Targeting and Prioritization of Geographic Areas in the Thief River Watershed
By Paul J. Radomski and Kristin Carlson

Summary

As threats to Minnesota's watersheds continue to mount, it is becoming increasingly important to identify and conserve high-priority areas. Identification of these priority areas, including sources of point and non-point pollution, will be crucial for targeting actions to improve water quality. There are multiple opportunities for protection or restoration in any watershed. Identifying which practices to implement and where in the landscape to implement them can help more effectively target efforts and more efficiently utilize limited resources.

To prioritize land within the Thief River watershed, we used a process that included the values-based model Zonation. This process began with the identification of the goals of the watershed and concluded with a review of the results. The identification of priority areas was based on the quantitative analysis (using Zonation) of a suite of data layers. Planning team members decided on what landscape features were included in the model, and weights were set based on a matrix ranking priority issues/concerns. The process was framed within the DNR's healthy watershed conceptual model, and included biology, hydrology, water quality, and geomorphology components. An additional component, designed to capture other "lands of concern" within the watershed was also included.

This approach recognized that attempts to solve clean water needs within the watershed are not separate from other natural resource needs; each priority area should provide multiple benefits. The model used in this process helps achieve this goal by identifying areas that provide multiple benefits while incorporating data valued by the community.

Results

The Zonation output maps ranked lands as to their importance for land management activities that would provide greater protection of ecosystem functions, especially water quality, and to their importance for application of various land best management practices. The Zonation priority map identified several potential priority areas. Lands south of the city of Holt, as well as those surrounding Grygla, were ranked high. The areas around Thief Lake, as well as those around the Eckvoll Wildlife Management Area, were ranked high as well. High priority ranked lands were also identified bordering the Moose River and County Ditch 20 (Figures 1 and 2). Priority areas are highlighted in Figures 2 and 3 and labeled in Figure 3. Table 1 describes the combinations of layers that led to the selection of each priority area. Table 1 is not an exhaustive list of the layers that influenced their ranking because each high priority area likely had other layers that were also influential in determining the high Zonation score. In addition, layers are not listed in order of importance (rather, they are listed generally in the order they appeared in the prioritization survey table). See Figure 3 for numbered locations. Priority areas were delineated based on the top 20% of Zonation output in private land ownership that were greater than 500 acres in size.

