Dowling Lake, Douglas County 2022-2031 Comprehensive Lake Management Plan

Supplemental Support Documents

Natural History

Climate

Watershed Land Cover

Soil

Water Quality

Aquatic Vegetation

Fish and Wildlife

Education and Outreach

Maps and Figures

February 2022

Lake Education And Planning Services, LLC

NATURAL HISTORY

GEOLOGY

Bedrock

In order to understand the state of Dowling Lake today, we must go back 1 billion years to understand the formation of the bedrock below our feet. Wisconsin's geology is largely defined by two periods of time: the Precambrian and the Paleozoic. In the **Precambrian era** (older than 600 million years ago) there was no life on land, and the continents that shape our world today were much different than they are now. In the midst of the Precambrian, between 1.0-1.6 billion years ago, was the Middle Proterozoic era. It is in this timeframe that the rocks from which our soil is derived was formed. This bedrock is classified as Keweenawan sandstone and Keweenawan basaltic lava flows, and these are the rocks that lie beneath Dowling Lake (Figure 2). These formations were later eroded into a large, flat plain by the end of the Proterozoic era. What is now Wisconsin was then flooded several times by ancient seas as climate caused the sea levels to rise and fall over millions of years during the Paleozoic era. Ultimately, it is Precambrian rocks that form the bedrock that lies beneath in Northern Wisconsin today. Over time, this bedrock has been eroded by wind, ancient seas, waves, and glaciers.

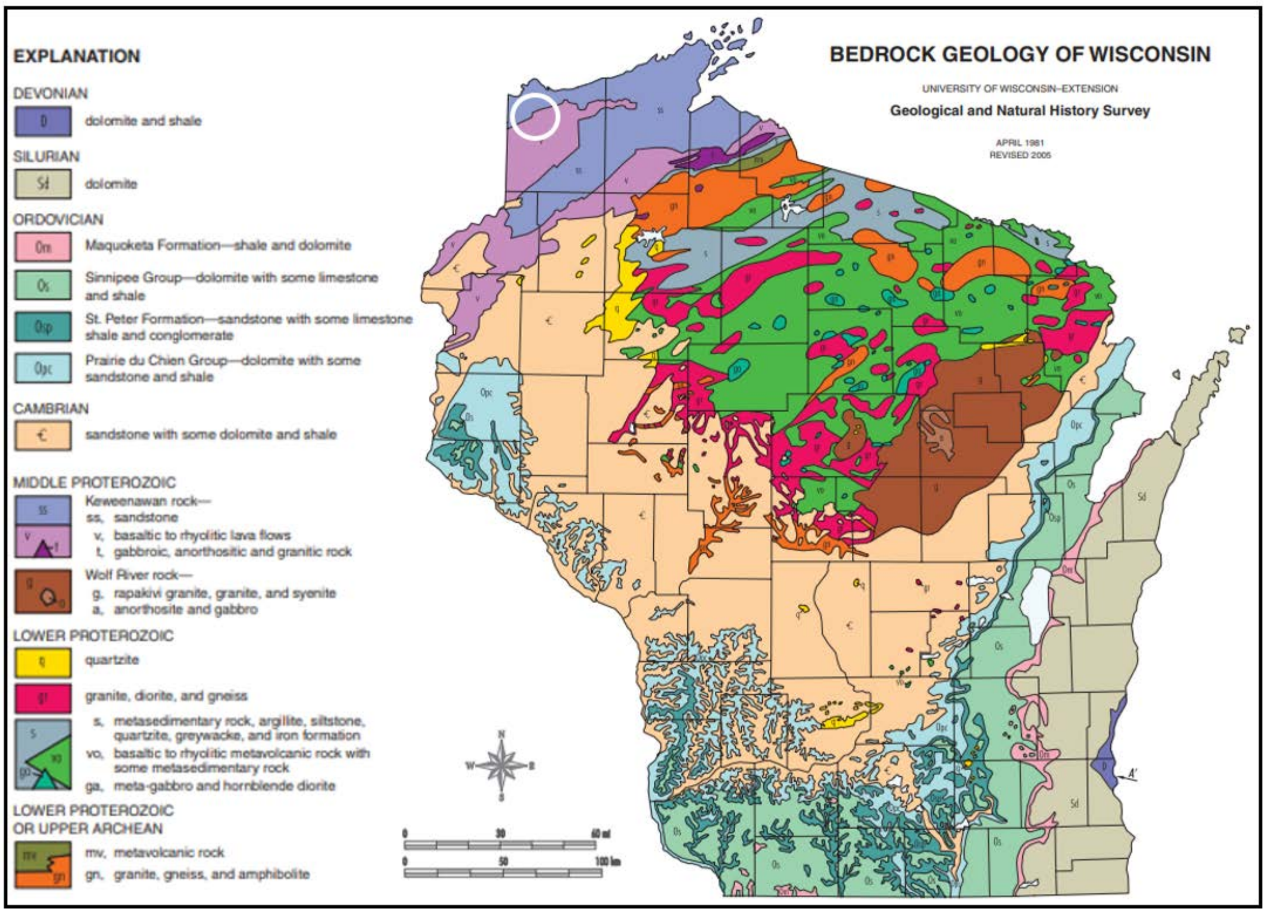


Figure 2. Wisconsin bedrock geology with Amnicon and Dowling Lakes circled in white (WDNR, 2005)

For more information: https://wgnhs.wisc.edu/wisconsin-geology/bedrock-geology/

Glaciation

As recent as 10,000 years ago, glaciers scraped across the billion-year-old bedrock, grinding it into smaller and smaller pieces and then moving and depositing that bedrock as the clay, sand, and gravel that make up the soil we see today. The past 2.5 million years have fluctuated between warm and cold in Earth's Northern Hemisphere as a result of changes in Earth's orbit and the tilt of its axis. The past 700,000 years have gone through 100,000-year cycles that are characterized by periods of warming and cooling. During periods of cooling, as snow and ice continued to build more than it was being melted, glaciers were formed. The last cycle of climate cooling and glacial expansion is known as the Wisconsin Glaciation. About 100,000 years ago, the Laurentide Ice Sheet spread from the Arctic and Canada into the Continental United States and what is now Wisconsin (Figure 3). It expanded in Wisconsin for 13,500 years before warming temperatures melted in back over the course of 7,000 years. As the glacier grew, its weight and gravity caused it to push heavily into the earth, scraping and plowing through the bedrock much like a snow plow through a fresh layer of snow (UW-Extension, 2020).

