Using GIS to Maximize Citizens' Contributions to Science and Community Planning

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Wisconsin is blessed with over 15,000 lakes. The Wisconsin state constitution guarantees that the waters of Wisconsin are held in trust for all of Wisconsin's citizens and the citizens of the United States. It protects their rights to boat, fish, hunt, and swim on navigable waters; enjoy the natural scenic beauty of navigable waters; and enjoy the quality and quantity of water that supports those uses. In 2008, the Wisconsin Department of Natural Resources (WDNR) launched the Critical Habitat Designation Program – a program that inventories public rights features and sensitive features of Wisconsin water bodies (http://dnr.wi.gov/lakes/criticalhabitat/). Here lies the complication: The WDNR has a budget capable of performing but a few lake assessments annually. Within this schedule, the first round of inventories won't be completed for another 2,000 years.

Another solution is necessary if recognizing and protecting critical habitats are important. This article describes how GIS has helped to enable an imaginative solution by engaging citizens to inventory and map critically important features on Moose Lake, a 1,670-acre drainage lake in Sawyer County, Wisconsin. With GIS, citizen contributions yielded valuable data, but more significantly produced passionate supporters that held a stake in the resource, in the data, and in the process.

Geographic Information for Protecting Our Rights, Responsibilities and Resources

Mother Nature is awe-inspiring and often works with subtlety. It's her natural scenic beauty and Northwood's character that brought folks from a cadre of backgrounds together. Over dinner parties and ice cream socials, people, that in their previous lives would have never crossed paths, were now sharing a meal and conversation about the things on Moose Lake they valued. Liberals and conservatives, retired professors and businessmen, teachers, and retired railway workers were asking questions about the resources they enjoyed (Figure 1).

"Why are the birch trees dying?" "How does the annual drawdown of the lake affect our fish?" "Should we expect more development to change the lake's character?" "Should we be worried about aquatic invasive species?" "How important are Moose Lake's natural areas for providing habitat?" The questions grew in complexity, but ultimately led to a very simple one: *"Who owns these resources?"*

This question alerted these citizens to a basic premise; no matter if it were land, water, fish, fowl, flora, fauna, pollution, invasive species, or endangered species, none can be effectively managed without clear knowledge of who owns the rights and has responsibility of the land.

This assertion led citizens to begin digging for answers. Remarkably, very little information existed for Moose Lake. The biggest surprise was in identifying land ownership. In 2007 Sawyer County was still relying on paper records to document ownership of its rural areas. Some records dated back to the mid 1800s when Wisconsin was first surveyed. Notably, the paper records recognized only six islands on Moose Lake – a gross miscalculation and reason for concern.

Citizens Take Action

Coming up with more questions than answers, the small group of citizens organized. They asked the Moose Lake Improvement Association (MLIA), a group with a mission similar to that of many lake associations, to allow them to form a voluntary citizen group – named the Ad Hoc Advisory Group for Natural Resources – with the purpose of understanding the island resources. Once approved, they came to the University for assistance. The University of Wisconsin-Stevens Point (UWSP) agreed to compile geographic data for Sawyer County, measure Moose Lake with finer resolution data, and distribute the data over the Internet for public access. The National Consortium for Rural Geospatial Innovations (RGIS), a consortium of national universities dedicated to providing access to GIS technology and data in rural places, including the Land Information and Computer Graphics Facility at the UW-Madison Campus, agreed to provide funding for the project. The results of this preliminary study are documented in Table 1.

