Dear Waterfowl Enthusiast,

If you hunt waterfowl or enjoy viewing shorebirds, then we have something new for you.

It's our first-ever long-range plan for managing Minnesota's shallow lakes. This effort aims to build waterfowl populations by more aggressively and intensively managing shallow basins on state-owned Wildlife Management Areas (WMAs) and adjacent federal Waterfowl Production Areas (WPAs).

If you are a duck hunter, you know what's happened. Ditching. Draining. Degradation. Depredation. These factors and more have greatly reduced Minnesota's ability to produce local ducks in spring and pull migrants into our state in fall. We believe waterfowl hunting can be better than it is. Our new shallow lakes plan can help make that happen by improving the quality and quantity of waterfowl habitat.

Minnesota is blessed with a WMA system that totals 1.3 million acres across 1,400 different sites. We have never forsaken these assets. Yet the time has come to increase their annual yield. The shallow lakes plan, which earned praise from Ducks Unlimited, Minnesota Waterfowl Association and others, is a conservation strategy for doing just that.

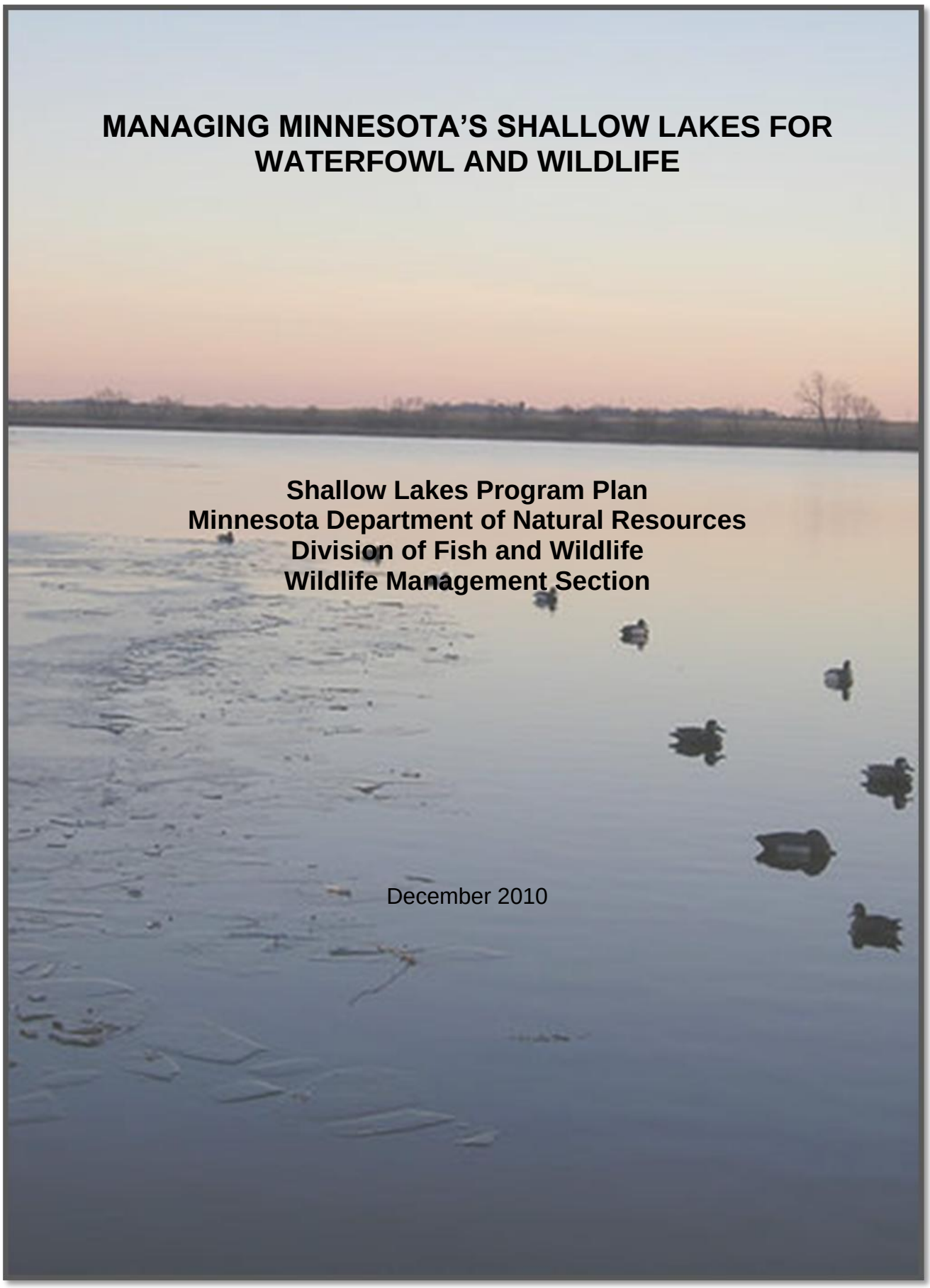
Thanks for your interest. Best wishes during your days afield.

Sincerely,

Dave Schad, Director

Division of Fish and Wildlife

Minnesota Department of Natural Resources



MANAGING MINNESOTA'S SHALLOW LAKES FOR WATERFOWL AND WILDLIFE

Shallow Lakes Program Plan
Minnesota Department of Natural Resources
Division of Fish and Wildlife
Wildlife Management Section

December 2010

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EXECUTIVE SUMMARY

The following goals for management and protection of shallow lakes have been identified in order to: meet the objectives in the Minnesota Department of Natural Resources' (DNR) Long Range Duck Recovery Plan (Duck Plan) and Division of Fish and Wildlife Strategic plan, and provide focus to shallow lake management efforts undertaken by the DNR Section of Wildlife Management.

The goal in the Duck Plan is to protect and manage at least 1,800 shallow lakes in Minnesota for their ecological, recreational, and economic importance to the citizens of the state with particular emphasis on wildlife and wildlife-based recreation. A shallow lake is defined as a lake that is at least 50 acres in size and no more than 15 feet deep. The objectives of this plan provide focus and criteria for identifying on which lakes to focus management efforts to insure the DNR is maximizing waterfowl and wildlife habitat on shallow lakes associated with public wildlife lands.

There are approximately 4,000 shallow lakes in the state; 1,000 of these lakes are currently managed for sport fisheries or used for aquaculture. Management of all of these lakes is not needed, nor possible, to achieve the goals of the Duck Plan or the Shallow Lake Program Plan (Program Plan). The following objectives are aimed at managing those basins with high wildlife management potential and maximum wildlife and public benefit. Progress towards the goals of the Duck Plan and the Program Plan will be measured by the following long-term objectives:

1) Assess habitat conditions of Minnesota's shallow lakes

2) Maximize management of all 200 shallow lakes within state Wildlife Management Areas (WMAs), federal Waterfowl Production Areas (WPAs), and National Wildlife Refuges (NWRs) and all state Designated Wildlife Management Lakes (DWLs) for high quality waterfowl habitat

3) Maximize management of the ~1,553 shallow lakes with a portion of their shorelines under state, federal or county ownership for high quality waterfowl habitat, including designation of an additional 30 lakes

4) Increase wildlife management of the 201 shallow lakes with public access, but no other large tracts of public land, especially those lakes that already are designated as Migratory Waterfowl Feeding and Resting Areas (MWFRAs) or have wildlife habitat

5) Increase awareness of the historic, cultural and natural resource benefits of wild rice and protect lakes containing natural stands of wild rice

INTRODUCTION

Minnesota has long recognized the role of shallow lakes for providing critical waterfowl and wildlife habitat. The definition of a shallow lake used in this plan is a lake that is 50 acres or greater in size and has a maximum depth of 15 feet or less. Several key shallow lakes have been actively managed for wildlife benefits for decades. Despite management of select shallow lakes, the overall condition of the resource has declined. Recently, the DNR and others have given renewed attention to the condition of the state's shallow lakes partly due to the decline in quality of waterfowl hunting and growing concern over poor water quality in many of these lakes.

The DNR released a new "Long Range Duck Recovery Plan" (Duck Plan) on April 21, 2006. This plan identified a strategic 50-year vision to restore, protect and manage a Minnesota landscape capable of supporting an average spring breeding population of one million ducks and restoring the historically abundant spring and fall migration of waterfowl. This landscape would also provide sufficient opportunities to support 140,000 waterfowl hunters and 600,000 waterfowl watchers.

Minnesota's shallow lakes are key components to this vision of a productive landscape for waterfowl. No other state has the diversity or quantity of shallow lake resources that Minnesota can provide. From the large prairie lakes to wild rice bays bordered by forest, the state has a unique resource that has been taken for granted and abused. These lakes provide habitat for many species of wildlife including waterfowl, other water birds, furbearers, amphibians, reptiles and fish. The Duck Plan suggests that at least 1,800 shallow lakes, almost half of the total resource, will have to be protected and managed if the state is going to achieve the targets set for recovery of duck populations.

Shallow lakes are important migration habitats as well as breeding habitats for over-water nesting species of waterfowl. Favored habitats are those that have thick stands of emergent vegetation including cattail, bulrush or sedge. Canvasbacks, redheads, mallards and ruddy ducks are all species that will nest over-water in emergent vegetation (Baldassarre and Bolen, 2006). This valuable breeding habitat has decreased with higher water levels in lakes and wetlands over the last two decades.

Diving ducks (canvasbacks, redheads, lesser scaup and ring-necked ducks) rely on lakes especially for both spring and fall migration habitat (Korschgen 1989). In the spring, it is important that these lakes provide abundant invertebrates to support female ducks that are preparing to breed and nest. For example, lipid and mineral reserves are important determinants of nest initiation and clutch size in lesser scaup (Anteau and Afton 2004). There is evidence that the quality of spring migration habitat in Minnesota has declined, particularly in the abundance of important invertebrates such as amphipods. Anteau and Afton (2006) attribute the decrease in lipid reserves to a corresponding decrease in the amount of amphipods in the diets of scaup during spring migration. Both invertebrates and plants are important nutrient sources to diving ducks in the fall. Ducks need to feed on these food sources relatively undisturbed to gain

weight for the remaining migration (Korschgen 1989). Thus it is important that shallow lakes provide both invertebrates and aquatic plants in order to meet migrational habitat needs of waterfowl.

Shallow lakes are important habitats for many species of wildlife beyond waterfowl. Many have large numbers of colonial nesting water birds (key example lakes are Thief, Marsh, and Christina). These lakes also provide important habitat to many environmentally sensitive species and species listed as having the "greatest conservation need" by the DNR in Tomorrow's Habitat for the Wild and Rare (THWR). Over 20 species listed as a species of greatest conservation need (SGCN) utilize shallow lake habitats (DNR 2006).

While the need to manage and protect shallow lakes currently exists, there are potentially dramatic shifts on the horizon that will further impact shallow lakes and their watersheds. These possible impacts include: changes in population demographics, land use changes, increased water demands, climate change, and invasive species. Because of these and a myriad of other issues, waterfowl and wetland managers are beginning to recognize that land protection through acquisition or easements is not enough to provide quality habitat or maintain water quality. The implications of these multiple impacts necessitate the need for active management of aquatic habitats and watersheds for wildlife and waterfowl (Baldassarre and Bolen, 2006). The benefits of active management to waterfowl migration habitat have long been recognized (Korschgen 1989). Active management may include drawdowns, herbicide treatments, rotenone treatments or other manipulations of fish communities, and managing run-off through wetland and grassland restoration. Likewise, in order for the state to have quality waterfowl habitat, active management and further protection of shallow lakes are necessary along with the strategies outlined in the State's Duck Plan.

This plan is a broad plan to guide wildlife management activities on shallow lakes over the next 45 years (the same time frame as the Duck Plan) but also provides short-term implementation targets and evaluation of habitats and management. The primary purpose of this plan is to provide focus to wildlife and waterfowl management activities on shallow lakes. However, a broader interest in the water quality of shallow lakes is also emerging as evidenced by the emphasis of shallow lake restoration in the recent Minnesota Statewide Conservation and Preservation Plan. Active management is also needed to achieve objectives beyond wildlife and waterfowl habitat, such as improving and protecting basic water quality in these lakes. Active management could include actions such as drawdowns and watershed restoration to improve or protect habitat or water quality. Broader management strategies could be developed to address those water quality needs that may also provide some wildlife and waterfowl habitat benefits. Such plans would likely require greater resources and more partners than are currently available for wildlife and waterfowl management purposes.

In the future, many shallow lakes will likely be determined to be impaired for nutrients as defined by the Clean Water Act. Total Maximum Daily Load (TMDL) studies and plans will then be required for the impaired basins. Strategies to improve water quality

through the TMDL process will likely focus on watershed restoration and management; however, the internal nutrient loading in these lakes will also need to be addressed to achieve noticeable water quality improvements. While the specific goals of TMDL plans are not generally to improve wildlife and waterfowl habitat, improvements in water quality will benefit wildlife habitat on shallow lakes.

The potential to manage shallow lakes is broad; this program plan provides a framework to manage shallow lakes associated with public lands which are specifically managed for wildlife purposes. While these criteria provide an overall approach, it is not meant to prevent area staff from implementing approaches and strategies that make sense at the local level. It does establish that Designated Wildlife Lakes (DWLs) or shallow lakes within and adjacent to Wildlife Management Areas (WMAs), United States Fish and Wildlife Service (FWS) Waterfowl Production Areas (WPAs), State Forests, State Parks and other public lands of high wildlife value should provide the cornerstones of waterfowl migration habitat in the state. Once the management needs of those lakes associated with public wildlife lands in a particular area have been adequately addressed, then management could be expanded to additional lakes.

STATEWIDE SHALLOW LAKE MANAGEMENT GOAL: Management and protection of 1,800 shallow lakes across the state for the benefit of wildlife and waterfowl.

This broad goal requires comprehensive strategies to improve wildlife and waterfowl habitat in shallow lakes across the state. An additional benefit of active management for high-quality habitat may also be improved water quality in these lakes. The following objectives have been identified in order to meet the above goal, to meet objectives related to shallow lakes in the state's Duck Plan, to implement some suggestions from the Wild Rice Legislative Report, and finally to provide wildlife managers with tools and criteria to focus shallow lake management efforts and activities that will maximize waterfowl and wildlife habitat while also providing public benefit.

There are just over 4,000 "shallow lakes" in the state – lakes that are 50 acres or greater in size and have a maximum depth of 15 feet or less. Management of all of these lakes is not possible or needed to achieve the goals of the Duck Plan or the Shallow Lake Program Plan. Resources are always limited, and it is critical to prioritize where resources will be allocated. Management focused on shallow lakes associated with public land managed for wildlife purposes or managed in part for wildlife value should form the basis of waterfowl migration habitat in the state. In many cases active shallow lake management can enhance both breeding and migration habitats in these lakes. Shallow lakes within or adjacent to WMAs and WPAs, State Forests, State Parks or county lands should be in good habitat condition, but often direct protection through fee title acquisition or conservation easements is not enough to insure quality habitat exists in these lakes. As the primary agency responsible for habitat management, it is critical that DNR staff are making every effort to provide quality habitat on shallow lakes where the DNR owns shoreline. These lakes should provide the foundation of waterfowl migration habitat throughout the state and set the example of the quality of habitat that can be provided through protection and management.

