Putting Conservation on the Map:
Benefits, Challenges, and Recommendations for the State Wildlife Action Plans

By Sarah Levy

I. Introduction

In 2000, Congress's ratification of the State Wildlife Grants Program led to the creation of the State Wildlife Action Plans (also known as Comprehensive Wildlife Conservation Strategies).[1] These plans detail, on a state-by-state basis, species of greatest conservation need, priority habitats, threats, research needs, and conservation actions. The "IAFWA Guiding Principles," a set of guidelines developed by the International Association of Fish and Wildlife Agencies for state plan coordinators, recommends that states, "make the Plan-Strategy spatially explicit, to the extent feasible and appropriate, with a full complement of GIS and other maps, figures, and other graphics, as well as appropriate text to provide sufficient detail and consistency in describing species and habitat conditions, conservation needs, conservation recommendations, and other issues/actions, so it can be used effectively by all partners."[2]

Research Questions

This research paper explores the answers to the following questions:

- To what extent did the nine states examined by students in the University of Michigan seminar use Geographic Information Systems (GIS) in conservation planning and data management?
- How did mapping affect plan success, implementation, and stakeholder involvement?
- What are the benefits and challenges in using GIS in the plans?

[1] For purposes of clarity, all general reference to plans and strategies will use the noun "plans." References to a specific plan or strategy will be referred to by the name chosen by the state.

[2] "*Guiding Principles for States to Consider in Developing Comprehensive Wildlife Conservation Plans/Wildlife Action Plans and Wildlife Conservation Strategies (Plans-Strategies) for the State Wildlife Grant and Wildlife Conservation and Restoration Programs*," (International Association of Fish and Wildlife Agencies, 2002).

- To what degree are GIS systems interoperable between states?
- What can states do to enhance GIS use and improve interstate interoperability?

Methodology

I examined the plans of the nine Northeastern states—Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania—to determine the extent to which GIS was used in the plans. I also conducted extensive interviews with GIS and affiliated professionals nationwide, and utilized interviews conducted by my seminar colleagues. In addition, I performed two in-depth case studies of the mapped information in the New York and New Jersey plans, and conducted an interoperability experiment to ascertain the degree to which the spatial data from the two states could be jointly used. I put together a suite of datasets based on species location data, species densities, and habitat type. The goal was for the data sets to be suitable for use by both New York and New Jersey, and for the data models to be easily interchangeable between types of organization frameworks.

From this interoperability experiment, I produced a series of maps based on the summed area of species shared between New York and New Jersey. From these maps, I determined the location of the greatest species density, and whether such results would prove useful to GIS technicians in either state.

Finally, I developed a set of recommendations based on my collected interviews and interoperability experiment on how Plan coordinators could better make use of spatial data in the Plans, and how to improve interstate GIS collaboration.

Background

A GIS is a "computer based system to aid in the collection, maintenance, storage, analysis and distribution of spatial data and information."[3] GIS is used to show the relationships between the absolute and relative locations of features, positions of objects in space, their quantitative and descriptive attributes, and analysis and display.[4] While the outputs of a GIS are often referred to simply as "maps," these products are capable of containing and visually demonstrating a substantial amount of information. For example, a map displaying a watershed is capable of storing information about the water's quality, flow rate, soils, depths, capacity for life, and pollution levels. The map could also visually show this information as well as the watershed's relative spatial location to other geographic features.

As GIS technology has improved and become more accessible, its tools have become increasingly critical in management of the environment. Over the past three decades, legislation designed to protect public health, endangered species or habitats, or handle conflict over natural resources have mandated—either explicitly or implicitly—spatial analysis.[5] The Clean Water Act, passed by the US Congress in 1972 to restore and maintain the integrity of the nation's waterways, requires the regulation of effluent, streamflow, and point and nonpoint-source discharge. Though at the time of the statute's passage GIS was still in nascent stages, the Clean Water Act's mandate that States consider a waterway's geographic location relative to pollution sources propagated the use of GIS to meet these federal regulations.[6] Nationwide, 31 states

[3] Paul Bolstad, *GIS Fundamentals: A First Text on Geographic Information Systems*, 2nd Edition ed. (White Bear Lake, MI: Eider Press, 2005).
[4] Ibid.
[5] Ibid.
[6] "Clean Water Act (Federal Water Pollution Control Act)," U.S. Congress (1972).

(57%) chose to include maps of habitat distribution in their Plans. States that did not include mapping used databases or lists to display SGCN and priority habitats.[7]

Because GIS has become fairly commonplace, it is unclear why only just over half of the plans use spatial data. Coordinators and interviewed GIS professionals have given reasons such as challenges from privacy right groups, resource barriers, and lack of technological know-how. The relatively low usage rate, coupled with these challenges raises questions about the level of importance of GIS to statewide conservation, its applications in the Plans, and how much plan implementation could be improved with the use of spatial data.

Furthermore, the emphasis on stakeholder and interagency collaboration in the State Wildlife Action Plans has created a perceived need for innovative, GIS-based approaches to creating multi-party and interstate dialogue opportunities. The major obstacles that the coordinators have faced in achieving these goals amount to a significant lack of interoperability between state spatial data sets. Because each state has been tasked with developing its own GIS specific to its plan, coordinators have used conflicting spatial scales, classification systems, species/habitat prioritization methodology, and data model structures. These incompatible data models have nearly completely stifled discourse, data sharing, and collaborative planning between states.

[7] Jeff Lerner, Bobby Cochran, and Julia Michalak, "Conservation across the Landscape: A Review of the State Wildlife Action Plans," (Washington D.C.: Defenders of Wildlife, 2006).

II. GIS in the Northeast Region

In order to gain a better understanding of the incidence and development of GIS in Plans in the Northeast, I assessed Plans according to five benchmarks:

- *How well-developed is the GIS?* This criterion includes considerations such as scale, complexity, attention to detail, and comprehensiveness.
- *How integrated is the GIS?* While many states have made use of spatial data, some states chose not to incorporate this data into the plan itself. This lack of integration disconnects plan species, threats, and actions from their respective spatial locations, weakening the overall effectiveness of both the plan and the GIS.
- *How dynamic is the GIS?* This includes pace and scope of updates and addition of new or changing information.
- *How accessible is the GIS?* Do stakeholders have access to data? How easy is the system to use?
- *What kind of reaction has the GIS generated from stakeholders?*

These five criteria were used as guides in evaluating a plan's GIS. After evaluation, plans were assigned one of three statuses: exemplar, developing, or GIS not used. It should be noted that because many states are in the process of updating or changing their systems, this assessment should be considered a brief "picture in time" of the current state of GIS in the northeastern region.

State	How Spatial Data was Included in the Plan
New Jersey	"Exemplar" status. Plan coordinators used the pre-existing New Jersey Landscape Project as a foundation, which proved to be a successful method of plan organization and incorporation of spatial data.
New Hampshire	"Exemplar" status. Though the New Hampshire GIS project was not finished until after the plan had already been completed, New Hampshire NGOs frequently make use of the plan's GIS component. One representative from a conservation NGO suggested that the spatial data was potentially the most useful part of the plan.
Maine	"Developing" status. While coordinators based the the plan on the pre-existing Beginning with Habitat GIS, the plan did not use spatially specific habitat areas or actions for prioritization and is limited to the southern part of the State. Maine recently completed a state-wide map of focus areas.
Rhode Island	"Developing" status. While a few maps were incorporated into the plan, use of spatial data could be significantly improved.
Massachusetts	"Developing" status. Like Maine and New Jersey, much of the plan was based on a pre-existing GIS, the Living Water and BioMap projects. However, this data was not directly incorporated into the plan, and its use could be improved.
New York	"GIS not used" status.
Connecticut	"GIS not used" status.
Pennsylvania	"GIS not used" status.
Vermont	"GIS not used" status.

GIS Status: Exemplar

The New Jersey and New Hampshire plans are considered "exemplars." In addition to having the most well-developed GIS embedded in their plans, the programs are continually evolving, have received praise from stakeholders, and are accessible to the public. Perhaps most importantly, the strength of their geographic information systems has made New Jersey's and New Hampshire's plans relevant and useable in the eyes of state conservation communities.

The GIS component of the New Jersey plan is called the New Jersey Landscape Project (see Figure 1), which the New Jersey Department of Environmental Protection (DEP) developed in 1994 to create a "landscape level approach to imperiled species conservation."[8] The purpose of the Landscape Project is to provide its users with scientific information that can be integrated with planning and land management programs at multiple scales in government, as well as for non-governmental organizations and private landowners.[9]

According to a representative of a New Jersey government agency, the driving force behind the creation of the Landscape Project was the preexisting regulatory protection for endangered and threatened species provided for in the Endangered Species Act.[10] Because the protection of these species often caused complications in state planning, the Endangered Species Program (ENSP) created the Landscape Project to offer pro-active information on where potential conflicts with species habitat may occur. The Project also serves a secondary purpose of making

Figure 1 The New Jersey Landscape Project is a landscape level approach to imperiled species conservation. Above is an image of the New Jersey forests habitat.

[8] New Jersey Endangered and Nongame Species Program, "*New Jersey Wildlife Action Plan*," Trenton, NJ: Division of Fish and Wildlife, New Jersey Department of Environmental Protection, 2006.
[9] Ibid.
[10] New Jersey Division of Fish & Wildlife Representative, Telephone interview with Sarah Levy, May 11, 2007. Ann Arbor, MI.

information on the characteristics of threatened and endangered species available to the public without putting the species in danger of public collection.[11] In addition to being the basis of the plan and the regulatory standard for all NJ Department of Environmental Protection permits, the Landscape Project is used by the New Jersey Office of Smart Growth, municipal and county planners, environmental commissions, non-governmental conservation organizations, the New Jersey Pinelands Commission, and the New Jersey Highlands Council for regulatory and planning efforts.[12]

Though the Landscape Project is used by multiple agencies, its use as the foundation for New Jersey's plan creates the potential for further collaboration with participating agencies and NGO's. As a result, the plan is highly spatial, well-integrated, and possesses a detailed orientation to spatial and ecological nuances that may not have been possible without the existence of the Landscape Project. The Landscape Project also appears to be one of the most valuable aspects of the plan for stakeholders. A representative from a large New Jersey conservation NGO said that the Landscape Project possesses "the best data far and away of just about everyone around."[13]

In contrast, New Hampshire's GIS tools were significantly enhanced during the creation of its plan, and formally released in October 2006 (see Figure 2).[14] Because some of the data on the quantity and distribution of habitats was incomplete, New Hampshire Fish and Game (NHFG)—with the help of The Nature Conservancy and The Society for Protection of NH Forests—created both detailed habitat profiles and a few species location maps through multiple

[11] The Landscape Project accomplishes this by including a "species lookup table" that accompanies each habitat shapefile. For more information on species location, see the *New Jersey Wildlife Action Plan*, Attachment A.
[12] New Jersey Division of Fish & Wildlife Representative, Telephone interview with Sarah Levy, May 11, 2007. Ann Arbor, MI.
[13] New Jersey Conservation NGO Representative, Telephone interview with Sarah Levy, September 27, 2007. Ann Arbor, MI.

[14] New Hampshire Fish and Game. Wildlife Action Plan Habitat Maps CD. February 2007.

methods. It is important to note that these basic habitat location maps were not available for public distribution prior to the plan publication. The New Hampshire Natural Heritage Bureau had developed habitat location maps at an earlier time, but made the data available only to government agencies seeking permit approval or private homeowners seeking information about their individual properties.[15] Habitat locations were analyzed for known risk factors, and threats and patterns of biodiversity were compared across scales for prioritization of species of greatest conservation need. Habitat types were prioritized based on where biological and landscape impacts are highest and human impacts are lowest, thereby isolating and identifying habitats that are most likely to maintain biological integrity over time. This prioritization scheme places greater map emphasis on preserving relatively "untouched" landscapes, such as contiguous forest tracts, as opposed to areas that might be under greater development pressures but possess fewer natural resources.[16]

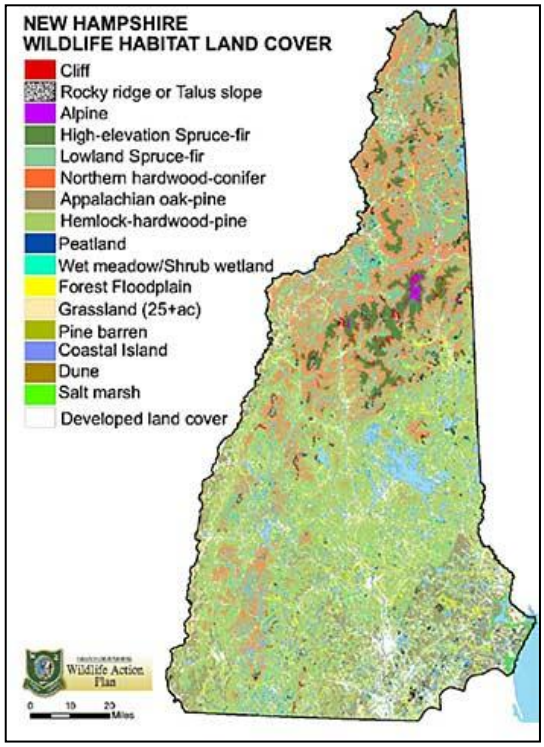


Figure 2 In the New Hampshire GIS, habitat types are prioritized based on where biological and landscape impacts are highest and human impacts are lowest.

New Hampshire NGOs and municipalities frequently utilize the GIS component of the plan. A representative from a conservation NGO suggested that the GIS component is potentially the most useful part of the plan. According to this representative, "the plan itself, the written plan

[15] New Hampshire Fish and Game Representative, Telephone interview with Michelle Aldridge, October 1, 2007. Ann Arbor, MI.
[16] New Hampshire Conservation NGO Representative, Telephone interview with Michelle Aldridge, October 10, 2007. Ann Arbor, MI.

of 1400 pages is too much for anybody to really wrap their mind around. But we use GIS constantly here in our planning work and our land conservation work. When the data became available, we were very pleased that it was essential information, particularly the habitat conditioning model."[17] The representative specifically discussed the usefulness of the mapped habitat features and statewide condition and habitat ranking to his organization.[18]

GIS Status: Developing

Maine, Rhode Island, and Massachusetts include GIS in their plans. However, the projects are either still in development or not fully integrated into the plans.

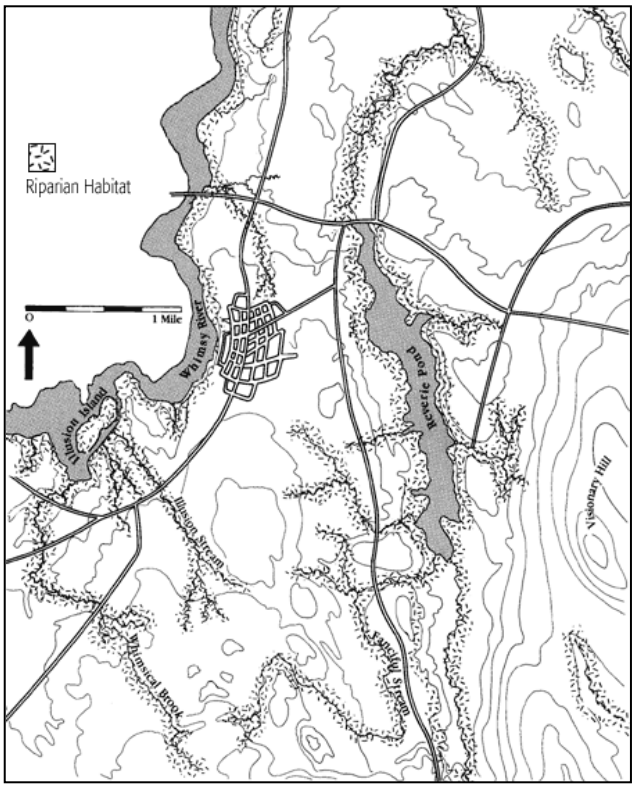


Figure 3 The above map is from Maine's Beginning with Habitat program, and depicts a riparian habitat area.