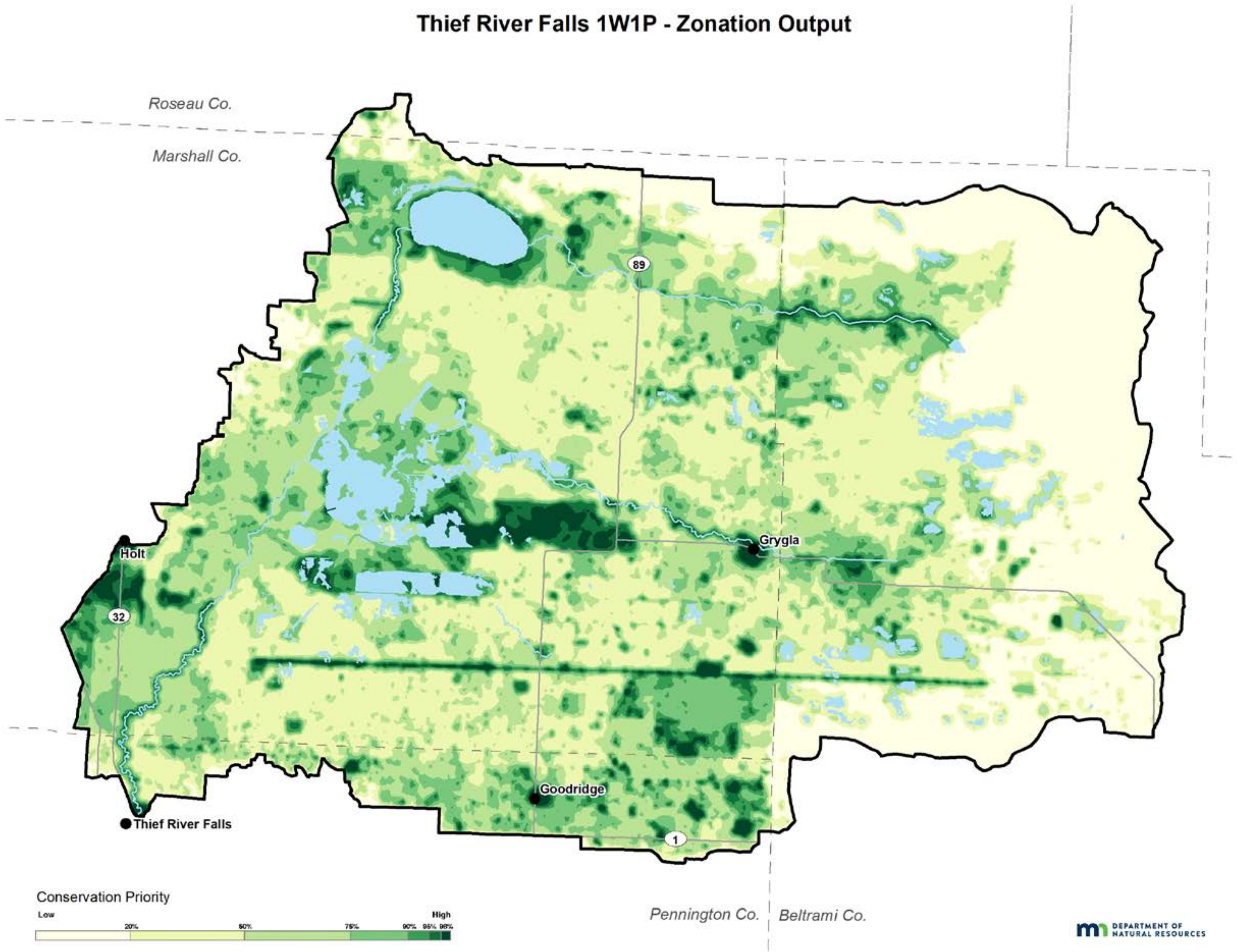

Figure 1. Priority map from Zonation analysis.