Phase 1 project deliverables revealed significant findings for Moose Lake and its larger region. Most telling was the comparison among the rudimentary physical statistics of Moose Lake. Whereas Sawyer County inventoried six islands, the WDNR hydrography data revealed a tenfold increase to 62 islands and 38 miles of island and mainland shorelines. Citizen field inventories verified the existence of 82 islands. Citizens visited each of the islands documented on the university's map, digitzed from 1-meter resolution, leaf-on imagery. In a few instances, citizen field inventories revealed that islands thought to be one large mass were actually two smaller islands with navigable water in between them. Citizen research at the county land records department and of plat maps informed the U.S. Forest Service and Xcel Energy managers of forgotten land holdings – land that these

Figure 1. Citizen contributors of Moose Lake gather to celebrate completing the Moose Lake Legacy Initiative final report.

organizations were not actively aware that they owned, but were responsible for managing. Citizens also alerted managers to more reason for concern. Inventories were beginning to reveal the significance of Moose Lake for harboring unique, rare, and endangered species. Inventories noted the presence of white cedar, increasingly rare due to heavy browsing by white-tailed deer. They also noted competition between cattails and the culturally significant wild rice.

To substantiate their findings, the ad hoc group of citizens once again sought permission from the MLIA to compete for a WDNR Lake Planning Grant. Phase 2 goals included: to become better informed about Moose Lake's islands, to build awareness of the study's findings, and to use the information to help identify islands worthy of management or conservation.

As the credibility of the citizen volunteers and their message progressed, fears from project skeptics started sparking. The prospect of lake planning incited unease among a small minority of landowners. Their allegation, *"This planning grant will only lead to the regulation of our lake, a lake district, increased taxes, and – at best – a diminution of our property rights and – at worst – an outright taking."* Although the objectives of the project fit with the stated mission of the MLIA, the skeptic's protests panicked the organization. The MLIA denied the citizen's request to solicit for the grant and altogether disbanded the ad hoc group.

With a clear sense of purpose and an appreciation for a participatory democracy, the group sought a more welcoming partner. The Couderay Waters Regional Land Trust (Trust) was aware of the group's objectives and embraced its notion to conserve the lake's most sensitive islands. The Trust commonly acquires conservation easements voluntarily from willing landowners and was intrigued by the proposal's notion to map shoreline characteristics and identify ecologically and aesthetically favorable characteristics for conservation.

The grant proposal solicited the WDNR to fund the citizen exploration of both island and mainland shoreline characteristics. Information gleaned from the project's first phase defined the ecological and aesthetic characteristics to measure and the questions the plan would address.

1. Examine the spatial relationship between Moose Lake and its watershed. How is Moose Lake affected by decisions made elsewhere?
2. Inventory island and mainland shoreline characteristics. Is Moose Lake ecologically and aesthetically significant within the larger regional context? Are the islands of significant importance?
3. Prioritize characteristics to recognize shorelines of exceptional quality. With limited funding for conservations easements, what shorelines are critical to meeting conservation goals?

All inventories would be conducted by citizens with training by professionals and attributes linked geographically to the nearest shoreline for prioritization. Citizens would examine 50 miles of shoreline and inventory aquatic macrophytes, coarse woody habitat, structures visible from the lake's littoral zone, rare and endangered species, aquatic invasive species, and other ecological and aesthetic indicators. The grant was funded and inventories proceeded from May to October 2008.

Maximizing Citizen Contributions

Normally a project of this size and scope would be conducted over the course of several seasons. A solution was necessary to maximize the contributions of volunteers while minimizing the potential for burnout. A handful of

Table 1. Project Deliverables.

