Biodiversity Values of Geographically Isolated Wetlands in the United States

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BIODIVERSITY VALUES OF GEOGRAPHICALLY ISOLATED WETLANDS IN THE UNITED STATES

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Executive Summary

As a result of a 2001 Supreme Court decision (Solid Waste Agency of Northern Cook County vs. U.S. Army Corps of Engineers, 2001), some wetlands and other waters that are considered “geographically isolated” from navigable waters no longer fall under the jurisdiction of the Clean Water Act. Scientific assessments of the potential impacts of the court’s decision are needed to provide guidance to the federal agencies, states, tribes and local governments that will have responsibility for protecting these valuable resources.

In this study we sought to assess potential impacts of the court’s decision on the nation’s biological diversity. To do so, we first used a nationally standardized classification of wetland ecological systems. We then established a working definition to categorize types as “geographically isolated,” and using expert knowledge of these wetland types, we narrowed the national list of wetland ecological systems to those that tend to occur “geographically isolated” from navigable waters. Through review of scientific literature, input from regional experts, and compilation of existing location data for at-risk species (those species considered rare, imperiled or critically imperiled using NatureServe’s standard criteria) we identified those at-risk species and plant communities that are supported by these isolated wetland types throughout the United States.

This assessment used the best currently available information. Because comprehensive wetland maps are unavailable nationally, this study focuses on documenting the number, or diversity, of isolated wetland types, rather than on the acreage these wetland types occupy. These analyses could be significantly augmented in the future with the collection of additional data on the occurrence of isolated wetland types, their spatial extent, and their associated species and communities.

Key Findings

Significant wetland diversity exists in every state of the nation. Of 276 types of wetland described for the United States, 81 (29%) met our project-specific definition of “geographically isolated.” These types of wetlands may no longer be regulated under the Clean Water Act. Their regulation will therefore largely be determined by how lawmakers, regulators, and the courts interpret the term “isolated.” Of the 636 U.S. terrestrial ecological system types (both upland and wetland) currently classified and described by NatureServe (NatureServe 2005), these 81 isolated wetland types amount to 13% of all “natural/near-natural” terrestrial ecological system types.

This study documents that isolated wetland ecological systems support high levels of biodiversity, including significant numbers of at-risk species and plant communities. For example:

- A total of 274 at-risk plant and animal species are supported by isolated wetlands, with more than one-third (35%) apparently restricted to these wetland types. At-risk animal species are even more closely tied to isolated wetlands; more than one-half of at-risk animals considered in this study appear to be obligate to isolated wetland habitats.
- A total of 86 plant and animal species listed as threatened, endangered, or candidates under the Endangered Species Act are supported by isolated wetland habitats. This represents about 5% of all plant and animal species currently listed under the Act. A majority (52%) of these listed species are completely dependent on isolated wetland habitat for their survival.
- Nearly half of isolated wetland types (35 of 81, or 43%) are known to support at least one listed species under the Endangered Species Act.

- On average 6% of the at-risk plant species in a given state are directly supported by isolated wetlands.
- Nearly one-quarter of U.S. counties (725 counties, or 23%) harbor at least one at-risk species associated with isolated wetland habitats, and 80 of these counties have five or more such species. Ten or more at-risk species associated with isolated wetlands are confirmed from 18 counties of California, South Carolina, North Carolina, Georgia, Alabama, Nevada, and Hawai'i. Merced County, California leads with 20 at-risk species tied to isolated wetland habitats.
- A total of 279 at-risk vegetation associations (9% of all plant community types classified in the U.S. National Vegetation Classification) were documented as being characteristic of isolated wetlands, and two-thirds (67%) of these associations are not found in any other types of habitat.

Wetlands that can be considered "geographically isolated" represent a considerable amount of the United States' ecological diversity and provide habitat for a considerable portion of the nation's flora and fauna. Significant loss of isolated wetland habitats could seriously affect opportunities for the survival and recovery of the many rare or endangered species that depend on them.

Although an unknown but potentially significant number and acreage of these isolated wetlands may lose protection under the Clean Water Act, some may continue to receive protection through other regulatory or voluntary incentive mechanisms. The Endangered Species Act continues to provide a direct regulatory mechanism. Apart from regulation, the U.S. Department of Agriculture's SwampBuster program is one example of public incentive that may afford some protection to isolated wetlands and the biodiversity they sustain.

Underlying any approach to conserve wetlands are the necessary data to adequately locate and identify sensitive resource values. These data are needed to clarify where sensitive resources occur, to allow stakeholders to minimize impacts, and to support mitigating actions. Substantial new investments are needed to systematically inventory wetland resources to more fully document their biodiversity values. This is perhaps the most efficient means to acquire sufficiently high quality and detailed information on wetland biodiversity values and forms the basis for sound resource management.

States, tribes and local governments will increasingly be in a position to decide the fate of those isolated wetlands that no longer are protected under the Clean Water Act. The information and analyses contained in this study are designed to assist policy-makers and land managers at federal, state, and local levels to better understand their biodiversity value and plan for their conservation.

Introduction

As a result of a 2001 Supreme Court decision, *Solid Waste Agency of Northern Cook County vs. U.S. Army Corps of Engineers* (SWANCC, 2001), an unknown but potentially significant number of wetlands and other waters throughout the United States are longer protected under the Clean Water Act. The SWANCC decision eliminated reliance on the so-called Migratory Bird Rule that included many geographically isolated wetlands within the jurisdiction of the Clean Water Act through their linkages to interstate commerce (Downing et al. 2003). The court ruled that, while the Clean Water Act was clearly intended to protect the "biological integrity" of "waters of the United States," the Act does not have jurisdiction over geographically isolated, intrastate, non-navigable waters based solely on habitat use by migratory birds. Since the SWANCC decision, scientists and policy-makers have struggled to understand exactly what water resources no longer receive federal protection under the Clean Water Act and what functions and ecological benefits these wetlands provide. Analysis of potential impacts of the SWANCC decision is needed to provide appropriate guidance to policy-makers as they tackle the difficult task of implementing the decision, and to states, tribes, and local governments, and private individuals that make most land use decisions in the United States.

NatureServe, through its staff and network of member programs, specializes in developing standardized national ecological classifications and in documenting the occurrence and status of at-risk species and ecological communities. Using this expertise we can begin to document biodiversity values provided by geographically isolated wetlands in the United States. In this study, we apply a project-specific definition for "geographic isolation" to a nationally standardized classification of wetland types. Using expert knowledge distributed across our network of member programs and partners, we then document knowledge of at-risk species and plant communities supported by these geographically isolated wetland types. The goal of this study is to make the information available to policy-makers and land-use planners and managers so that they better understand the potential impacts of the SWANCC decision.

Background

A 2003 special issue of the journal *Wetlands* (Vol. 23, No. 3, 2003) was devoted to a range of inter-related topics stemming from the SWANCC decision (Nadeau and Leibowitz 2003). That issue provided a number of updated perspectives on the legal and policy environment for wetland regulation and protection (Downing et al 2003, Christie and Hausmann 2003), ecological perspectives on the definition, description, distribution, function, and conservation of isolated wetlands and associated species (Tiner 2003b, Sharitz 2003, Richardson 2003, Haukos and Smith 2003, Bedford and Godwin 2003, Zedler 2003, Van Der Valk and Pederson 2003, Tiner 2003c, Leibowitz 2003, Whigham and Jordon 2003, Gibbons 2003), and a synthetic view of the potential aquatic resource impacts of SWANCC (Leibowitz and Nadeau 2003), and gaps in our scientific knowledge about geographically isolated wetlands.

Undefined terminology found in the statute and the lack of further interpretation by courts (Downing et al. 2003) has posed a challenge to regulators trying to implement the SWANCC decision. The SWANCC decision placed a much greater emphasis than previous rulings on "navigable" waters forming the basis for Clean Water Act jurisdiction. However, terms such as "a significant nexus" with, and "adjacency" or "tributary" to, navigable water bodies are not defined, leaving considerable room for interpretation and new litigation. So far, states have responded in a variety of ways to address the more limited federal jurisdiction, but their actions provide less protection than the Clean Water Act, and a majority of states have taken no action (Christie and Hausmann 2003).

The SWANCC decision has stimulated new research and discussion about wetland resources (e.g., Petrie et al. 2001, Tiner et al. 2002) and has highlighted the need for additional dialogue between scientists, conservationists, resource managers, and policy-makers (Leibowitz and Nadeau, 2003). However, clarifying the impact of the SWANCC decision is continually hampered by technical and scientific uncertainty. Additional uncertainty results from the lack of an agreed-upon definition for an "isolated wetland" in the legal arena. Furthermore inadequate mapped information to document baseline status and trends among these wetlands and associated resource values, and insufficient knowledge of hydrologic and ecological processes that connect wetlands to navigable water bodies in diverse landscape settings makes it difficult to fully understand which wetland habitats might be at risk as a result of the ruling.

Close analysis of wetland ecosystems suggests that the concept of isolation is best viewed along a continuum, and that all wetlands are, in some form, hydrologically and ecologically connected to navigable water bodies (Leibowitz 2003, Winter and Labaugh 2003). Indeed, geographic, ecologic, and hydrologic isolation can be described at multiple spatial and temporal scales. Wetlands within a large, closed basin in central Nevada would be deemed isolated at a regional scale, but locally, could be connected to navigable water bodies. Other wetlands remain hydrologically isolated much of the time, but periodic events reconnect them with navigable waters. In most instances, isolation is best analyzed from the perspective of individual species or processes of concern. Individual wetlands in a complex of prairie potholes could be viewed as isolated from the perspective of amphibians with limited dispersal capabilities; but from the perspective of migratory waterfowl, these same wetlands might form a highly inter-connected network of stopover points. This ambiguity in defining "isolation" leads to a number of alternative methods for identifying and mapping these wetland types, and analyses that yield varying results (Tiner 2003c).

Questions of Clean Water Act jurisdiction are likely to be settled in the policy and legal arenas. Regardless of what is to be ultimately deemed jurisdictional through the Clean Water Act, practical methods and tools, where a series of indicators are used to categorize a given seemingly isolated wetland will be critical for helping determine jurisdiction on the ground. For example, new research documenting semi-aquatic species that require isolated wetlands for portions of their life cycle could provide a more solid ecological basis for jurisdiction under the Clean Water Act (Leibowitz 2003). These species would arguably provide a "significant nexus" between isolated wetlands and the biotic integrity of navigable waters. This is because without sufficient wetland habitat to support them, these species could no longer contribute to the biotic integrity of regulated waters. Practical indicators might include diagnostic species, recurring biotic communities, or environmental conditions that provide critical habitat for the species of interest.

With or without greater clarity on the jurisdiction of the Clean Water Act, it remains important to document the growing body of knowledge about wetland ecosystems in the United States. A clearer view of benefits or values provided by seemingly isolated wetlands is essential for balanced and thoughtful policy. This knowledge also forms the basis for practical tools to identify, manage, and protect wetland resources, regardless of the policy framework in place. Biodiversity values of isolated wetlands have so far been documented in several forms (e.g., Bedford and Godwin 2003, Gibbons 2003, Zedler 2003), some focusing on species diversity or on characteristic taxonomic groups. Until now, we know of no study that focuses on the at-risk species and communities supported by isolated wetland habitats as a means of describing their biodiversity value.

NatureServe and its Network of Natural Heritage Programs

NatureServe is a non-profit, non-advocacy conservation organization that provides the scientific information and tools needed to help guide effective conservation action. Together with its network of natural heritage member programs, NatureServe is a leading source for detailed information about rare and endangered species, ecological communities, and characteristic ecosystems (collectively referred to as "elements of biodiversity" using NatureServe methodology). NatureServe and its member programs operating in every state, the District of Columbia, and the Navajo Nation, work together to help inform land use planning by collaborating with a diverse user community including public agencies, tribes, landowners, universities, natural history museums, private industry, and other non-profit organizations.

For three decades NatureServe has established and maintained a system for documenting the conservation status of biodiversity elements (Master 1992, Master et al. 2000, Stein et al. 2000, Master et al. 2003, Brown et al. 2004). Standard procedures are used to assess and rank elements in terms of their global, or rangewide, status, ranging from critically imperiled (G1) to secure (G5). Conservation status ranks (G1, G2, G3, G4, and G5) have been applied to more than 50,000 plant and animal species and several thousand plant community types in the United States.

Field-based "element occurrence" data are gathered through inventories for most rare and vulnerable species and for rare and characteristic communities and ecological systems, and are housed with NatureServe member programs. These combined data represent tens of thousands of field-verified localities, or "occurrences" of biodiversity elements relevant to this study.

For over 15 years, NatureServe has provided international leadership in standardized ecological classification (e.g., Grossman et al. 1998, Comer et al., 2003, Josse et al. 2003). Ecological classifications have proven fundamental to effective resource conservation because they provide working assumptions about the composition, structure, and function of ecosystems. NatureServe ecological classifications are continually updated and served over the Internet (NatureServe 2005). NatureServe and its science partners have developed an integrated classification approach for "ecological systems" now being applied to mapping applications across the hemisphere.

Ecological systems are defined with groups of *plant community types*[1] that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. Ecological systems represent an integrated multi-factor approach and scale of ecological classification that is readily applicable to resource assessment, management, and monitoring. In addition, ecological system units serve as useful descriptors of habitat for many species of conservation concern. Because our approach to classification explicitly integrates factors that define wetland hydro-geomorphology, our system should provide users with insight into the likelihood that certain wetland types would fall under federal jurisdiction.

NatureServe also manages descriptive data on over 5,000 vegetation associations forming the U.S. National Vegetation Classification (US-NVC). These US-NVC associations define community components of each ecological system type. Since standard conservation status ranks (G1 through G5) have been applied to most

[1] By *plant community type*, we mean a vegetation classification unit at the association or alliance level of the U.S. National Vegetation Classification (US-NVC) (Grossman et al. 1998, Jennings et al. 2004, NatureServe 2005), or, if these are not available, other comparable vegetation units. US-NVC associations are used wherever possible to describe the component biotic communities of each terrestrial system.

documented plant associations in the United States, those considered at-risk (G1, G2, and G3) that are linked to each wetland ecological system type may be readily identified.