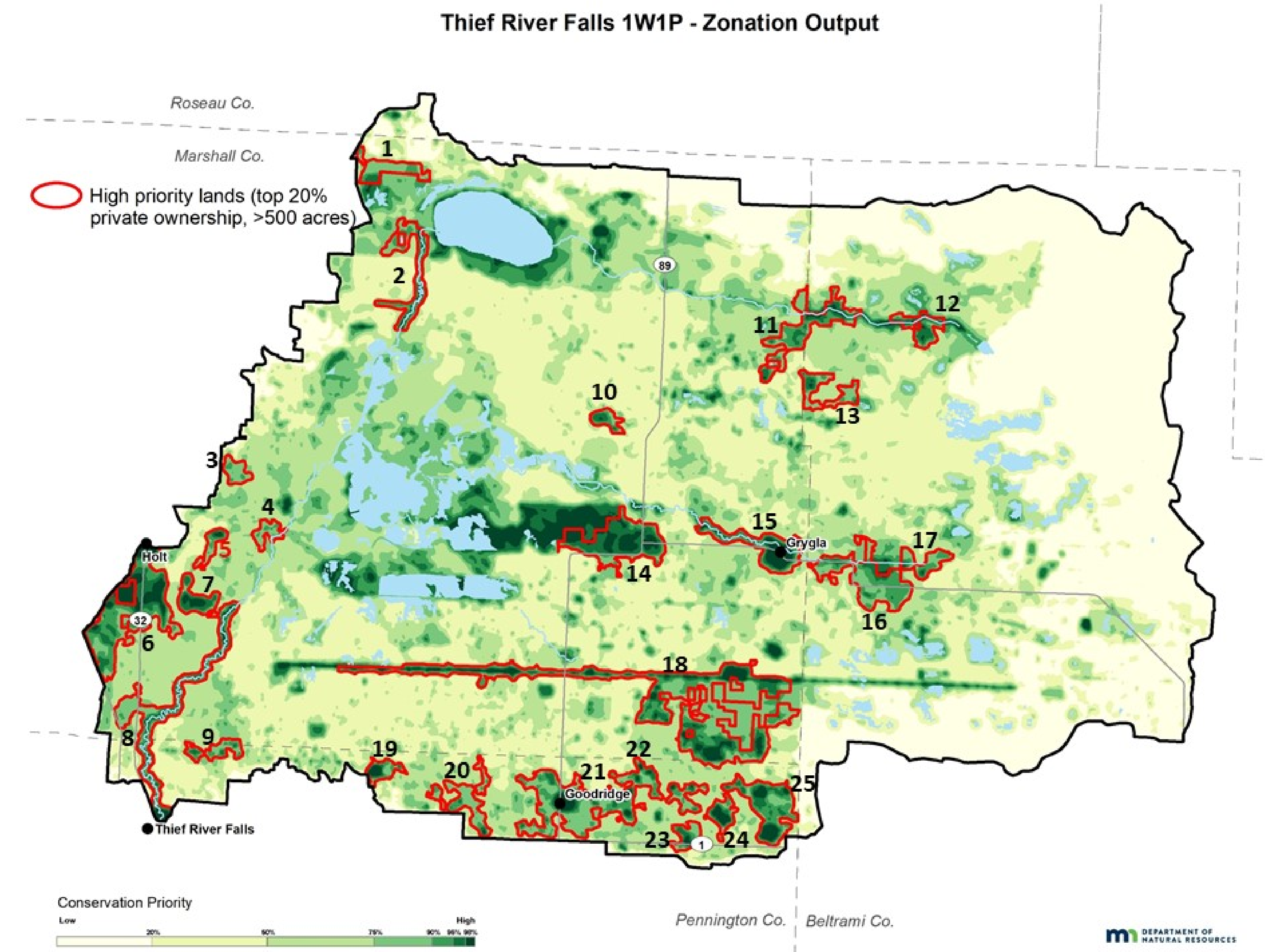

Figure 2. Potential priority areas map from Zonation analysis. Highlighted areas are those large tracts (>500 acres) of privately owned lands that scored in the top 20% of Zonation output.

Table 1. Data layers influencing Zonation high priority areas in the Thief River Watershed. Potential Priority Area numbers correspond with the labels in Figure 2.

Potential Priority Area Number	Ditches contributing more sediment	High water yields (runoff)	Riparian/floodplain	High total suspended solids pollution	High total phosphorus pollution	High total nitrogen pollution	Wetlands	Impaired stream catchments	Rare features	MBS Sites of biodiversity significance	Lakes biological significance / shallow lakes	Shoreland	Prairie core areas	Low IBI stream catchments	Ecological connections	Vulnerable cultivated crops	Urban areas	Drinking water supply management area vulnerability	Groundwater contamination susceptibility
1											X		X						X
2			X									X	X						
3			X					X											
4			X					X											
5			X					X											
6								X	X				X						
7								X							X				
8								X	X										
9			X											X					
10			X			X			X										
11				X	X	X			X					X					
12					X	X								X					X
13				X	X	X		X						X					
14								X											
15			X					X									X	X	
16			X					X	X										
17			X					X								X			
18	X												X						
19							X		X	X				X	X				
20			X											X					
21														X			X	X	
22														X		X			
23									X					X		X			
24														X	X				
25		X							X					X					

Methods

Values-based models, such as Zonation, are an efficient method for prioritizing places on the landscape for protection or restoration of water resources. These models integrate individual landscape features with context and connections, and use an objective function to identify priority resource areas. The use of an additive benefits (i.e., multiple benefits) objective function in the value model allows for the inclusion of multiple landscape features. Value models also lend themselves to collaborative efforts, by providing an opportunity for participants to decide what features are valued and the ranking of those valued features. In addition, value models and the DNR five-component healthy watershed model used to structure the content in the value model are simple concepts that are easy to explain and apply at the local government scale. Value models do not provide guidance on what practices should be implemented where, so additional analysis and/or discussion on effective and appropriate best management practices will be necessary when project planning.