One pillar of Maine's plan is its Beginning with Habitat program, which has provided detailed GIS maps and other planning materials to local governments for nearly a decade (see figure 3).[19] This program includes the identification and mapping of spatially specified species-at-risk habitat area, which are designated based on a variety of criteria including the locations of rare flora and fauna and significant wildlife habitat and the overlap of these features with large blocks of

[17] Ibid
[18] Ibid.
[19] Maine's Comprehensive Wildlife Conservation Strategy (Augusta: ME: 2005), p. 2-4

undeveloped land. Beyond a description of this program and the inclusion of a small map of focus areas, Maine's plan did not use spatially specific habitat areas or actions for prioritization, but organized its SGCN into generic primary and secondary habitats (such as coastal wetlands).[20] While Beginning with Habitat was previously restricted to Southern Maine, the state completed a state-wide map of focus areas in place at the end of 2007.[21] The lack of spatial specificity in Maine's plan has proven to be a point of frustration for participating stakeholders. A representative from a large Maine NGO said, "what we have are long tables and lists of species and generic habitats and geographic regions of the state, which…don't have the same power as, I think, a map would have."[22]

Rhode Island created a GIS component with help from The Nature Conservancy and Doris Duke Conservation Fund grant money. A representative at a large Rhode Island NGO said the maps were "good," but that Rhode Island still needed to create focus areas, boundaries, and a better overall analysis of ecological areas.[23] According to a Rhode Island agency representative, creating the maps was "an exercise, because it was required of the plan…we just overlaid a bunch of stuff and came up with some mumbo-jumbo about priority areas, because the plan wanted that in there."[24] This individual acknowledges that the state will need to develop new GIS products because existing coverages are not sufficient.[25]

[20] Massachusetts Division of Fish & Wildlife Department of Fish and Game (MDFW), "Commonwealth of Massachusetts 2005 Comprehensive Wildlife Conservation Strategy," (Boston, MA: 2005)
[21] Maine Department of Inland Fisheries and Wildlife Representative, Telephone interview with Lauren Pidot, April 11, 2007. Ann Arbor, MI.
[22] Maine Conservation NGO Representative, Telephone interview with Lauren Pidot, April 19, 2007. Ann Arbor, MI.
[23] Rhode Island Conservation NGO Representative, Telephone interview with Joel Visser, October 23, 2007. Ann Arbor, MI.
[24]Rhode Island Department of Environmental Management Division of Fish and Wildlife, Telephone Interview with Joel Visser, September 27, 2007.Ann Arbor, MI.
[25] Ibid.

GIS Status: Not Used

New York, Pennsylvania, Vermont, and Connecticut either do not have GIS projects related to their plan, or the projects are minimal in output. Representatives of Pennsylvania's state agencies say that they decided not to create maps or priority conservation areas in part because of the difficulty in distinguishing one priority area from another. In a recent interview, representatives said "you could almost cover the entire state with priority areas, depending on which species you include."[26] Instead, Pennsylvania identifies a new priority habitat every year and calls for projects in and surrounding those sites. The priority habitat for 2006, for example, was 'Wet Thickets'. Pennsylvania relies on the mapping expertise of partners like the Nature Conservancy for spatial data.[27]

In New York, the state plan was divided into eleven Huc-4 level watersheds (see figure 4).[28] These watersheds are intended to capture the ecological variation in New York State and are used to organize species and delineate threats and conservation actions. However, there are a few major GIS-related drawbacks with New York's current organizational method. First, New York is the only state in the Northeastern region that chose to use watersheds. This makes working with other state SWAP GIS projects

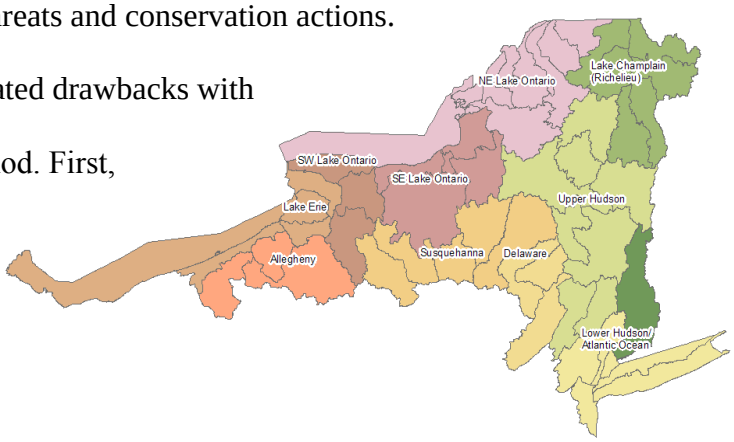


Figure 4 New York State was divided into eleven watershed sections at the "subregional" level of the United States Geological Survey's four-digit Hydrologic Unit boundaries.

[26] Representatives Pennsylvania Game Commission and Pennsylvania Game and Boat Commission, Telephone interview with Ashley Lowe, October 1, 2007. Ann Arbor, MI.
[27] Ibid.
[28] The Huc-4 watershed level represents the "subregional" level of the United States Geological Survey's 4-digit Hydrologic Units boundaries. For more information, visit http://water.usgs.gov/GIS/huc.html.

nearly impossible because the habitat and species classification is so different. One person who participated in plan development called the idea to organize the plan by watershed "harebrained" and said that it "didn't make sense biologically, climactically, demographically, or from an implementation standpoint."[29] A former coordinator of New York's Natural Heritage Program attempted to incorporate some the Program's spatial data in the plan. However, this individual's efforts were rebuffed by state agency members who were afraid of political fallout from property rights and privacy advocacy groups. According to one individual who participated in the planning process, the Natural Heritage Program has more information about wildlife in New York than any other organization or agency in the state.[30]

[29] New York Conservation NGO Representative, Telephone interview with Michael Jastremski, October 10, 2007. Ann Arbor, MI.
[30] Ibid.

III. Benefits of GIS in the State Wildlife Action Plans

Systematic Conservation Planning

Use of GIS in can lead to a more systematic approach to conservation planning, increase efficiency in use of resources, enhance flexibility and adaptability, and allow for accountability and critical review.[31] Margules and Pressey outline six distinctive characteristics of systematic conservation planning in relation to establishing biodiversity reserves, all of which implicitly assume a use of spatial analysis in setting explicit, quantitative goals and monitoring the achievement of those goals. Margules and Pressey state that systematic "conservation planning is a spatial exercise" and "essentially a matter of comparison."[32] Their metrics mention use of the GAP analysis (a method of identifying gaps among existing conservation areas[33]), and the need for more effort to be applied to mapping patterns and monitoring rates of threats.[34]

Groves, et. al, and Theobald and Hobbs more explicitly encourage the use of GIS in their respective conservation planning frameworks. Groves, et. al., developed a seven-step framework to conserve biodiversity in which two steps—assessing existing conservation areas and evaluating ability of conservation targets to persist—are based in spatial analysis. The fourth step, "assess existing conservation areas," suggests the use of GAP analysis to determine which landscape features are adequately managed in existing conservation areas, and which areas may need greater protection. The fifth step, to "evaluate the ability of conservation targets to persist," requires the use of GIS-based suitability indicators to combine value criteria and create a qualitative ranking system for priority landscapes. These suitability indexes can steer planners

[31] C.R. Margules and R.L. Pressey, ""Systematic Conservation Planning"," *Nature* 405 (2000).
[32] Ibid.
[33] Michael D. Jennings, "Gap Analysis: Concepts, Methods, and Recent Results," *Landscape Ecology* 15 (2000).
[34] Margules and Pressey, "Systematic Conservation Planning".

towards conservation areas that will have higher probability of persistence and a lower probability of managerial failure.[35] Theobald and Hobbs' framework to evaluate how planning can affect critical habitat involves the use of spatial modeling. These spatial models have three components: mapping critical habitat, creating alternative development scenarios, and generating indexes of impact indicators.[36] The common thread throughout these three frameworks is the use of rigorously established, quantitative metrics for assessing success, resilience, and value of a landscape. A GIS provides an advantage in this regard by allowing for the use of spatially-referenced suitability layers.

New Hampshire's development of GIS tools during the creation of its plan significantly enhanced plan usability and precision, and also appears to have helped conservation planners in New Hampshire understand the landscape better than before the creation of the plan. One representative of an NGO in NH said that the species and habitat profiles were "a great way of gathering all the information together for a given species and putting it through the same filters and coming up with a fairly concise summary of what we know. As a result of doing that we have fairly up-to-date summaries for distribution of dozens of wildlife species, at least the ones that are widespread."[37] In a more measured response, a NH agency representative said that while the GIS is not intended to reflect exact measurements or movements of wildlife and habitat, "Every one of these polygons has God knows how many variables attached to it that were then

[35] Craig R. Groves and Et. al., ""Planning for Biodiversity Conservation: Putting Conservation Science into Practice"," *BioScience* 52, no. 6 (2002).
[36] David M. Theobald and N. Thompson Hobbs, ""A Framework for Evaluating Land Use Planning Alternatives: Protecting Biodiversity on Private Land"," *Conservation Ecology* 6, no. 1 (2002).
[37] New Hampshire Conservation NGO Representative, Telephone interview with Michelle Aldridge, October 10, 2007. Ann Arbor, MI.

used to do this modeling and come up with conservation focus areas… it's just meant to lump things and then rank them and send us in a direction of where things are in the most trouble."[38]

Increased Stakeholder Participation

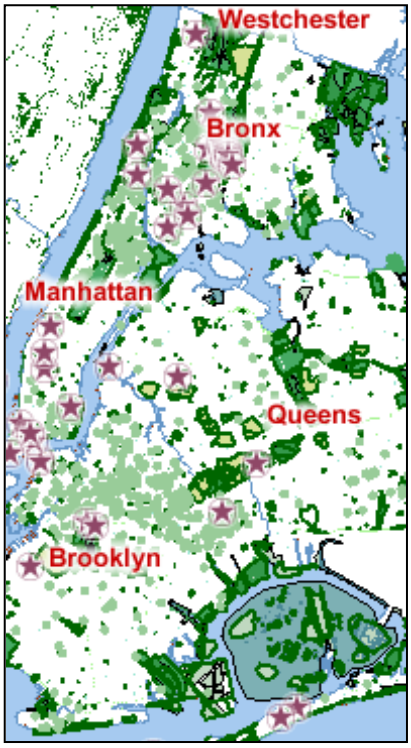


Figure 5: OASIS is an interactive mapping application in New York City that allows users to create personalized maps of greenspace in their neighborhoods.

GIS can also be a critical component of effective data distribution and stakeholder engagement. Using GIS to display policy issues with spatial implications can "persuasively convey ideas and convince people of the importance of those ideas." Distributing spatial information to involved participants can ultimately lead to improved policymaking.[39]

Using GIS to broaden public involvement in policymaking is referred to as Public Participation GIS (PPGIS). While early analyses of PPGIS demonstrated its effectiveness as a tool for advocacy groups, marginalized communities, and grassroots organizations, cutting-edge uses of PPGIS employ internet tools and open-source software to provide open access to spatial information.[40] The New York City Open Accessible Space Information System Cooperative (OASIS) is a partnership of over 30 public and private organizations, state agencies, and academic institutions to enhance stewardship of open space in New York City through an interactive mapping application (see figure 5). OASIS allows users to create personalized

[38] Representative of Vermont Fish and Wildlife,Telephone interview with Nicole Lewis, November 8, 2007. Ann Arbor, MI.
[39] Renee Sieber, "Public Participation Geographic Information Systems: A Literature Review and Framework," *Annals of the Association of American Geographers* 96, no. 3 (2006).
[40] Ibid.

maps—down to the street scale—of public land, community gardens, golf courses, superfund sites, and green markets. The OASIS website also includes a community wiki for information about partners and projects.[41]

While no state in the Northeastern region has developed a mapping system as complex or interactive as OASIS, New Jersey intends to set up a formal implementation tracking mechanism in 2008. This mechanism will be an interactive spatial database where users can enter information, learn about other projects, and adapt to other successes and failures.[42] A similar database, currently under development by Defender of Wildlife and partners called The Conservation Registry will perform a similar function, but is intended to operate nationwide (for more information on the Conservation Registry, see the "Recommendations" section).[43]

Power through Visual Representation

In addition to being a tool for data distribution and stakeholder engagement, GIS can also empower agencies, organizations, or individuals through products that effectively display priority areas, costs, and benefits.[44] One affiliate of a large, national NGO said that her organization used maps to prod state-based member organization into plan participation. The affiliate said, "[The national organization] would periodically ask us, 'How are you doing? Are you involved?' And send us a map of the states with various colors for their degree of

[41] "Oasis NYC.Net," The Graduate Center, CUNY. http://www.oasisnyc.net/ (2007)
[42] New Jersey Division of Fish & Wildlife Endangered and Nongame Species Program Representative, Telephone Interview with Sarah Levy, September 19, 2007. Ann Arbor, MI, 2007

[43] Conservation Registry, "Conservation Registry," Defenders of Wildlife, www.conservationregistry.org. (2007)
[44] Sieber, "Public Participation Geographic Information Systems: A Literature Review and Framework."

involvement. That acted in an odd way as kind of a spur – if you're not involved you should be, you're left out, you're not colored yet."[45]

When visually represented, complex data can be reduced to colors, attributes, points, and lines. While the transformation of two-dimensional data into three-dimensional data can alter its structure, the reduction of complexity in data visualization can allow a greater number of people to comprehend the information, and participate in implementation. One member of an NGO in Maine said, "I imagine…that [the maps are] galvanizing and leads to more cooperation, better synergy, and therefore more effective use of everyone's money."[46]

Maps are particularly effective for the plans when used to distribute information to small towns that may not have the technological capabilities of producing their own maps. Maine's Beginning with Habitat Program has emphasized distributing its products to local governments and organizations. An individual who works with the program said, "[Beginning with Habitat is] effective at getting the word out there. Again, we wrestle every day with how do we get more local implementation prior to significant losses of habitat and open space at the local level. It's a big one. Changing local culture is a pretty tough sell, and you just have to keep at it until you can identify local champions who can be your foot soldiers."[47]

Small cities and towns may also need help in understanding or implementing the distributed data. One member of a Vermont NGO said that while handing out maps helps, the maps are useless if no one knows how to read them. The individual said of his stakeholders, "They've asked for advice in interpreting the inventory maps. A lot of these towns do have access to GIS and a lot of our data is on a statewide server that's available to everyone. But the

[45] Maine Conservation NGO Representative, Telephone interview with Lauren Pidot, April 19, 2007. Ann Arbor, MI.
[46] Ibid.
[47] A Northeast Wildlife agency representative, Telephone interview with Michelle Aldridge, October 12, 2007. Ann Arbor, MI.

problem has been, not in the distribution of the statewide data, but the problem has been in understanding what to do with that data."[48]

[48] A Northeast Wildlife Agency Representative, Telephone interview with Michelle Aldridge, October 4, 2007. Ann Arbor, MI.