PHASE 1 DELIVERABLES
Moose Lake shoreline database digitized from 2005 National Agricultural Inventory Program imagery
Field verification of 82 Moose Lake islands
Compilation of 29 geographic data layers from state and federal sources
Crafted county-wide maps highlighting resources for each of Sawyer County's watersheds
Mapped ownership patterns from hardcopy sources
Delivered GIS data to the local tribe, county and regional planning commission
Hosted a public internet mapping services providing access to project data layers
PHASE 2 DELIVERABLES
Moose Lake Legacy Initiative Final Report – April 2010
Watershed Maps (West Fork of the Chippewa River)
Water Resources
Environmental Corridors
Pre-settlement Vegetation
Land Cover, 2001
Publicly Managed Lands
Impervious Surfaces
Tree Canopy Density
Glacial Geology
Citizen Lake Inventories and Maps
Shoreline Ownership
Aquatic Macrophytes (Emergent and Floating Leaf)
Wild Rice and Cattail Interface
Course Woody Structure
Visible Structures
Ecological Reference Areas and Refugia
Aesthetic Shoreline Condition
Wildlife Observations
Three Priority Scenario Maps
Priority Shorelines Scenario 1
Priority Shorelines Scenario 2
Privately Owned Priority Shorelines Scenario 2
Wild Rice of the West Fork of the Chippewa River map and data
Public Presentations
Wisconsin Land Information Association Annual Conference, February 19, 2009
Annual Northwest Wisconsin Lakes Conference, June 19, 2009
Moose Lake Improvement Association Annual Meeting, July 4, 2009
Town of Round Lake Open House, July 2009
ESRI International Users Conference, July 15, 2009
Department of Natural Resources Board Meeting, August 12, 2009
Sawyer County Lakes Forum, September 2009
Wisconsin Department of Natural Resources Northwest District Meeting, Fall 2009.

volunteers took charge in a cheerleader capacity. They set the pace, scheduled inventories, recruited participants, and identified and utilized each person's strengths. Notably, citizen participation, travel, and volunteered equipment and supplies exceeded the contribution of the WDNR's initial $10,000 grant.

For each inventory (see Table 1, Phase 2, Citizen Lake Inventories), resource professionals validated project methods and trained citizens to conduct them. Three resource professionals; a biologist from the U.S. Forest Service, an aquatic invasive specialist from Sawyer County, and the statewide citizen lake monitoring coordinator, trained citizens to conduct inventories and determine which resource characteristics to seek out.

Professional training was advantageous in several ways. Pedagogically, the project provided a ripe learning opportunity and method to teach interested volunteers about critical habitats. Moose Lake provided the classroom. The GIS maps provided the learning tools to help students recognize locations and spot patterns and areas of significance. Resource professionals and citizens acted both as instructors and students. Each shared information and experiences about an issue from their perspective. Maps effectively communicated patterns to each person involved by relating information to places they knew well.

One project task provides an excellent example of the rich educational discussion. Our citizens (and the university consultant) pondered how to conduct the inventories of rare and endangered species (Figures 2 and 3). Finding rare flora and fauna is difficult even when one knows what to look for. Steven Spickerman from the U.S. Forest Service offered a practical alternative. *"Plants are always on the move,"* he said. *"Instead of looking for individuals plants, it is more important to map assemblages of healthy ecosystems."* Spickerman referred to healthy ecosystems as *ecological reference areas*, or areas that are good representations of healthy ecosystems. Immediately, questions emerged and the conversation ignited. *"How might this relate to the dying of our birch trees?"* one citizen asked. Spickerman responded by evoking the map on pre-settlement vegetation and noting Wisconsin's forest cutover in the 1920s and '30s and the soil moisture conditions in the area. *"The climax species for this area are sugar maple, yellow birch, and hemlock. The conditions of the forest are naturally allowing the transition from white birch, to white pine and ultimately the climax species for the area."* Project maps and lake inventories substantiated Spickerman's assertions.

Figure 2. Professionals training citizens. Steven Spickerman from the U.S. Forest Service describes ecological reference areas *or areas that are good representations of healthy ecosystems.*

Figure 3. Citizen scientists document the ecological and aesthetic indicators of Moose Lake on hard copy maps and note books.

One citizen asked about the significance of white cedar. *"White cedar are heavily browsed by white-tailed deer,"* he began, *"but here on the Moose Lake islands they are common, why?"* After observing the islands, the vernacular experiences of a few citizens emerged.

