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KEEPING COMMON SPECIES COMMON

GAP ANALYSIS Bulletin

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The Gap Analysis Program ... in Brief

The Mission of the Gap Analysis Program (GAP) <http://gapanalysis.nbii.gov> is to promote conservation by providing broad geographic information on biological diversity to resource managers, planners and policy makers who can use the information to make informed decisions.

GAP's motto is "Keeping common species common." This means protecting them BEFORE they become threatened. We promote biodiversity conservation by developing and sharing information on where species and natural communities occur and how they are being managed for their long-term survival. We work cooperatively with federal, state and local natural resource professionals and academics to provide this kind of information.

GAP activities focus on the creation of regional and national datasets and maps that depict patterns of land management, land cover and biodiversity. These data can be used to identify "gaps" in conservation--instances where an animal or plant community is not adequately represented on the existing network of conservation lands. Our data and analytical tools have been used in hundreds of applications: from basic research to comprehensive state wildlife plans; from educational projects in schools to ecoregional assessments of biodiversity.

GAP is one of the Biological Informatics Programs in the USGS' Core Science Systems <http://www.usgs.gov/core_science_systems/> division. Through building partnerships among disparate groups, GAP hopes to foster the kind of collaboration that is needed to address conservation issues on a broad scale.

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Executive Summary

Kevin Gergely
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Various arenas of scientific research can be plagued with ongoing issues that dominate discussion as various studies look at remarkably similar questions over and over again in slightly different contexts. In the natural resource realm, for example, we often look at the primary life history influences on a species or population and try to determine the tipping point between population declines and sustainability. In the social science world, we often see a debate emerge in the literature as researchers explore institutions in our society and try to ascertain whether current trends and policies emerge from them, or whether they have simply evolved to reflect society. Over the years, those of us involved in the USGS National Gap Analysis Program (GAP) have often wondered aloud, among ourselves, similar questions.

We are proud that, beginning in the 1980s, we were at the forefront of scientists and technicians who took on the greatest questions of conservation biology and tried to attack them strategically by using remote sensing and GIS to create data sets that could be applied across large regions, even nationally. But what we cannot say for sure, as the sociologists might ask, is how conservation science might have evolved without GAP.

What might have happened, for instance, if a few leaders in the conservation community, with some support from the U.S. Fish and Wildlife Service (USFWS), and the involvement of colleges and universities across the country, had not conspired and agreed to develop an analysis of the biodiversity of the U.S., which ultimate lead to the development of GAP? It is easy for us to believe the influence of GAP has been tremendous because of the continued interest and the duplication of the concept across regions and organizations that we have both witnessed and participated in. But in fairness, we may have just been part of a larger cultural change in the conservation community as many scientists, scholars and practitioners converged around the idea of using newly available data and analytical advancements to deal with issues surrounding rapidly declining or rare species.

It may not matter that much. Like the SLOSS (single large or several small) debates of years ago, the chicken and egg question of what drives which in society can be an interesting diversion. More importantly, however, we might want to pay close attention when we see a convergence of ideas from different organizations and actors. As I look at the updates and articles in this volume, I notice two important things. First, the focus of the last couple of years, in which we deliberately tried to push our projects over the hump to make sure analysis was possible at a national scale, is paying off. Updates related to the National Land Cover Viewer <http://lc.gapanalysisprogram.com/landcoverviewer/> and to the Protected Areas Database of the US (PAD-US) <http://www.gap.uidaho.edu/padus/protectedareas.html> discuss how GAP has crossed one of its most important milestones for a large portion of the data developed in recent years. These data have been incredibly complex, both conceptually and practically speaking. With GAP's relatively small budget, it has been difficult to plan and carry out projects of this scale in a reasonable timeframe. It would not have been possible without partnerships with like-minded organizations.

Secondly, the nature of our partnerships has changed over time. In the late 1990s, GAP worked closely at the state level as an organizational unit for building a national-scale effort, but also because the involvement of state agencies is critical for conservation efforts to be successful. Necessity has been the driver of adaptation. With limited resources, we had to look hard at what major data development projects we could actually manage, and look for partnerships to help us meet our national objectives. Without contributions from programs like LandFire, a USGS- and Forest Service-led effort that included mapping of ecological systems, the GAP-managed Land Cover Viewer would not have been possible. This sort of partnership is evident throughout all our land cover and protected areas work. This has been possible, likely not because we sought it out, but because there does seem to be a convergence of ideas related to the need for consistent, seamless data sets that allow analysis of biodiversity.

Another example of convergence is GAP's involvement with the multi-agency State of the Birds report <http://www.stateofthebirds.org/>. GAP originated out of the Cooperative Research Unit program when it was a part of the FWS. There has been a long history of small projects and a lot of back and forth, but the needs of the FWS have always made managers view GAP data as a bit tangential. The bird conservation community has had a long history of looking at the complete life history needs for many species across their full range. This has brought them to the table with many different agencies. As they develop their third report, which will attempt to give some data-driven analysis, they have moved in our direction, seeing the need for protected areas and land cover data that is national and consistent across regions. In turn, we see the need to move a little further in their direction, and push for classifications and data resolutions that are meaningful to managers.

This year, as discussed inside, our challenge is to bring the species distribution and range data to the same point as the land cover and protected areas data. A year from now GAP should be serving a species data viewer with ranges, modeling information, predicted distributions, protection status and taxonomic information for most vertebrate species in the U.S. But more importantly, we hope to see a convergence of agencies and efforts in building these data, and using them to assess the most pressing biodiversity issues in the country. While GAP is a small program, the current emphases in the Department of Interior on Landscape Conservation Cooperatives and Regional Climate Science Centers again reflects a convergence of ideas, that multi-discipline, large geographic scale observation and analysis is the appropriate approach to society's current natural resource concerns.

GAP program staff and partners have held this as a collective viewpoint for many years. Whether we are leading the effort, or simply following the times, it certainly seems like there is a need and opportunity for greater cooperation and mutual use of data. One thing is sure, given our experience over many years of data development, post hoc integration is important, but we need to understand our convergence of issues sooner and have an a priori plan to develop the data we need through partnerships as well. The needs are too great to go it alone. While planning to get ahead of endangered species crisis through data-driven planning might seem a little pie-in-the-sky opportunistic to some, the likely alternative is to fall into our historical roles of trying to quantify limiting factors and predicting tipping points for populations. This is a corner the wildlife community may have inadvertently backed itself into, trying to use science to predict minimum viable populations. There has to be a better way.

GAP National Land Cover Data: Recent Developments

Anne Davidson
National Gap Analysis Program, University of Idaho, Moscow, Idaho

The National Gap Analysis Program (GAP) has been a pioneer in broad-scale land cover mapping efforts. Beginning in the 1980s, GAP mapped land cover on a state-by-state basis for use in the mapping of wildlife habitat distributions. These state projects were often the first attempts at land cover mapping conducted in the state and are often credited with expanding the local expertise necessary to do remote-sensing-based land cover mapping projects. However, differences in source data and classification systems used by the individual states hampered efforts to use state-level data for regional assessments that included analysis across the entire range of a wildlife species. Recently GAP has been working to update these early land cover mapping efforts by developing regional land cover mapping products. Regional land cover projects were completed for the Southwest, the Southeast and the Northwest regions. Data from these projects were combined with data generated by the Landfire project (www.landfire.org) to create a seamless dataset for the conterminous United States.

Goals

The creation of high quality land cover maps furthers GAP's mission of "keeping common species common" by identifying those places in the

Figure 1. The final version of the land cover map contains 551 Ecological Systems and modified Ecological Systems.

country with sufficient good quality habitat to support wildlife as well as by providing a seamless land cover map for the entire US that can be used for habitat conservation. Current GAP land cover mapping efforts strive to maintain consistency in the mapping of large geographic areas, allowing for habitat modeling across entire species' ranges and for planning efforts at the national scale.

Accomplishments

In February, 2010, GAP launched an online national land cover viewer to enable users to easi-

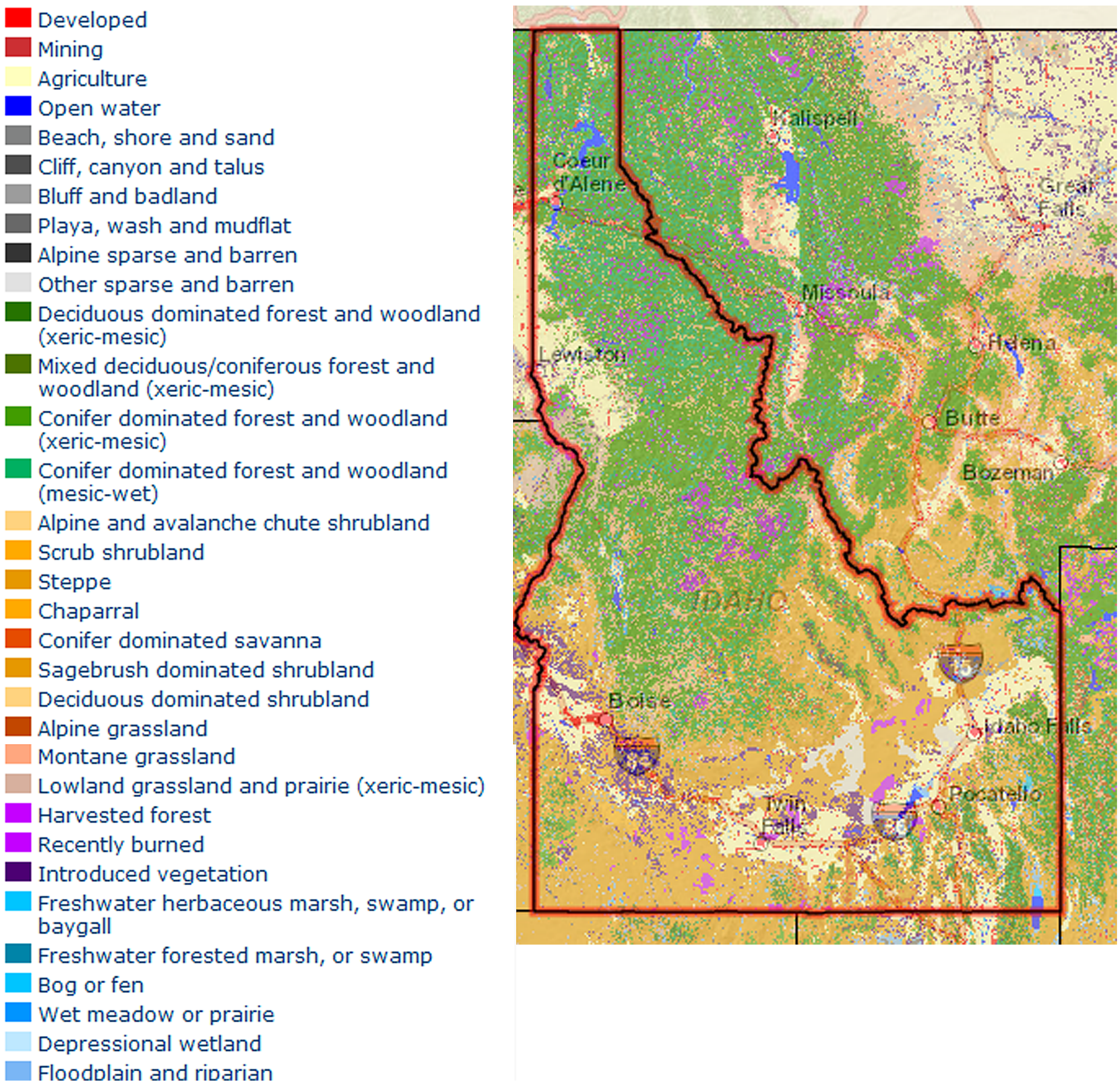

Figure 2: This screen capture from the National Land Cover Viewer displays the land cover for Idaho with the level 2 classification which contains 43 classes, and incorporates information on elevation and climate.

ly explore and download data (http://gapanalysis.nbii.gov/landcover).

The viewer, designed by Applied Geographics in conjunction with GAP expertise, displays GAP national land cover data at three hierarchical levels of thematic resolution. Level 1, with eight classes, generalizes to the level of vegetative physiognomy (e.g., grassland, shrubland, forest). Level 2, with 43 classes, incorporates information on elevation. Level 3, with 586 classes, uses the ecological systems classification developed by NatureServe. Because the three levels are hierarchical, users can view and download land cover data at the classification detail needed for their project. The land cover interface draws the national land cover data quickly and allows for nearly instantaneous zooming and panning.

The viewer lets users choose from among four base maps over which to display land cover data: topology, roads and towns, a high resolution satellite image or USGS topographic quadrats. Users can also adjust the transparency of the land cover data, which allows them to see that data in relation to other familiar landscape features. Detailed descriptions of the ecological systems (i.e., Level 3) are generated by clicking on the land cover data in the viewer and are displayed in a separate popup window. Land cover summary reports can be generated by state or county. These types of summaries are required by many different types of users but can be time consuming and technically challenging to generate.

Since the national land cover viewer's launch, an average of approximately 150 visitors per day have visited the web site. Visits peaked in mid-June at 2,800 visitors per day, after a USGS press release. Visitors to the land cover viewer represent a wide variety of federal, state and private agencies. Users of the viewer live in each of the 50 states as well as 49 different countries. Of the states, California and Washington have had the greatest number of viewers, while Canada and Japan have the highest number of viewers outside of the U.S.

During the next year, GAP will continue to add functionality to the land cover viewer with a new release planned for Spring 2011. We are working to improve the national land cover data set by working with vegetation ecologists and other natural resource experts to identify mapping errors and improve and standardize the mapping of Ecological Systems across the country. We are working to crosswalk the Ecological Systems classification to the National Vegetation Classification (NVC) and to allow users to view the land cover data at the various hierarchical levels represented by the NVC. GAP is also incorporating land cover data from Alaska and Hawaii into the viewer. Once this is accomplished, land cover summary statistics will be generated for the 50 states. We are also planning to integrate the Protected Areas of the United States (PAD-US) dataset into the viewer. This will allow users to explore the land cover within the country's National Parks and other protected lands. Comments on the GAP land cover viewer and the underlying data can be emailed to adavidson@uidaho.edu.

GAP Stewardship Program Goals and Protected Areas Database of the United States (PAD-US) Updates

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Protected areas are an essential component of the international effort to conserve biodiversity. These lands protect vital ecosystems and species However, because they are owned and managed by a wide variety of federal, state and local agencies, non-profit organizations and even private individuals; it has been difficult to develop a clear picture of how much land is actually being saved. Creating a complete, current and accurate inventory of U.S. protected areas supports critical efforts to conserve biodiversity, improves strategic land acquisition, broadens public access to information on recreation, strengthens regional and multi-state collaboration, and builds a greater capacity for evaluating and defining open space protection accomplishments.

Accurate land stewardship information is also fundamental to achieving the USGS Gap Analysis Program's (GAP) goal of keeping common species common by identifying those species and plant communities not adequately represented in existing conservation lands. Unfortunately, disjointed sources of boundary information and changing management directives make it difficult to compile and maintain a comprehensive stewardship database. GAP is continually challenged to standardize and aggregate new information in a timely fashion.

In April, 2008, GAP and the Doris Duke Foundation funded the PAD-US Design Project to develop an overall strategy for improving protected land inventories in the United States. More information about this strategy is in the report, "A Map for the Future," published in July 2009 and available for download at www.protectedlands.net. As called for in the PAD-US design report, efforts have been made to expand federal funding available for implementing major improvements to data inventories. While current federal budget challenges have resulted in no immediate action, interest in improving the inventory of U.S. protected areas remains strong. The lack of expanded funding, however, means that substantial work on the project must be deferred.

Goals

GAP Stewardship Program goals for 2010 were generally focused on improving coordination with partners and increasing database management efficiency in order to provide more timely updates. We plan to continue publication of frequent database updates while implementing the primary recommendations summarized in "A Map for the Future."

Following the PAD-US Design Project our goals for 2011 are to:

- Improve federal agency coordination to increase the efficiency of data maintenance and to facilitate wider adoption of the data by federal managers.
- Support state efforts to greatly improve their data inventories and apply PAD-US standards
- Pilot proposed changes to database structure and content, including an assessment of user preferences and efficiencies gained.

Accomplishments

GAP's primary accomplishments in 2010 were:

1) Published PAD-US version 1.1. Updates to PAD-US version 1.1 follow standards to retain boundaries and attributes 'as is' from the data source (with duplicate records removed), which may include some overlaps in ownership and missing attribute information like parcel names. Significant effort was placed

into the reorganization, standardization and complete attribution of fields in the PAD-US schema. GAP made several primary updates between PAD-US versions 1 (April 2009) and 1.1 (May 2010), including:

a) The northwest states (WA, OR, ID, WY, MT, CA) were updated in partnership with the BLM, USFS, GreenInfo Network and TNC's Washington and Wyoming field offices.
b) The northeast states (ME, VT, NH, MA, CT, RI, NY, NJ, DE, PA, OH, WV, MD, VA) were updated in partnership with The Nature Conservancy's Eastern Regional Office.
c) A complete national update from The Nature Conservancy's Conservation Data Information Systems (CDIS) Unit included nature preserves and publicly available conservation easements.
d) Development of a new core attribute schema with "Category" (Fee or Easement parcel), "Manager Name", "Secondary Designation Name" and "Status" (Designated or Proposed site) to complement existing fields in PAD-US version 1 such as "Owner Type", "Owner Name" and "Primary Designation Type".
e) IUCN Category conservation measures were updated. USGS GAP is the official source of IUCN Categories and GAP Status Codes.

2) Worked directly with UNEP-World Conservation Monitoring Center (WCMC) to incorporate IUCN categorized protected areas from PAD-US version 1.1 into the World Database for Protected Areas (WDPA) and increase the efficiency of annual updates.