IV. Challenges to GIS Development

Intrastate Challenges

Intrastate challenges can be clustered into three general areas. **The first is the difficulty in translating priority species and habitats into spatial data.** In part this struggle stems from the desire to characterize the entire state as a priority habitat, particularly in smaller states. A representative from a state agency in Massachusetts said, "we have such a small state that [all areas are] important to someone, to some set of species somewhere. And that's my way of telling you that we don't have a list of priorities."[49] The representative continued on to say that Massachusetts stresses biological diversity as a goal as opposed to individual species and habitats.[50]

However, such prioritization is necessary for systematic conservation planning, write Theobald and Hobbs,

> *Even though an entire county or planning area may contain habitat, rather than 'painting the whole county red,' areas need to be targeted on the basis that their loss would limit the abundance and or presence of species. In fact, identifying areas that are not important to maintaining biodiversity often is an effective strategy. Identifying which areas to protect relies on clearly defining the species and goals for species that should be protected.*[51]

If a state's plan coordinators felt skittish declaring some areas to be priorities and others not, could they have "painted the whole county"—but in different shades of red? Coordinators could have developed different categories of priorities, even as simple as "priorities in urban

[49] Massachusetts Division of Fish & Wildlife Department of Fish and Game Representative, Telephone interview with Edalin Michael, April 26, 2007. Ann Arbor, MI.
[50] Biomaps and Living Waters, the geographic databases associated with the Massachusetts plan, do prioritize by "core habitat" and "supporting habitat." However, the Massachusetts plan itself does not have a list of priorities.
[51] Theobald and Hobbs, ""A Framework for Evaluating Land Use Planning Alternatives: Protecting Biodiversity on Private Land"."

areas," "priorities in exurban areas," and "priorities in rural areas." Theobald and Hobbs seem to emphasize that the importance of systematic conservation planning lies in the specificity of the targets as opposed to the nature of the targets themselves.

Difficulty in prioritization is also due to reluctance by coordinators to "narrow" focus areas because of a desire for flexibility and fear of excluding potential partners. One state agency representative said of his state's minimal GIS use,

> *We have not defined focal areas to this point. I don't know that there's any reason to do that. I mean, in some ways I don't want to formalize drawing rings around areas. You know part of my approach in writing the plan was to put enough stuff in there that we have enough flexibility to do anything that was important as the need came up, so in one way that is why we did not prioritize. And realistically, in terms of expenditures and funding, we're only going to be able to spend state wildlife grant funding with people who have match. So there's almost no point in prioritizing right now because our ability to do something is going to be dictated by circumstances that are not biological. So that's why it was very soft, I mean, a laundry list, but no prioritization. That was done intentionally.*[52]

This "laundry list" comment was repeated often in interviews with both coordinators and stakeholders in the Northeast. Stakeholders seemed to both appreciate and resent the lack of prioritization—saying that it made implementation more difficult—while coordinators seemed to believe that creating an all-encompassing plan would improve conservation in their state. The discordant viewpoints on this strategy—broad and inclusive on one end of the philosophical scale, versus specific and potentially exclusive on the other—pose somewhat of a circular dilemma for plan coordinators. The breadth that the plan coordinators intend to be interpreted as flexibility and inclusiveness, stakeholders perceive as lack of practicality. The more tailored the goals, the narrower the audience; as goals grow more extensive, the plan becomes more inclusive

[52] Rhode Island Department of Environmental Management Division of Fish and Wildlife, Telephone Interview with Joel Visser, September 27, 2007. Ann Arbor, MI.

at the expense of guidance grounded in concrete actions (and thereby losing potential audience member seeking more meticulous instruction).

Another oft-repeated barrier to developing GIS projects is political resistance. In Maine, the northern two-thirds of the state is predominantly owned by large land holders, particularly timber companies. In northern Maine the prospect of spatially specific priority maps are considered with a high level of suspicion, though focus areas are currently being identified and mapped for this region. A representative from an NGO in Maine described the reasons it has taken the state nearly a decade to expand this program to the northern reaches of the state,

> *It's such a different landscape, different ownership, different land use, different pressures and threats…In the southern part of the state you can have a generic blob that may cover parts of three towns and say this is an important area… its not threatening. But you put the same size blob in northern Maine and it may end up being all in one forest company's ownership. So it's a very different thing. That's very threatening.*[53]

Property rights concerns were also mentioned by people associated with the plans in New York and Vermont. One stakeholder in Vermont said that the plan development process was extremely productive until the discussion moved to the development of spatial data. This individual claimed that some elements of state government and wildlife stakeholder groups thought that maps would be inappropriate, and the conservation and momentum that had built up around plan development subsequently broke down.[54]

A representative of a national NGO that specializes in GIS and conservation said that opposition to mapping because of property rights concerns may be a less significant issue if a more "personal" approach is taken in data gathering. The representative cited an experience she

[53] Maine Conservation NGO Representative, Telephone interview with Lauren Pidot, April 19, 2007. Ann Arbor, MI.
[54] Representative of Vermont Conservation NGO, Telephone interview with Nicole Lewis, October 29, 2007. Ann Arbor, MI.

had doing survey work for the Natural Heritage Program in northern Michigan. She said that though the Upper Peninsula is a "stronghold" of property rights activists, she encountered "a really high percentage" of people who her permission to gather data on their land. The representative said that the property owners almost never placed a restriction on how the data could be used, and were curious about the results of the survey. She also said that an active property rights movement in a state could pose more barriers, but ultimately, gathering data is about "how it's handled, how it's presented, and how you talk about it."[55]

Interstate Challenges

The main impediment to GIS collaboration is embedded in the Congressional edict that each state was responsible for developing its own plan. **As a result, each state also developed—or did not develop—its own GIS, complete with individual standards, data systems, and scales**. Each state also has varying capabilities for developing GIS. The states in the northeastern region that had GIS that pre-dated the creation of their plans—Maine's Beginning with Habitat program, Massachusetts' BioMap and Living Water, and New Jersey's Landscape Project—had a distinct advantage over states without pre-existing GIS. The only state in the Northeastern region that developed a GIS at the same level of comprehensiveness as the aforementioned states during the creation of its plan is New Hampshire. One state agency representative said said—in comparing her state's relatively rudimentary GIS system to a state's that was more advanced—"You need to understand that [the other state was] doing that spatial analysis for different reasons much in advance of writing their plan… So what they're doing is great, and it may be

[55] National Conservation NGO Representative, Telephone interview with Sarah Levy, October 23, 2007. Ann Arbor, MI.

that we get to that point because we're in the process of updating our statutes on threatened and endangered species, but we're definitely not there right now."[56]

For states that have GIS, data must be somewhat comparable in scale and classification systems in order to be truly interoperable. For example, New Jersey's data is mapped at the 1-meter by 1-meter scale and hand-digitized. No other state in the Northeastern region has a GIS project that comes close to such fine-scale mapping. Representatives of a New Jersey state agency said that they are not particularly interested in coarse scale data from neighboring states, because it would be difficult to work into The Landscape Project.[57] The representative from the aforementioned national conservation NGO cautioned that despite being possible, spending time pairing incompatible data may not ultimately prove useful,

> *One of the big no-nos and big dangers of GIS analyses is putting things that were developed at different scales together and trying to analyze it…*
> *"You suggest that the more general information can tell you something more specific than it can really tell you. You may even draw those conclusions. It's similar to, if you have data with an uncertainty factor associated with information, if you draw conclusion that are certain within a 5% range of data that's uncertain within a 10% level, your conclusions don't mean anything. They might look good, but they won't mean anything. Similarly, if you have that was developed at the 10 square mile level, and you interface that with data at a 1m level, that's inappropriate. You can take your 1 m layer back up to 10. But you would have wasted a whole lot of machine memory in the process.*[58]

However, the importance of scale accuracy is context-driven, and dependent on the use of the GIS. For scientific surveys of plant species, or GIS used for engineering purposes, the use of comparable scales can be critical for precise policy analysis. However, if a GIS is primarily used

[56] New York Department of Environmental Conservation Representative, Telephone interview with Michael Jastremski, October 9, 2007. Ann Arbor, MI.

[57] New Jersey Division of Fish & Wildlife Representatives, Telephone interview with Sarah Levy, October 3, 2007. Ann Arbor, MI.

[58] National Conservation NGO Representative, Telephone interview with Sarah Levy, October 23, 2007. Ann Arbor, MI.

for less scientific purposes—as a tool for interaction or entertainment—then analogous scales may be of a lesser priority than strength of the interface or user-friendliness.

States also must be willing to share data. Aside from conventional concerns over ownership of information, states have expressed hesitancy to share information because of the sensitive nature of publicizing locations of endangered species. As a part of this collaboration project, the New Jersey Natural Heritage program was contacted in order to procure data for comparisons with the data from the New York Natural Heritage program. At the time of the writing of this paper, the data had still not been released. The representative from the national NGO said, "New Jersey…worries a lot about exploitation of information, so they don't want information very available. The number of instances and people using it to find orchids to dig up is probably an undocumented number to start with, but I'm sure you could count them on one hand. And how much damage has been done by not sharing information?"[59]

Willingness to share may also be dependent on the use of the GIS for regulatory or planning purposes. Representatives from a New Jersey state agency discussed that because the Landscape Project is mainly used for regulatory purposes, it would be difficult to share that data across state lines, because other states would have different regulations. On the other hand, they cited an example of how New Jersey caught a bobcat and put a GPS collar on it. The cat crossed the Delaware River twice into Pennsylvania. If Pennsylvania has a trapping season for bobcats, "and the cat is crossing state lines, then I think there needs to be collaboration."[60]

The Landscape Project emphasis on species citing for regulatory purposes as opposed to active conservation work has led to various critiques from individuals working in the conservation field in New Jersey. One stakeholder said that the Landscape Project only shows

[59] Ibid.
[60] New Jersey Division of Fish & Wildlife Representatives, Telephone interview with Sarah Levy, October 3, 2007. Ann Arbor, MI.

"existing conditions" and that its purpose is to maintain the "status quo" without offering a picture of a "better future." The stakeholder said, "The Landscape Project is great for what it's meant to do, but it just wasn't meant to get into that new area of recovery or restoration."[61]

Representatives from the New Jersey state agency discussed the possibility of creating two sets of mapping in the future: one oriented to depicting requirements for landuse regulations, and one oriented towards conservation planning. One offered an example of a stream encroachment rule that prevents development up to 150ft away from a stream if certain endangered or threatened species are present. When asked to develop specific mapping around that rule, the representative suggested that there were differences in how the landuse regulation program and the Landscape Project's biologists would want the mapping done. The representative also said that it is difficult to "combine those two and make a map that either one of those are happy with."[62] The second representative added that the potential disadvantage of creating two sets of maps is that people may go directly to the regulatory map instead of the planning map if their intention is to just do the bare minimum to meet regulatory requirements.

[61] New Jersey Conservation NGO Representative, Telephone Interview with Sarah Levy, September 24, 2007. Ann Arbor, MI.
[62] New Jersey Division of Fish & Wildlife Representatives, Telephone interview with Sarah Levy, October 3, 2007. Ann Arbor, MI.

V. New York-New Jersey Interoperability Experiment

The object of this experiment was to design species data models that could be utilized by both New York and New Jersey. The final project would be a map of tabulated areas of species presence of both New York and New Jersey by USGS watersheds and national ecoregional maps. Because New York's CWCS did not utilize any spatial data, I opted to use New York Natural Heritage Program data for analysis purposes instead.

Step 1: Gathering Data

First, I sought national ecoregional and watershed maps with boundaries that could be used for tabulating areas. Ecoregions are defined by common terrestrial characteristics, such as vegetation, climate, soils, and topography. I chose three ecoregional maps to use in this research:

- **Bailey's Ecoregions,** compiled by the USDA Forest Service, are ecosystems of regional extent that share terrestrial characteristics. Bailey's ecoregions maps are categorized into four major units: Domains, divisions, provinces, and sections.[63]
- **Omernick's 1987 Aquatic Ecoregions** were originally demarcated for nationwide studies of

Analysis Steps:

1. Data gathered
2. Creating species shapefiles
3. Shapefiles converted to raster grids
4. Grids reclassified such that each species was given a unique number
5. Species "weights" summed by area using raster calculator
6. Summed grids overlayed with shapefiles and tabulated

[63] NationalAtlas.gov, "Bailey's Ecoregions and Subregions of the United States, Puerto Rico, and the U.S. Virgin Islands," http://www.nationalatlas.gov/mld/ecoregp.html. (2007)

water resources, but are often used in other types of ecological studies. Omernick's ecoregions are based on land use patterns, land surface form, vegetation, and soils.[64]

- **The World Wildlife Fund's** (WWF) Conservation Science Program has identified 825 global terrestrial ecoregions, and is currently developing 450 freshwater ecoregions. WWF has used the ecoregions to develop a set of 200 "Priority Ecoregions" that have exceptionally high levels of biodiversity, high species richness, or unusual ecological phenomena.[65] Because WWF's ecoregions are on a global scale, they are much coarser that Bailey's or Omerick's.[66]
- **USGS Watershed** layers at all scales (regions, sub-regions, accounting units, and cataloging units).[67]
- **Natural Heritage data from New York State**: Though New York's CWCS does not offer tools for spatial analysis, New York State does possess one of the most-well developed Natural Heritage Programs in the nation.[68] The New York Natural Heritage program is a member of Natureserve's Natural Heritage Network, and is run as a partnership between the New York State Department of Environmental Conservation (NYS DEC) and The Nature Conservancy.[69] The Program's 2007 "Animals" shapefile was used for analysis, contingent on an agreement that species locations would never be published. The shapefile contains attribute information on species location, state and

[64] William H. Hargrove and Robert J. Luxmoore, "A New High-Resolution National Map of Vegetation Ecoregions Produced Empirically Using Multivariate Spatial Clustering," http://www.geobabble.org/~hnw/esri98/. (2008)
[65] World Widlife Funding, "Conservation Science: Ecoregions," World Wildlife Fund, http://www.worldwildlife.org/science/ecoregions.cfm. (2007)
[66] The Environmental Protection Agency (EPA) has also recently developed state-level ecoregional maps, but New Jersey's was still in draft stage and New York's had not been developed at the time this paper was written.
[67] USGS, "Hydrological Unit Maps: What Are Hydrological Units?," United States Government, http://water.usgs.gov/GIS/huc.html. (2007)
[68] New York Conservation NGO Representative, Telephone interview with Michael Jastremski, October 10, 2007. Ann Arbor, MI.
[69] Department of Environmental Conservation, "New York Natural Heritage Program." http://www.nynhp.org/ (2008)

national listing and ranking status, description of the area in which the species was sighted, threats to the species, and other observational data.

