Prairie Pothole Region Integrated Landscape Conservation Strategy-

Report for USDA- Farm Service Agency Agreement with US Fish and Wildlife Service-Habitat and Population Evaluation Team (HAPET; Agreement #: 13-IA-MRE CRP)

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Summary:

The Prairie Pothole Region Integrated Landscape Conservation Strategy (PPRILCS) is a collaborative effort, initiated and led by the US Fish and Wildlife Service- Habitat and Population Evaluation Team (HAPET-Region 3) with support from USDA- Farm Service Agency, working in partnership to promote interdisciplinary and inter-agency coordination of conservation programs to achieve value-added benefits for wildlife, water quality, and flood reduction in agricultural landscapes. The PPRILCS partnership is developing innovative decision support tools to guide strategic conservation for multiple environmental and economic benefits. PPRILCS links multi-benefit spatial models and innovative GIS-based decision support tools to guide the integration of conservation programs. As such, PPRILCS is both a venue for nontraditional inter-agency coordination and a nexus for the integration of spatial models.

Toward these ends, the PPRILCS partnership is working to develop, coordinate, and systematically leverage an array of spatial models that prioritize conservation efforts and predict outcomes, using the best available science, for **1) wildlife, 2) water quality, 3) flood reduction, and 4) agricultural economics**. The resulting products are intended to be utilized to identify priorities for single objectives and systematically evaluate shared priorities/targets for multiple objectives, and to explore cost-benefit relationships of various possible landscape-scale conservation strategies. The envisioned package of spatial models will ultimately inform conservation design scenarios, help to set reasonable population targets, and inform water quality and flood reduction targets, to help to answer the questions "*what is a truly 'functional landscape' and what does it look like?*", (i.e., "*how much is enough?*", "*how much is too*

much?", *"how do we get there most efficiently—and what will it cost?")*, in more meaningful and accurate ways than have previously been possible.

The desired end products for this effort are twofold:

1) Map-based priorities highlighting the greatest opportunities for multiple conservation benefits
2) A "bottom up" process for evaluating explicit conservation strategies and/or targets and their related (multi-benefit) outcomes.

The success of this effort thus far has greatly benefited from the contributions of a wide array of partners, without which this effort would not be possible. A detailed list of participants is provided in *Appendix A*.

The following report describes the philosophical basis of "integrated" multiple-objective conservation, highlights the overall PPRILCS framework, describes the progress and current status of the technical teams' efforts, and provides a series of examples to illustrate how this increasingly powerful toolset can be applied in the context of multi-scaled conservation design strategies to inform spatial priorities for the restoration of wetlands and uplands, strategic targeting of CRP and other conservation programs, as well as a wide variety of other conservation planning and design applications.

It should be noted that many of the underlying components (including the foundational LiDAR topographical data, landcover data, hydrologic models, nutrient models, and a suite of wildlife species models) have only recently been completed; some are still in development. The complexity of this effort, and interdependency of partners' contributions, has meant that progress has not always been as rapid as was originally hoped. As such, the PPRILCS pilot effort remains a work in progress.

Responding effectively to the diverse conservation challenges in the PPR depends on the collective technical capacity of the PPRILCS partnership, the political will to think beyond silo programs and single objectives, and ultimately the ability to move forward with an agreed upon work plan that builds upon partners' respective expertise in a systematic and inter-dependent way. This effort, in many ways, embodies a new way of doing business amongst the conservation community—spanning well beyond the scope of any single agency or organizational mission, toward value-added products that are greater than the sum of their parts. We are continually reassessing and adapting based on emerging opportunities and available resources.

The tools described below provide the foundation for what is becoming one of the most powerful sets of integrated spatial planning and outcome-based modeling toolsets available to the conservation community—anywhere in the world. Each of the respective tools serves a purpose independently, but exactly how to integrate these tools has been an ongoing process of exploration and discovery for the partnership as a whole. As of fall 2013, the fundamental building blocks are largely complete for our first pilot study area—the Buffalo River (HUC08) watershed in Minnesota. The conceptual framework has been firmly established; yet much work remains to integrate and apply these techniques toward their full potential.

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Background:

Study Area

The eastern Prairie Pothole Region of Minnesota and Iowa (henceforth, the PPR) encompasses an area historically covered by extensive tallgrass prairie and densely distributed depressional "pothole" wetlands that were formed by remnant glacial debris from the Wisconsin Glaciation, deposited approximately 12,000 years ago. The pre-settlement prairie-wetland system of the PPR was dynamic and highly productive, driven by natural climatic variations that affected hydrologic cycles and fire patterns across the region, creating a diverse mosaic of wetlands and grasslands that supported abundant resident and migratory wildlife populations and provided a broad range of ecosystem services—much of which persist today at vastly diminished levels.

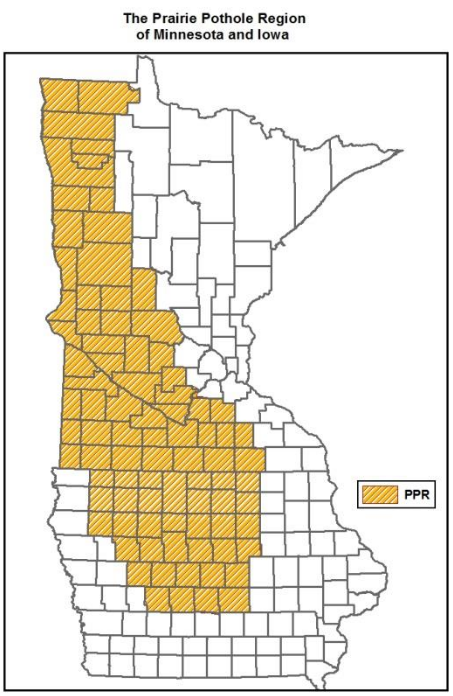


Figure 1. The Prairie Pothole Region (PPR) of Minnesota and Iowa.

Agricultural conversion has greatly altered the PPR landscape and continues to do so. The rich soils maintained by the deep roots of the native grasses encountered by early settlers provided optimal conditions for agricultural crops, yet the sheer density of wetlands posed many challenges for farmers. Extensive conversion to agriculture began in the 1800s, as settlers plowed up prairie and drained wetlands on a field-by-field basis, using hand tools and horse or oxen-drawn plows. Technology evolved rapidly into the 1900s, leading to widespread industrialized approaches to wetland drainage and grassland conversion that utilized enormous steam-powered dredging machines that altered vast stretches of the region's landcover and hydrology. Federal policies continued to encourage extensive wetland drainage into the 1970s. What remains today is a highly modified agricultural landscape, dominated by corn and soybeans. In Minnesota and Iowa, less than 0.1% of the native prairie remains and approximately 80% of wetlands have been drained, approaching 100% loss in the most intensively farmed counties of southern Minnesota and throughout Iowa; essentially all remaining unprotected habitat continues to be threatened by row crop conversion, driven by unprecedented agricultural commodity values in recent years.

Agricultural transformation of the PPR landscape has arguably provided society with food, livestock and feed, and energy crops from some of the world's best farmland. Yet there have also been undeniable consequences for native wildlife, nutrients and sediment in water, flooding problems, and declines in a multitude of other ecosystem services like carbon storage and pollination, many of which have yet to be fully quantified by researchers. Compared to historical levels, waterfowl and grassland bird populations have declined dramatically, water quality problems have increased, and widespread flooding has occurred with greater intensity and increased frequency in recent years—all of which impose certain costs on society, at various scales, that can be quite difficult to account for in space and over time.

Today's conservation estate in the PPR is a patchwork of thousands of state, federal, private, and NGO-owned parcels, a combination of permanently protected habitat, temporary easements, and some unprotected habitats remaining on private lands. Parcels range greatly in size, landscape context, management practice, and ecological functions—from small isolated wetlands embedded within cornfields, small patches of remnant native prairie, and temporarily protected fields of dense non-native grasslands, to permanently protected tracts of upland and wetland habitat, clustered wetland-grassland "complexes", Wildlife Management Areas, Waterfowl Production Areas, State Parks, and National Wildlife Refuges; various temporary and permanent easement programs like the Conservation Reserve Program (CRP) and the Wetland Reserve Program (WRP) are also widespread and play an undeniably important role in conservation throughout the region.

While a diverse array of conservation programs serve to protect remaining habitat and restore croplands to grassland and wetland cover, habitat is simultaneously being lost. Agricultural production continues to drive the conversion of unprotected grasslands to cropland, and the drainage and consolidation of wetlands, at a pace that has been difficult for conservation programs to match. The expiration of temporary conservation easements enrolled in CRP has resulted in declines of hundreds of thousands of acres of conservation lands in recent years—a trend that may continue into the future as several hundred thousand acres of CRP enrollments will expire over the next decade in this region.

The PPR landscape continues to change. The need for a comprehensive conservation strategy for the PPR has arguably never been greater. In Minnesota alone, over $70 million is spent annually on wetland restoration efforts and sales tax revenue provided through the Minnesota Clean Water, Land, and Legacy Amendment is expected to provide upwards of an additional $80 million per year for habitat protection and restoration efforts over the course of 25 years. Comparable funds are available to support clean water projects, and a diverse contingent of federal, state, and NGO partners simultaneously focus on water-related objectives (though notably this tends to be a different group of agencies and individuals than those who work on wildlife habitat conservation). In some cases these projects align in similar geographies (at times driven by defined spatial priorities or "focal areas" in related plans) and can work to complement each other.

Yet wildlife, water, and agricultural conservation groups tend to work toward different ends, at different scales, in different geographies, with different programs and funds, through different partnerships. Since the 2008 passage of Minnesota's Legacy Amendment, only one project has been funded that explicitly ties wildlife habitat and clean water objectives to leverage the different Legacy funds together. While the many benefits of public conservation lands and the many conservation programs, including CRP, are undeniable, it remains largely unclear how much value-added benefits are provided, or could be provided, by leveraging these programs together. PPRILCS is working to highlight where such programs are working together effectively, and identifying where opportunities exist to do better.

Conservation Planning and Implementation in the PPR

Many plans exist to inform conservation visions for the PPR, including the recently developed Minnesota Prairie Conservation Plan (2012), waterfowl plans, pheasant plans, and a wide variety of regional bird population targets have been established (though most at very broad multi-state scales); Iowa has similarly identified conservation focal areas. Various lists of priority wildlife species exist, ranging in number from a few species to several hundred Species of Greatest Conservation Concern. Total Maximum Daily Load (TMDL) limits are defined for some watersheds with impaired water quality, and the MN Pollution Control Agency has recently committed to developing water quality targets for all major (HUC-08) watersheds, with increasing pressure to account for explicit outcomes through legislation like the Minnesota Clean Water Accountability Act (2013). Exactly how all these various plans and planning targets do or do not fit together remains unclear.

Put simply, we do not know if existing conservation plans fit together in a coherent way; we do not know how much value-added potential is being missed through a failure to integrate plans, priorities, targets, and tools. We do not, thus far, have strong institutional mechanisms to drive integration for multiple benefits. We do not regularly have clear objectives or explicit targets to define "success" or set measurable outcomes related to some balanced and transparent vision for "functional landscapes". Yet agencies are increasingly being asked to estimate and report benefits and set measurable targets at meaningful scales—related to their primary mission/objectives, but also increasingly for collateral benefits as well.