The following objectives are aimed at managing those basins with high management potential and maximum wildlife benefit. Progress towards the goal of 1,800 managed shallow lakes will be measured by progress towards the following long-term objectives:

1) Assess shallow lakes for management need and potential,
2) Maximize management of shallow lakes for waterfowl and wildlife habitat that are designated as wildlife management lakes or are within public lands,
3) Maximize management of shallow lakes for waterfowl and wildlife that are adjacent to public lands with wildlife habitat,
4) Increase waterfowl and wildlife habitat in shallow lakes with public access that do not have tracts of shoreline specifically managed for wildlife,
5) Designate "Important Wild Rice Lakes" to further increase awareness of the historic, cultural and habitat importance of wild rice.

The department currently manages approximately 300 shallow lakes for wildlife resource benefits across the state. An additional 1,500 lakes must be added to meet the goals of the duck plan. A 45-year time frame with annual implementation targets is set to achieve this goal.

Objective 1: Fully assess habitat of Minnesota's shallow lakes and document resource condition, determine management potential, and evaluate results of management activities on the subset of shallow lakes that are actively managed.

Justification:
In recent years with the addition of full-time staff and seasonal interns, the number of surveys on shallow lakes has increased. Yet, a large number of shallow lakes have not been surveyed within the last 10 years or have never been surveyed at all. Certainly additional management opportunities exist, and basins in good condition need to be identified so preservation and protection efforts can be prioritized. Completed surveys have helped determine conditions of shallow lakes at regional- and lake-level scales. However, due to the dynamic nature of these lakes over relatively short time periods, the constant threat of invasive species, and future consequences of climate change, continued surveys are necessary to provide up-to-date knowledge of the condition of the resource. These surveys also provide a measure of management success and provide information on management failures that may be used in future management decisions. Habitat and water quality information prior to and after management are necessary to develop adaptive management strategies.

Primary Strategies:
- Assess lakes using established lake survey protocols for shallow lake surveys (including water quality sampling)
- Utilize remote sensing tools as technologies become more advanced
- Employ invertebrate and fish sampling on a subset of basins

- Assess/monitor potential stressors (e.g. watershed size, crop coverage, feedlots, ditches or tiles, impervious surface, near shore development) to determine management feasibility
- Assess outlet condition where water level management may be appropriate

Target 1a: Conduct initial habitat assessments on all 1,954 shallow lakes associated with public land within 10 years.

Implementation:

- Survey a minimum of 200 lakes per year
- Coordinate with State Park staff to determine highest priority shallow lakes within/adjacent to State Parks that are in need of habitat surveys
- Develop and evaluate additional assessment techniques through partnership with research groups and other entities
- Maintain the Wildlife Lake Database to organize survey data and produce survey reports on demand
- Make habitat survey reports available on the DNR internet site
- Maintain and update as needed the list of managed wild rice lakes

Target 1b: Conduct periodic surveys to evaluate habitat conditions on those lakes that are actively managed to support adaptive management strategies.

Implementation:

- Survey lakes within two years after a management action
- Maintain the Wildlife Lake Database to organize survey data and produce survey reports on demand
- Maintain and update as needed the list of managed wild rice lakes
- Partner with the Wetland Wildlife Research Group and Universities on research that will lead to improvements in management abilities and opportunities on shallow lakes

Objective 1 Operational Plan:

- Seven two-person, out-fitted field survey crews per summer
- Four additional specialists to oversee field crews
- Provide specific training to field crews for invasive species identification
- One specialist serving as the Statewide Field Survey Coordinator
- One specialist dedicated to maintain database and manage data
- One specialist dedicated to enter survey data into database and produce survey reports
- Partner with other agencies or provide data to other agencies that are also charged with assessing water quality in the state's lakes
- Continue to monitor habitat on Shallow Lake Case Study Lakes
- Schedule coordination meetings with DNR Wetland Research as needed to explore new survey and assessment tools, techniques, and methods

- Provide pre-management data to Wetland Wildlife Research for shallow lake research project
- Schedule regular coordination meetings with DNR Regional Wildlife Staff

Objective 2: Maximize management of shallow lakes for waterfowl and wildlife habitat that are Designated Wildlife Lakes or are located completely within public lands.

Justification: Designated Wildlife Lakes, shallow lakes and wild rice lakes within Wildlife Management Areas, Waterfowl Production Areas, and National Wildlife Refuges (NWRs) should have high quality habitat. While some of these lakes are currently actively managed, additional opportunities for increased management and habitat improvement still exist across the state. Many of these lakes have dilapidated water control structures in need of replacement, and some designated lakes have never been actively managed.

The shallow lakes located completely within these areas of public ownership have protection from shoreline development and often have large areas of upland buffers; however this protection has not insured that these basins have high quality wildlife and waterfowl habitat. As with other shallow lakes, many of the lakes within these areas of public ownership are impacted by invasive species, excessive nutrient loading, and climate change. Monitoring data on some lakes that are actively and intensively managed shows dramatic improvements in habitat and water quality can be achieved (Figure 1).

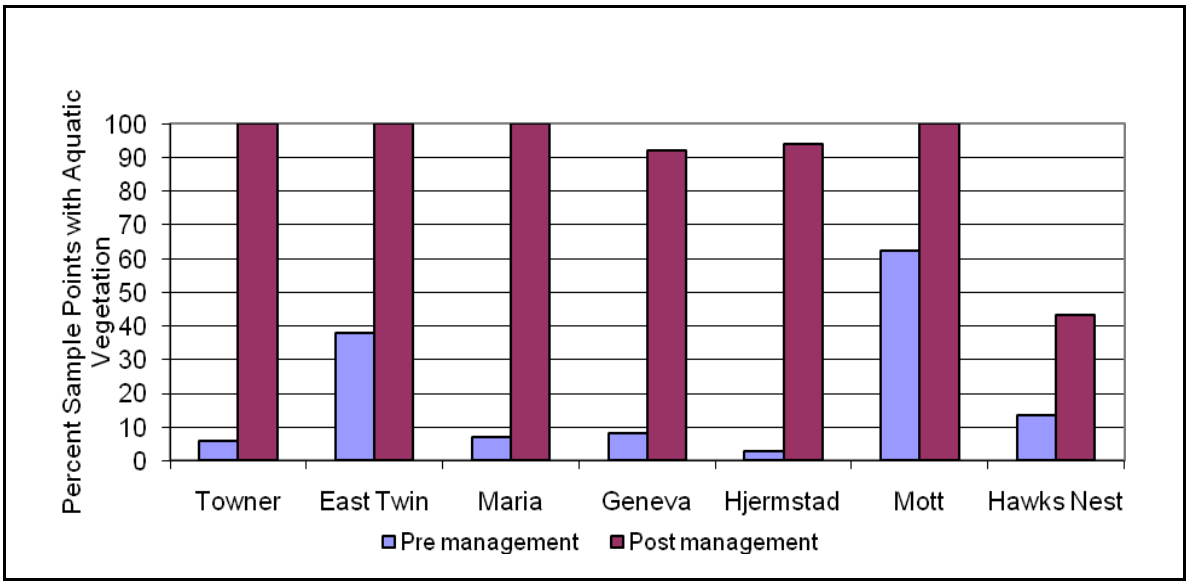

Figure 1. Pre and post-management aquatic plant survey data from recently managed shallow lakes. Pre-management data was collected at least one year prior to management action; post-management data was collected 1-3 years after a specific management action.

The Shallow Lakes Program places a high priority on assessing habitat conditions on DWLs or basins completely within public land. Those lakes with outlets may have drawdown potential; those lakes without outlets could be potential rotenone treatment candidates. While the authority to manage basins within federal public wildlife lands lies with the FWS, the DNR can and does work cooperatively to provide technical assistance and survey information on these basins to encourage active management for high quality habitats. There are some basins where both agencies own shoreline and management is a cooperative effort.

Managing these lakes also is consistent with goals in the Duck Plan to manage habitat in complexes of grasslands, wetlands and shallow lakes. Most of the shallow lakes identified in this category already are a part of, or the start of, a complex of wetland, grassland, or other natural habitats.

Primary Strategies:

A part of achieving this objective includes a change to the current statutory language in 97A.101 to allow regulation of bait harvest (minnows as defined in 97A.015 Subd. 29) in Designated Wildlife Lakes.

Rational: The Section of Wildlife spends great amounts of resources on management of individual lakes, especially Designated Wildlife Lakes (DWLs). Much of this management is aimed at managing or minimizing fish populations in these lakes; however Wildlife has no authority to regulate the use of these basins for bait trapping activities. While it may not be necessary to restrict bait trapping on all DWLs, it would be beneficial to have the option as another management tool. Such regulation could be used to limit disturbance during the waterfowl nesting season, protect high quality brood habitat, or to protect against exotic species introduction. Such protections exist for basins within WMAs, so it is reasonable and logical to consider extending the same protections to DWLs. Also, regulations restricting bait harvest already apply to waters infested with certain invasive species.

Potential regulation options include limiting the time of year bait could be harvested, completely prohibiting bait harvest, or allowing bait harvest by special permit only.

Additional Strategies:

- In-Lake Management
    - Water level management including installation of permanent water control structures or use of temporary pumps or siphons
    - Rotenone treatments to manage fish populations (best conducted on isolated lakes or groups of lakes)
    - Maintenance of water levels through beaver dam removal and outlet channel clean out

    - Seeding of wild rice in appropriate habitats
    - Invasive species control (including carp, cattail, purple loosestrife, and Eurasian watermilfoil) where these species are impacting wildlife habitat using fish barriers, biocontrols, pesticides, and herbicides
    - Predator fish stocking to manage benthivorous and planktivorous fish species (needs to be combined with other management strategies)
    - Establishing Migratory Waterfowl Feeding and Resting Areas (MWFRAs), Refuges and Sanctuaries to minimize waterfowl disturbance
    - Establishing motorized surface use restrictions to reduce waterfowl disturbance and/or prevent damage to aquatic habitats
- Watershed Management
    - Wetland and grassland restoration and/or protection through fee title acquisition, conservation easements through non-profits and farm bill programs, and special efforts like the Working Lands Initiative
    - Improved watershed management through controlled drainage and promoting other Best Management Practices (BMPs)
    - Management of wetlands and lakes connected to Designated Wildlife Lakes, and lakes with adjacent public land

Target 2a: By 2030, actively manage as many of the shallow lakes completely within WMAs and all the DWLs for high quality waterfowl habitat as feasible. Work cooperatively with the FWS and other partners to increase active management of shallow lakes and other water bodies within WPAs and NWRs. Table 2 provides a summary of numbers and distributions of these lakes.

Implementation

- A map and list of shallow lakes completely contained within WMAs, WPAs and/or NWRs is included in Appendix A
- 10 WMA/WPA/NWR basins will be surveyed every year (under Objective 1)
- Management or protection of 33 *new* basins under Objectives 2-5 needs to be accomplished annually; a portion of those would come from this category
- Overall annual goals for Objectives 2-5 include:
    - 50 basins identified for feasibility studies
    - 20 basins identified for wild rice designation
    - 10 basins receiving new or replacement water control structures

Target 2b: Increase grassland and wetland restoration and protection of native habitats in the direct contributing catchment basins of these important lakes. In this case the direct catchments are targeted to improve complexes of wetlands and grasslands near shallow lakes to improve breeding duck habitat. Spreading

these efforts across the entire watershed would not result in great habitat improvement and it would be also difficult to do on a scale that would improve water quality.

Implementation

- Coordinate and support implementation of grassland and wetland restoration objectives in the Duck Plan

Objective 2 Operational Plan:

- Coordinate with Regional and Area Wildlife staff to identify 1-2 new projects per work area per year
- Four additional specialists to handle project logistics in NE, NW, and metro/central Minnesota
- One dedicated realty specialist to work on easements and acquisitions for shallow lake and wildlife projects
- Include shallow lake management targets in work plans of Area Wildlife staff
- Work with the DNR Division of Waters to delineate catchments of basins between 50 and 100 acres in size (those shallow lakes that have not had catchments yet delineated)
- Make the priority shallow lakes GIS coverage available on network servers (on DRS)
- Incorporate priority shallow lake catchment scoring criteria into the DNR WMA acquisition process
- Coordinate with other agencies implementing conservation to facilitate consideration/priority of land and wetlands within priority shallow lake catchments (facilitate habitat complexes adjacent to shallow lakes). Work in watersheds would also be beneficial from a water quality perspective.

Objective 3: Maximize management of shallow lakes for waterfowl and wildlife that are adjacent to public lands managed specifically for wildlife or public lands with wildlife habitat value.

Justification: Shallow lakes with a portion of their shorelines surrounded by public lands that are valuable for wildlife should also have high quality habitat. Only a few of these lakes are currently managed, and many additional opportunities for increased management and habitat improvement exist. The shallow lakes located partially within these areas of public ownership have some protection from shoreline development and may have large areas of upland buffers. This protection, however, has not insured that these basins have maintained the ecological functions of high quality shallow lakes with good wildlife and waterfowl habitat and water quality. As with other shallow lakes, many of the lakes adjacent to these areas of public ownership have also suffered from invasive fish species, excessive nutrient loading, high water levels and climate change. Managing these lakes adjacent to public lands is also consistent

with the goals in the Duck Plan, as shallow lakes are key components to habitat complexes of grasslands and wetlands.

Throughout the forested areas of Minnesota and much of the transition zone, the best waterfowl habitat is contained in wild rice lakes. Many wild rice lakes are plagued by high, stabilized water levels due to the installation of dams. These dams were put in after the drought of the 1930's and have been especially damaging to wild rice during the above average precipitation Minnesota has experienced since the early 1990's. Beaver dams have also been damaging to the state's wild rice resource. The current joint DNR-Ducks Unlimited wild rice management project has proven that removal of these dams is a cost-effective management strategy, and these efforts should continue. Abundant wild rice has benefited many species of wildlife including muskrats and other furbearers on some of these lakes. Recommendation 6 in the DNR's 2008 Wild Rice Study Legislative Report also supports additional wild rice management.

There are 25 shallow lakes completely within or have shoreline contained within State Parks or State Recreation Areas (with no other public land adjacent to them). These lakes provide valuable habitat for native wildlife and flora and recreational and educational opportunities for the public. Additional management opportunities may exist on these lakes. Such management would be a joint effort between the Division of Fish and Wildlife and the Division of Parks and Trails and would be consistent with overall management plans and goals of the particular park and the Minnesota State Parks Strategic Plan.

Since these lakes have adjacent upland habitat, they are already forming a habitat complex and should receive higher priority for active management. However, they also have portions of shoreline in private ownership. Wildlife Lake Designation, flowage easements, or fee-title acquisition from willing sellers will be required in order for active water level management to occur on these basins. Since these lakes have a portion of their shorelines under private ownership, increasing public awareness of shallow lake ecology and management will be a critical component of implementing management on these lakes. Landowner and public buy-in will be essential for obtaining legal control for water level management activities.

There may be some opportunities for wildlife management on basins formerly used by the DNR Section of Fisheries Management (Fisheries) as "Northern Pike Spawning Areas." These are usually smaller wetlands or shallow lakes with connections to larger fishing lakes where Fisheries acquired land or easements for the purposes of creating or enhancing northern pike spawning habitat. There are approximately 18 Northern Pike Spawning Areas on shallow lakes. Fisheries is no longer actively managing many of these areas, and management of at least two have already been turned over to the Section of Wildlife Management for waterfowl and wildlife management purposes.