- **Landscape Project data from New Jersey:** Because efforts to collect New Jersey Natural Heritage data were denied for concerns over the sensitivity of species locations, I used Landscape Project data instead. Data was originally derived from a Rutgers University center for Remote Sensing and Spatial Analysis (CRSSA) landuse/landcover data set, and enhanced with subsidiary data. ENSP selected the CRSSA's raster-based data set because of its updatability. In the second version of the Landscape Project, ENSP switched to New Jersey's Department of Environmental Protection's (DEP) vector-based modeling primarily to remain consistent with other mapping applications. Species data and wildlife records are taken from the Natural Heritage Programs Biological Conservation Database, ENSP surveys, staff and consulting reports, and public sitings.[70]

The New Jersey Landscape Project (NJLP) developed a set of unique ecoregions and conservation zones specific to New Jersey. While these ecoregions are loosely based on geological provinces, they also incorporate state municipal boundaries, major roads, and preexisting ecologically designated areas to aid conservation planning and regulation efforts. According to representatives of a New Jersey state agency, New Jersey opted not to use watersheds as New York did because they felt that watershed boundaries didn't represent terrestrial species in any kind of uniform way.[71]

[70] NJWAP, "*New Jersey Wildlife Action Plan*," Trenton, NJ: Division of Fish and Wildlife, New Jersey Department of Environmental Protection, 2006.
[71] New Jersey Division of Fish & Wildlife Representatives, Telephone interview with Sarah Levy, October 3, 2007. Ann Arbor, MI.

The state is divided into five geographic landscape regions: the Skylands Region, Piedmont Plains Region, Pinelands Region, Constal Region, and Delaware Bay Region. Each of these geographic regions are further subdivided into 26 conservation zones.

The state is also divided into five habitat types: Emergent Wetland, Forested Wetland, Forest, Grassland, and Beach. These habitat types are each represented as shapefiles in the Landscape Project's geodatabase. Each shapefile's attribute table contains size, area, and characteristic information about species locations and status, delineated by "patches," or polygons.[72]

Step 2: Creating species shapefiles

I isolated species common to both New York and New Jersey into individual shapefiles, and merged the state shapefiles into particular New York-New Jersey shapefiles (see figure 6). The following species were chosen for analysis, based on the fact that they could be found in both datasets:

- Bog Turtle
- Northern Harrier
- Piping Plover
- Sedge Wren

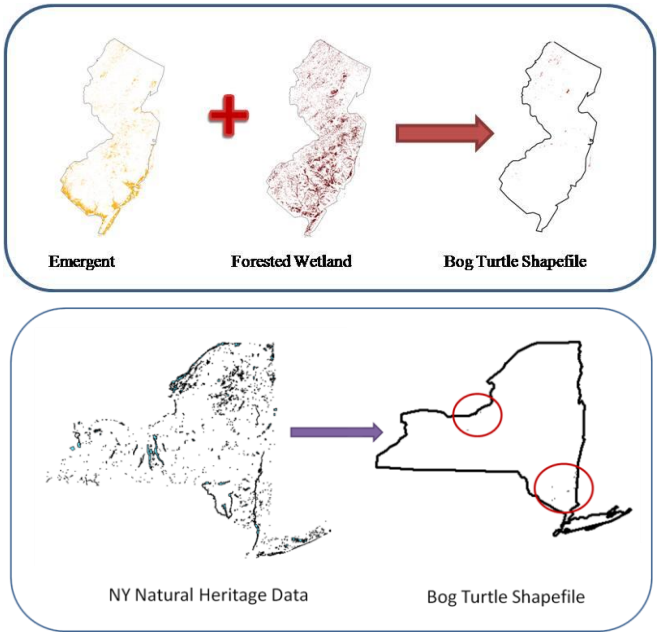


Figure 6: These figures demonstrates the process for creating species shapefiles for New York and New Jersey. The process was significantly more complicated for New Jersey because of its de-coupled species locations and shapefiles.

[72] Ibid.

- Timber Rattlesnake
- Upland Sandpiper

With the New York Natural Heritage data, creating species shapefiles was a fairly straightforward task. Because species were listed as items in the attribute table, it was a simple selection process.

Species themselves are not named in the Landscape Project shapefiles. Each patch contains an attribute titled "link" with a number that relates to separate habitat tables (see figure 7). For example, link "7" in the "Beach" shapefile represents the Northeastern Beach Tiger Beetle from the Imperiled-Beach species lookup table, which contains all state and federally endangered/threatened species records. There is also a Priority-Beach lookup table, which contains all priority/special concern species. Each habitat type has two such tables, and there is no overarching framework linking tables together. To complicate matters further, "counts" of species were calculated differently for the Imperiled species lookup tables and the Priority species lookup tables.[73]

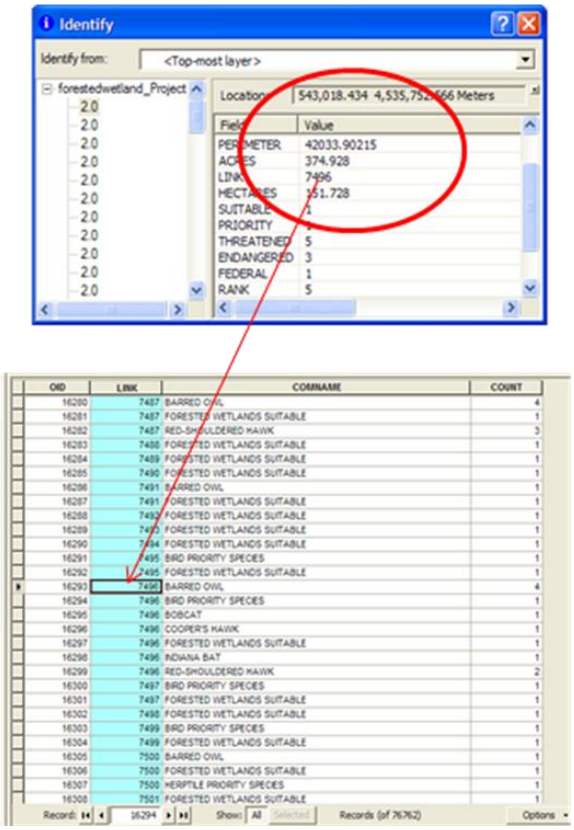


Figure 7: Above is a screen shot of the attributes from one habitat patch, and its link to the species lookup table.

[73] New Jersey Division of Fish & Wildlife Representative, Telephone interview with Sarah Levy, May 11, 2007. Ann Arbor, MI.

The result of such disconnection is a confusing path for users to associate species with habitat. It is fairly simple for users to find species once they know what habitat type *and* geographic location they're interested in, but it is much more complex to find the geographic location of a particular species. For example, if a group is particularly interested in the Bog Turtle, it is impossible to find the Bog turtle using the shapefiles, and nearly impossible to find geographic locations for the Bog Turtle using both the species location table and the shapefiles.

Steps 3-5: Rasterization, Reclassification, and Summation

Once all six species shapefiles were created, all were converted into grids and reclassified according to species presence. Each was given a value such that when grids were summed, each possible combination of grids resulted in a unique amount (see text box at right).

Grid Reclassification

Bog Turtle
Species: 1, No data: 0

Northern Harrier
Species: 10, No data: 0

Piping Plover
Species: 100, No data: 0

Sedge Wren
Species: 1000, No data: 0

Timber Rattlesnake
Species: 10000 No data: 0

Upland Sandpiper
Species: 100000 No data: 0

Step 6: Tabulation

Once summation was complete, summed grids were overlayed with the national ecoregional and watershed maps, and total species area was tabulated (see figure 6).

Results

According to the analysis, the area with the greatest density of species in New York and New Jersey is located in the Pinelands National Reserve in southern New Jersey, also called The Pine Barrens. The Reserve consists of over 1.1 million acres of protected forests and waterways, and also encompasses private farms and a few small towns.[74] Of all species studied in this analysis, the most prevalent was the Timber Rattlesnake, both in the Pinelands National Reserve and in the study overall. Timber Rattlesnake accounted for over 75% of all species area, followed by the Northern Harrier with close to 20%.

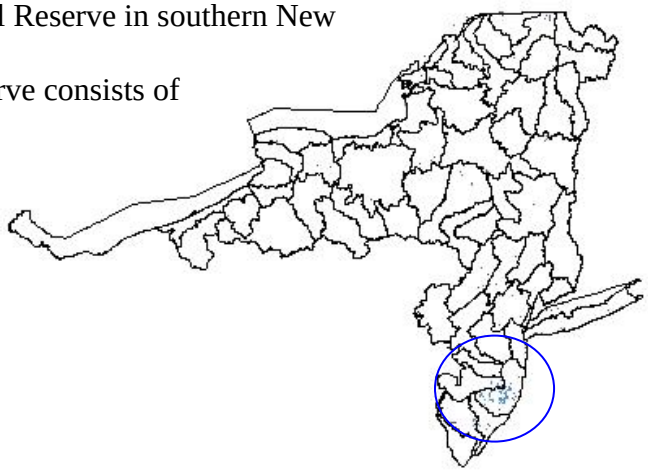


Figure 6: The figure above-right is a completed map of tabulated species area in the NY-NJ region overlayed by USGS watersheds. The circled area (lower right corner) is the location of the highest species density.

Experiment: Lessons Learned

Because the Pinelands National Reserve is an internationally recognized area of biodiversity and accounts for the largest amount of open space on the Mid-Atlantic seaboard between Richmond and Boston,[75] it is possible that the results of the analysis are correct: The Pinelands National Reserve contains the greatest density of species in New York and New Jersey. However, there are a number of lessons to be learned from this experiment:

[74] "New Jersey Pinelands Commission," NewJersey.gov, http://www.nj.gov/pinelands/reserve/. (2008)
[75] Ibid.

1. Differences in data collection methodology between the databases can significantly affect experiment outcomes. In this case, data creation methodology, and accuracy between the New Jersey Landscape Project and the New York Natural Heritage Program may have influenced the overall number of species tallied in each database. The scale and methodology by which data is created can be a critical indicator of how accurate the data is. Using data created by the same methods suggests—but does not necessarily indicate—that the data have comparative accuracy levels. Data was used without regard to methodology for purposes of experiment completion. The high number of species in New Jersey compared to New York suggests that the Landscape Project may have had a higher number of species overall, or perhaps higher numbers of certain numbers of species (such as Timber Rattlesnake).

Furthermore, there may be more rigorous vetting or data entry methods that affected how the data was computed. For example, in the New York Natural Heritage Program species layer's attribute table, each patch can be attributed with any given number of species sighted. Each patch in the Landscape Project may similarly be attributed to any number of species, but species are then divided into various categories, of which only species in the priority folder were counted.

This type of matching is not imperative *if* accuracy is not the highest priority of the database, such as if database managers prioritize stakeholder interaction with the data, or data submission and accessibility. If accuracy is a priority, then data-matching should not be attempted unless there is certainty of similar methodological processes.

2. Likewise, species patch sizes should be determined using similar methodologies. The New Jersey Landscape Project opted to create species patches based on habitat and type of species, which may have given each species patch a greater overall area than species in the New York Natural Heritage Program. Landscape Project patch sizes were developed based on size of

the element and proximity to species of conservation need. In addition, different habitat types possessed different creation criteria. Originally, the Landscape Project was only going to include certain size patches if they met the size criteria, and each patch was going to be ranked on the basis of criteria like contiguousness and area and number of species citings. The patches that ranked the highest in each category would be assigned the greatest overall score for conservation need. Currently, patch sizes are ranked only for priority according to species present.[76] Pinelands forest patches were may have included extra patch space due to an inclusion of "connection corridors."[77]

This patch delineation methodology is unique to the Landscape Project. However, similar problems may arise when trying to compare patch/polygons from any two databases. If a user is working with an interactive database where untrained individuals are capable of drawing their own polygons, then tabulating areas of the polygons would not be a suitable method for analysis.

3. Expect a Large Variance in Data Accessibility: While the Landscape Project data was easily available online with clear navigational tools and metadata, New York's Natural Heritage Program data was only available by request. Because data on threatened or endangered species often is not posted because of concerns over its exploitation or misuse, accessibility to this type of data is limited more often than not. If a user is attempting to gain access to this data, it is important to seek out database managers who would be willing to grant use-rights through the signing of a waiver or oral commitment to protect the data. Database managers should consider increasing accessibility to students, academics, or other members of the conservation community, perhaps by membership or following a background screening process.

[76] New Jersey Endangered and Nongame Species Program, "*New Jersey Wildlife Action Plan*," Trenton, NJ: Division of Fish and Wildlife, New Jersey Department of Environmental Protection, 2006.
[77] Ibid.

This experiment demonstrated the extent and limits of using data from two different GIS databases for a joint purpose. If one was looking for a rough idea of species locations, or species density, this type of analysis could be useful. One can use this final product to show locations of species, or to make more general statements such as "the Pinelands National Reserve has a high density of species compared to surrounding areas." However, it is unlikely that conservation professionals would be interested in such a rough analysis, particularly when similar analyses that have been vetted by more rigorously academic processes are available. Perhaps the most important conclusion one can deduce from this experiment is the impracticality of using GIS databases from different two different plans, and two different states, for one analysis.

VI. Recommendations

Recommendation 1: Mechanisms for Standardization/Cross-walking

While it may not be feasible for each state to use identical methodologies in creating GIS data for their plans, one option is for a common standard to be developed, and for each state's classifications to be crosswalked. While this is being completed in the northeast in a project titled the "Northeastern Regional Habitat Cover Maps," Natureserve is one of a a few organizations that have developed national classification systems that could be used on a broader scale.

Northeastern Regional Habitat Cover Maps

The Northeast Association of Fish and Wildlife Agencies contracted with the Wildlife Management Institute to administer The Regional Conservation Needs Program, a program that addresses landscape-level issues in the Northeastern region. The program is funded through a grants program and a small percentage of each participating state's SWG funding. At a regional meeting in October, 2007, NEAFWA Directors approved a grant titled, "Creation of Regional Habitat Cover Maps: Application of the Northeast Terrestrial Habitat Classification System." This map and classification system will act as a regional base map for terrestrial and aquatic habitat, as well as a dynamic database of protected areas. According to a member of the Virginia Department of Game and Inland Fisheries and contributor to this project, "the idea is that with good assessments of aquatic and terrestrial habitat from a regional standpoint, and we know which ones are better protected than others, we can then start to take some regional priority species, tie them in, and develop analysis by looking at local areas."[78]

[78] Virginia Department of Game and Inland Fisheries, Telephone Interview with Sarah Levy, October 3, 2007. Ann Arbor, MI, 2007

Because these maps will be developed at a regional-scale, finished products will likely be coarser than individual state efforts, the representative said. As a result, a crucial component of this regional project is a focus on crosswalking individual state classifications up to the regional classifications to create nested systems. The representative gave an example of how Delaware developed nine categories of pond types. At the regional level, all those ponds will be classified as, "North Atlantic Coastal Plain Pond Shore Communities." The representative said, "We want to make sure that what we're doing is not going to supplant any effort in individual states. We don't expect to necessarily replace the mapping going on there, we hope to be compatible and take it from a regional perspective."[79]

Natureserve

Natureserve acts as both professional network and central planning agency to all of the State Heritage Programs. While membership in the Natureserve network is voluntary, a representative of the organization said that 100 percent of heritage programs are currently enrolled in the network, indicating that all states currently have programs that use a common methodology and data management structure, and share information with the network so it can be used to build up regional, national, or continental data on the status of species or habitats.