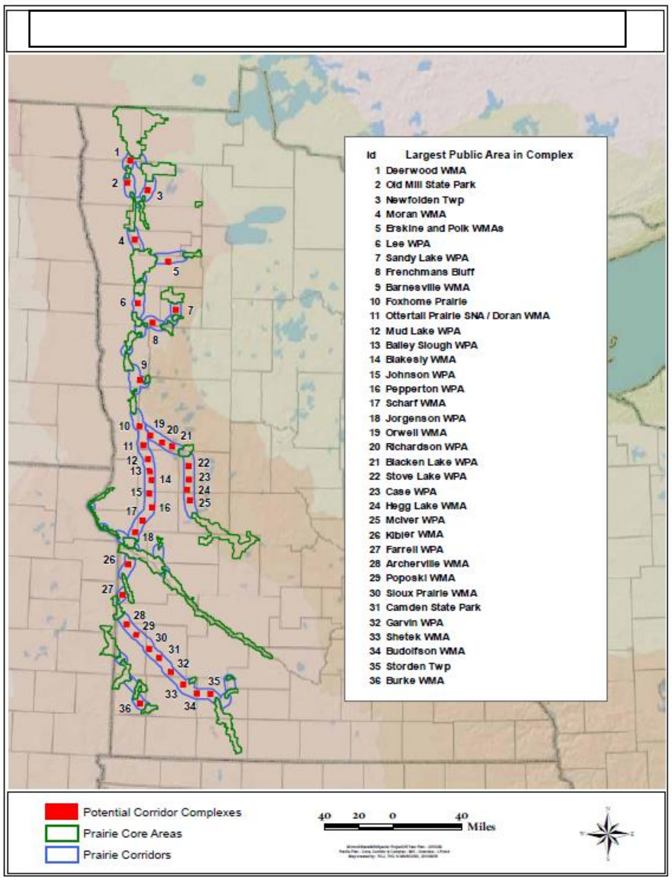


Figure 2. ***MN Prairie Conservation Plan (2012) Focal Areas.*** *The plan identifies focal areas for terrestrial habitat work and sets acreage targets. However, water quality, flood reduction, agricultural priorities, and economic considerations are not part of the plan. Many opportunities exist to build on past efforts and help guide programs to achieve multiple benefits, and to help connect different plans and tools for greater efficiency.*

Given the magnitude of funding anticipated for conservation and the overall potential for restoration in this region, there is a remarkable opportunity to promote greater coordination and efficiency through well-informed collaborative planning and strategic targeting. There is increasing pressure to do so coming from many different directions; and ultimately, the public expects a clear vision for conservation, a reasonable degree of coordination, and accountability for real-world outcomes.

PPRILCS is attempting to harness recent advances in multi-benefit spatial modeling to provide the technical basis to respond to long-standing challenges and emerging opportunities. It is often politically and/or technically challenging to establish targets for wildlife populations, nutrient or sediment levels, or flood reduction—more is generally better, from the perspective of conservation (and generally at odds with goals of maximizing agricultural productivity). PPRILCS begins with establishing strategic priorities, and builds upon that foundation to work systematically toward outcome-based targets and "functional landscape" design.

<u>**A Vision for "Functional Landscapes" Based on Explicit Measurable Objectives**</u>

Strategic Habitat Conservation (SHC), the adaptive management "business model" of the US Fish and Wildlife Service (USFWS), describes a process through which conservation partners work to link biological planning, conservation design, on-the-ground implementation, and research and monitoring to achieve explicit objectives, defined in terms of environmental targets for priority species or other ecosystem services. Biological planning, often considered the first step in the SHC cycle, is founded on the notion that partners can and should determine population targets (a desired size of total animal numbers for particular priority species), and that GIS-based conservation design analyses can then work to prioritize where habitat protection and/or restoration efforts can be implemented to most efficiently achieve the desired targets. SHC is acclaimed for promoting greater efficiency, greater transparency, more effective communication and accountability, thereby encouraging the conservation community to move away from reactionary or opportunistic approaches toward a more proactive paradigm.

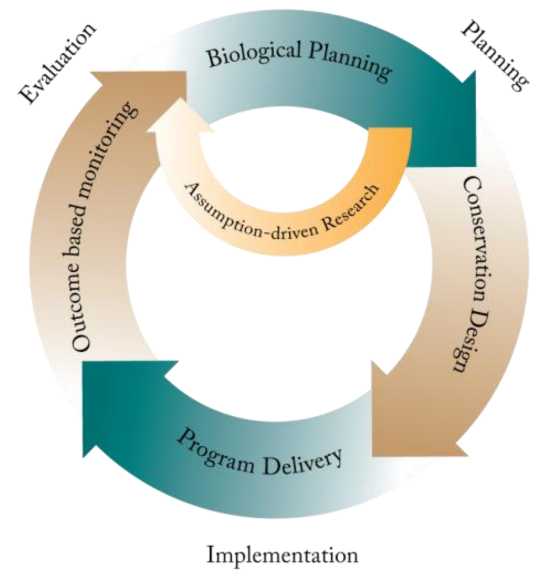


Figure 3. The Strategic Habitat Conservation Cycle. *The cycle typically begins with biological planning, selecting priority wildlife species and setting explicit population for those species. The same approach can be applied to other conservation outcomes (for water quality, flood reduction, etc.); such targets may be inter-related though are regularly dealt with independently.*

In practice for wildlife, however, the process for setting population targets has generally been applied on a species-by-species basis, may lack transparency, can be difficult to scale down to levels directly applicable to management actions, and at times can be downright arbitrary. Partners typically work collaboratively to set population targets based on observed (or assumed) population trends or comparisons with historical population levels; the basis for establishing these targets is not always clear nor are targets necessarily a science-based quantitative estimate that describes the minimum population required to sustain a species over time or an estimate of optimal levels reflecting some strategic landscape design. Thus population targets may be agreed upon by conservation partners, formally or informally, but targets regularly do not directly reflect a scientifically or economically based target nor necessarily a clear vision of what defines a functional or sustainable landscape at some particular scale—rather they reflect a series value judgments about risks, tradeoffs, and uncertainty that are almost always implicit rather than expressly detailed. Population targets rarely account for collateral benefits or tradeoffs associated with multiple species, other desired ecosystems services, or political and economic constraints. Minimum populations necessary for a species' continued survival can be quantitatively evaluated based on genetics and meta-population dynamics for the rarest species, but the definition of conservation "success" for the majority of species of conservation concern, particularly at scales relevant to management decisions, tends to be vague at best.

The general process and range of options for setting population targets has been discussed in detail elsewhere (see Detmers 2009), and has largely focused on dealing with individual species on a case-by-case basis. Few studies, however, have considered the ability for “collateral” ecosystem services, set within an economic framework, to systematically guide the level for biological population targets and other desired ecosystem services (and their associated spatial priorities). A framework for dealing with multiple species in the context of other directly related ecosystem services is largely lacking—the risks, values, constraints, and techniques for doing so have not been comprehensively evaluated. Expanding the SHC framework to go beyond wildlife, encompassing a broader array of ecosystem services like flood reduction and water quality, is theoretically possible and conceptually appealing, yet faces many parallel philosophical and technical challenges.

Single attribute spatial prioritizations can serve to guide strategic habitat conservation without the necessity of population objectives; they can be applied as an index for prioritization that falls largely within the realm of the existing conservation paradigm, which has in recent years (at least in some cases) embraced the notion of promoting the strategic acquisition of sites that would provide the maximum benefit for a single objective (or in many cases a combined overlay of multiple species’ priorities)—and either proactively target the highest priority sites or use spatial priorities to rank available opportunities reactively as they emerge. To this end, SHC has served to encourage extensive progress amongst conservation partners in many places to move beyond simple opportunistic conservation practices. However, population targets for multiple species (and other conservation or economic objectives) may be either reinforced or found to be entirely incoherent when evaluating the relationships between multiple potentially competing (biological and/or ecosystem services) objectives and their associated tradeoffs, particularly in light of economic constraints. An expanded application of SHC that incorporates multiple benefits may help to inform how this complexity plays out in the real world—yet exactly what this means in application has yet to be demonstrated.

Does integration of multiple benefits bring added value to SHC? If so, how do we promote an integrated approach to conservation? Does the integration of multiple benefits alter conservation strategies or reinforce existing approaches? How can multiple competing objectives be dealt with in a meaningful way to inform a vision of “functional” landscapes?

The answer to these questions depends, in part, on the congruence between various interrelated objectives and priorities. For example, if spatial priorities for restoration projects are highlighted in similar locations and the acreage necessary to achieve a desired outcome target is a linear function of the area they encompass, for each objective, then the results will be inherently compatible across multiple objectives. However, if priorities exist at different locations or at different scales, or if one objective requires vastly more acreage (or cost) than the other objectives—essentially if responses are area-sensitive in such a way that response patterns diverge in non-linear patterns—it may be much more challenging (if not impossible) to find common ground that satisfies all objectives.

Addressing the complex realities of environmental economic policies is beyond the scope of this paper. However, we propose that an integration of multiple objectives, incorporating ecosystem services and optimization analyses into a multi-objective framework for SHC, provides an important foundation for strategic planning that can more effectively inform individual population targets at multiple scales and help to guide a vision for "functional" landscapes moving forward. We provide a proof of concept, drawing from existing datasets and spatial models for the PPR, to demonstrate the value-added nature of an "integrated" approach to SHC. Further, we describe a means for progress, despite some apparent incongruence in existing conservation and economic paradigms, in such a way that eases conflict, enables greater transparency, accountability, coordination, and efficiency.

Background on PPRILCS Partnership

In response to the preliminary Steering Committee meetings (Summer 2010), PPRILCS technical teams were established, charged with developing a proof of concept and scope of work to assess the feasibility of an "integrated" conservation strategy—incorporating wildlife habitat, water quality, flood reduction, and agricultural economics—for strategic conservation at the HUC-08 watershed scale. It was decided that technical teams should focus on one or more pilot studies to demonstrate a proof of concept.

The Buffalo River watershed in northwestern Minnesota was selected by the technical teams to be the first pilot study area, due primarily to shared partner interest, readily available data and models, existing partnership technical capacity for spatial modeling, and ongoing decision support tool development that could potentially be leveraged as a component of the Red River Basin Decision Information Network (RRBDIN).

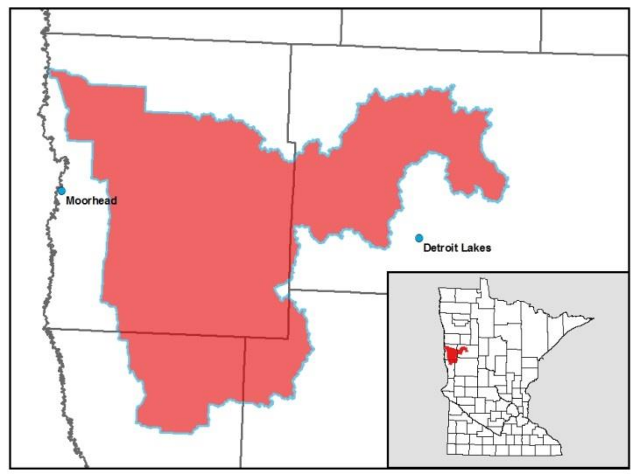


Figure 4. The Buffalo River Watershed, MN--PPRILCS Pilot Study Area. *This area was selected to demonstrate proof of concept for an "integrated strategy" that incorporates spatial models for wildlife, water quality, flood reduction, and agricultural productivity.*

Technical Teams were asked to develop a framework to evaluate an array of related topics:

- Develop a tool that could be applied to prioritize wetlands and upland (including CRP lands) for multiple benefits.
- Support the development of a "blueprint" for functional landscape design that incorporates upland and wetland habitat within an agricultural matrix.
- Provide the technical capacity for evaluating environmental and economic tradeoffs
- Explore the implications of an "integrated strategy"—does this approach actually provide greater benefits or increased efficiency (compared to the status quo)?
- Inform targets for success at multiple spatial scales—how much is enough and what will it cost to achieve targets?
- Develop an application for planning and accountability that could potentially be applied/expanded throughout the PPR in Minnesota and Iowa.

USFWS-HAPET has served in a leadership and coordination capacity for this effort, with ongoing support from USDA-Farm Service Agency; participants have served primarily in a collateral duties capacity with no funding provided. Thus the work that follows is largely drawing from, and attempting to help guide and leverage, the momentum of various partners' planning and modeling efforts.

PPRILCS Framework:

The PPRILCS technical teams have developed an approach that can be summarized as follows:

1) **"What are the objectives of concern and how do we measure them?"**—Identify specific metrics to evaluate desired conservation outcomes.
2) **"Where is best?"**— Model spatial priorities based on landscape functions for individual objectives.
3) **"What are the predicted benefits?"**— Assess respective benefits of conservation design strategies (alternatives) using outcome-based spatial models.
4) **"How much will it cost?"**— Incorporate multi-benefit spatial models within an economic modeling framework; evaluate cost-benefit relationships, optimization strategies, and alternative design strategies.
5) **"How much is enough?"****— Assess existing targets for conservation outcomes (and/or economic constraints), where applicable; provide tools to inform systematic "functional landscape" targets for wildlife populations, nutrient levels, peak flow reduction, or agricultural productivity.

