Improving Selective Dam Removal in Wisconsin

Mark Wegener, Patrick Engineering, Inc.;
Helen Sarakinos, River Alliance of Wisconsin

Abstract

Wisconsin has emerged as a national and world leader in the selective removal of dams. These actions have demonstrated that selectively removing dams can help restore river ecosystems, improve fish and wildlife populations, and increase recreational opportunities. With the increasing availability of ecological data, and improvements to spatial analysis tools, there exists an opportunity for improving the 'selectivity' of selective dam removal with respect to the restoration of river ecosystems. Specifically, by using a Geographic Information System (GIS) to examine those river attributes that are traditionally affected by dam removals, it is possible to prioritize existing dams based on the predicted ecological benefits of their removal.

Background

Since the mid-1800s, Wisconsinites have harnessed the power of flowing water to move timber, irrigate crops, operate mills, generate power and for myriad other purposes. That development has left behind a legacy of almost 4000 dams built on the rivers and streams of the state, over 600 of which are located in the Lake Michigan Basin of Wisconsin alone.

Over the last 150 years, the cumulative impact of these dams on Wisconsin streams and rivers has been extensive. After polluted runoff, dams constitute one of the greatest threats to river ecosystems in the state. Dams alter the flow of water and prevent the natural movement of sediment in the river channel. They also block fish and mussel passage, limit their access to habitat, fragment river ecosystems and impair water quality both in the reservoir and downstream.

Furthermore, many dams on Wisconsin rivers are becoming old, obsolete and unsafe. Data from the Wisconsin Dam Inventory shows that 60% of Wisconsin dams are between 50 and 100 years old. Another 10% are older than 100 years. The National Association of State Dam Safety has stated that the engineering life of the average dam is fifty years. Beyond that age, dams, like roads, bridges and other infrastructure, require maintenance and repairs to remain safe and fully functional. With almost half of the dams in the Lake Michigan basin owned by individuals or municipalities, these often-expensive repairs can place a heavy or unreasonable financial burden on the dam owner.

Not all dams are created equal. Just as some dams serve a greater human benefit than others, some do more harm to rivers than others, either because of their size, location on a river, proximity to species of concern or their role in exacerbating other river problems (e.g. nutrients, invasive species). The goal of this project is to utilize GIS analysis to evaluate the relative impacts of dams in the Lake Michigan Basin on river ecosystems and to determine where maximum restoration benefit could be gained through selective dam removal.

Methods

With the increasing availability of ecological data, as well as the emergence of new tools for performing spatial analysis, there exists an opportunity for improving the 'selectivity' of selective dam removal with respect to the restoration of river ecosystems. Specifically, by using a GIS to examine those river attributes that are traditionally affected by dam removals, it is possible to prioritize existing dams based on the predicted ecological benefits of their removal.

This project focused on the 630 dams in the Lake Michigan Basin of Wisconsin. Each dam's removal priority was determined by incorporating existing spatial and tabular datasets into a GIS database, and then using spatial analysis techniques to develop additional data. These data were then examined together to quantify the effects of each potential dam removal. For each potential removal, the key ecological questions answered include:

1. *Which rivers have highest and lowest density of dams?*

   To determine dam density within a watershed, a spatial join was performed to establish the number of dams per watershed. This figure will then be compared to GIS-calculated river length within the watershed to determine a density for each watershed. Watershed values were then assigned to every river in the watershed.

2. *Which dams affect fisheries habitat?*

   Dams were assigned a fishery habitat score based on the presence of coldwater and warm water sport fish on the river where the dam is located.

3. *Which dams impact the habitat of species of concern?*

   Dams were assigned a species of concern score based on the cumulative total of state or federal endangered species for the water body the dam lies on. The cumulative total is exclusive, in that species are not double-counted if they are listed on both state and federal lists.