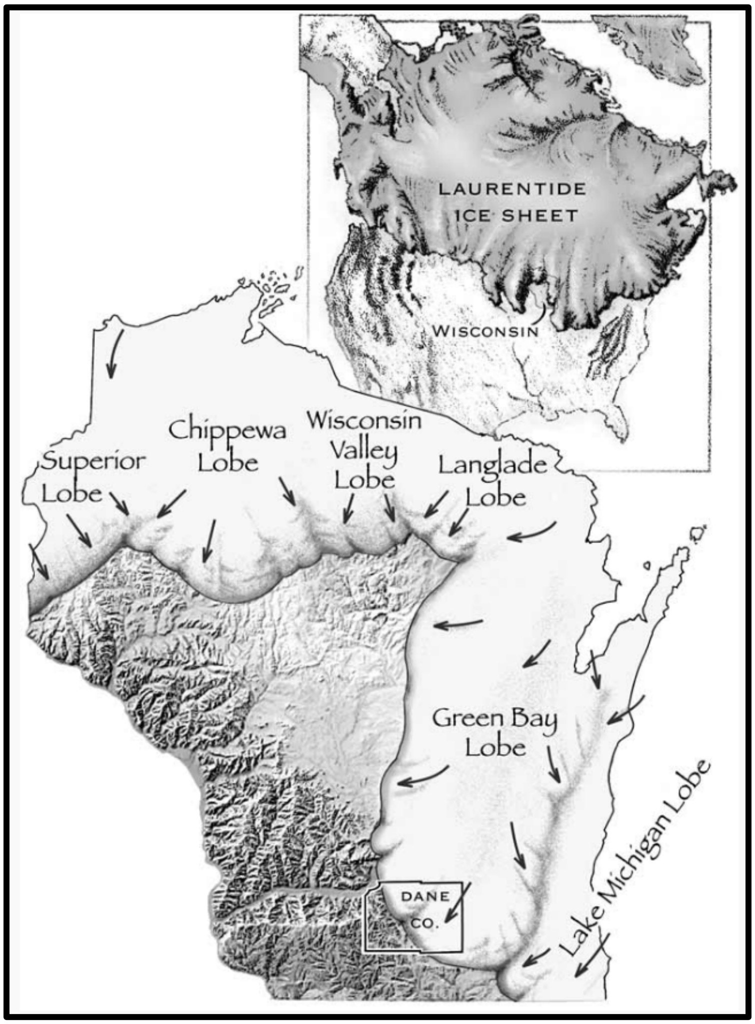


Figure 3. Glacial lobes of the Laurentide Ice Sheet that covered Wisconsin (UW-Extension, 2020)

This last period of glaciation shaped the landscape in Wisconsin that we see today. As the glaciers melted and receded, large volumes of water flowed from the glaciers, carving rivers and valleys through the vast amounts of sand, gravel, and other materials broken, carried, and deposited by the glacier's retreat. The many lakes and wetlands in the area of Dowling Lake are a direct result of the last glacier carving out small depressions and leaving behind immense chunks of ice that would later melt and form a lake in the hole left behind. This is likely how Dowling and Amnicon Lakes were formed (UW-Extension, 2020).

Concurrent with the last glacier that covered Wisconsin was the era of the woolly mammoth. As the glacier retreated and the climate warmed, the tundra that was characteristic of the mammoth's primary habitat was replaced by spruce forests, following which the mammoth was replaced by the American mastodon (UW-Extension, 2020).

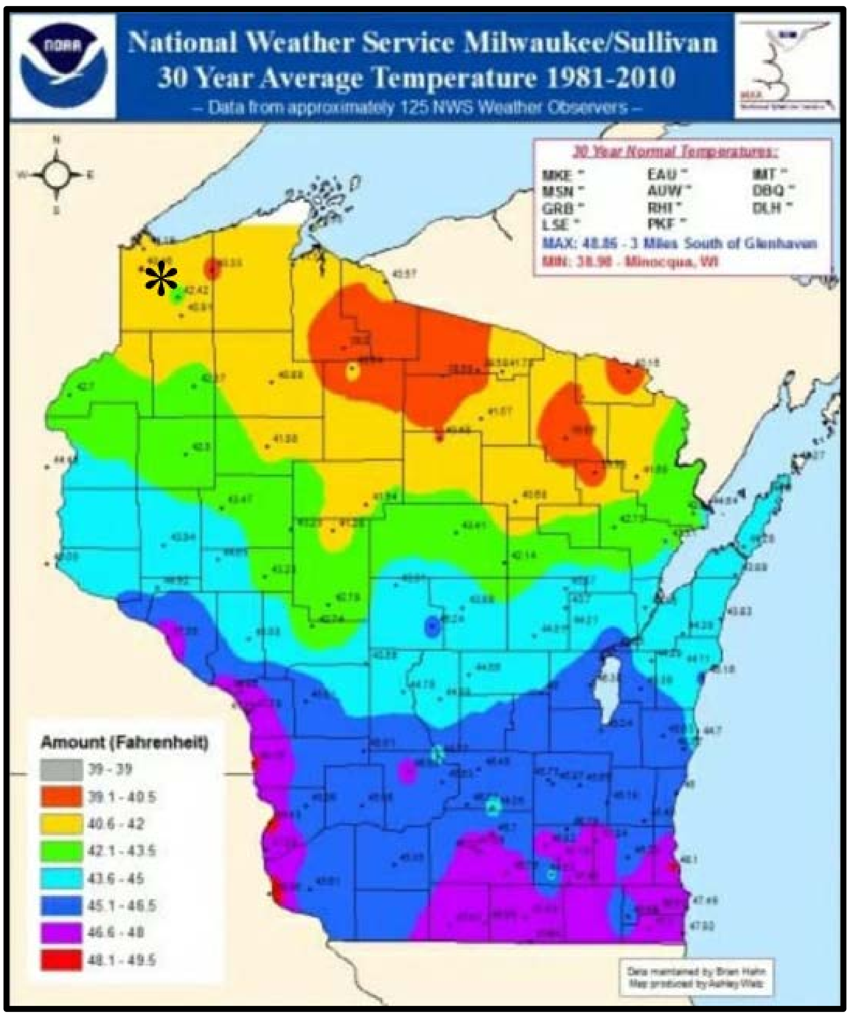
For a video showing Wisconsin's last glacial advancement and retreat see: https://wgnhs.wisc.edu/wisconsin-geology/ice-age/

<u>CLIMATE</u>

The **climate** of an area is defined based on long-term trends in temperature and precipitation. Measured and monitored by the National Weather Service (NWS) through the National Oceanic and Atmospheric Administration (NOAA), temperature and precipitation change on a daily basis: this is **weather**. When this data is compiled over many years, this is climate. Both temperature and precipitation (which includes snowfall and rain) in the Amnicon and Dowling Lake area are continuously measured by the Duluth Weather Station.