3) Reclassified the status of state data inventories to prioritize partnership efforts, starting with Tier 1 and Tier 2 states. Classification definitions are:

a) <u>Tier 1</u>: a state that is in the best position, relative to other states, to continually provide the data necessary for the success of PAD-US. States included in reliable regional datasets are Tier 2 due to the current challenge of integrating large regional data into PAD-US.
b) <u>Tier 2</u>: a state whose data is reliable but needs revision, or collaboration among several data stewards, to fit properly into the PAD-US data set.
c) <u>Tier 3</u>: a state with some or little data, generally disaggregated and difficult to integrate into PAD-US.

4) Identified additional State Data Stewards, Data Coordinators or Data Contributors across the US and began developing these partnerships with the goal of improving state data inventories and use of PAD-US standards to increase the efficiency of future updates and provide capacity for local review. Roles are defined as:

a. <u>Data Steward</u>: The entity generally recognized by the state as the aggregated source for state data. Can be a federal/state agency, university or NGO with a presence in the state and substantial resources to maintain protected areas data for the state in a manner easily consumed by PAD-US.
b. <u>Data Coordinator</u>: The entity that collaborates with multiple state agencies to develop an aggregated state dataset following PAD-US standards.
c) <u>Data Contributor</u>: The landowner or management entity with independent data of varied extent or quality. These are the sources the coordinators or stewards compile.

We expect eight cooperative agreements with state entities to be in place by the end of September to jump start this work and hope to provide similar resources to other stewards each year. Several additional state entities or NGO's are voluntarily providing state data in accordance with PAD-US standards. Coordinators or Stewards have been confirmed in: Arizona, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Idaho, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Missouri, Montana, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Puerto Rico, Rhode Island, Vermont, Virginia, Washington, West Virginia and Wisconsin.

5) Refined Master Stewardship List (MSL) of management designations for the nation and reassigned conservation measures (categorically assigned default GAP Status Codes and IUCN categories). This work is in review; additional reviewers are welcome.

Goals for the Upcoming Year

In general, GAP will continue to implement recommendations following the PAD-US Design Project (2008-2009) as summarized in, "*A Map for the Future*". Efforts include:

1) Current work on a significant federal lands update for PAD-US version 1.2, expected November 2010, with the Department of Defense (DOD), the National Parks Service (NPS), the Bureau of Land Management's National Landscape Conservation System (NLCS) and NOAA Marine Protected Areas. Emphasis is placed on improving work flow between federal agency data updates and their aggregation into PAD-US. In addition, PAD-US version 1.2 will include additional US Territory updates such as Puerto Rico, the Virgin Islands and the Pacific Islands.

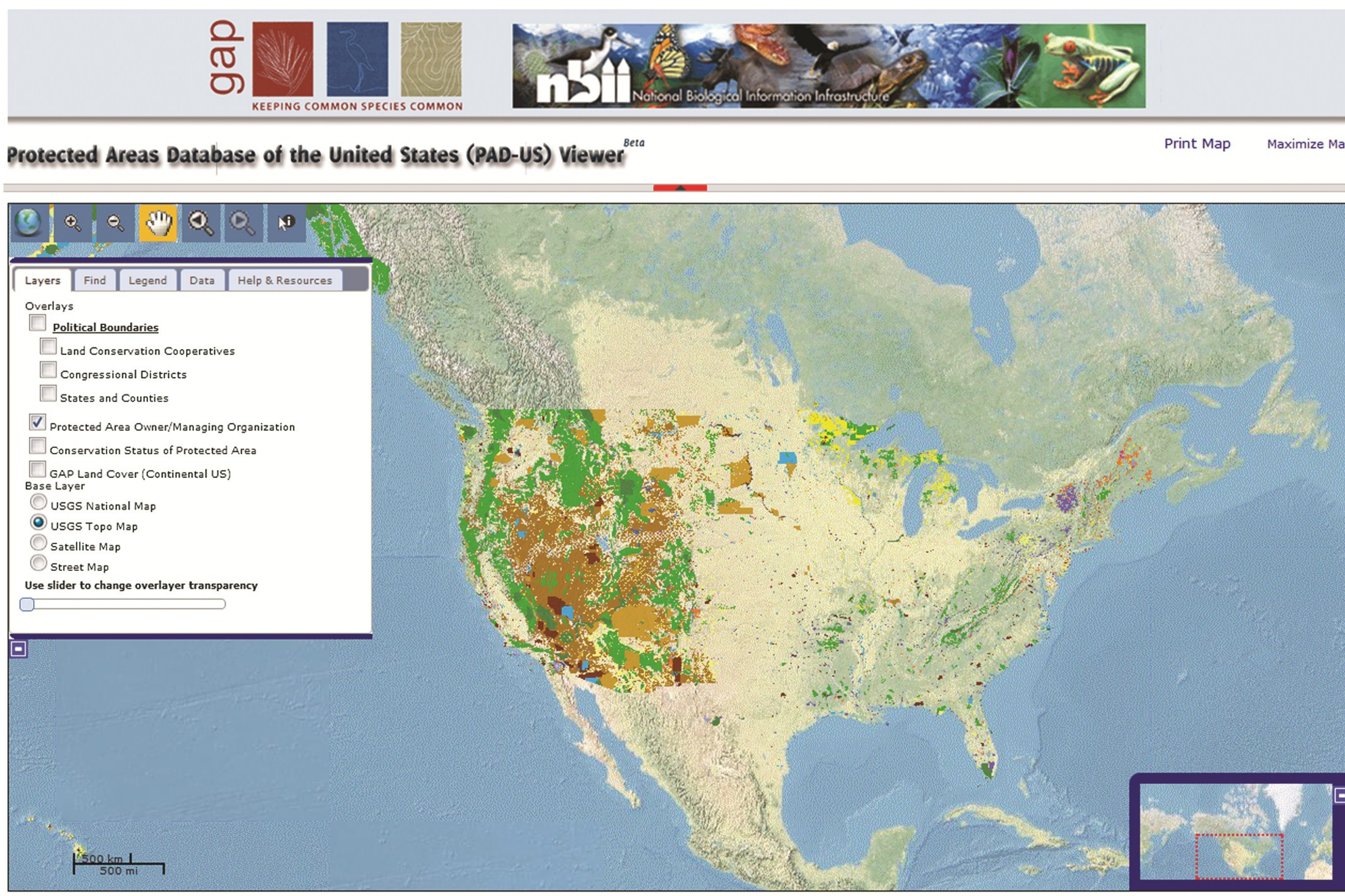

Figure 1. The Protected Areas Database Viewer facilitates exploration and use of GAP's protected areas data.

2) Follow federal lands PAD-US update with a state data update in Summer 2011 building on cooperative agreements and other partnerships developed. Continue to identify and develop future data stewards.

3) Continue to test the implementation of a new PAD-US data structure, including multiple feature classes such as: Fee, Designations, and Easements with content organized as subtypes with applicable topology rules.

Outreach

A redesigned PAD-US viewer presented PAD-US version 1.1 to the public in May 2010. New functions, such as the ability to query by owner or designation were added. In addition, a layer showing land conservation cooperative units and a USGS national map layer were added. Once completed, the redesign made the application easier to navigate. The site continues to be popular with visitors from each state, numerous federal, state and local government personnel, private companies, educational institutions and foreign countries.

Mapping Species Ranges and Distribution Models across the United States

Jocelyn Aycrigg
National Gap Analysis Program, University of Idaho, Moscow, ID

In 2008, GAP embarked on an effort to create species distribution models across entire species ranges for a large number of species that occur in the continental US. We began by creating a species list for the US based on the species lists that were developed for the Southwest (SWReGAP), Southeast (SEGAP), and Northwest (NWGAP) GAP regional projects. We then compiled species lists from all the remaining states (e.g., California, Midwestern and Northeastern states). Once a comprehensive list was assembled, each species was verified using the most current information regarding that species (Crother 2008, Wilson and Reeder 2005, American Ornithological Union's 2008 checklist).

We defined a species range as a coarse representation of the total areal extent of a species or the geographic limits within which a species can be found (Morrison and Hall 2002). To represent

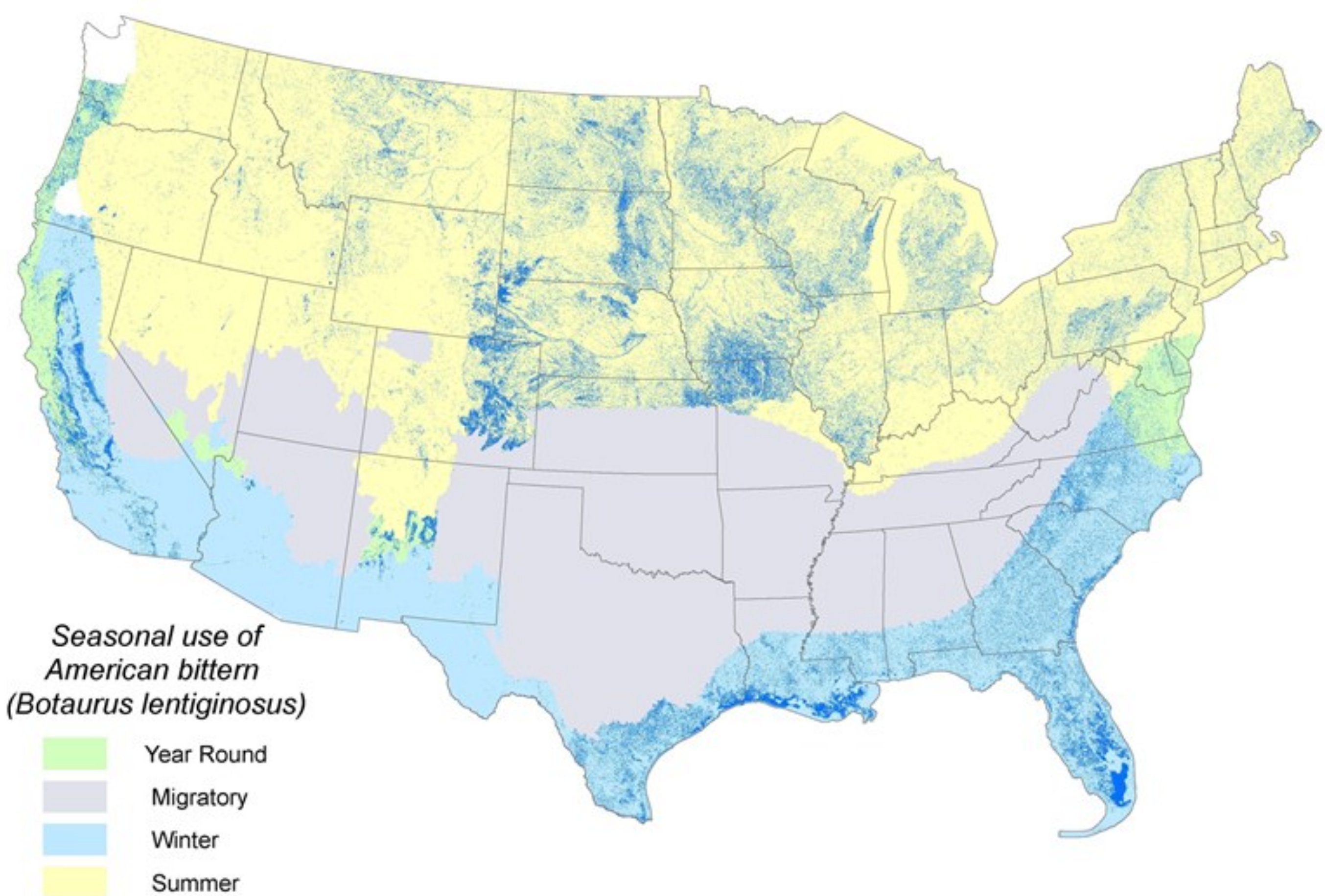

Figure 1. Range map for the American bittern (*Boraurus lentiginosus*) with predicted distribution in dark blue. The predicted distribution model is based on habitat variables such as land cover classes. A separate predicted distribution was created for summer and winter.

these geographic limits, we used a national database of standardized 12-digit hydrological units (HUCs). We are using information from NatureServe, SWReGAP, and SEGAP to create our species ranges. The NWGAP species ranges will be incorporated as soon as they are finalized. To date, we have completed national range maps for most of the approximately 700 bird species included on our species list.

We will use each species range to provide the biological context within which to build our species distribution models. We have defined a species distribution as the spatial arrangement of environments suitable for occupation by a species. In other words, a species' distribution is created using a model to predict areas suitable for occupation within that species' range. Our distribution maps, which are the result of our distribution models, are created at a 30m resolution. We are using deductive modeling approaches based on habitat associations and expert input. We will also be starting to collect species point observations for use in inductive modeling as well. Whichever modeling approach is used to create a species' distribution model will be applied consistently across its range. For those species with ranges entirely within the regional extents of SWReGAP, SEGAP, or NWGAP projects, we are using the existing distribution models as our national distribution models for that species.

Our goal is to build species range maps and distribution models with the best available data for use in assessing conservation status, conservation planning, and research (e.g., climate change impacts). This is our first attempt to build species models across a species' entire range rather than stopping at state or regional boundaries. These models will provide a base from which we can iteratively improve the model when new data become available. They will also provide the basis of a national biodiversity assessment.

The next few pages describe species modeling efforts that are contributing towards this national goal. Some of these are regional modeling efforts that were started prior to moving to national scale models (e.g., NWGAP, SEGAP,). Some are regional projects that are already working within the national framework (e.g., NEGAP). Some are modeling efforts based on species groups, such as reptiles or birds, that have a national perspective.

Currently, our main modeling approach is deductive; however, NWGAP and AKGAP species modeling includes inductive modeling. We are focusing our initial efforts on building, expanding, or updating our deductive species models, but we will also expand our inductive modeling efforts over time.

To date, about 200 species ranges and distribution models have been completed by regional GAP projects. Additionally, we have completed about 300 bird ranges and distribution models. These completed species ranges and distribution models will be available via our web site for viewing and downloading (gapanalysis.nbii.gov). As more species ranges and distribution models are completed over the next year; we will continually update our web site. We are currently exploring methods for interactively viewing GAP species data via the web.

Furthermore, through our nationwide bird modeling project, described below, we also have created core datasets needed for conducting national species modeling. These include a national wildlife habitat relationship database on which all our current deductive modeling efforts are based. This database contains wildlife habitat relationships to land cover and other spatial habitat parameters (e.g., elevation, slope) based on literature, taxonomic information (e.g., ITIS codes), and information about the status of the modeling effort for each species (e.g., available model, model spatial extent, partners involved, and projected completion). This database will be integrated into the GAP web site to allow users to check the modeling status for any species. Several key national ancillary data layers (e.g., stream velocity, distance to forest edge) were created through this effort and will be incorporated into other continental scale modeling efforts as described below. These national ancillary data layers will be available from the GAP web site.

GAP's modeling strategy is aimed towards our new national level vision. We believe our strategy over the next 1-2 years will position us well for conducting nationwide biodiversity assessments, while also building and expanding our species modeling data, models, and expertise.

Species Groups Modeling Efforts

Mapping Range, Distribution, and Habitat Quality for Vertebrates in the Northwestern United States

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The State Natural Heritage Programs of Wyoming, Montana, Idaho, Oregon, and Washington are mapping range, distribution, and habitat quality for each of 700 vertebrate species (mammals, amphibians, reptiles, and birds) found throughout the northwestern U.S. NWGAP is supported and directed by the National Gap Analysis Program and is anticipated to be complete by winter 2011.

The list of target taxa was derived from a list of all vertebrates that have been documented in the region. Zoology teams from each state culled from this list all vagrant species and other taxa not relevant to conservation in the region. Remaining species that occur in the northwest only during migration will receive range maps, but not distribution or habitat quality maps. A "modeling season" was assigned to each species that occupies different portions of the northwest in summer and winter. Therefore, distribution and habitat quality maps for those species will be specific to the modeling season.

For each species range, documented observations and expert input were combined to attribute each northwestern 10-digit hydrological unit (HUC) by occupation status (e.g., known, suspected), season, and origin (e.g., native, exotic). These maps will undergo a final expert review in fall 2010, which will provide a general quality ranking for each map. The final maps will be delivered in winter 2011.

Physically-suitable environments within a species distribution will be modeled with the MAXENT algorithm, using climatic variables as predictors at points of known species occurrence (Phillips et al. 2004, Phillips et al 2006). Geo-referenced observations of each target species were assembled by project teams and filtered, as needed, to produce a set of reliable and seasonally-appropriate points. For each species MAXENT will summarize the points in terms of six climatic variables that preliminary analyses indicated are both reliable predictors of presence and also uncorrelated with one another. Each resulting map will be assigned a quantitative quality rank derived from MAXENT output statistics.

Figure 2: Northwest GAP states.

Biologically-suitable environments will be land cover types, in the NWGAP land cover dataset, deemed by regional experts as suitable for occupation by each target species. For each species an initial list of suitable land cover types was produced by cross-walking suitable types from each of the five state's previous GAP project to current land cover map types. These initial lists were edited by project teams, and will be further edited by a wider audience of biologists in fall 2010. Resulting maps will be assigned general quality rankings derived from expert review.

The final distribution map for each target species will be the spatial intersection of physically- and biologically-suitable environments. These maps will be assigned general quality ranks derived from the ranks of the two component maps, and will be delivered in winter 2011.

Habitat quality is the degree to which an environment contributes to positive rates of survival and reproduction for a given species. For each species, we will map habitat quality on a *high-medium -low* scale via two modifications of its distribution map. First, the habitat quality of small and isolated patches of suitable environment will be designated *low*, on the general assumption that such patches support low rates of survival and reproduction. Second, we are polling experts on the relative habitat quality of land cover types for each species. This input will allow us to grade all suitable environments by habitat quality; i.e., the two-category (*present, absent*) distribution map will be converted into a four-category (*high, medium, low, absent*) habitat quality map. We anticipate delivery of final habitat quality maps in winter 2011.