"When snowshoeing Moose Lake in the winter, I've noticed deer carcasses on the ice, taken by wolves." Our citizens advanced a hypothesis. *"Might the wolves be protecting white cedar on the islands, because deer have learned they are vulnerable on the ice?"* Again, citizen-collected GIS data supported the hypothesis. White cedar are much more prevalent on the islands than on mainland shorelines. These inventories led Spickerman to believe that Moose Lake islands are perhaps one in only ten sites in the 800,000 acres of the Chequamegon National Forest of this quality and size.

Eight inventories were encoded on hardcopy maps and notebooks (Figure 4). Citizens drew and numbered shoreline segments on the maps. They recorded the segment number and the unique ecological and aesthetic characteristics of that segment in their notebooks. After the inventories were completed, the university consultant scanned each hard-copy map and referenced them to real-world coordinates so they could be encoded in a geographic information system (GIS). Heads-up digitizing methods converted hand-drawn line segments into digital lines that captured all of the citizens' notes. The shoreline, the convergence of the riparian and littoral zones, accommodated all inventoried attributes. Statistics for each inventory were compiled and maps were crafted to share the message about the ecological and aesthetic significance of Moose Lake (Figures 5 and 6).

Figure 4. A hard copy used by citizens to inventory coarse woody habitats. Shorelines were segmented and numbered and linked to a corresponding number in a notebook documenting the characteristics of each line segment. Digital techniques can employ SmartPhones, tablets, and other mobile GIS devices to produce similar results.

Prioritizing Shorelines

Now, with the most complete set of information about the lake and region compiled since the Great Depression era, citizen volunteers sought to pursue the project's final goal. Forty-six people, including citizen volunteers, Trust board members, resource professionals, and representatives from the MLIA were invited to learn about the data collection efforts, their significance, and how to use them to prioritize shorelines. Twenty-four people attended. Maps illustrated the inventory methods and findings so each participant had an understanding about the resources present.

Participants had another opportunity to weigh in. *"Given the information provided about the watershed and the Moose Lake inventories,"* the consultant started, *"what characteristics are important and should be prioritized for conservation, using voluntary conservation easements with willing landowners?"* Participants were forthcoming. One participant offered, *"Like on land, varieties of plants are beneficial for providing habitat. Where varieties of aquatic plants exist, those shorelines should be rated high."* Another chimed in, *"Areas where riparian trees are returning to hemlock should also be rated highly, but where white-cedar are present, those are areas of highest concern."*