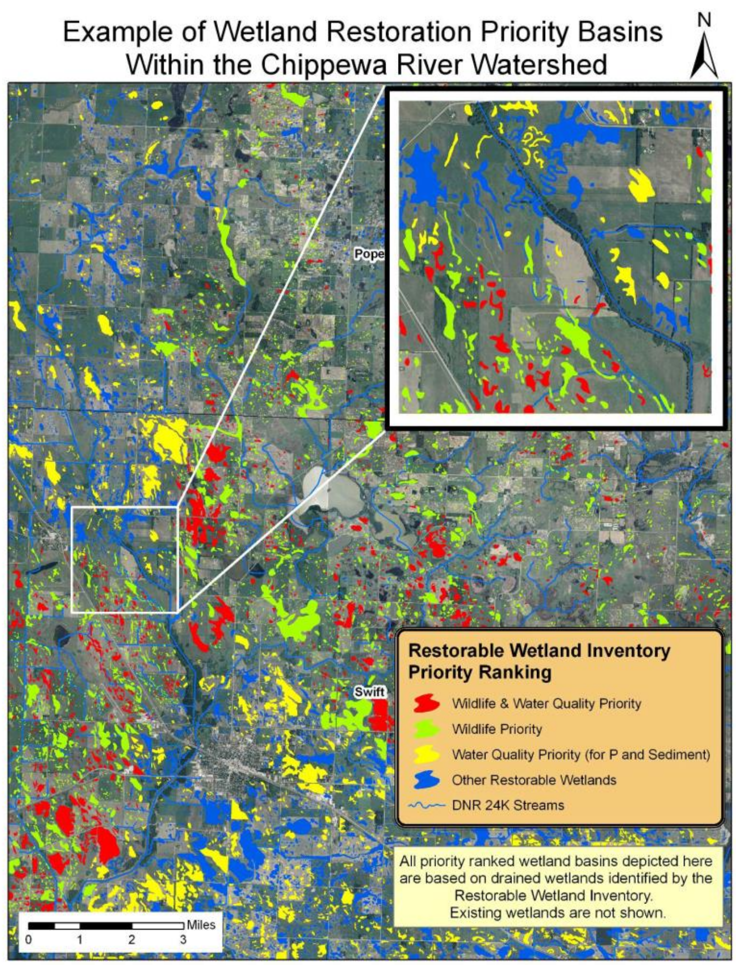


Figure 5. A Prototype Example of Multi-Benefit Wetland Restoration Priorities from the MN Wetland Restoration Strategy (2009). *Partners have not yet realized this vision for an integrated analysis. Recent advances in data and spatial modeling provide the basis for proceeding with an integrated strategy. The PPRILCS partnership has been working to make this vision a reality.*

*(**note that PPRILCS participants are not proposing to set targets themselves, but rather are working to provide the technical basis for policy makers or local/regional collaborative planning groups to evaluate what is possible and/or how to most efficiently achieve desired targets).*

Summary of Accomplishments and Status Updates:

The PPRILCS Technical Teams have selected explicit objectives (and associated metrics) for wildlife, water quality, and flood reduction; teams have also identified various strategies for maximizing multiple benefits and have envisioned an economic framework for evaluation of tradeoffs and cost-benefit relationships. Spatial models have been developed, or are near completion, for each objective. Upon completion, the package of models will be assembled to identify shared spatial priorities and to evaluate the implications of various integrated conservation strategies using the GIS-based Integrated Valuation of Environmental Services and Tradeoffs (InVEST; Natural Capital Project), as described below.

Wildlife Technical Team Objectives, Metrics, and Prioritization Framework

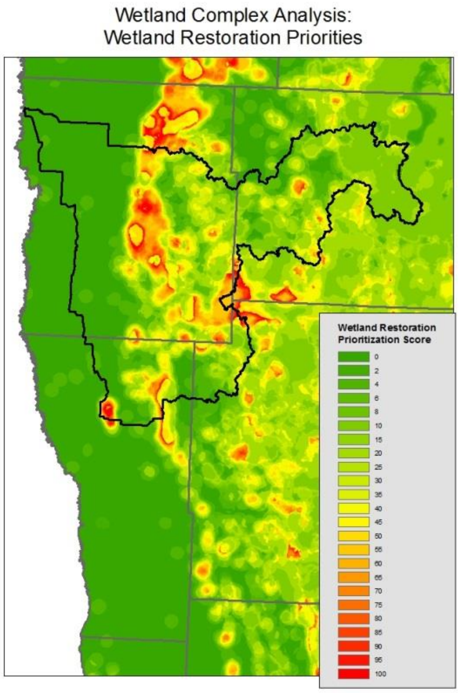
Drawing heavily from the MN Prairie Conservation Plan, the PPRILCS Wildlife Technical Team has identified a suite of wildlife species priorities. This subset of species was chosen to represent the range of habitat needs throughout the region. While clearly not all wildlife species needs will be covered by these 9 species, it was assumed that this species list would be reasonably encompassing of landscape-scale habitat considerations.

Priority Wildlife Species Identified by the PPRILCS Wildlife Technical Team
Mallard
Blue-winged Teal
Greater Prairie Chicken
Western Meadowlark
Sedge Wren
Grasshopper Sparrow
Pheasant*
Frog Species*
Butterfly Species*
(**Models not currently available)*

HAPET has developed a wide array of bird models that encompass the PPR, and HAPET has recently updated grassland bird models for the entire Prairie Pothole Joint Venture (PPJV) area. Three taxa (pheasants, frogs, and butterflies) are currently lacking spatial models; partners are working to fill those gaps.

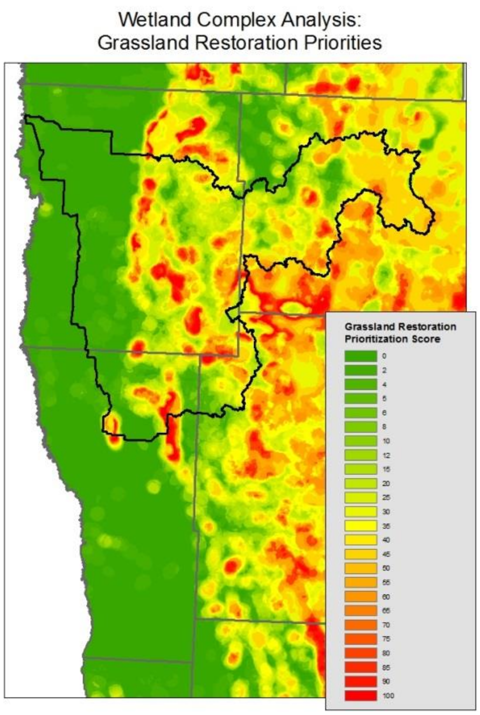
A variety of spatial wildlife models are readily available. However, these models are typically used to estimate existing populations (based on existing landcover) and do not necessarily translate directly into spatial priorities for restoration. Integrating the different models is not mathematically straightforward. Individual species' models can be utilized to prioritize for each particular species, based on a series of fairly simply assumptions, but the team decided that individual species models were best used as tools for evaluating wildlife population outcomes in response to various potential landscape design strategies that prioritize based on landscape functions and underlying biological principles, which could then be tested to identify the most appropriate landscape design strategies:

1) **Wetland-Grassland Complexes Strategy** (increased grasslands where wetlands exist, increased wetlands where grasslands exist).



Wetland Restoration Priority Index

Wetland (% Cover) \ Grassland (% Cover in 1 mile radius)	0	5	10	15	20	25	30	35	40	45	50+
>20	10	10	20	20	30	40	40	45	50	50	50
20	10	10	20	20	30	40	50	55	60	60	60
18	8	20	30	40	55	75	90	100	100	100	100
16	6	20	25	40	50	70	85	90	100	100	100
14	4	15	25	40	45	65	75	80	90	95	95
12	2	10	20	35	45	60	70	75	80	85	85
10	2	8	20	35	40	55	65	70	75	80	85
8	2	6	20	30	40	50	60	65	70	70	75
6	0	6	15	30	40	50	55	60	65	65	65
4	0	4	15	25	35	45	50	55	60	60	60
2	0	4	10	20	35	40	45	50	55	55	55
0	0	4	8	15	30	35	40	45	50	55	55



Grassland Restoration Priority Index

Wetland (% Cover) \ Grassland (% Cover in 1 mile radius)	0	5	10	15	20	25	30	35	40	45	50+
>20	30	45	55	60	80	90	100	100	65	45	40
20	30	40	50	60	80	90	100	100	65	45	40
18	30	35	35	55	75	85	100	100	60	45	40
16	25	30	35	50	70	80	85	90	60	45	40
14	20	30	35	45	60	70	80	85	55	40	35
12	15	25	35	40	50	60	65	70	50	40	35
10	12	20	30	30	40	50	55	55	45	35	35
8	8	15	20	25	35	40	45	45	40	30	30
6	6	12	20	25	30	40	45	45	30	25	25
4	4	8	15	20	25	25	30	35	25	25	25
2	2	4	10	15	20	20	25	30	20	20	20
0	0	0	5	10	15	20	20	25	15	15	15

Figure 6. Wetland Complex Priorities for Wetland and Grassland Restoration. *Priorities were identified based on the desired target of 40% grassland and 20% wetland in a 4-square-mile area, as a means to prioritizing multi-species benefits according to recommendations in the MN Duck Plan and MN Prairie Plan.*

The Minnesota Prairie Conservation Plan built on the wetland complex targets established in the Minnesota Duck Plan and elsewhere. Similar thresholds (approximately 40%-50% grassland in a 4-9 square-mile area) have been identified elsewhere in the region as important goals for grassland birds and waterfowl alike, thus this strategy was selected as a fairly simple means for identifying shared priorities. This is considered one means for prioritizing multi-species benefits, though this is simply one strategy amongst many others that the teams wish to evaluate in terms of multiple benefits (and costs).

2) **<u>Grassland Bird Conservation Area (GBCA) Strategy</u>** (promoting large blocks of relatively contiguous grassland habitat).

In addition to prioritizing wetland complexes, the team felt that many priority species of grassland birds are dependent on large landscapes dominated by grassland cover; in many cases these may exist in areas that would not be considered high priority based solely on wetland complex considerations. Thus the team incorporated HAPET's Grassland Bird Conservation Area (GBCA) model to define additional spatial priorities.

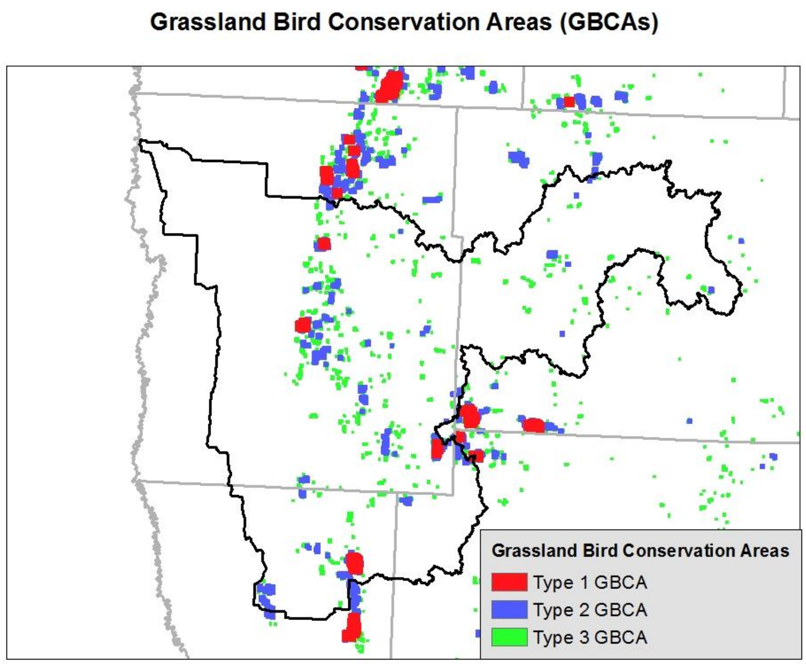


Figure 7. Grassland Bird Conservation Area Priorities. Large tracts of grassland habitat are identified based on the amount of grass in the landscape at various scales.

GBCAs are priority areas for grassland protection and enhancement that are thought to provide suitable habitat for many or all priority grassland bird species in the PPR. All GBCAs consist of a grassland core with a surrounding 1-mile wide matrix. Core areas are at least 95% grassland, at least 50 meters from woody vegetation, and may contain up to 30% wetland habitat.

GBCAs have been defined at 3 levels to address the needs of grassland breeding birds with differing levels of requirements. Each type is differentiated on the basis of size, width, amount of grass in the landscape, and the types of wetlands considered compatible (e.g., temporary wetlands are considered compatible for all GBCA types because they are typically dry for much of the nesting season).

- **Type 1 GBCA** – at least 640 acres of grassland at least 1 mile wide. Matrix and core are at least 40% grassland.

- **Type 2 GBCA** – at least 160 acres of grassland at least ½ mile wide. Matrix and core are at least 30% grassland.
- **Type 3 GBCA**– at least 55 acres of grassland at least ¼ mile wide. Matrix and core are at least 20% grassland.