Alaska Gap Analysis Project Species Modeling Update

Tracey Gotthardt
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The Alaska Gap Analysis Project (www.akgap.info) is a joint project spanning three University of Alaska campuses (Anchorage, Fairbanks, and Juneau). The Alaska Natural Heritage Program, at the University of Alaska, Anchorage, is coordinating the species modeling effort and is responsible for producing and disseminating final models and other project related data products.

The objective of AKGAP is to produce spatially explicit models that predict the range and distribution of Alaska's terrestrial vertebrate species a to support analysis of conservation status. To address some of the challenges associated with deductive modeling techniques that crosswalk species habitat associations to land cover classes, we are using a combination of deductive and inductive modeling techniques and using methods similar to NWGAP (Aycrigg and Beauvais 2008). By combining the strengths of these two modeling techniques, we aim to produce more robust distribution models that are of high utility to resource managers.

During the first year of a 3-year project (2009-2011), we focused on the selection of 435 target species, formation of species-expert and review teams, establishment of a data-gathering framework, collating occurrence data for inductive modeling, and producing preliminary watershed-scale range maps for each of the target species.

In the second year, we have transitioned to the modeling process by focusing on refinement of analytical methods, including development of preliminary inductive and deductive models, populating the habitat-associations database and conducting the cross-walk of habitat descriptions from the literature to ecological systems from the LANDFIRE legend, producing final expert-reviewed range maps, collating ancillary data layers necessary for both deductive and inductive modeling and deriving new layers from existing layers. We conducted a modeling workshop to test the effectiveness of modeling methods and developed techniques to automate the process. We also completed the synthesis of occurrence data, now totaling more than1.5 million records from 650 unique data sources.

During the final year, we will focus on running inductive and deductive models independently and then combining inductive and deductive models to produce draft final distribution models. We will validate the models to assess model accuracy and facilitate a comprehensive expert review process. Lastly, we will incorporate expert comments to produce final distribution maps, prepare associated metadata, and complete a project report.

Modeling Wildlife Habitat throughout the Western United States: A Prototype for Use in Gap Analysis

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New Mexico State University is currently completing a project combining NWGAP and SWReGAP species models to create western-wide species distribution models. This project is a prototyping effort to identify the process and methods for species habitat modeling over the Western US. The objectives were to identify species to use as prototypes, combine existing species deductive models, obtain species occurrences points for inductive modeling, and conduct inductive modeling using biophysical envelope datasets. Our goal was to compare the deductive and inductive models with regards to modeling technique and effort.

We identified 69 species of greatest conservation need (SGCN) as designated by the State Wildlife Action Plans (SWAPs) as well as species of concern from state wildlife agencies, Partners in Flight, and Joint Ventures. To support the National Gap Analysis Program, we also included deductive models for an additional 70 species to complete their US range.

Using the selected species, we obtained the models from SWReGAP and NWGAP to merge datasets for western-wide and future nationwide application. Consolidation of species ranges was a priority and the National Gap Analysis Program has been incorporating these for the entire nation based on 12-digit HUCs. For initial modeling, we used the SWReGAP habitat modeling database modified to include 283 land cover types identified in the Western GAP land cover dataset. We also created additional datasets of elevation, aspect, slope, distance to springs, distance to lakes, and distance to perennial streams. Data for California was included with use of the California Wildlife Habitat Relationship database. Our process was similar to the SWReGAP process in that we ran models at 240-m resolution to identify general model characteristics and then ran refined models at 30-m resolution.

Inductive modeling requires species occurrence records and environmental variables to define the species habitat relationships. We obtained species occurrence records from NWGAP, state natural heritage programs, and online databases (e.g., Global Biodiversity Information Facility and Arctos). We obtained 550,208 total records with 265,190 (48%) reflecting museum records. Because maximum entropy (MAXENT) was used for NWGAP and applied to a project related to SWReGAP, we used it to model the selected species (Phillips et al. 2004, Phillips et al 2006, Boykin et al. 2008). We reviewed various climate datasets, such as WorldClim, Daymet, and PRISM (Parameter-elevation Regressions on Independent Slopes Model). Based on Daly et al.'s (2008) comparison of these three datasets, we used the PRISM dataset. To maintain temporal relevancy with the PRISM dataset, we only included occurrence records from 1971 to present.

Bioclimatic envelopes were created for each species in MAXENT. Initially, we used 19 bioclimatic variables derived from PRISM and then reduced each model's variables with a standardized procedure, and analyzed the final model using the area under the curve (AUC) metric, omission rates, and fractional area prediction rates.

The inductive models were converted to binary envelopes to combine the final climatic model with the deductive biophysical models and to mask out the biophysical range of the species. Two commonly used thresholds for creating binary envelopes out of the probability surface were used. We are currently comparing species specific models and will complete this project in 2010.

Southeast Gap Analysis Project Species Modeling Update

Steve Williams
North Carolina State University, Raleigh, NC

Predicted habitat maps for Southeast Gap Analysis Project (SEGAP) have been created for all terrestrial vertebrate species that breed in the Southeastern U.S. or use habitat there for an important part of their life history. Decisions were made on which species were mapped based on standard GAP guidelines. Species lists were created for each of the nine southeastern states (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee and Virginia) by state-level GAP projects; these lists were compiled and pared down to remove some subspecies and domesticated species. Subspecies were only included when supported as distinct and non-overlapping from either the full species or other subspecies. The final list includes 606 species of amphibians, mammals, reptiles, breeding birds, and wintering waterfowl.

All species' geographic known range extents were delineated as single or multiple polygons. Migratory species were primarily represented by breeding season ranges; however, wintering ranges for waterfowl and migratory bats were also delineated (33 species). Processes used to create range polygons were unique because information on the current geographic range of a species varied widely. However, a generalized approach used a variety of sources to develop species' ranges including information in two broad categories: 1) species location records and range maps available digitally or in print, and 2) digital spatial data of environmental parameters including watersheds and ecoregions (Omernik 1987, 1995).

Deductive models of presence/absence for a species' habitat may include a number of spatially explicit data sources. GAP models typically involve land use/land cover data as the primary input. However, other environmental features that make up the landscape constituting species' habitats can be valuable inputs to modeling.

SEGAP attempted to use ancillary data (e.g., soils, elevation, and stream velocity) in addition to land cover to develop species models. Many of these data layers act as surrogates for one or more aspects of a species' habitat that may only be inferred from available, remotely sensed information. The final SEGAP species models are being incorporated into the national data framework of the National Gap Analysis Program.

Northeast Gap Analysis Project Species Modeling Update

Steve Williams
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The Northeast Gap Analysis Project (NEGAP) began in 2008 and is being developed within the newly developed national data framework of the National Gap Analysis Program. It will build upon the national wildlife habitat relationship database, known range dataset, and recently completed national ancillary datasets used in deductive habitat modeling.

Of the 291 NEGAP bird species, 199 draft models have been developed currently. To target species that are of high conservation concern for state wildlife agencies, models for the remaining bird species (92) identified as SGCN by Northeastern SWAPs are also being developed. Subsequently; 248 mammals, reptiles, and amphibians, which are SGCN species, will be modeled. To build upon the national data framework, each species will be modeled throughout its entire known range within the continental US, rather than only for its NEGAP extent. In addition to these targeted SGCN species, other species as identified by conservation partners through joint workshops with the Northeast Landscape Conservation Cooperative and the Atlantic Coast Joint Venture may be added to the initial efforts. The species identified through these workshops will form the basis of a conservation design effort. NEGAP species models are anticipated to be completed in 2011.

Species Groups Modeling Efforts

Overview of Nationwide Bird Modeling

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This project, which began in 2009, was the first to begin mapping and modeling species over their entire range, which included up to the entire continental US. This project expanded upon the modeling processes used by SEGAP and SWReGAP, which adopted a deductive modeling approach that was based on information put into a wildlife habitat relationship database and spatial ancillary data, such as land cover, elevation, and slope. The species included in the project were a subset of all the birds included in the national species lists and were considered conservation priority species. We decided to focus on birds for this initial national modeling effort because of conservation interest by Partners in Flight and state partners in the SWAPs. Some of the bird species included had previously been modeled by SEGAP or SWReGAP. This project built upon those models to create models that covered the entire species range.

The initial step was to create species range maps, which were a compilation of SEGAP, SWReGAP, and NatureServe range maps. These were created by attributing 12-digit HUCs within a species' range with origin (e.g., native, introduced), presence (e.g., known, historic), reproductive use, and season (e.g., winter, summer). Each range was reviewed for accurate representation of each species.

We also modified existing wildlife habitat relationship databases from SEGAP and SWReGAP to create a national wildlife habitat relationship database, which is the database that all national species deductive modeling efforts are using. This project populated this database with information on habitat associations from a literature review of peer-reviewed and gray literature for the selected bird species.

Because this was the first project to create national species distribution models, it was also the first to need national coverages of ancillary data. The GAP National Land Cover data were available for use from the National Gap Analysis Program. However, the project team had to create the additional necessary national ancillary data, which included elevation, slope, aspect, distance from forest edge, forest interior patches, percent canopy cover, hydrography (proximity to water, fresh, brackish or salt water, and salinity), stream velocity, and human impacts.

This project was completed in 2010 and produced species distribution models for 322 bird species of conservation concern. It also produced all the national ancillary data needed for additional modeling at the national scale as well as the national wildlife habitat relationship database. This project positioned the National Gap Analysis Program and all its partners well for continuing to produce national level deductive models.

Overview of Nationwide Reptile Modeling

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NMSU is currently modeling species distributions for 150 reptiles across their entire range within the US. The overall goal is to create, review, and finalize nationwide species distribution models for all reptile species. Specific objectives of this research include: 1) Identify a list of approximately 150 reptile species to model; 2) Research species habitat associations and compile the information in the national wildlife habitat relationship database; 3) Complete deductive habitat models; 4) Review models for accuracy and work with species experts to have these models reviewed; and 5) Continued cooperation with National Gap Analysis Program, state and federal agencies, and non-governmental organizations.

Currently, we are identifying a list of up to 150 reptiles on which to focus our effort. These species will be identified at the species level, unless specific modeling or management issues are identified to warrant the inclusion of subspecies and sufficient data are available to create a representative subspecies model.

Adopting processes used and documented by SWReGAP, SEGAP, and NWGAP efforts and the mapping strategy identified by the National Gap Analysis Program; we are creating habitat models for each species by reviewing literature to include state, regional, and national species accounts, state wildlife agency online databases, and primary literature in order to populate the national wildlife habitat relationship database. Specific notations on each species will include the potential for inductive modeling, additional datasets that could be useful in modeling (e.g. soils), and other informative details to help substantiate the deductive models and provide for further model refinement. Species experts will be contacted when possible to obtain the most recent information.

We are working with the National Gap Analysis Program and North Carolina State University (NCSU) in populating the database, running the models, reviewing the models, and finalizing the models. Extensive cooperation is necessary and leads to constructive feedback on reptile species range maps and models. This project is anticipated to be complete in 2011.

Incorporating Interspecific Relationships to Map Secondary Cavity User Distributions

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Primary cavity excavators (PCEs) such as woodpeckers are considered to be an ecologically important guild due to their excavation of cavities. Approximately 100 species of birds and mammals are secondary cavity users (SCUs) and utilize cavities for nesting and/or roosting (Aitken and Martin 2007). These secondary cavity users cannot excavate their own cavities, and thus may depend on the cavities that are excavated by woodpeckers in areas where natural cavities are limited.

Although many ecologists have recognized that functional dependencies exist between primary cavity excavators and secondary cavity users, much remains to be learned about the ecological importance of these relationships. Woodpecker-excavated cavities reflect the size of the excavator, and generally, these cavities are only as large as they need to be for users to enter (Jackson and Ouelette 2002, Walters et al. 2002). Secondary cavity users range from small passerines and mammals to large cavity nesting ducks, and not all woodpecker-excavated cavities are likely to provide adequate nest/roost sites. For instance, cavity-nesting ducks in coniferous forests are likely restricted to areas where either Pileated woodpeckers (*Dryocopus pileatus*) or Northern flickers (*Colaptes auratus*) exist; other woodpecker species create cavities that are too small for this group. Therefore, specific relationships between secondary cavity users and primary cavity excavators might exist, and these relationships are important to consider when mapping species distributions of secondary cavity users.

The major objectives of this project are to: 1) Review the peer-reviewed literature to determine the current state of knowledge relative to secondary cavity user dependencies on specific primary cavity excavators, 2) Incorporate those dependencies into GAP maps by intersecting secondary cavity user distributions with specific excavator distributions, and 3) Evaluate how secondary cavity user distributions within and outside of protected lands change with the incorporation of primary cavity excavator distributions.

To date, we have completed the review of peer-reviewed literature to determine the current state of knowledge relative to secondary cavity user dependencies on specific primary cavity excavators (Vierling et al. in prep). These data were based on peer-reviewed literature only, and search terms were not restricted by region. In general, some regions, such as the Southwest, contain more information about PCE/SCU relationships than other regions (Vierling et al. in prep).

In order to assess how secondary cavity user distributions change with the inclusion of primary cavity excavator distributions; we are focusing our initial efforts on the SWReGAP region. Species distribution maps in this region have been recently revised, and multiple studies from this region explicitly describe relationships between secondary cavity users and specific primary cavity excavators. The mapping of secondary cavity user distributions with the incorporation of primary cavity excavator relationships is ongoing and is expected to be completed in 2011.

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Using Gap Analysis of Long-term Biodiversity Protection to Inform Conservation Priorities: The Five Valleys Land Trust

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In preparation for the Northwest Regional Land Trust Alliance annual meeting in May, 2010, GAP initiated a project with the Five Valleys Land Trust (FVLT) to demonstrate the application of GAP data to the land trust's conservation activities. FVLT is a widely-known and well-respected community-based land trust with a leadership role in local and regional land protection initiatives in western Montana. The trust has helped conserve 50,922 acres of Western Montana.

Faced with the challenge of efficiently allocating its financial resources among available conservation opportunities, the trust needed to find a mechanism to identify high priority areas for conservation in their large service area. The FVLT maintains a spatial database of their easement holdings and service area boundary in a Geographic Information System (GIS). GAP was able to use this data to characterize land ownership and vegetation cover types within FVLT conservation easements and to assess the long-term conservation of biodiversity in the nearly eight-million-acre FVLT service area. Ultimately GAP provided FVLT with a summary of the land cover types protected by their holdings as well as a summary of the land cover in their entire service area. GAP supported the assessment with newly released land cover and protected areas data.

Methods

GAP conducted analyses with the Protected Areas Database of the United States (PAD-US) version 1.1 and GAP National Land Cover (version 1) within FVLT conservation easements and their overall service area boundary (provided by FVLT) in ArcGIS, a Geographic Information System. We provided FVLT with a list of land cover types, stratified by area, that are currently protected by their easements. To provide context, we also mapped land ownership and land cover within the area serviced by the trust. Using GAP status codes (Crist 2000), a measure of management intent to protect biodiversity, GAP was able to assess the conservation status of each ecological system in the FVLT Service Area by comparing the amount of each system that occurred on already-protected land to the total amount of that system in the FVLT service area.

Figure 1: The Five Valleys Land Trust's Service Area encompasses much of southwestern Montana.

Results and Discussion

The area managed by each land owner (e.g. US Forest Service, Bureau of Land Management, State Fish and Wildlife, The Nature Conservancy) in relation to FVLT easements in their service area were summarized in ArcGIS (Figure 2). We conducted land cover assessments at coarse- and fine -scales. Fine-scale land cover data described the

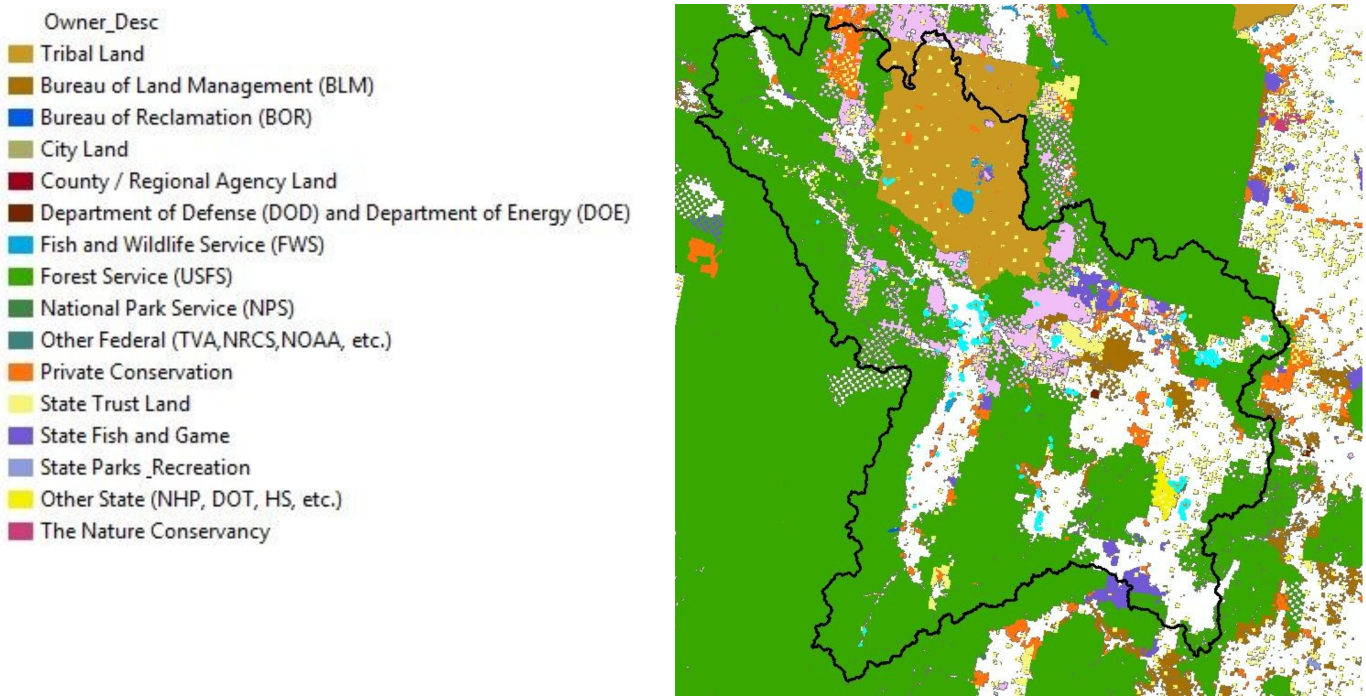

Figure 2. Land owners in the Five Valley Land Trust Service Area with FVLT parcels highlighted in blue.

natural ecological system (Comer et al. 2003) or developed land use class (e.g. cultivated crops, pasture, harvested forest) present on each 30 m^2 area in FVLT holdings and their service area. To facilitate interpretation, this information was also presented as simplified, coarser groups (level 1) such as: forest and woodland systems, shrubland, steppe and savanna systems, grassland systems, riparian and wetland systems, and human land use.