Currently NatureServe's data on rare species and ecological classifications are publicly available on the NatureServe Explorer website (www.natureserve.org/explorer). This site houses searchable data on more than 60,000 plants, animals, vegetation associations, and ecological systems and provides comprehensive text reports containing available data on taxonomy, description, distribution, and conservation status of these elements of biodiversity. Some 500,000 localities, or occurrences, of at-risk species tracked by NatureServe member programs are maintained in central databases. As applicable, all of these data were used in this analysis.

Key Objectives and Project Tasks

Four primary areas of activity characterize this project.

1) Through review of published literature and consultation with ecologists throughout the United States, we established a project-specific (*non-jurisdictional*) definition for the term "geographically isolated wetland" with sub-categories of "strict" and "partial" isolation. This definition was intended to be applied to classified wetland *types* (i.e., an entire class of wetlands rather than individual wetland localities).

2) We evaluated NatureServe's Ecological System Classification (Comer et al. 2003, NatureServe 2005) to identify which of the ecological system types known to occur within the United States fit this project-specific "geographically isolated" definition.

3) We documented current published and expert knowledge to identify the "at-risk" species[2] (i.e., those animals[3] and vascular plants ranked by NatureServe as critically imperiled, imperiled, or vulnerable (see Table 1) and/or those with status under the federal Endangered Species Act) that are closely and predictably associated with each of the selected ecological system types for some or all of their habitat requirements. We also documented current knowledge on component plant communities for each of the selected wetland ecological system types, along with their known distribution and global conservation status.

4) To be most useful to states, tribes, and local communities, we have upgraded the NatureServe Explorer website (www.natureserve.org/explorer) to provide ecological systems data in a user-friendly format. Users can search and report on wetland ecological system types that meet our project-specific definition for "geographically isolated" and can view the at-risk species and plant communities that are closely and predictably associated with these ecological systems. At the NatureServe website, users can also find a series of dichotomous keys and photos for field identification of wetland types that meet our project-specific definition of "geographically isolated."

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[2] Infra-specific taxa (subspecies and varieties) were included for both animals and plants in this study only if they had status under the Endangered Species Act.
[3] Including mammals, birds, reptiles, amphibians, freshwater fishes, butterflies and skippers, and large branchiopods (i.e. fairy shrimp, clam shrimp, and tadpole shrimp)

This report provides an update on a preliminary analysis that focused on 20 states (Comer et al. 2005). Similar procedures were used for the 20-state effort, but a more complete evaluation of wetland types, and species tied to those wetland types, is presented here.

Methods

Standard Ecological Classification

Standard ecological classification provides an important tool for comparative analysis of wetland types and a framework for establishing practical indicators of wetland status and trends, especially where landscape setting and hydro-dynamics are integrated factors. Development of a standard classification is a critical first step to consistent identification and mapping of ecological units. Having a standard classification allows the identification of patterns in biodiversity among wetland types and across regional landscapes. It also allows better documentation of factors that determine the ecological function of each wetland type in diverse landscape settings and clarification of indicators for use in protection, management, and monitoring.

Tiner (2003a) and others have provided excellent overview discussions of some geographically isolated wetland types in the United States. These overview descriptions have been based on numerous and varied regional and local classification efforts. While these disparate classification efforts form the basis for our understanding of these wetland systems, a consistent standard for their classification is desirable to allow for more repeatable and rigorous comparative analysis.

Our current effort builds on NatureServe's existing national classification of terrestrial ecological systems, which includes both wetland and upland types (Comer et al. 2003, NatureServe 2005). In this study we updated the national ecological system classification and identified all of the system types that fit our project-specific definition of "geographically isolated." See Appendix I for a description of the methodology used to define and describe ecological systems, and Appendices II and III, as well as www.natureserve.org/explorer, to view current descriptive information on these types.

Geographically Isolated Wetland Ecological Systems

For this study, we have established a practical definition to identify "geographically isolated" wetland ecological systems.

Throughout this report we will interchangeably use the terms *isolated wetland ecological systems, ecological system types,* and *isolated wetlands* to refer to the *classification units* that are the focus of this study and the primary unit of analysis. We will use the term "occurrence" when we reference on-the-ground examples of these classification units. If the term "occurrence" is not used, we are referring to the classification unit (the isolated wetland ecological system type, e.g., "Northern California Claypan Vernal Pool"). So a statement like "California has more than 12 isolated wetland ecological systems," means that there are more than 12 different classified types of isolated wetland systems in California. A statement like "Florida has more than 40 occurrences of "Central Florida Herbaceous Pondshore" means that in more than 40 places the "Central Florida Herbaceous Pondshore" type has been located, mapped, and documented as occurring in Florida.

In this study we make NO statements about the acreage of wetlands in the United States. Wetlands of types of interest to this analysis have not been comprehensibly mapped across the United States, so as yet, we are unable to analyze and document acreages. Instead, this analysis combines much site-specific data of rare and endangered biodiversity elements with knowledge of wetland types that support them.

NOTE: *The following project-specific definitions were developed solely to facilitate this analysis using an existing classification of wetland ecological system types from NatureServe's databases, to create linkages to at-risk species, and to allow documentation of scientific methodology. They are NOT intended to be a guide for regulatory or other purposes. In other words, they are not intended to be used to determine whether a given wetland system falls under the jurisdiction of the Clean Water Act. These definitions do not represent an endorsement by NatureServe of any particular regulatory or other use by the Environmental Protection Agency, the Army Corps of Engineers, or other federal and state agencies or stakeholders.*

As Tiner (2003a) describes, the common non-regulatory definition for wetland "emphasizes three important attributes: (1) hydrology—the degree of flooding or soil saturation; (2) vegetation—plants adapted to grow in water or in a soil or substrate that is occasionally oxygen deficient due to saturation (hydrophytes); and (3) soils—those saturated long enough during the growing season to produce oxygen-deficient conditions in the upper part of the soil, which commonly includes the major part of the root zone of plants (hydric soils) (Cowardin et al. 1979)." [To supplement this definition and to help identify wetlands in the United States, the U.S. Fish and Wildlife Service (USFWS) prepared a list of wetland plants (Reed, 1988). In addition, the Soil Conservation Service developed a list of hydric soils for the United States (see http://soils.usda.gov/use/hydric/).]

"…On the basis of plant and soil conditions, wetlands typically fall into one of three categories: (1) areas with hydrophytes and hydric soils (marshes, swamps, and bogs); (2) areas without soils but with hydrophytes (aquatic beds and seaweed-covered rocky shores); and (3) areas without soil and without hydrophytes (gravel beaches and tidal flats) that are periodically flooded. The USFWS definition does not include permanent deep-water areas (>2 m deep) as wetlands (Cowardin et al. 1979). However, permanent shallow waters that commonly support aquatic beds and emergent plants (erect, rooted, non-woody plants that are mostly above water) are classified as wetlands …"

Our project-specific definition of geographically isolated wetlands accepts the premise of these definitions and follows from them. We define geographically isolated wetlands as:

- ***Geographically Isolated Wetland Systems*** are NatureServe ecological system types that are predominantly wetland, and where more than 80% of all known occurrences are completely surrounded by uplands and there are no apparent surface water inlets and/ or outlets.

Because commonly referenced "isolated wetland" definitions are intended for application to individual wetland occurrences, an additional criterion must account for variation among occurrences of a given wetland *type*. Therefore, our rule was that if more than 80% of all known occurrences of a given wetland type meets the above definition it would be considered a geographically isolated wetland *type*. While one could likely identify individual occurrences for most types of wetland that could be considered "geographically isolated," this additional criterion provides focus on a subset of wetland types where the isolated condition is quite characteristic.

We then established two sub-categories for isolated wetlands—*Strict Isolation* and *Partial Isolation*—to further refine the categorization of wetland ecological system types. Once a given wetland type has met the definition above for "geographically isolated," these additional definitions can be applied. We used *hydrologic regime* as the primary factor to define these sub-categories. We used physical characteristics that could be easily mapped to allow for reasonable inferences about the hydrologic regime.

- ***Strict Isolation***. An ecological system type is *strictly* isolated if more than 80% of all known occurrences have very infrequent interchange of *both surface water and ground water* between the wetland and other water bodies. This condition may be inferred where occurrences are geographically isolated and near-impermeable substrates are characteristic.

For example, a classified wetland type that overwhelmingly occurs on solid rock surfaces or clay pans at least 75 meters distant from a mapped 100-year floodplain would likely meet these criteria. Similar geographically isolated wetland types with shallow (< 1 meter), porous surface layers over near-impermeable surfaces (clays or thick concretions) may also fit this description. Overflow of these wetlands could cause seepage to ground water from around the rim of existing hard pans, but a distance of at least 75 meters from 100-year floodplains is likely adequate to infer hydrologic isolation from nearby water bodies.

- ***Partial Isolation.*** An ecological system type is *partially* isolated if more than 80% of all known occurrences have very infrequent interchange of *surface water* between the wetland and other water bodies. Practically, this is limited to geographically isolated wetlands where various types of substrates are characteristic (any unconsolidated material). No assumptions are made about the type and frequency of groundwater exchange between these wetlands and other water bodies.

To summarize, the difference between “strict isolation” and “partial isolation” sub-category definitions is that “partial isolation” does not require that we infer no interchange of ground water between these wetland and the broader aquatic ecosystem.

Examples of geographically isolated wetland ecological systems include:

Atlantic Coastal Plain Northern Pondshore. This system includes groundwater-flooded depressions with a flora generally restricted to the Atlantic Coastal Plain from the southern portion of the Delmarva Peninsula to Cape Cod, Massachusetts. Ponds may contain permanent surface water, such as the deep glacial kettle holes of Cape Cod and Long Island, New York, or may be shallow basins where groundwater drops below the surface late in the growing season. This system occurs on sandy deposits such as outwash plains of the glaciated region (Long Island and Cape Cod), on the deep sands of the New Jersey Pine Barrens, or on finer sediments of the Coastal Plain of Cape May, New Jersey, the Delmarva Peninsula, and the Chesapeake Bay region. The vegetation of steeper-sided basins (generally those containing permanent water) are characterized by strong zonation, with a border of tall shrubs, such as *Vaccinium corymbosum*, and several concentric bands or zones dominated by different associations, depending on geography. Characteristic species in Massachusetts and Long Island include *Rhexia virginica, Cyperus dentatus, Gratiola aurea, Panicum verrucosum, Euthamia caroliniana (= Euthamia tenuifolia), Carex striata, Juncus pelocarpus, Rhynchospora capillacea, Rhynchospora macrostachya, Xyris difformis, Fimbristylis autumnalis, Scleria reticularis, Sabatia kennedyana, Drosera filiformis, Juncus militaris*, and many others.

Ponds of the New Jersey Pine Barrens share many of these species, with others including *Juncus repens, Muhlenbergia torreyi, Rhynchospora oligantha*, *Rhynchospora cephalantha, Rhynchospora chalarocephala*, and many others. In shallow basins, such strong zonation is generally lacking but still remains evident in some cases. On Cape Cod, Long Island, and New Jersey, this system most often occurs within an upland matrix of pitch pine barrens.

From Cape May and south, the system occurs within an upland matrix of mixed hardwood forests. It may include swamp forest species, such as *Liquidambar styraciflua, Acer rubrum,* wetland oaks such as *Quercus phellos*, and in Virginia and scattered locations on the Inner Coastal Plain of Maryland *Nyssa biflora*. The vegetation is characterized by many of the species from New England, New York and New

Jersey, but also includes *Juncus repens, Boltonia asteroides, Fimbristylis perpusilla, Coelorachis rugosa, Dichanthelium spretum, Saccharum giganteum, Eleocharis quadrangulata, Cephalanthus occidentalis,* and others.

South Florida Cypress Dome. This system is found primarily in the Everglades and Big Cypress regions. It consists of small forested wetlands in poorly drained depressions which are underlain by an impervious layer that impedes drainage and traps precipitation. They receive their common name from the unique dome-shaped appearance in which trees in the center are higher than those around the sides. *Taxodium ascendens* is the dominant tree, with the oldest and largest individuals characteristically occupying the center, and smaller and younger individuals around the margins. Pools of stagnant, highly acid water may stand in the center of these depressions ranging from 1-4 feet in depth, but becoming increasingly shallow along the margins. The understory flora is typified by species with tropical affinities.

Great Lakes Wet-Mesic Lakeplain Prairie. This system is found on the lakeplain near the southern and central Great Lakes of the United States and Canada. They occur on level, sandy glacial outwash, sandy glacial lakeplains, and deposits of dune sand over silty/clayey glacial lakeplains. Characteristic soils are sands and sandy loams, loams with poor to moderate water-retaining capacity, typically occurring over less permeable silty clays. There is often temporary inundations after heavy rains or in the spring, followed by dry conditions throughout much of the remaining growing season. The vegetation of this system is dominated by tallgrass species typically 1-2 m high. *Andropogon gerardii, Calamagrostis canadensis, Carex* spp. (*Carex aquatilis, Carex bicknellii, Carex buxbaumii, Carex pellita (= Carex lanuginosa)*), *Panicum virgatum, Spartina pectinata, Schizachyrium scoparium*, and *Sorghastrum nutans* are the most abundant graminoid species.

West Gulf Coastal Plain Pine-Hardwood Flatwoods. This flatwoods system is found throughout inland portions of the West Gulf Coastal Plain. These areas are usually found on nonriverine, Pleistocene high terraces. Soils are fine-textured and subsurface hardpans may be present. The limited permeability of these soils contributes to shallowly perched water tables during portions of the year when precipitation is greatest and evapotranspiration is lowest. Soil moisture fluctuates widely throughout the growing season, from saturated to very dry, a condition sometimes referred to as “xerohydric.” Saturation occurs not from overbank flooding but typically whenever precipitation events occur. Local topography is a complex of ridges and swales, often in close proximity to one another. Ridges tend to be much drier than swales, which may hold water for varying periods of time. Within both ridges and swales there is vegetation variability relating to soil texture and moisture and disturbance history. Driest ridges support *Pinus taeda* and *Quercus stellata*; more mesic ridges have *Pinus taeda* with *Quercus alba* and species such as *Symplocos tinctoria* and *Viburnum dentatum*. Fire may have been an important natural process in examples of this system.