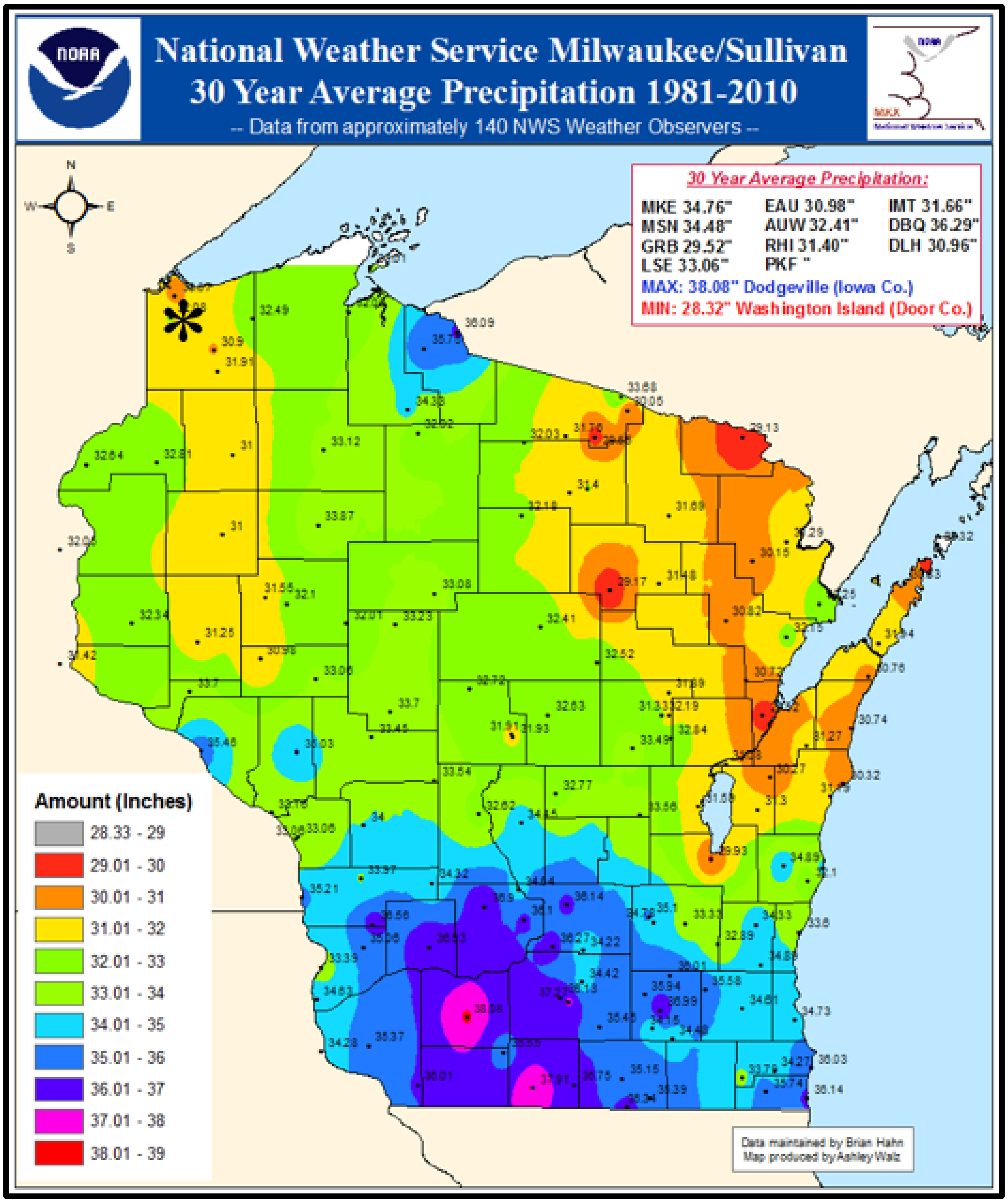
Temperature

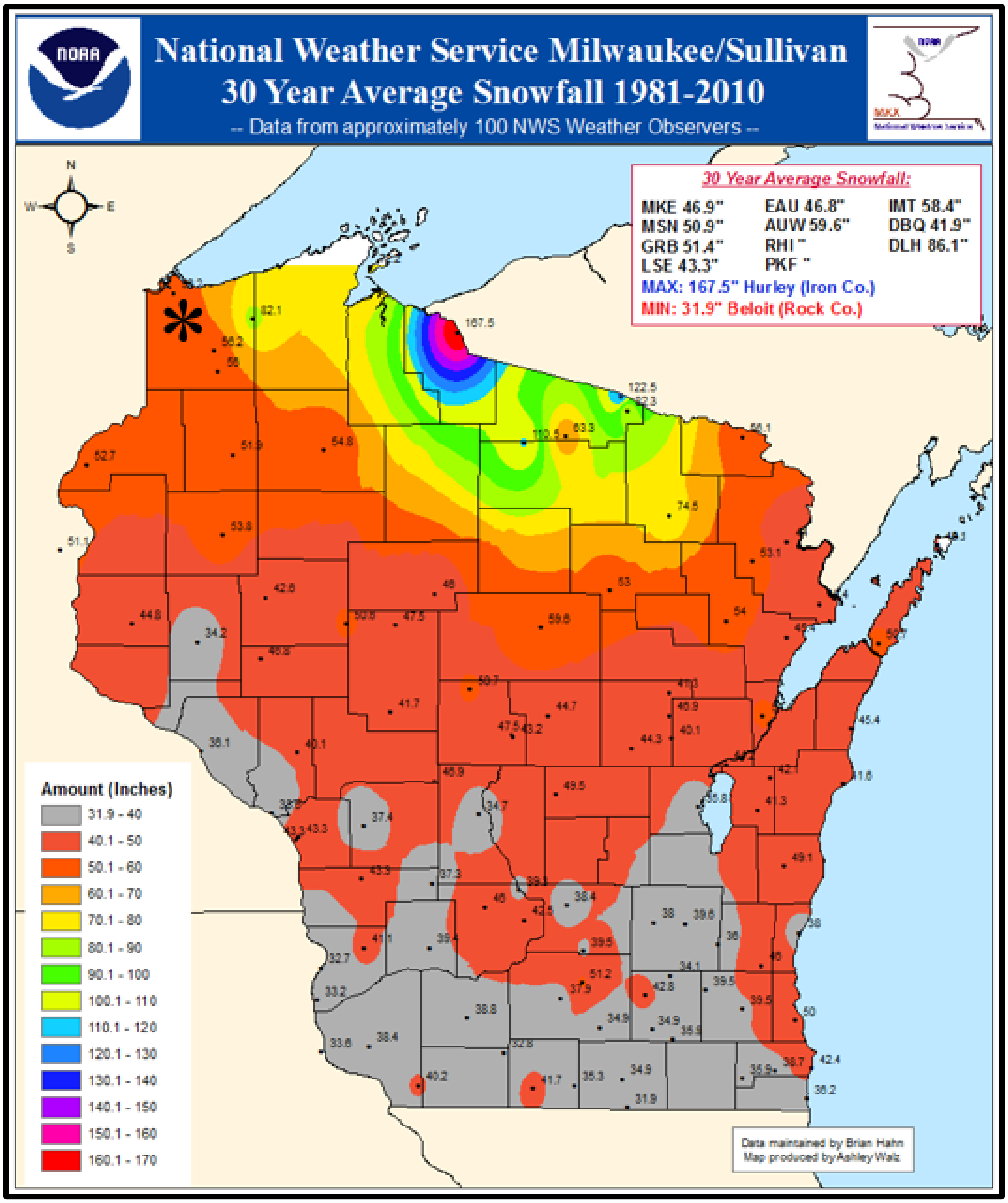
The average yearly temperature for Amnicon and Dowling Lakes area is approximately 41°F (Figure WiTemp). This measurement relates to the fact that Northern Wisconsin can reach temperatures well below 0°F in the winter and over 100°F in the summer. The average yearly temperature from 1981-2010 indicates that the plant community of Douglas County is hardy and can survive wild fluctuations in conditions. The lakes are also subject to freezing in the winter, turnover in the fall and spring, and stratification in the summer. These conditions are conducive to nutrient release from the sediment and potentially winterkills when oxygen becomes depleted in shallow lakes like Dowling. See section ### for more information.