Once the percent of all land cover types protected in perpetuity were determined (Figure 3), the analysis was refined to map the location and extent of under-protected (defined as less than 40% protected) ecological systems in the service area (Figure 4). FVLT easements primarily protect grassland (39%) and shrubland, steppe or savanna systems (31%); however, 19% preserve working farmland. The dominant land cover types in the FVLT service area (Figure 5) are forest and woodland systems (58%) that are largely federally protected (Figure 4).

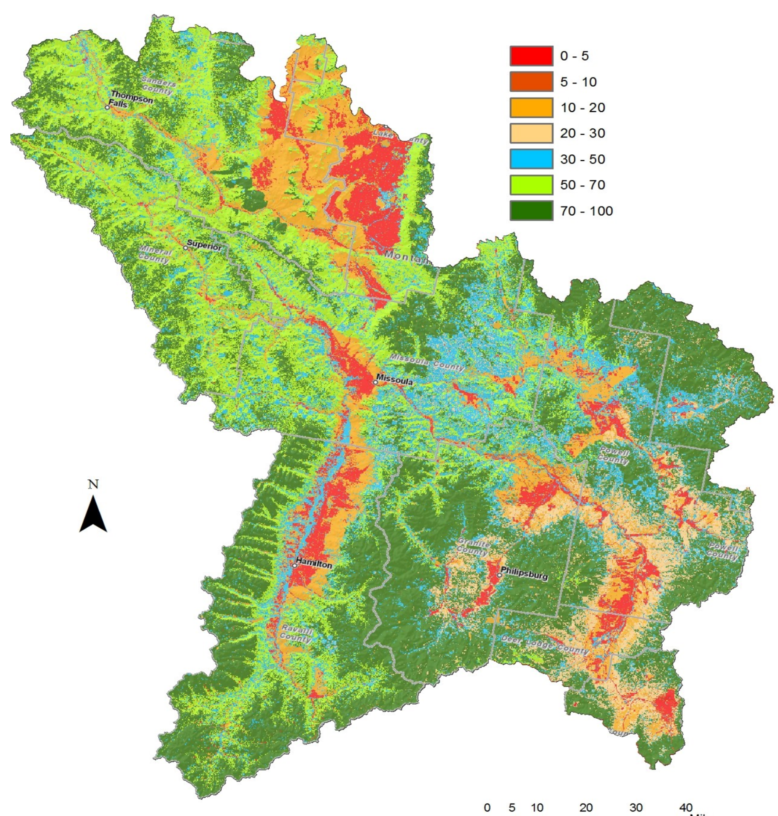

Figure 3. Percent of Land cover (level 1) protected in the FVLT Service Area . GAP status 1,2, and 3 lands are included.

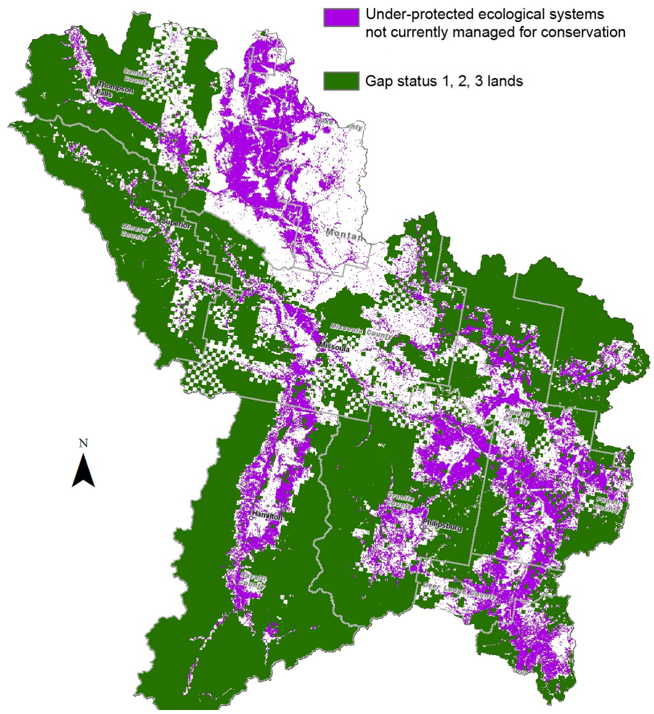

Figure 4. Location of under-protected ecological systems in the FVLT service area that are not currently protected as GAP Status 1, 2 or 3.

The FVLT plans to review these identified conservation priorities in relation to other conservation drivers (e.g. presence of wetlands, habitat for species of greatest conservation need, wildlife corridor connectivity, proximity to public lands or existing easements) to establish future objectives. The assessment provided valuable information to the FVLT during the development of its strategic plan. Other land trusts could do similar kinds of analyses of the land cover types and species that occupy their easements to ensure that they are maximizing the conservation impact of their purchases.

PAD-US (version 1.1) and GAP's National Land Cover data can be downloaded from: http://www.gapanalysis.nbii.gov . GAP is working to improve and update these data sets. For more information contact Lisa Duarte regarding PAD-US (lduarte@uidaho.edu) or Anne Davidson regarding land cover (adavidson@uidaho.edu).

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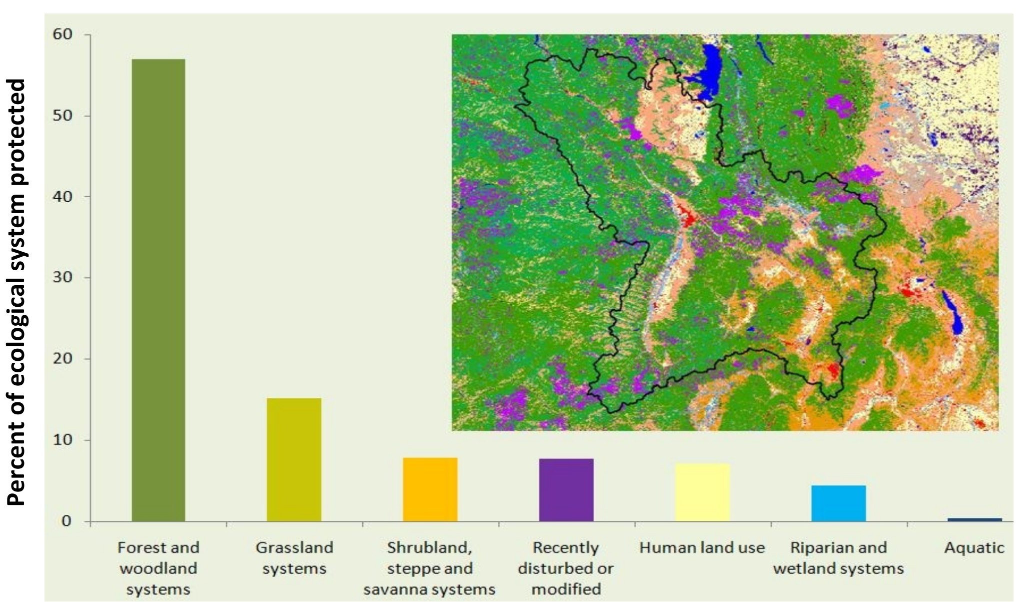

Figure 5: The dominant land cover types in the FVLT service area are forest and woodland systems (58%) and grassland systems (15%).

Modeling Vegetation Dynamics and Habitat Availability in the Southeastern U.S. Using GAP Data

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Resource agencies are increasingly challenged to predict and respond to the potential effects of climate and land use change on the habitats they manage. Historically agencies have focused on managing individual public lands. Over time, the scale and extent of the potential impacts of these new threats will require that managers consider strategies across ownership boundaries and at a landscape scale. The Southeastern U.S. has experienced rapid land use change (Loveland and Acevedo 2006) with three primary drivers of change (timber management, regeneration of forests from farmland, and urbanization (Napton et al. 2010).

Given the need to make management decisions now without perfect knowledge, modeling provides a practical approach to studying the potential impacts of land use and climate change. Models can help identify sensitivities in a system that should guide future research, and they can serve as a meaningful tool for implementing an adaptive management strategy (Turner et al. 2001, Gardner et al.1999).

To help inform these management decisions we are leveraging existing data from the Southeast Gap Analysis Project to model vegetation dynamics across the region. The three core GAP datasets (land cover, stewardship and terrestrial vertebrate species models) were completed for the region in 2007. Those data have since been used in a variety of derivative projects and products, including the development of national datasets (i.e. the Public Areas Database and the National Gap Land Cover). In the Southeast, we have used the data to model future vegetation and habitat under two climate change scenarios as part of the Designing Sustainable Landscapes Project (DSL; http://www.basic.ncsu.edu/dsl), guided by the Atlantic Coast Joint Ventures Program. In the Southern Atlantic Migratory Bird Initiative (SAMBI), our objectives were to:

1. Project the effects of climate change on vegetation dynamics
2. Use the projected vegetation dynamics to model potential future habitat distribution for avian species

This article focuses on how the Gap Analysis datasets provided the foundation for our research. The outcome of this work will directly inform the development of optimal conservation strategies and decision support tools to guide conservation planning for the SAMBI.

Methods

Study area

The SAMBI area includes the coastal plain from Southern Virginia through Georgia and Northern Florida (Figure1). Within the area a variety of bird species and habitats have been identified as priority for conservation and management through a series of workshops led by the USFWS Joint Venture Program (Watson and McWilliams 2005). The Longleaf/Slash Pine Flatwoods and Savannahs and Longleaf Sandhills that occur throughout the region have been identified as important for the management of nine of the priority species including Red-cockaded Woodpecker, Northern Bobwhite, Loggerhead Shrike, Prairie Warbler, Bachman's Sparrow, Henslow's Sparrow, Brown-headed Nuthatch, American Kestrel and Red-headed Woodpecker. Conservation lands represent less than 10% of all lands in the SAMBI, with several larger managed lands scattered throughout (i.e. Apalchicola , Croatan, and Francis Marion National Forests; Camp LeJeune, Fort

Steward, and Fort Bragg; Okefenokee, Swan Quarter, Cedar Island, Pea Island and Alligator River National Wildlife Refuges; Cape Hatteras and Cape Lookout National Sea Shores). Omernik recognized three Level III (Southeastern Plains, Middle Atlantic Coastal Plain, and Southern Coastal Plain) and 29 Level IV ecoregions within the study area (USEPA 2010).

Modeling Vegetation Dynamics

An overview of the modeling approach is provided in Figure 1. For the SAMBI, we are focusing on a 100 year time period (2001 - 2100) and two climate change scenarios models (B1 and A2). We are using the spatially-explicit forest landscape simulation model TELSA (Tool for Exploratory Landscape Scenario Analyses; Kurz et al. 2000) to simulate vegetation dynamics. TELSA integrates state-and-transition vegetation models that are developed using the Vegetation Dynamics Development Tool (VDDT; ESSA 2007) with the spatial distribution of vegetation types to simulate both deterministic (i.e. aging) and stochastic (e.g. fire) processes.

For the simulation landscape, there are four major inputs to TELSA: (1) a polygon map of vegetation types, (2) a non-spatial state-and-transition model for each vegetation type, (3) an initial age for each polygon, and (4) an initial structural stage for each polygon. In order to develop the map of

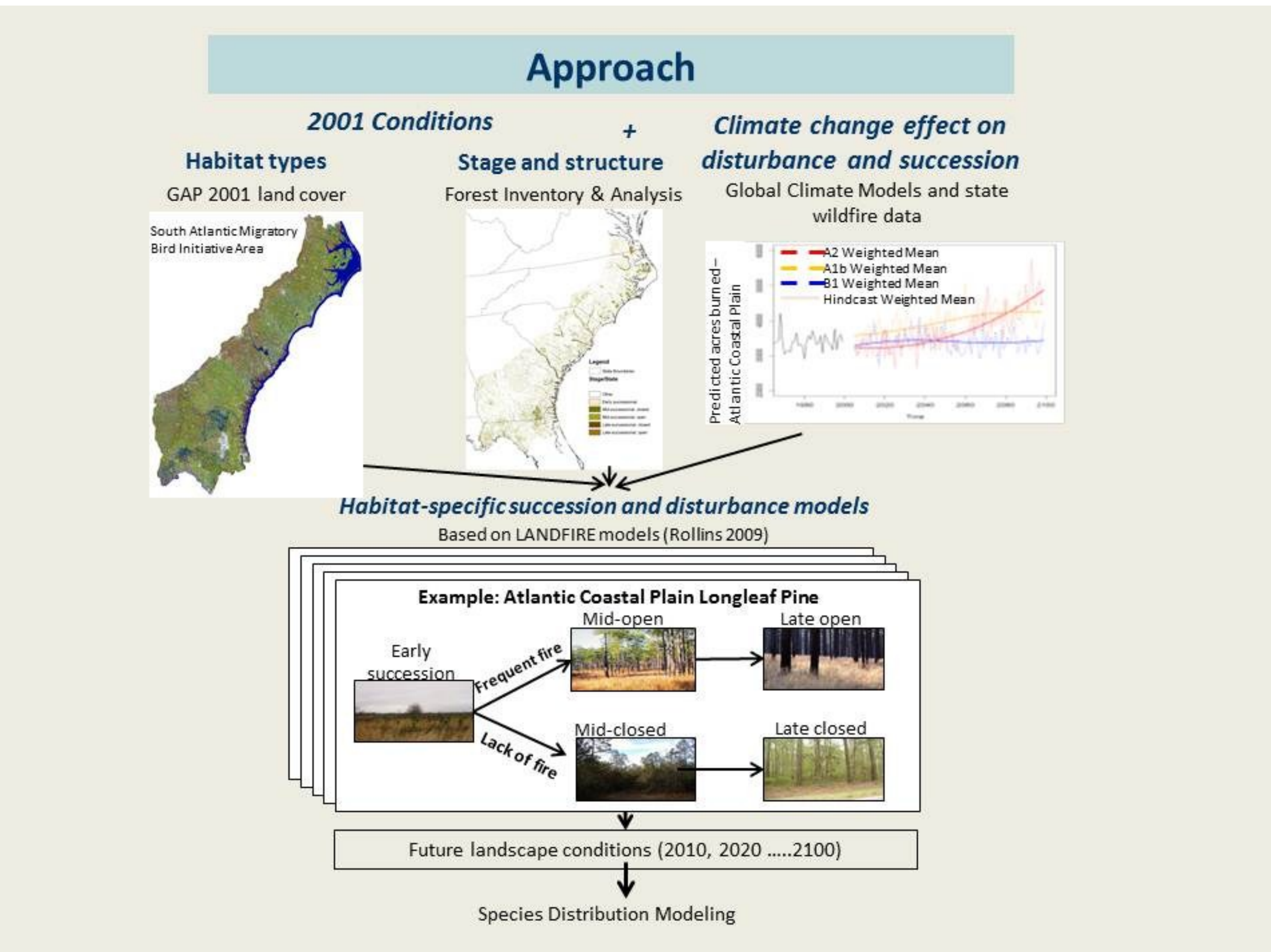

Figure 1. Modeling future landscape conditions and habitat availability in the Southern Atlantic Migratory Bird Imitative Area (SAMBI).

vegetation types, we divided the SAMBI into polygons using the SEGAP land cover map. This map represents 2001 era land cover at 30m resolution. The vegetation classes in the map generally correspond to NatureServe's Ecological Systems classification (Comer et al. 2003). We included modifiers to the Ecological Systems to accommodate variation in the vegetation. For example, we included three modifiers to the Atlantic Coastal Plain Sandhills Longleaf Woodland an Open Understory, a Scrub/shrub Understory, and a Loblolly Pine modifier. The National Land Cover Dataset 2001 (Homer et al. 2007) was used to represent the remaining land cover classes.

To the base map, we assigned a state-and-transition model to each of the vegetated map classes. For most of the ecological systems, those models were developed as a part of the LANDFIRE Project (Rollins 2009). Each of those models has states representing combinations of successional stage (early, mid, or late succession) and structural stage (open or closed canopy). Succession is deterministic, while disturbances such as fire are probabilistic. Models were drafted and reviewed by regional vegetation ecologists, who described the states, and developed probabilities to represent disturbance transitions.