Great Plains Prairie Pothole. This system is found primarily in glaciated northern Great Plains of the United States and Canada, and is dominated by depressional wetlands. It is typified by several classes of wetland vegetation distinguished by changes in topography, soils and hydrology. Many of the basins within this system are closed basins and receive irregular inputs of water from their surroundings (groundwater and precipitation), and export water as groundwater. Hydrology of the potholes is complex. Precipitation and runoff from snowmelt are often the principal water sources, with groundwater inflow secondary. Evapotranspiration is the major water loss, with seepage loss secondary. Most of the wetlands and lakes contain water that is alkaline (pH >7.4). The concentration of dissolved solids in these waters ranges from fresh to extremely saline. The vegetation of this system is a function of the topography, water regime, and salinity. In addition, because of periodic droughts and wet periods, many wetlands within this system may undergo successional cycles. This system includes elements of emergent marsh and wet, sedge meadows that develop into a pattern of concentric rings.

Inter-Mountain Basins Greasewood Flat. This system occurs throughout much of the western U.S. in inter-montane basins and extends onto the western Great Plains. It typically occurs near intermittent drainages on stream terraces and flats or may support inclusions of more sparsely vegetated desert playas. Sites typically have saline soils, a shallow water table, and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. This system usually occurs as open to moderately dense shrublands dominated or codominated by *Sarcobatus vermiculatus*, *Atriplex canescens, Atriplex confertifolia*, or *Krascheninnikovia lanata* may be present to codominant. Occurrences are often surrounded by mixed salt desert scrub. The herbaceous layer, if present, is usually dominated by graminoids including *Sporobolus airoides, Distichlis spicata*, or *Eleocharis palustris*.

Northern California Claypan Vernal Pool. This system occurs as shallow ephemeral water bodies found in depressions (up to several hectares in size) among grasslands and open woodlands throughout the northern Central Valley of California. These vernal pools include a clay hardpan that retains water inputs throughout some portion of the spring, but typically the depression dries down entirely into early summer months. They tend to be circumneutral to alkaline and slightly saline wetlands with characteristic plant species including *Downingia bella, Downingia insignis, Cressa truxillensis, Plagiobothrys leptocladus (= Allocarya leptoclada), Pogogyne douglasii, Eryngium aristulatum, Veronica peregrina, Lasthenia ferrisiae, Lasthenia glaberrima*, and *Spergularia salina (= Spergularia marina)*. Due to draw-down characteristics, vernal pools typically form concentric rings of similar forb-rich vegetation.

Hawai'i Montane Bog. This system occurs primarily between 1067 and 1670 m (3500-5500 feet) elevation as isolated small depressions on flat or gently sloping topography in high rainfall areas in cloud forests and other wet forests on all of the high islands. At their extremes, they are also known to occur at subalpine elevations [2270 m (7446 feet)] on Maui, and at low elevations [646 m (2120 feet)] on Kaua'i. Soils remain saturated on a shallow to deep layer of peat (0.01-5 m), underlain by an impervious basal clay layer that impedes drainage. A few bogs occur on steeper terrain were precipitation is extremely high, such as in North Bog in the Wai'ale'ale summit region of Kaua'i, where soils remain saturated despite adequate drainage. The vegetation is an uneven hummocky matrix of sedges and grasses, including *Rhynchospora rugosa ssp. lavarum (= Rhynchospora lavarum), Oreobolus furcatus, Dichanthelium*, *Panicum*, and *Deschampsia*, imbedded in moss (*Racomitrium lanuginosum*, *Sphagnum* spp.). Dwarfed woody plants can occur as scattered individuals, in clumps, or as a continuous layer and include *Metrosideros polymorpha, Cheirodendron* spp., and *Vaccinium* spp. Associated ferns and herbs include *Sadleria* spp., *Polypodium* spp., *Hymenophyllum* spp., *Elaphoglossum* spp., *Athyrium* spp., *Schizaea robusta, Selaginella deflexa, Plantago* spp., *Astelia* spp., *Viola* spp., *Machaerina* spp., *Lysimachia* spp., and on Kaua'i, the boreal catchfly *Drosera anglica*.

The full diversity of wetland types that occur in the United States has been extensively described. Summary dichotomous keys and descriptions for all wetland ecological systems meeting our project-specific definition for "geographically isolated" are found in Appendix II & III.

Linking At-Risk Elements of Biodiversity with Isolated Wetlands

We documented current data and knowledge from the state natural heritage programs and the NatureServe Central Databases to identify the "at-risk" elements (i.e., those animals, vascular plants, and US-NVC plant associations ranked as critically imperiled (G1), imperiled (G2), or vulnerable (G3) (see Table 1) and those species listed as endangered, threatened, or candidate species under the Endangered Species Act) that are **"**closely associated**"** with each of the isolated wetlands.

Table 1. NatureServe Conservation Status Ranks

	Rank	Definition
Extinct or Possibly Extinct	**GX**	**Presumed Extinct** (species) — Not located despite intensive searches and virtually no likelihood of rediscovery. **Eliminated** (ecological communities)—Eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.
	GH	**Possibly Extinct** (species) Missing; known from only historical occurrences but still some hope of rediscovery. **Presumed Eliminated**— (Historic, ecological communities) Presumed eliminated throughout its range, with no or virtually no likelihood that it will be rediscovered, but with the potential for restoration, for example, American Chestnut Forest.
At-Risk	**G1**	**Critically Imperiled**—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
	G2	**Imperiled**—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
	G3	**Vulnerable**—At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
Secure or Apparently Secure	**G4**	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
	G5	**Secure**—Common; widespread and abundant.
Variant Ranks	**G#G#**	**Range Rank**—A numeric range rank (e.g., G2G3) is used to indicate the range of uncertainty in the status of a species or community. Ranges cannot skip more than one rank (e.g., GU should be used rather than G1G4).
Infraspecific Taxon Ranks	**T#**	**Infraspecific Taxon** (trinomial)—The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles outlined above for global conservation status ranks. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1. A T-rank cannot imply the subspecies or variety is more abundant than the species as a whole-for example, a G1T2 cannot occur. A vertebrate animal population, such as those listed as distinct population segments under the U.S. Endangered Species Act, may be considered an infraspecific taxon and assigned a T-rank; in such cases a Q is used after the T-rank to denote the taxon's informal taxonomic status. At this time, the T rank is not used for ecological communities

The first step in this process was to define the terms "closely associated" with a given isolated wetland type. We adapted the existing, commonly applied concepts for describing wetland affinities to plants (USACE 1987, Reed 1998) to describe the relative association of at-risk species with isolated wetland systems.

Obligate to Isolated Wetlands. *Almost always occurs in isolated wetland systems (estimated probability >99%) under natural conditions.*

Facultative to Isolated Wetlands. *Usually occurs in isolated wetland systems (estimated probability 67% - 99%) but occasionally occurs in systems that are not isolated wetland systems.*

While NatureServe maintains a centralized data set for some 500,000 localities (occurrences) of rare and endangered plant and animal species, we do not currently have centralized occurrence data for all wetland types across the United States. Therefore, we could not implement a relatively straightforward process of overlaying nationally standardized spatial information to analyze co-occurrence of at-risk species and communities with isolated ecological system types. While our at-risk species occurrence information provides a wealth of insights, these particular questions of co-occurrence with specific wetland types must, for now, be addressed using expert knowledge.

Given this situation, we developed distinct processes to compile knowledge of at-risk species and plant community co-occurrence with wetland ecological systems types. For at-risk species, we first drafted a subset of wetland-dependent species to be evaluated in greater depth. Using knowledge from across the network of NatureServe member programs (and beyond), we then finalized the list of wetland species. Regional experts then indicated the specific isolated wetland system types that characterize habitat for each species, along with the degree of their association (i.e., obligate vs. facultative) to isolated wetland types. More specific aspects of methodology for animal, plant, and community groups are described below.

Animal Species Linked to Isolated Wetlands

We developed a draft list of animals with conservation status ranks of G1-G3 (T1-T3) that may be strongly associated with isolated wetland habitats by using habitat characterizations for animal species included in the NatureServe Central Databases. The animal groups examined included all U.S. vertebrates, butterflies and skippers, and large branchiopods (i.e., fairy shrimp, clam shrimp, and tadpole shrimp). Our initial list of animal groups to consider also included additional invertebrate groups, but as the project proceeded, we found that adequate habitat information was not readily available for these groups. We generated an initial working list of animals by selecting those species found in swamps, marshes, temporary pools, bogs, fens, and springs (the standard habitat options available in the NatureServe animal species database). NatureServe zoologists then removed from the initial list species commonly occurring in wetlands directly connected to rivers, lakes, or other potentially navigable waters. The resulting list included some 150 species potentially closely associated with isolated wetlands.

Reviewing existing occurrence data and in consultation with colleagues in each state, NatureServe zoologists further narrowed this list to 33 species, then classified each of these species as "obligate" or "facultative" to isolated wetlands. Where sufficient information exists, each species was also assigned to specific isolated wetland ecological systems that are known to characterize their habitat.

Plant Species Linked to Isolated Wetlands

NatureServe's databases do not currently contain comprehensive habitat data for plant species; instead, we relied on Synthesis of the North American Flora (Kartesz, 1999) to develop an initial list of at-risk plant species that may be supported by isolated wetlands. Using Kartesz (1999) and the NatureServe databases, we compiled a list of 1,028 G1-G3 native vascular plants that occur in wetlands within the United States. Subspecies and varieties (T1-T3) with status under the Endangered Species Act were also included. Kartesz (1999) assigned the status of "wetland plant" to species of North America. We used this attribute because Kartesz' definition of "wetland plant" is quite broad, and because he has comprehensively assessed wetland status for the vascular flora of North America. We then divided that list into regional subsets for review by fourteen natural heritage program botanists. The botanists used our definition for "isolated wetland" and their knowledge of the ecology of these plants to remove from the list any plants not associated with (i.e., having less than 67% of occurrences in) isolated wetlands and to add missing isolated wetland plant species.

By reviewing existing occurrence data and consulting colleagues in each state, each of the regional botanists classified each of these species as "obligate" or "facultative" to isolated wetlands. They also assigned each species to specific isolated wetland ecological systems that are known to characterize their habitat. We compiled these data and resolved regional differences through consultation with botanists and ecologists. In cases where the species was suspected to be closely associated with isolated wetlands but there was insufficient information to confirm a "facultative" association (i.e. that more than two-thirds of their occurrences are in isolated wetlands), an indicator category of "unconfirmed" was assigned.

Plant Communities Linked to Isolated Wetlands

As noted above, NatureServe ecological systems are defined with groups of plant communities that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. We defined component plant communities for each ecological system using the U.S. National Vegetation Classification (US-NVC) where available. Appendix III lists the set of associations (with their conservation status ranks) that are characteristic of each isolated wetland system. California, Alaska, and Hawai'i are states in which the US-NVC has not been substantially developed and in which association-scale units have, in most cases, not been given global ranks (G-ranks). All other states have relatively comprehensive and updated information at the association scale of the US-NVC.

Our analysis of the listed associations for these states focused on the degree to which G1-G3 plant associations are also described for other ecological systems that do not meet our working definition for "geographically isolated" wetland status. This clarified the degree to which they should be considered "obligate" or "facultative" to isolated wetlands. We considered those US-NVC association that are documented only for isolated wetlands to be "obligate" while we listed those known from other wetland systems as "facultative."

Knowledge and Data Gaps

Although the network of natural heritage programs have become a well-recognized source of biological inventories in the United States (and elsewhere), their work is far from complete. Inventory completeness for wetlands and their associated rare species vary widely from state to state. This report makes use of the best available data on at-risk species, communities, and isolated wetland types, but much additional inventory data are needed to strengthen and further corroborate the results of the study. In this study we document not only the available knowledge on isolated wetland systems and their associated at-risk species, but the data gaps as well.

We surveyed ecologists and biologists from natural heritage programs from each state to identify the important data gaps associated with isolated wetlands in their state. Each program was given a table of all at-risk plants, animals, and plant associations listed for their state, along with a listing of isolated wetland ecological system types. Additional room was left to document inventory status for wetland types of their state-specific wetland classification. We asked scientists the following questions and summarized the results in a tabular format.

1) **How complete is the locality, or occurrence, data in your state for biodiversity linked to geographically isolated wetlands?** For each element, respondents could choose from high (>75%) completeness, medium (50-75%), low (<50%), or no inventory.

2) **What proportion of data is processed?** In programs with ongoing field inventory, there is commonly a significant lag time between field data collection and availability of results for land use planning. For each element, respondents could choose high (>75%) proportion processed, medium (50-75%), low (<50%), or none processed.

Respondents were also provided with a comments field for each element to include any other insights or clarifications to compliment the tabular data. These surveys were completed between May and August 2005.

Results

Isolated Wetland Ecological Systems

Of the 276 wetland and riparian ecological systems described for the United States (NatureServe 2005), 81 (29%) met our working definition for “geographically isolated,” based on documented knowledge of their distribution and typical site characteristics. Of the 81 isolated wetland types, only 16 (20%) fall into the strict isolation subcategory, while the remaining 65 systems (80%) fall into the partial isolation subcategory (Tables 2-4). Using our definition, isolated wetlands make up 13% of the 636 “natural/near natural” terrestrial ecological system types (*both upland and wetland*) currently classified and described by NatureServe for the United States (NatureServe 2005)

Central Interior Highlands and Appalachian Sinkhole and Depression Pond / Photo by Irvine Wilson, Virginia Dept. of Conservation and Recreation.

REGIONAL PATTERNS OF ISOLATED WETLAND SYSTEMS

Many factors of regional climate and characteristic landforms describe the distribution of these wetland types. Summary information in Table 2 is organized by clusters of states in broad biogeographic regions of the United States.

Along the *North Atlantic Coast*, there are relatively few geographically isolated wetland types (n=3), typically found in glaciated landscapes that support depressional bogs, more extensive spruce-dominated flats, or small seepages wetlands, such as the Acadian-Appalachian Conifer Seepage Forest.

Further south, along the *Central Atlantic Coast*, isolated wetland types are also limited in number (n=4) and tend to occur in association with maritime dunes, or shallow pondshores and swamps further inland.

The *South Atlantic and Gulf Coast* region includes the greatest documented diversity in isolated wetland types (n=24) of any region in the country, owing to its great vegetation diversity and variability of wetland environments. The wetlands range from “Carolina Bay” depressions, to shallow pondshore types such as the Central Florida Herbaceous Pondshore, to forested flatwoods such as the West Gulf Coastal Plain Pine-Hardwood Flatwoods, scattered across extensive low plains.