Natureserve has also contributed a common classification system that could be used on an interstate basis. Originally, the classification system they developed, The National Vegetation Classification (NVC), was the first national vegetation classification. According to the representative, TNC's rationale for developing the NVC was to establish a consistent classification in the country that was at a scale "appropriate for conservation decisions." At the time, the only classification systems on a national scale that existed were Bailey's ecoregions, or

[79] Ibid.

other large scale systems. Natureserve's originally plan was to advise states to hire ecologists to find or develop individual classifications. After a time, it because obvious that state-by-state classification systems were not "roll-uppable," or compatible for interstate analysis or products. The NVC was intended to both be "roll-uppable" and fine-enough scale to make conservation decisions. One of Natureserve's most recent developments has been the Ecological Systems of the United States, a terrestrial classification system that defines ecological units at the meso-level.[80]

Recommendation 2: Make use of national mapping systems

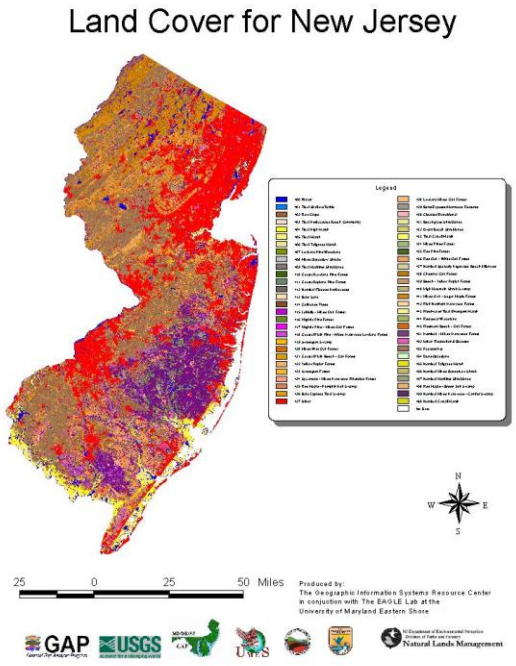


Figure 7: The USGS GAP Analysis is working on providing GAP data for every state, as well as developing regional GAP landcover maps.

If individual states do not possess the resources to develop their own maps, agencies could make use of pre-existing national mapping systems, including the GAP Analysis. The GAP Analysis is a method of identifying gaps among existing conservation areas.[81] By identifying these gaps, policy-makers can assess highest priority land acquisitions or habitats or species of greatest conservation not adequately protected by existing conservation lands. The GAP analysis is a coarse-filter approach, and focuses on community-based habitat units as well as on individual species.

Jill Maxwell of the USGS GAP Analysis

[80] "Ecological Systems of the United States," (NatureServe). http://www.natureserve.org/ (2007)
[81] Jennings, "Gap Analysis: Concepts, Methods, and Recent Results."

Program conducted a national study to assess the use of GAP Data in the State Wildlife Action Plans. State coordinators were asked about the extent to which they used elements of GAP data in their plans, the importance of GAP data to the plans, their plans to use GAP data in the future, and the value of possible improvements to the GAP program. Out of 44 responding states nationwide, thirty four of the respondents used GAP data, and half used landcover data extensively or exclusive of other GAP data. Vegetation data was the next highest data set used by 33 percent of respondents, while vertebrata distribution maps were used by a quarter of respondents. Of the thirty-four respondents who used the GAP data, over 75 percent used the data to identify the distribution and location of species of greatest conservation need (SGCN). Of the modifications to the GAP Analysis desired by coordinators, the three identified as the highest priority were more information on habitat change, finer scale mapping for specific species, and more information on habitat conditions.[82]

New Jersey was one of the states that chose not to use GAP Analysis. A New Jersey state agency representative familiar with the Landscape Project said that it was completed at a much finer scale than GAP, and so GAP wasn't really helpful to them. However, the representative acknowledged that New Jersey could do a better job of developing GAP Data so that New Jersey could be compared to other states across the nation. The representative said, "if you wanted to compare states, it would be good to have a similar product like the Gap Analysis so that you would be comparing apples to apples instead of everyone trying to change their datasets to match." [83]

[82] Jill Maxwell, "Role of Gap Data in State Wildlife Plan Development: Opportunities and Lessons Learned," *GAP Analysis Bulletin* November no. 14 (2006).
[83] New Jersey Division of Fish & Wildlife Representatives, Telephone interview with Sarah Levy, October 3, 2007. Ann Arbor, MI.

While the scale of GAP may serve bigger states better than smaller states, the main criticism leveled at the GAP Analysis has been the low level of accuracy associated with such coarse-scale analysis. One agency representative from the New York said, that the GAP analysis "wasn't worth it" because the accuracy ratings on it were "just awful." The representative cited ratings lower than 40% in some cases in a GAP analysis done several years ago in New York. Much of the validation results for the recently completed Southwest Regional Gap Analysis Project (SWReGAP) fell into the 50-70% range.[84]

The GAP Analysis, Natureserve maps and databases, and other such products are constantly evolving as technology improves, and could provide the basis for the types of rigorous assessment demanded by resource management professionals. However, such coarse-scale maps may have low accuracy ratings, and do not provide for real-time interaction with the data. One of the major strengths of the Plans is the emphasis on stakeholder engagement in plan creation and implementation. A series of robust but non-dynamic national maps may facilitate conversations between state agencies or resources professionals, but may not have the drawing power to engage local conservation organizations or individual conservationists.

Recommendation 3: Build an Interactive GIS database

Initiatives currently being developed under the auspices of PPGIS provide an opportunity for a dynamic and engaging tool. One of the most promising new developments, coordinated by the Defenders of Wildlife, is called the The Conservation Registry. The Registry is a virtual geodatabase that maps, tracks, and records conservation action across the United States. The

[84] J. Lowry et al., "Mapping Moderate-Scale Land-Cover over Very Large Geographic Areas within a Collaborative Framework: A Case Study of the Southwestern Regional Gap Analysis Project
" *Remote Sensing of Environment* 108 (2007).

goals of the Registry are to facilitate partnerships, identify conservation projects and areas, and increase efficiency in actions. The Conservation Registry is currently being piloted in Idaho, Oregon, and Washington. If successful, Defenders of Wildlife plan on expanding the Registry nationwide in 2009.[85]

According to an NGO representative familiar with the project, the idea for the Registry began when the Defenders were working with state agency partners to design State Wildlife Action Plans and realized that states did not have the capacity to build geodatabases that were nationwide in scope. They decided to create such a database that served two purposes: to act as a synthesis tool to bring together information of conservation projects occurring across the landscape, and to act as a project management tool for those agencies or organizations that do not necessarily have a database or tracker system. Because natural resource databases that serve similar functions already exist, the Conservation Registry will have a two-way data sharing mechanism so that information can be "harvested" from existing databases, and users can pull Registry data for their own purposes. Defenders of Wildlife considers itself to be the "coordinator" of the project, but has acquired over 35 partners who have promised resource assistance or technical aid.[86]

The creators of the database have tried to balance usability and precision, so that it can be used by resource professionals seeking a more rigorous understanding of the landscape, as well as individuals who may not be as familiar with the technology. The mapping platform is based on Googlemaps, which is intended to create a familiar, functional, and user-friendly experience. Users enter information about projects into the database, including location, purpose, partners,

[85] "The Conservation Registry." http://www.conservationregistry.org/ (2008)
[86] National Conservation NGO Representative, Telephone interview with Sarah Levy, January 25, 2008. Ann Arbor, MI.

and goals of the project, and then can draw the project directly onto the mapping interface with line and polygon tools. The database also provides the ability to link to other information—metadata, maps, reports, etc—to keep the emphasis of the database on synthesis and linkage rather than storage. The interviewed representative said, "One of the things that we've had to keep in mind throughout the development is this balance between simplicity and precision. We don't have to scare some of the less technical users away from using this. That's why we've focused on making this a user-friendly website. But we also want it to act as a powerful analytic tool for those users that are resource professionals that actually use the data."[87]

Challenges facing the Conservation Registry include privacy and property rights-based opposition to publishing spatial information, as well as scale-compatibility issues. The plan for dealing with opposition to the database is based on an arrangement where users' names and information will be protected unless volunteered, and users can submit land-use information for aggregate reporting purposes without submitting specific project locations. As for scale compatibility, the representative said that it's an issue that the database professionals will deal with at a later stage, but "from our developers' perspective, it's doable."[88]

Recommendation 4: Build Support for GIS/Mapping within the Agency

Reasons cited in the "Intrastate Challenges" section for not creating GIS—including difficulty in defining priorities and privacy/property rights concerns—have been overcome by states that possess agency leadership that understand the benefits of spatial systems, and have been able to successfully overcome lobbying efforts by groups opposed to their development. When New Jersey state representatives were asked whether they had ever faced political

[87] Ibid.
[88] Ibid.

opposition to developing the Landscape Project, the representatives responded that they had, but that the Landscape Project had enough support to overcome such opposition.[89] In contrast, a representative from a state agency in New York said that "fear of political fallout" from property rights and advocacy organizations led to agency leadership deciding against developing a comprehensive mapping system.[90]

If coordinators hope to use spatial data in their plans, educating others in their agency, non-agency stakeholders, and lobbyists opposed to such efforts about the benefits of GIS in systematic conservation planning may be an initial step to achieving that goal. It is possible that individuals who fear spatial data-gathering may not understand the collection process, or how the data will be used. Furthermore, political leadership in the state may be fearful of fallout without understanding the detriment of having a non-spatial plan. This cross-spectrum educational effort may help to alleviate concerns and also provide a basis for partnership for a PPGIS that the state may be interested in developing.

[89] New Jersey Division of Fish & Wildlife Representatives, Telephone interview with Sarah Levy, October 3, 2007. Ann Arbor, MI.

[90] New York Department of Environmental Conservation Representative, Telephone interview with Michael Jastremski, October 9, 2007. Ann Arbor, MI.

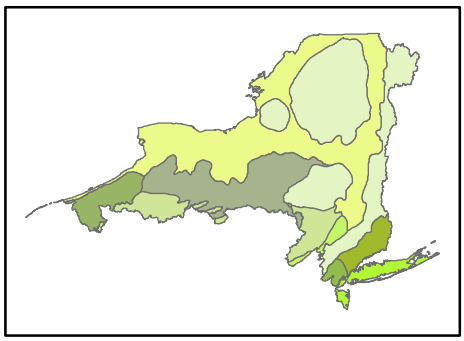
VII. Conclusion

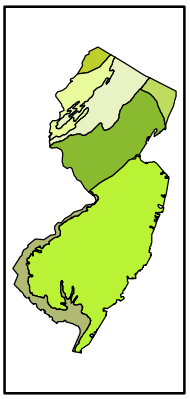
The use of GIS has become a crucial element of landscape ecology and conservation planning. As technology improves and software becomes more accessible, GIS will become a standard part of a conservationist's toolkit. Already, hundreds of companies and websites have developed GIS "freeware" that is available on the internet and can perform many of the same functions as ESRI-distributed software. Googlemaps offer simple tools to users who want to make and distribute their own maps. It will be imperative for coordinators of the State Wildlife Action Plans to recognize this transition and adapt accordingly. It will not be enough to simply provide the public with maps; savvy users will demand interactive maps, and will want opportunities to post their own conservation data.

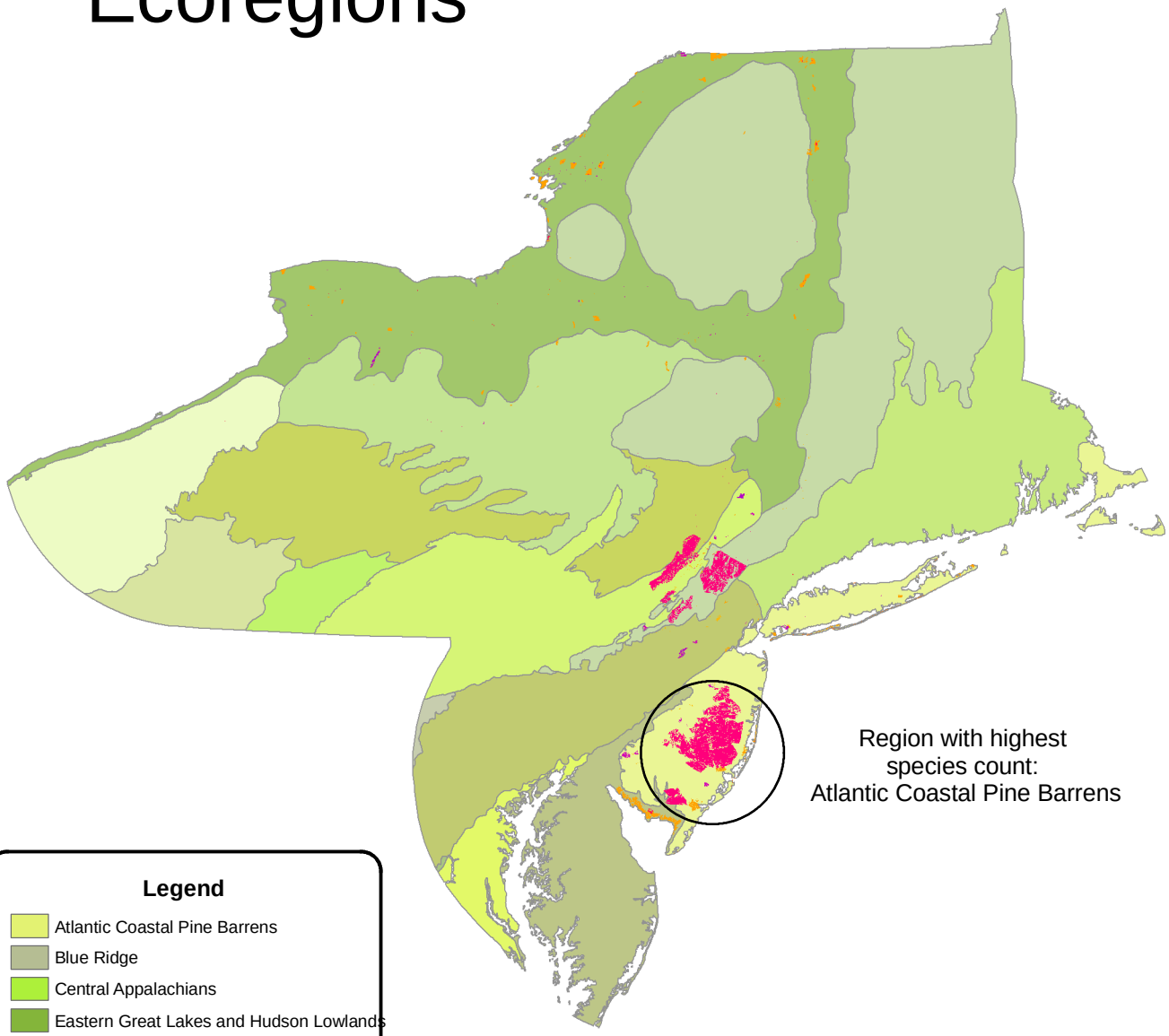
The main challenge to developing such a national system might be persuading a critical mass to adopt it. This will take leadership and initiative on the part of a trusted organization or central agency that can make a credible case to states that collaboration and data sharing is in their best interest. The Defenders of Wildlife organization is taking a first step towards this kind of system with the Conservation Registry. It is essential that plan coordinators and leaders in the conservation community recognize the benefit in such a system to successfully build a national network of non-game wildlife and habitat protection.