The first step of the four-step process involved determining which features should be included in the Zonation model. The analysis included 22 features (i.e., data layers), grouped within four components (Table 1). Each data layer was on the same grid with a resolution of 30 by 30m. We used high-resolution data to maximize local planning realism and for greater practicality in local government water resource planning and implementation.

Weights were used to identify which features were valued more. Within the healthy watershed framework, for example, water quality features could be weighted higher than biological features. The feature-specific weights used in Zonation were set based on the ranking of the features within a Priority Matrix. Committees of local stakeholders ranked a suite of resource concerns within a matrix, and then matched identified resources to existing spatial datasets. The rankings of the concerns within the matrix were translated into weights for use in the Zonation model. Local staff reviewed the list of datasets and weights prior to inclusion in the model.

The value models were developed using Zonation software (Moilanen et al. 2009). Zonation produces a nested hierarchy of spatial priorities. It begins with the full landscape and iteratively removes cells that contribute least to the objective; therefore, the removal order is the reverse order of the priority ranking. Zonation assumes that the full watershed is available for consideration. In these models, the lakes were masked out prior to analysis. This focused the prioritization on the terrestrial parcels, in accordance with the protection and restoration goals of the Thief River watershed. Zonation's algorithms seek maximal retention of weighted normalized landscape features.

To produce a map that identified areas on the landscape that provide multiple benefits, we used the additive benefit function within Zonation. This function aggregates values by summation across features:

$$V(P) = \Sigma w_j N_j(P)^{z_j}$$

where the value of a parcel *V(P)* is equal to the summation of weighted *w* normalized features of the parcel $N_j(P)$ to the power of *z* (set to 0.25 for all features).

Additionally, Zonation allows ranking to be influenced by neighboring parcels, so that highly valued areas can be aggregated, and fragmentation of areas can be minimized. We utilized the distribution-smoothing algorithm in Zonation, which assumes that fragmentation (low connectivity) generally should be avoided for all features. Initial analyses indicated that a connectivity distance of 200m may be appropriate for local government efforts targeted at the watershed scale. We found that very small connectivity distances made no difference in prioritization, since the connectivity effect did not extend very far, and very large connectivity distances aggregated cells across unrealistically large areas. We also found that across a modest range of connectivity distances the results were minor.

Table 2. Descriptions for features (i.e., data layers) used in land prioritization value models and Zonation score.

Reduce Erosion & Runoff		**Zonation input score**
Focus on Ditches likely contributing more sediment	Extensive stretches of ditch segments with likely substantial slumping banks (land area encompassed by stream buffer distance). Source: County data based on expert opinion.	3
Focus on Areas with high water yields (runoff)	Estimated annual water yield (volume in inches/acre or cubic feet per second (cfs)/acre) by catchment as determined by hydrological models. Source: PTMApp	3
Protect or Restore Stream riparian and floodplain areas	Stream riparian areas and potential flood zones (based on location, elevation and soil type). Source: DNR and Flood maps	3
Focus on Areas contributing more to floodwaters in the City of Crookston	Estimated reduction in peak stream flow at Crookston gage for each square mile detained in a sub-basin. Source: Red Lake Watershed District, Red River Watershed Management Board, HDR.	3
Focus on Catchments with high pollution	Estimated total suspended solids, total nitrogen, and total phosphorus by catchment as determined by hydrological models. Source: PTMApp	3
Protect Existing wetlands	Remaining wetlands as documented by the National Wetland Inventory (NWI).	2
Focus on Lands associated with impaired streams	Catchments (i.e., drainage basins) upstream of dissolved oxygen, total suspended solids, and bacteria impaired streams within the watershed. Identified as impaired by the MPCA.	2