4. *How much connectivity restored with a given removal?*

   A map topology was created in the feature dataset, which snapped dams to the hydrography layer. The hydrography was then split at the dam point locations using a custom .dll. A geometric network was then created with the weight equal to the shape length of each individual stream segment. This supported the return of trace lengths in map units. Once the flow direction was set to the digitized direction, the dams layer was disabled so that all traces stopped at dam points. Flags were then placed to establish the connectivity restored for each dam, which was accumulated and summed for each dam.

5. *Which removals will impact headwater areas?*

Using calculated stream order layer, a query was created which took into account not only stream order of each stream segment, but also the size of the water body the stream segment was flowing into. The segments returned by this query were defined as headwaters, and dams within a certain stream proximity to these segments were assigned a score for headwaters impact.

6. *Which removals will mitigate water quality problems?*

Dams were selected and assigned a score for water quality issues based on the presence of stream segments with water quality issues adjacent to the dam.

7. *Which removals are on specially designated rivers?*

Dam location will be overlaid with rivers that have a WDNR designation as an Outstanding Resource Water (ORW), Exceptional Resource Water (ERW), or rivers that are ranked by the Wisconsin DNR's Northern Resource Initiative (NRI).

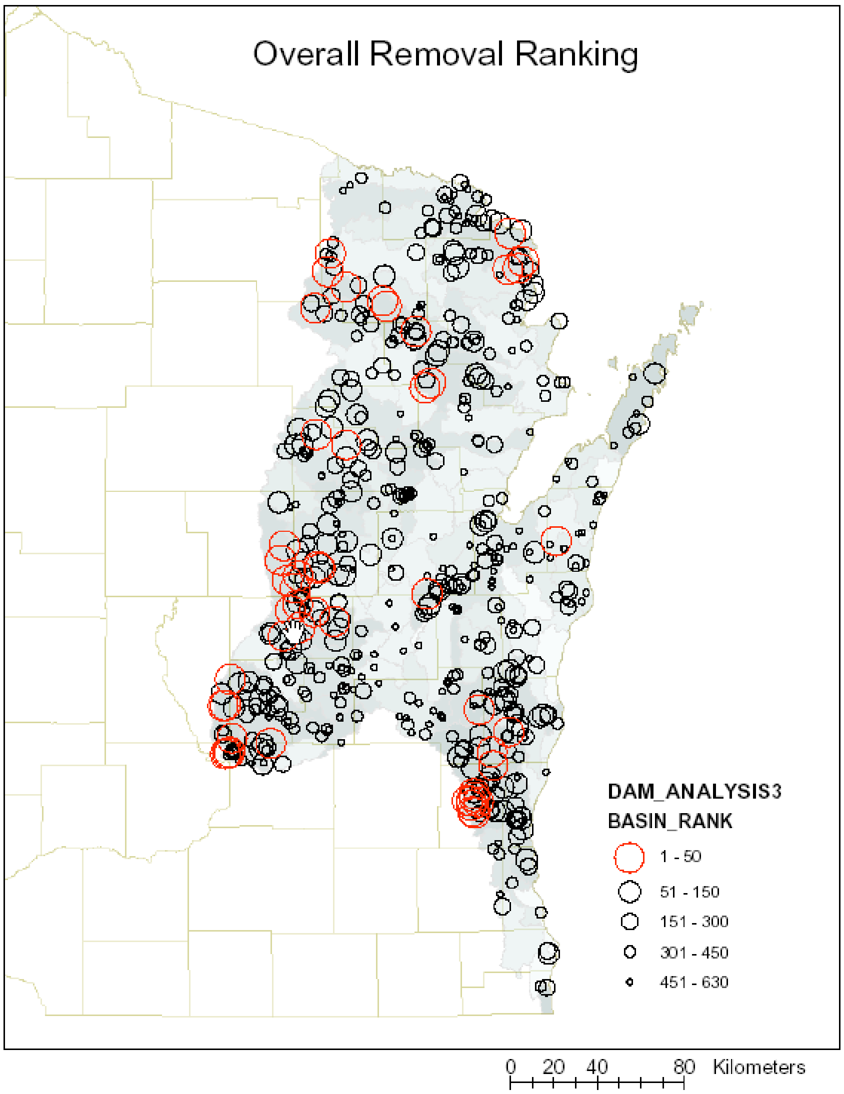
Additional dam-specific logistical attributes that were included in the analysis include:

- Ownership status
- Impoundment size
- Structure size
- Purpose of dam
- Population around impoundment
- Last inspection date

All data were organized in a GIS relational database using the Wisconsin Department of Natural Resources (WDNR) Water Body Identification Code (WBIC) as a primary key. Pertinent river datasets available with WBIC links include the WDNR 1:24,000 hydrography layer, water quality data, fisheries data, presence of species of concern, and presence of special designation. Dam-specific attributes with a WBIC link include dam locations, dam name, location, purpose, impoundment data (depth, area, storage), inspection dates, contact information, age, size, and status. The GIS environment allowed for the development of necessary data that do not currently exist, including calculations where spatial characteristics are considered (such as connectivity restored by a given dam removal).

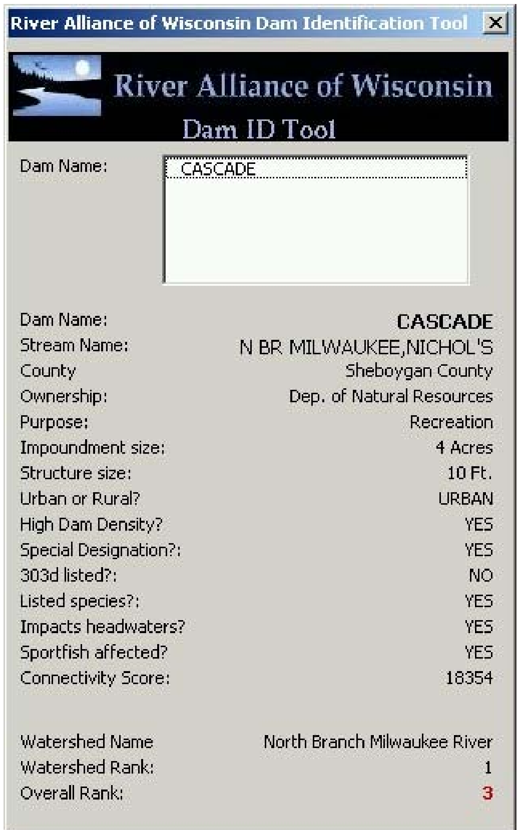
Results

A weighting and rating of all of the assembled data attributes allowed for a cumulative ranking of removal projects based on the provision of maximum ecological benefit. The ranking was performed for the entire Lake Michigan Basin, and within specific watersheds within the basin. Results can be queried and/or displayed based on basin, county, WDNR Geographic Management Unit (GMU), or any other spatial index layer for which data exists.



To facilitate interaction with the analysis results, a custom tool, called the ‘DamID Tool’ was created using VBA and ArcObjects. This ArcMap tool allows users to select a dam in the map window, and receive a form-based report with the dam removal ranking, as well as the results of the analyses and logistical information about the selected dam.

DamID Tool



Although many other factors go into the decision of whether or not to remove a dam (socio-economic, legal, political etc…), such a ranking based on ecological benefits of removal will certainly provide a valuable tool for decision-makers considering potential removal projects.

Next Steps

The next step for this project is to expand the geographic scope of the analysis to include the entire state of Wisconsin. There are also plans to develop and launch an ArcIMS Internet site to deliver the findings to the public.

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Author Information

Mark Wegener
Senior GIS Analyst
Patrick Engineering
613 Williamson St. Suite 201
Madison, WI 53703
TEL: 608-258-9167 ext.7833
FAX: 608-258-9168

Helen Sarakinos
Dams Program Manager
River Alliance of Wisconsin
306 E. WIlson, Ste. 2W
Madison, WI 53703
TEL: (608) 257-2424 ext.112
FAX: (608) 260-9799