The *Upper Great Lakes* region includes eight isolated wetland types, mostly located among coastal dunes, flat-to-undulating glacial outwash and “ice-contact” landscapes, or in the case of Great Lakes Alvar, where flat dolomite “pavement” is at or near the soil surface, seasonal flooding/drought cycles are characteristic.

The *Central Hardwoods and Interior Highlands* region extends from the central Appalachian through the Ozark Mountains and other lowlands of the central Midwest. Nine isolated wetland types are found in this region, typically in small depressions or on clay-rich plains where one may encounter North-Central Interior Wet Flatwoods. At the base of gentle wooded slopes, seepage fens also are characteristic in several forms, from those found in the Appalachian or Ozark foothills to those found along gentle slopes in more northerly, glaciated landscapes.

Extending out onto the *Great Plains* region, five major isolated wetland types are characteristic, including the often-described prairie potholes. But also, several types of closed and open depressional wetlands are characteristic, located among sand hills or scattered across extensive, fine-textured alluvial plains.

Throughout the *Intermountain and Rocky Mountain* region, six different types of isolated wetlands are found, mostly limited to arid environmental settings; vernal pools, playas, alkaline closed depressions, and greasewood-dominated flats are characteristic in cold-desert, intermontane basins. Rare isolated wetland types include swales among active and stabilized dunes and "hanging gardens" found with cracked, seeping bedrock of canyon walls on the Colorado Plateau.

The *Southwest* region, extending from central Texas west through southeastern California, includes seven isolated wetland types, from bedrock flatrock systems of the Edwards Plateau to warm desert playas, interdunal swales, to Sonoran fan palm oases.

Open, herbaceous-dominated vernal pools find their highest diversity on types in the *Pacific Coast* region, from southern California north through western Washington. There are also other alkali closed-basin wetlands, interdunal wetlands, and wet prairies among the 10 isolated wetland types in this region.

Alaska includes just two described isolated wetland types, in interdunal areas and in isolated depressional bogs found throughout Alaska's interior.

Hawai'i also includes two described isolated wetland types, one being a montane bog, and another being a type of vernal pool.

Table 2. Isolated Wetland Ecological Systems in the United States.
All types identified by region; also indicating the hydrogeomorphic class and type of isolation.

PROJECT REGION **Ecological System**	**Hydrogeomorphic Class**	**Isolation Type**
NORTH ATLANTIC COAST (ME, NH, VT, MA)		
Acadian Near-Boreal Spruce Flat	Extensive Wet Flat	Partial
Acadian-Appalachian Conifer Seepage Forest	Seepage-Fed Sloping	Partial
Atlantic Coastal Plain Northern Bog	Depressional	Partial
CENTRAL ATLANTIC COAST (NY, CT, RI, NJ, MD, DE)		
Atlantic Coastal Plain Northern Basin Peat Swamp	Depressional	Partial
Atlantic Coastal Plain Northern Basin Swamp and Wet Hardwood Forest	Seepage-Fed Sloping	Partial
Atlantic Coastal Plain Northern Dune and Maritime Grassland	Depressional	Partial
Atlantic Coastal Plain Northern Pondshore	Depressional	Partial
SOUTH ATLANTIC AND GULF COAST (VA, NC, SC, GA, FL, AL, MS, LA)		
Atlantic Coastal Plain Clay-Based Carolina Bay Wetland	Depressional	Partial
Atlantic Coastal Plain Sandhill Seep	Seepage-Fed Sloping	Partial
Atlantic Coastal Plain Southern Depression Pondshore	Depressional	Partial
Central Florida Herbaceous Pondshore	Depressional	Partial
East Gulf Coastal Plain Dune and Coastal Grassland	Depressional	Partial
East Gulf Coastal Plain Northern Depression Pondshore	Depressional	Partial

PROJECT REGION Ecological System	Hydrogeomorphic Class	Isolation Type
East Gulf Coastal Plain Sandhill Lakeshore Depression	Depressional	Partial
East Gulf Coastal Plain Southern Depression Pondshore	Depressional	Partial
East Gulf Coastal Plain Southern Loblolly-Hardwood Flatwoods	Extensive Wet Flat	Partial
Floridian Highlands Freshwater Marsh	Depressional	Partial
South Florida Cypress Dome	Depressional	Partial
South Florida Depression Pondshore	Depressional	Partial
Southeastern Coastal Plain Interdunal Wetland	Depressional	Partial
Southern Appalachian Seepage Wetland	Seepage-Fed Sloping	Partial
Southern Coastal Plain Nonriverine Basin Swamp	Depressional	Partial
Southern Coastal Plain Nonriverine Cypress Dome	Depressional	Partial
Southern Coastal Plain Sinkhole	Depressional	Partial
Southern Piedmont / Ridge and Valley Upland Depression Swamp	Depressional	Strict
Southern Piedmont Granite Flatrock	Seepage-Fed Sloping	Strict
Texas-Louisiana Coastal Prairie	Extensive Wet Flat	Partial
Texas-Louisiana Coastal Prairie Pondshore	Depressional	Partial
West Gulf Coastal Plain Flatwoods Pond	Depressional	Partial
West Gulf Coastal Plain Nonriverine Wet Hardwood Flatwoods	Depressional	Partial
West Gulf Coastal Plain Pine-Hardwood Flatwoods	Extensive Wet Flat	Partial
UPPER GREAT LAKES (MN, WI, MI)		
Boreal-Laurentian Bog	Depressional	Partial
Boreal-Laurentian Conifer Acid Swamp	Depressional	Partial
Boreal-Laurentian-Acadian Acidic Basin Fen	Depressional	Partial
Great Lakes Alvar	Extensive Wet Flat	Partial
Great Lakes Dune and Swale	Depressional	Partial
Great Lakes Wet-Mesic Lakeplain Prairie	Depressional	Partial
Laurentian-Acadian Conifer-Hardwood Acid Swamp	Extensive Wet Flat	Partial
Northern Great Lakes Interdunal Wetland	Depressional	Partial
CENTRAL HARDWOODS AND INTERIOR HIGHLANDS (MO, AR, KY, TN, IN, OH, PA, WV)		
Central Interior Highlands and Appalachian Sinkhole and Depression Pond	Depressional	Partial
North-Central Appalachian Seepage Fen	Seepage-Fed Sloping	Partial
North-Central Interior and Appalachian Acid Peatland	Depressional	Partial
North-Central Interior Freshwater Marsh	Depressional	Partial
North-Central Interior Shrub-Graminoid Alkaline Fen	Seepage-Fed Sloping	Partial
North-Central Interior Wet Flatwoods	Extensive Wet Flat	Partial
North-Central Interior Wet Meadow-Shrub Swamp	Depressional	Partial
Ozark-Ouachita Fen	Seepage-Fed Sloping	Partial
South-Central Interior / Upper Coastal Plain Wet Flatwoods	Extensive Wet Flat	Partial
GREAT PLAINS AND TALLGRASS PRAIRIE (ND, SD, NE, KS, OK, IA, IL)		
Eastern Great Plains Wet Meadow, Prairie, and Marsh	Depressional	Partial

PROJECT REGION **Ecological System**	**Hydrogeomorphic Class**	**Isolation Type**
Great Plains Prairie Pothole	Depressional	Partial
Western Great Plains Closed Depression Wetland	Depressional	Strict
Western Great Plains Open Freshwater Depression Wetland	Depressional	Partial
Western Great Plains Saline Depression Wetland	Depressional	Partial
INTERMOUNTAIN AND ROCKY MOUNTAIN (NV, UT, ID, MT, WY, CO)		
Colorado Plateau Hanging Garden	Seepage-Fed Sloping	Strict
Columbia Plateau Vernal Pool	Depressional	Strict
Inter-Mountain Basins Alkaline Closed Depression	Depressional	Partial
Inter-Mountain Basins Greasewood Flat	Depressional	Partial
Inter-Mountain Basins Interdunal Swale Wetland	Depressional	Partial
Inter-Mountain Basins Playa	Depressional	Partial
Northern Rocky Mountain Wooded Vernal Pool	Depressional	Strict
SOUTHWEST (AZ, NM, TX)		
Central and Upper Texas Coast Dune and Coastal Grassland	Depressional	Partial
Chihuahuan-Sonoran Desert Bottomland and Swale Grassland	Depressional	Partial
Edwards Plateau Granitic Forest, Woodland and Glade	Depressional	Strict
North American Warm Desert Interdunal Swale Wetland	Depressional	Partial
North American Warm Desert Playa	Depressional	Partial
South Texas Dune and Coastal Grassland	Depressional	Partial
PACIFIC COAST (CA, OR, WA)		
California Central Valley Alkali Sink	Depressional	Partial
Mediterranean California Alkali Marsh	Depressional	Partial
Mediterranean California Coastal Interdunal Wetland	Depressional	Partial
Modoc Basalt Flow Vernal Pool	Depressional	Strict
North Pacific Hardpan Vernal Pool	Depressional	Strict
Northern California Claypan Vernal Pool	Depressional	Strict
Northern California Volcanic Vernal Pool	Depressional	Strict
Northern Columbia Plateau Basalt Pothole Ponds	Depressional	Strict
Sonoran Fan Palm Oasis	Seepage-Fed Sloping	Partial
South Coastal California Vernal Pool	Depressional	Strict
Willamette Valley Wet Prairie	Extensive Wet Flat	Partial
ALASKA		
Boreal Depressional Bog	Depressional	Partial
North Pacific Coastal Interdunal Wetland	Depressional	Partial
HAWAI’I		
Hawai’i ‘Ihi’ihiluakea Vernal Pool	Depressional	Partial
Hawai’i Montane Bog	Depressional	Strict

HYDROGEOMORPHIC PATTERNS OF ISOLATED WETLAND SYSTEMS

Most wetlands meeting our project-specific definition of geographically isolated fall into the “depressional” hydrogeomorphic (HGM) class (Brinson 1993). Sixty-two of 81 types, or 77%, were categorized as such (Table 3). Roughly equal numbers of types fall in the other two HGM classes of “extensive wet flat” (n=9) and “seepage-fed sloping (n=10).” Isolated wetlands occurring as extensive wet flats tend to be limited to relatively flat regional landscapes, either in the Atlantic and Gulf coastal plain or in northern sub-boreal regions. Those falling into the seepage-fed sloping HGM class are found in more varied circumstances throughout the country.

Nearly all wetland types meeting the “strict” isolation subcategory were in the depressional HGM class as well. These are typically wetlands that form in shallow basins where surface and/or ground water consistently accumulates over impermeable substrates (Smith et al. 1995, Rheinhart et al. 2002). They more often occur in the western states where arid environments are more common than in eastern states. Inter-montane basins can often support depressional wetlands where rain and surface water is concentrated. Vernal pools and desert playas often meet the “strict” isolation definition in this part of the country. The relatively few types of strictly isolated wetlands in the other study regions that fall under this subcategory include isolated seepage wetlands and seasonally flooded areas occurring on rock flats.

Table 3. Numbers of Isolated Wetland Ecological Systems by Region, Hydrogeomorphic Class, and Isolated Wetland Type

	Hydrogeomorphic Class			Isolated Wetland Type		
Study Region	**Depressional**	**Extensive Wet Flat**	**Seepage-Fed Sloping**	**Strict**	**Partial**	**Total**
North Atlantic Coast	1	1	1	0	3	3
Central Atlantic Coast	3	0	1	0	4	4
South Atlantic and Gulf Coast	18	3	3	2	22	24
Upper Great Lakes	6	2	0	0	8	8
Central Hardwoods and Interior Highlands	4	2	3	0	9	9
Great Plains and Tallgrass Prairie	5	0	0	1	4	5
Intermountain and Rocky Mountain	6	0	1	3	4	7
Southwest	6	0	1	1	6	7
Pacific Coast	9	1	0	6	4	10
Alaska	2	0	0	0	2	2
Hawai’i	2	0	0	1	1	2
Total	62	9	10	14	67	81

STATE COMPARISONS OF ISOLATED WETLAND SYSTEM DISTRIBUTION

As noted above, for the United States as a whole, 29% of the wetland systems met our project-specific definition for geographically isolated. Figure 1 indicates numbers of isolated wetland ecological system types known from each state. From state to state, these proportions vary, depending on the diversity of wetlands, both isolated and non-isolated, known to occur (Table 4). Numbers of isolated wetland types by state range from a low of one (West Virginia) to a high of 16 (New York and Texas). Numbers of all wetland types (isolated and non-isolated) vary by state and range from a low of six (Iowa) to a high of 56 (Florida). Proportions of wetlands categorized as isolated vs. non-isolated were lowest in Alaska, Hawai’i, Kentucky, Tennessee, and West Virginia. In Indiana, Iowa, Kansas, Michigan, Minnesota, North Dakota, and Wisconsin, more than half of the wetland system types meet our project-specific definition for geographically isolated (Table 4). Appendix VIII provides a list of the isolated systems occurring in each state.