Precipitation

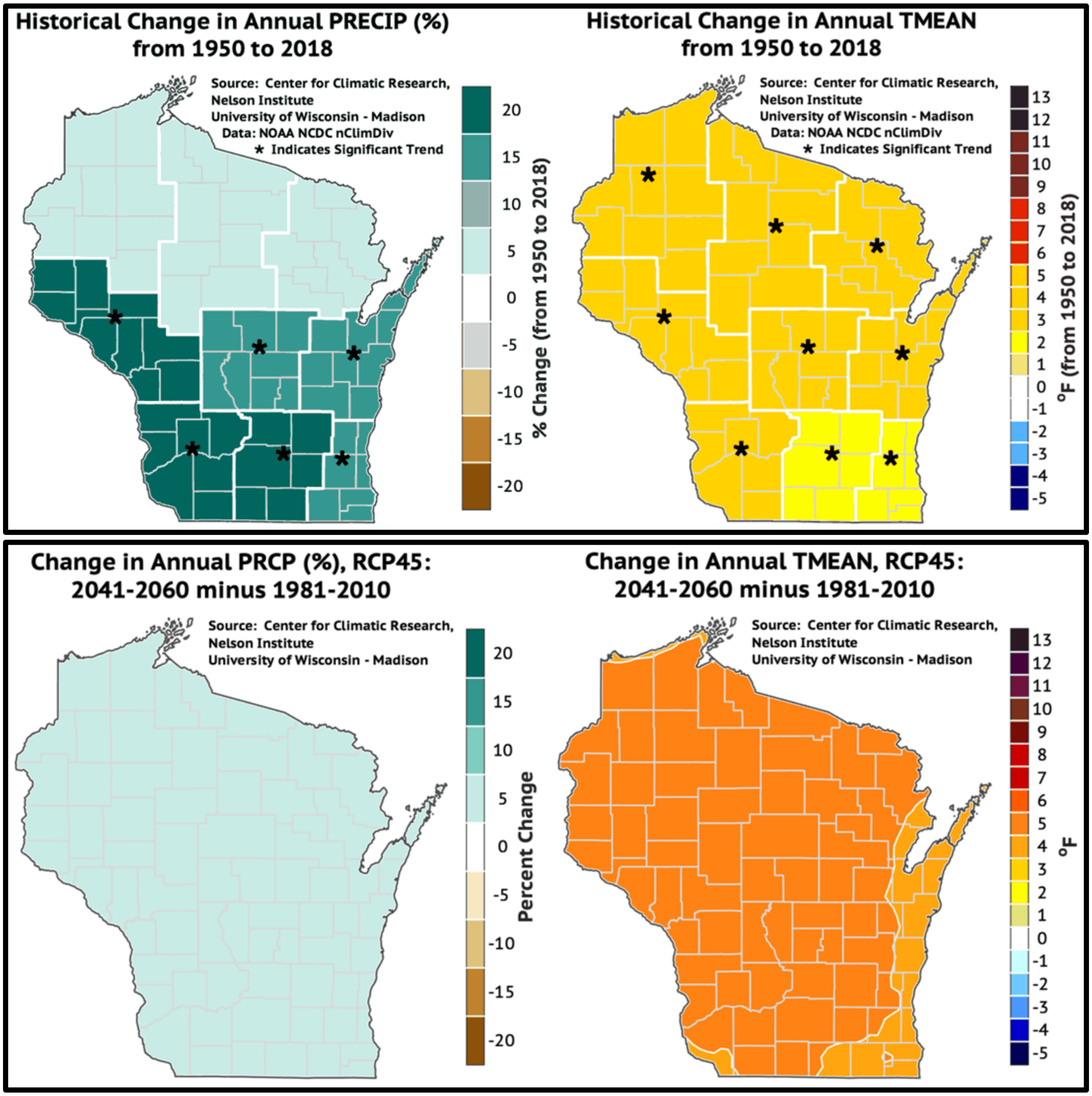
The average yearly amount of precipitation, including ice and snow, for the Amnicon and Dowling Lakes area is approximately 31.50 inches (Figure WiPrecip). About two-thirds of this value currently falls during the growing season. Because snowfall in inches is not the same as rainfall in inches (snow contains air whereas rainwater does not), snowfall is included in this average as a liquid value (by melting snow and measuring it). The area receives a yearly average of about 55 inches of snow (Figure WiSnow). Thus, the majority of the area's precipitation is received in the winter months. Ultimately, plants use the water from precipitation and snowmelt in photosynthesis and release much of it back into the atmosphere. This water also replenishes the shallow aquifer of the area, as rainfall and snowmelt easily infiltrate into the sandy soils of the area, which in turn helps maintain lake and river levels through groundwater infiltration and springs.





Future

Data from 1950 to 2018 has shown that Douglas County has received less precipitation and has become significantly warmer (Figure HistoricalChange). Research from the University of Wiconisn-Madison has revealed that Douglas County receives 5% less annual precipitation now than it did in 1950, and the area is 4°F warmer on average now than it was in 1950 (Figure HistoricalChange). Based on current climate and predicted future climatic conditions, it is likely that the Amnicon-Dowling area will become even warmer and more dry (less precipitation) in the future (Figure PredictedChange). This means that the soils will contain less moisture, lake levels may decrease, and there will be fewer days of ice cover on the lakes. These conditions will likely stress the plants and animals that live in the lakes and may cause a shift towards species that can tolerate warmer water and lower oxygen levels within the next 40 years.



WATERSHED LAND COVER

Watershed Background

Watersheds – the area that separates waters flowing to different rivers or basins – can be examined from multiple levels that range in size from thousands of square miles to just a small lake Table. Dowling and Amnicon Lakes are a very small fraction of the Great Lakes Basin that includes all five Great Lakes because, as part of the Amnicon River, it eventually reaches Lake Superior (Table 1). At the next level, the lakes fall in the Lake Superior Basin that includes all waters that drain to Lake Superior (Table 1). Next, Amnicon and Dowling are part of the Amnicon River Watershed that extends from central Douglas County north to Lake Superior (Figure WatershedLocations). In the Amnicon River Watershed there are 641 total miles of streams, 7,915 acres of lakes, 42,307 acres of wetlands, 49.8 miles of outstanding/exceptional waters, 59.2 miles of trout streams, 0 miles of impaired streams, and 760.7 acres of impaired lakes. The Amnicon River also boasts a series of waterfalls in the Amnicon Falls State Park. The Amnicon River Watershed is then subdivided even further into the Upper, Middle, Lower, and Little Amnicon River watersheds; as the headwaters to the river, Amnicon and Dowling are in the Upper Amnicon River Watershed (Table 1; Figure WatershedLocations). Nestled in the Upper Amnicon Watershed, Amnicon and Dowling each have a small area that drains directly to the lakes. Because the lakes and their drainage areas are so small, the lakes are interconnected, and the ADLMD manages both lakes, the drainage areas have been combined in these analyses (Table 1; Figure WatershedLocations).