Primary Strategies

- In-Lake Management
  - Water level management including installation of permanent water control structures or use of temporary pumps or siphons
  - Rotenone treatments to manage fish populations
  - Maintenance of water levels through beaver dam removal and outlet channel maintenance
  - Seeding of wild rice in appropriate habitats
  - Invasive species control (including carp, cattail, purple loosestrife, and Eurasian water milfoil) where these species are impacting wildlife habitat using fish barriers, biocontrols, pesticides and herbicides
  - Predator fish stocking to manage benthivorous and planktivorous fish species
  - Establishing MWFRAs, Refuges and Sanctuaries to minimize waterfowl disturbance
  - Establishing motorized surface use restrictions to reduce waterfowl disturbance and/or prevent damage to aquatic habitats and control internal nutrient loading
- Watershed Management
  - Wetland and grassland restoration and/or protection through fee title acquisition, conservation easements through non-profits and farm bill programs, and special efforts like the Working Lands Initiative
  - Improved watershed management through controlled drainage and promoting other Best Management Practices (BMPs), including BMPs in managed forests
- Public Awareness
  - News releases highlighting shallow lake management projects
  - Informational and educational videos
  - Provide information through the Shallow Lakes web page on the DNR website
  - Explore opportunities for interpretive displays on shallow lake ecology at State Parks
  - Continue support of the Shallow Lake Forum and other meetings and conferences
  - Prepare articles for the Conservation Volunteer and similar publications
  - Shallow lake brochures
  - Presentations at lake association meetings, waterfowl symposiums, and special workshops

Target 3a: By 2056, actively manage the majority of the 1,553 shallow lakes with a portion of their shorelines under state, federal, or county ownership (WMAs, State Forests, State Parks, WPAs, NWRs, county lands) for high quality wetland wildlife habitat with special emphasis on waterfowl habitat. Management of shallow lakes associated with State Parks also falls under

this goal; however, management on these basins needs to consider the management goals of the individual state park. It is expected that there would be goals that would be mutually beneficial to both the Division of Parks and Trails and the Section of Wildlife Management. Management emphasis in the prairie and transition zones will be on water level management and/or biomanipulation and protecting those lakes that are in good condition. Increased wild rice enhancement and protection will be emphasized in the forested areas of the state. Management of terrestrial vegetation around shallow lakes in forested lands owned by the DNR is guided by DNR Subsection Forest Resource Management Plans (SFRMPs). This Shallow Lakes Program Plan is not intended to replace or change the existing SFRMP process. Table 2 provides a summary of numbers and distributions of these lakes.

Implementation
A map of shallow lakes adjacent to (but not completely contained within) WMAs, WPAs, NWRs, State Forests and county lands is included in Appendix A.

- 40 lakes from this list will be surveyed every year
- 15 management plans will be developed every year
- Management and/or protection of 33 *new* basins under Objectives 2-5 needs to be accomplished annually in order to achieve the target of 1,800 managed lakes by 2056; a portion of those would come from this category.

Target 3b: Designate an additional 30 lakes as wildlife management lakes under M.S. 97A.101

Implementation
- Start the 97A.101 designation process on 4-6 lakes per year.
- Complete the designation process on 2-3 lakes (with parts of their shorelines already under public ownership) per year as wildlife management lakes under M.S. 97A.101, achieving designation of at least an additional 30 lakes in 10 years.
- Basins targeted for designation will have high management potential and high likelihood of achieving desirable habitat conditions after management (e.g. lakes with small watersheds and few connections).

Target 3c: Increase grassland and wetland restoration and protection of native habitats in the direct contributing catchment basins and along the shorelines of these lakes in the prairie and transition zones.

Implementation
- Support implementation of grassland and wetland restoration objectives in the Duck Plan.

- Coordinate targeting of restoration and protection in shallow lake watersheds.
- Target management of lakes in prairie and transition regions that are, or can be, parts of habitat complexes of wetlands and grasslands.
- Use GIS tools and work with Area Wildlife staff to identify lakes that have the potential to be managed as a part of a habitat complex of grasslands, wetlands or native habitats

Target 3d: Protect waterfowl habitats in shallow lakes in forested areas.

Implementation
- Work with partners to protect shorelines of important wild rice lakes through conservation easements.
- Work with other Divisions on formulating management plans for forested shallow lakes. Such plans would usually focus on in-lake management techniques and motorized surface use management, but would also encourage best management practices in the upland areas.
- Acquire shoreline habitats on important wildlife lakes through fee-title acquisition.
- Identify specific opportunities for shallow lake management projects in state forests.

Target 3e: Increase public knowledge and understanding of shallow lake ecology and management.

Implementation
- A minimum of 5 news releases on shallow lake projects will be put out annually
- Additional information and education materials including brochures and videos will be produced and distributed.
- The DNR Shallow Lakes Program website will be maintained.
- Public presentation opportunities will be sought out.
- Involvement in the Shallow Lakes Forum will continue.

Operational Plan
- Coordinate with Regional and Area Wildlife staff to identify 1-2 new projects per work area per year.
- Four additional specialists to handle project logistics in NE, NW and metro/central Minnesota.
- One dedicated realty specialist to work on easements and acquisitions for shallow lake and wildlife projects.
- Include shallow lake management targets in work plans of Area Wildlife staff.

- Wildlife managers will coordinate with the Division of Forestry on potential shallow lake management through the Interdisciplinary Forest Management Coordination Framework.
- The Shallow Lakes educational brochure will be updated through the Shallow Lake Forum.
- Each Shallow Lake Program staff member will be required to do at least one educational/informational presentation annually.
- The DNR Shallow Lakes Program website will be updated monthly.
- News releases will be done on all new lake management projects.
- Local Shallow Lake Program staff specialists will do news releases annually on local shallow lake condition and project updates.
- Maintain existing Shallow Lake Program staff level commitment to this activity.
- Each Shallow Lake Program specialist can realistically complete one designation per year with help from Area Wildlife staff.
- Coordinate with Regional Wildlife staff and Shallow Lake Program staff to further prioritize lakes for designation.
- Make the priority shallow lakes GIS coverage available on network servers (on DRS).
- Incorporate priority shallow lake catchment scoring criteria into the DNR WMA acquisition process.
- Coordinate with other agencies implementing conservation to facilitate consideration/priority of land and wetlands within priority shallow lake catchments (facilitate habitat complexes adjacent to shallow lakes).
- Work with the Wild Rice Work Group to identify wild rice lakes in need of protection through conservation easements or fee title acquisition.

Objective 4: **Increase waterfowl and wildlife habitat in shallow lakes with public access that do not have tracts of shoreline specifically managed for wildlife.**

Justification:

There are 201 shallow lakes with public access but without other adjacent public wildlife lands. Many of these lakes are managed for game fish populations, but some also have waterfowl habitat and provide public hunting opportunities. Some of these lakes are designated Migratory Waterfowl Feeding and Resting Areas (MWFRAs) but are also managed as recreational fisheries. Currently most do not have formal wildlife management plans or joint fisheries and wildlife management plans. Many do not have lake habitat assessments. Many of these lakes are in areas of the state where all the lakes are shallow, thus both fisheries and wildlife management goals need to be considered. Fisheries and Wildlife should coordinate survey efforts to have a basis of information for these lakes that could be used for formulating joint management strategies. Because only a small portion of the shoreline of these lakes may be under public ownership, additional steps will be required if active water level management is appropriate on a lake-by-lake basis. Some

shallow lakes adjacent to public lands are currently managed for recreational fishing but still provide valuable waterfowl habitat. It is critical that wildlife habitat needs are also addressed in the management plans for these lakes.

The same tools used on lakes with partial public ownership of shoreline can be used to manage lakes without adjacent public land beyond the public water access site. Public support of proposed management actions will be critical on these lakes, and active water level management will likely be controversial due to perceptions that aquatic vegetation is not desirable on many lakes. Management with sport fish/predator fish may be a component of management plans, since many of these lakes are already managed for sport fisheries. While it may be difficult to meet multiple goals associated with managing for both fish and wildlife habitats and uses, there are examples of successful joint management plans on shallow lakes in Minnesota (Fulda, Scotch, and others) and from other states (Big Muskego, Wisconsin).

As with Objective 3, increased public awareness of shallow lake issues and management techniques will be important to build public support for projects under Objective 4. News releases, informational publications and videos, Shallow Lake Forums, and presentations at various meetings (Minnesota Waterfowl Association, Minnesota Waters conferences, water quality workshops, watershed districts) will be utilized. As the public becomes more aware of shallow lake problems and tools to address those problems, acceptance of active management of these lakes will increase.

Primary strategies

- In-Lake Management
    - Water level management including installation of permanent water control structures or use of temporary pumps or siphons.
    - Wildlife Lake Designation or other legal processes in order to manage water levels.
    - Rotenone treatments to manage fish populations.Maintenance of water levels through beaver dam removal and outlet channel maintenance.
    - Seeding of wild rice in appropriate habitats.
    - Invasive species control (including carp, cattail, purple loosestrife, and Eurasian watermilfoil) where these species are impacting wildlife habitat using fish barriers, biocontrols, pesticides, and herbicides.
    - Predator fish stocking to manage benthivorous and planktivorous fish species (predator fish selected for ecological conditions found in shallow lakes).
    - Establish MWFRAs, Refuges and Sanctuaries to minimize waterfowl disturbance.
    - Establish motorized surface use restrictions to reduce waterfowl disturbance and/or prevent damage to aquatic habitats.

    - Local ordinances to protect shorelines or enact surface use restrictions.
- Watershed Management
    - Wetland and grassland restoration and/or protection through fee title acquisition, conservation easements through non-profits and farm bill programs, and special efforts like the Working Lands Initiative.
    - Improved watershed management through controlled drainage and promoting other Best Management Practices (BMPs)
    - Partnerships with other entities doing watershed work (e.g. working forestry easements, watershed district efforts to improve water quality).
- Public Awareness
    - News releases highlighting shallow lake management projects.
    - Informational and educational videos.
    - Provide information through the Shallow Lakes web page on the DNR website.
    - Continue support of the Shallow Lake Forums and other meetings and conferences.
    - Prepare articles for the Conservation Volunteer and similar publications.
    - Shallow lake brochures.
    - Presentations at lake association meetings, waterfowl symposiums, and special workshops

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Target 4a: Increase management efforts to benefit wildlife on the 201 shallow lakes with public access but without large tracts of public land managed for wildlife adjacent to shorelines. Table 1 provides a summary of numbers and distributions of these lakes.

Implementation

- 5 lakes from this list will be surveyed every year. Wildlife lake surveys should be coordinated with Fisheries surveys, as it would be beneficial to have both fisheries assessments and wildlife assessments from the same year.
- Develop joint Wildlife and Fisheries management plans for those lakes that are Migratory Waterfowl Feeding and Resting Areas and are managed for game fish.
- All management plans, including Comprehensive Lake Management Plans and Lake Vegetation Management Plans, developed for all lakes with public access should be reviewed through an interdisciplinary process by both Wildlife and Fisheries staff at Area and Regional levels. Such review should occur early in the process of developing management strategies.

Target 4b: Use Wildlife Designation as a tool if primary management emphasis is for wildlife and waterfowl management.

Implementation

- Identify shallow lakes that have public access with no additional public land and are not currently managed by Fisheries but may have wildlife management potential.

Operational Plan

- In order to implement this piece of the plan, a specific policy is needed.

Proposed Policy: Lake management plans for shallow lakes developed by the Division of Fish and Wildlife for any purpose will be subject to interdisciplinary review and comment at the area and regional level by both the Fisheries and Wildlife Management Sections prior to approval by the respective Section Chief. Note: management plans for Designated Lakes currently are reviewed and approved by the Division Director.

Rational: Existing policy requires a coordinated review by DNR Fisheries and Wildlife staff for aquaculture license applications and the use of wetlands for fish rearing purposes. This coordination is carried out at the area level with regional and central office involvement as necessary. The benefit of this coordination should be extended to lake management plans for shallow lakes regardless of the primary management focus.

This review and comment policy would reduce potential conflicts (for example, when a lake with a Migratory Waterfowl Feeding and Resting Area is managed as a recreational fishery), provide a united defense of plans, and foster additional joint Fisheries and Wildlife management plans. Wildlife currently requests Fisheries review of management plans developed during the Wildlife Lake Designation process.

- Shallow Lake Program staff will request review of Fisheries management plans on these 201 shallow lakes that are managed as recreational fisheries.
- Development of joint Fisheries and Wildlife management plans will be requested on a case-by-case basis except for those lakes that are also Migratory Waterfowl Feeding and Resting Areas.
- Fisheries and Wildlife staff will develop joint management plans on MWFRA lakes that are managed as recreational fisheries through a specific process including Area, Regional and Central Office staff.
- The Shallow Lakes educational brochure will be updated through the Shallow Lake Forum.
- Each Shallow Lake Program staff member will be required to do at least one educational/informational presentation annually.
- The DNR Shallow Lakes Program website will be updated monthly.
- News releases will be done for all new lake management projects.

- Local Shallow Lake Program specialists will do news releases annually on local shallow lake conditions and project updates.

	Forest	Transition	Prairie	Total
Total number of shallow lakes	1216	1462	1391	4069
Priority Shallow Lakes				
Objective 2				
Designated Wildlife Lakes	6	15	23	**44**
Completely within WPAs	0	2	15	**17**
Completely within NWRs	17	16	8	**41**
Completely within WMAs	21	51	15	**87**
Completely within State Parks	4	5	2	**11**
Objective 3				
Partially in WMAs	88	213	307	**608**
Partially in WPAs	2	52	170	**224**
Partially in NWRs	2	23	0	**25**
State Forest and County lands	563	105	14	**682**
Partially in State Parks	3	8	3	**14**
Objective 4				
Public Access, no additional public land	43	69	89	**201**
Total	749	559	646	**1954**

Table 1. Shallow Lakes by Ecoregion, Program Plan objectives and public land category. The total number of lakes exceeds the 1800 statewide target, and this list will change as patterns of public land ownership change. Given that there will be limitations preventing management of all of these lakes above, the additional lakes will provide managers some discretion on which to manage while still achieving the goal.

Objective 5: Increase awareness and protection of lakes containing measurable stands of wild rice.

Target 5: Identify and maintain a list of "Important Natural Wild Rice Areas" as recommended in the 2008 Wild Rice Study Legislative Report.

Justification:
Wild rice is an important waterfowl and wildlife resource. The 2008 report on wild rice specified the state would identify and publish a list of important natural wild rice areas. While this listing will not offer any direct protection or additional legal authority for active management, it will increase awareness of the value of wild rice and give local governments an additional tool that could be used in conjunction with local ordinances to protect this valuable resource. The state provides the overall framework for shoreline management, but shoreline ordinances are developed and administered locally. Often local governments lack specific information on a particular water body or natural resource. A list of the state's most important wild rice areas, compiled from professional and public input, would call attention to the significance of these areas, provide local governments with information about a valuable resource in their local

jurisdictions, and increase awareness among the public about these noteworthy sites.

Primary Strategies

- Identify and maintain a list of “Important Natural Wild Rice Areas”.
- Publish the list on the DNR website and make it available to resource professionals, citizens, and local units of government.
- Identification and listing provides information to local governments to enact additional protections of these lakes/areas through local ordinance. It also provides information to and increases awareness among citizens.

Implementation

- The interagency Wild Rice Work Group established through the recommendation of the 2008 Wild Rice Study Legislative Report will work to establish criteria for important wild rice lakes. The DNR Shallow Lakes Program will work through the Work Group, DNR Wildlife staff, and stakeholders to identify a list of lakes that meet the criteria for listing as important wild rice areas.
- Wild rice distribution and lakes managed for wild rice are illustrated in Appendix A.