Protect or Improve Fish & Wildlife Habitat		Zonation input score
Protect Rare plants or animals	Locations of species currently tracked by the DNR, including Endangered, Threatened, and Special Concern plant and animal species as well as animal aggregation sites. Excluded locations with high uncertainty. Source: DNR.	2
Protect Sites of biodiversity significance	Areas with varying levels of native biodiversity that may contain high quality native plant communities (e.g., native prairies, fens, quality forests, meadows, swamps, etc.), rare plants, rare animals, and/or animal aggregations. Identified by Minnesota Biological Survey. Source: DNR.	2
Protect or Restore Lakes of biological significance and Priority Shallow Lakes	Catchments of high quality lakes. List of high quality lakes based on dedicated biological sampling. Source: DNR's Lakes of Biological Significance and DNR's Shallow Lakes Program	3
Protect or Restore Shoreland	Land within 1000 feet of lake shoreline and all lands located within 300 feet of a protected water stream or 1000 feet of a lake.	3
Protect or Restore Prairie core areas	Areas with concentrations of native prairie and grasslands. Source: DNR Prairie Plan.	2
Focus on Lands associated with potential restorable wetlands	Potentially restorable wetlands based on an inventory and analysis. Source: BWSR.	2
Focus on Lands associated with low biological diversity streams	Catchments (i.e., drainage basins) upstream of low fish IBI streams within the watershed. Identified by the MPCA.	2
Protect or Restore Ecological connections	Ecological corridors between generally large, intact, native or "semi-natural" terrestrial habitat patches. Data Source: DNR.	2
Protect or Improve Lands of Concern		**Zonation input score**
Implement BMPs on Vulnerable cultivated croplands	Land cover type is cultivated crops (areas used for the production of annual crops or actively tilled areas) with low crop productive index (CPI). Crop productivity index (CPI) ratings are relative rankings of soils based on their potential for intensive crop production (especially corn production). Ratings range from 0 to 100 with higher numbers indicating higher production, therefore (100 – CPI) was used to identify low productivity lands. Classification from NRCS.	3
Implement BMPs on Areas with high wind erodibility	Cultivated crop areas with high wind erodibility indices. Source: Soil Survey Geographic Data Base (SSURGO).	2
Protect or Improve Urban areas and undeveloped lands adjacent to urban areas	Urban lands have opportunities for improved management of stormwater runoff. Those areas close to existing development may be more likely to be developed, and some of these lands that provide important ecosystem services may be of conservation value.	2

Protect Groundwater		Zonation input score
Focus on Drinking Water Supply Management Area (DWSMA) vulnerability	The risk associated with potential contaminant sources within a public water supply DWSMA to contaminate its drinking water supply. This risk is based on the aquifer's inherent geologic sensitivity, the assessed vulnerability of the public water supply well(s), and the composition of the groundwater. In highly vulnerable DWSMAs, there is a strong causal relationship between land use activities on the surface and groundwater quality.	3
Focus on Drinking source water assessment areas (SWA)	Source water assessment area (SWA) is the surface and subsurface area surrounding a public water supply well that completely contains the scientifically calculated time-of-travel area. The primary purpose of the SWA is to give the public water supplier an idea of the potential size of the final Wellhead Protection Area (WHPA). Source: MDH.	3
Focus on Groundwater contamination susceptibility	The pollution sensitivity of near-surface materials from the transmission time of water through 3 feet of soil and 7 feet of surficial geology, to a depth of 10 feet from the land surface. Source: DNR; Pollution Sensitivity of Near-Surface Materials.	2
Focus on Groundwater at greatest risk to nitrate contamination	Areas vulnerable to nitrate pollution to groundwater. Source: County.	2

References

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