VIII. Appendix

Omerick's Ecoregions







Region with highest species count:
Atlantic Coastal Pine Barrens

Legend

- Atlantic Coastal Pine Barrens
- Blue Ridge
- Central Appalachians
- Eastern Great Lakes and Hudson Lowlands
- Erie Drift Plain
- Middle Atlantic Coastal Plain
- North Central Appalachians
- Northeastern Coastal Zone
- Northeastern Highlands
- Northern Appalachian Plateau and Uplands
- Northern Piedmont
- Piedmont
- Ridge and Valley
- Southeastern Plains
- Western Allegheny Plateau

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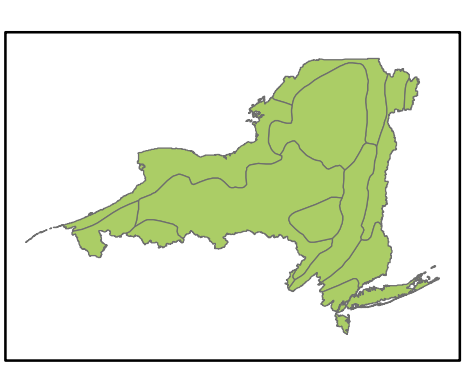
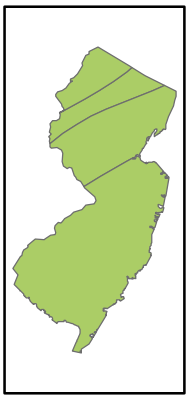
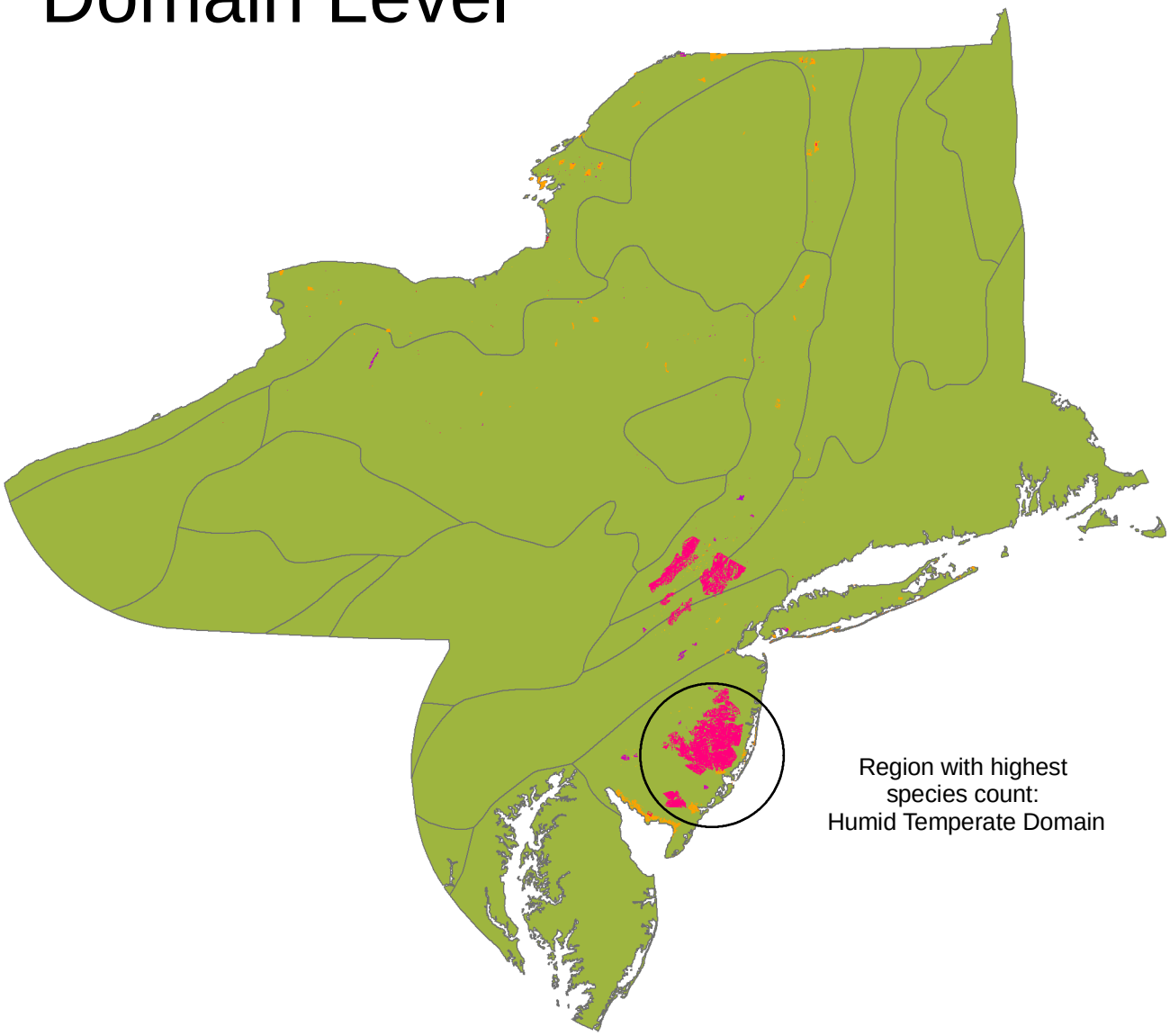
0 62.5 125 250
Miles

Sarah Levy
University of Michigan
School of Natural Resources and Environment
April 15, 2008

Bailey's Ecoregions: Domain Level







Region with highest species count: Humid Temperate Domain

Legend

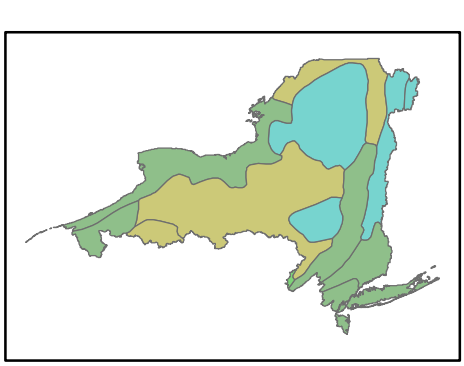
HUMID TEMPERATE DOMAIN

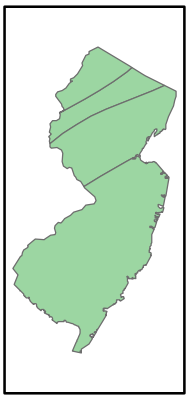
Ü

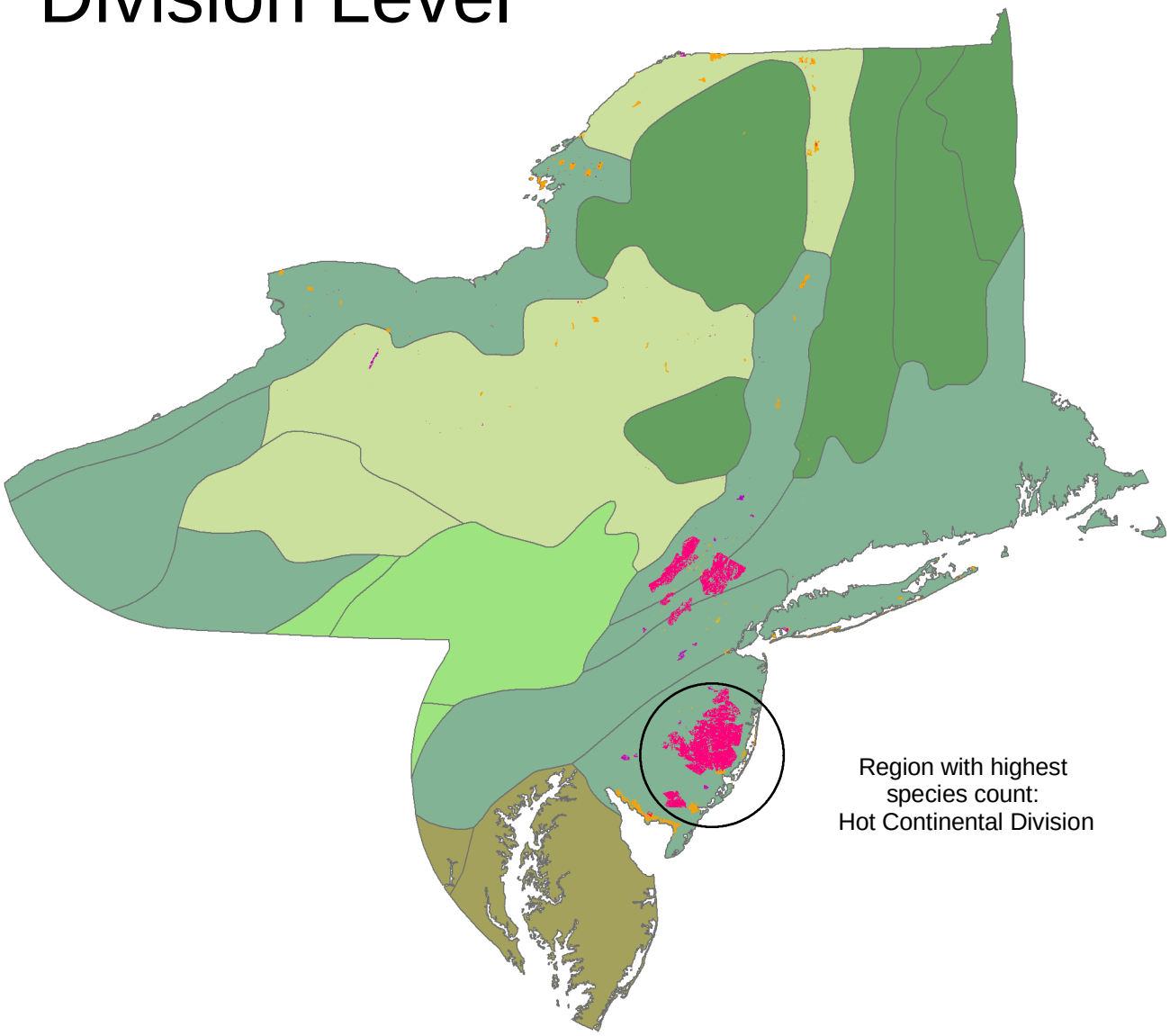
0 62.5 125 250 Miles

Sarah Levy
University of Michigan
School of Natural Resources and Environment
April 15, 2008

Bailey's Ecoregions: Division Level







Region with highest species count: Hot Continental Division

Legend

DIVISION

- Hot Continental Division
- Hot Continental Regime Mountains
- Subtropical Division
- Warm Continental Division
- Warm Continental Regime Mountains

Ü

0 62.5 125 250 Miles

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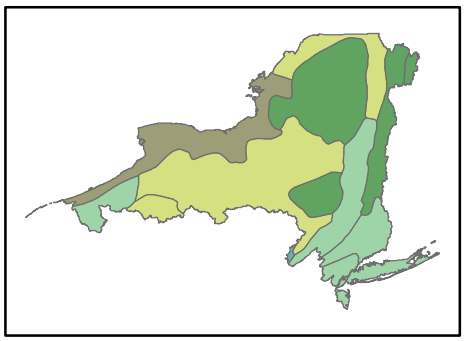
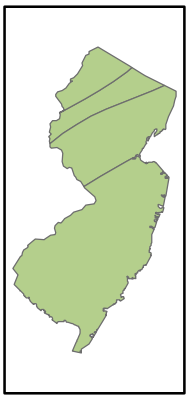
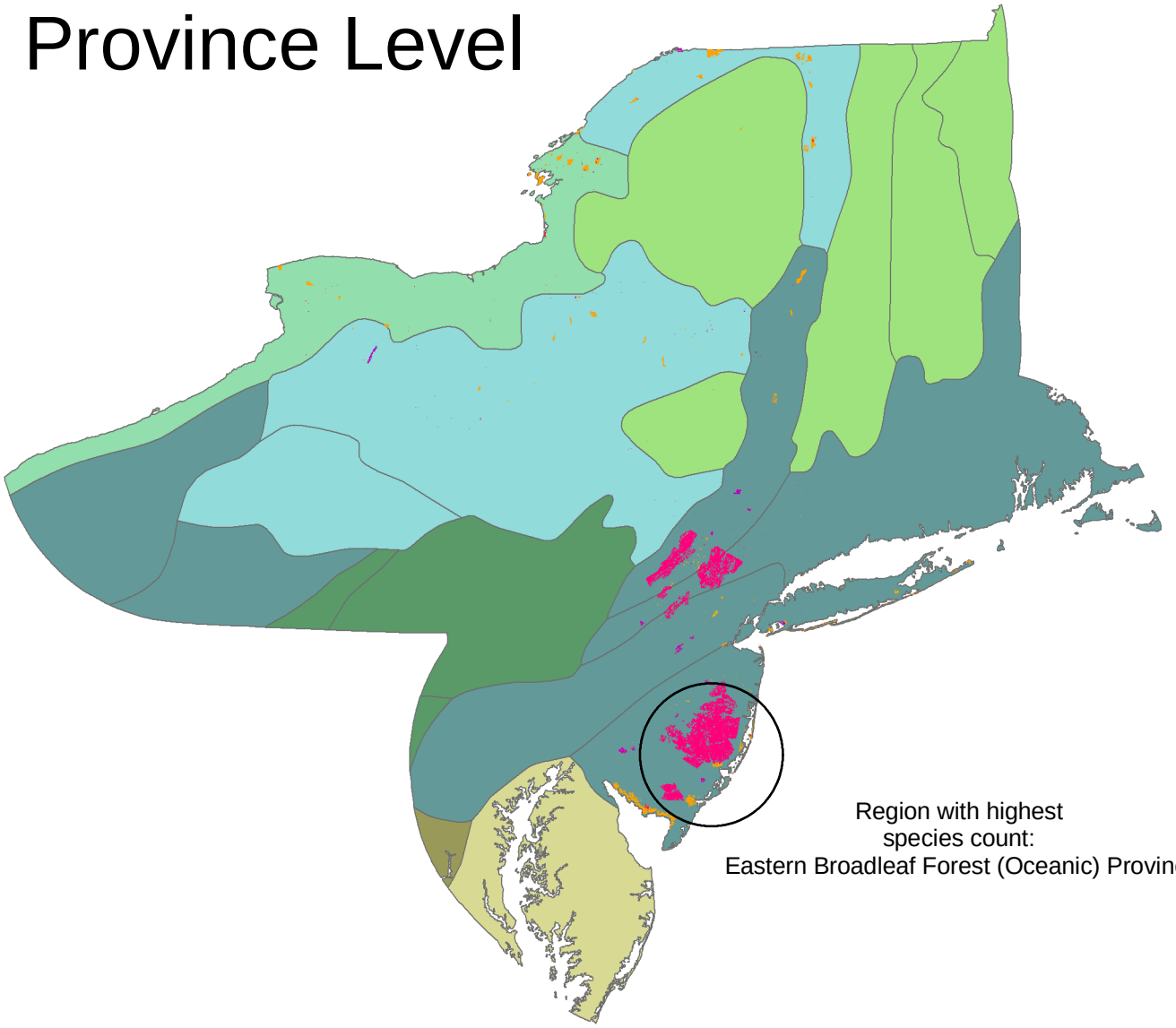
Bailey's Ecoregions: Province Level