Operational Plan

- A Wild Rice Work Group (WRWG) is already established to develop recommendations and collaborate on wild rice issues, including managing wild rice, encouraging wild rice harvesting, and increasing public awareness of the importance of wild rice.
- The WRWG and sub-work group committees need to meet regularly and establish goals with specific timelines.
- A Shallow Lakes Program specialist currently serves on these committees which provide input and recommendations for identifying and listing “Important Natural Wild Rice Areas”.
- Develop a specific public input process (work with SORA and the Native American Bands) to identify and list “Important Natural Wild Rice Areas”.
- Target for start of process: January 2011.

BACKGROUND

Basic Shallow Lake Ecology and Management

The following background is provided to put the proposed management of shallow lakes in this plan into a scientific, ecological, and wildlife habitat context. The science of shallow lake ecology is a relatively new area of study. Only in the last 20 years has shallow lake ecology become a distinct topic within the broader fields of limnology and ecology.

Key to understanding and managing shallow lakes is defining what makes them unique from deep lakes. Deep lakes thermally stratify, or separate into layers based on water temperature, during the summer months. The epilimnion, the layer nearest the surface, is isolated for most of the summer from the nutrients contained in the sediments of the lake bottom due to this stratification. Shallow lakes do not form stable, distinct thermal layers during the summer months. The water column is mixing throughout the summer, and there is exchange of nutrients between the water and lake sediments (Scheffer 2004). This frequent water-sediment interaction results in a nutrient rich environment. A shallow lake compared with a deep lake of the same size and same watershed is going to have higher nutrient concentrations.

Another difference between shallow and deep lakes is the abundance and importance of aquatic plants. Aquatic vegetation growth is limited to the shallow areas of deep lakes, but aquatic plants can grow over the entire bottom in a shallow lake. Because aquatic vegetation can have such extensive coverage in these lakes, it is a key component of a shallow lake ecosystem.

There is evidence that shallow lakes can exist in either of two conditions: one of clear water and abundant vegetation or one of turbid water, little or no aquatic vegetation but abundant algae. Such shifts in condition can also occur in deeper lakes, but are not as evident as in shallow lakes. Each state is relatively stable depending upon nutrient concentrations. In the clear water state, aquatic plants serve to keep the water clear by protecting sediments from wind-resuspension, providing habitat for filter-feeding invertebrates and storing nutrients. Lakes in the clear water condition also support a greater diversity of wildlife and waterfowl. In the turbid water condition, algae and suspended sediments prevent the growth of aquatic plants and the water stays turbid. Lakes in this turbid condition provide little or no habitat for wildlife and waterfowl.

Many shallow lakes are in the turbid condition due to eutrophication caused by changes in watersheds of lakes that increases external nutrient loading. Changes in the fish community of a shallow lake can also cause deterioration from clear water to turbid water. Lakes dominated by bottom feeding fish and other planktivorous fish tend toward the turbid water condition. Bottom feeding fish (carp, bullheads) stir-up bottom sediments and uproot aquatic vegetation but more importantly increase internal nutrient loading through their metabolic activities (Brabrand et al. 1990, Persson 1997, Zimmer et al. 2006). Planktivorous fish consume small invertebrates that filter feed on algae.

These invertebrates can filter enough algae out of the water at times to have impacts on water clarity.

Due to stabilizing interactions, once a lake is in the turbid condition it is difficult to restore a clear water regime and watershed management alone may not be to reverse the lake back to the clear water condition. Additionally, in large watersheds, it is not feasible to restore pre-settlement conditions to the extent that would be required to see noticeable changes in habitat quality in a lake. Some type of in-lake management is required to change the cycling of nutrients already in the lake. Changing how nutrients are cycled in a lake and where they are stored requires dramatic manipulations of the biological interactions occurring among fish, invertebrates and algae. Common techniques to switch a lake from the turbid to the clear state include drawdowns, changing the fish community through chemical treatments, predator stocking or through other means (winter drawdown). These manipulations allow a brief window of low fish abundance. Without predation pressure from fish, invertebrate populations flourish, grazing on algae and improving water clarity, and allowing aquatic plants to grow. The plants then stabilize the clear water in the lake. If carp are present in the system, and are able to repopulate after a partial winterkill or incomplete kill from a chemical treatment, improvements in water clarity and habitat maybe short-lived. Partial winterkills can create reproductive opportunities for carp. They are able to have a successful year class in the absence of competition or predators (Bajer and Sorensen 2009). Such partial winterkills are common in shallow lakes, even those with aeration systems.

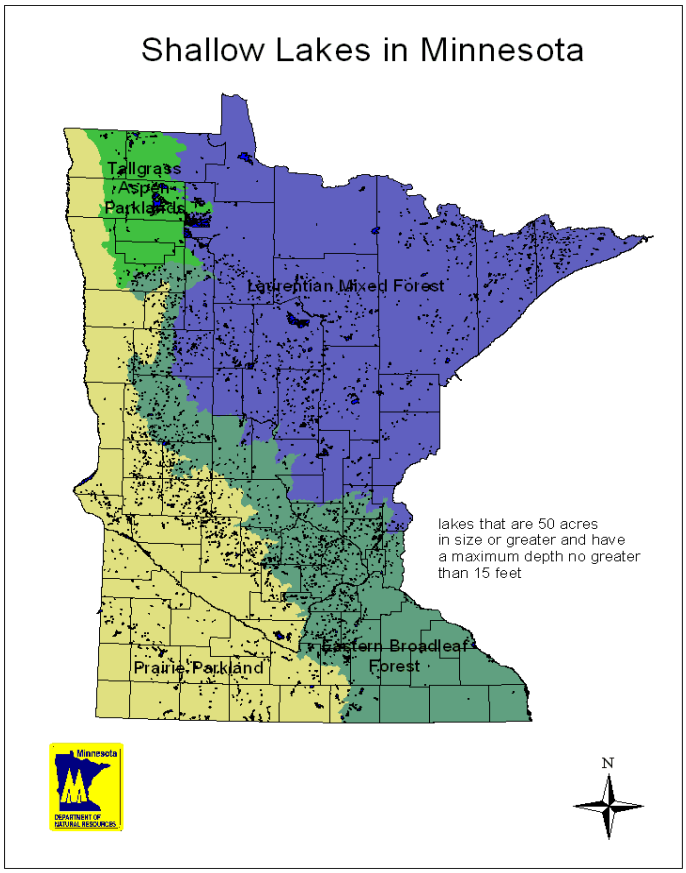

Figure 2. Shallow lakes are distributed through the forest, transition and prairie portions of the state.

While biological interactions in shallow lakes can cause switches from the clear to the turbid state and vice versa, underlying nutrient levels in a lake also influence the likelihood that a lake will be turbid or clear. At low nutrient levels, a shallow lake is more likely to be clear, at mid-levels of nutrients a lake can switch between both states and at

high nutrient levels, a lake is more apt to have turbid water. Many things can influence the underlying nutrient levels in lakes, including watershed size, soil type, topography, and watershed development (Moss et al. 1997). Such factors need to be considered when choosing shallow lakes to manage and when formulating expectations from management. Those lakes with watersheds that have higher percentages of native vegetation and intact wetlands should be high priority for protection (both lake and watershed). Lakes with impacted watersheds are going to require more aggressive in-lake management and also restorative measures in their watersheds. Even with aggressive management, it may be difficult to maintain high water clarity in some lakes, although improvements in habitat are likely possible. For example, active management of a highly eutrophic system may not result in long-term improvements in water clarity, but increases in tolerant species of aquatic plants (ie sago pondweed) maybe attainable. In those cases, repeated management would be necessary to maintain habitat.

Shallow Lakes in Minnesota

Resource Base

Minnesota has a resource of over 4,000 shallow lakes (Figure 2). The majority of these lakes fall between 50 and 100 acres in size; 115 are over 1,000 acres, and nearly 50 exceed 2,000 acres. These shallow lakes are 50 acres or greater in size and have a maximum depth of 15 feet or less. Examples of large lakes include Minnesota's most famous waterfowl hunting lakes such as Swan Lake in Nicollet Co. (9,346 acres), Heron Lake in Jackson Co. (8,251 acres), Lake Christina in Douglas Co. (3,978 acres), Pelican Lake in Wright Co. (2,793 acres), Thief Lake in Marshall Co. (7,430 acres) and Big Rice Lake in Cass Co. (2,717 acres). Approximately 1,700 shallow lakes have been drained prior to the 1970's, and most of those remain drained. Table 2 provides a summary of general information on numbers and uses of shallow lakes in Minnesota.

While shallow lakes are distributed throughout the state (Fig. 2), habitat characteristics vary among and within regions. Habitat and water quality tend to be poor where watersheds have been dramatically altered by agricultural or urban development.

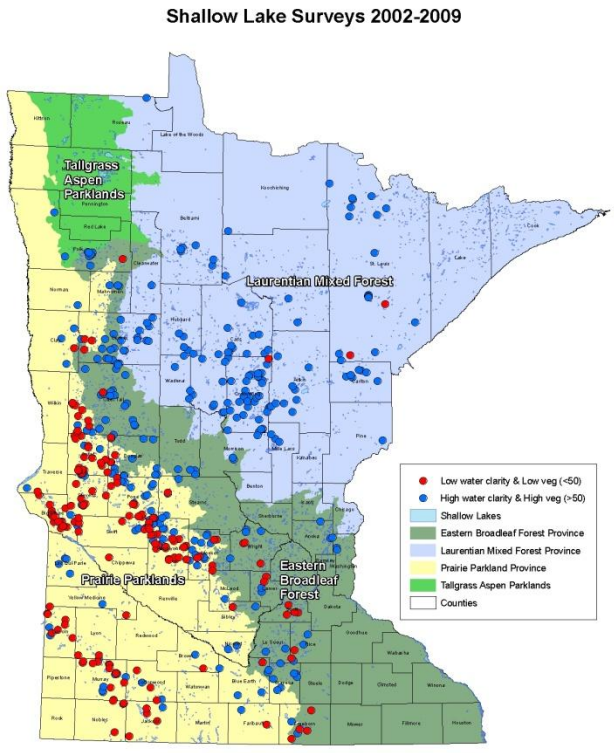

Figure 3. Red dots lakes in poor condition, blue dots indicate lakes in good condition

Data from DNR shallow lake surveys (Figure 3) suggest that the majority of prairie region shallow lakes have poor water clarity and consequently poor conditions for submerged aquatic plants and invertebrates, the primary sources of food for migrating and breeding ducks.

Total Existing Shallow Lakes, or lakes 50 acres or greater in size with maximum depths of 15 feet or less (there are still many lakes with unknown/unrecorded water depths)	~4069
Shallow Lakes fully drained or partially drained (according to Bulletin 25)	1752
Designated Wildlife Lakes under M.S. 97A.101 (2010)	44
Shallow Lakes Managed for Game Fish	754
Shallow Lakes Used for Aquaculture	199
Shallow Lakes associated with public lands (State, Co. and USFWS)	1709
Shallow Lakes with public access but no other public land	201
Shallow Lakes with Wild Rice	559
Shallow Lakes with MWFRAs	37

Table 2. General shallow lake information. There is overlap in lakes in each category, for example, wild rice lakes may also be counted in lakes associated with public lands, or a Designated Wildlife Lake could also have a MWFRA.

Importance of Shallow Lakes for Waterfowl

Quality shallow lakes are critical habitats for waterfowl production and migration. These lakes play two important roles in waterfowl production. The first is providing abundant energy in the form of aquatic invertebrates for breeding hens. These invertebrates are most important for diving ducks, particularly lesser scaup. The second contribution is in providing high quality duckling brood habitat. High quality brood habitat leads to increased ducking survival rates and duckling survival is a critical component to improving the duck recruitment rate.

Emergent aquatic plants such as rushes, wild rice and rooted common cattail enhance brood habitat by providing protective cover from weather and predators, and by providing habitat for aquatic invertebrates. Aquatic invertebrates such as insects, amphipods and snails are critical for duckling growth and survival. An abundance of invertebrates reduces the time ducklings spend foraging, which increases their survival rates. The quality of shallow lakes providing brood habitat has dramatically declined due to a combination of factors including prolonged periods of high water that favor winter survival of undesirable fish, such as bullheads and carp. These fish reduce the invertebrates and aquatic plants necessary for brood survival (Buoffard and Hanson 1997, Hanson and Riggs 1995).

Ducks are driven by their need for food and rest during fall migration. Temporary and seasonal wetlands sometimes fill these needs for dabbling ducks during extremely wet falls, particularly within the prairie region of the state. However these ponds are usually dry during the average fall. Typically it is the larger, more permanent wetlands and shallow lakes that provide the most important fall habitat. Unfortunately in Minnesota, the quality of this habitat has declined markedly due to shoreline development, drainage, excessive runoff, sedimentation, and dominance by invasive plant and fish species.

The worst damage has occurred within the prairie and transition portions of the state (Figure 3). The impacts of wetland drainage are multifold including direct loss of habitat for wetland dependant species, increased nutrients and siltation in remaining wetlands and lakes, altered hydrology including loss of flood storage, increases in water levels and altered food webs (Blann et al. 2009). Subsurface drainage tile also can divert ground water into surface drainage, further adding water that normally go to ground water recharge to these systems (Leopold 1968 and Skaggs et al. 2005). Restoration of wetland and grassland complexes within the watersheds of these lakes will help reduce excessive runoff and improve water quality in the long-term. However watershed work alone will not resolve in-lake degradation problems nor restore invertebrate populations related to high populations of undesirable fish species including carp and bullheads. It is not completely understood how much conservation and management will be needed to show improvement in the condition of aquatic systems in these impacted landscapes (Blann et al. 2009)

Importance of Shallow Lakes to Other Wildlife and Species of Greatest Conservation Need

Shallow lakes provide important habitat to many environmentally sensitive species and species listed as having the “Greatest Conservation Need” by the MnDNR in Tomorrow’s Habitat for the Wild and Rare (THWR). Over 20 species listed as a species of greatest conservation need (SGCN) utilize shallow lake habitats (MnDNR 2006). They include many water bird species that nest on shallow lakes including grebes and terns. Their habitats have been negatively impacted by loss of emergent vegetation or increases in water level bounce caused by change in watersheds or lake outlets. Shorebirds also utilize shallow lake habitat, especially those that are in a natural or managed drawdown during their migration. Several species of frogs, toads and turtles are also found in shallow lakes.

Shallow lakes were listed as “key habitats for species of greatest conservation need” specifically in six of the state’s 25 ecological subsections. Those six subsections were located in the Prairie Parklands and Eastern Broadleaf Forest provinces. Management options to support SGCN in the report include preventing loss and degradation of shallow lakes, focus on protecting larger shallow lakes and wetland complexes, manage for natural water regimes in shallow lakes, manage infestations of invasive plants and animals in shallow lakes, and protect known nesting areas for Forster’s terns.