We then assigned each polygon an initial age based on county level summaries of the US Forest Service Forest Inventory and Analysis (FIA) data (USFS-FIA 2010) based on a crosswalk between the forest types and the mapped cover forest classes. Initial ages were assigned so that the age distribution for the given forest type in each county was the same as the age distribution of plots in the FIA database. The ages were used as a basis for assigning the appropriate stage label (early, mid, or late successional) to each polygon. Finally, we assigned an initial structural stage to each polygon based on the s-class dataset produced by LANDFIRE (Zhu et al. 2006).

The combination of ecological system, age (early, mid, and late stages), and structure (early successional, closed, open) constitutes a state-class label for each polygon. TELSA simulates succession, disturbance, and management on an annual time step. The result of each time step for each polygon is a condition (structure and successional stage). We produced outputs from TELSA every 10 years from 2010 to 2100.

Climate Change

There is a growing body of evidence that anthropogenic emissions of greenhouse gases are warming the planet and will likely cause significant climatic changes in this century (IPCC 2007). In order to simulate vegetation dynamics under these projected future climate conditions, we are using observation data to relate climate variables (temperature and precipitation) to ecosystem processes. Once the relationship is established, we then project the change in disturbance probability under the two climate change scenarios developed by the IPCC (A2, B1). The SAMBI study area falls completely within the Coastal Plain Ecoregion, where fire is a dominant disturbance factor. For this study we used historic (1979 – 2010) climate and fire occurrence data to hindcast the relationships between the acres burned and climate variables (i.e. temperature and precipitation). Those relationships have then been incorporated in to the modeling as a fire probability multiplier in the TELSA model runs.

In addition to the vegetation dynamics modeling, we have incorporated urban growth and sea level rise model projections for the study area. Those methods and results will be presented in subsequent articles.

Modeling Habitat Dynamics

Five species were considered for the pilot test of this approach: Bachman's Sparrow (*Aimophila aestivalis)*, Northern Bobwhite (*Colinus virginianus)*, Red-cockaded Woodpecker (*Picoides borealis), Cerulean Warbler (Dendroica cerulean)* and Brown-headed nuthatch (*Sitta pusilla*). For each species, habitat availability was modeled based on habitat associations to land cover classes, as well as to a variety of ancillary variables (e.g. species range, distance to water, and elevation). The modeling approach and development of the data layers is described in detail on the Southeast Gap Website (www.basic.ncsu.edu/segap). For this project the habitat associations included the structural attributes based on the projected age and stage for each polygon being modeled. For example, the literature suggest that brown-headed nuthatch prefers evergreen woodlands with open under-stories, therefore they would be attributed to polygons in which longleaf woodlands were modeled as having open understory and excluded from closed structure class.

Results

Vegetation Dynamics

Vegetation dynamics were modeled for 94 of the 110 map classes in the SAMBI. The remaining 16 represented anthropogenic (e.g. urban, agriculture) or non-vegetated cover classes (e.g. water, barren land) that would not be impacted by the vegetation modeling, but would be impacted by urbanization, sea-level rise or management actions such as restoration and will be explored in subsequent research. Figure 1 shows the initial conditions used for modeling vegetation dynamics. Dominant vegetation types in the study areas include the evergreen managed pine forests (11%), Atlantic Coastal Plain (ACP) Upland Longleaf Pine Woodlands (7%), ACP Small Blackwater River Floodplain (5%), and ACP Blackwater Stream Floodplain Forest (3%) ACP Dry and Dry Mesic Forest (3%), ACP Fall Line Sandhills Longleaf Pine Woodland, and ACP Peatland Pocosin (2%).

In order to explore the potential impact of climate change on the vegetation, we focus on the results for the ACP Upland Longleaf Pine Ecological System. The longleaf pine system has been identified as one of the most important native ecosystems for conservation (Watson and McWilliams 2005). Historically this type was estimated to dominate the upland sites throughout the ACP (Frost 2006) and currently there a variety of conservation efforts focused specifically on restoration of this ecosystem. The distribution of the state and stage within the ACP Upland Longleaf Woodland is shown in Figure 2. The LANDFIRE estimates of the distribution for the presettlement conditions are that 80 percent of the type would have been in the mid- and late-successional open classes due to the frequent fires and large continuous blocks that allowed for efficient fire movement across the landscape (Frost 1998). Under current conditions the majority of the acreage (58%) was mapped in the mid-successional closed condition. Under the two climate scenarios (A2 and B1) the

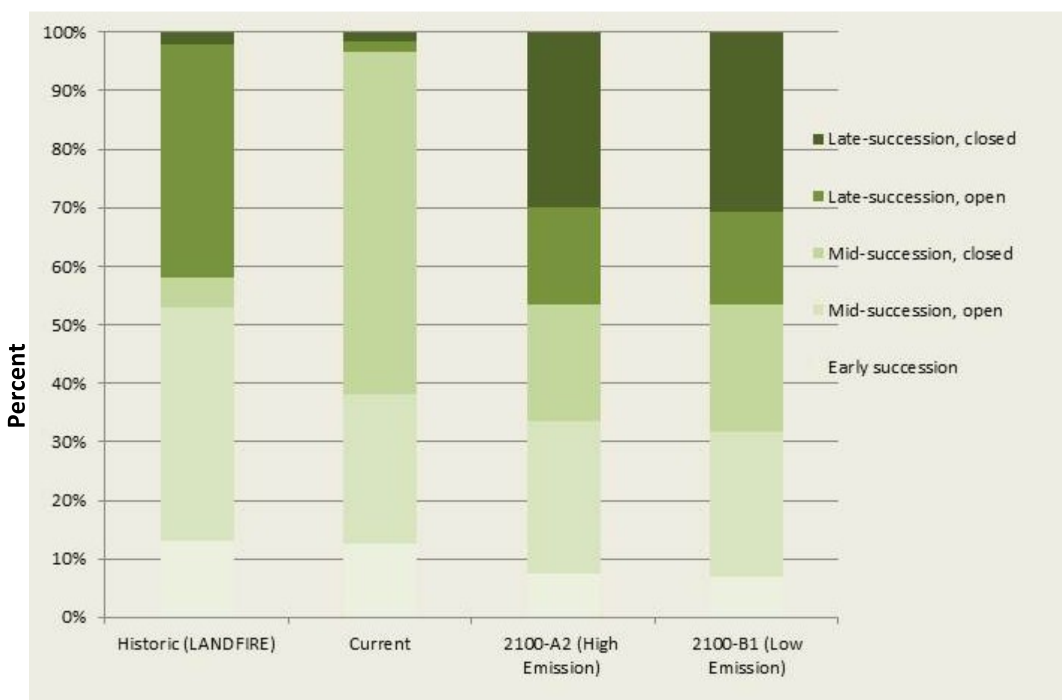

Figure 2. Proportion of Atlantic Coastal Plain Upland Longleaf for Presettlement (estimate), current conditions (mapped) and future projections based on vegetation dynamics modeling and two IPCC climate scenarios (A2 and B1).

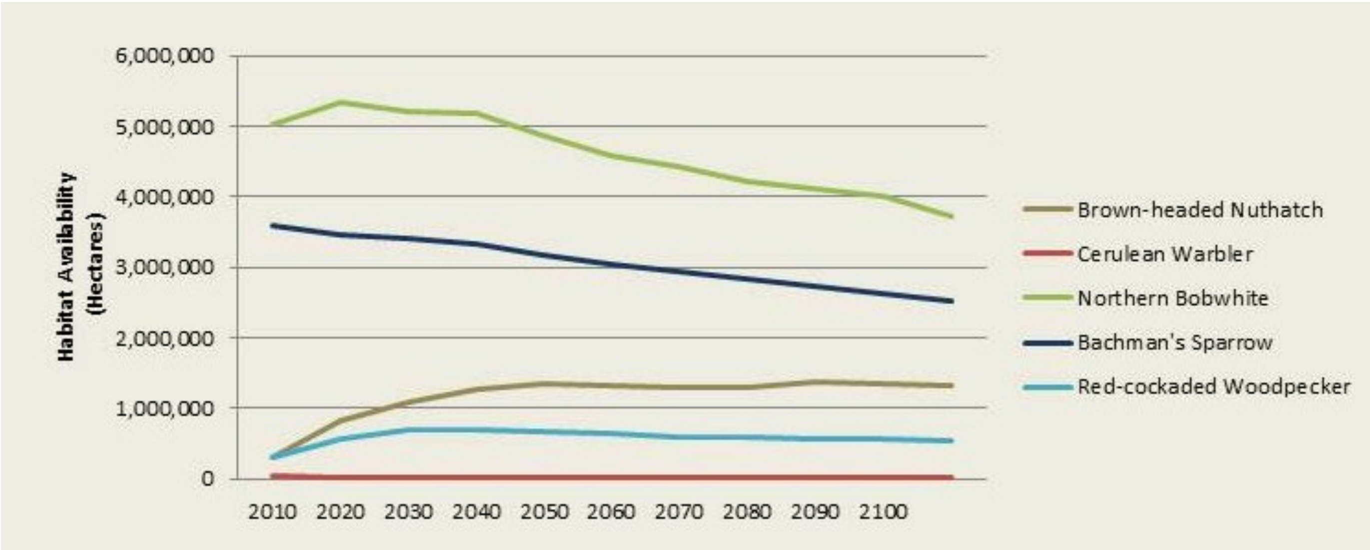

Figure 3. Modeled habitat availability through time for five priority bird species of the South Atlantic Migratory Bird Initiative Area (SAMBI).

model projections suggest a slight shift toward more stands with open under-story, but still a considerable proportion (approximate 50%) remaining in the closed condition.

Habitat Availability

Projected habitat availability by 2100 for three of the five priority species declines through 2100 in the A2 model scenario (Figure 3). The Brown-headed nuthatch and Red-cockaded woodpecker models show a slight increase in the modeled habitat availability at 2100 relative to the initial conditions, although following 2030 the trend is relatively flat. Both Brown-headed nuthatch and Red-cockaded woodpeckers prefer open understory in mature evergreen stands. The increase in the proportion of mid- and late-successional open stands due to increased burning would explain the increase in modeled habitat availability. Cerulean Warblers have a limited range within the SAMBI, primarily along the Roanoke River corridor. Figure 4 shows the difference based on a single monte-carlo simulation for the A2 scenario where habitat availability is projected to decline as a result of disturbances (e.g. fire, flood) in the floodplain habitats. Those disturbances lead to a transition from mature floodplain forest to early successional habitats considered unsuitable for the warbler. It is important to remember that sea-level rise and urbanization are two other model processes leading to some of the changes in habitat availability.

Discussion

In the Southeastern U.S., rapid urbanization, climate change, and the direct and indirect impacts of those two processes on ecosystems are major challenges to developing long-term conservation strategies. An effective conservation strategy must provide information that will allow managers to adapt to these changing conditions. In this project, we are modeling future landscape conditions under climate change scenarios in order to provide managers with that information.

Throughout this project, GAP datasets provide an ecologically rich foundation upon which to build a regional assessment. Detailed GAP land cover data provide the spatially explicit baseline conditions for vegetation dynamics modeling in the DSL project. General land cover products, while critical to addressing many resource management questions, do not provide the detail necessary to describe the important ecological processes that will drive dynamics. For example, ACP

Peatland Pocosin and Canebrake and the Central ACP Wet Longleaf Pine Savanna and Flatwoods are both wetland systems dominated by sparse evergreen trees in the over story that are mapped as Wetland Forest in a general land cover map. However, the understory composition and disturbance regimes for these two systems are quite different. The higher thematic resolution of the GAP land cover map captures those differences and provides the vegetation dynamics model with a more complete set of parameters with which to simulate the potential impacts of climate change on these systems. Finally, the GAP species models provide the link from landscape process to supporting species. The landscape dynamics model outputs are used to generate habitat availability maps for priority species through time and those maps are used in the conservation strategy.

Resource managers are going to continue to need access to decision support tools that integrate the state of the science information. Our ability to provide those tools will depend on a commitment to updating the core datasets through time and to provide for monitoring that will help reduce the uncertainty in an efficient and focused manner.

At the same time, the approach can be applied to explore a wide array of questions about species and ecosystems and their potential sensitivity to land use and climate changes. An adaptive management approach will require that the core datasets necessary to ask and refine the questions about these potential impacts be updated through time.

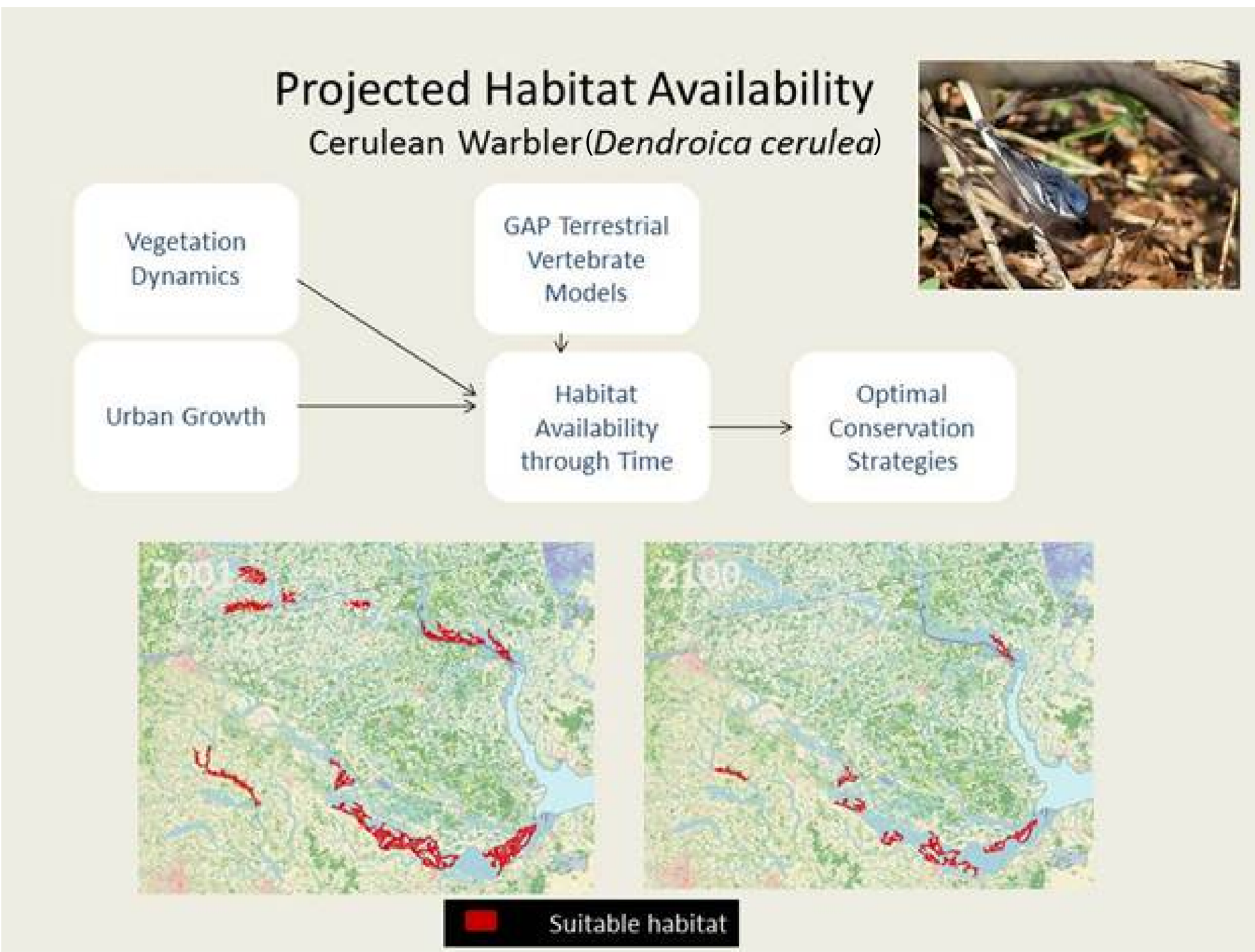

Figure 4. Current and future habitat availability for Cerulean Warbler. Future projection based on A2 emission scenario.

In the fall of 2009 the USGS brought together an interdisciplinary team of scientists to develop a research plan to assess the potential impacts of these changes Southeastern systems. Three broad focus areas were proposed; a coastal assessment to study sea-level rise and inundation modeling, an integrated terrestrial assessment to study changes in habitat availability and avian occupancy due to landscape change (i.e. urbanization and vegetation dynamics), and an aquatic assessment linking hydrologic processes to aquatic species occupancy (Dalton and Jones 2010). An overarching theme of the assessment was the integration of downscaled climate data projections and incorporating measures of uncertainly with respect to the use of global climate models in ecosystem assessments. The work described here provides the basis for the approach to the integrated terrestrial assessment and the Southeast GAP datasets help make that possible.

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Aquatic GAP Program Update

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Over the last year, the Aquatic Gap Analysis Program (AGAP) has been focusing on several aspects of the program to address program development needs. The program's major initiatives have focused on completing several watershed basin analyses through the accomplishments of AGAP partners, integrating program efforts into national initiatives, and improving the process through which information and data dissemination of AGAP products is handled. Work to improve on these goals through the implementation of programmatic standards will provide additional guidance for future projects supported through Aquatic GAP.