Region with highest species count:
Eastern Broadleaf Forest (Oceanic) Province

Legend

PROVINCE

- Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province
- Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province
- Eastern Broadleaf Forest (Continental) Province
- Eastern Broadleaf Forest (Oceanic) Province
- Laurentian Mixed Forest Province
- Outer Coastal Plain Mixed Forest Province
- Southeastern Mixed Forest Province

N

0 62.5 125 250 Miles

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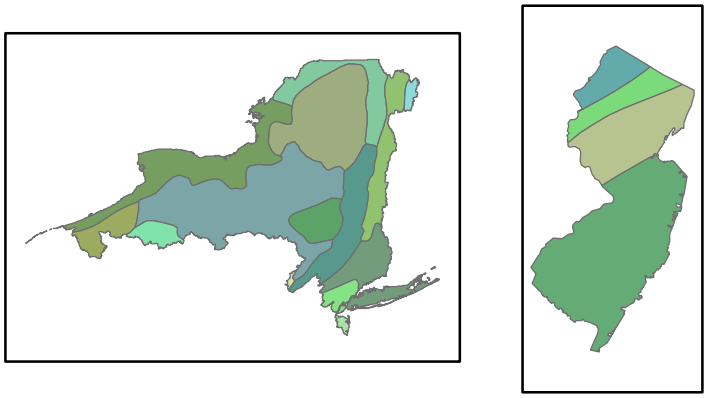
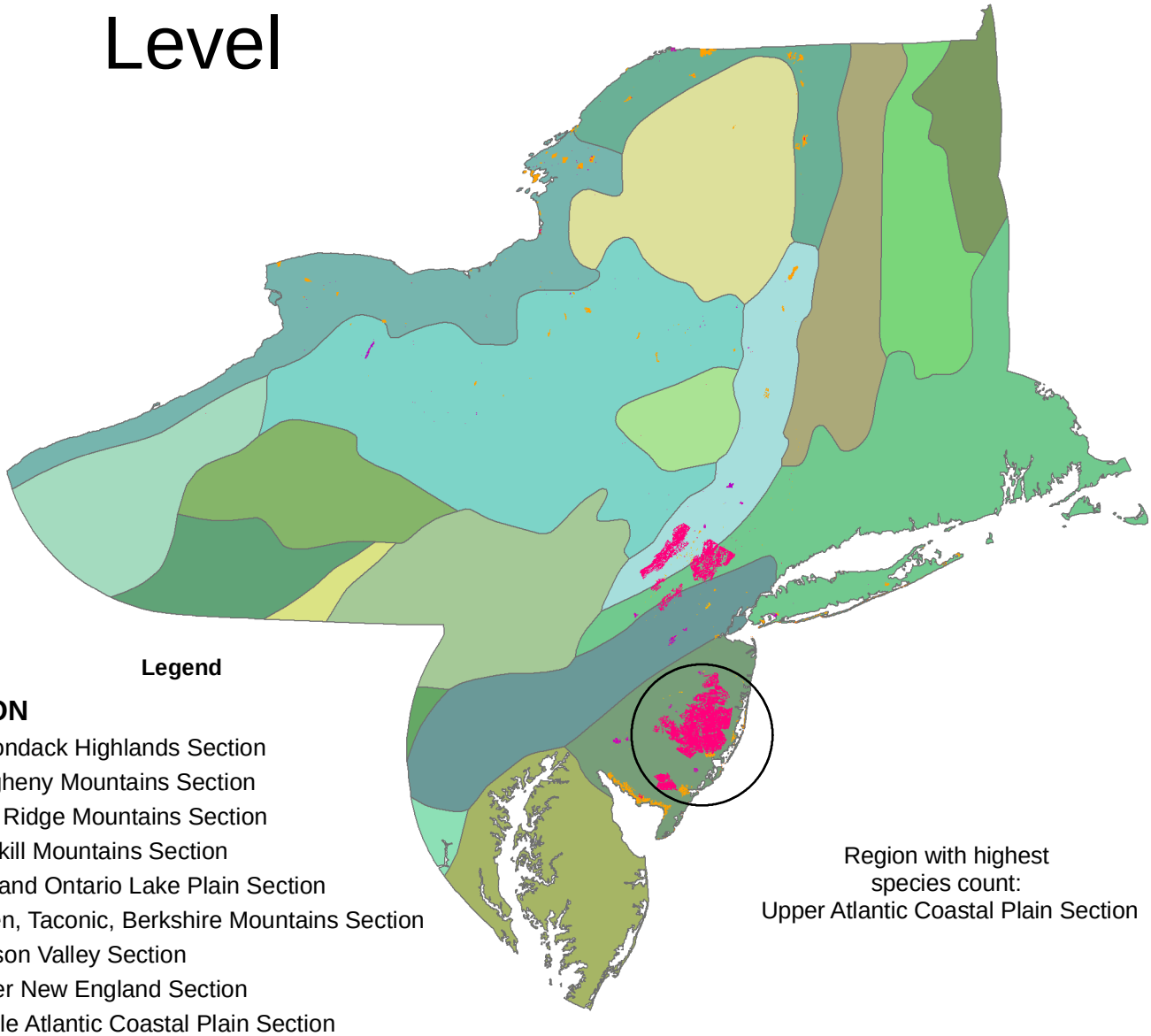
Bailey's Ecoregions: Section Level





Legend

SECTION

- Adirondack Highlands Section
- Allegheny Mountains Section
- Blue Ridge Mountains Section
- Catskill Mountains Section
- Erie and Ontario Lake Plain Section
- Green, Taconic, Berkshire Mountains Section
- Hudson Valley Section
- Lower New England Section
- Middle Atlantic Coastal Plain Section
- New England Piedmont Section
- Northern Appalacian Piedmont Section
- Northern Glaciated Allegheny Plateau Section
- Northern Ridge & Valley Section
- Northern Unglaciated Allegheny Plateau Section
- Southern Appalachian Piedmont Section
- Southern Unglaciated Allegheny Plateau Section
- St. Lawrence Valley Section
- Upper Atlantic Coastal Plain Section
- Western Glaciated Allegheny Plateau Section
- White Mountains Section

Region with highest species count: Upper Atlantic Coastal Plain Section

Ü

0 62.5 125 250 Miles

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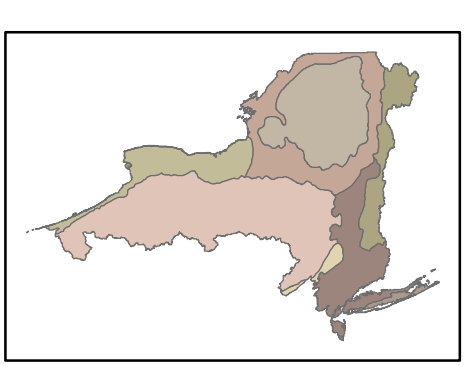
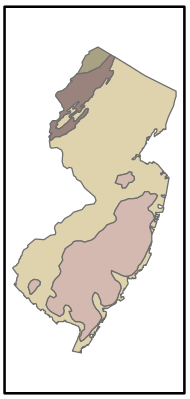
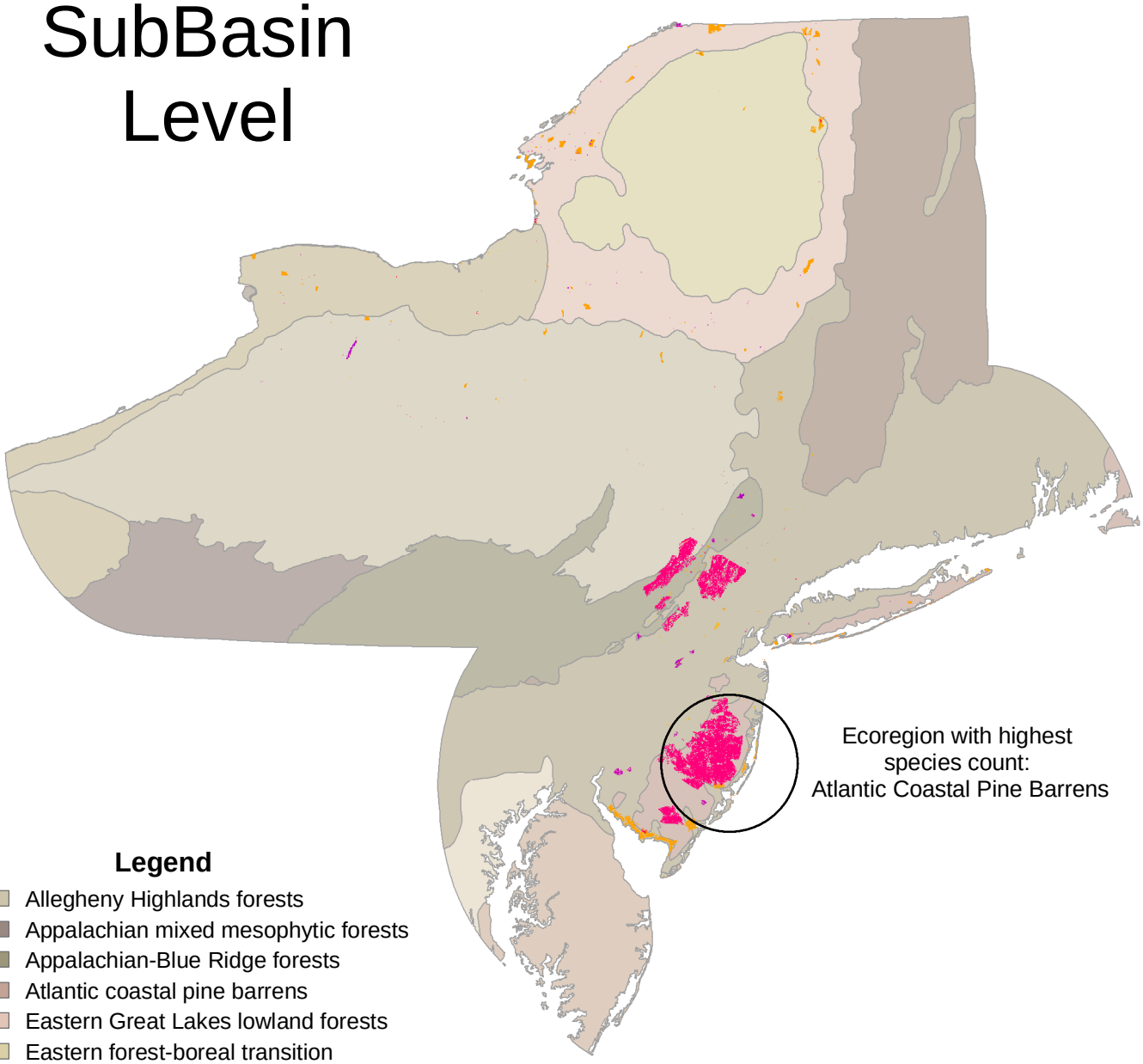
April 15, 2008

USGS Watersheds: SubBasin Level







Ecoregion with highest species count:
Atlantic Coastal Pine Barrens

Legend

- Allegheny Highlands forests
- Appalachian mixed mesophytic forests
- Appalachian-Blue Ridge forests
- Atlantic coastal pine barrens
- Eastern Great Lakes lowland forests
- Eastern forest-boreal transition
- Lake
- Middle Atlantic coastal forests
- New England-Acadian forests
- Northeastern coastal forests
- Southeastern mixed forests
- Southern Great Lakes forests

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0 62.5 125 250
Miles

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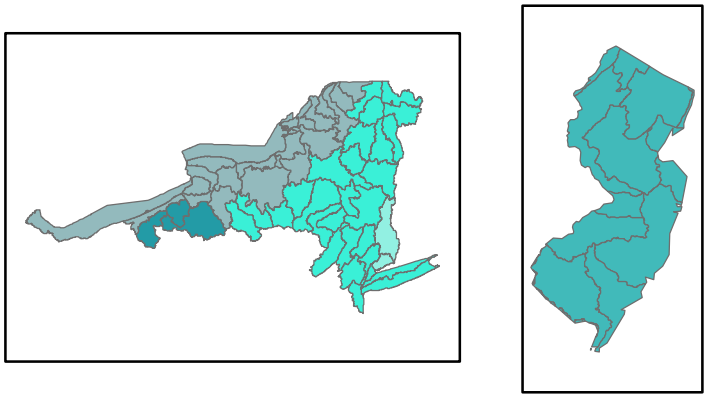
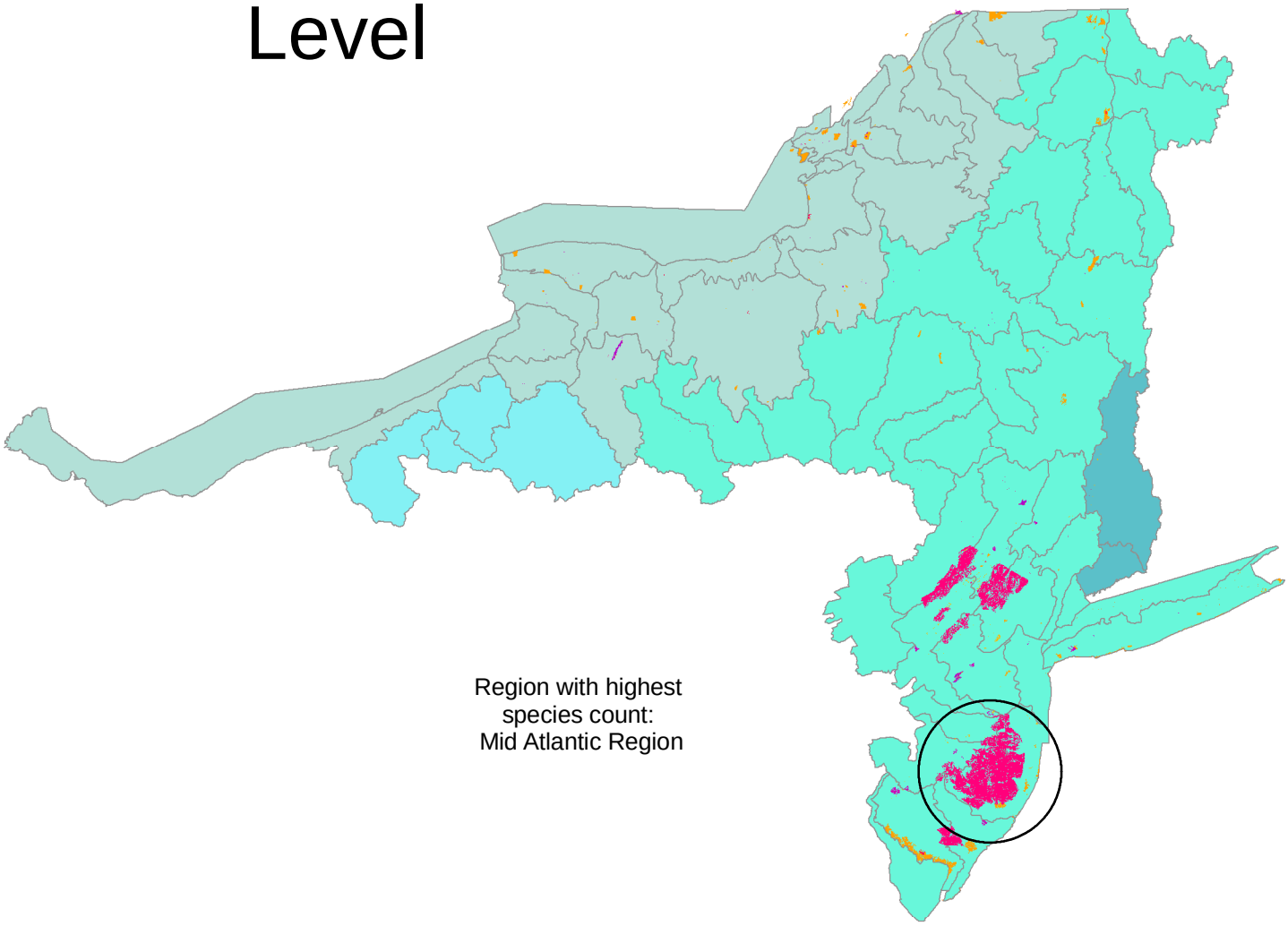
School of Natural Resources and Environment
April 15, 2008