3) **<u>Native Prairie and Grassland Connectivity Strategy</u>—**Drawing from the Minnesota Prairie Plan, this strategy focuses on connecting remnant native prairie patches to promote diversity and likelihood for restoration success on nearby lands, as well as to provide additional opportunities for grazing-based working lands applications. Lands are prioritized based on their 1) parcel size, 2) proximity to native prairie patches, and 3) proximity to riparian areas. This approach draws from The Nature Conservancy's work to guide Local Implementation Teams working to deliver conservation programs in response to the MN Prairie Conservation Plan. Again, this ranking system is one consideration amongst several others, and additional work (some of which is described below) is needed to integrate various wildlife priorities and ensure that these various prioritization schemes do indeed result in maximized benefits for the various priority wildlife species.

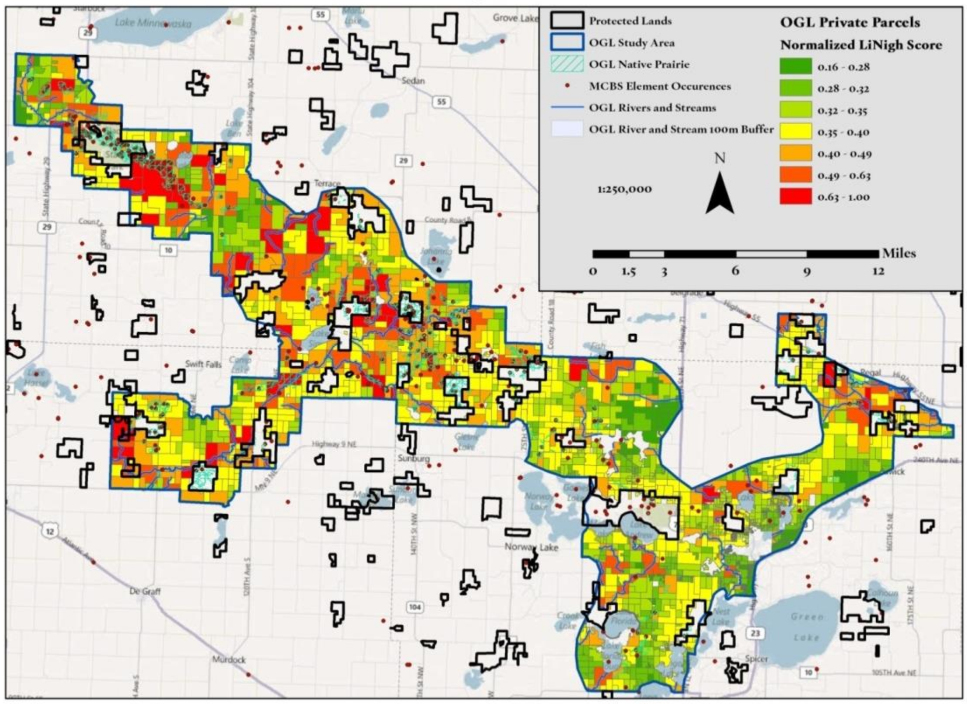


Figure 8. An Example of Native Prairie Connectivity Priorities. *Parcels are prioritized based on proximity to native prairie patches, parcel size, and adjacency to riparian areas. Connectivity is intended not only to promote the success and diversity of prairie restorations, but also to provide increased opportunities for rotational grazing and other "working lands" approaches.*

It should also be noted that the wildlife team has repeatedly emphasized the need for evaluating underlying assumptions. The proposed priority species and prioritization schemes need to be evaluated, both in terms of their ability to adequately represent the needs of other species of concern, and also in terms of how accurately the various strategies do indeed fulfill the desired benefits for these and other species. The importance of on-the-ground validation of restoration outcomes (for wildlife and other benefits) cannot be overemphasized.

Ultimately, SHC emphasizes the importance of species-based metrics for success. The various strategies described above must be evaluated in terms of their outcomes for wildlife populations. These are considered alternative strategies and each is likely to have certain trade-offs. The goal is to inform--and ultimately achieve—desired population targets for the priority wildlife species. Strategic landscape design will provide a means for streamlined tools to prioritize conservation work, and which can be compared and integrated with the strategies developed for water quality and flood reduction, while simultaneously avoiding the best agricultural lands. This is the vision of the PPRILCS partnership.

Water Technical Team Objectives, Metrics, and Prioritization Strategies

The Water Team has been building upon efforts set in motion by a combination of groups—the Minnesota Board of Water and Soil Resources (BWSR), the Minnesota DNR, Iowa DNR, Houston Engineering International, the International Water Institute, US Army Corps of Engineers, and others. LiDAR-based digital elevation models have provided a vast amount of data and now serve as the foundation for very high resolution prioritization and outcome-based modeling opportunities to assess water quality and flood reduction outcomes of various possible conservation strategies.

In many ways, the water conservation community is now better positioned than ever before to incorporate a Strategic Habitat Conservation (SHC) styled approach, by identifying priorities and setting clear outcome-based objectives. Along with the Restorable Wetland Inventory data, which has mapped drained wetlands throughout the PPR region of MN (along with comparable efforts in IA), LiDAR-based data allows for the very precise estimation of benefits (nutrient levels, water volume) associated with specific wetland basins. Tools recently developed for the Red River Basin Decision Information Network (RRBDIN; http://www.rrbdin.org/) provide the basis for detailed prioritization and planning applications that have previously not been possible.

However, such paradigm shifts do not come easily or quickly. Flood reduction targets have been encouraged throughout the Red River Basin, though they have been established (by county or otherwise) with varying degrees of consistency. Spatial priorities and targets/metrics remain undefined for water quality for most watersheds, though recent legislation like the Clean Water Accountability Act (2013) in Minnesota highlights the emerging importance of a strategic approach and many of the needed tools to establish spatial priorities and outcome-based targets have recently been developed in our pilot study area.

Priority Water Quality and Flood Reduction Attributes
Water Volume
Nitrogen levels
Phosphorous levels
Sediment levels

LiDAR data has been "digitally corrected" in the Buffalo Watershed to account for culverts that are otherwise difficult to identify using automated process and which often cause critical errors in hydrologic models. Related efforts are underway to align spatial priorities with model-based outcomes for water volume, stream power, and sediment, and nutrient levels.

In general, a wide range of hydrologic models exist, some of which are readily available for our pilot study—SWAT, HEC-HMS, HSPF, GSSHA models—and each has it's appropriate uses and respective weaknesses. While a full review of hydrologic models is beyond the scope of this report, it has become clear that the water conservation community is moving in toward more strategic targets, and that the tools are now available to promote spatial prioritization and explicit outcome-based target setting for planning and implementation. The challenge is transitioning from the available models, which have traditionally been used descriptively to explain watershed hydrology, toward a modeling approach that can be used to identify spatial priorities for restoration in such a way that can readily explore (and explicitly estimate) the outcomes associated with various possible conservation design strategies.

RRBDIN has been assembling a number of foundational data layers, and developing LiDAR-based models to build a package of web-based GIS tools; meanwhile Houston Engineering has been leading the development of nutrient models that encompass our study area, which are now readily available. The teams are now working to develop a detailed work plan that lays out the technical process and respective contributions from partners to provide spatial priorities for wetland and grassland restoration, and then uses these models to estimate outcomes for agreed upon conservation strategies.

Flood Reduction Modeling and Prioritization Process

With regard to flood reduction priorities and water volume estimates, a great deal of progress has been made over the last year. The team has been working to prioritize sub-watersheds and catchment-scale sites based on their contribution to flooding events. Henry Van Offelen and Jim Solstad (Minnesota DNR) have developed a sub-watershed-scale prioritization process for flood reduction, focusing in on a combination of water volume and timing, utilizing a HEC-HMS model to develop stacked hydrographs to prioritize sub-watersheds and then incorporating a combination of drainage area and basin volume to prioritize at finer scales (along with other factors).

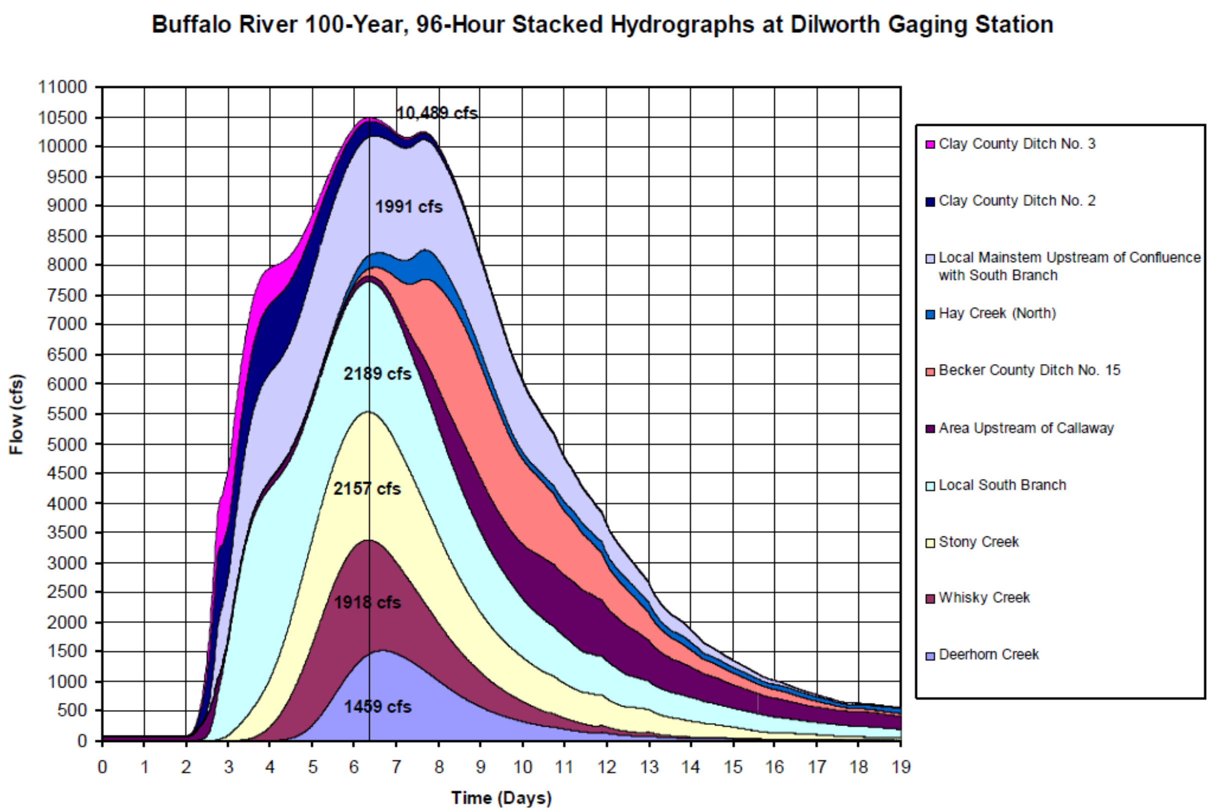


Figure 9. A Stacked Hydrograph for the Buffalo River Watershed. *Spatially explicit sub-watershed contributions to peak flow events are estimated and utilized to guide the prioritization of wetland and upland restoration efforts for flood reduction objectives.*