AGAP has a responsibility to uphold the standards of the US Geological Survey (USGS) to disseminate information products to our stakeholders in ways that contribute to their needs most effectively. Two efforts currently underway within AGAP – a web site and a map viewer - will address this priority. The new Gap Analysis Program web site <http://blogs.nbii.gov/gapanalysis/gap-analysis/aquatic-gap/> will include Aquatic GAP project reports, highlights, access to data products, and an Aquatic GAP map viewer. The Aquatic GAP Viewer, a web-based application, will enable the querying and visualization of the modeled presence of over 500 aquatic vertebrate and invertebrate species in streams and rivers across the continental United States. The tool brings together data from eight regional projects (Iowa, Flint River Basin in Georgia, Kansas, Upper Missouri, Missouri, Pennsylvania, South Dakota, and Ohio) into a unified inter-

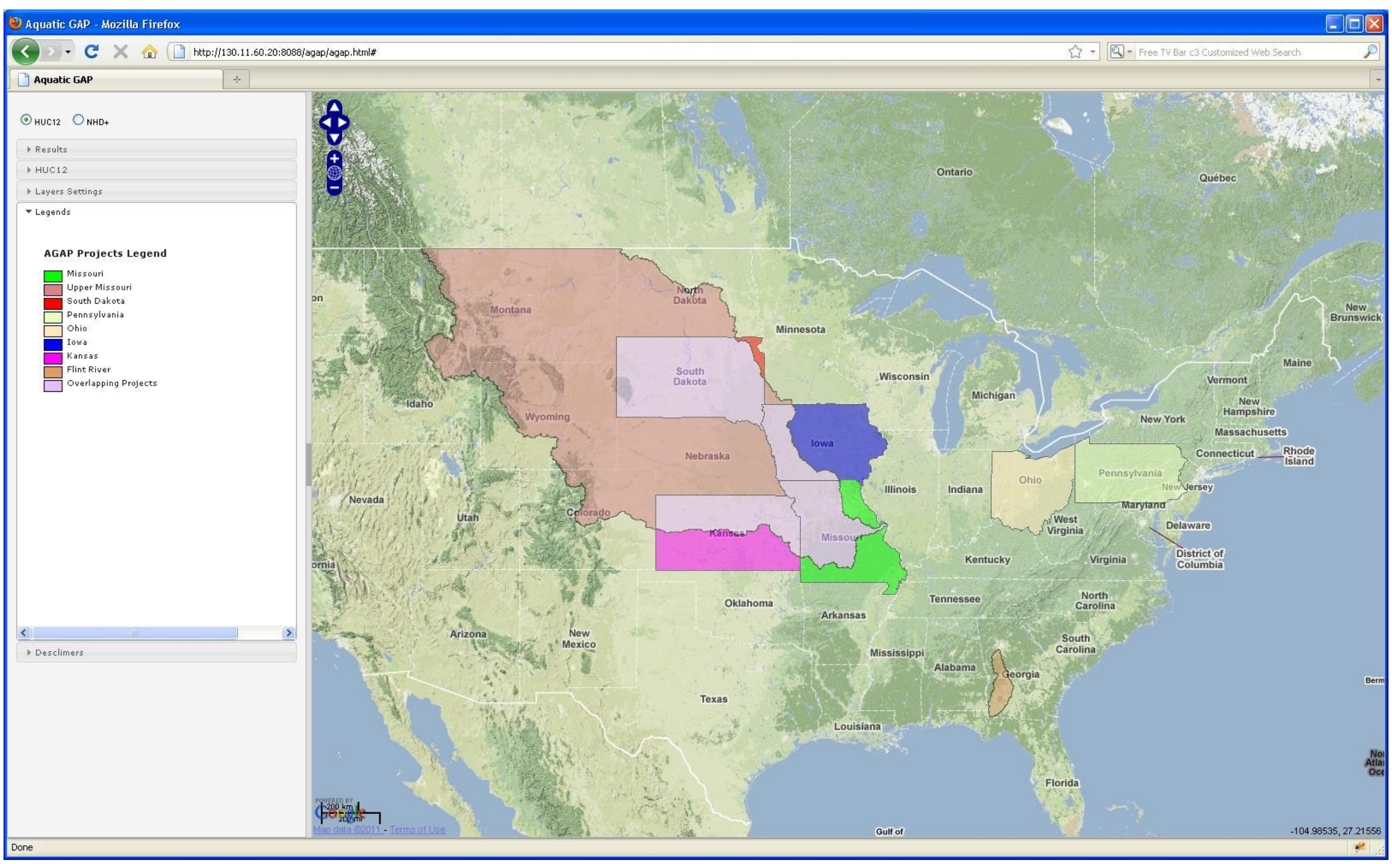

Figure 1: Distribution and spatial coverage of projects completed under the National Aquatic GAP program.

face and data model that is queryable using National Hydrography Dataset Plus (NHDPlus) catchment identifiers or Hydrologic Unit Codes (HUC12) (Figure 1). Users will access data through an intuitive map-based user interface that allows them to drill down from national, regional, and GAP project views to specific water bodies of interest. The Aquatic GAP Viewer also hosts public web services toolkits that enable the integration of Aquatic GAP species HUC12 and NHDPlus query capabilities into external applications. Visualizing Aquatic GAP data at the HUC12 scale (Figure 2) will enhance users' abilities to consider collectively the amphibian, bird, mammal, and reptile species models being generated by GAP, and will encourage the consideration of future integrated modeling approaches.

To the degree that program resources have allowed, AGAP has upheld commitments to partners who have initiated watershed basin analyses over the past several years through the completion of these projects. Based upon this level of commitment and funding support, AGAP will complete the full basin analysis of the Missouri River basin and the Great Lakes watershed this year, and anticipates completion of a full basin analysis of the Colorado River in three years. These quality data products should prove valuable reference tools for the resource managers associated with those regions.

Conservation policy-makers and resource managers have a critical need for national scale data to inform decisions in a strategic and effective manner. In support of this priority, AGAP has worked closely with the National Fish Habitat Action Plan to support efforts contributing to the national assessment product. Intended for release this year by the National Fish Habitat Board, this product will include the "Status of Fish Habitats of the United States 2010" report and an online map and data viewer. One example of AGAP's contribution to the product is its support of work that corrected location inaccuracies of the geospatial data in the Army Corps of Engineers' National Inventory of Dams, and then linked them to the NHDPlus system. A necessary step to accomplish the data quality

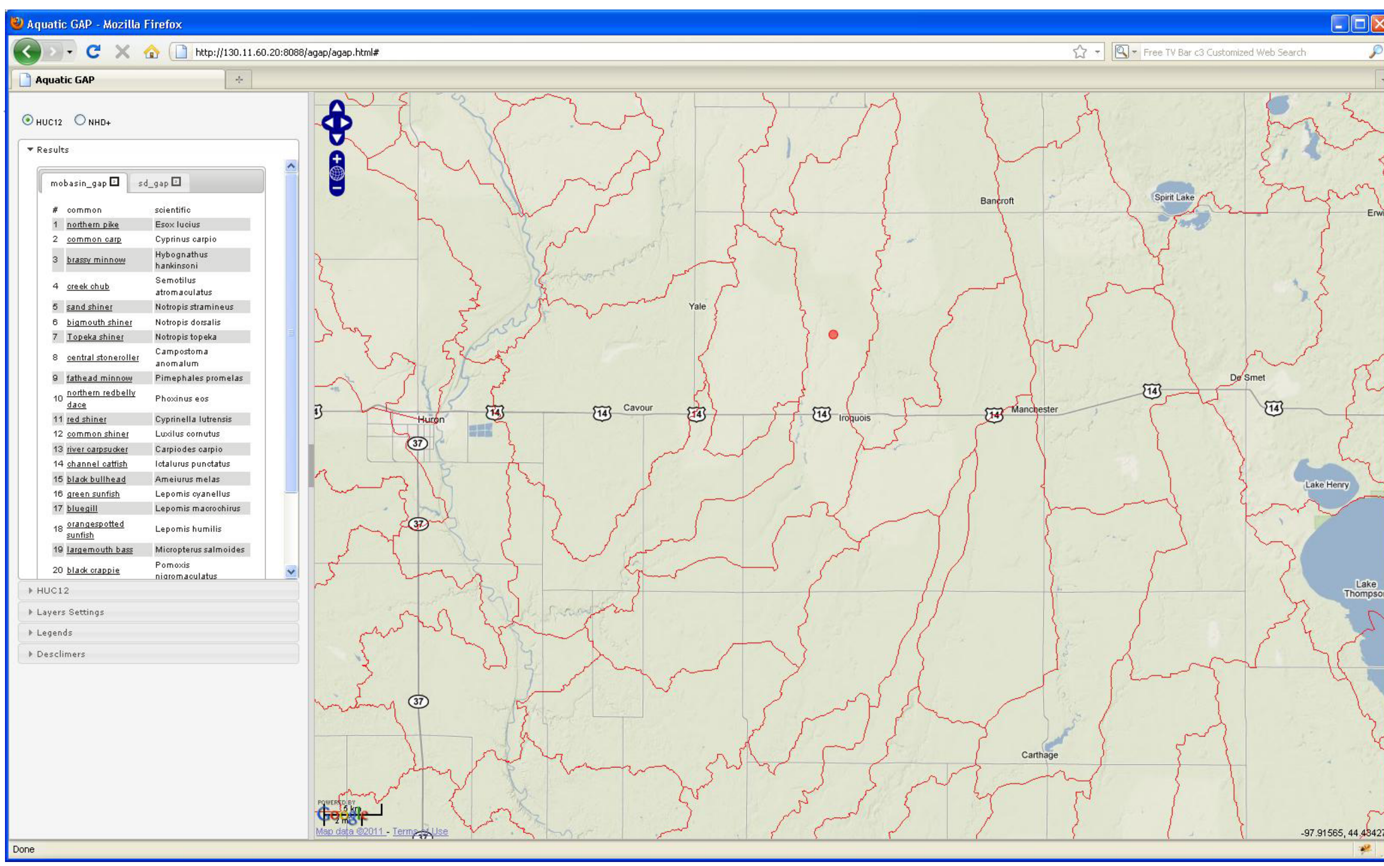

Figure 2. Predicted species occurrence results from a HUC12 spatial query.

standards established by the National Fish Habitat Board, this corrected data provided needed information to address habitat fragmentation in the national assessment. AGAP will consider support for similar national products that align with the research needs established by national initiatives like the National Fish Habitat Action Plan in the future.

In further support of the development of national scale data and products, AGAP plans to release new guidelines for future projects soon. AGAP projects will continue to incorporate all key components; however, additional guidelines will be consistent with those established by the National Fish Habitat Board, including linking data to the finest spatial units of the scalable national framework. Program consistency will enhance the ability for future data products generated by AGAP to be leveraged and seamlessly integrated into the National Fish Habitat framework, thereby increasing the relevancy and application of products developed. Establishing these standards will increase the ability of the natural resource community and other stakeholders to use AGAP products to compare regions across the United States, to identify species and habitats not adequately represented in existing conservation lands, and to develop more strategic conservation approaches.

GAP Data goes Mainstream: Recent Applications of GAP Data

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Over the course of 2010 we have seen GAP data used in several new and interesting projects. One of our primary goals is to provide our data and maps to the public, so that it can be used to inform and educate the public about conservation and natural resources management issues. In the paragraphs below, some innovative uses of our data are highlighted.

2010 Terrestrial Protected Areas Atlas

The Commission on Environmental Cooperation (CEC) recently published the 2010 Terrestrial Protected Areas Atlas and database as part of its initiative to harmonize environmental data for Canada, Mexico and the United States. The atlas includes an updated terrestrial protected areas map which includes federal and state data from PAD-US version 1. The atlas also incorporates IUCN categorized parcels from Canada, the US and Mexico as well as "other conservation lands" (GAP 3 in the US). The Terrestrial Protected Areas map depicts protected areas that are managed by national, state, provincial or territorial authorities throughout North America. These areas constitute a system of ecologically-based protected areas subject to broad and regional cooperation.

State of the Birds

In 2011, the annual State of the Birds report (www.stateofthebirds.org) will focus on birds on public lands. The source for the public lands data is USGS GAP's Protected Areas Database for the US, Version 1.1 (PAD-US 1.1). GAP's data is an appropriate source for this analysis. Furthermore, USGS GAP's national land cover data are being

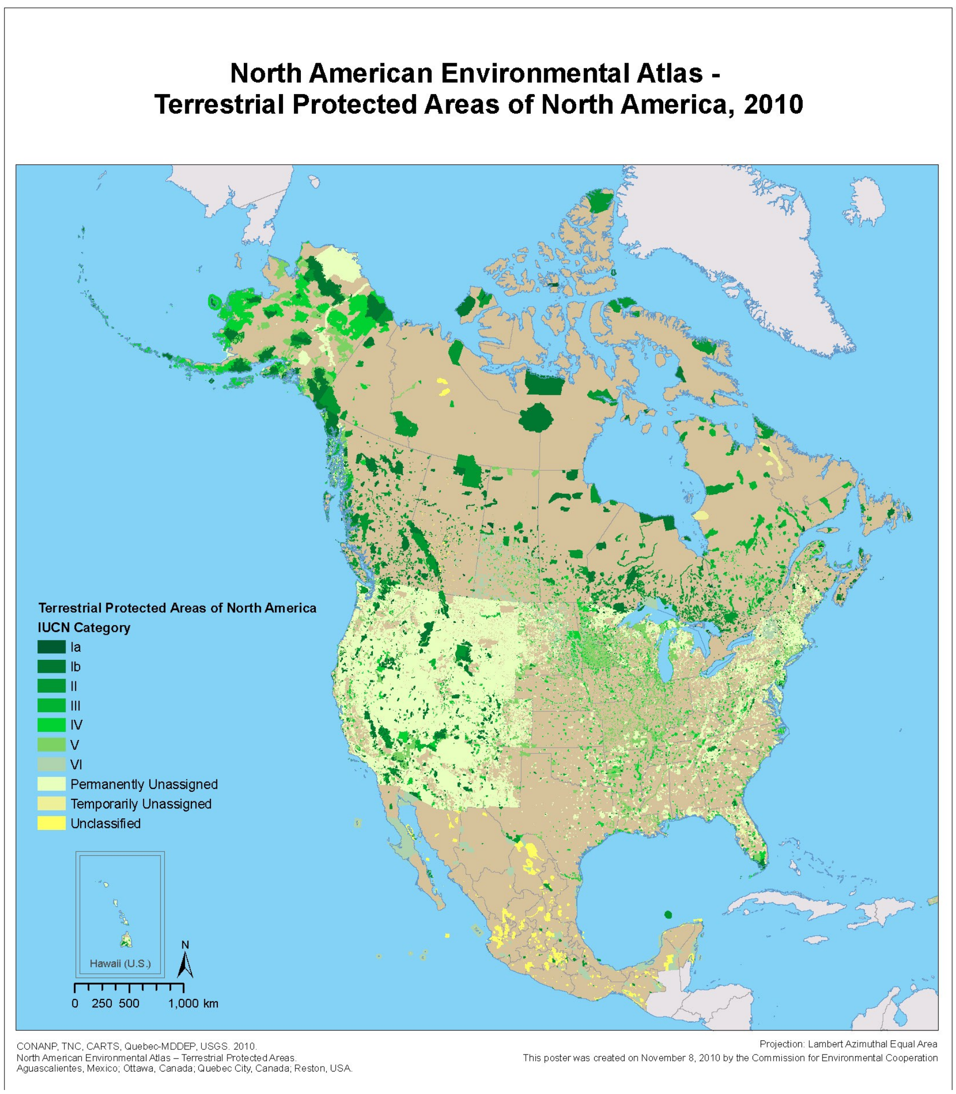

Figure 1: Map showing terrestrial protected areas of North America.

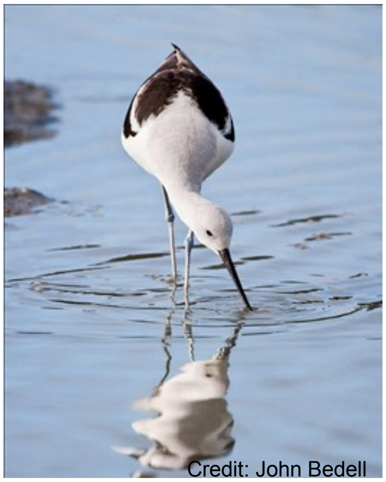

Figure 2: The American Avocet *(Recurvirostra Americana)* whose population has declined during the past 40 years.

used to identify nationwide biomes for an overall assessment of bird habitat on public lands by biome. Lastly, Alaska GAP bird ranges were included in the analysis of public lands available to birds in Alaska.

The yearly report synthesizes data from three long-running bird censuses conducted by thousands of citizen scientists and professional biologists. It is the product of a collaborative effort as part of the U.S. North American Bird Conservation Initiative, between federal and state wildlife agencies, and scientific and conservation organizations including partners from the American Bird Conservancy, Association of Fish and Wildlife Agencies, Cornell Lab of Ornithology, Klamath Bird Observatory, National Audubon Society, The National Fish and Wildlife Foundation, The Nature Conservancy, U.S.D.A. Forest Service, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. The State of the Birds Report will be released in March 2011.