At 4.04 square miles, the drainage area that feeds into Amnicon and Dowling Lakes is just a small piece of the much larger Amnicon River Watershed, which covers about 314 square miles is relatively small – 4.04mi^2 (Table 1). There is a small main inlet to Dowling Lake – the head waters to the Amnicon River – that drains a woody wetland complex. There are two other small inlets to the lake: an intermittent stream on the north end of the lake, and a small inlet from Newman Lake on the east shore. Dowling then feeds into Amnicon through another small channel, and then Amnicon Lake drains through the southwest corner to the Amnicon River (Figure WatershedLocations).

Table 1. Amnicon-Dowling drainage basin sizes

Drainage Basin	**Area mi^2**
Great Lakes Basin	295,710.00
Lake Superior Basin	31,700.00
Amnicon River Watershed	313.64
Upper Amnicon River Watershed	48.94
Amnicon-Dowling Drainage	4.04

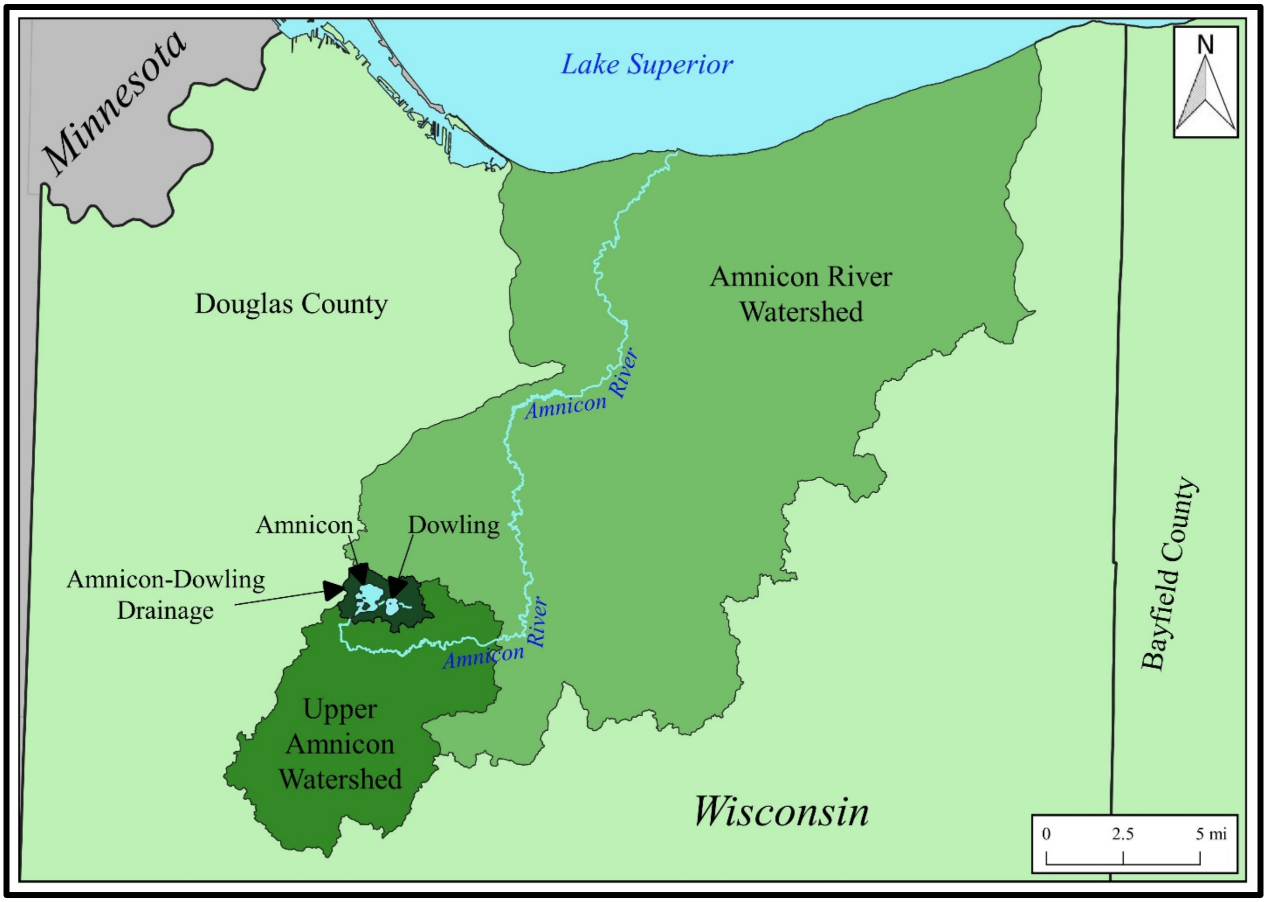


Figure WatershedLocations. Amnicon and Dowling watersheds.

Land Cover Background

Using National Land Cover Database (NLCD) information to map the land cover in the watershed, it is possible to determine what kind of vegetation and development is present in a given area. NLCD data is compiled using satellite imagery that photographs the earth in 30m by 30m square pixels that are then analyzed based on the percent of 28 possible land cover classifications. The dominant land cover type is then selected for that pixel. Altogether, NLCD data delineates a fine scale representation of land cover that can be analyzed and compared through time.

Of the 28 possible NLCD land cover classifications, 13 were found in the Amnicon-Dowling drainage watershed (Figure NLCD descriptions).