Shallow Lakes and Wild Rice

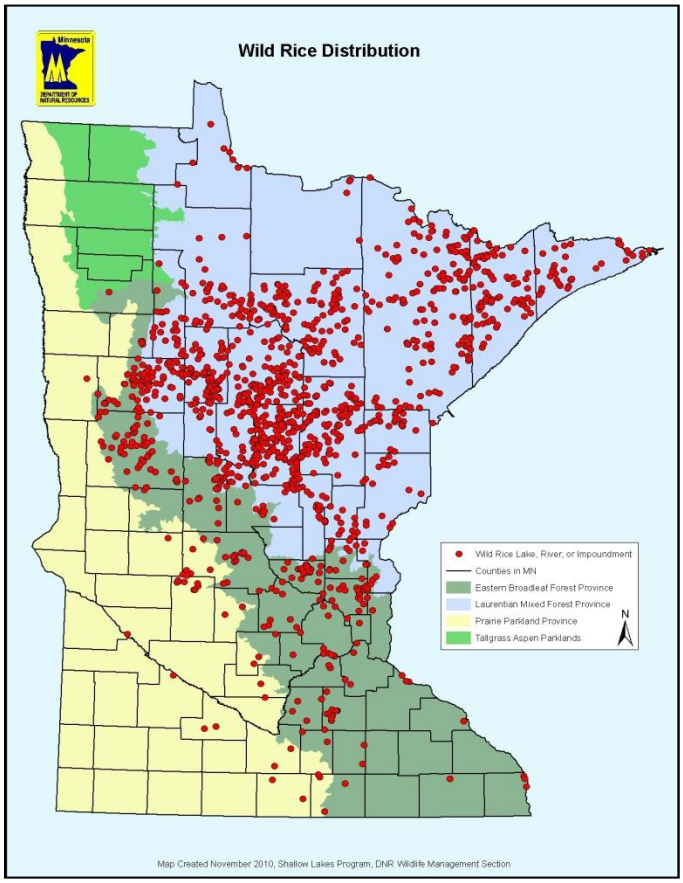

Figure 4. Wild rice distribution

Minnesota ranks first in the nation among states for natural wild rice production. While not all wild rice lakes are shallow lakes, Minnesota has over 1,000 (Figure 4) lakes containing stands of wild rice; over half of these are shallow lakes. Wild rice provides important brood and migration habitat for ducks in the forest and portions of the transition zone. Many of these wild rice stands have deteriorated due to high water caused by lake-outlet blockages by beaver dams and dense growths of hybrid or narrow-leaf cattail. Managing wild rice remains an ongoing project for the DNR. In recent years, Ducks Unlimited, tribal governments, and lake associations have been important partners in these efforts.

Wild rice stands are also susceptible to damage by shoreline development. Over the last 20 years, housing density has increased in both the forest and transition areas of the state and growth was greatest in counties with abundant forests and lakes (Gustafson et. al. 2005.). This area is also the part of the state with the most wild rice habitat. A recent study found an average of 66% loss of aquatic vegetation along developed shorelines (Radomiski and Goeman, 2001). Many counties with the bulk of the state's wild rice lakes (Figure 4) are also expected to receive the brunt of a 24% increase in Minnesota's population by 2035 (Figure 5).

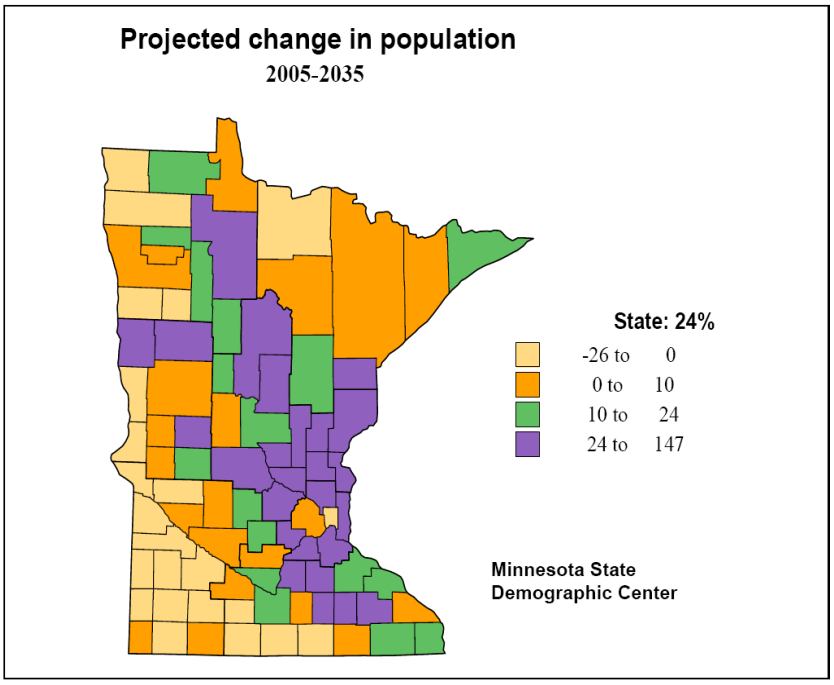

Figure 5. Projected population change by county.

Waterfowl Hunting and Wildlife/Waterfowl Viewing

Despite substantial losses in the quantity and quality of the state's shallow lakes, Minnesota remains one of the most important waterfowl production and harvest states in the Mississippi Flyway. Minnesota typically fields over 100,000 waterfowl hunters and 400,000 waterfowl watchers/birders a year, one of the highest in the nation. Annual trip and equipment expenditures by these enthusiasts in 2001 totaled more than $224 million and generated more than $20 million in state tax receipts.

Declines in shallow lake quality directly affect waterfowl hunting opportunities. Places to hunt and waterfowl to see are critical elements leading to hunter satisfaction (Schroeder et al. 2007). Restoring and protecting the habitat needed by migrating ducks is obviously beneficial for hunters as well. Access to some shallow lakes can be physically intimidating for many hunters and impossible for those challenged by age or physical ability. Balancing the issue of increased disturbance with appropriate access will be a challenge for the DNR, particularly as the population ages.

SHALLOW LAKE MANAGEMENT FOR WILDLIFE

In Minnesota, there are approximately equal numbers of shallow lakes in the forest, transition and prairie areas (Figure 2), but the characteristics and conditions of the lake resources differ considerably among the ecological zones. Management strategies must differ accordingly.

Many of the shallow lakes of the prairie and western portions of the transition zone are large semi-permanent and permanent water bodies dominated by cattails and bulrushes along the shorelines and dense stands of submerged food plants, such as sago pondweed, throughout the basins. Reflecting the rich prairie landscape, the lakes are inherently nutrient-rich and can support an abundance of invertebrates and food plants.

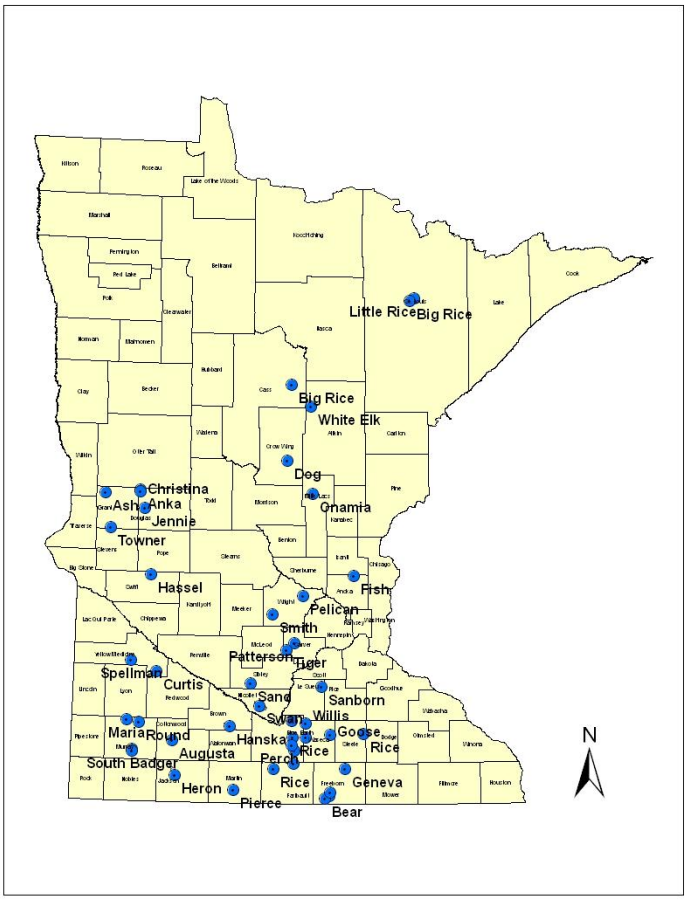

Figure 6. Lakes Designated as Wildlife Management Lakes under M.S. 97A.101

The quality of waterfowl habitat in prairie lakes is highly influenced by water clarity, abundance of aquatic plants and invertebrates. Often, excessive nutrients and undesirable fish can cause degradation of water clarity and these lakes shift to turbid, algae-dominated basins with few plants and invertebrates. Lakes in this condition have little value for waterfowl. Historically, frequent winterkills, low water cycles, and isolation from other water bodies, limited fish populations and maintained good quality habitat in prairie lakes and wetlands.

Productivity of lakes and soils decreases as one moves north and eastward in the state. Lakes in the forested area of the state are less likely to have problems with excessive nutrient inputs. This area has also been less impacted by wetland drainage. The best waterfowl lakes in the forest are wild rice lakes. As mentioned earlier, wild rice stands provide important brood and migration habitat for waterfowl, but many of these wild rice stands have deteriorated due to high water caused by lake-outlet blockages by beaver dams and other obstructions. Managing wild rice is an ongoing project for the DNR and

other partners, including Ducks Unlimited, tribal governments, and lake associations. For example, in 2007, over 170 lakes were managed for wild rice.

One of the primary tools the DNR has available for shallow lake management for wildlife is Lake Designation through Minnesota Statute (M.S.) 97A.101. This statute allows lakes to be designated specifically for wildlife management through a formal public hearing process. Such designation provides DNR wildlife managers with authority to manage water levels and control motorized use. Only 44 (Figure 6) of the more than 4,000 shallow lakes have been formally designated for wildlife management through this process. In comparison, about 754 shallow lakes have or are managed for recreational fishing in Minnesota by DNR Fisheries. An additional 199 lakes are licensed for private aquaculture activities. The lakes with recreational fisheries are evenly distributed throughout the state, but most of shallow lakes used for aquaculture are located in the prairie and transition areas of the state (Figure 7).

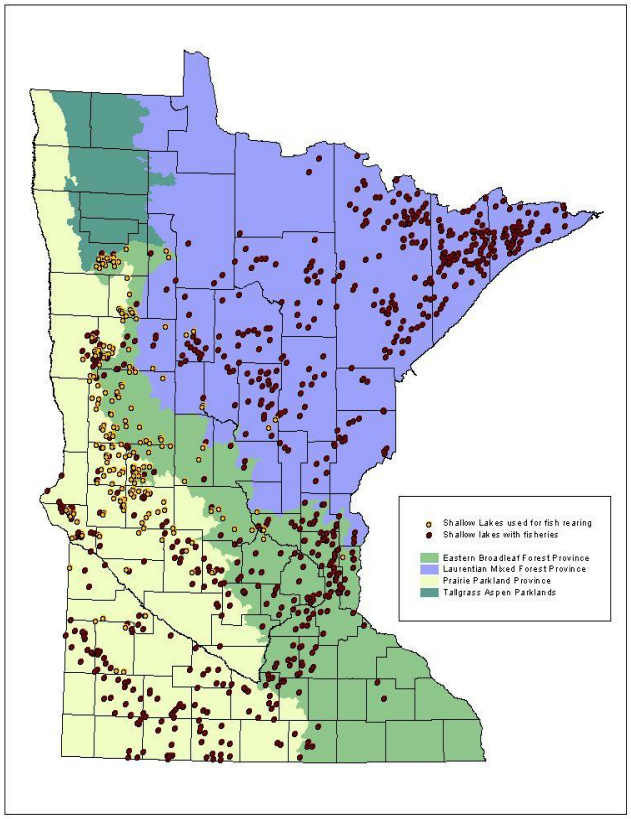

Figure 7. Shallow lakes with recreational fisheries or with aquaculture use.

THE CHALLENGES

The problems plaguing shallow lakes occur at several management scales ranging from specific lakes to landscape levels. Table 3 highlights these problems in light of these different scales. Some of these issues are explored further in the following text.

Problem:	Scale of Impacts at:				Possible Management Tools/Strategies
	In-Lake	**Shoreline**	**Watershed**	**Landscape**	
Lack of Information	Unknown Lake Condition Contribution of groundwater/water tables	development Thresholds trigger in-lake habitat decline	Extent of impact Sources of greatest stressors	Unknown impacts of Climate and Land Use Changes	• Lake surveys • Additional research • Drainage Inventory • Ground water assessments • Long-term monitoring
Climate Change	Lack of Winterkill Lakes drying up? Increased algal growth	--	Increased Precipitation Increased evaporation	Changes in water levels Changes in fish populations/community structure, alterations to wet-dry cycles	• Active management including water level manipulation and biomanipulation • Vulnerability assessments • Adaptive management
Land Use	Increased sedimentation and nutrient inputs	Conversion of Natural Shoreline	Loss of Wetlands, Permanent Cover, increased runoff	Loss of Wetlands and Permanent Cover, increased runoff	• Cost share/incentive programs for restoration activities • Conservation easements • Restoration of wetlands and grass lands • active in-lake management
Development	Increase in nutrient inputs	Housing and Agriculture Decreased habitat complexity	Housing and Agriculture	Loss of habitat	• Cost share/incentive for conservation easements • Direct protection through acquisition • Restoration, protection through conservation easements • Implementation of best management practices • Active lake management
Hydrological Alterations	Outlet Changes Irrigation Industrial allocation Ditches Drainage	Erosion Vegetation changes	Increased Runoff Loss of wetlands Loss of isolation		• Active water level management • Provide incentives for watershed restoration and restoration of historical hydrological regimes
Invasive Species	Aquatic Plants and Animals	Aquatic and Terrestrial Plants		Change in ecological structure and function	• Prevention: information and education, regulations • Biomanipulation, active management including water level and herbicide or piscicide treatments
Physical Disturbance	Boating Angling	Removal of near shore vegetation			• Regulatory including MWFRAs, surface use restrictions through Designation or local ordinance • Improved coordination of lake management between Fisheries and Wildlife
Competing Uses	Aquaculture Angling Recreational boating		monocultures	Decrease in diversity	• New aquaculture licensing criteria • Special regulations • Surface use restrictions • Vegetation management plans • Improved coordination of lake management plans between Fisheries and Wildlife

Table 3. Problems impacting shallow lake habitat at multiple scales and potential tools to address those problems.

Water Levels and Water Quality

More than a century and half of agricultural and urban development has taken its toll on Minnesota's shallow lakes. The prairie area of the state is substantially drained with fewer than 10% of the original wetlands remaining; some shallow lakes were also drained. Row crops such as corn, soybeans and sugarbeets dominate the landscape. Runoff is much greater due to loss of wetlands and reduced soil porosity due to loss of perennial grass cover. Shallow lakes are often the receiving waters for much of this drainage and runoff. The result of decreased watershed storage and increase in drainage systems is lakes with more hydrological "bounce" in water levels (flashy hydrographs) and increased levels of dissolved nutrients.

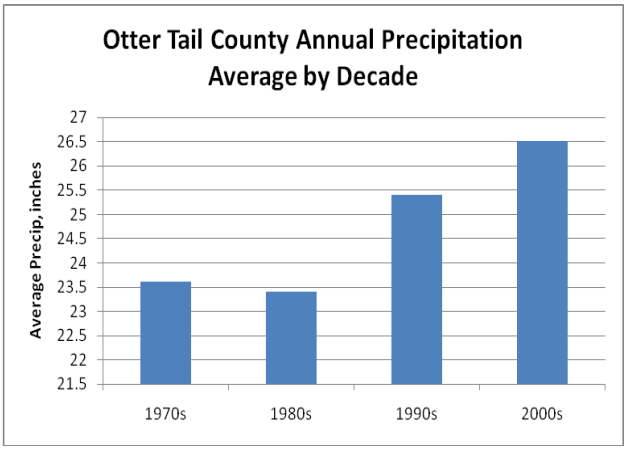

Figure 8. Precipitation data for Otter Tail County, MN from 1973-2009. Annual average by decade based on all available data in Otter Tail County from Minnesota State Climatology records.