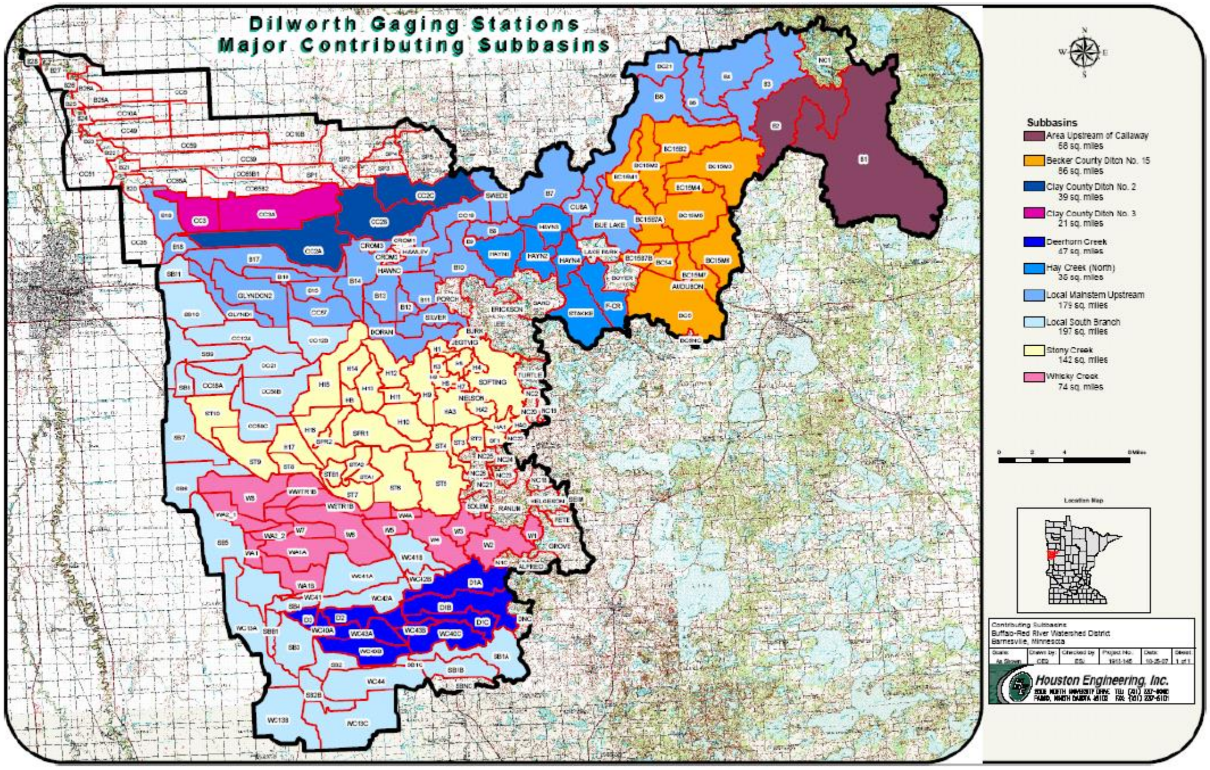


Figure 10. Spatially Explicit Sub-watershed Priorities for Flood Reduction. *Priorities can be identified based on peak flow events associated with the stacked hydrograph data in Figure 9. Finer scale priorities can then be identified based on volume (per sub-basin) and drainage-area-to-volume ratios.*

Flood reduction outcomes can then be attributed to restoration strategies and evaluated at multiple scales, based on both wetland and upland restoration. However, the technical capacity to do such analyses “on the fly” is not necessarily readily available, due to the complexity of the underlying models and data and the necessary technical support. PPRILCS teams are working to utilize these models to develop multi-benefit priorities and assess the outcomes, cost-benefit relationships, and tradeoffs of different restoration strategies (based on different prioritizations and/or different weightings of objectives, as described below). As these models become available, the next step is agreeing upon the various watershed design alternatives/strategies that will be modeled by partners to explore implications for multiple benefits.

Water Quality Modeling and Prioritization Process

Nutrient-based priorities have been more challenging to complete at a scale that can estimate the benefits associated with the restoration of individual basins or upland tracts. Many hydrologic models that have been available in the past are relatively coarse or highly specialized and not necessarily practical for the applications envisioned by the PPRILCS technical teams. That being said, new tools have been developed, led by the International Water Institute, MN BWSR, and Houston Engineering. The first iteration of these tools is now complete, providing spatial priorities for water quality. However, it appears that outcome-based estimates of nutrients associated with particular restoration strategies in the Buffalo Watershed may require additional funding to complete. Sediment can be estimated/prioritized using existing datasets and most of the underlying models are now built that would support the prioritization process moving forward, and also supports some capacity to provide explicit outcome-based estimates.

The *Water Quality Decision Support Application* (WQDSA) is an RRBDIN pilot project for the major watersheds located within the Minnesota Portion of the Red River Basin, funded by a Clean Water Legacy grant. The overarching goal is to create, distribute and demonstrate the use of water quality related products derived from high resolution topographic data collected using LiDAR-derived data in a Structured Decision Making process. The pilot application demonstrates how these data can be used for describing and understanding the condition of a watershed, assessing pollutants sources, prioritizing sub-watersheds relative to Best Management Practice (BMP) implementation and developing a BMP implementation plan for agricultural landscapes.

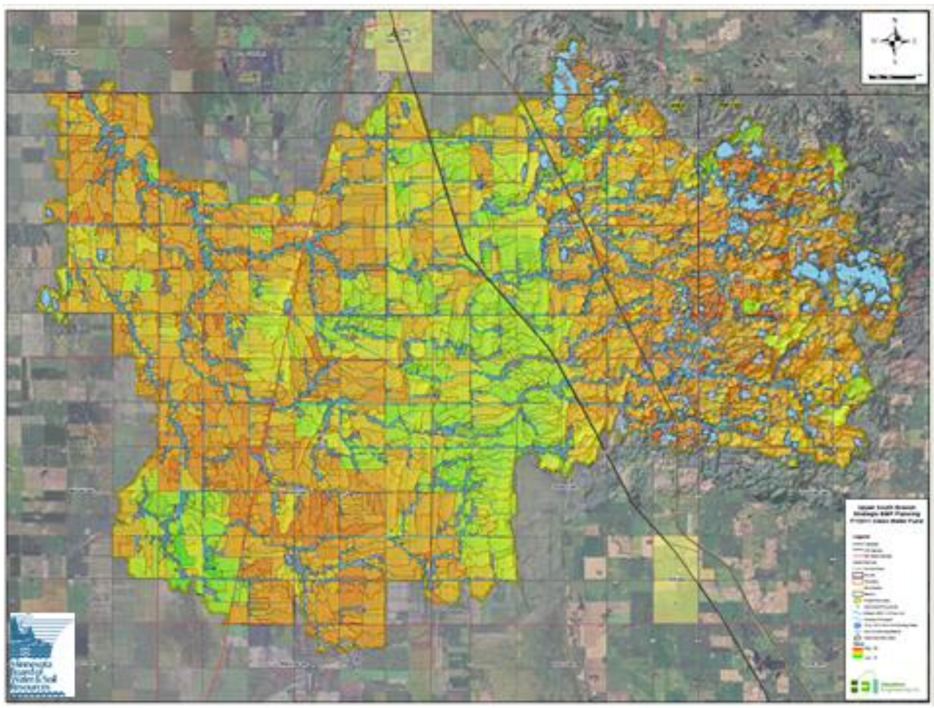


Figure 11. An Example of Field-scale Sediment Reduction Priorities. *The MN Board of Water and Soil Resources, along with other partners, has worked to develop a process for prioritizing sediment reduction efforts at the sub-basin scale, using LiDAR-derived data.*

The WQDSA provides land and water managers with geospatial data and online tools to prioritize and implement actions on the landscape to achieve water quality objectives identified in local and state plans and ensure that decisions to spend public funds are strategic, defensible and transparent. Local and state water plans consistently identify two primary objectives: 1) reduce erosion and sediment in surface runoff from agricultural fields, and 2) reduce peak flow events that transport the largest sediment loads by accelerating rates of field and channel erosion. The WQDSA allows users to 1) identify the water quality problems, 2) establish goals and objectives, 3) reference planning documents, 4) interactively create maps of projects for demonstration and marketing, 5) save projects in a database for future refinement, and 6) potentially export relevant information in a format suited to existing planning and reporting tools.

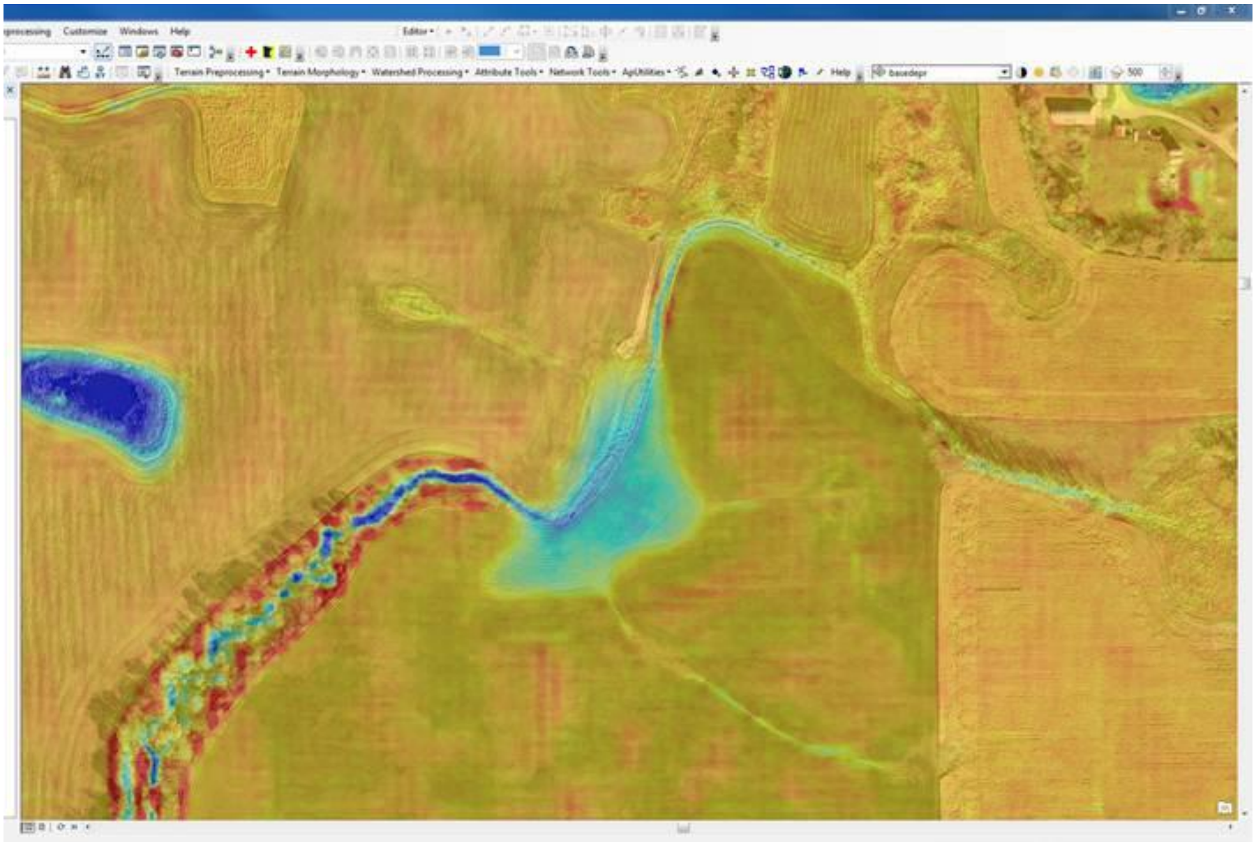


Figure 12. LiDAR-derived Drained Wetland Basins. *High resolution LiDAR digital elevation data can inform the location of drained wetland basins and provides the basis for the spatial modeling of water volume and nutrient levels associated with individual basins, sub-watersheds, and watershed-scale restoration strategies.*

Agriculture and Economics Team

In addition to prioritizing conservation in "working lands" (based on grazing opportunities and/or "third crop" opportunities), the agriculture and economics team has selected to draw from the USDA-Natural Resources Conservation Service (NRCS) Crop Productivity Index (CPI) as a means for prioritizing agricultural lands (i.e., lands to avoid for conservation purposes due to their highly productive agricultural potential, also likely to be correlated with cost and inversely correlated with the probability of acquisition for conservation).

CPI ratings provide a relative ranking of soils based on their potential for intensive crop production. An index can be used to rate the potential yield of one soil against that of another over a period of time. Ratings range from 0 to 100. The higher numbers indicate higher production potential. The ratings are based on physical and chemical properties of the soils and on such hazards as flooding or ponding. Available water capacity, reaction (pH), slope, soil moisture status, cation-exchange capacity (CEC), organic matter content, salinity, and surface fragments are the major properties evaluated when CPI ratings are generated. The soil properties selected are those that are important for the production of corn.

