
Food supply or trophic structure changes	Nutrient input regime alteration
Habitat destruction (loss of species' habitat)	Organic matter input regime alteration [1]
Habitat fragmentation	pH regime alteration
Habitat degradation	Salinity regime alteration
Increased noise levels	Sediment load alteration
Loss of ecological functions	Turbidity alteration
Natural succession	Water temperature regime alteration
Other habitat stressor	

Organism Stresses	Toxins
Competition	Herbicides and fungicides
Complications due to small populations (stochastic fluctuation, etc.)	Insecticides
Genetic alteration (e.g., hybridization)	Metals
Intentional take (hunting, poaching, fishing, trapping, research)	Organic pollutants
Parasitism	Other toxin [2]
Predation	
Unintentional capture or killing (roadways, towers)	

[1] This is differentiated from "Nutrient input regime alteration" because "Organic inputs" refers to natural sources, such as detritus, leaves, etc., while nutrient inputs refers to artificial sources, such as livestock waste or fertilizer runoff.

[2] This refers to either a specific toxin not otherwise listed or an unspecified amalgamation of toxins, such as fuel, salt, and chemicals from road surface runoff.

Table 2.10. Sources of stress on species and habitats (from Salafsky et al. (2003) and Richter et al. (1997)).

Sources of Stress	
Agriculture	Native species
Atmospheric deposition	Non-target species management [5]
Climate alteration or atmospheric change	Other land management [6]
Economic use of species [1]	Other sources of stress [7]
Exotic or introduced species [2]	Recreational use of habitat
Forestry	Recreational use of species
Industrial: mineral extraction	Roadways
Industrial: power generation	Scientific use of species
Industrial: rights-of-way [3]	Waterway navigation
Industrial: other [4]	Unknown
Municipal development (urban, suburban, and rural residential)	

[1] This refers to commercial (but not recreational) use of a species, including harvest or the pet trade.
[2] This refers to any species that is introduced into the area in which it causes the stress, even if that species is native to other portions of the state (such as red fox *Vulpes vulpes* on the barrier islands). This category may include animals or plants.
[3] This refers to any rights-of-way, including rail, road, power, pipeline, or other infrastructure.
[4] This refers to any industrial source of stress not specifically listed above, such as miscellaneous accidental discharges and remnant mill dams.
[5] This refers to management intended to affect species other than the one stressed; this may include intended positive effects (managing habitat for one species to the detriment of the stressed species) or negative effects (unintended take of the stressed species while trying to control another species).
[6] This includes any specific land management technique other than those specifically listed in this table.
[7] This category is intended to allow TAC members to define sources not otherwise listed.

Table 2.11. Scales for measuring stress (from Salafsky et al. (2003)). "Spatial Scope" indicates the values assigned to scope when TACs considered species grouped by habitat, while "Species Scope" indicates the values assigned when individual species were considered.

	Ranking			
Variable	**4**	**3**	**2**	**1**
Spatial Scope	Throughout (>50%)	Widespread (15-50%)	Scattered (5-15%)	Localized (<5%)
Species Scope	Most or all (>50%)	Many (15-50%)	Some (5-15%)	Few (<5%)
Severity	Serious damage or loss	Significant damage	Moderate damage	Little or no damage

2.5.2. Analysis of Data from TACs

The purpose of collecting these data from the TACs was to determine the biggest threats to wildlife and to prioritize them and their associated conservation actions. We therefore needed to devise a method to analyze the input from the TACs that would enable us to rank both individual stresses and sources of stress on a statewide basis. Due to similarities within and differences between the approaches taken by the terrestrial and aquatic TACs, we elected to keep their stresses separate during this analysis.

We created a new variable (magnitude, M) based on scope and severity. If scope and severity are equal, then M is the same value. If scope and severity are not equal, M is equal to the lower of those two scores (Salafsky et al. 2003). If either scope or severity was reported to be unknown, $M = 0.5$. Reversibility was discarded for analysis, since not all threats received reversibility scores.