NLCD Land Cover Classification	Description
Open Water	areas of open water, generally with < 25% cover of vegetation or soil.
Developed, Open Space	areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for < 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings.
Developed, Low Intensity	areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.
Developed, Medium Intensity	areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50- 79% of the total cover. These areas most commonly include single-family housing units.
Developed, High Intensity	highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Deciduous Forest	areas dominated by trees generally > 5m tall, and > 20% of total vegetation cover. > 75% of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	areas dominated by trees generally > 5m tall, and > 20% of total vegetation cover. > 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	areas dominated by trees generally > 5m tall, and > 20% of total vegetation cover. Neither deciduous nor evergreen species are > 75% of total tree cover.
Shrub/Scrub	areas dominated by shrubs; < 5m tall with shrub canopy typically > 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Grassland/Herbaceous	areas dominated by gramanoid or herbaceous vegetation, generally > 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Pasture/Hay	areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for > 20% of total vegetation
Woody Wetlands	areas where forest or shrubland vegetation accounts for > 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	areas where perennial herbaceous vegetation accounts for > 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Figure NLCD descriptions. NLCD land cover classification description (USGS, 2019)

For more information on the NLCD: https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects

Land Cover

The sandy soils and temperate climate of the area determine what plant species can naturally grow there and what forms of development and agriculture are possible. Within the watershed drainage area, the dominant land cover type is WOODY WETLANDS (37.72% of the drainage area), followed by MIXED FOREST (21.74%), OPEN WATER (20.93%), DECIDUOUS FOREST (8.33%), and DEVLEOPED OPEN SPACE (4.42%; Table 2, Figure 8). All other land cover classifications make up less than 10% of the total drainage area combined (Table 2, Figure LCPie). All levels of development, including agriculture, makes up 8.11% of the watershed while natural forest and wetland cover make up the remaining 91.89%.

Table 2. NLCD land cover percent and acreage for Amnicon-Dowling drainage

NLCD Land Cover Classification	% Land Cover	Acres
Woody Wetlands	37.72%	974.79
Mixed Forest	21.74%	561.91
Open Water	20.93%	540.95
Deciduous Forest	8.33%	215.33
Developed, Open Space	4.42%	114.34
Developed, Low Intensity	1.97%	50.82
Evergreen Forest	1.76%	45.51
Pasture/Hay	1.22%	31.50
Emergent Herbaceous Wetlands	0.58%	15.04
Developed, Medium Intensity	0.48%	12.34
Grassland/Herbaceous	0.43%	11.23
Shrub/Scrub	0.40%	10.28
Developed, High Intensity	0.02%	0.56

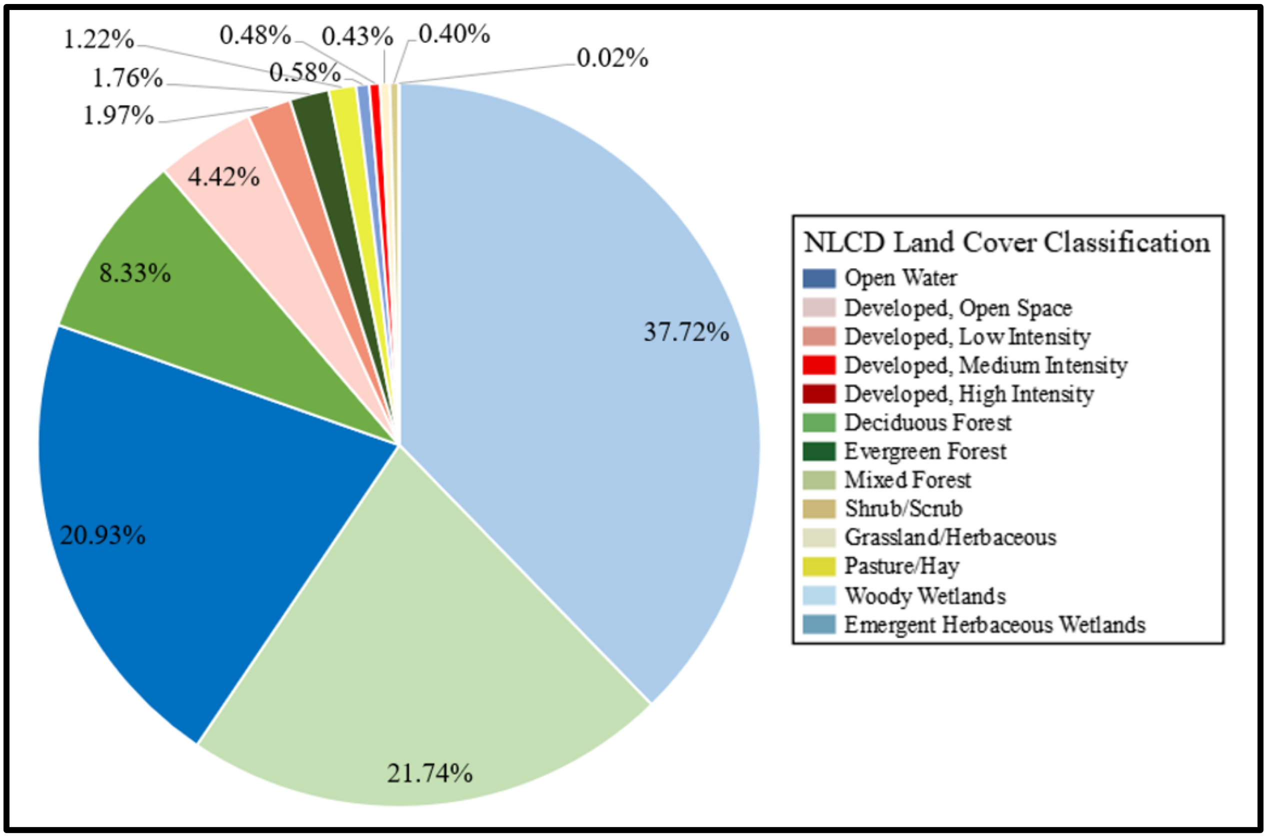


Figure LCPie. Amnicon-Dowling watershed land cover (NLCD, 2016)

The majority of the development in the drainage area is within 300 feet of the lakes, and beyond that is largely natural wetland and forest cover (Figure LandCover). The north side of Amnicon and the entirety of Dowling are densely developed with homes and cabins on relatively small lots (Figure 1). There is a large complex of woody wetlands comprised mostly of tag alder swamps that overlay the poorly drained organic soils with some evergreen forests in sandy drained areas mixed in to the east and southeast of Dowling where the headwaters of the Amnicon River begin (Figure LandCover; Figure Wetlands; Figure SoilDrainage). The wetland is mostly bound on its northern border by Tri Lakes Road. North of Dowling Lake is pock marked with a mosaic of woody wetlands, mixed forests, and deciduous forests where there is a complex of soil types and the soil is moderate to poorly drained (Figure LandCover; Figure Wetlands; Figure SoilDrainage). The area to the north of Amnicon is also mostly woody wetlands with some areas of pasture/hay fields. West of Amnicon has the highest concentration of development in the drainage area where there are the most roads, parking lots, businesses, and homes (Figure LandCover). The southern edge of Amnicon is mostly undeveloped with woody wetlands and mixed forests with some agriculture on the edge of the drainage area (Figure LandCover; Figure Wetlands). The ADLMD has purchased several lots in this area to preserve the natural shoreline and ensure that the lots do not become developed in the future (Figure 1).