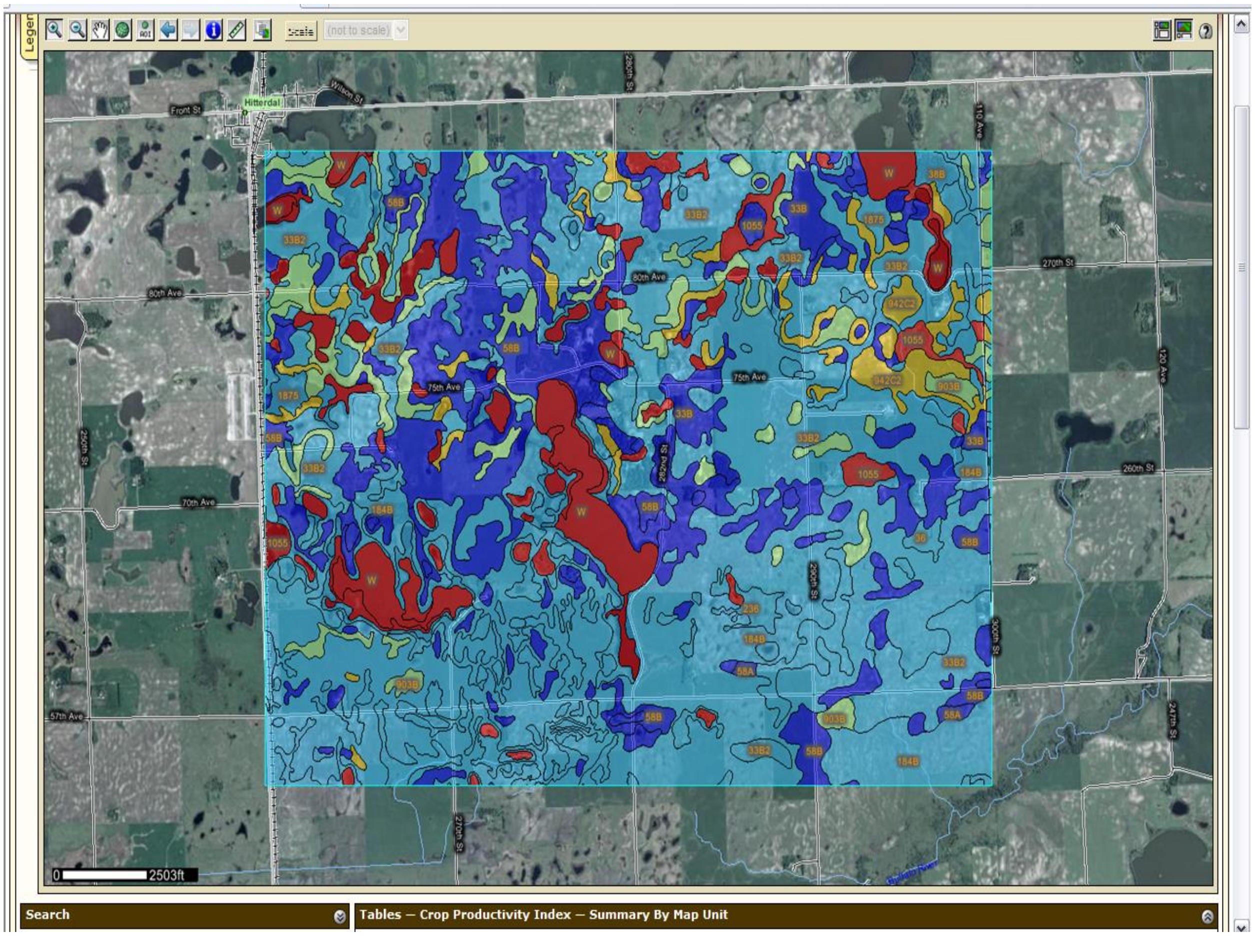


Figure 13. An Example of Crop Productivity Index (CPI) Data. *Agricultural priorities can be identified based on soil characteristics and other local factors related to the production potential for corn. These areas can then be incorporated as high cost (or lower priority) areas for conservation, prioritizing conservation in areas where row crop agriculture is less likely to be profitable.*

Economics Modeling and Integration Framework

We have been in discussions with researchers at the University of Minnesota, as well as the Natural Capital Project (based at Stanford University) about opportunities to apply InVEST economic models systematically alongside our wildlife and hydrology spatial models.

InVEST provides a useful framework for linking spatial models to evaluate cost-benefit relationships and generate efficiency frontier curves (see examples below), to explore alternative options and associated tradeoffs (including econoimic implications). InVEST is modular, in that it can incorporate customized models into the GIS framework, then apply various landcover change scenarios to evaluate respective outcomes, costs, and to compare tradeoffs. There are some challenges in getting our models to align properly, and some of the technical aspects of doing this will need to be worked out in partnership with experts at the university. There is an interest in this project and willingness to work with us, though some funding may be required, depending on the level of support needed to see this through.

Data from the University of Minnesota- Minnesota Land Economics data center provides economic data that can inform land values and crop productivity estimates. Thus far we are relying on CPI data to inform agricultural priorities, though additional input from agricultural agencies/partners would be welcomed. The DNR has also recently developed a "third crop" priorities layer that we intend to incorporate to prioritize additional agricultural considerations and opportunities.

By applying our spatial models in InVEST, we can test various conservation design strategies at the watershed scale and evaluate the costs, benefits, and tradeoffs of various strategies. Different weightings can also be applied through optimization processes, to evaluate different approaches, help set conservation targets, develop rules of thumb for strategic targeting, and ultimately highlight priority conservation areas for achieving mulitiple benefits at the least cost.

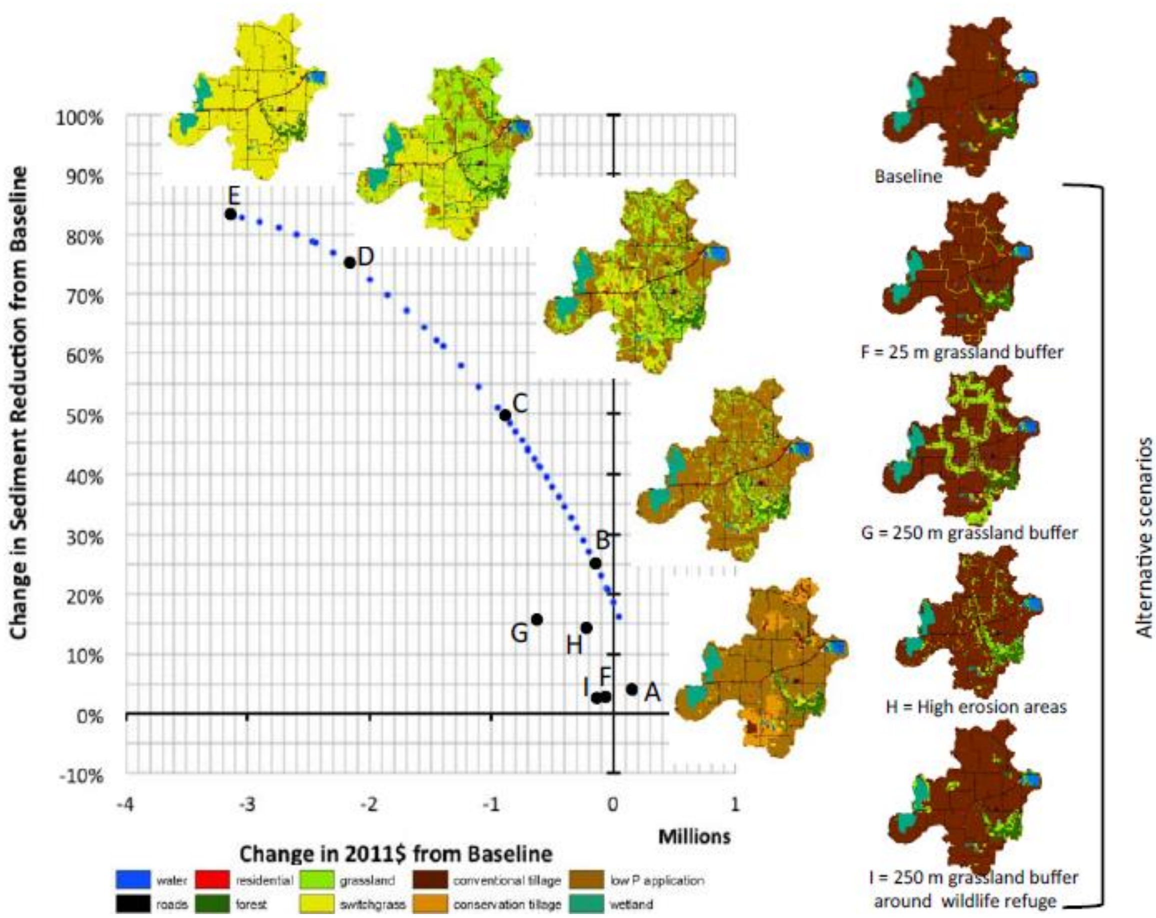


Figure 14. An Example of InVEST Modeling Applied to Evaluate Cost-benefit Relationships.* *Different conservation strategies and landscape designs can be evaluated using InVEST, to compare tradeoffs and explore opportunities for maximizing efficiency at any scale of interest. In this case, points B, C, D, and E represent 25%, 50%, 75%, and 100% improvements in sediment, respectively.* ***(*From Dalzell, B., D. Pennington, S. Polasky, D. Mulla, S. Taff and E. Nelson (2012). Lake Pepin watershed full cost accounting project.)***

Optimization Techniques

Lastly, PPRILCS teams have explored options to integrate spatial models and prioritization schemes into more complex optimization strategies to maximize multiple benefits while minimizing cost. The intent is to explore the most efficient options for landscape design while simultaneously exploring different value-weightings for various objectives (wildlife, water quality, flood reduction, and agriculture). Paul Radomski and Chris Karlson (MN DNR) utilized ZONATION conservation planning software to develop a prototype process for optimization for the PPRILCS pilot study area

Zonation produces a nested hierarchy of conservation priorities. It begins with the full landscape and iteratively removes parcels (cells) that contribute least to conservation; therefore, the removal order is the reverse order of the priority ranking for conservation. Zonation assumes that the full watershed is available for conservation. In our models, the lakes were masked out prior to analysis. This focused the prioritization on the terrestrial parcels, in accordance with the conservation and restoration goals of our partners. Zonation's algorithms seek maximal retention of weighted normalized conservation features.

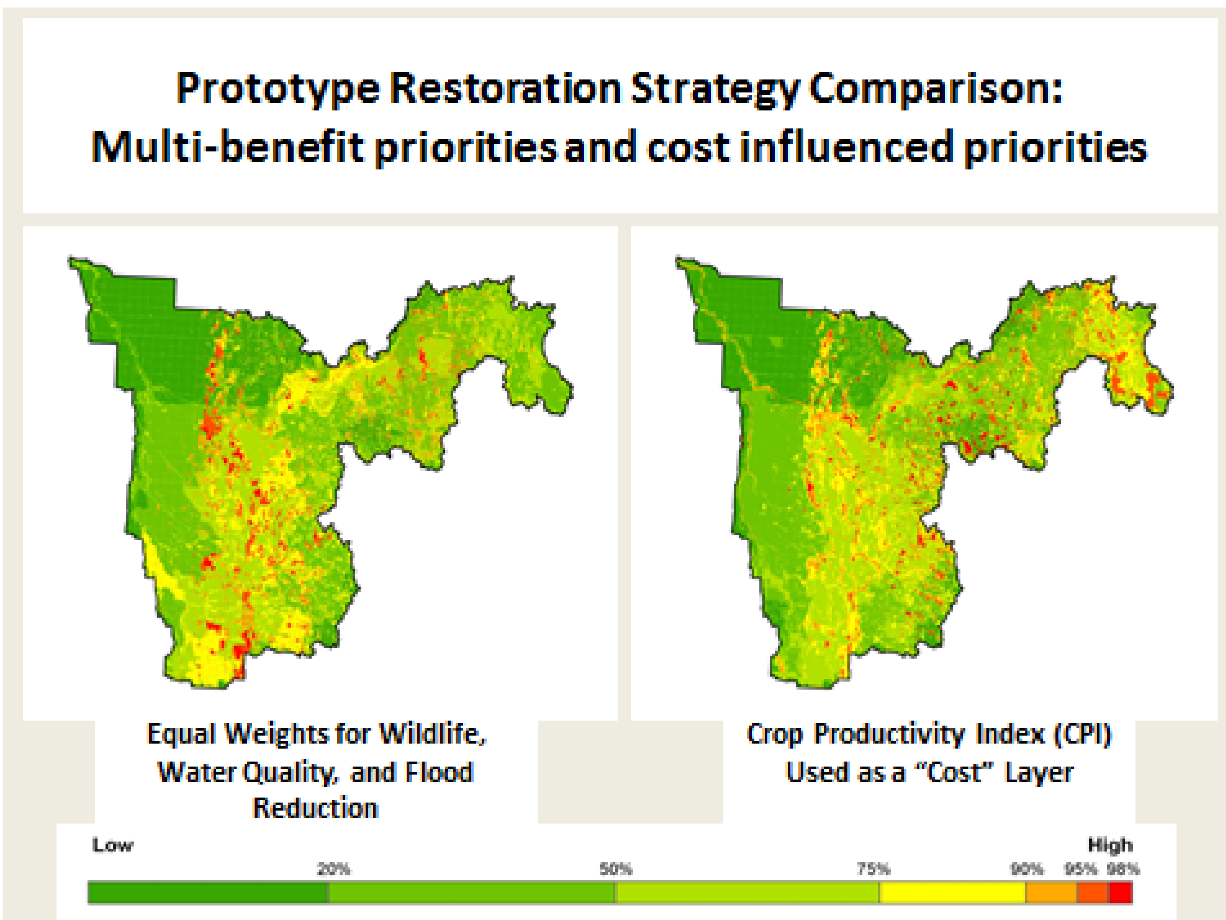


Figure 15. An Example of Optimization Techniques Applied to the Study Area. *Zonation conservation planning software was used to highlight areas that provide the greatest benefits for wildlife, water quality, and flood reduction, at the least cost (while avoiding highly productive agricultural lands).*

There are three commonly definable objective functions possible in Zonation: core area, target-based planning, and additive benefit functions. The core area objective function aims to retain high-quality occurrences of each feature. This function is most appropriate when there is a definite set of conservation features and all of them are to be conserved. The target-based planning objective function is a prescriptive approach where requirements are specified *a priori* for each feature. This function produces a minimum set coverage solution, and is most appropriate when a defined proportion of the watershed is assigned for conservation.