In addition to increased drainage, parts of the state have also experienced a trend of increased average annual precipitation in recent decades. Figure 8 shows how annual precipitation has increased in Otter Tail County in the last 20 years compared to the two decades prior. Similar patterns are evident in many other counties of the state. This increased precipitation has resulted in increased lake water levels. Deeper water combined with mild winters, earlier ice-out on lakes and increased connectivity (Figure 9) has decreased frequency of fish winterkill. Many of these lakes were important waterfowl lakes, but they now sustain game fish populations. Recent research predicts further reductions in the frequency and extent of winterkill in temperate lakes due to climate change. Duration, volume and temporal extent of anoxia are predicted to decrease in northern temperate lakes (Fang and Stefan 1997, 2000). When winterkills do occur, undesirable fish re-infest the lake quickly through enhanced drainage networks, thus increased connectivity from ditching and tiling in these systems has also led exacerbated degradation.

Increased numbers and types of fish in shallow lakes have added to water quality problems. Carp and other benthivorous fish increase nutrient levels in basins through their foraging activity and through excreted nutrients (Lougheed et al. 1998). These nutrients contribute to algal blooms that decrease water clarity and submerged aquatic plants. Research has clearly documented poor habitat quality in basins with high densities of undesirable fish, including such native species as black bullheads and fathead minnows (Hanson et al 2005, Herwig et al. 2006, Zimmer at al 2006).

Increases in nutrients, higher water levels, suspension of bottom sediments, invasive species, algal blooms and shoreline disturbance have combined to eliminate aquatic plants and invertebrates and decrease water clarity and quality in many basins. Nearly two-thirds of the shallow prairie lakes surveyed by Minnesota DNR Shallow Lakes Program have poor water clarity and quality.

Continuing research has led to a better understanding of the intricacies of these relationships among fish, invertebrates, water clarity and lake nutrient levels. Although much remains to be learned, it is clear that lake management approaches cannot ignore biological interactions occurring in lakes if the management goal is related to waterfowl, fish or water quality.

Invasive Species

Invasive fish, particularly carp, pose a serious challenge to maintaining water quality, desirable aquatic plants and invertebrates (Parkos et al. 2003). Documentation of problems with common carp in Minnesota date back at least to the 1940s and are generally limited to the southern half of the state (Sharp 1942). This fish was recognized as problematic in other parts of the country by the early 1900's. Four new species of Asian carp that have not yet invaded Minnesota are- silver (*Hypophthalmichthys molotrix)*, black (*Mylopharyngodon piceus*), big head (*Hypophthalmichthys nobilis*), and grass (*Ctenopharyngodon idella*) – are at our doorstep. These fish species have been raised commercially and used experimentally in aquaculture ponds in many southern and Midwestern states and escaped into the wild. They have since been expanding in the Mississippi and Illinois Rivers and their tributaries. Some of these fish feed on plankton at the base of the food web and their impact on invertebrates and aquatic ecosystems could be devastating to Minnesota's aquatic habitats and fisheries. They could reach the state from either the Mississippi River and potentially through the Great Lakes (spread from the Illinois River). Currently, a temporary electric barrier in Illinois is the only protection from further invasion towards Minnesota via the Great Lakes. However, at least one carp has been found above this barrier already. There is no barrier (other than existing dams) on the Mississippi to prevent upstream spread into Minnesota. As of 2008, no known viable populations of these fish exist in the state; however a grass carp was caught in the St. Croix River in the spring of 2006, a big head carp was caught by a commercial fisherman in the fall of 2007 on Lake Pepin, and two grass carp, one bighead carp, and one silver carp were caught by a commercial fisherman in the Mississippi River near LaCrosse, Wisconsin in November 2008 (Associated Press).

Zebra mussels (*Dreissena polymorpha*) are small clams that are native to the Caspian Sea region of Eastern Europe. The small bivalves were introduced into the Great Lakes through ballast water from ships. They were first found in Minnesota in 1989 in Duluth Harbor of Lake Superior and have since spread to over three-dozen other waterbodies in the state, including the Mississippi River near Brainerd (MN invasive species website). It seems likely that these mussels will eventually be introduced into shallow lakes in the state. These mussels can be abundant and are an attractive food source

for migrating and over-winter diving ducks (Petrie and Schummer 2002). In some of the Great Lakes, zebra mussels have attracted large numbers of diving ducks. These filter-feeding mussels also harbor environmental contaminants. The contaminants accumulate in the mussels' fatty tissues. High concentrations of methyl mercury and polychlorinated biphenyls (PCBs) were found in mussels in Minnesota and Iowa after only one growing season. There is great concern that these mussels could be a source for translocation of contaminants into higher trophic levels of the food web including into waterfowl (Cope and Bartsch 1999, MacIsaac 1996). There is evidence from many lakes including Lake Erie that water clarity increases after introduction of zebra mussels due to their filter feeding. They have been intentionally introduced into lakes in the Netherlands as a tool to improve water clarity (MacIsaac 1996). Submerged aquatic vegetation could increase in lakes where these mussels become established.

Other invertebrate invasive species are cause for concern as well. Recent scuap die-offs in Lake Winnibigoshish have been linked to the invasive faucet snail *(Bithynia tentaculata*). These small snails are native to Europe and were mostly introduced into the Great Lakes via ballast water. They are intermediate hosts to trematode parasites. Diving ducks consume the snails and are killed by the trematodes. Although faucet snails not been documented in any Minnesota shallow lakes yet, they may already be present in some and would survive if introduced, as their preferred habitats are freshwater ponds and shallow lakes with abundant aquatic plants (Kipp and Benson 2008).

Shallow lakes have been degraded by other invasive species such as hybrid cattail, purple loosestrife, and reed canary grass. These invasive plants have displaced desirable native vegetation (bulrush, wild rice, broad-leaf cattail) in some lakes and have altered the hydrology in many. Hybrid cattail, in particular, can clog outlet channels and increase sedimentation in these areas, ultimately affecting lake water levels. Additionally, this plant can completely in-fill all of the open water areas of lakes and wetlands if it is not managed. Once it has filled in a basin, it may be difficult to remove, especially if it forms a floating mat. Lakes completely choked by hybrid or narrow-leaf cattails have little value for waterfowl.

An invasive European genotype of common reed grass (*Phragmites australis)* has displaced native forms of the plant in New England states and has been found in isolated locations in Minnesota (Saltonstall 2002). This plant has the tendency to form monocultures similar to or worse than hybrid cattail. It also has the potential to alter hydrology and reduce open water habitats in many of the state's shallow lakes. It could further displace native vegetation across the state and could be particularly threatening to native wild rice stands.

At least two species of submerged invasive aquatic plants, Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) are found in the state and have spread to some shallow lakes. These plants can displace native submerged plants that are more desirable for waterfowl habitat. Curly-leaf pondweed can affect internal nutrient cycling resulting in mid-summer algal blooms. Once these

plants are in a lake, they are nearly impossible to eliminate. Management focuses on reducing nuisance conditions and is expensive. Attempts at control usually involve multiple herbicide applications, although drawdowns can be used to reduce both of these species. There are several other submerged invasive aquatic plants present in other states that would also be troublesome if introduced to Minnesota's shallow lakes; hydrilla *(Hydrilla verticillata)* is one example.

There is evidence that climate change affects an ecosystem's susceptibility to invasive species; climate change may lend to a change in species composition due to changing environments. Conditions may become less than ideal for native species, leaving systems susceptible to biological invasions. Some scientists suggest that under these circumstances, it may be necessary to view new species as a part of these changing systems rather than trying to eradicate them (Walther 2009).

Fish Rearing

Loss of wetland quantity and quality has created a scarcity of wetlands in some parts of the state, resulting in competition for remaining wetlands and shallow lakes. Two of these competing uses are fish rearing for the bait industry and for game fish stocking in lakes. The bait and aquaculture industry are economically and socially important in Minnesota. Current statutes support the use of public programs to promote aquaculture (M.S. 17.49) and the use of wetlands for commercial purposes (M.S. 103B.3355). Bait dealers can catch baitfish from wild stock in lakes and wetlands, and they can also raise baitfish in public waters with a permit. There is little regulation on the actual harvest of bait from public waters. The bait harvesters must be licensed but then can trap in almost any basin on which they have legal access.

The legislature has also been pressed by anglers to strongly encourage increased levels of walleye stocking. The fingerlings to support these stockings are raised in natural wetlands and shallow lake basins. More than 2,000 basins are currently approved for fish rearing activities; 199 of these are shallow lakes (greater than 50 acres in size). In some shallow lakes, walleye rearing has been beneficial to reduce fathead minnows, improving water clarity, submerged plant abundance and aquatic invertebrate abundance (Herwig et al. 2004). Walleye fry predate on fathead minnow fry and have effectively controlled fathead minnows during the years of fry stocking. Joint management of wetlands has occurred successfully between DNR Fisheries and Wildlife and DNR Fisheries and the USFWS. Wetlands or shallow lakes are treated with rotenone usually by Fisheries in cooperation with Wildlife or the USFWS to remove bullheads and or carp and then the water bodies are used for walleye rearing activities. Current DNR fish rearing methods and activities do not include stocking of fatheads minnows or other forage fish to increase production.

Recent concerns over the impact of fish rearing has led to additional research by the DNR and increased interest by the state legislature. As a result, in 2006 the DNR unsuccessfully proposed a moratorium on the use of additional basins for fish rearing until ecological criteria could be established to measure the impact of rearing activities

on individual wetlands and shallow lakes. The 2007 legislature required the DNR to submit a report on the effects of fish rearing, and this report was submitted in January of 2008.

Physical Disturbance

Disturbance to waterfowl by watercraft often accompanies increasing human populations and shoreline development. Negative impacts to waterfowl caused by motorized surface use of lakes has been documented both during spring and fall migration (Kahl 1991, Havera et al. 1992). Waterfowl often take flight when approached by motorboats. Boating activity related to fishing, hunting and general recreation can decrease the amount of time the ducks have to forage and increase energy expenditure through flying from the disturbance. Kahl (1991) quantified the time and energetic impacts of boating disturbance for canvasbacks on a Wisconsin lake. Boating disturbance accounted for 50% of the time canvasbacks spent away from feeding areas during the spring migration in this study. Several other studies have documented negative impacts of motor boat activities on migrating and breeding waterfowl (Korschgen and Dalhgren 1992, Liddle and Scorgie 1980). Currently under Minnesota law, specific lakes can be designated Migratory Waterfowl Feeding and Resting Areas (MWFRAs), which restrict motorized use only during the waterfowl-hunting season. Recreational fisheries and high water have impacted some MWFRAs. Without opportunities to rest and refuel undisturbed, waterfowl move through the state quickly.

The DNR recently completed a statewide survey of refuges and rest areas and found significant gaps in the statewide quantity and quality of sites available to migrating flocks. Although the process for establishing refuges and rest areas differs by ownership and type, it is usually dependent on citizen initiation and support.

In addition to direct disturbance of birds, power boating can also directly and indirectly impact aquatic vegetation (Asplund and Cook, 1997) and increase turbidity in shallow lakes (Anthony and Downing, 2003, Wagner 1991). Motors can directly impact aquatic plants by uprooting and cutting them. Motor boating activity particularly in shallow lakes with soft bottom substrates can increase phosphorus concentration in the water column by disturbing lake sediments (Yousef et al. 1980).

Increased Shoreline Development

Ever increasing demand for shoreline property has resulted in development on lakes that historically would not have been considered suitable for lake homes. In addition to increased surface use, which can lead to waterfowl disturbance, shoreline development usually results in loss of shoreline vegetation and submerged vegetation. Both types of aquatic vegetation are valuable for wildlife and waterfowl habitat. Increased development can result in increased pressure to manage lakes for a sport fishery, which can lead to further habitat changes and increased conflicts between fishermen and waterfowl hunters. Management based on the ecological function of a shallow lake may become more difficult in these situations.

Increased shoreline development can indirectly impact management potential of a basin. Drawdowns have long been recognized as valuable management tools for wetlands and shallow lakes, not only for waterfowl and wildlife benefits, but also for water quality improvements. This tool, however, is controversial and often not viewed as beneficial by shoreline owners. As shoreline development increases on a particular shallow lake, it becomes politically difficult to perform managed drawdowns on that lake.

Climate Change

In the next 100 years, average temperatures in both winter and summer are predicted to increase by 5-12^{o}F in winter and even more in the summer (Kling et al. 2003). Precipitation patterns are also predicted to change with the frequency of extreme weather events increasing by 50-100% of current values (Kling et al. 2003). The impacts of these changes on shallow lakes are unknown. However, one likely impact that may already be occurring is decreased winterkill of fish populations. Many studies have shown that fishless basins provide the best waterfowl habitat, but are increasingly rare (Hanson and Riggs 1995, Bouffard and Hanson 1997). Fishless basins tend to be small and isolated. Drainage and tiling have led to direct loss of these basins or connected them to other water bodies with fish. Frequent winterkill is one of the mechanisms that eliminate fish from a lake or wetland. Recent research (Fang and Stefan 2000) indicates that the likelihood of winterkill is strongly reduced in northern states under several predicted climate change scenarios. Ice out data from Minnesota also indicates a trend of shorter duration of ice cover on Minnesota Lakes (Figure 9). Shorter duration of ice cover would contribute to reduced frequency of winterkill.

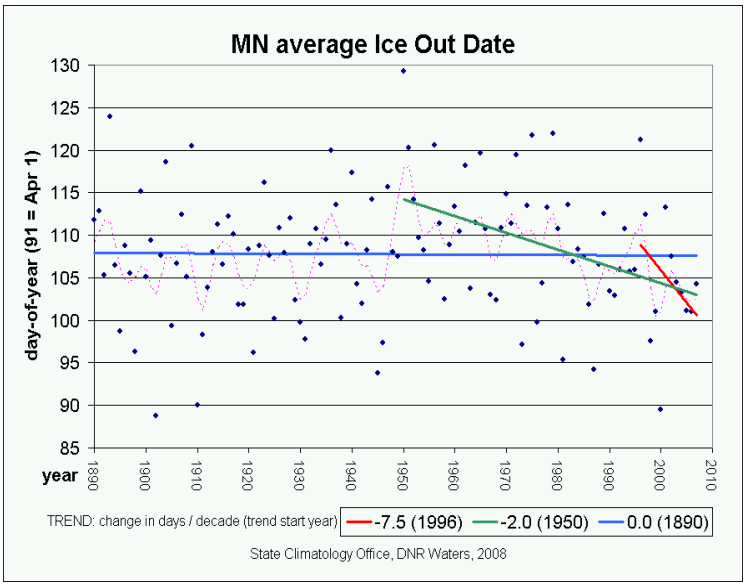

Figure 9. Average date of lake ice out from historical data on several lakes across the state. Pink dashed line represents short term trends.

There are several other potential affects of climate change that are less well understood including the impacts of warmer temperatures on invertebrate populations and aquatic vegetation. Models indicate that rainfall amounts and timing of rainfall events will be more variable in Minnesota. More rainfall would have negative impacts on aquatic vegetation in shallow lakes. The increased runoff associated with more severe rain events is expected to increase pollution of the state's surface waters (Carstensen et al. 2008). This added pollution would also have negative impacts on aquatic vegetation and waterfowl habitat. Increased warming may lead to increased summer water temperatures could exacerbate internal phosphorus loading in lakes (Malmaeus et al.