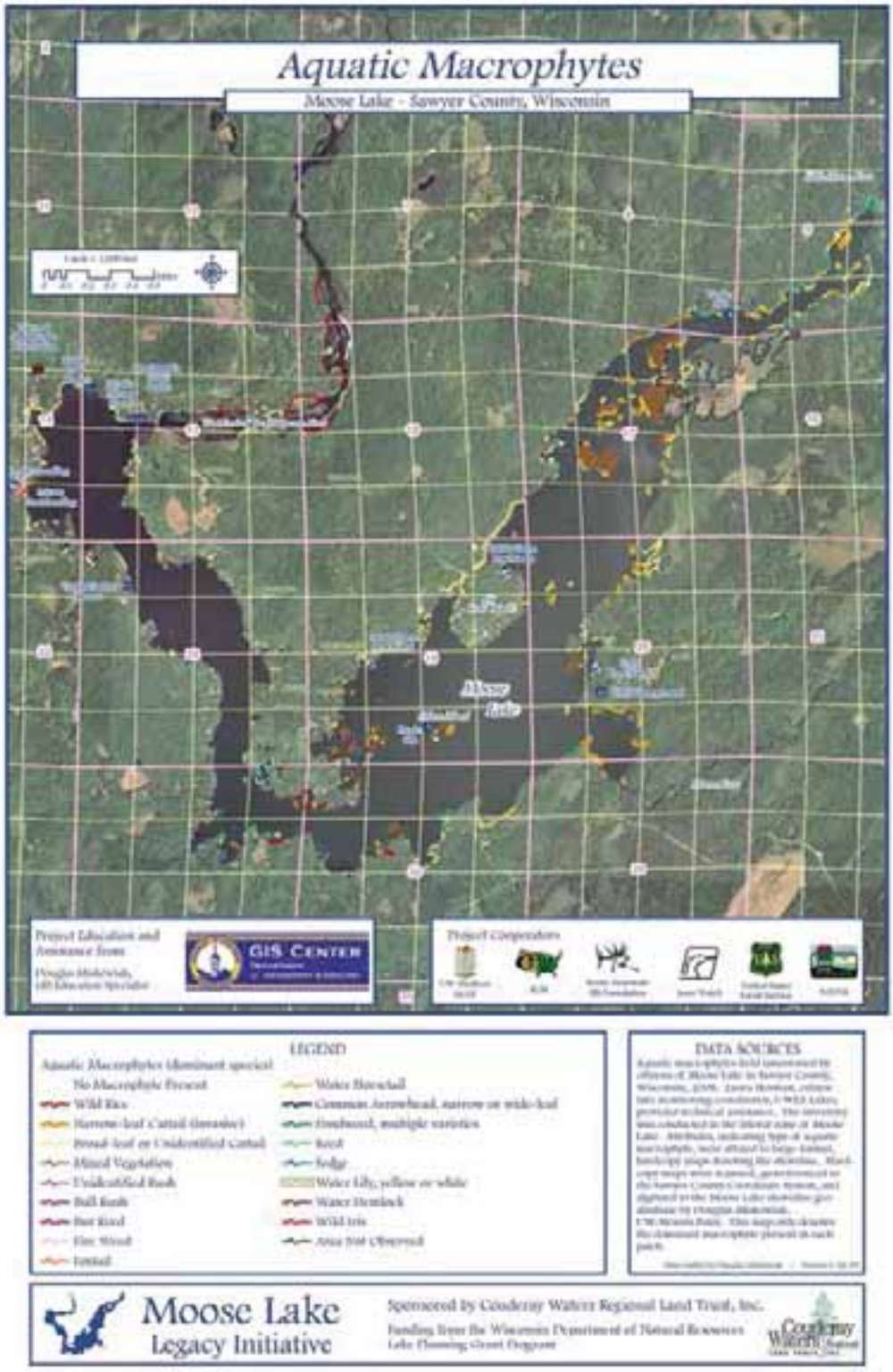

Figure 5. A finished inventory map documenting occurrences of aquatic macrophytes. Table 1 lists the various inventories and corresponding maps.

The conversation continued for almost two hours and was recorded on flip charts. Each shoreline was rated on a scale from *absolute priority, high priority, moderate priority, low priority,* to *not considered for conservation*, based upon the shorelines' ecological and aesthetic characteristics. The sophisticated priority exercise was processed in an ordinal (ranked) fashion. Shorelines with any single characteristic prioritized as *absolute priority*, were given that ranking. Shorelines that had an equal amount of high ratings as low ratings were given a *moderate* ranking. Shorelines with more high ratings than low ratings were given a high ranking and finally shorelines with more low ratings than high ratings were given low priority status.

The conservation priority map emerged. Overlaid with property ownership information, the Trust and its partners could quickly identify which landowners to solicit for conservation easements. The map provided a decision support system for evaluating costly conservation choices (Figure 7).

Owning the Message

From the initiative's beginning to its end, project critics had tried to take control of the message to derail the project. GIS helped project volunteers own the message by building it based upon facts observable on the landscape. At the Independence Day meeting of the MLIA, project detractors tried once again. Equipped with t-shirts stating that they will create their own legacy, the "Concerned Citizens of Moose Lake" reiterated that the initiative would lead to regulation, a lake district, more taxes, restrictions on jet skis, water skiing, and float planes. At the meeting, presenters from the Initiative were able to describe the role of the Trust and the findings from the initiative. Questions emerged about the role of the trust. *"Will the trust regulate critical habitats? What if I'm in a critical habitat? What if landowners don't want to participate?"* Each question was addressed in-kind by a Trust board member. To paraphrase, *"The trust does not have authority to regulate. The trust works individually with willing landowners to negotiate voluntary conservation agreements, whereby they donate or sell development rights. If landowners don't want to participate, they don't have to."*