We used the additive benefit function variant of Zonation, which aggregates values by summation across features:

$$V(P) = \Sigma w_j N_j(P)^{z_j} - \Sigma w_k N_k(P)^{z_k}$$

where the value of a parcel *V(P)* is equal to the summation of weighted *w* normalized conservation features of the parcel $N_j(P)$, squashed to the power of *z*, minus the summation of the weighted normalized alternative land use features of the parcel $N_k(P)$, squashed by *z*. We used $z_j = 0.25$ for conservation features and $z_k = 4$ for alternative land uses.

The additive benefit function is appropriate when tradeoffs between conservation features are allowed and it is necessary to account for alternative land use features. In our analyses, we developed prioritizations that would minimize interference with important agricultural areas. Additionally, Zonation allows ranking to be influenced by neighboring parcels, so that highly valued areas can be aggregated. This minimizes fragmentation of conservation within the landscape. We utilized the distribution-smoothing algorithm in Zonation, which uses an aggregation kernel α parameter. Using this algorithm assumes that fragmentation (low connectivity) generally should be avoided for all conservation features. Initial analyses indicate that an aggregation kernel α of 0.01, which corresponds to a connectivity distance of 200m, may appropriate for conservation efforts targeted at the watershed scale. We found that very small connectivity distances made no difference in parcel prioritization, since the connectivity effect did not extend very far into neighboring parcels, and very large connectivity distances aggregated parcels across unrealistically large areas. We also found that across a modest range of connectivity distances the results were minor. The connectivity distance can be conservation feature-specific; for example, if a species' dispersal capability or fragmentation vulnerability was known, then a species-specific parameter could be explicitly used. The data layers used in the analysis are found in Table 1, and each layer was on the same grid with a resolution of 30 by 30m. We used high-resolution data to maximize conservation planning realism and for greater practicality in local government conservation planning and implementation.

The results of this initial prototype application of optimization techniques are meant to demonstrate proof of concept and are not intended to function as a final product. More work will be needed to evaluate the weighting strategies associated with the different layers. Once complete, different strategies (and/or one or more optimized strategy) can be compared in terms of modeled outcomes and costs, ideally using the InVEST framework described above. The results allow us to evaluate multiple benefits and iteratively inform conservation targets in working landscapes for local planning applications; combining at multiple scales can help inform watershed, statewide, or regional conservation targets and may help to ease conflict between conservation and agricultural land uses.

Systematically Informing Explicit Conservation Targets for Multiple Benefits

Defining a single conservation objective at a single scale is no easy task; working with multiple objectives at multiple scales is immensely more complex. Yet it may be the case that meaningful and transparent outcome-based objectives must be defined in a broader context of related ecosystem services and economic tradeoffs to be meaningful and ultimately useful. To define one objective for a single metric of ecosystem function in isolation is prone to being arbitrary (laden with extensive assumptions about risk, politics, and economics), particularly given the inherent tradeoffs, value judgments, and scale-dependencies associated with establishing such targets. Integrating multiple objectives systematically within an economic framework has the potential to be profoundly insightful with regard to setting realistic expectations, exploring cost-benefit relationships, and ultimately establishing a reasonable range of targets that signify a balanced and sustainable (resilient) system. But what does it really mean to do so?

Additionally, the logistical challenges associated with the coordinated modeling of multiple species guilds' populations poses unique challenges; aligning models and scenarios for an array of ecosystem services, ensuring that model inputs and outputs align and that shared scenarios are evaluated, can be immensely challenging and likely necessitates an innovative inter-agency interdisciplinary partnership that is largely beyond the scope and duties of any particular group.

Given the challenges associated with establishing population targets for individual species, it is reasonable to question whether it is desirable or even possible to develop a range of attributes that define a "functional landscape", at a specific scale (eg. a watershed) that are based on (an acceptable range of) desired future conditions. Setting target objectives for one attribute is difficult, but may be much less meaningful than the even greater challenge of defining conservation objectives as a whole that would start to narrow in on the range of acceptable values and strategic spatial priorities for specific focal ecosystem services that together define a vision for functionally restored landscapes—a desired end goal (or range of conditions) that captures an acceptable balance between natural and human-economic systems. Such an approach, if possible, may have profound implications, not only relating to the issue of "how much is enough?" but also "where is best?".

Further complicating matters, maximizing economic productivity, for which no normative basis exists that some level of income is enough or too much (i.e. more economic productivity is better indefinitely unless a point is reached when net costs are incurred), means that many conservation groups are cautious about defining an end target for individual species, fearing the possibility that such targets could be too low or too high, that the perceived costs associated with achieving objectives might be politically damaging, that actually attaining targets could remove the *raison d'etre* for future conservation once attained, or even simply suggesting that setting target levels at all is counterproductive to conservation ideals. It may be fair to ask then—if economic targets are never established, why should conservation targets be prescribed? Some have argued that doing so would be self-defeating for conservation interests. The notion of economic productivity appears to be directly in conflict with conservation objectives, at least as these paradigms currently stand—though there is reason for hope that, in time, there may be a merging of conservation and economic (natural and human) systems.

The field of ecological economics has described the basis for incorporating environmental costs of ecosystem services into decision making, which could conceivably drive profound changes in decisions being made for economic profits (as externalized costs suddenly become part of the "equation"), thereby discouraging costs that have heretofore been invisible to those profiting from various forms environmental degradation. Individual landowners, business owners, or corporations often do not incur the economic consequences of externalized environmental costs, garnering profits while simultaneously increasing costs on society at large (either now or at some yet to be realized point the future).

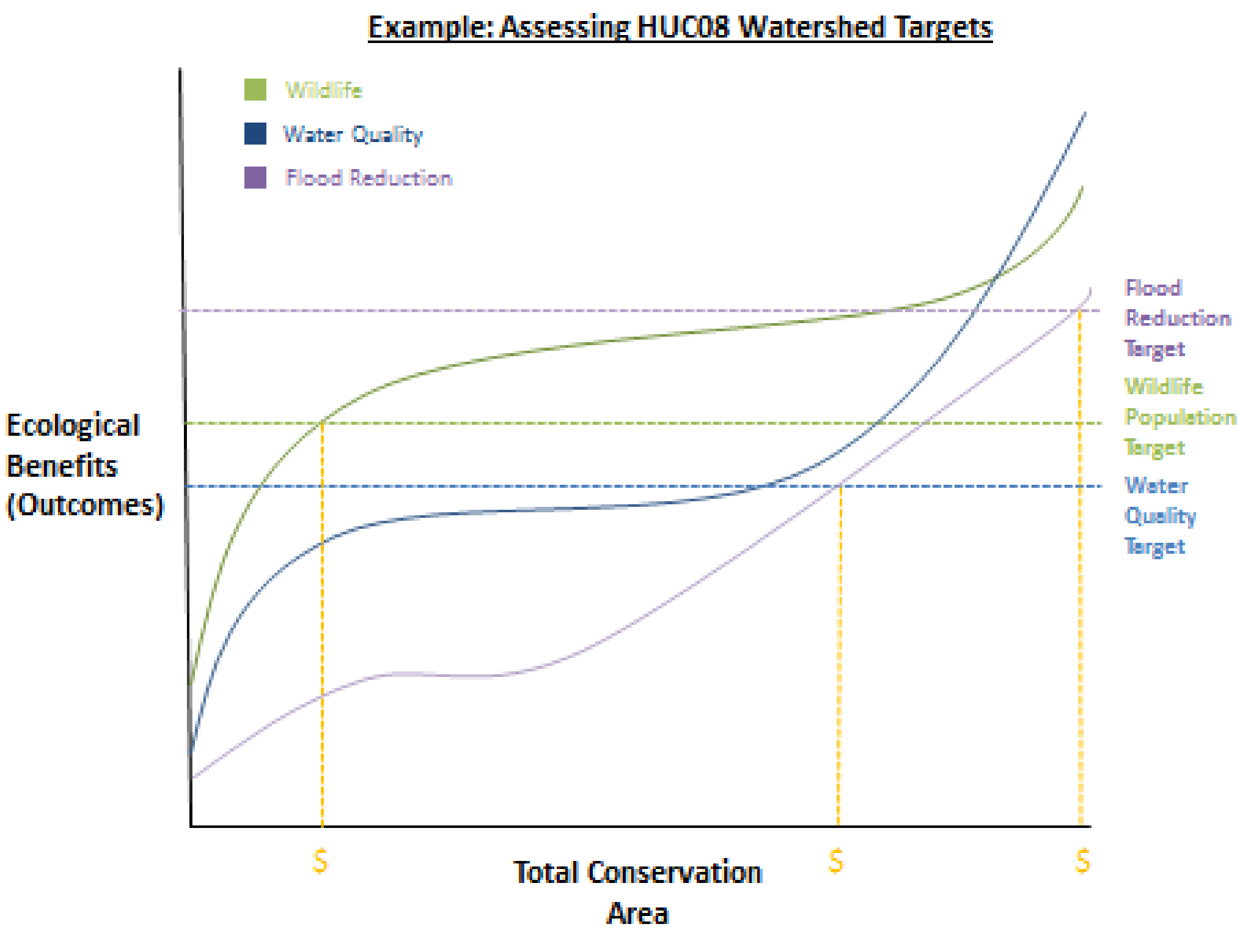


Figure 16. Multi-benefit conservation outcomes evaluated in the context of targets and costs. *A hypothetical example of multi-benefit outcomes associated with a single prioritization scheme illustrates how, as conservation area is increased (according to the spatially explicit landscape design), additional benefits are provided at additional cost. Outcomes can be estimates for respective metrics. Targets can be assessed (or established when none exist), and collateral benefits can be evaluated. Multiple different scenarios can be evaluated in comparison, or stacked and weighted to consider combined results. PPRILCS is working to integrate models to predict multi-benefit outcomes for future alternative landscape designs.*

The formal application of SHC to multi-objective problems is complicated by the complexity of potentially competing objectives operating at multiple scales, in this case ranging from a wide array of wildlife species of concern, nutrient retention goals, flood reduction targets, and ongoing demands for agricultural productivity. The benefits of doing so are unclear and yet to be fully explored. Specific population targets are not defined for most wildlife species, or are defined somewhat arbitrarily, rarely defined at sub-regional scales; water quality metrics are rarely modeled for specified watersheds (unless Total Maximum Daily Loads have been established, which are few and far between and only encompass a subset of water quality metrics), and flood reduction targets are complicated by the temporal and spatial realities of water moving through the system.

In practice, conservation groups tend to work toward incremental progress, driven largely by a focus on single objectives (ie. more habitat for wildlife species, sediment reduction, nutrient reduction, or flood reduction) presumably attained by increasing the conservation estate with no definition of the end goal at scales directly relevant to a local/district manager. Decisions are made at the national, regional, and local scale about the allocation of funds, and then local managers are left to do the best they can with the available resources. Meanwhile, agricultural and economic objectives tend to focus on maximizing productivity (and related profits) at the farm scale, with limited incentives for consideration to be given to ensuring the appropriate balance of ecosystem services at broader watershed, county, or regional scales. Thus the dominant paradigms for agriculture and conservation appear to be incongruent; conflict and competition over a limited land base is perpetuated, both in practice and in public discourse.