Using Habitat Affinity (DGIF 2005), we created queries (one for aquatic species and one for terrestrial species) that produced the number of species in each tier for every stress/source/magnitude combination (see Table 2.13 for an example). Species were separated by whether they are *biologically* aquatic or terrestrial, and not necessarily by where each species occurs in the Results section (Chapters 4-10). For instance, waterfowl occur in the terrestrial section in Chapter 5, the Mid-Atlantic Coastal Plain. However, for the purpose of this analysis, most were grouped with the aquatic species, as they tend to spend nearly all of their time in Virginia on the water (since most are wintering, and not breeding, species). Some, such as American black duck *Anas rubripes*, were included in both terrestrial and aquatic analyses, because they spend a considerable portion of their Virginia lives in each.

Table 2.12. Examples of stress/source/magnitude combinations. These examples are for aquatic species. The last four columns indicate the number of species instances in each tier affected by the combination. This is not a complete list but is only intended to illustrate the kinds of combinations that occurred.

Stress	Source Of Stress	Magnitude	Tier I	Tier II	Tier III	Tier IV
Habitat degradation	Atmospheric deposition	2	1	0	0	0
Habitat degradation	Atmospheric deposition	2	0	0	1	0
Habitat degradation	Exotic or introduced species	3	0	0	1	0
Habitat degradation	Exotic or introduced species	2	1	0	0	0
Habitat degradation	Native species	3	0	1	0	0
Habitat degradation	Recreational use of habitat	2	1	0	1	0
Habitat degradation	Source not appropriate	3	0	0	2	1
Habitat destruction	Agriculture	3	2	1	5	6
Habitat destruction	Exotic or introduced species	3	1	0	0	10
Habitat destruction	Exotic or introduced species	2	0	1	0	0
Habitat destruction	Exotic or introduced species	1	0	1	0	0
Habitat destruction	Exotic or introduced species	0.5	0	2	0	0
Habitat destruction	Forestry	2	1	0	0	0
Habitat destruction	Municipal development	4	2	1	5	6
Habitat destruction	Municipal development	3	0	1	0	0
Habitat destruction	Municipal development	0.5	0	2	0	0
Habitat destruction	Native species	1	0	2	0	0
Habitat destruction	Roadways	3	1	0	0	0
Habitat destruction	Roadways	3	0	0	2	0
Habitat destruction	Roadways	2	1	1	3	6

Using stress/source/magnitude combinations and the number of species in each tier that shared each of these combinations, we proceeded to weight each stress/source combination by magnitude and by tier. This was accomplished through the following method for each combination.

1. Multiply the number of species in each tier, Tier*N*, by its weight, *W* (Tier I = 4, Tier II = 3, Tier III = 2, Tier IV = 1). This weights each stress/source/magnitude combination by the number of species in each tier that are affected by the combination. Note that Tier*N* is not necessarily the actual number of species, but the number of species instances. This means that a species may be counted more than once, if it is assigned a stress-source combination more than once. This occurs when a species occurs in more than one drainage or habitat type. This weighting is still appropriate, because the stresses on different habitats or drainages are separate and should all be counted equally.

$$W*\text{Tier}N$$

2. Sum these products.

$$\Sigma(W{*}\mathrm{Tier}N)$$

3. Multiply this sum by magnitude, M. This weights the above score by magnitude and produces a score for each stress/source/magnitude combination.

$$M(\Sigma(W{*}\mathrm{Tier}N))$$

4. Since one stress/source combination could have more than one magnitude, we next summed the scores for all magnitudes within a stress/source combination for a final score, F, for that combination.

$$F = \Sigma(M(\Sigma(W{*}\mathrm{Tier}N)))$$

We were able to use F for stresses, sources of stresses, and combinations of stresses and sources. To rank stresses irrespective of source, we summed all final scores for a given stress. To rank sources of stress irrespective of stress, we summed all final scores for a given source.

The "Top 10" stresses, sources, and stress/source combinations for terrestrial and aquatic species appear in Chapter 4 (Tables 4.18-4.23). Complete lists appear in Appendix G.

2.5.3. Review of the Literature

Several sources of published literature proved valuable in identifying threats and developing potential conservation actions and monitoring plans for each Tier I species. The literature generally supported what the TACs reported, and filled in the gaps where there was not enough time in the meetings to gather all the desired information. We utilized Federal recovery plans for those species that are listed as Federal endangered or threatened. Final or draft State recovery plans were also available for some State endangered or threatened species. These recovery plans, along with many other publications, allowed us to augment the Tier I species accounts with additional considerations in terms of stresses, conservation actions, and monitoring needs, some of which took into account range-wide concerns in addition to Virginia-specific issues. Therefore, each Tier I species account includes the threats information gleaned from the literature and any species-specific threats identified by the TACs.