Other questions emerged about the project results. One question in particular illustrated the value of documenting resources with GIS. *"How significant*

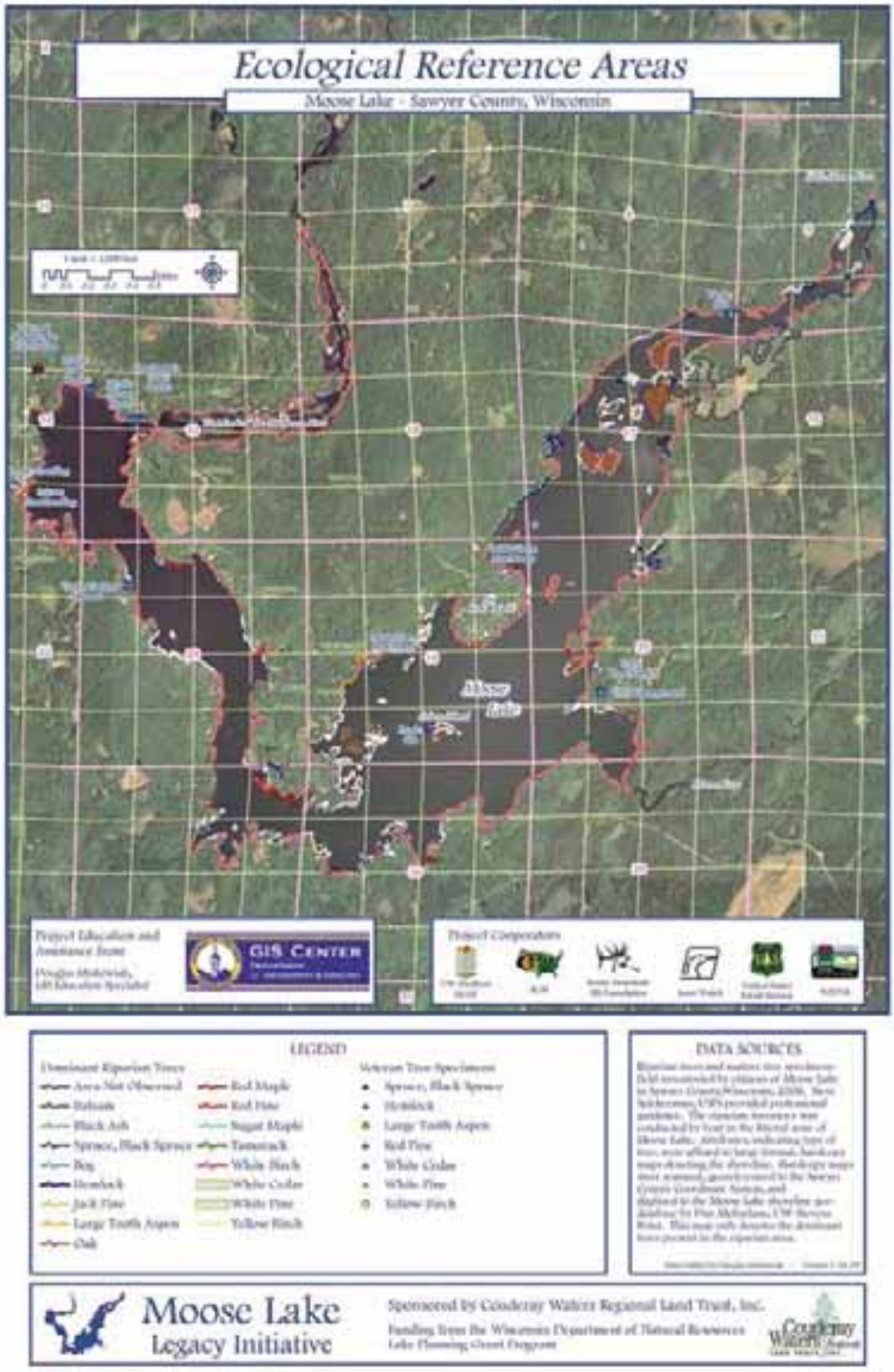

Figure 6. A finished inventory map documenting ecological reference areas.