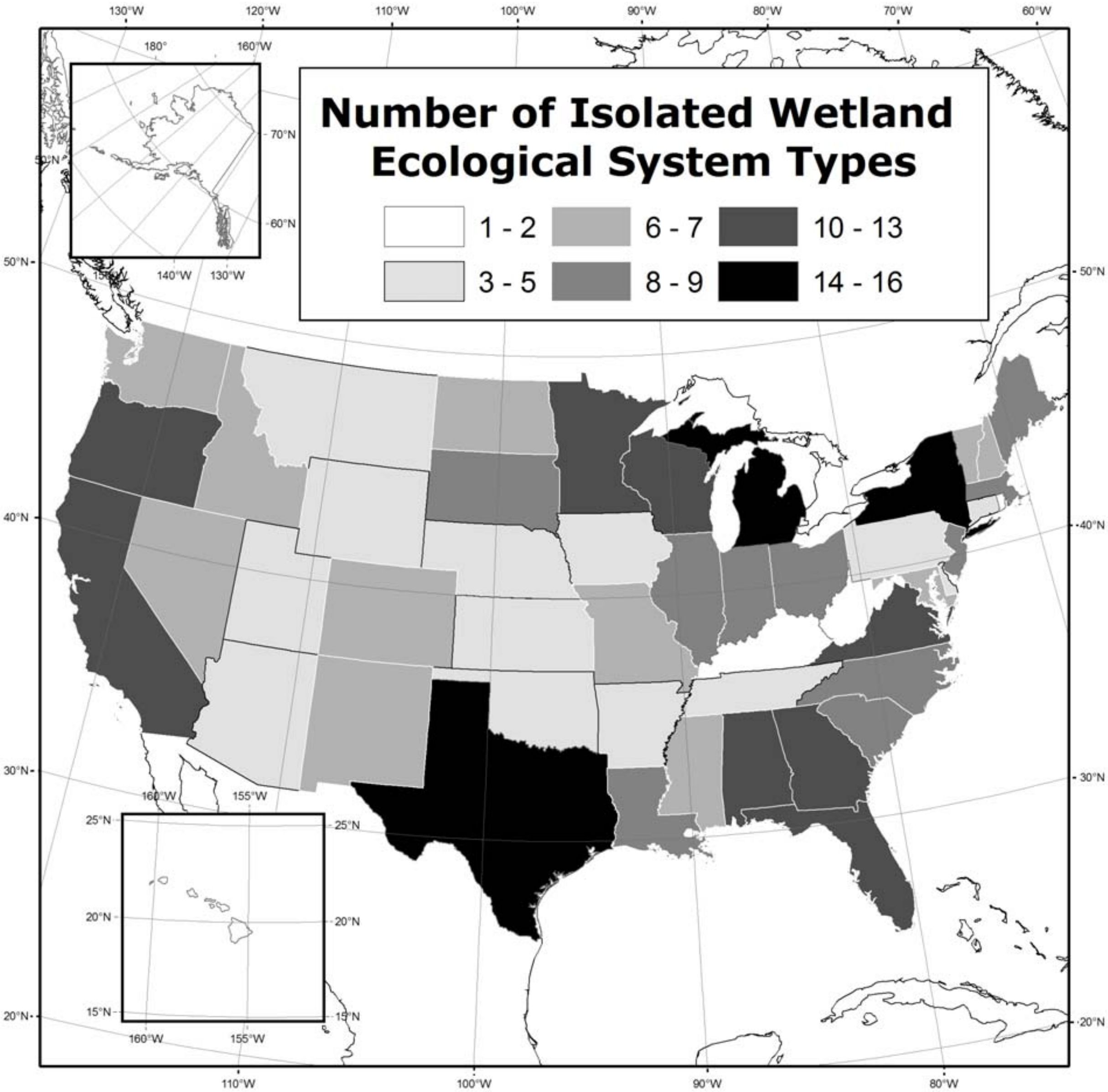

Figure 1. Number of Isolated Wetland Ecological System Types per State

Table 4. Numbers of Isolated Wetland vs. non-Isolated Wetland Systems by State

State	# Isolated Wetland Systems			# Wetland Systems	Percent Isolated
	Strict Isolation	Partial Isolation	Total		
Alabama	2	10	12	33	36%
Alaska*	0	2	2	19	11%
Arizona	1	4	5	17	29%
Arkansas	0	4	4	17	24%
California	5	8	13	36	36%
Colorado	2	4	6	17	35%
Connecticut	0	5	5	17	29%
Delaware	0	5	5	13	38%
Florida	0	12	12	56	21%
Georgia	2	10	12	38	32%
Hawai'i*	1	1	2	12	17%
Idaho	1	5	6	17	35%
Illinois	0	9	9	18	50%
Indiana	0	8	8	12	67%
Iowa	0	5	5	6	83%
Kansas	1	3	4	7	57%
Kentucky	0	2	2	15	13%
Louisiana	0	8	8	34	24%
Maine	0	8	8	27	30%
Maryland	0	6	6	21	29%
Massachusetts	0	8	8	26	31%
Michigan	0	14	14	26	54%
Minnesota	0	13	13	23	57%
Mississippi	0	7	7	25	28%
Missouri	0	6	6	14	43%
Montana	1	4	5	20	25%
Nebraska	1	3	4	10	40%
Nevada	1	6	7	24	29%
New Hampshire	0	7	7	28	25%
New Jersey	0	8	8	18	44%
New Mexico	0	6	6	17	35%
New York	0	16	16	36	44%
North Carolina	2	7	9	33	27%
North Dakota	0	7	7	13	54%
Ohio	0	9	9	18	50%
Oklahoma	1	3	4	11	36%
Oregon	6	6	12	41	29%
Pennsylvania	0	5	5	17	29%
Rhode Island	0	2	2	7	29%
South Carolina	2	6	8	28	29%
South Dakota	1	7	8	18	44%
Tennessee	0	3	3	17	18%
Texas	2	13	15	47	32%

State	# Isolated Wetland Systems			# Wetland Systems	Percent Isolated
	Strict Isolation	Partial Isolation	Total		
Utah	1	4	5	14	36%
Vermont	0	7	7	21	33%
Virginia	2	9	11	40	28%
Washington	4	3	7	30	23%
West Virginia	0	1	1	8	13%
Wisconsin	0	13	13	23	57%
Wyoming	1	4	5	17	29%
United States	**14**	**67**	**81**	**276**	**29%**

**Classification is in development in Alaska and Hawaii.*

At-Risk Animal Species Linked to Isolated Wetlands

Over 150 animal species were closely evaluated for strength of association with isolated wetland habitats, and 33 at-risk species were found to be closely associated with these habitats (Appendix IV). Of these animal species, 13 have status under the U.S Endangered Species Act (ESA) (i.e., they are threatened, endangered or candidate species) (Table 5). Eight of those with status under ESA are considered "obligate" to isolated wetlands. Figure 2 depicts the numbers for at-risk animal species in isolated wetlands by state. At-risk animal species tend to be most concentrated in southern latitudes.

Houston Toad (Bufo houstonensis) / *Photo by Dr. Robert Thoman, USFWS*

ESA-listed animal species include vertebrates, such as the dusky gopher frog (*Rana sevosa*), from the coastal plain of Alabama, Louisiana, and Mississippi, to insects, such as the delta green ground beetle (*Elaphrus viridis*) in Northern California Claypan Vernal Pools, to crustaceans, such as the Riverside fairy shrimp (*Streptocephalus woottoni*) found in South Coastal California Vernal Pool. A total of 12 geographically isolated wetland types support at least one listed or candidate species under ESA (Table 5). Two types of California vernal pools are known to support up to 4 listed species.

A majority (54%), or 18 of 33, of these animal species are considered "obligate" to isolated wetland habitats (Table 6). Appendix IV provides information on the specific ecological systems that provide habitat for each of these species. Three at-risk species are known to occur in wetland habitats that generally meet our project-specific definition for an isolated wetland type, but we were unable to establish a specific association with a classified wetland type, so those species are listed as "unconfirmed."

Table 5. Isolated Wetland Ecological Systems Containing Animal Species with ESA Status*
** ESA threatened, endangered or candidate species*

Isolated Wetland System	Type of Isolation	Total # of Animal Species with ESA Status
Northern California Claypan Vernal Pool	Strict	4
South Coastal California Vernal Pool	Strict	4
East Gulf Coastal Plain Southern Depression Pondshore	Partial	2
Inter-Mountain Basins Alkaline Closed Depression	Partial	2
Mediterranean California Coastal Interdunal Wetland	Partial	2
Atlantic Coastal Plain Southern Depression Pondshore	Partial	1
East Gulf Coastal Plain Northern Depression Pondshore	Partial	1
Mediterranean California Alkali Marsh	Partial	1
Sonoran Fan Palm Oasis	Partial	1
Southern Coastal Plain Nonriverine Cypress Dome	Partial	1
West Gulf Coastal Plain Flatwoods Pond	Partial	1
West Gulf Coastal Plain Pine-Hardwood Flatwoods	Partial	1

REGIONAL PATTERNS IN AT-RISK ANIMAL SPECIES

The largest numbers of at-risk animal species in this study are found in the Pacific Coast (n=15), South Atlantic and Gulf Coast (n=7), and Southwest (n=5) regions. When ESA status is considered, the Pacific Coast includes a disproportionate share (n=10) while the remainder occur in the Southwest, Intermountain and Rocky Mountain and South Atlantic and Gulf Coast regions.

Table 6. Numbers of At-Risk Animal Species in Isolated Wetlands, by Region

Region	At-Risk Species Dependence on Isolated Wetlands			Total # At-Risk Species in Region	Total # of At-Risk Species in Region with ESA Status
	Obligate	Facultative	Unconfirmed		
North Atlantic Coast	1	1	1	3	0
Central Atlantic Coast	1	1	0	2	0
South Atlantic and Gulf Coast	4	3	0	7	2
Upper Great Lakes	0	0	1	1	0
Central Hardwoods and Interior Highlands	2	0	1	3	0
Great Plains and Tallgrass Prairie	1	0	0	1	0
Intermountain and Rocky Mountain	1	0	0	1	1
Southwest	3	1	1	5	1
Pacific Coast	8	7	0	15	10
Alaska	0	0	0	0	0
Hawai'i	0	0	0	0	0
U.S. Total*	**18**	**12**	**3**	**33**	**13**

** Because species can occur in more than one region, total counts for the U.S. do not equal the sum of values across regions.*

STATE COMPARISONS OF AT-RISK ANIMAL SPECIES

The percentage of at-risk animals in a given state that occur in isolated wetlands ranges from 0-4% (4% in Massachusetts) (Figure 2, Table 7). Some 28 states include no at-risk species linked to isolated wetland types. However, these percentages may change into the future as habitat information is developed for additional invertebrate groups. California has the greatest number of at-risk animals (n=15) occurring within isolated wetlands. California also has the highest number of ESA listed animal species (n=10) while all of the rest of the states have 2 or fewer. Appendix VIII provides a list of the G1-G3 animal species occurring in isolated wetland types in each state.

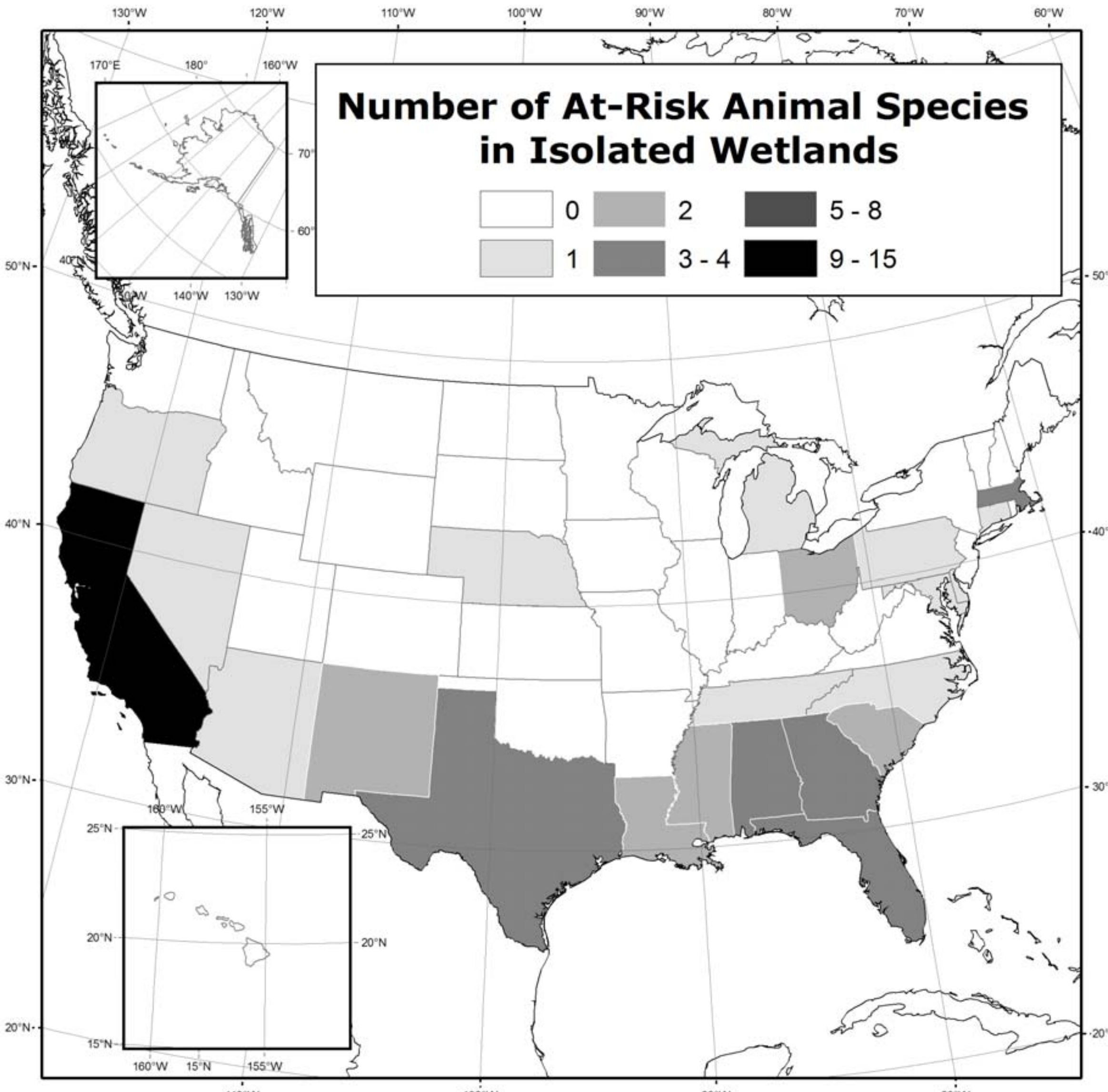

Figure 2. Number of At-Risk Animal Species in Isolated Wetlands per State

Table 7. Animal Species Associated with Isolated Wetlands in Each State

State	# At-Risk Animals in Isolated Wetlands (number with ESA Status)	Total # At-Risk Animals	Percent of At-Risk Animals That Occur in Isolated Wetlands
Alabama	4 (2)	515	1%
Alaska	0 (0)	73	0
Arizona	1 (0)	339	<1%
Arkansas	0 (0)	216	0
California	15 (10)	774	2%
Colorado	0 (0)	99	0
Connecticut	1 (0)	46	2%
Delaware	1 (0)	35	3%
Florida	4 (1)	357	1%
Georgia	3 (1)	351	1%
Hawaii	0 (0)	152	0
Idaho	0 (0)	195	0
Illinois	0 (0)	136	0
Indiana	0 (0)	121	0
Iowa	0 (0)	60	0
Kansas	0 (0)	67	0
Kentucky	0 (0)	216	0
Louisiana	2 (1)	121	2%
Maine	0 (0)	89	0
Maryland	1 (0)	64	2%
Massachusetts	3 (0)	70	4%
Michigan	1 (0)	88	1%
Minnesota	0 (0)	80	0
Mississippi	2 (1)	174	1%
Missouri	0 (0)	168	0
Montana	0 (0)	119	0
Nebraska	1 (0)	44	2%
Nevada	1 (1)	178	1%
New Hampshire	0 (0)	57	0
New Jersey	0 (0)	69	0
New Mexico	2 (0)	242	1%
New York	0 (0)	117	0
North Carolina	1 (0)	391	<1%
North Dakota	0 (0)	25	0
Ohio	2 (0)	97	2%
Oklahoma	0 (0)	177	0
Oregon	1 (1)	374	<1%
Pennsylvania	1 (0)	118	1%

Table 7. Animal Species Associated with Isolated Wetlands in Each State

State	# At-Risk Animals in Isolated Wetlands (number with ESA Status)	Total # At-Risk Animals	Percent of At-Risk Animals That Occur in Isolated Wetlands
Rhode Island	0 (0)	31	0
South Carolina	2 (1)	250	1%
South Dakota	0 (0)	28	0
Tennessee	1 (0)	463	<1%
Texas	4 (1)	426	1%
Utah	0 (0)	141	0
Vermont	0 (0)	38	0
Virginia	0 (0)	291	0
Washington	0 (0)	191	0
West Virginia	0 (0)	127	0
Wisconsin	0 (0)	85	0
Wyoming	0 (0)	72	0

At-Risk Plant Species Linked to Isolated Wetlands

A total of 1028 at-risk species were closely evaluated for strength of association with isolated wetland habitats. Of these plant species, 241 were documented as being closely associated with isolated wetlands. Seventy-three of these 241 species have status under the U.S Endangered Species Act (ESA) (i.e., they are threatened, endangered or candidate species) (Appendix V). Thirty-seven of the 73 plant species with ESA status (51%) are obligate to isolated wetlands. Some 38% of the isolated wetland system types (n=31) support at least one plant species with ESA status (Table 8).