2.5.4. Spatial and Temporal Trends in Human Population Growth

Using census data, we analyzed the status and trends of Virginia's human population. It was assumed that the higher the human population density in an area, the greater the rate of conversion of natural habitat to development has been. Therefore, large increases of population density in the past represent a large proportion of habitat degradation and loss. Areas predicted to have high population growth in the future are expected to experience more conversion of natural habitat to developed areas and therefore to have a negative impact on wildlife diversity.

We used spatial data and statistics from the 2000 census to reveal the status of population density in Virginia (USCB 2003). The census 2000 block group was the spatial unit used for all analyses. Density was calculated by dividing total population by land area, in square kilometers, within each block. Data and software from GeoLytics were used to show past trends and future estimates. GeoLytics' CensusCD® provided normalized census data from 1980 and 1990 to the 2000 census block group boundaries (Geolytics 2005a). GeoLytics' and Easy Analytics Software Inc.'s CensusCD® Estimates (2004), Projections (2009), and Consumer Expenditures & Profiles provided predictions on population levels at 2004 and 2009, again using the 2000 census block groups (GeoLytics 2005b).

To evaluate past population growth, the percent population change from 1980 (earliest available date) to 2000 was calculated and mapped for each block group. To map future trends, the predicted percent population change from 2000 to 2009 was calculated and mapped. However, since relatively small increases in population can result in high percentage increases (e.g., an increase from two to four people is

100% population growth), percentage numbers alone do not indicate areas of high habitat conversion. Areas with moderate population density that are predicted to have higher than average growth are more likely to impact wildlife resources. We labeled block groups that had at least 20 people/km^2 in 2000 and are expected to grow by at least 15% by 2009 as High Impact Growth Areas. Since the average population density in 2000 was 69 people/km^2 and the population is expected to grow by 11% from 2000 to 2009, we felt that areas with more than 20 people/km^2 and with at least 15% growth are regions with high development impact.

The results of these analyses of census data are presented in Chapter 4. Maps and discussion highlighting human population status and High Impact Growth Areas at the ecoregion level are presented in the beginning of each ecoregional chapter.

2.5.5. Terrestrial Habitat Status and Trends Assessment

Trends were assessed for terrestrial habitats based on the type of habitat.

2.5.5.1. Forested Habitats

Forest Inventory Analysis (FIA) data were used to assess trends in our three generalized forest types (USFS 2001). The FIA program is administered by USFS to inventory forestland nationwide. Confidential points are surveyed and extrapolated to the state level using remotely sensed data (Alerich et al. 2004). These data points were then attributed with the ecoregion in which they occur by John Scrivani at VDOF. This allowed us to determine current forest cover (as of 2001) in each of our six ecoregions. However, due to changes made in FIA methodology over the course of the program, the data we possessed did not allow for trends to be determined on an ecoregional basis. Therefore, we used FIA trends to determine trends in forest cover at the statewide level (Scrivani and Pemberton 2003). This information appears in Chapter 3.

2.5.5.2. Open Habitats

We had greater flexibility assessing open habitat types at the ecoregional level due to the availability of NRI data (USDA 2000). This dataset contains landcover for all portions of the state not under Federal ownership, based on permanent, confidential sampling points revisited at regular intervals. Current landcover and trends (1982-1997) by open habitat type were determined by the NRCS office in Beltsville, Maryland, and provided directly to us (USDA 2000). Statewide information from NRI is provided in Chapter 3. While there are some concerns related to the statistical reliability of some of these trends, this partnership allowed us to at least describe trends in broad terms, which is done in each ecoregional chapter (Chapters 4-9). Trends information were combined for the Northern and Southern Cumberland Mountains; due to their small size, analyzing habitat trends in these ecoregions separately did not provide meaningful results.

2.5.5.3. Wetlands

Spatial analysis of any kind is not currently feasible for status or trends of wetland habitat in Virginia. Therefore, wetland status and trends were determined from a literature review on a statewide basis. Where possible, specific information on parts of the state are included, though these do not necessarily relate to the ecoregions used in this strategy. Relevant national and regional information is also included. All wetlands information not specifically related to a Tier I species is presented in Chapter 3. Information that is related directly to the habitat of a specific Tier I species may be found in the Tier I species accounts within the ecoregional results chapters.