are the white cedar 'relics' on Moose Lake as compared to everywhere else?" Here the university consultant pointed directly to the map that documented each instance of white cedar. He then noted the conversation with biologist, Steven Spickerman, that Moose Lake is perhaps one of ten sites in the 800,000 acres of the Chequamegon National Forest that harbors white cedar. After the meeting, members of the MLIA came up to project members to congratulate them on the products and results. Ironically, some members thought that future projects should be conducted through the MLIA.

How GIS Helped

This article describes the messy art and science of democracy. It illustrates the tenacity required to disseminate even the most simple of messages among allies and critics. How did GIS help? First, the maps resonated with project volunteers and incited their participation. The maps provided a tangible product whereby citizens could see the result and value of their time invested. They were able to relate places that they love to potential threats and opportunities. Second, by involving citizens in GIS data creation and prioritization they owned a stake in the data and the planning process as well. As stakeholders in the process they became active to share the story of Moose Lake without professional help. Third, involving citizens in a GIS enabled process helped them become the smartest people about the resource. Citizen volunteers knew more about the resource than local resource professionals, even informing the U.S. Forest Service and Xcel Energy of their forgotten island land holdings. Fourth, GIS mapping and statistical analysis helped our citizens speak to the facts about the resource. Pointing to maps, citizen contributors were able to clearly and credibly communicate sophisticated messages about the aesthetic and ecological significance of Moose Lake. In comparison to project skeptics that relied on conjecture, speaking to the facts in public venues won the Initiative credibility. Finally, maps are incredibly engaging. Whether critic or partner, the maps attracted droves to discuss issues surrounding Moose Lake. The proof is in the ability of these maps to attract over 100 people to a public meeting on the July 4th holiday weekend.

Sustaining a Legacy of Information

Over 30 datasets were developed and compiled during the Initiative. The shoreline database holds 33 attributes that capture the aesthetic and ecological condition of Moose Lake. These data