Eastern prairie white-fringed orchid (Platanthera leucophaea) / *Photo by Jim Henderson.*

Plant species with ESA status include northeastern bulrush (*Scirpus ancistrochaetus*) found along the north Atlantic Coastal Plain, or little amphianthus (*Amphianthus pusillus*) found in Granitic flatrock pools of Georgia, South Carolina, and Alabama, or spring-loving centaury (*Centaurium namophilum*) found only in alkaline closed depressions of Nevada. The Hawai'i Montane Bog is known to support 14 plant species with ESA status, followed by the North Pacific Hardpan Vernal Pool (n=10), Northern California Claypan Vernal Pool (n=8), the Inter-Mountain Basins Alkaline Closed Depression (n=7), the South Coastal California Vernal Pool (n=6), and Northern California Volcanic Vernal Pool (n=5). Twenty-five other isolated wetland types are known to support between one and four ESA status plant species. Ten of the 16 isolated wetland types in the subcategory of "strict" isolation support plant species with ESA status.

Proportionally, 32% (n=77) of the at-risk plant species appear to be obligate to isolated wetland habitats. A total of 141 (58%) were listed as facultative. Twenty-three of the at-risk plant species are known to occur in isolated wetland types, but we were unable to confirm that these isolated wetland habitats represent greater than two-thirds of the species' occurrences. Appendix V and Appendix VIII each include information on the specific ecological systems that provide habitat for each of these species.

Table 8. Isolated Wetland Ecological System Containing Plant Species with ESA Status*

** ESA threatened, endangered or candidate species*

Isolated Wetland System	Type of Isolation	Total # of Plant Species with ESA Status
Hawai'i Montane Bog	Strict	14
North Pacific Hardpan Vernal Pool	Strict	10
Northern California Claypan Vernal Pool	Strict	8
Inter-Mountain Basins Alkaline Closed Depression	Partial	7
South Coastal California Vernal Pool	Strict	6
Northern California Volcanic Vernal Pool	Strict	5
Atlantic Coastal Plain Northern Pondshore	Partial	4
Atlantic Coastal Plain Clay-Based Carolina Bay Wetland	Partial	3
Atlantic Coastal Plain Southern Depression Pondshore	Partial	3
Central Interior Highlands and Appalachian Sinkhole and Depression Pond	Partial	3
Southern Piedmont Granite Flatrock	Strict	3
California Central Valley Alkali Sink	Partial	2
Central Florida Herbaceous Pondshore	Partial	2
East Gulf Coastal Plain Northern Depression Pondshore	Partial	2
Great Lakes Dune and Swale	Partial	2
Mediterranean California Coastal Interdunal Wetland	Partial	2
North-Central Interior Wet Meadow-Shrub Swamp	Partial	2
Southern Appalachian Seepage Wetland	Strict	2
Colorado Plateau Hanging Garden	Strict	1
East Gulf Coastal Plain Southern Depression Pondshore	Partial	1
Eastern Great Plains Wet Meadow, Prairie, and Marsh	Partial	1
Great Lakes Alvar	Partial	1
Great Lakes Wet-Mesic Lakeplain Prairie	Partial	1
Great Plains Prairie Pothole	Partial	1
North American Warm Desert Playa	Partial	1
North-Central Interior and Appalachian Acid Peatland	Partial	1
Northern Columbia Plateau Basalt Pothole Ponds	Strict	1
Northern Great Lakes Interdunal Wetland	Partial	1
Northern Rocky Mountain Wooded Vernal Pool	Strict	1
Southern Coastal Plain Nonriverine Cypress Dome	Partial	1
Willamette Valley Wet Prairie	Partial	1

Regional Patterns in At-Risk Plant Species

The Pacific Coast region and the South Atlantic and Gulf Coast region include substantially greater numbers of at-risk plant species (112 and 69, respectively) associated with isolated wetland types than the other regions (Table 9). The Intermountain and Rocky Mountain region and Hawai'i are second, supporting 37 and 35 species, respectively. A third tier of regions includes the Central Atlantic Coast (n=19), the Central Hardwoods and Interior Highlands (n=18), the Southwest (n=14), and North Atlantic Coast (n=10). The remaining regions (Upper Great Lakes, Great Plains and Tallgrass Prairie, and Alaska) are known to support fewer than 10 at-risk plant species in isolated wetland types. Similar regional patterns follow when considering plant species with ESA status.

Table 9. Numbers of At-Risk Plant Species Tied to Isolated Wetlands, by Region

Region	At-Risk Species Dependence on Isolated Wetlands			Total # At-Risk Species in Region	Total # of At-Risk Species in Region with ESA Status
	Obligate	Facultative	Unconfirmed		
North Atlantic Coast	1	9	0	10	2
Central Atlantic Coast	6	11	2	19	5
South Atlantic and Gulf Coast	21	35	13	69	13
Upper Great Lakes	1	7	1	9	3
Central Hardwoods and Interior Highlands	2	11	5	18	5
Great Plains and Tallgrass Prairie	0	3	2	5	1
Intermountain and Rocky Mountain	15	19	3	37	8
Southwest	4	6	4	14	1
Pacific Coast	37	74	1	112	40
Alaska	0	1	0	1	0
Hawaii	6	22	7	35	14
U.S. Total	**77**	**141**	**23**	**241**	**73**

** Because species can occur in more than one region, total counts for the U.S. do not equal the sum of values across regions.*

STATE COMPARISONS OF AT-RISK PLANT SPECIES

The percentage of at-risk plant species in a given state that occur in isolated wetlands ranges from 0% in South Dakota to 16% each in Delaware and Rhode Island (Figure 3, Table 10). While only South Dakota has no at-risk plant species known to occur in isolated wetland types, 19 states have fewer than five. California has by far the greatest number of at-risk plant species occurring within isolated wetlands (n=104). A second tier of states, including Alabama, Florida, Georgia, North Carolina, South Carolina, Hawai'i, and Nevada, have between 28 and 39 at-risk plant species. Twenty-one states have between 5 and 27 at-risk plant species. California also has the most species with ESA status (n=34), followed by Hawai'i (n=14), while all remaining states have 10 or fewer species with ESA status tied to isolated wetlands. Appendix VIII provides a list of the at-risk plant species occurring in isolated wetlands in each state.

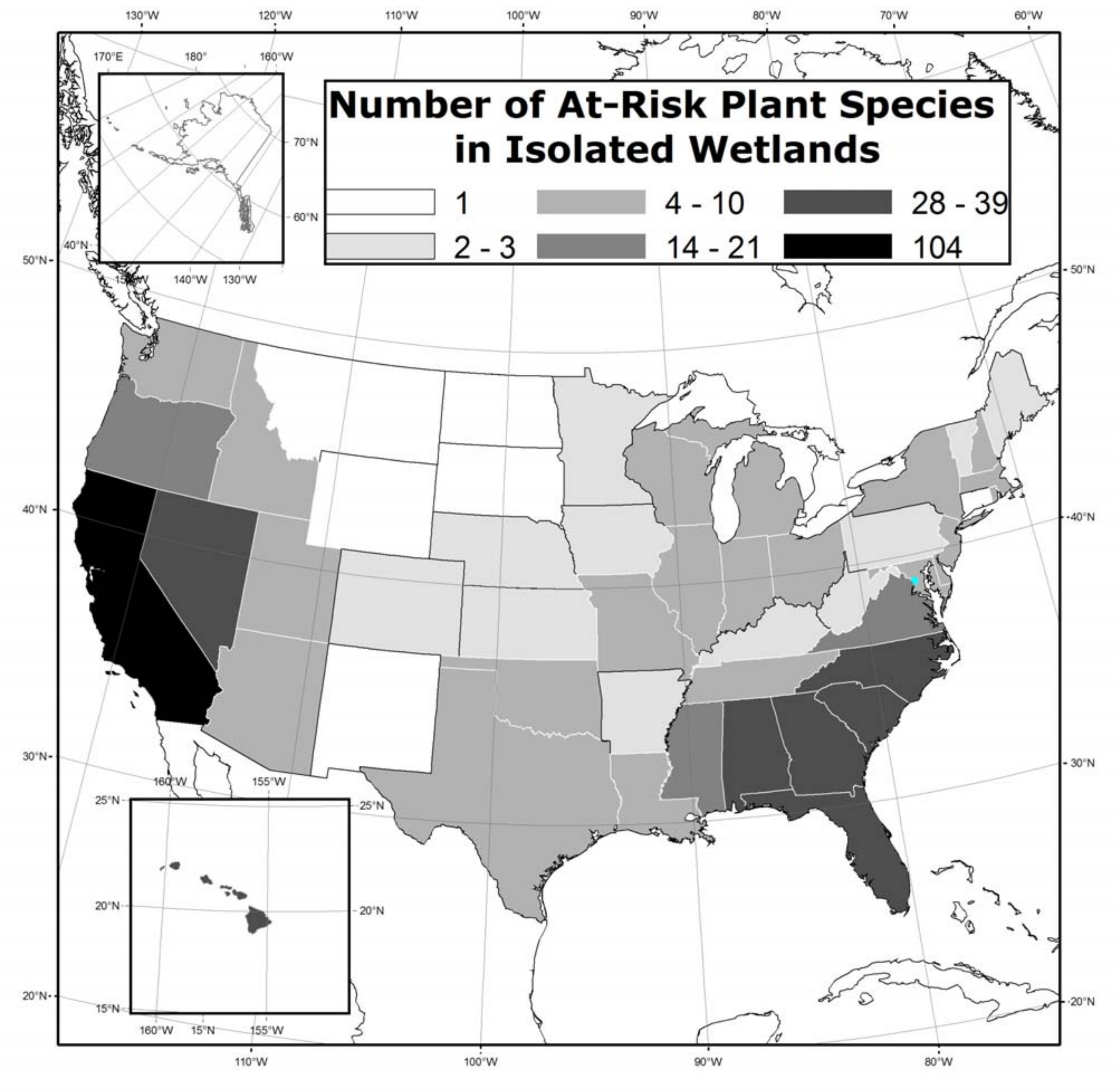

Figure 3. Number of At-Risk Plant Species in Isolated Wetlands per State

Table 10. Plant Species Associated with Isolated Wetlands in Each State

State	# At-Risk Plants in Isolated Wetlands in State (number with ESA Status)	Total # At-Risk Plants	Percent of At-Risk Plants That Occur in Isolated Wetlands
Alabama	30 (4)	313	10%
Alaska	1 (0)	195	1%
Arizona	6 (1)	555	1%
Arkansas	3 (1)	97	3%
California	104 (34)	1743	6%
Colorado	3 (0)	364	1%
Connecticut	1 (0)	57	2%
Delaware	7 (1)	45	16%
Florida	36 (2)	499	7%
Georgia	39 (8)	402	10%
Hawaii	35 (14)	911	4%
Idaho	5 (1)	204	2%
Illinois	5 (1)	53	9%
Indiana	6 (1)	54	11%
Iowa	3 (1)	33	9%
Kansas	2 (0)	43	5%
Kentucky	3 (0)	77	4%
Louisiana	6 (1)	123	5%
Maine	3 (1)	63	5%
Maryland	10 (2)	83	12%
Massachusetts	8 (1)	55	15%
Michigan	8 (3)	88	9%
Minnesota	2 (0)	68	3%
Mississippi	14 (1)	133	11%
Missouri	7 (3)	83	8%
Montana	1 (1)	173	1%
Nebraska	2 (0)	25	8%
Nevada	31 (6)	463	7%
New Hampshire	4 (1)	52	8%
New Jersey	10 (1)	66	15%
New Mexico	1 (0)	374	<1%
New York	8 (2)	103	8%
North Carolina	28 (4)	377	7%
North Dakota	1 (0)	15	7%
Ohio	5 (1)	60	8%
Oklahoma	4 (1)	79	5%
Oregon	21 (7)	614	3%
Pennsylvania	3 (1)	78	4%

Table 10. Plant Species Associated with Isolated Wetlands in Each State

State	# At-Risk Plants in Isolated Wetlands in State (number with ESA Status)	Total # At-Risk Plants	Percent of At-Risk Plants That Occur in Isolated Wetlands
Rhode Island	5 (0)	32	16%
South Carolina	28 (4)	259	11%
South Dakota	0 (0)	17	0%
Tennessee	10 (1)	239	4%
Texas	8 (0)	474	2%
Utah	7 (1)	501	1%
Vermont	3 (1)	50	6%
Virginia	19 (3)	202	9%
Washington	5 (2)	284	2%
West Virginia	3 (1)	84	4%
Wisconsin	5 (2)	67	7%
Wyoming	1 (0)	180	1%

Known Occurrence of At-Risk Plant and Animal Species in U.S. Counties

Given that much land use planning takes place at a county level, it is useful to indicate which counties in the United States are known to substantially contribute to biodiversity values associated with isolated wetland types. Systematic field inventory for at-risk biodiversity are sufficiently limited, so answering this question remains difficult; i.e., areas with no documented locations of at-risk biodiversity may indeed support these species and communities (see section below on Knowledge and Data Gaps for further explanation of limitations of these data). However, of the 274 at-risk species associated with isolated wetlands included in this study, documented occurrences from 48 states (data from New Hampshire and Massachusetts were not included here) are available for 208. For these 208 species, a total of 8,140 occurrences were attributed to the U.S. County where they are located. These data provide an initial indication where at-risk biodiversity associated with isolated wetlands tend to be concentrated.