2.5.5.4. Barren Habitats

Barren habitats in this strategy include both bare ground habitats (such as rocky balds and beaches) and developed areas. Developed urban areas are included in NRI; see Section 2.5.5.2 for details on that analysis. Developed urban area trends are reported statewide (Chapter 3) and in each ecoregional chapter.

Coastal beach areas were determined from the 2001 NLCD dataset, selecting all barren areas (USGS 2001b). This likely slightly overestimates total beach area, but is a reasonable estimate. Protected area was determined using DCR (2003).

Assessments of status and trends in other barren areas are not feasible at this time. Some information for coastal habitats, such as beaches and mudflats, is available qualitatively from the literature in Chapter 4.

2.5.6. Aquatic Habitat Status and Trends Assessment

Most of the monitoring efforts for aquatic habitats are aimed at assessing water quality. From this standpoint, there are many efforts underway. Unfortunately, most are not wide in scope or consistent in methodology making statewide or even drainage-wide assessments difficult or impossible. Also, original analyses to assess aquatic habitat trends are outside the scope of the strategy. Therefore, to address trends in aquatic habitats, we performed literature review and questioned experts as to the best available reports and datasets for this use. The results of this review are presented in the strategy.

There were a few programs that seemed most promising for current or future trends assessments: the DEQ Probabilistic Modeling effort (ProbMon, Dail et al. 2004; DEQ and DCR 2004) and the USGS National Water Quality Assessment Program (NAWQA) (USGS 2001a, 2005). Of these two, DEQ's ProbMon is the only one that is statewide in scope and is assessing quality within ecoregions. It was designed to assess chemical, physical, and biological conditions. There are also a number of citizen monitoring efforts underway that are producing data that could potentially be assessed for trends. These include the Alliance for the Chesapeake Bay Citizen Monitoring and the Izaak Walton League's Save Our Streams program.

Other assessments of aquatic habitat trends would include analyses of the impoundment of streams, channelization, stream bed alteration, and water withdrawal. We have not located any resources summarizing the trends in these activities in Virginia, but are still investigating. We report historical trends, impacts, and applicable programs in Chapter 3.

2.5.7. Subterranean Habitat Status and Trends Assessment

Subterranean habitats afford an interesting challenge. To our knowledge, the most recent comprehensive work on Virginia caves is Holsinger (1975). This and other sources, where available, were used to determine current statewide status for caves.

Subterranean habitats also include groundwater, which harbors many invertebrate SGCN. Little information is available on groundwater as habitat; however, where possible we have extracted information from DEQ and DCR (2004) and USGS summary water quality reports (Ator et al. 1998; Spruill et al. 1998; Denver et al. 2004) to determine current status of groundwater in Virginia. This information is found in Chapter 3.

2.5.8. Species Trends Assessment

For the vast majority of species, no population trend data are available. Trends are generally only available for those species that are critically endangered and very closely monitored. Trends are also available for many of the birds, due largely to the BBS program (Bird TAC 2004; Rosenberg 2004). Since trend data are not available for most species, we elected to only attempt to report such trends for Tier I species, in the context of each ecoregion chapter's Tier I species accounts. In addition, placement of the SGCN into the four tiers of imperilment also indicates in relative terms the historic and recent trends of each species' population (see Section 2.3.2).

For each Tier I species, the existing literature was examined for trend information. In addition, the TACs were consulted for any trend information of which they were aware, since many members of these committees are involved heavily in research and monitoring of SGCN.

2.5.9. Conservation Actions Assessment

One of the most critical parts of the CWCS is the identification of priority conservation actions. Actions can be prioritized using several different approaches including assessment of the threat(s) addressed, the species or communities affected, and the ease in implementing the action. Conservation actions for Virginia's SGCN are presented in three ways. One indicates the conservation actions that address the top 10 aquatic and top 10 terrestrial threats identified by the TACs. The second will present the conservation actions identified by the TACs in three prioritized tiers. The final presentation will include a listing of conservation actions from the TACs, the External Steering Committee, and the community meetings.