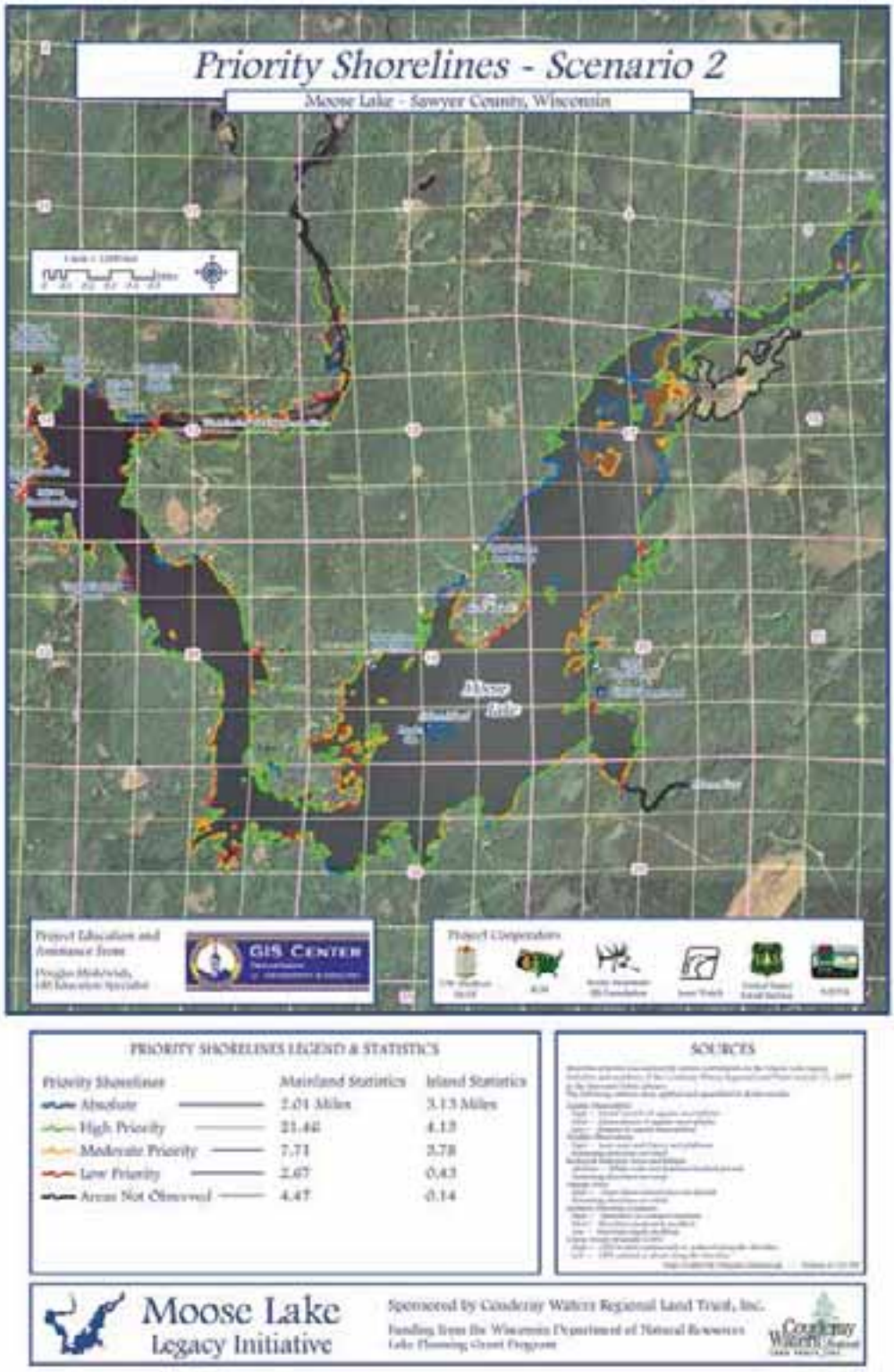

Figure 7. Priority shorelines scenario maps indicate areas of highest priority for meeting conservation objectives.

represent a massive contribution of citizen and professional collaboration. Not surprisingly, those that created the data believe the findings are significant and want the data preserved to compare change over time and to inform future projects. To facilitate this, UWSP submitted all GIS data in addition to the finished plan document. Even though some WDNR researchers desire access to the project's data, and although the WDNR funds the lake planning grants and the creation of these data, a mechanism doesn't currently exist for hosting and distributing project data. Why? The WDNR doesn't host data that they aren't responsible for creating themselves.

Volunteered geographic information sometimes known as crowdsourcing is a widely used technique in collecting data for natural resources planning. Cornell Lab of Ornithology for example, has long employed volunteers to track the locations of birds. Their website documents 120 citizen science projects that range from monitoring whales and glaciers to honey bees and bats (**http://www.birds.cornell.edu/citscitoolkit/projects/alphabetical**). The UW-Stevens Point GIS Center has developed and refined procedures for citizens to generate geographic information useful for lakes planning. Citizen scientists are ready to contribute. A conversation must begin to institutionalize these procedures and make citizen contributions and data accessible for critical decision-making. Wisconsin has only been a state for 166 years. Can we wait another 2,000 years before we understand the resources it harbors?

The Moose Lake Legacy Initiative final report, project maps and photo album can be found online at **www.uwsp.edu/GIS**. Click on *Research and Innovation* and *GIS Center Research*.

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