2006). Management strategies to deal with or reduce internal nutrient loading will continue to be needed.

OPPORTUNITIES AND MANAGEMENT APPROACHES

The multiple problems affecting shallow lakes require a variety of tools to address those problems. Some of the most common tools are summarized below. While this and other plans will provide the overall framework for a state-wide management approach, each managed lake will require an individual management plan that will include multiple strategies and tools to deal with specific impacts or threats. Shallow lake management requires ingenuity and creativity; therefore this list is not comprehensive, and new tools may be developed. The tools in this summary can be divided into three basic categories: direct protection, habitat and water quality improvement, and regulatory and policy protections.

Direct Protection

Some shallow lakes in the state are in good condition both with respect to waterfowl habitat and water quality. The primary management objective for those lakes should be to maintain and protect that existing habitat. The likely reason some of these lakes remain in good condition is absence of invasive species, small watershed with less development or little loss of native vegetation and wetlands, and lack of extensive shoreline development. For such lakes surface use restrictions could be implemented to protect the aquatic plants, maintain water clarity, and minimize disturbance. Watershed and shoreline protection can be done through direct acquisition from willing sellers and through conservation easements available through various programs and non-profit organizations (RIM, WRP, USFWS, NRCS, SWCDs and DU). Additionally, new programs providing incentives for conservation easements or acquisitions targeted for shallow lake watersheds and lakeshores could be developed. All of the above tools require working cooperatively with various partners.

Criteria to consider for targeting lakes for direct protection are: quality of existing habitat, size of watershed (smaller the better), waterfowl use, water level management potential, and proximity to features that would contribute to a complex of habitat.

Such tools can also be applied to degraded lake systems as a part of a comprehensive habitat restoration plan that includes in-lake management. Research on shallow lake management demonstrates that watershed restoration is not sufficient to restore water clarity and plants in degraded shallow lakes due to continued internal nutrient loading. However, wetland and grassland restoration and protection would also serve additional benefits by forming habitat complexes of shallow lakes, wetlands and grasslands. These complexes are a key component of achieving the goals of the Duck Plan.

Habitat and Water Quality Improvement Tools

Shallow prairie lake ecosystems evolved under climatic conditions that featured periodic droughts of varying degrees of intensity. Severe droughts typically occurred every 8-15 years with mild droughts occurring about twice as often. The result was basins with good quantities of emergent vegetation such as bulrush and lush submerged vegetation. The periodic droughts combined with severe winters to limit fish populations. Lakes with flowing outlets often harbored game fish that moved upstream in the spring. The surrounding uplands were typically dense prairie grass that enhanced infiltration of rain, minimizing the amount of run-off into lakes and streams. Changes mentioned above (climate change, altered hydrology) have reduced or eliminated natural drought cycles.

Drawdown

The most effective management technique mimics historical droughts through water level manipulation known as a “drawdown”. A drawdown is an effective and relatively inexpensive shallow lake management tool that addresses both problems with internal nutrient loading and loss of aquatic plants. This temporary water level manipulation restores aquatic vegetation, improves water clarity, removes fish or temporarily reduces fish abundance and increases invertebrate abundance. Sediments are consolidated when they are subjected to drying, reducing wave re-suspension thereby increasing water clarity when the basin is re-flooded. Sediments are also aerated, reducing release of phosphorus into the water column. Additionally, many aquatic plant seeds, especially bulrush, need to be dried or need mud flats to germinate. Since natural droughts occur periodically, drawdowns will also need to be repeated over time as habitat conditions change.

Fish Management

On many basins, drawdowns are not possible. Some lakes do not have outlets, or the outlets lack sufficient change in topography to lower water levels. Lakes with large watersheds are difficult to drawdown. For these basins, other tools need to be considered including rotenone treatments, fish barriers and predator fish stocking. These tools need to be applied to appropriately identified problems in conjunction with individual lake management plans. Like drawdowns, fish management in shallow lakes is an on-going process; the results of any single treatment are not going to last indefinitely. Management and treatments will need to be repeated if habitat quality is to be maintained.

Fish barriers are installed to prevent or reduce carp populations. Barriers come in several different types and configurations including physical barriers, mechanical barriers and electric barriers. These barriers reduce or prevent upstream movement of fish. Preventing downstream movement is more difficult. The site and budget will determine which barrier is best suited to a particular site. Ideally, these barriers are placed prior to drawdowns or chemical treatments aimed at reducing fish populations.

Basins that have limited connections to other water bodies are the best candidates for fish barriers. In many situations however, it is difficult to find an effective fish barrier or means of removing fish above a barrier.

Rotenone is a piscicide derived from plants from the *Derris* genus. It has been used as a fisheries management tool for decades. Wildlife managers in Minnesota and elsewhere use this chemical primarily to manage carp in shallow lakes. Due to the cost and overall desire to limit chemical treatments, this tool is usually used when full drawdowns are not possible as a means of fish control. Rotenone can be most effective when applied to isolated water bodies, those either naturally isolated or through means of fish barriers. However due to the difficulty of obtaining effective treatments in shallow, nutrient rich systems, treatments may need to be repeated or combined with drawdown. It typically is applied in the late fall, but a specific treatment plan needs to be prepared for each basin considered for such a treatment.

Predator fish stocking has been studied as a management tool for degraded systems, including wetland systems in Minnesota. The idea is predators can control lower trophic levels and ultimately result in reduced algal biomass. An example of predator stocking in Minnesota has involved experimental stocking of walleye to control fathead minnows in wetland systems (Herwig et al. 2004). In the simplest explanation, walleye fry eat fathead fry, zooplankton populations are able to increase and these zooplankton reduce algae abundance through their filter feeding activities. Northern pike have been used in other states to try to reduce carp recruitment (Cunningham, personal communication). Carp reach a large enough size in their second year of growth to escape predation pressure by other fish; however control likely occurs at larval or early stages. Research has also shown that this tool is usually not effective when used alone but should be combined with other management treatments (Scheffer 2004).

Fish populations can naturally occur in shallow lakes. Historically, they have been periodically limited by winter-kill, although less so more recently as discussed earlier. Popular game species including northern pike, largemouth bass, sunfish, perch and crappies can all naturally occur in some shallow lakes. Given the natural occurrence of these species, it may be appropriate to use fish as a management tool in these shallow lakes. In fact, it will be necessary in many lakes to manage them in part for recreational fishing opportunities. In many shallow lakes, it is not feasible to manage them without fish. Game fish may provide some competition and control, as mentioned above, of less desirable species. Conflicts between waterfowl hunters and fishermen have occurred when management of fish and waterfowl interests do not align. Fish populations can be maintained by aeration even when water quality and aquatic plant abundance has deteriorated, resulting in lakes with recreational fishing opportunity but poor water quality and wildlife habitat. When fish are present or used as a management tool in shallow lakes, careful balance of expectations both among resource managers and the public are necessary. When aeration is considered to maintain gamefish populations, ultimate goals should be to maintain good water quality. In “deeper” shallow lakes, or tweeners, aeration may be used as a tool to maintain piscivorus fish aimed at controlling carp and other fish that contribute to internal nutrient loading. Everyone will need an

appreciation of the dynamic nature of these systems for such management approaches to be successful.

The general public often perceives some of these in-lake tools, including drawdowns and rotenone treatments, as being overly drastic. Research on management of degraded shallow lakes indicates that these drastic measures are exactly what is needed to overcome multiple stressors (loss of plants, abundant algae, suspended sediments, internal nutrient loading from fish) that are maintaining the poor habitat and water quality conditions.

These in-lake strategies should be combined with watershed restoration and protection. Key watershed tools are best agricultural management practices and wetland and grassland protection and restoration. Biomanipulation attempts are more likely to be successful in improving water clarity in those cases where watersheds have more grassland (Reed 2006).

Restoration and protection of watersheds could also make these shallow lakes more resistant and resilient to impacts caused by many different stressors including climate change. Loss of biodiversity and function makes systems less resistant to impacts including pollution and climate change (Folke et al 2004). The resilience of ecosystems can be reduced by anthropogenic pressures and ultimately affect ecosystem function. An ecosystem's capacity to absorb changes and "repair" itself is not a certainty, thus adaptive management will be necessary to maintain ecosystem function or desired ecological states (Folke et al. 2004).

Habitat Management for Wild Rice

Management of lakes for wild rice has been focused in the forested part of the state. Historically, the native range of this plant extended well beyond the forested regions of the state, but it is not currently common in lakes much beyond the transitional zone.

Lakes in the forested region have been less impacted by wetland drainage. Management for wild rice has included removal of beaver dams or cattail bogs that have obstructed lake outlets. This management is relatively inexpensive, yet effective. Removing outlet obstructions minimizes both high water and rapid water level changes, which can damage wild rice.

In some instances, water levels on historic wild rice lakes have been raised or stabilized by installation of dams, or the outlets were impacted by road culverts. Simply modifying the dam or outlet structure to allow historical water levels and natural fluctuations can be enough to restore wild rice. Lake Onamia is an example of wild rice restoration by outlet dam replacement.

There are some lakes that historically have produced wild rice, but it is unlikely a viable seed bank remains due to the number of years since it has grown. Seeding may be considered if the reason for the original loss of wild rice has been mitigated.

Regulatory Tools for Protection of Shallow Lakes and Wildlife Resources

Legal Issues Associated with Water Level Management and Lake Designation Through M.S. 97A.101

Water levels and water management is governed through M.S. 103G and associated rules in Chapter 6115. Changes in water levels or active management of water levels in lakes is difficult to achieve in many cases due to requirements in statute. There are some allowances in statutes that can allow water level management through permitting and following of statutory procedure/requirements. A limitation of the 103G statute is the regulatory authority is below a lakes Ordinary High Water (OHW) Level only. It does not regulate some practices around lakes that can ultimately impact lake water levels and water quality. For example, a field can be tiled and out-letted into a protected water body as long as the tile outlet is above the OHW level. Mitigation of such water level impacts involves work below the OHW level, thus requiring sometimes multiple permits and regulatory approvals so at times it seems that the scales are tipped against wildlife managers desiring to protect and improve habitat and water quality in shallow lakes.

Management of water levels in lakes and wetlands can be governed by many laws and levels of government which makes implementing new water level management projects a complicated and lengthy process. Such management is regulated by the state both through DNR and the Board of Water and Soil Resources through M.S. 103A-G statutes (and the Wetland Conservation Act M.R. Chapter 8420). The Army Core of Engineers also has regulatory authority over some of these projects. Any water management project involves coordination with multiple entities and agencies that may have regulartory authority over a particular aspect of a project, resulting in a long and usually complicated process toward implementation.

M.S. 97A.101 is one of the strongest legal management tools available to the Section of Wildlife for shallow lake management purposes. This authority was originally passed by the legislature in1969 by adding language to Section 97.48 subdivision 11 of the 1967 Session Laws. This additional authority to manage water levels for the benefit of wildlife was added due to the support from the Southern Minnesota Waterfowl Association and other sportsmen's groups. The new statutory language gave the department the authority to manage water levels on designated lakes for the benefit of wildlife without obtaining written permission or flowage easements from all riparian landowners. Legal requirements include legal notice and a public hearing on the proposed management.

Originally the statute applied to the portion of the state south of U.S. Highway 12. In 1975, the statute was modified to apply to the entire state. Further modifications have occurred to the statute including the prohibition of airboat use on designated lakes and the addition of authority to restrict motorized surface use.

Other legal mechanisms to manage water levels in lakes are also available and include: obtaining flowage easements from all riparian landowners, acquiring all shorelines

through fee-title purchase or obtaining signatory permission for one-time drawdowns. Wildlife Lake Designation is the most public of these options as an extensive review process is required. Through this statute, drawdowns can be conducted without permission from all landowners, making it the only viable option for water level management authority in some cases. One-time signatures are not often used to gain management permission, as a capital investment in a water control structure would not be made without long-term management authority. In 2009, additional language was passed (M.S. 103G.408) by the legislature allowing drawdowns if 75% of riparian owners signed off on the proposed management and a public hearing was held. This new language may offer expanded water level management opportunities beyond those for wildlife benefits. Further changes in statutes that regulate drainage surrounding lakes and water level management may be needed to fully achieve goals of this plan or to deal with problems of water quality in lakes beyond the scope of this plan.

The lake designation process is long and can be controversial. Survey and feasibility studies are often needed to determine management potential. Legal access and control of the lake outlets are required in order to construct structures. Landowners and local units of government are involved in the process and review of draft management plans. As of February 2010, 44 lakes have been designated for wildlife management purposes.

Shoreline Classification

Shallow lakes have few regulations and statutes that apply specifically to wildlife and waterfowl habitat. These lakes receive protection under shoreline rules, as do all public waters. Many shallow lakes fall under the zoning classification of Natural Environment Lakes, which have the most stringent shoreline development standards of the current classifications. Statewide shoreline management standards may soon undergo revision with options to increase protections of sensitive shorelines/areas, many of which would likely be on shallow lakes. Current standards allow local units of government to implement more stringent standards than the basic statewide standards. Some counties have implemented special standards on lakes with sensitive habitats including some shallow lakes. Current Aquatic Plant Management Rules also limit aquatic vegetation removal on all protected water bodies.

Surface Use and Hunting Regulation

There are options to limit surface use of shallow lakes in order to reduce disturbance to waterfowl and/or protect aquatic vegetation from damaged caused directly by motorboats or indirectly from increased turbidity caused by motor-boating activities. Wildlife lake designation statute including Minnesota Statute 97A.101 provides the authority to restrict motorized surface use on Designated Wildlife Lakes. This is the only tool available for limiting motor-boating activity outside of the waterfowl-hunting season for the benefit of waterfowl.

The intent of the following regulations is to protect migrating waterfowl. These regulations apply only during the waterfowl-hunting season and do not protect the lake habitats that waterfowl are using.

MWFRAs can be used to minimize boating disturbance but only during the waterfowl season. MWFRAs are open to hunting, but not motorized boat use (M.S. 97A.095)

Refuges can be used to limit hunting-related disturbance during the waterfowl-hunting season. Lakes within refuges are closed to hunting but not other forms of surface use. Surface use is not restricted during the rest of the year. (M.S. 97A.085 and 97A.095).

Migratory Waterfowl Sanctuaries can be used to prevent all surface use, including hunting, during the waterfowl-hunting season. Lakes within Sanctuaries are open to surface use the rest of the year. (M.S. 97A.095).