Numbers of at-risk species vary from zero to 20 species per U.S. County. Of the 3141 counties analyzed, 725 counties (23%) include one or more at-risk species that are associated with isolated wetlands, and 80 counties have 5 or more. Eighteen counties, mostly in California and South Carolina, but also including North Carolina, Georgia, Alabama, Nevada, and Hawai'i, support 10 or more at-risk species. Merced County, California is known to support 20 at-risk species.

Figure 4 depicts an area-weighted count of documented at-risk species presence by US county. This area-weighting [the number of species documented for each county was divided by the total area of each county (in 100 km2)] creates a relatively comparable measure of counties across the country that factors in species/area relationships. Six counties fall in the highest index category (7.3-12.6 species/100km2). These counties include Evans, Baker, and Rockdale counties in Georgia; Cape May County, New Jersey; York County, Virginia; and New Hanover County, North Carolina. Some 28 other counties, from California, Hawai'i, Florida, Alabama, Georgia, South Carolina, North Carolina, Virginia, Maryland, New Jersey, and Rhode Island, fall into the second index category (4.3-7.2 species/100km2). Appendix VI contains a list of

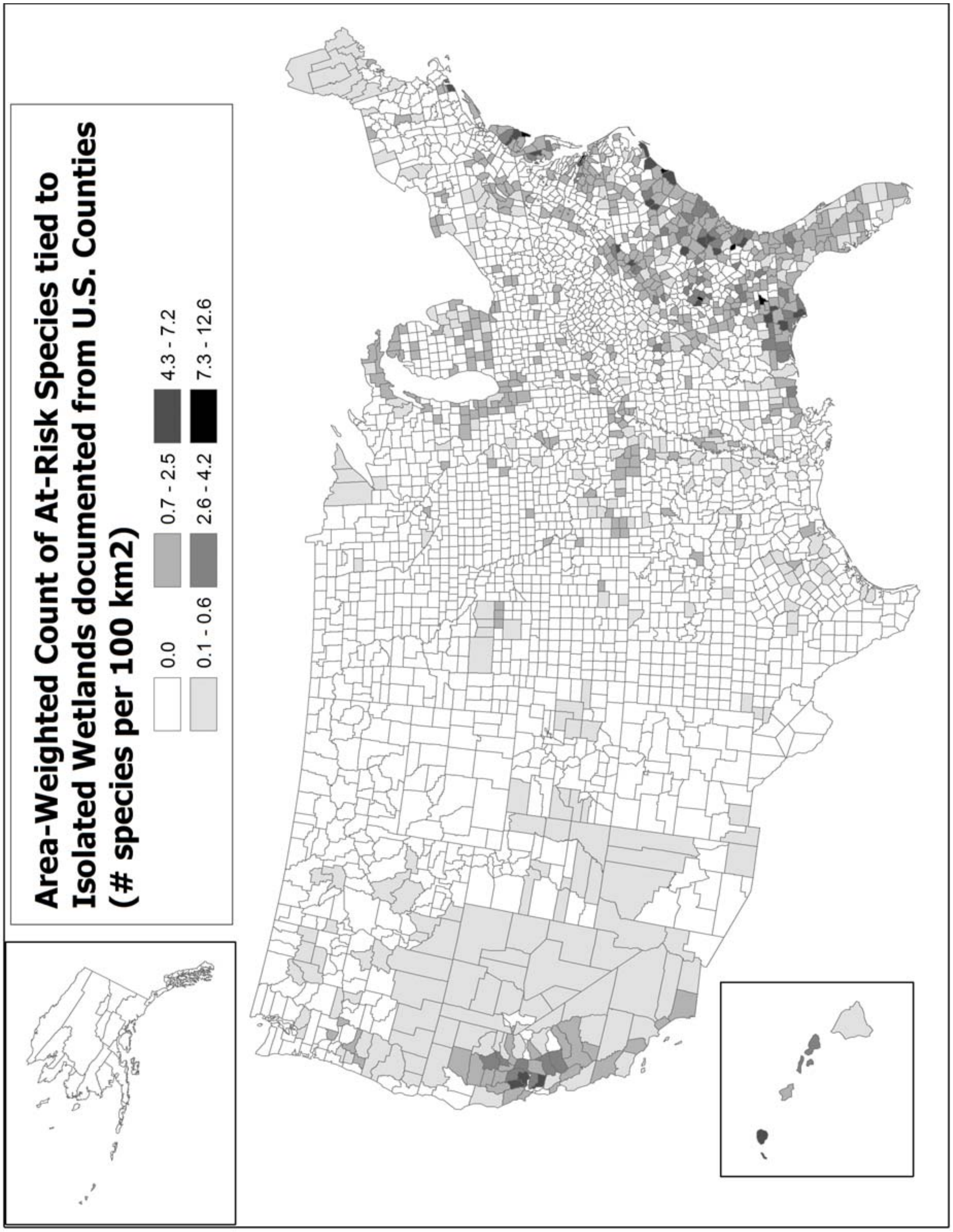

Figure 4. Area-weighted Number of At-Risk Species Associated with Isolated Wetlands per U.S. County

all U.S. counties with at least one documented occurrence of at-risk species associated with isolated wetlands.

Taking into account the limitations of these data, these areas of the United States clearly indicate a high probability of occurrence of isolated wetland types that are known to support at-risk species. Given variation in development pressure across the country, these areas should certainly form one focus for systematic field inventory to ensure that appropriate data are available for land use planning.

At-Risk Plant Communities Linked to Isolated Wetlands

Southern Piedmont / Ridge and Valley Upland Depression Swamp /
Photo by Gary P. Fleming, Virginia Dept. of Conservation and Recreation.

As stated previously, U.S. National Vegetation Classification (US-NVC) associations are used as descriptors of wetland ecological system types. Most ecological systems support a mix of common associations with a relatively low number of rare associations. A total of 279 out of the 3136 (9%) at-risk (G1-G3) US-NVC associations were documented as being characteristically found with geographically isolated wetland ecological systems. This represents 5% of all 5524 currently documented US-NVC associations (*both upland and wetland*).

Proportionally, numbers of at-risk (G1-G3) associations follow similar general patterns as at-risk plant species. Most at-risk plant associations involved in this analysis appear to be obligate to isolated wetlands, with a total of 176 (63%) listed as obligate nationally. The proportion of obligate communities is highest in the South Atlantic and Gulf Coast states (78%) and lowest in the Great Plains and Tallgrass Prairie (30%) and Intermountain and Rocky Mountain (30%) states.[*] In other words, 78% of the associations that occur in isolated wetland systems in the South Atlantic and Gulf Coast states are restricted to those isolated wetland ecological system types. In the Great Plains and Tallgrass Prairie states, 70% of the associations that occur in isolated wetland ecological systems can also occur in other types of ecological systems.

Appendix VII contains the associations listed in each isolated wetland system in this study. Appendix VIII contains the associations listed by isolated wetland system along with the species contained within the same isolated wetland type.

[*] Alaska and Hawai'i are not included here because data for these states are too limited.

REGIONAL PATTERNS IN AT-RISK ASSOCIATIONS

Table 11 includes the number of at-risk associations found with isolated wetlands by region. Those listed also as characteristic for other wetland systems are listed as "facultative" to isolated wetlands, while those listed solely for isolated wetland types are listed as "obligate" communities. The South Atlantic and Gulf Coast region includes substantially greater numbers of G1-G3 associations found with isolated wetlands than the other regions. A second tier of regions has 30-51 at-risk plant associations listed. These include the Central Hardwoods and Interior Highlands (n=51), Great Plains and Tallgrass Prairie Region (n=44), Pacific Coast (n=34), Central Atlantic Coast (n=34), Intermountain and Rocky Mountain (n=30), and the Southwest (n=30).

Table 11. Numbers of At-Risk US-NVC Plant Associations in Isolated Wetland Systems by Region

Study Region	Obligate	Facultative	Total
North Atlantic Coast	6	8	14
Central Atlantic Coast	19	15	34
South Atlantic and Gulf Coast	103	29	132
Upper Great Lakes	7	17	24
Central Hardwoods and Interior Highlands	33	18	51
Great Plains and Tallgrass Prairie	11	33	44
Intermountain and Rocky Mountain	9	21	30
Southwest	23	7	30
Pacific Coast	16	18	34
Alaska*	0	2	2
Hawaii*	2	0	2
United States**	**176**	**103**	**279**

**Classification is in development in Alaska and Hawaii.*

*** Because associations can occur in more than one region, total counts for the U.S. do not equal the sum of values across regions.*

STATE COMPARISONS OF AT-RISK ASSOCIATIONS

As noted above, for the nation as a whole, 9% of the at-risk plant associations occur in isolated wetland systems. Totals for individual states range from 2% in Nevada and Wyoming to 47% in Rhode Island (Figure 5, Table 12). Florida has the greatest number of at-risk plant associations occurring within isolated wetlands (n=47) and West Virginia has the lowest (n=1). Five states, including Alabama, Georgia, North Carolina, South Carolina, and Texas, each have between 25 and 47 at-risk associations listed. Thirty-seven states have 5-25 at-risk associations listed. Seven states have fewer than five. Appendix VIII provides a list of the G1-G3 plant associations occurring in isolated wetlands in each state.

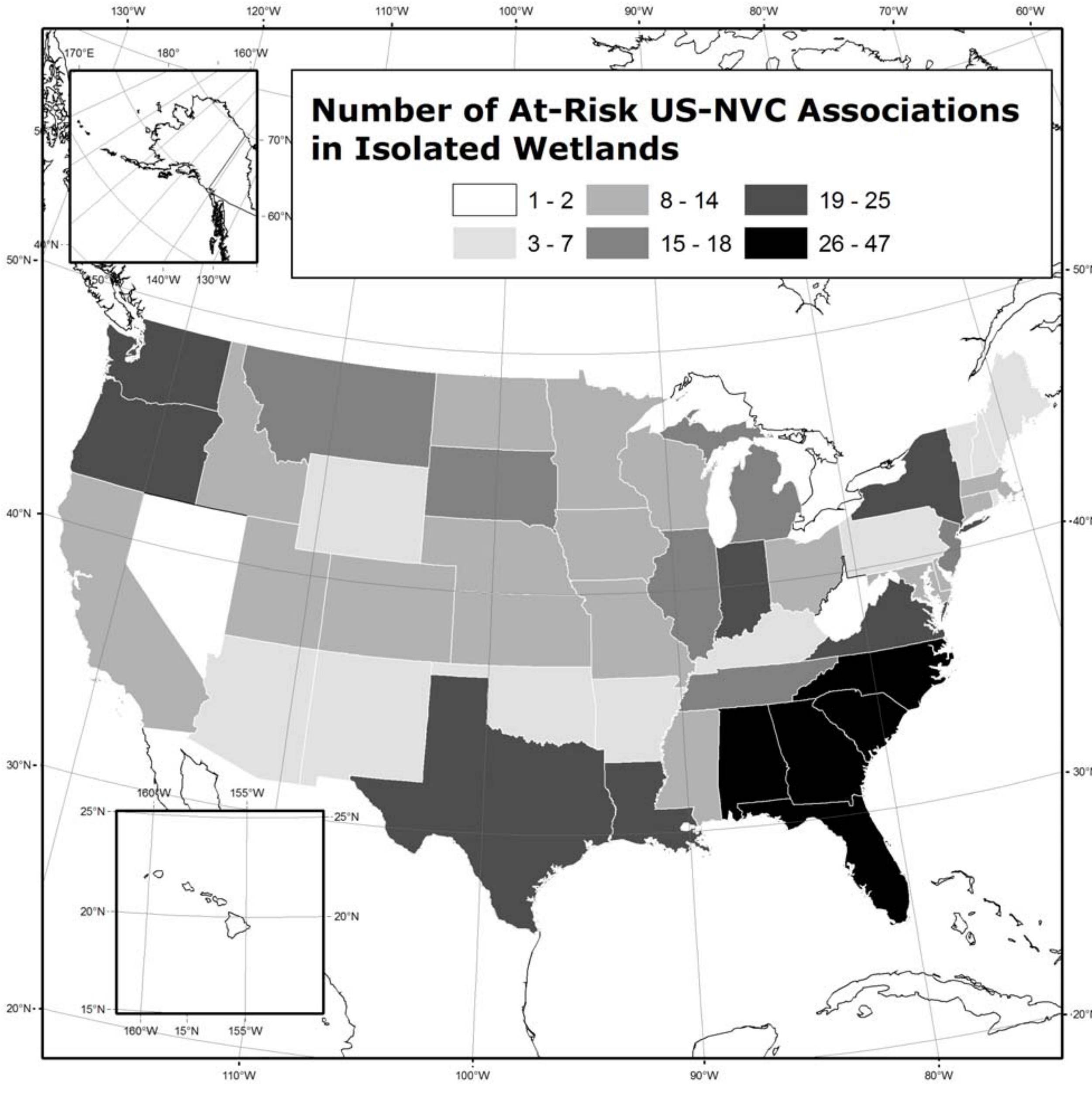

Figure 5. Number of At-Risk Plant Communities in Isolated Wetlands per State

Table 12. Numbers of At-Risk US-NVC Plant Associations in Isolated Wetland Systems by State

State	# At-Risk Wetland Plant Associations in Isolated Wetlands	Total # At-Risk Plant Associations	Percent of At-Risk Associations That Occur in Isolated Wetlands
Alabama	36	161	22%
Alaska*	2	16	13%
Arizona	3	74	4%
Arkansas	7	118	6%
California	8	266	3%
Colorado	9	250	4%
Connecticut	11	30	37%
Delaware	11	30	37%
Florida	47	267	18%
Georgia	40	196	20%
Hawaii*	2	100	2%
Idaho	8	292	3%
Illinois	17	75	23%
Indiana	20	60	33%
Iowa	10	42	24%
Kansas	10	41	24%
Kentucky	7	76	9%
Louisiana	21	144	15%
Maine	3	18	17%
Maryland	10	51	20%
Massachusetts	12	35	34%
Michigan	15	74	20%
Minnesota	13	66	20%
Mississippi	13	84	15%
Missouri	13	74	18%
Montana	15	246	6%
Nebraska	11	38	29%
Nevada	2	84	2%
New Hampshire	7	25	28%
New Jersey	17	55	31%
New Mexico	5	172	3%
New York	20	73	27%
North Carolina	43	274	16%
North Dakota	14	55	25%
Ohio	14	50	28%
Oklahoma	5	80	6%
Oregon	22	464	5%
Pennsylvania	5	23	22%
Rhode Island	7	15	47%
South Carolina	34	181	19%
South Dakota	16	76	21%
Tennessee	18	175	10%

State	# At-Risk Wetland Plant Associations in Isolated Wetlands	Total # At-Risk Plant Associations	Percent of At-Risk Associations That Occur in Isolated Wetlands
Texas	25	238	11%
Utah	9	136	7%
Vermont	7	25	28%
Virginia	23	172	13%
Washington	20	324	6%
West Virginia	1	30	3%
Wisconsin	12	75	16%
Wyoming	4	202	2%
United States**	**279**	**3136**	**9%**

Classification is in development in Alaska and Hawaii.