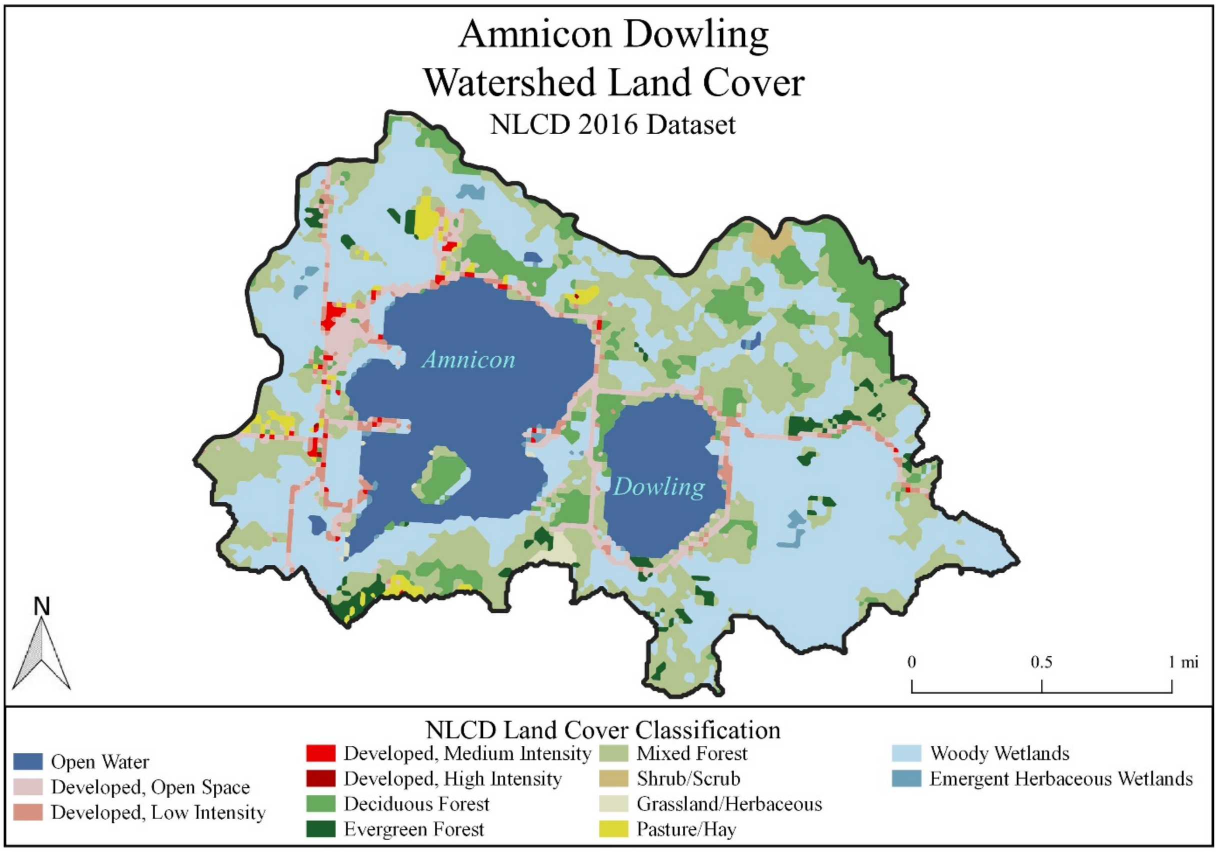


Figure LandCover. NLCD 2016 land cover of the Amnicon Dowling watershed area

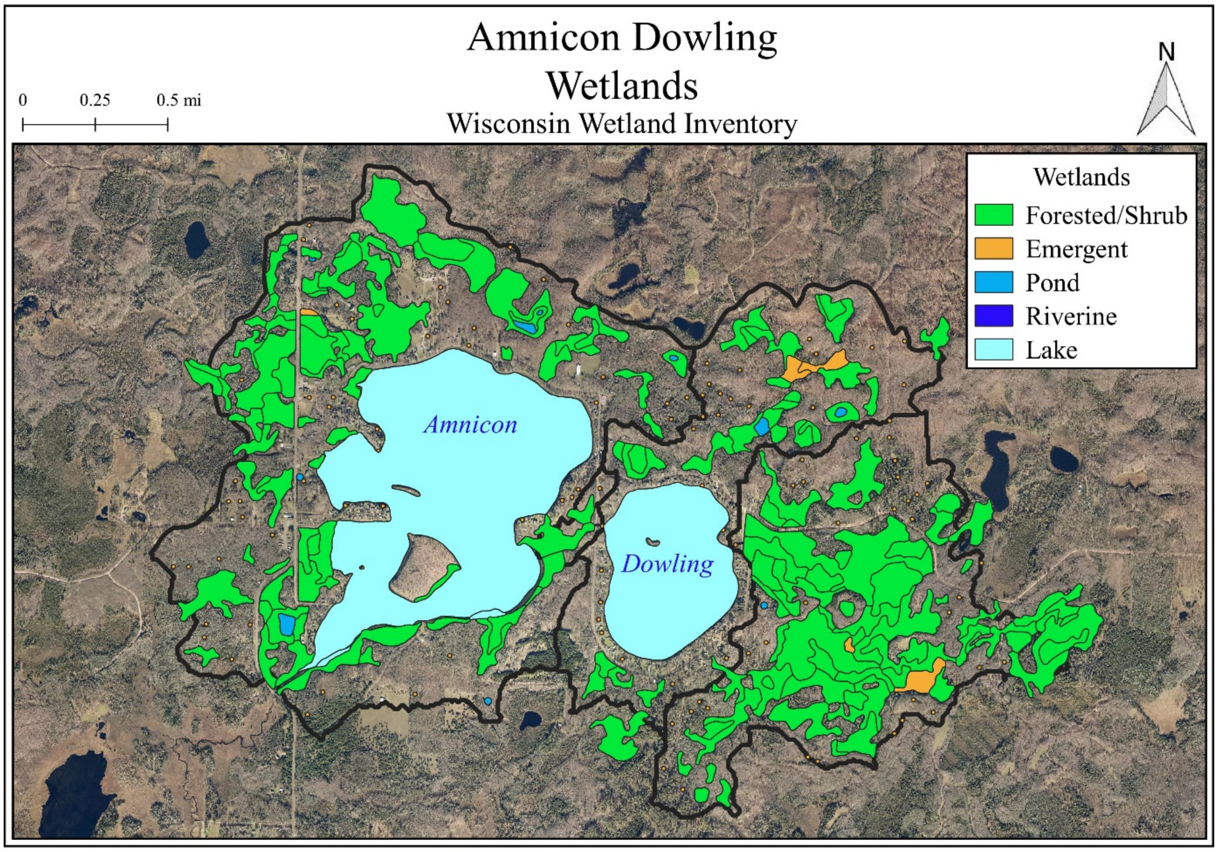


Figure Wetlands. Wisconsin Wetland Inventory of wetlands in the Amnicon Dowling watershed area

The **canopy cover** (the proportion of the forest covered by leaves in the crowns of the trees) helps slow down rainfall before it hits the ground and reduce erosion. The Amnicon-Dowling watershed has relatively high canopy cover, averaging about 70% (Figure CanopyCover). There are some human-caused gaps in the canopy where there is agriculture and development, and there are some natural gaps in wetland and pond areas (Figure CanopyCover; Figure LandCover).