This PPRILCS case study is intended to serve as a proof of concept, illustrating how spatial restoration priorities can be evaluated individually and then integrated, as tools to produce multiple benefits. The PPRILCS pilot effort begins with independent spatial prioritization for single objectives (or guild-type objectives) and then combines multiple objectives, using an optimization framework, to inform the basis for a systematic approach toward defining conservation targets and evaluating what costs and collateral benefits are associated with the pursuit of any particular objective(s). By evaluating the tradeoffs and highlighting shared priorities, partners (and the public) can begin to narrow in on a range of acceptable values, highlight strategic opportunities, explore tradeoffs, and set the stage for a more thorough evaluation of the economic implications of landscape restoration.

The proposed framework is not intended to provide any one perfect solution, but rather to inform an iterative process that serves as the foundation for envisioning watershed-scale targets for multiple objectives and ensuring that conservation approaches leverage limited resources to achieve desired outcomes most efficiently.

Conclusions and Recommendations:

An "integrated strategy" is possible, likely beneficial in many different ways, and increasingly in demand for accountability and efficiency.

PPRILCS partners have been working to evaluate how well model inputs and outputs align, and what it would take to feasibly evaluate various scenarios to demonstrate the value of an integrated multi-benefit approach. It has at times been admittedly quite challenging. Yet in the end partners agree that this is a worthwhile pursuit that could pay enormous dividends in the end, including far-reaching implications for planning and accountability, easing conflicts between conservation and agriculture, promoting wiser choices for public funds, and helping the public and decision makers to more clearly envision the working functional landscapes that they want to achieve in the future.

We can only move as fast as we can move together.

This is a complex effort with many pieces in development; we're all learning as we go. Progress has been slow but steady, relying almost exclusively on collateral duties from all team members. The overall effort is very inter-dependent on the contributions of each of the teams, making it difficult to proceed quickly even when models may be readily available for some components. An agreed upon package of scenarios is in development and once finalized will provide an integrated work plan for moving forward.

The application of this approach to CRP is important and timely, and serves as a good opportunity to focus the effort on real-world tools that can make a difference.

The most recent Steering Committee meeting resulted in acknowledging that CRP makes for a perfect case study for moving this effort forward, and responds to a clear need of USDA-FSA to account for and prioritize the multiple benefits being provided by CRP. Developing ranking tools for expiring CRP is a priority for the next phase of this effort, and as HAPET proceeds with a Prairie Pothole Joint Venture analysis of the benefits of CRP, partners have committed to leveraging that work to consider other benefits of CRP within the pilot study area.

We are developing innovative approaches for spatial prioritizations; these can serve as useful stand-alone products on their own, but they are also supporting something bigger.

Spatial prioritization work is relatively straightforward. Strategic Habitat Conservation (SHC) has gained traction in the wildlife habitat world over the past 5-10 years, yet this type of landscape-scale planning and design work is relatively new in the realm of water quality and flood reduction. LiDAR-based products have greatly empowered our capacity to consider new approaches for prioritization and to develop outcome-based hydrologic models, yet much of the technical work related to how to actually apply this very high resolution data has been evolving over recent years. Partners have actively been working to bring all components up to speed so that we are able to work with models that are responding to comparable input and outputs, so that we can effectively explore shared conservation design "portfolios" of interest.

Additional opportunities exist to expand PPRILCS to other pilot study watersheds; parallel work is ongoing as part of the US Army Corps-led Minnesota River Interagency Study Team effort and also through working being led in Iowa by the Iowa DNR.

Ongoing opportunities have been identified to expand this approach in other places. The primary means for doing so may be through the identification of shared scenarios for evaluation, such that we test a comparable range of design scenarios in deferent settings and work to develop landscape design "rules of thumb", when possible. If we are exploring similar outcome metrics, using comparable models at similar scales, with inter-related inputs and outputs, results will be informative and help accelerate region-wide applications of these concepts.

Several new datasets have been developed that will provide the foundation for this effort moving forward; as of fall 2013, we largely have what we need to move ahead with analyses.

The USFWS Habitat and Population Evaluation Team (HAPET) has been working with USGS- Earth Resources Observation Systems (EROS) Data Center to develop an updated landcover layer for the Prairie Pothole Joint Venture, particularly focused on identifying grassland with greater accuracy. Previous habitat models had been based on 2001 imagery and were considered largely outdated; new 2011 imagery is now finalized and available (as of August 2013), and along with LiDAR-derived products will provide the basis for scenario modeling as this effort moves forward. As of September 2013, the Water Quality Decision Support Application, along with other aspects of the Red River Basin Decision Information Network, provide a strong foundation for moving forward with water quality and flood reduction prioritizations and outcome-based modeling. The PPRILCS partnership continues to explore opportunities to utilize the InVEST economic tools as a framework for integrated analysis.

We are inter-dependent on the contributions of partners and need to finalize scope/commitments before proceeding with scenario modeling work.

While landcover data and a few other water-related models have been significant hold ups thus far, it has also become apparent that modeling a collection of landscape design scenarios requires a certain level of agreement before partners proceed with active modeling of outcomes and other related applications (optimization, etc.). It is important to realize that each point along the "efficiency horizon", and any other particular design strategies of interest, for each outcome, entails a model run. For spatial models that incorporate landscape context, and for physical-based hydrologic models, this means that providing estimates of outcomes entails more than simply working with a single attribute table of potential (restorable) additive benefits; each scenario essentially requires a model run. This means we have to agree upon a collection of scenarios/strategies to evaluate, develop the base data to feed into the models, and then various partners will be running models based on their area of expertise, many of which will incorporate strategies for benefits outside their typical management objectives.

We continue to work toward innovative solutions on the cutting edge of conservation; this is a new way of doing business and we're learning as we go. Ongoing leadership and coordination is critical.

While a great deal of hard work remains, this venue has been increasingly valuable for partners to ensure coordination and to help inform the development of tools that will promote a broader range of applications in the future. We have never before been positioned to do this work so well and a great deal of synergy is emerging, though without active leadership and coordination we may fall far short of our desired end goals. HAPET continues to provide leadership along these lines, when possible, yet other agencies may need to consider appointing specific "integration" contacts who work to reach beyond the traditional scope and mission of the agency toward these value-added products.

We live and work in a world of focused "silo" programs that pursue single objectives much smaller in scope, often without considering the cost-benefit relationships or landscape/economic contexts. Working toward this end will continue to be challenging and will increasingly demand proactive leadership from within each of the partner agencies/organizations, to ensure effective communication and to link emerging tools and respond to evolving agency needs.

Next Steps and Remaining Challenges:

Completing this pilot study effort requires the finalization of each modeling component, then the systematic application of models to a series of scenarios, and then the integration of all of the information into final prioritization maps and applied tools for planning. This is not a traditional linear process and represents many logistical and technical challenges.

We intend to apply this approach prioritize CRP and other conservation programs, and will continue to develop streamlined products as the various components are completed. Over the near term, we anticipate the following timeline:

- Agree upon package of scenarios/strategies to be evaluated for CRP (Fall 2013)
- Finalize models and spatial priorities for each team/objective (Winter 2013)
- Refine and apply optimization process to subset of scenarios (Winter 2013-2014))
- Incorporate models into InVEST framework to evaluate economic implications and tradeoffs (2014)
- Apply integrated modeling package to produce benefits curves and assess cost-benefit relationships; Write up results for peer-reviewed publication (2014)
- Work to apply tools with local planning/implementation groups (SWCD, watershed district, etc.). (2014 and beyond)
- Expand this effort statewide and mesh with related efforts Iowa; expand more broadly, to additional pilot studies or throughout the PPR of MN and IA, if/when possible (2014)

One of the most difficult aspects of this work is that the various components must be aligned such that similar inputs and outputs can be utilized by the models, and linked when appropriate to estimate the desired outcomes of interest. Generating efficiency frontier curves requires extensive numbers of model runs, which must be agreed upon beforehand and then carried out by a variety of technical experts that can directly work with the input data to run the models. Various strategies can be explored, but using high-resolution spatial models can be very data and time intensive, and thus a balance must be found between complexity and simplicity. Scenarios have to be agreed upon, such that each component aligns with the rest to support a meaningful and reasonably accurate systematic analysis in the end. If we can effectively combine our collective brainpower and technical expertise, the possibilities are limitless.

Appendix A

PPRILCS Steering Committee Members

Wayne Anderson, MN Pollution Control Agency

Bill Becker, Lessard-Sams Outdoor Heritage Council

Terry Birkenstock, US Army Corps of Engineers

Todd Bishop, Iowa DNR

Steve Chaplin, The Nature Conservancy

Chris Ensminger, Iowa DNR

Steve Hirsch, Minnesota DNR (Ecological Resources)

Skip Hyberg, USDA- Farm Service Agency

John Jaschke, Board of Water and Soil Resources

Rex Johnson, US Fish and Wildlife Service

*Tim Koehler, USDA-Natural Resources Conservation Service

Jim Leach, US Fish and Wildlife Service

Eric Lindstrom, Ducks Unlimited

Kevin Lines, Board of Water and Soil Resources

*Sean McMahon, Iowa Director, The Nature Conservancy

Barb Pardo, US Fish and Wildlife Service

Thom Petersen, Minnesota Farmer's Union

Rob Sip, MN Department of Agriculture (Agriculture Development and Financial Assistance)

Barbara Weisman, Minnesota Department of Agriculture

Bob Welsch, Minnesota DNR

**Invited participant*

PPRILCS Wildlife Technical Team Participants:

Steve Chaplin, Senior Conservation Scientist, The Nature Conservancy

Ryan Drum, Wildlife Biologist, USFWS- Habitat and Population Evaluation Team

Lisa Gelvin-Innvaer, Regional Non-game Wildlife Specialist, MN DNR

Kristin Karlson, Research Scientist, MN DNR

Jeff Lawrence, Waterfowl Population Research Group Leader, MN DNR

Kevin Lines, Conservation Easements Program Administrator, BWSR

Ray Norrgard, Wetland Wildlife Program Coordinator, DNR

Doug Norris, Wetlands Program Coordinator, MN DNR

Mark Oja, State Biologist (MN), USDA-Natural Resources Conservation Service (NRCS)

Joe Pavelko, MN Director of Conservation Programs, Pheasants Forever

Lee Pfanmuller, State Planning Coordinator, Audobon Society

Paul Radomski, Research Scientist, MN DNR

*John Schneider, Ducks Unlimited

PPRILCS Water Quality and Flood Control Team Participants

*Charlie Anderson, District Engineer, POR Engineering

Wayne Anderson, Agricultural Liaison, MN PCA

Ann Bannitt, Water Mgmt and Hydrology Section, US Army Corps of Engineers

Kristin Blann, Freshwater Ecologist, TNC

Rich Davis, Biologist, USFWS (Ecological Services)

Mark Deutschman, Houston Engineering

Jeremy Erickson, Project Manager, Natural Resources Research Institute, UM-Duluth

Mark Gernes, Water Quality Division, MN Pollution Control Agency

Nick Gervino, MN Pollution Control Agency

Henry Van Offelen, Natural Resource Scientist, MN Center for Environmental Advocacy

Rebecca Seal-Soileau, Geologist, US Army Corps of Engineers

Jim Solstad, Surface Water Hydrologist, MN DNR

Rob Sip, Environmental Policy Specialist, MN Dept of Ag

*Aaron Spence, GIS Specialist, BWSR

Brian Tangen, Biologist, Northern Prairie Wildlife Research Center, USGS

*Sean Vaughn, GIS Hydrologist, MN DNR

Barbara Weisman, Senior Planner, MN Dept of Ag

<u>PPRILCS Agriculture and Economics</u>

*Greg Anderson, Agricultural Program Specialist, Farm Services Agency

Wayne Anderson, Agricultural Liaison, MN PCA

Mark Dittrich, Senior Planner (Conservation Drainage), MN Dept of Ag

Warren Formo, Executive Director, MN Ag Water Resource Coalition

*Tabor Hoek, Private Lands Coordinator, BWSR

Bonnie Keeler, University of Minnesota

Mark Lindquist, Biofuels Program Manager, MN DNR

Sheldon Myerchin, State Coordinator, Private Lands Program, USFWS

*Steve Polasky, Professor of Ecological Economics, UofM

Rob Sip, Environmental Policy Specialist, MN Dept of Ag

Dan Svedarsky, Professor of Agriculture and Natural Resources, UM-Crookston

Steve Taff, Professor of Economics, University of Minnesota

Linda Meschke, Rural Advantage

*Chris Radatz, Public Policy Team Director, MN Farm Bureau