2.5.9.1. Conservation Actions for the "Top 10" Stresses

During the threats assessment meetings, the TACs recommended conservation actions to address the identified stress/source combinations. For each stress/source combination, we compiled appropriate actions across habitat groups within each taxon and across taxa. The conservation actions that were associated with the "Top 10" stress/source combinations for terrestrial and for aquatic species appear in Chapter 10. These were determined solely from the responses from the TACs.

2.5.9.2. Prioritizing Conservation Actions

As mentioned above, the TACs were asked during a series of meetings held in late 2004 to provide a list of actions that would address the threats they had identified and any other significant actions that would address the declines of the SGCN. As with the threats information, the actions were collected for each habitat group except for the mammals, for which conservation actions were assigned to each species.

The TACs provided dozens of conservation actions for habitats and for individual species. We consider all of the actions provided by the committee members to be of some priority. However, we decided that, given the process through which the information was gathered. we could apply a method to further prioritize these actions.

We grouped conservation actions where appropriate. Many of the actions were repetitive or could be described more generally to provide a simpler picture of conservation needs in Virginia. For example, the actions "thinning," "cut at high elevations," "lower stocking density," and "uneven-aged management" were grouped into "Alteration of current forest management regimes (thinning, high elevation cuts, lower stocking density, and uneven-aged management)". The details are maintained in the parenthetical statement.

We weighted each conservation action based on the number of species in each tier that it would affect, similar to how stresses were scored. First, for each conservation action, the number of species in each tier addressed by that action, Tier*N*, was multiplied by its weight, *W* (Tier I = 4, Tier II = 3, Tier III = 2, Tier IV = 1). Then these weighted sums were combined to determine the action's score. These scores were then separated into aquatic and terrestrial conservation actions and broken into three prioritized tiers. The tiers were created in the same manner as for the species of greatest conservation need, using Jenks optimization method in ArcView® 3.2. Three tiers of conservation actions were created: highest priority, high priority, and priority.

The actions were also categorized into one of eight categories: coordination, education, enforcement, habitat management, land protection, planning, regulations/policy/law, and species management. The final products are lists of tiered conservation actions for terrestrial species and aquatic species grouped by action category (Chapter 10).

2.5.9.3. Concatenated List of Conservation Actions

As described in previous sections, conservation actions were gathered from TACs, the ESC (Section 2.1), and the public (Section 2.2.3). These conservation actions were combined or generalized where appropriate as described above. The actions from all three sources were combined into one list and is provided in Chapter 10 as the complete list of actions with an indication of the source of the action (i.e. TAC, ESC, and/or public).

2.5.9.4. Specific Actions from Education and Outreach

A critical part of most successful conservation efforts is education and outreach. Education and outreach promote long term support of existing and new programs through increased understanding and appreciation for wildlife, its habitats, and our connection to both. We felt it was important for a comprehensive strategy for wildlife to include a detailed description of education and outreach needs.

Jeff Trollinger and Lou Verner of DGIF's Watchable Wildlife program developed a list of specific actions that would address the educational needs identified by the ESC and the TACs. This list was distributed amongst other DGIF educational staff and education and outreach staff of other agencies. Their comments were incorporated as provided. These actions are at a finer level of detail than most of the actions provided by the other groups. Therefore, they are presented in their entirety in Appendix M.

2.6. Research and Information Management Needs

Members of the TACs provided recommendations for needed research pertaining to the SGCN, threats, and habitats. These are presented in Chapter 10. In addition, within the Tier 1 species accounts in each ecoregional chapter, there is a section on research and monitoring needs for that species.

From the beginning of this project, there has been recognition at both the state and national level that there are many gaps in information management. In fact, the Organization of Fish and Wildlife Infromation Managers (OFWIM) has made several recommendations to improve information management related to the CWCS. These recommendations will be presented and addressed in Chapter 10.

2.7. Monitoring and Adaptive Management

We gathered information on existing monitoring programs from DGIF biologists and ESC members. These monitoring programs are implemented by DGIF and other natural resource organizations throughout the state. Some are statewide in focus; others are long term monitoring programs in place on specific landholdings. We also developed a list of widely accepted texts documenting methods to monitor different taxonomic groups. Lastly, we put together a framework for practitioners of the strategy to develop monitoring plans as conservation actions and research projects are implemented. This information and additional details of DGIF's plans for monitoring and adaptive management are presented in Chapter 10.

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