Western Soundscape Archive

The Western Soundscape Archive (WSA), begun in November of 2007, features recordings of animals and environments throughout the western United States. The website currently includes representative sounds of 95% of the West's bird species, all of the region's frogs and toads, and more than 100 different types of mammals and reptiles. The site

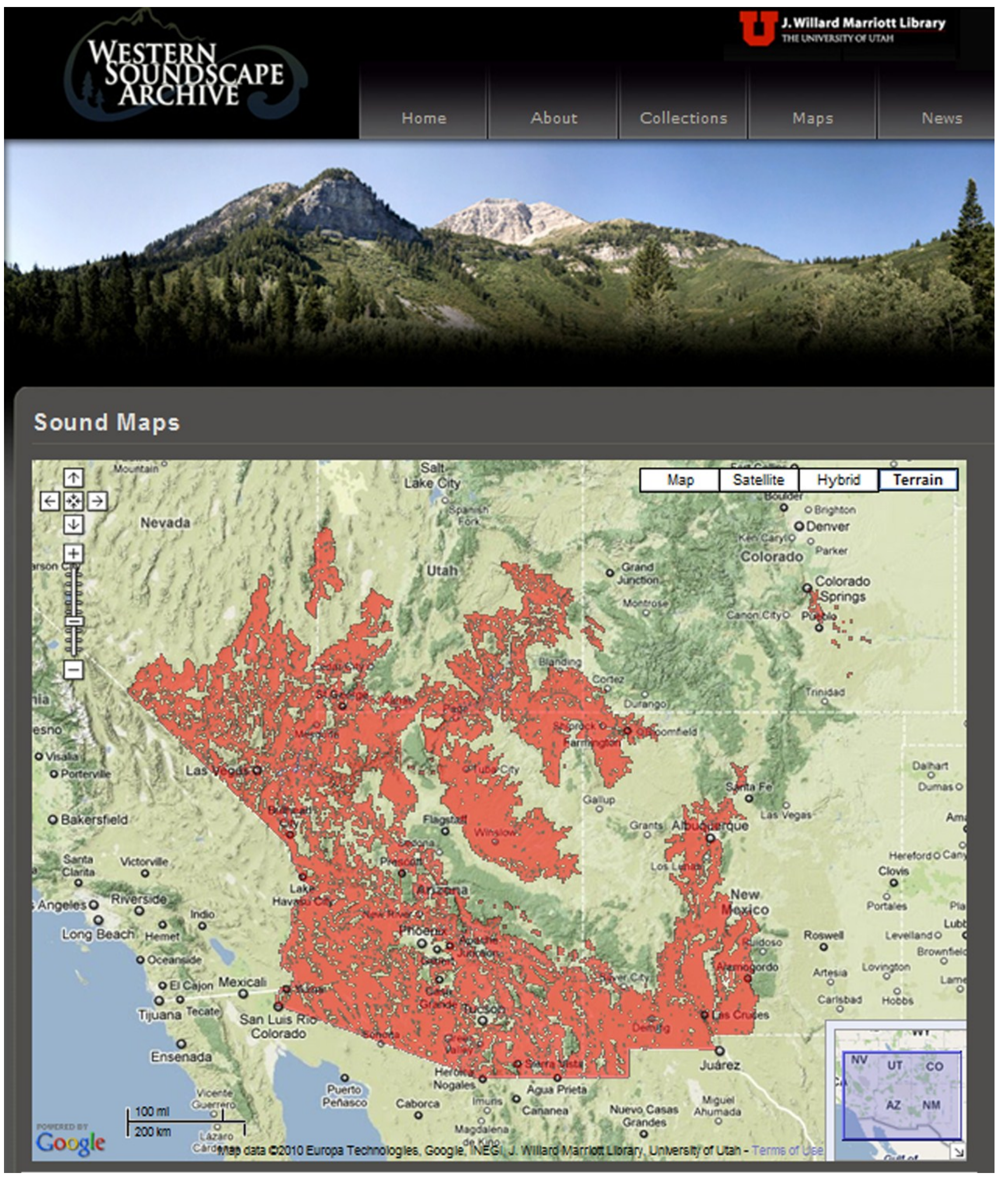

Figure 3: Screen shot of the Western Soundscape Archive's use of SWReGAP species distribution data as a component of its species sound maps. The reddish areas show the distribution of Bendire's Thrasher *(Toxostoma bendire).*

has incorporated predicted distribution maps (Figure 3) from the Southwest Regional Gap Analysis Project (SWReGAP) into its site, so that users can not only hear an animal's voice, but also see its distribution across the southwest.

Southern Forests for the Future

The forests of the southern United States are a vast local, national, and global treasure. Spanning approximately 214 million acres, they stretch from Texas to Virginia and from Kentucky to Florida. They comprise 40 percent of the land area of the 13 states that constitute the U.S. Forest Service's "southern region," and 29 percent of the total forestland in the United States. They are the dominant form of land cover throughout the region. The World Resources Institute (WRI) Southern Forests for the Future project seeks to raise awareness of the threats facing the forests of the southern United States and lay the foundation for increasing the acreage that is conserved or managed in a sustainable manner. To address this, WRI has created time-series maps that reveal trends and changes in southern forests and has developed a new web portal that allows schoolchildren, universities, citizens, interest groups, and others to access these maps and other information. To facilitate learning about the southern forests, the organization has created an online map viewer (Figure 4) that incorporates GAP protected areas data as one of the key layers.

The viewer is accessible through the Southern Forests of the Future web site <http://www.seesouthernforests.org/explore-maps>.

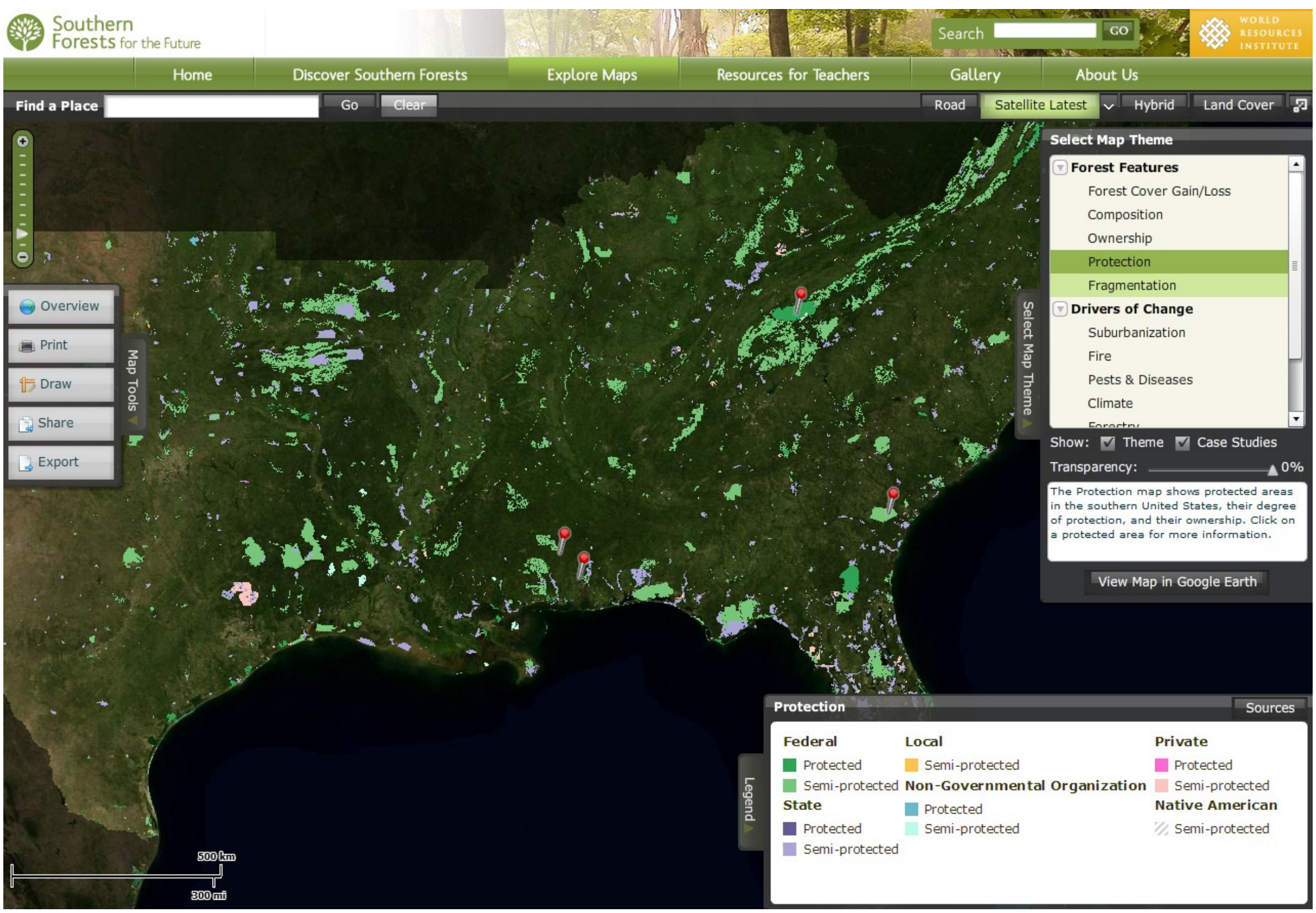

Figure 3: The Southern Forests of the Future map viewer incorporated GAP PAD-US data. This screen shot shows the location of protected areas in the Southeastern United States.

United States Department of Interior Strategic Plan for Fiscal Years 2011-2016

The Department of Interior (DOI) is the steward of 20 percent of the Nation's lands including national parks, national wildlife refuges, and other public lands. It is responsible for migratory wildlife conservation; historic preservation; endangered species conservation; surface-mined lands protection and restoration; mapping, geological, hydrological, and biological science for the Nation. In its strategic plan for fiscal years 2011-2016, the DOI has included a map of the Protected Areas of the United States' Database (PAD-US), version 1.1, as an example of how the USGS will deliver high resolution geospatial databases and maps to support public purposes and enhance resource management. PAD-US will help the DOI achieve one of its core missions; ie., to provide a scientific foundation for decision making for the country. The plan states, "We will deliver high resolution geospatial databases and topographic map images to support public purposes and enhance resource management."

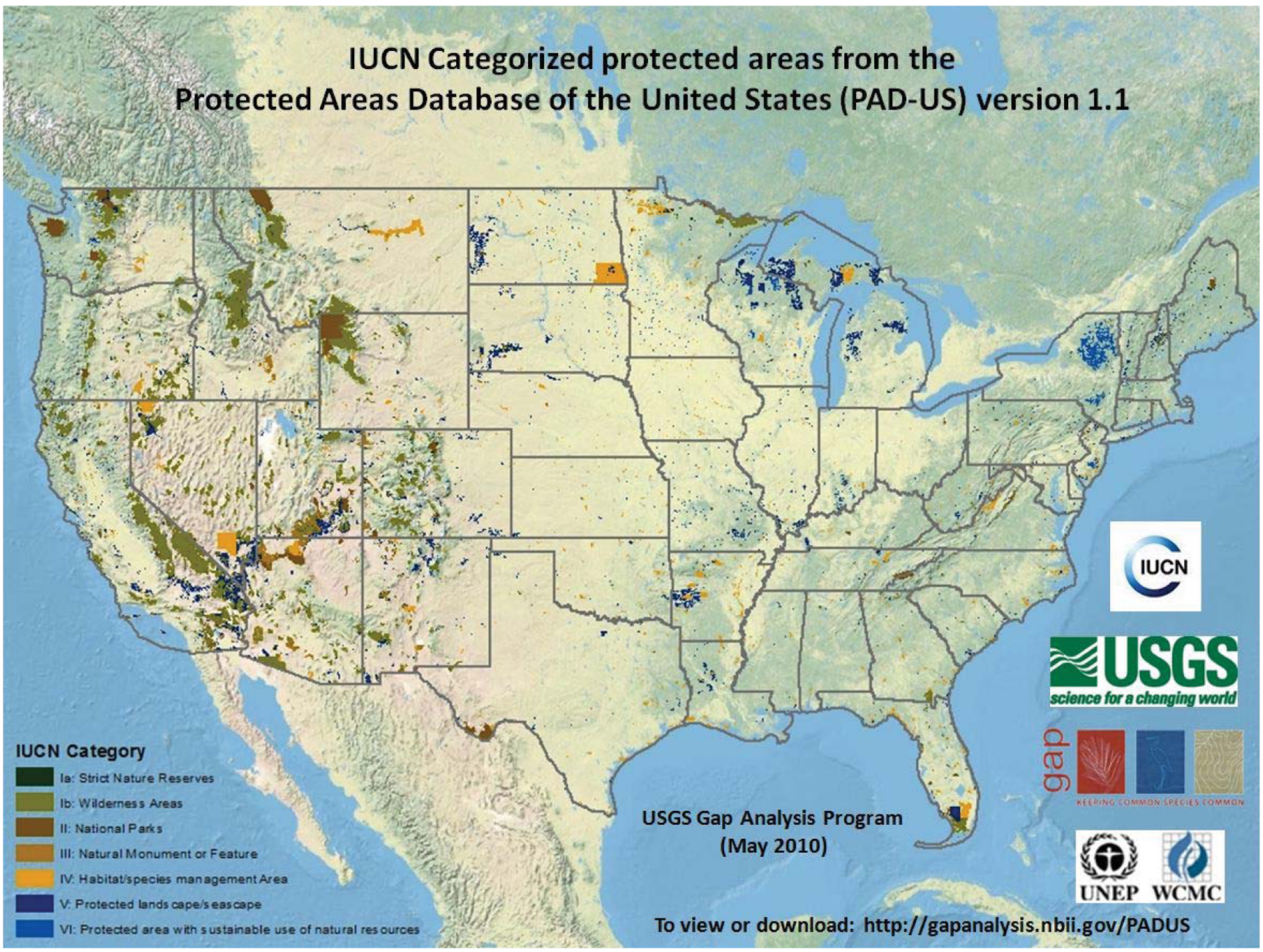

Figure 4: The United States' Department of Interior Strategic Plan includes this image of the Protected Areas of the United States Database (PAD-US), version 1.1, as an example of how the USGS will deliver high resolution geospatial databases and maps to support public purposes and enhance resource management.

Gap Analysis of Ecological Systems Nationwide

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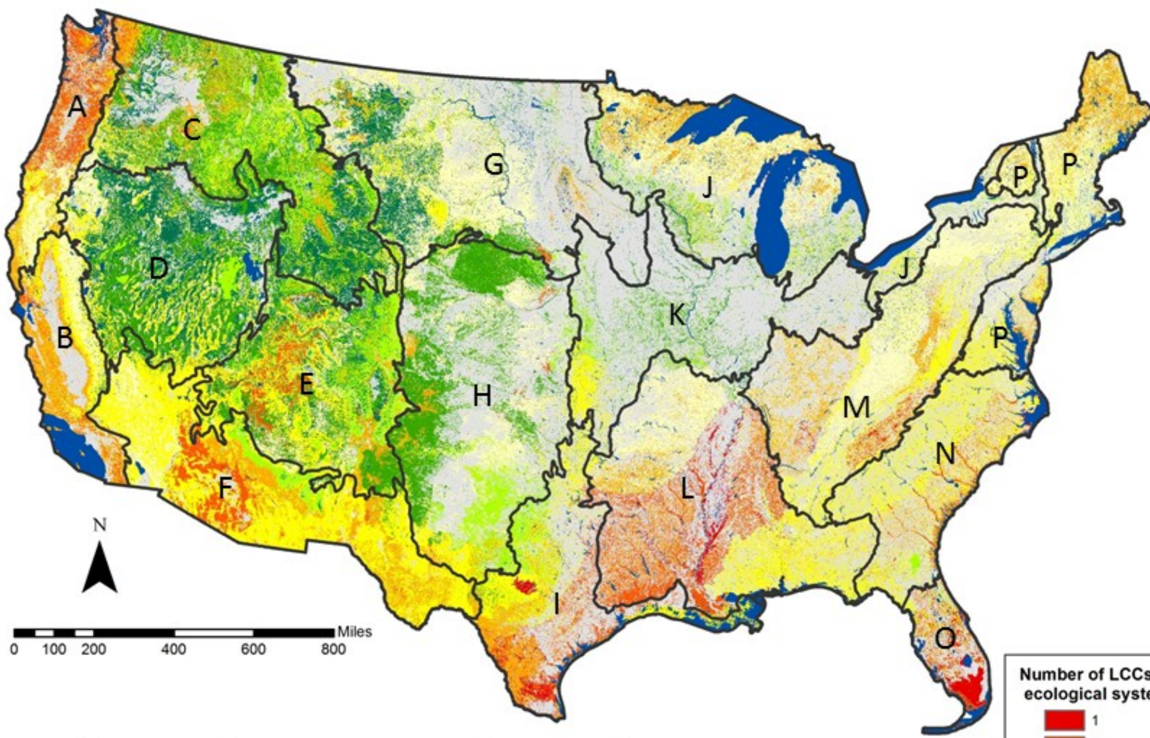
The conservation community has increasingly focused on landscape scales for national decision making, but the lack of relevant and consistent data at a national scale has been an impediment. That impediment has been overcome with the availability of national data for ecological systems (i.e, vegetation communities) as well as newly developed landscape units for conservation initiatives. Ecological systems are groups of vegetation communities that occur together within similar physical environments and are influenced by similar ecological processes



LCC Label	LCC Name	LCC Label	LCC Name
A	North Pacific	I	Gulf Coast Prairie
B	California	J	Upper Midwest and Great Lakes
C	Great Northern	K	Eastern Tallgrass Prairie and Big Rivers
D	Great Basin	L	Gulf Coast Plains and Ozarks
E	Southern Rockies	M	Appalachian
F	Desert	N	South Atlantic
G	Plains and Prairie Potholes	O	Peninsular Florida
H	Great Plains	P	North Atlantic

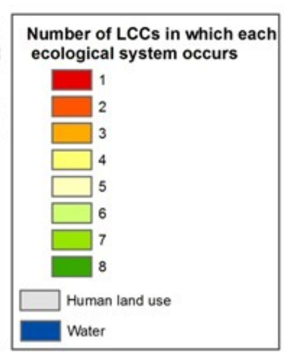


Figure 1. Redundancy of ecological systems within Landscape Conservation Cooperatives. Human land use and water were not included in the analysis. The GAP National Land Cover Data was used for the ecological systems. Lower values indicate low redundancy while higher values imply high redundancy of ecological systems between Landscape Conservation Cooperatives.

(e.g., fire or flooding), substrates (e.g., peatlands), and environmental gradients (e.g., montane, alpine or subalpine zones; Comer et al. 2003). Landscape Conservation Cooperatives (LCCs) are newly defined conservation initiative units that promote conservation-science partnerships between USFWS, USGS, other federal agencies, states, tribes, NGOs, universities, and other stakeholders. There are 16 defined within the continental US (Figure 1) and their intent is to inform resource management decisions to address landscape-scale stressors.