USGS Watersheds: Region Level





Region with highest species count:
Mid Atlantic Region

Legend

REGION

- Great Lakes Region
- Mid Atlantic Region
- New England Region
- Ohio Region

Ü

0 62.5 125 250 Miles

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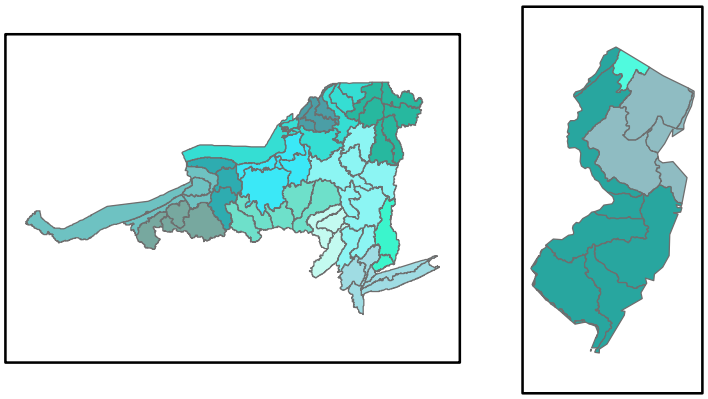
USGS Watersheds: Subregion Level



Subregion with highest species count: Delaware

Legend

SUBREGION

- Allegheny
- Connecticut Coastal
- Delaware
- Eastern Lake Erie-Lake Erie
- Lower Hudson-Long Island
- Northeastern Lake Ontario-Lake Ontario-St. Lawrence
- Northestern Lake Ontario-Lake Ontario-St. Lawrence
- Richelieu
- Southeastern Lake Ontario
- Southwestern Lake Ontario
- Susquehanna
- Upper Hudson

Ü

0 62.5 125 250 Miles

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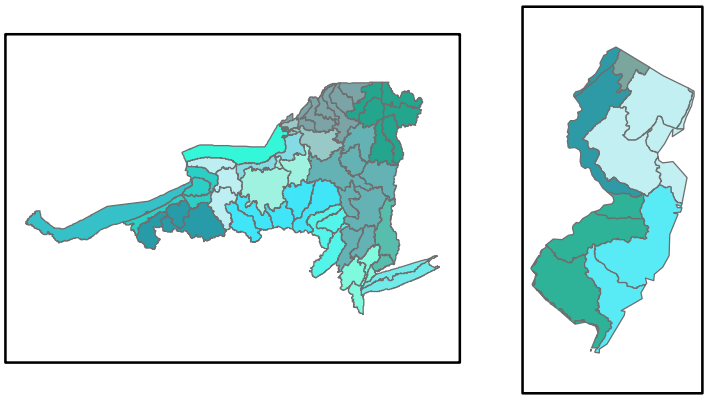
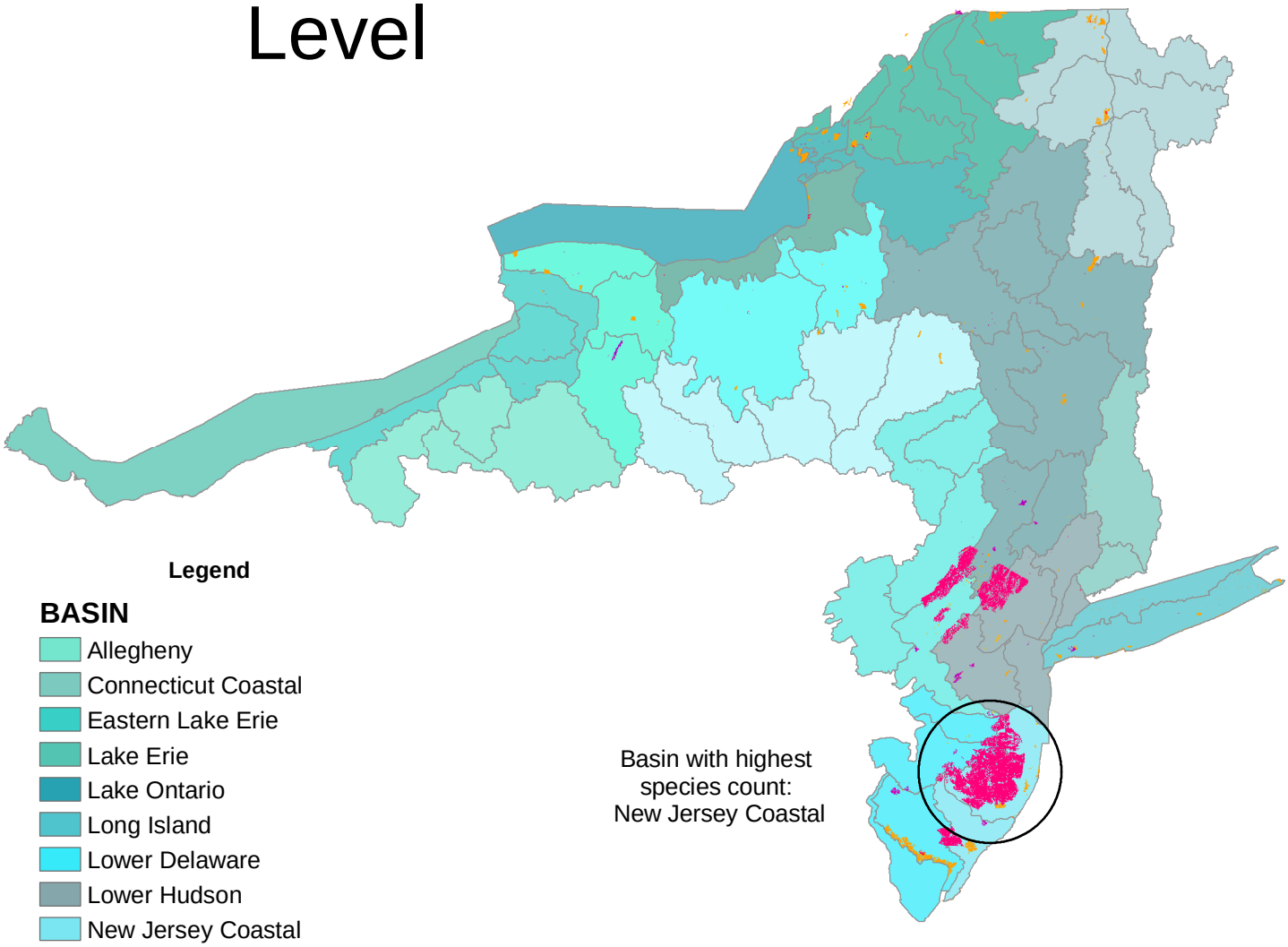
USGS Watersheds: Basin Level





Basin with highest species count: New Jersey Coastal

Legend

BASIN

- Allegheny
- Connecticut Coastal
- Eastern Lake Erie
- Lake Erie
- Lake Ontario
- Long Island
- Lower Delaware
- Lower Hudson
- New Jersey Coastal
- Northeastern Lake Ontario
- Oswego
- Richelieu
- Southeastern Lake Ontario
- Southwestern Lake Ontario
- St. Lawrence
- Upper Delaware
- Upper Hudson
- Upper Susquehanna

Ü

0 62.5 125 250 Miles

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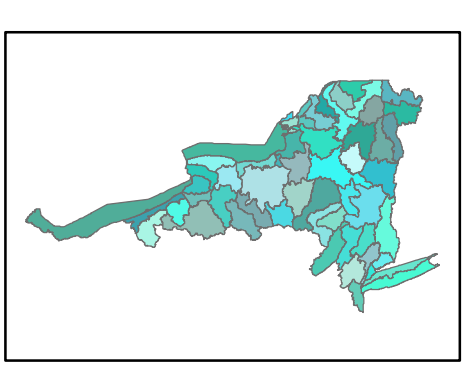
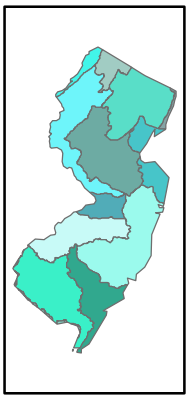
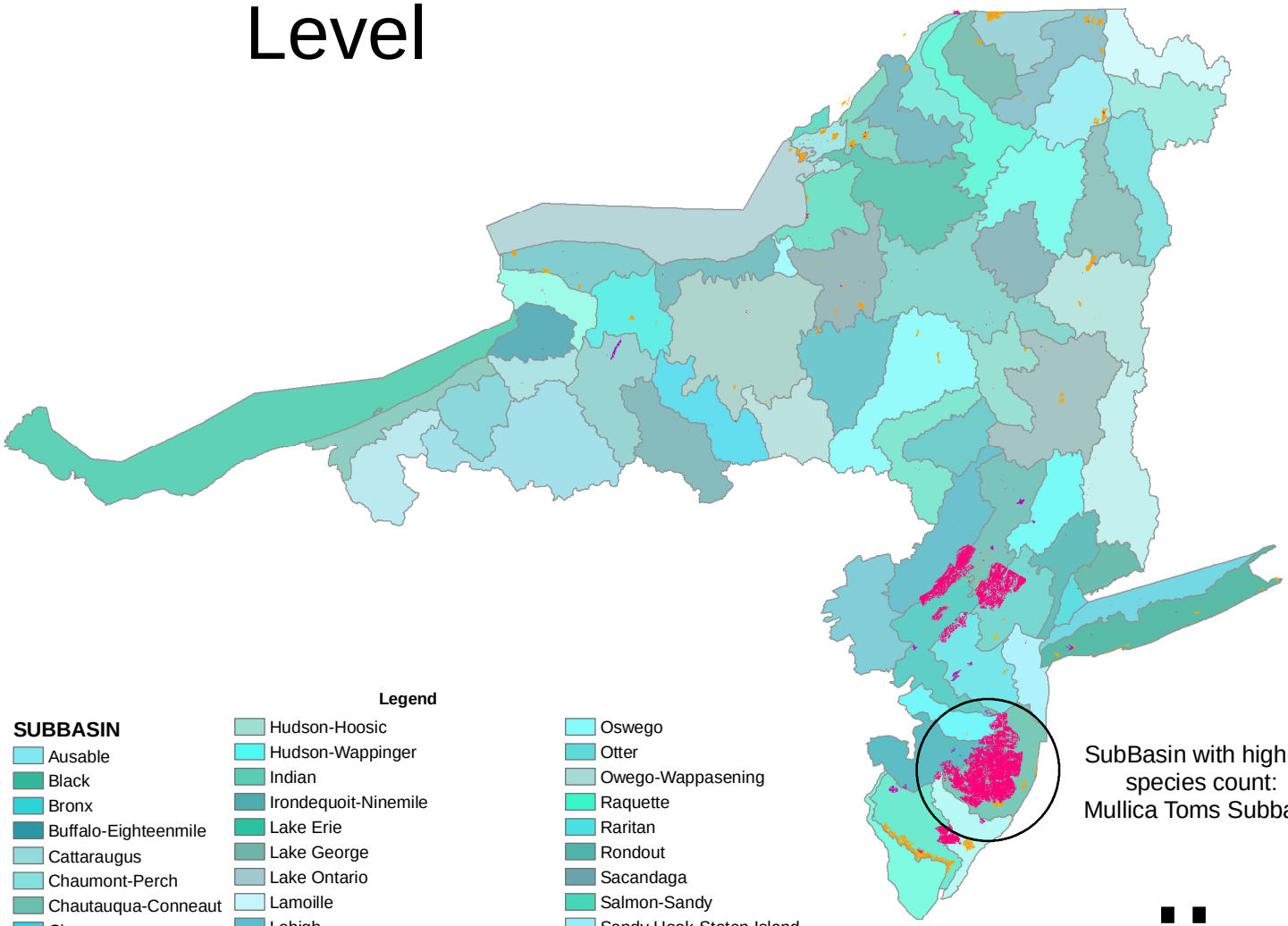
April 15, 2008

USGS Watersheds: SubBasin Level







Legend

SUBBASIN

- Ausable
- Black
- Bronx
- Buffalo-Eighteenmile
- Cattaraugus
- Chaumont-Perch
- Chautauqua-Conneaut
- Chemung
- Chenango
- Cohansey-Maurice
- Conewango
- Crosswicks-Neshaminy
- Delaware Bay
- East Branch Delaware
- English-Salmon
- French
- Grass
- Great Chazy-Saranac
- Great Egg Harbor
- Hackensack-Passaic
- Housatonic
- Hudson-Hoosic
- Hudson-Wappinger
- Indian
- Irondequoit-Ninemile
- Lake Erie
- Lake George
- Lake Ontario
- Lamoille
- Lehigh
- Lower Delaware
- Lower Genesee
- Lower Hudson
- Middle Delaware-Mongaup-Brodhead
- Middle Delaware-Musconetcong
- Middle Hudson
- Mohawk
- Mullica-Toms
- Niagara
- Northern Long Island
- Oak Orchard-Twelvemile
- Oneida
- Oswegatchie
- Oswego
- Otter
- Owego-Wappasening
- Raquette
- Raritan
- Rondout
- Sacandaga
- Salmon-Sandy
- Sandy Hook-Staten Island
- Saugatuck
- Schoharie
- Seneca
- Southern Long Island
- St. Regis
- Tioga
- Upper Allegheny
- Upper Delaware
- Upper Genesee
- Upper Hudson
- Upper St. Lawrence
- Upper Susquehanna
- Winooski

SubBasin with highest species count:
Mullica Toms Subbasin

Ü

0 62.5 125 250
Miles

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