*** Because associations can occur in more than one region, total counts for the U.S. do not equal the sum of values across regions.*

Knowledge and Data Gaps

Much of the uncertainty about the impact of the SWANCC decision on biodiversity results from the ongoing process of ecological classification, which depends on the accumulated knowledge and data from field inventory. Beyond this, there remains the lack of an agreed-upon regulatory and scientific definition for "isolated wetland," inadequate mapped information to document baseline status and trends among these wetlands and associated resource values, and incomplete inventory of wetlands and their associated rare species to better link at-risk species with their habitat.

Classifying Wetland Types

The process of identifying, classifying, and describing isolated wetlands was advanced considerably through this study. However, there remain several areas where classification of wetlands will likely see incremental change as field inventory proceeds and new data are compiled that contribute to classification efforts. For example, "woodland vernal pools" from the northeast and Great Lakes states are not currently differentiated as wetland ecological system units. These types are not consistently described across the region, so their classification remains a challenge. In some instances, especially in the Great Lakes, known occurrences could be appropriately classified within the concept of North-Central Interior Wet Flatwoods. However, there are other instances where these pools occur as small depressions among mesic to dry-mesic forest environments. Their high variability (hydrologic, substrate, floristic, etc.) from occurrence to occurrence makes classification very difficult. Another example includes desert springs, some of which are sufficiently shallow to meet our working definition of "wetland." These are typically viewed as highly localized freshwater aquatic communities, often directly linked to streams, and were excluded from this analysis.

Implementing a Definition of "Geographically Isolated"

Because we lack comprehensive mapped occurrence data, categorization of wetland types as "geographically isolated," using our project-specific definition remains a significant challenge for researchers and practitioners alike. Given incomplete occurrence data and information on the extent of their interaction with other water bodies, it remains difficult to appropriately categorize some types. The list of isolated wetlands identified in this study should be viewed as the result of analysis of the best available—but not comprehensive—data and expert knowledge. It is possible, that with additional mapping and information on connectedness of wetlands to water bodies, that the list of wetlands we consider to be "isolated" and their type of isolation (partial vs. strict), could shift. At this time, we cannot predict the direction of the shift (i.e., whether there will be greater or fewer types that are designated as isolated).

Gaps in Field Inventory

This study made use of natural heritage program data and documented knowledge of isolated wetlands and their associated G1-G3 species and communities. These data by no means represent a complete inventory of all isolated wetlands. Though the heritage database represents the most comprehensive source of this type of data, they are far from complete. Appendix IX provides state-by-state summaries of known data gaps, where data from 44 states plus the Navajo Nation are reported. Occurrence information pertaining to species that occur in isolated wetlands varies from quite good for some high-profile species to poor for many others. Seventeen programs report that the majority of at-risk plant and animal species associated with isolated wetlands within their jurisdiction have occurrence data that they would rate as either medium (50%-75%) to high (>75%) in completeness. These include California, Arizona, Colorado, Montana, the Navajo Nation, Nevada, Missouri, Indiana, Arkansas, Wisconsin, Virginia, Maine, Massachusetts, New York, New Jersey, Rhode Island, Delaware, and Connecticut. However, most species supported by isolated wetlands need further inventory work. This is particularly true for invertebrates and cryptic vertebrates and many plant species.

In general, significant new inventory efforts across all taxonomic groups are needed. Occurrence information also varies significantly by state due to availability of funding for inventory work and the richness of at-risk species in a state. In some instances, there remains backlog of data gathered from field surveys that still needs to be processed into natural heritage databases. This type of circumstance was reported for 50% or more of at-risk species in eight states, including Arkansas, Maine, New Mexico, Oklahoma, South Dakota, Texas, Utah, and Wyoming.

On the whole, occurrence information for plant communities and ecological systems remains very poor. Of the 45 programs reporting, only nine indicated that the majority of isolated wetland types, and/or related plant communities, have occurrence data that they would rate as either medium (50%-75%) to high (>75%) in completeness. These programs included Connecticut, Idaho, Indiana, Maine, Massachusetts, Maryland, Missouri, Oregon, and Rhode Island. Included within these are programs that primarily use a state-level classification, so translation to standard, national classification units requires an additional step. However, methods for mapping using remote sensing and terrain modeling, along with advancing methods for field data gathering, could rapidly speed up the development of occurrence data for these wetland types if resources were allocated.

This study should provide sufficient perspective, as well as detailed data, to prioritize future efforts relevant to isolated wetlands in the United States. We expect that with future, focused ecological inventory, we could effectively identify isolated wetlands in each state along with the many at-risk species that utilize them as habitat. This detailed occurrence information can then form the foundation for sound decision making and conservation of these biodiversity values.

Linking Species to Ecological Systems

Traditionally, habitat information for species has been recorded using coarse and non-standard concepts rather than within the framework of the more specific ecological systems as defined in this assessment.

Consequently, our knowledge of the precise ecological systems used by species remains incomplete. Future increased collaboration between zoologists, botanists, and those familiar with ecological classification, will be useful in refining our knowledge of species associations with isolated wetland systems. As more information about species linkages is gathered, it is possible that the list of species closely tied to isolated wetlands or their obligate/facultative status will shift. Without further information, it is difficult to predict the direction of the shift (i.e., whether more or fewer species will be identified as closely tied to isolated wetlands or whether there will be more or fewer species with "obligate" or "facultative" relationships to the isolated wetland systems).

Discussion

The U.S. Supreme Court's SWANCC decision has highlighted the need for new research and for additional discussion about wetland resources among scientists, conservationists, resource managers, and policy-makers. Understanding the impacts of SWANCC on the function and value of isolated wetlands will be critical as the SWANCC decision is implemented. NatureServe, through its network of member programs, completed this initial assessment to contribute to this ongoing science-policy dialogue. This study provides an analysis of the possible impact of the decision on the biodiversity of isolated wetlands. It is based upon the best available data, and should help policy-makers and resource managers from federal, state, tribal and local governments understand the potential biodiversity impacts of the SWANCC decision in their jurisdiction and to inform conservation and planning decisions.

What is At Risk?

This study shows that some 29% of riparian and wetland ecological system types documented for the United States met our definition of "geographically isolated" and therefore may no longer be under the jurisdiction of the Clean Water Act after the SWANCC decision. Of course, as mentioned previously, we are making no statements here regarding wetland *acreage*. Comprehensive wetland maps are unavailable nationally, and we cannot say anything substantive about wetland acreage at risk without this critical information. More than 80% of these isolated wetland ecological system types fit the sub-category of "partial isolation" and therefore, most likely fall into a significant regulatory gray area. The protection status of these isolated wetland types will be most directly affected by the interpretation of the SWANCC decision. The fate of these wetlands will depend on how policy-makers and/or permitting authorities interpret the term "isolated" and the subsequent measures they put in place for their conservation.

Wetlands that may be at-risk due to the SWANCC decision are exceptionally valuable for their biodiversity values.

- A total of 274 at-risk plant and animal species are supported by isolated wetlands, and 35% of these species are not known to be supported by any other type of natural habitat (the number is higher for animal species alone—over 50% of the at-risk animal species in this study are obligate to isolated wetland habitats).
- A total of 86 plant and animal species listed as "threatened," "endangered," or "candidate" under the Endangered Species Act are supported by isolated wetland habitats. This represents about 5% of all plant and animal species currently having status under ESA. A majority (52%) of these species with ESA status are completely dependent on isolated wetland habitat for their survival.
- Forty-three percent (n=35) of isolated wetland types are known to support at least one species with status under the U.S. Endangered Species Act.
- On average, 6% of the at-risk plant species in a state are directly supported by isolated wetlands.
- Twenty-three percent of all U.S. counties (n=725) have documented occurrences of at-risk species that are known to be associated with isolated wetland habitats and 80 counties have occurrences of five or more at-risk species. In 18 counties of California, South Carolina, North Carolina, Georgia, Alabama, Nevada, and Hawai'i, there are occurrences of 10 or more at-risk species associated with isolated wetland habitats. Merced County, California is known to support 20 at-risk species in isolated wetland habitats.

- A total of 279 at-risk U.S. National Vegetation Classification associations were documented as being characteristics of isolated wetlands, and 67% of these associations are not known to be supported by any other types of natural habitat.

Significant loss of isolated wetland habitats could therefore have a serious impact on the survival of the at-risk species that depend on them. The Clean Water Act provided one of the few federal mechanisms for the protection of these biodiversity values. Plant associations that are tied to isolated wetlands may lose the little federal protection they had prior to the SWANCC decision.

Beyond the Clean Water Act: Other Mechanisms for Protecting Isolated Wetlands

While loss of protection due to SWANCC will put many isolated wetlands at-risk, some may still be protected through other non-Clean Water Act mechanisms.

Endangered Species Act

As was documented above, isolated wetlands provide habitat for a large number of endangered, threatened and candidate species. Occurrences of these isolated wetlands containing listed species may be protected under the Endangered Species Act by virtue of the at-risk species they contain. This study provides a listing of the specific isolated wetland systems that are likely to contain listed species. If incorporated into the permitting process, this information could be used to help to ensure that impacts are minimized on isolated wetlands and the listed species they support. For example, a given wetland or set of wetlands that could be effected by proposed development could be screened by wetland scientists to clarify which wetland ecological systems types they represent, and which of these is known to support listed species. Whether or not listed species are known from the project area, new field survey could be more efficiently prioritized and implemented to ensure that the ESA listed species populations and critical habitat have been fully considered.

Agricultural Incentive Programs

USDA Food Security Act's SwampBuster program and other conservation set-aside programs like the US Department of Agriculture's Wetland Reserve Program and Conservation Reserve Program provide some protection to wetlands if they occur on agricultural lands (e.g., a farmer participating in the SwampBuster program may lose federal benefits for draining wetlands on his property without appropriate authorization). SwampBuster defines wetlands somewhat differently than the Clean Water Act (Tiner, 2003b). As this program was not under consideration in the SWANCC case, isolated wetlands are still under the purview of this program where they occur on agricultural lands. Isolated wetlands in agricultural settings, therefore, might continue to have some level of protection under SwampBuster.

Non-Federal Regulations

States, tribes, and local governments will likely have a greater responsibility for regulating and managing isolated wetlands after SWANCC. While some states like Wisconsin and Ohio addressed this issue by extending existing state regulations to protect isolated wetlands when they do not have federal jurisdiction, and others have attempted some other regulatory response, about two-thirds of the states have made no attempt to fill the gap left by SWANCC (Christie and Hausmann, 2003; Christie pers. comm.). It is our hope that the information in this report will demonstrate to state regulators and the general public the biodiversity values of isolated wetlands in their jurisdiction.

The impact of state and local regulation on isolated wetlands will vary by many factors, including the degree to which the wetlands occur on public lands. Those isolated wetlands on public lands will likely pose less of a protection challenge than those on private lands. The typical mix of land ownership of isolated wetlands across the United States suggests that their conservation should involve a mix of stakeholders, including federal, state, county, and township land managers and regulators as well as private landowners.

Systematic Inventory of Wetland Resources

Underlying any approach to conserve wetland resources are the data to adequately locate and identify sensitive resource values. These data are needed to clarify where sensitive resource values occur, allow stakeholders to minimize conflict, and support mitigating actions. Substantial new investments are needed to systematically inventory wetland resources to fully document biodiversity values. Examples of systematic inventory include those for California vernal pools (Keeler-Wolf et al. 1998), canyon seeps (Jankovski –Jones et al. 2001), Atlantic coastal plain pondshores (Sperduto 1994), and Great Lakes lakeplain prairie (Comer et al. 1995). This is perhaps the most efficient means to acquire sufficiently high quality and detailed information on wetland biodiversity values and forms the basis for sound resource management.

Making Use of This Information

Having an understanding of the isolated wetlands and the species they support in a given jurisdiction is critical to the development of any policy or land management decision. Data from this study are available as appendices of this report and on the NatureServe Explorer website (www.natureserve.org/explorer). Appendix VIII and NatureServe Explorer will be of most use to state wetland regulators and managers that need to understand which isolated wetlands occur in their state and which at-risk species (G1-G3 and listed endangered, threatened and candidate species) and communities are supported by them. Those who want a quick summary list of isolated wetland systems and their related species and communities should consult Appendix VIII. Those who are interested in detailed type-by-type descriptive information should consult NatureServe Explorer. Detailed descriptions of the isolated wetland ecological systems are found in Appendix III and are also on NatureServe Explorer. Having an understanding of the limitations of the data is also critical to policymaking. Appendix IX provides a summary of known data gaps and some recommendations for additional inventory.

Users needing specific locational information for isolated wetlands or their associated species should directly contact the natural heritage program in the state(s) of interest for more information.

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