We used the GAP National Land Cover Data along with boundaries for LCCs to conduct a redundancy analysis of ecological systems by LCCs (Shaffer and Stein 2000). Redundancy is calculated by counting the number of LCCs in which each ecological system occurs. Lower redundancy values indicate unique ecological system while higher values show where ecological systems are redundant between LCCs (Figure 1). We did not include human land use or water in our redundancy analysis. This information is important for setting priorities for conservation initiatives and planning within each LCC with regards to ecological systems.

This analysis and the results are part of a more extensive gap analysis of ecological systems nationwide. These data along with additional analyses will be submitted for publication to a peer reviewed journal.

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US Virgin Islands Gap Analysis Project

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The U.S. Virgin Islands (USVI) are located in the Caribbean just east of Puerto Rico in the northwestern most section of the Lesser Antilles. The USVI cover 350 km² and include St. Thomas, St. John, St. Croix, and a number of cays. They harbor relatively high numbers of species and substantial levels of endemism, particularly among the reptiles. The databases of species occurrence, land cover, and stewardship for the USVI GAP are being integrated with the Puerto Rico Gap Analysis Project (PRGAP) and the Puerto Rico-USVI Integrated Terrestrial-Aquatic Gap (Integrated Gap) to allow regional analyses of terrestrial and aquatic biodiversity.

USVI GAP includes 143 species of terrestrial vertebrates: 107 birds, 21 reptiles, eight amphibians and seven mammals. These include endemic, breeding resident, breeding migrant, established exotic and nonbreeding migrant species. The majority are breeding residents. Breeding migrants include birds and marine turtles - which use terrestrial habitat for nesting. Ten to 20 percent of the amphibians and reptiles are endemic. We are following the traditional GAP approach, developing geospatial information and databases on land stewardship, species occurrence, and land cover. We have developed innovations using three integrated sets of minimum mapping units to display species ranges and model predicted distributions including nested grids of two km² and 24 km² hexagons and a grid of subwatersheds and cays. We are using EO-1 ALI scenes from 2007 pan-sharpened to 10 m spatial resolution for the land cover mapping. EO-1 ALI has a spectral range similar to that of Landsat 7 ETM+ with a few additional spectral bands and a higher resolution panchromatic band. Finally, we are integrating information on canopy cover and canopy heights extracted from LIDAR data from 2004.

Results

Stewardship

We identified 88 stewardship areas for the USVI, which represent approximately 20% (7,120 ha) of the land area. Accurate spatial information was available for only 78 areas, 69 of which have some management for biodiversity conservation (Gap status 1 to 3) (Figure 1). We identified 20 stewardship areas that are managed primarily for biodiversity conservation (Gap status 1). Along with several cays (e.g., Turtledove cay, Congo cay, Cockroach cay), Status 1 lands included the land and cays under the jurisdiction of the USVI National Park Service, the Great Pond within the East End Marine Park, Sandy Point Wildlife Refuge, Buck Island Reef National Monument, Buck Island National Wildlife Refuge, Saba Island and Little St. Thomas. Land ownership of the stewardship areas is shared among 18 organizations or agencies. The primary land owners are federal agencies (61 %), followed by local government (34 %), nongovernmental organizations (4 %) and finally, private owners (1%). Area management is shared among 19 organizations. Fifty-seven percent of the total stewardship area is managed by federal agencies, 33% by local governmental agencies, 7% by nongovernmental organizations, 2% is co-managed by local and federal agencies, and 1% is co-managed by government agencies and NGOs. The major federal land manager is the US National Park Service, while the primary local governmental land managers are the USVI Department of Sport, Parks and Recreation together with the Department of Planning and Natural Resources (particularly the Division of Fish and Wildlife). The Nature Conservancy represents the primary nongovernmental land manager in the USVI.

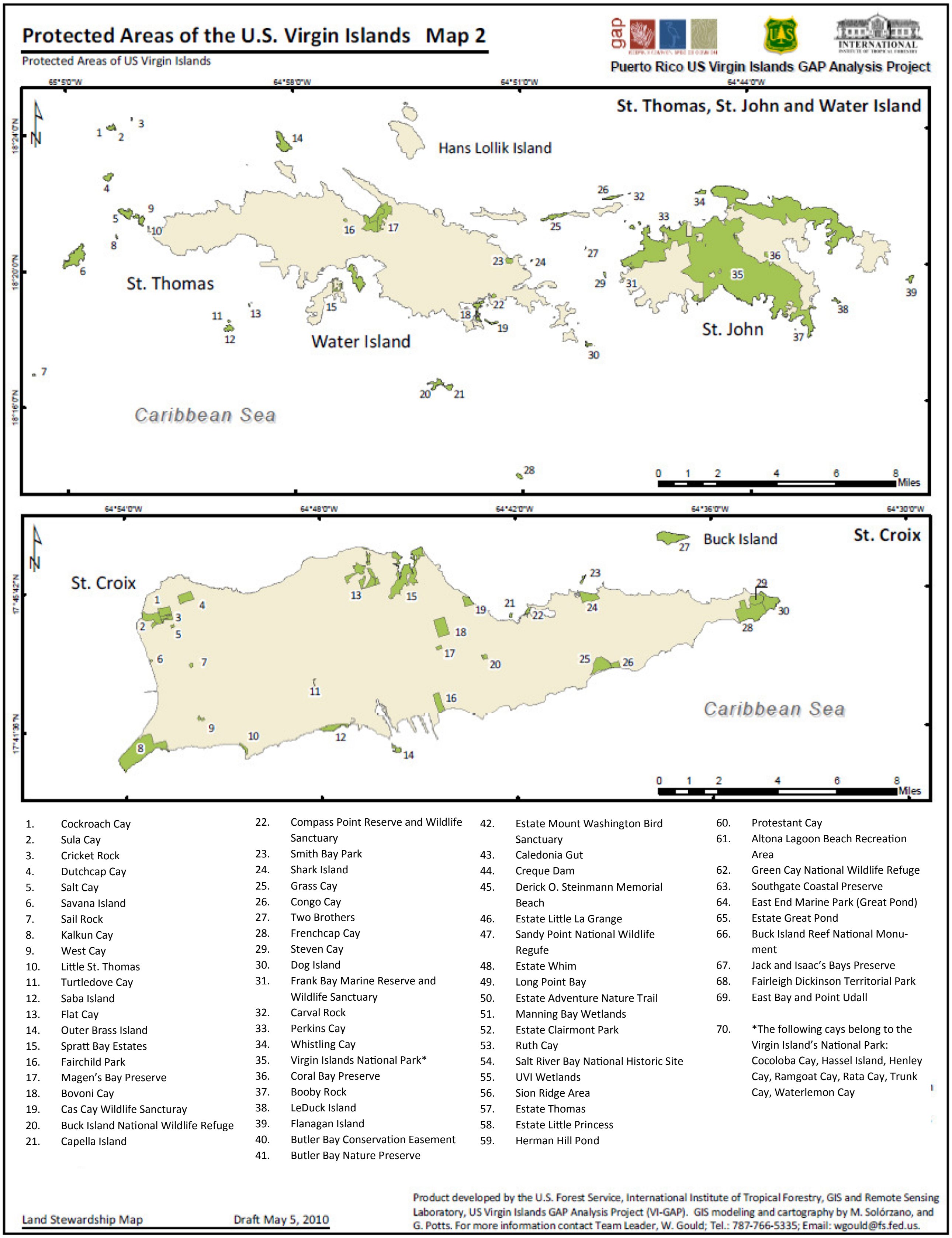

Figure 1. Protected areas (Gap status 1, 2 and 3) in the U.S. Virgin Islands.

Land cover

Traditionally, GAP projects have relied on satellite imagery from Landsat 5 TM and Landsat 7 ETM+ to provide the spatial and spectral information to derive land cover habitat maps at 30 m spatial resolution. Puerto Rico GAP (Gould et al. 2008) incorporated the Landsat 7 ETM+ 15m panchromatic band to enhance the spatial resolution and infrared bands in order to improve the delineation of habitats at the sub-pixel level in complex tropical landscapes. Current Landsat 7 ETM+ imagery and scene acquisition is limited by the scan line correction (SLC) error, horizontal lines with no data that appear across the entire image since July 2003, and the Long Term Acquisition Plan (LTAP), the use of a set of criteria that includes cloud-cover forecasts (Landsat Project Science Office, 1998) to guide Landsat image collections. These limitations make the collection of new images and the use of existing images for tropical humid regions with a high potential for cloud cover difficult.

For the USVI GAP, alternative imagery was used from the Advanced Land Imager (ALI) onboard the Earth Observation 1 (EO-1) satellite. EO-1 was launched by the US Geological Survey (USGS) in 2000 as a one year technical mission for data continuity assessment for the Landsat programs <http://eo1.usgs.gov/ali.php>. The advantages of EO-1 ALI over Landsat 7 ETM+ include: improved spectral resolution, 9 bands covering blue to short wave infrared wavelengths compared to 6 bands on the ETM+; better radiometric resolution, 16-bit rather than 8 bit; a 10m panchromatic band; and off NADIR viewing angles for image collections. One major disadvantage of the EO-1 ALI sensor is that no significant archive of imagery covering the USVI was readily available. Data collections have to be scheduled through a Data Acquisition Request (DAR) with the EROS data center. Other limitations include a smaller swath width (37 km) compared to Landsat 7 (185 km) and the lack of a thermal band on the ALI sensor. Images were collected between April 2007 until September 2007.

Preprocessing included atmospheric correction - with each band corrected individually - using IDRISI Taiga software and the ATMOS module, full radiative transfer model. Each band was then exported into ERDAS Imagine 9.3 to add initial projection information and the bands were stacked into one image file with the panchromatic band left separate. The sea was then masked out of the imagery using a manually digitized coastline based on 2004 aerial photos buffered by 20 meters in order not to mask out any coastal features that might not perfectly match the coastline file. The 10m panchromatic band was then used to sharpen the nine 30m reflectance bands using the Principle Component Analysis spatial enhancement in ERDAS 9.3. Each image was then reprojected to state plane, NAD 83 and georectified to a 2004 aerial photo mosaic of the U.S. Virgin Islands.

We created a cloud and cloud-shadow free image from each scene for classification. Three masks were created using Principle Component Analysis (PCA) on the visible (blue, green and red bands) and the near infrared (NIR) to short wave infrared (SWIR) bands separately. A cloud mask was created using PCA on the visible bands and a cloud-shadow mask was created using PCA on the NIR to SWIR bands. The cloud mask captured most of the urban pixels due to spectral similarity with cloud pixels so we created an urban mask using inverse PCA that could be subtracted from the cloud mask.

We stratified the imagery using geoclimatic zones and classified using an unsupervised Kohonen's Self-Organizing Map (SOM) neural network with IDRISI Taiga software. The input for the neural network included the nine spectral bands of each ALI image as well as a Soil-Adjusted Total Vegetation index (SATVI) product. The SATVI product is sensitive to green and senescent vegetation and helps reduce noise created by variation of topographic illumination within a scene as well as additional shadowing caused by the viewing angle of the satellite. The neural network classification was refined into useful land cover types through visual interpretation using field information, site visits, aerial photography from 1999, 2004, and 2007, and by comparing classification results to previous land cover maps (Conservation Data Center 2000, Kennaway et al. 2008). Reports focusing on specific areas within the U.S. Virgin Islands (Daley 2009, Weaver 2006a, Weaver 2006b, Damman and Nellis 1992) provided additional information for interpretation.

We used three EO-1 ALI images for the St. Croix land cover classification (Figure 2). The best cloud free image (June 14, 2007) was used as a base image. Images from June 24, 2007 and September 14, 2007 were used to fill in missing data due to cloud cover and cloud shadow. This provided an 89% cloud and cloud shadow free image for St. Croix. The remaining 11% of missing data was taken from two Landsat 7 ETM+ images from January 31, 2009 and February 16, 2009. The Landsat images were processed and classified using the same procedure used with the EO-1 ALI images. They were then pan sharpened to 15m spatial resolution, misaimed, and classified using the SOM neural network. The resulting classification was then resampled to 10m and manually edited to match the ALI classification.

The initial land cover classification included closed forest, open forest, shrubland, open forest shrubland and scrub, natural grasslands, maintained grasslands, urban, water and mangrove. These were then manually edited to clean confused classes. Additionally, discrete raw LiDAR data collected in January and February 2004 by 3001 Inc. (US Army Corps of Engineers contractor) covering St. Thomas, St. John and the east and west sections of St. Croix were processed using FUSION/LDV 2.70 processing software (McGaughey 2009). Various products were derived from the LIDAR data: bare earth surface elevations, canopy cover, and canopy height. These were used to refine the land cover classification, for example, to separate closed woody vegetation based on canopy height, i.e., closed shrubland, closed forest, and gallery forest.

A number of ancillary layers were used to stratify the classification to provide a detailed land cover classification of habitat. These layers included the National Wetland Inventory (NWI), Geology and 30m Digital Elevation Models from the USGS and U.S. Environmental Protection Agency (USEPA) National Hydrography Dataset (NHD), NOAA Environmental Sensitivity Index (ESI), Holdridge Ecological Life Zones, the Natural Resources Conservation Service Soil Survey of the USVI and a number of derived products created at the IITF GIS and Remote Sensing laboratory such as bare earth surfaces, canopy cover, canopy height, landforms, coastline, slope, aspect and watersheds. The final land cover classification for St. Croix consisted of fifty one classes at 10m spatial resolution (Figure 2).

Species Distribution Modeling

We are currently modeling species distributions for our final gap assessments.

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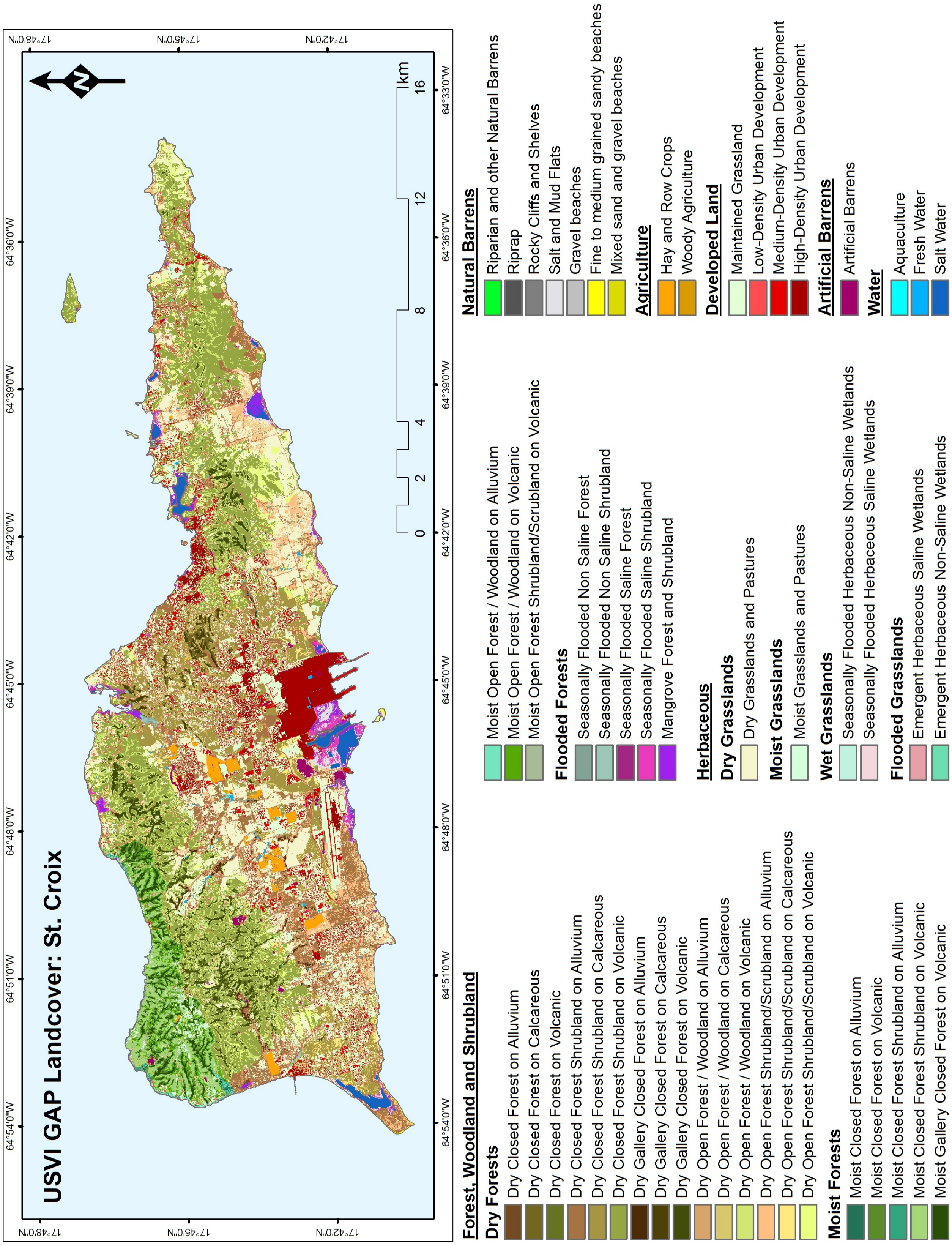

Figure 2. Land Cover of St. Croix in the U.S. Virgin Islands.

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The 2011 issue of the Gap Analysis Bulletin is the eighteenth in a series of annual publications produced by the Gap Analysis Program. Gap Analysis Bulletin No. 18 features articles on various aspects of gap analysis methods and results. This issue emphasizes GAP's national species modeling effort; other topics addressed include protected areas, land cover, and aquatic gap analysis.

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