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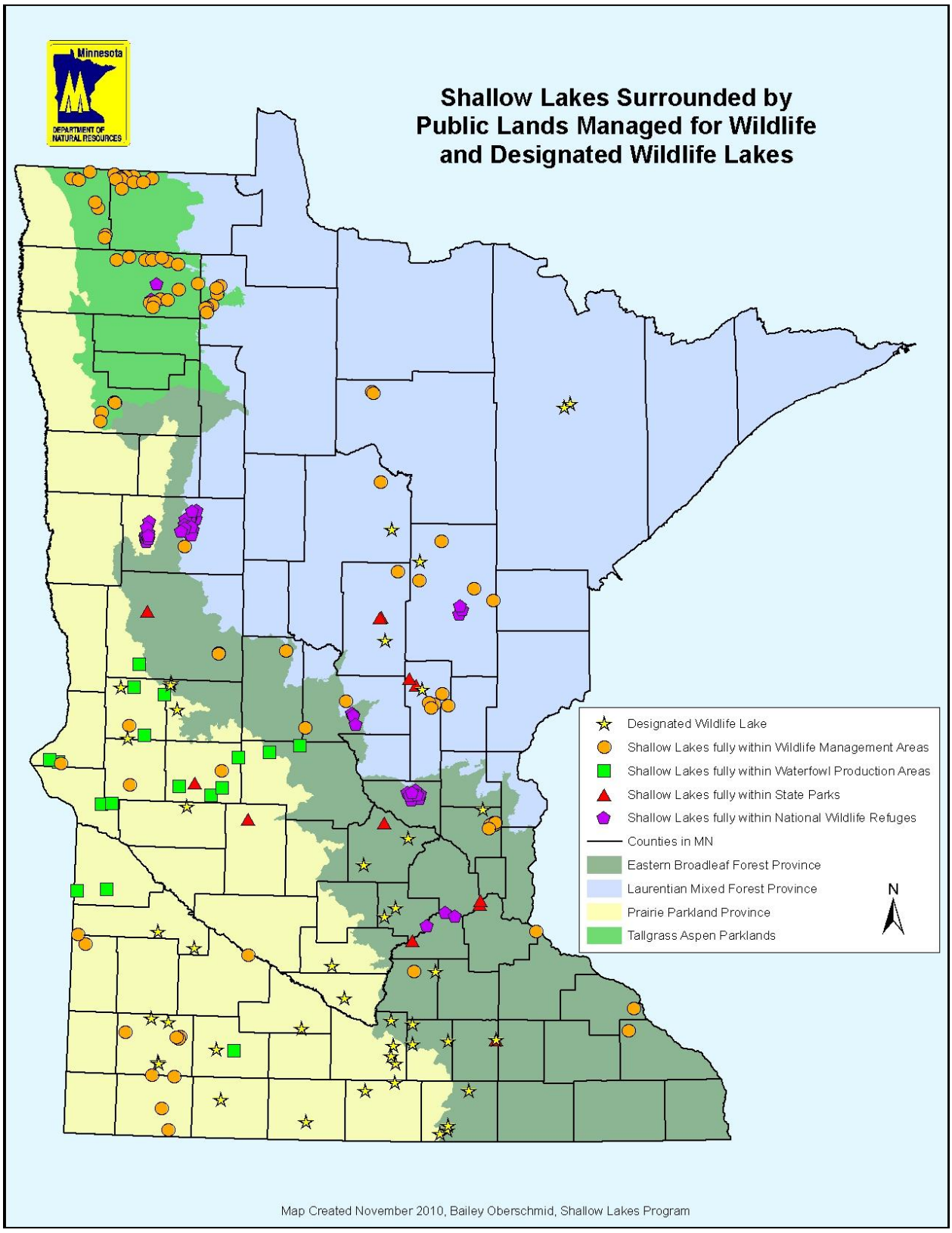
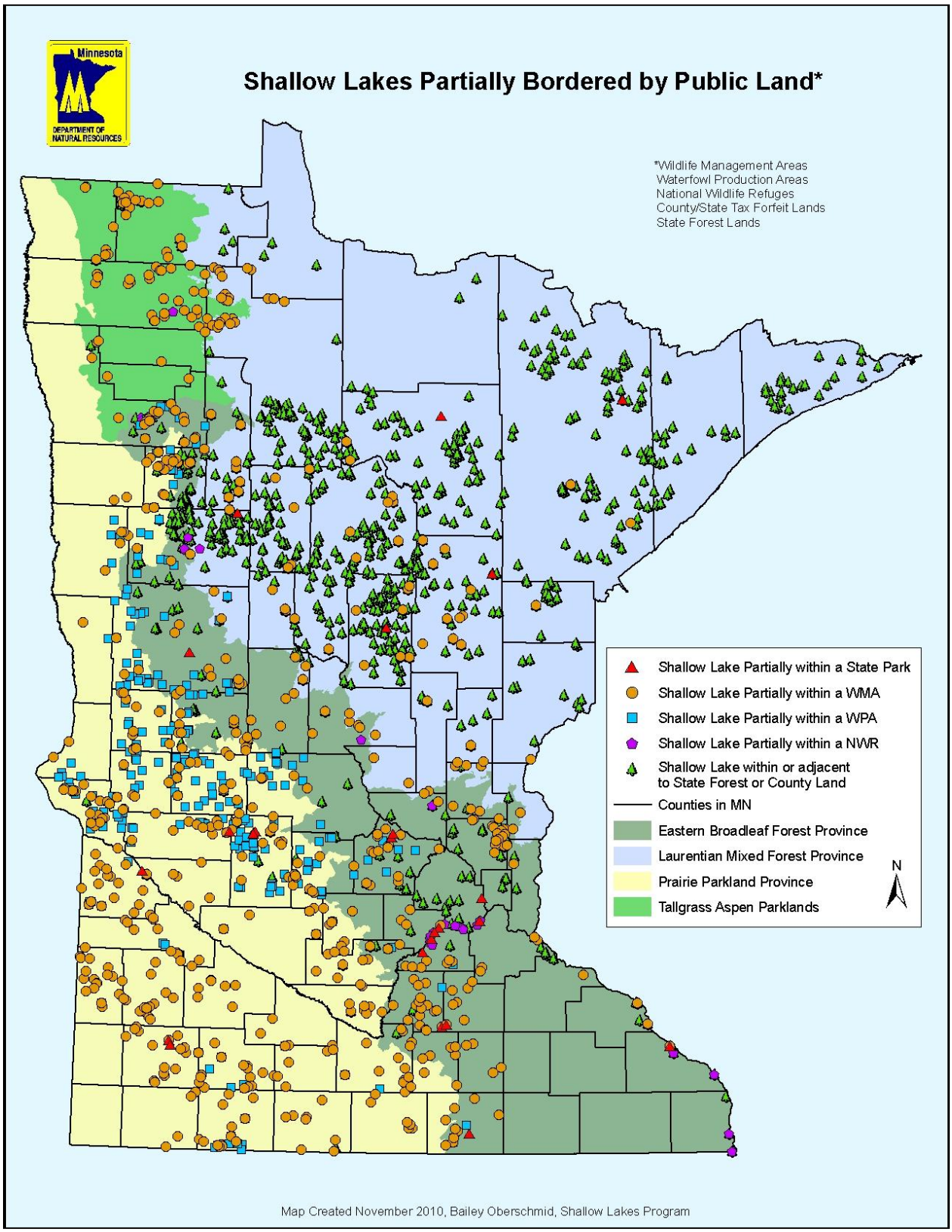
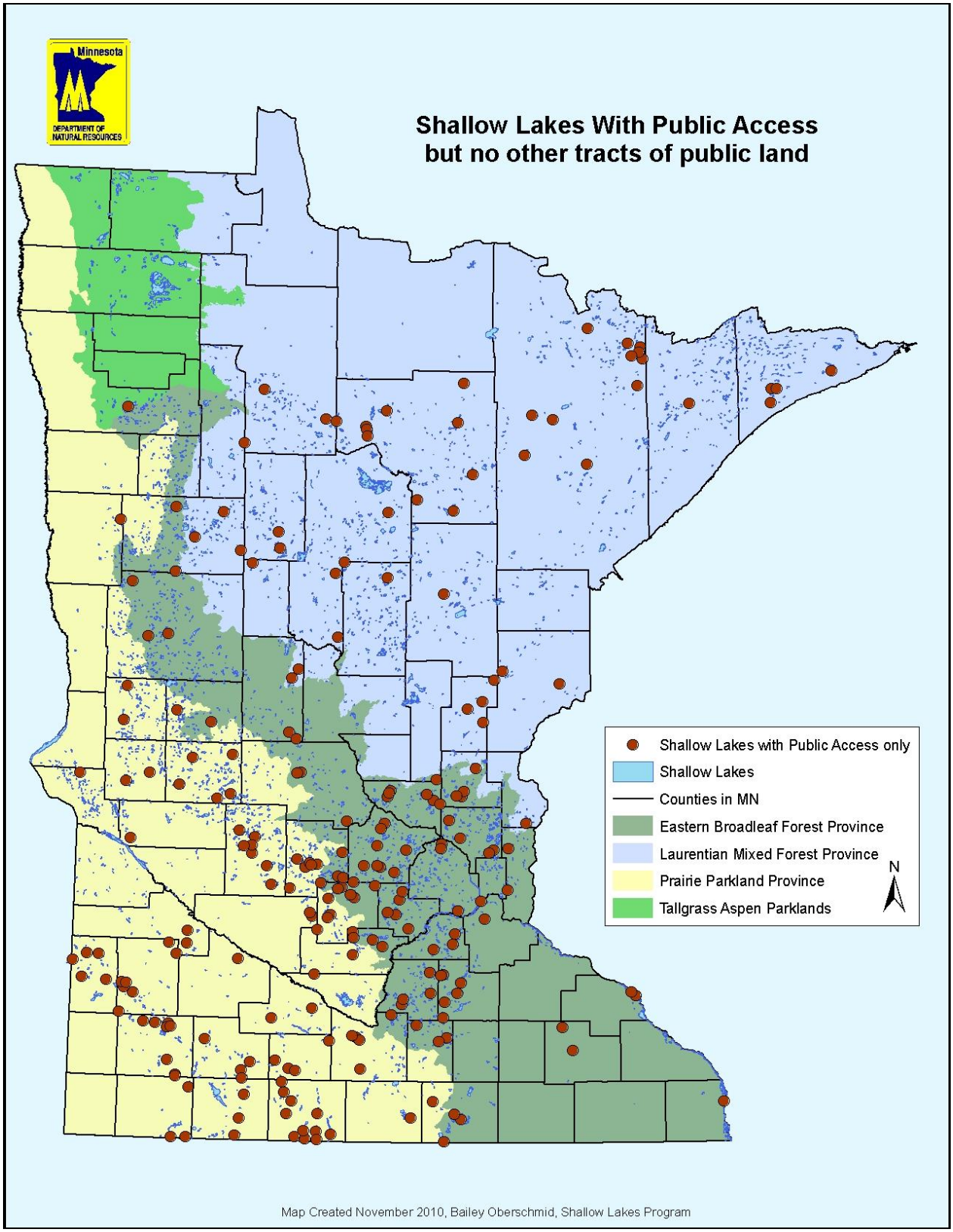
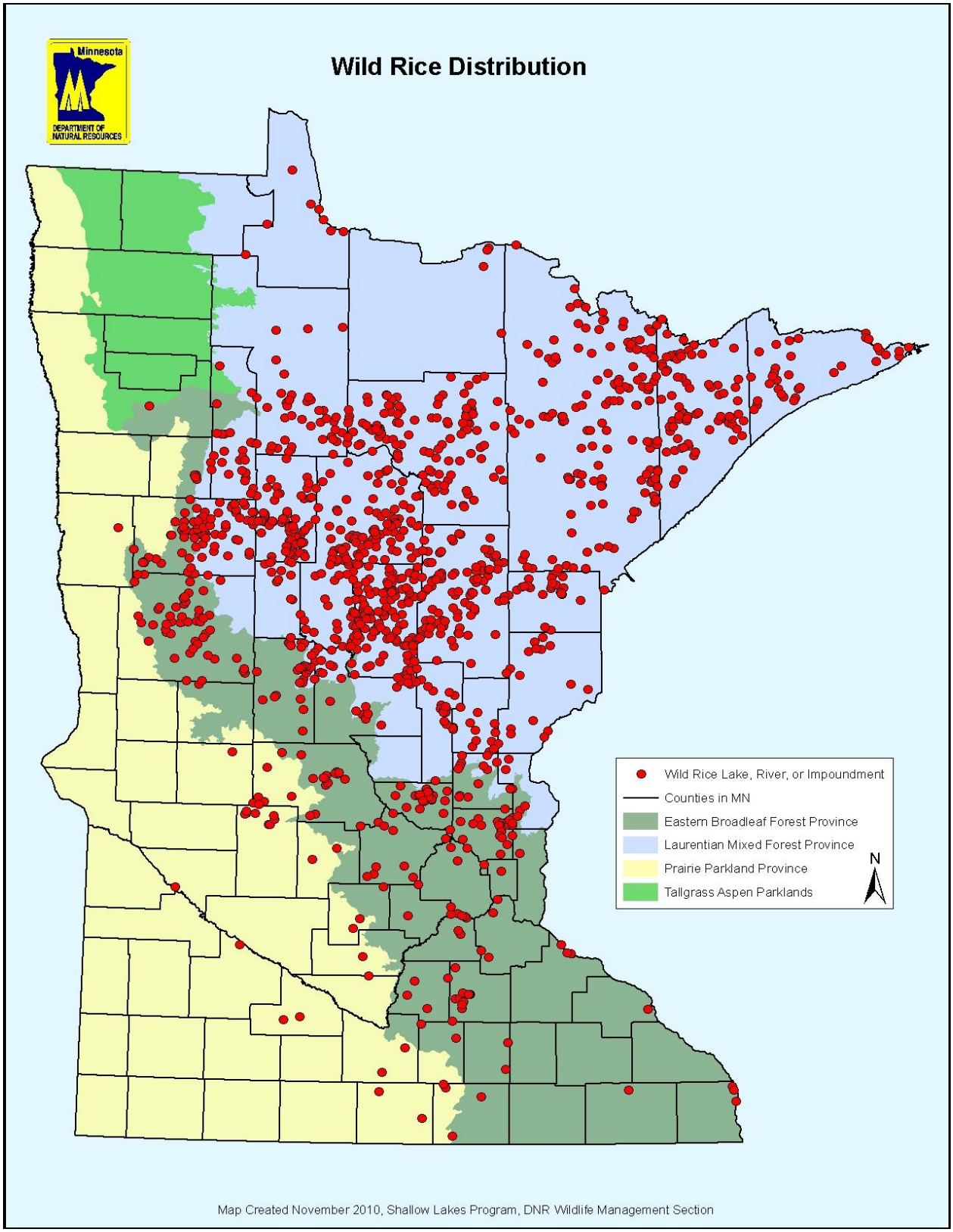
Appendix A: Distribution Maps of Shallow Lakes Targeted for Management




Minnesota
DEPARTMENT OF NATURAL RESOURCES
Shallow Lakes Partially Bordered by Public Land*
*Wildlife Management Areas
Waterfowl Production Areas
National Wildlife Refuges
County/State Tax Forfeit Lands
State Forest Lands
Shallow Lake Partially within a State Park
Shallow Lake Partially within a WMA
Shallow Lake Partially within a WPA
Shallow Lake Partially within a NWR
Shallow Lake within or adjacent to State Forest or County Land
Counties in MN
Eastern Broadleaf Forest Province
Laurentian Mixed Forest Province
Prairie Parkland Province
Tallgrass Aspen Parklands
N
Map Created November 2010, Bailey Oberschmid, Shallow Lakes Program


Minnesota
DEPARTMENT OF NATURAL RESOURCES
Shallow Lakes With Public Access
but no other tracts of public land
Shallow Lakes with Public Access only
Shallow Lakes
Counties in MN
Eastern Broadleaf Forest Province
Laurentian Mixed Forest Province
Prairie Parkland Province
Tallgrass Aspen Parklands
N
Map Created November 2010, Bailey Oberschmid, Shallow Lakes Program


Minnesota
DEPARTMENT OF NATURAL RESOURCES
Wild Rice Distribution
Wild Rice Lake, River, or Impoundment
Counties in MN
Eastern Broadleaf Forest Province
Laurentian Mixed Forest Province
Prairie Parkland Province
Tallgrass Aspen Parklands
N
Map Created November 2010, Shallow Lakes Program, DNR Wildlife Management Section