Where canopy cover is lacking and development is high, there are more **impervious surfaces**. These are areas where water cannot naturally infiltrate into the ground because of a barrier like asphalt, concrete, roofs, and compacted gravel. Impervious surfaces can increase erosion and the amount of pollutants like sediment, nutrients, and other chemicals into lakes by not allowing the water to percolate into the ground like it would naturally. The watershed has the most impervious surfaces where there are high densities of homes and businesses, as well as where the roads circle the lakes (Figure Imperv).

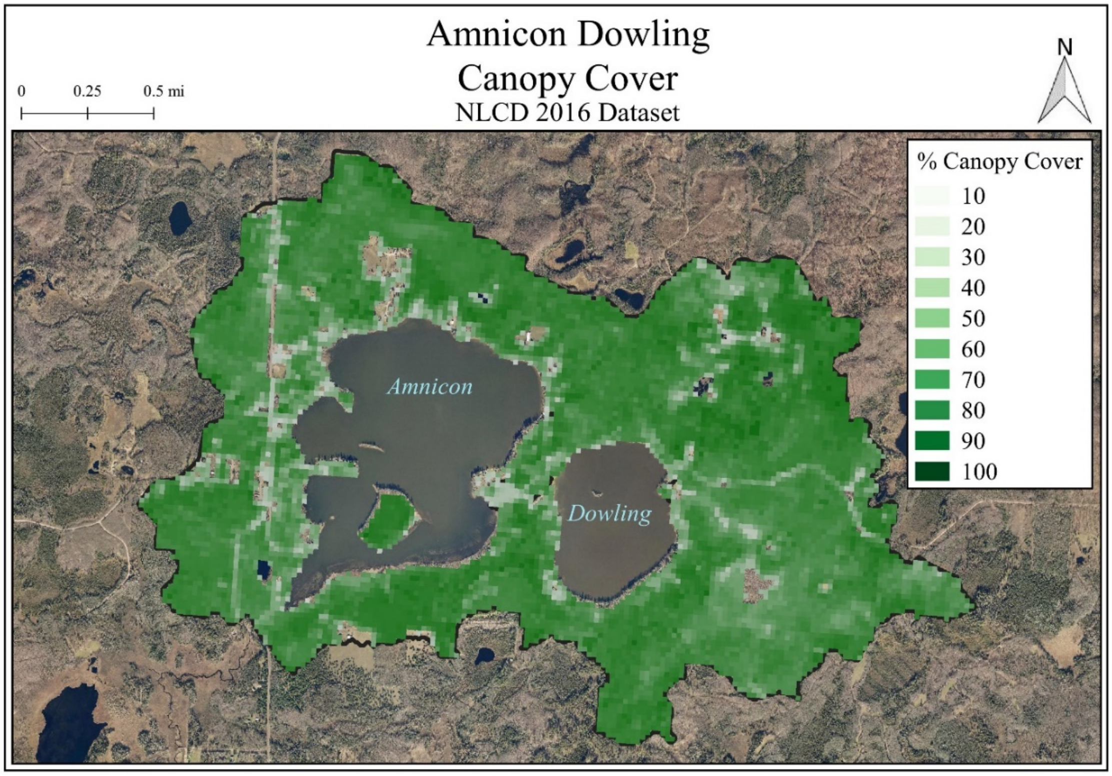


Figure CanopyCover. NLCD 2016 canopy cover of the Amnicon Dowling watershed

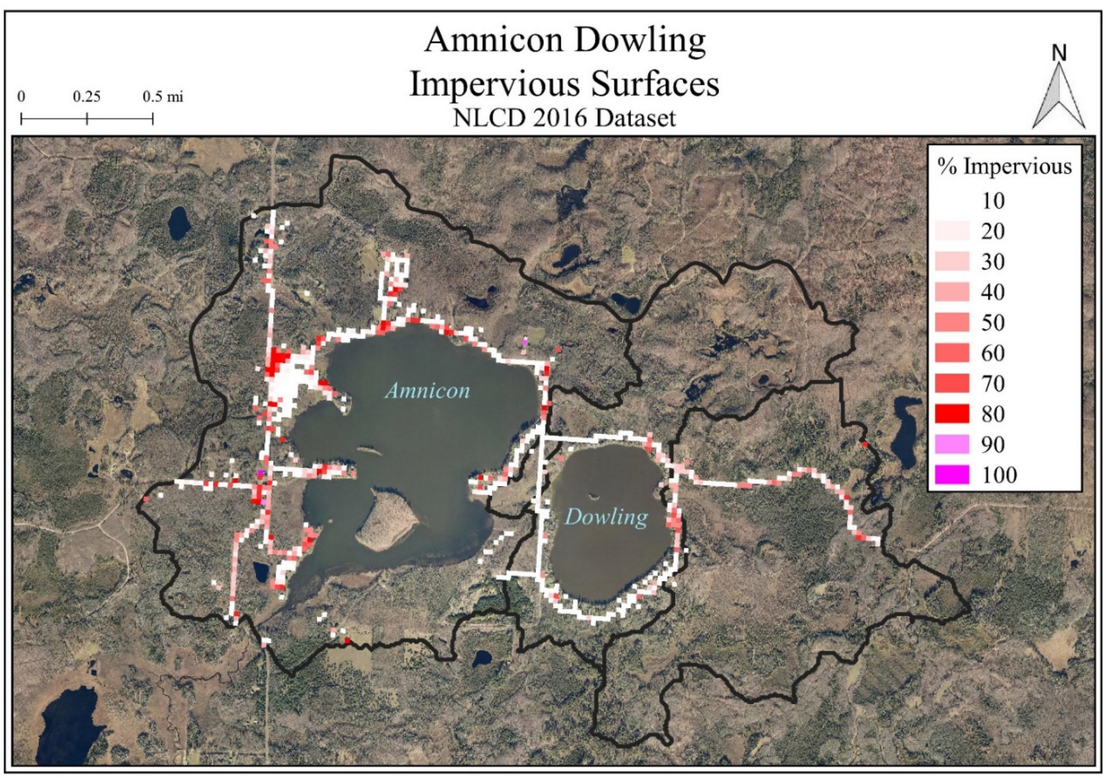


Figure Imperv. NLCD 2016 impervious surfaces of the Amnicon Dowling watershed

Soils

From the outwash of the last glacier came nutrient-rich sediment deposits that over time became colonized by plants, and as these plants died, their organic material built up into the soils we see today. The drainage that surrounds Amnicon and Dowling Lakes is characterized by two Land Type Associations: Pattison Moraines and Dairyland Moraines (Figure 4). A **moraine** is a large deposit of rocks and sediment left behind by a glacier, and the Pattison and Dairyland Moraines are both sandy deposits formed where the Superior Lobe of the Laurentide Ice Sheet was receding (Figure 3).

Figure 4. Land Type Associations of Amnicon and Dowling Lakes (WDNR, 2020)

The Pattison Moraine contains soils that are well drained, sandy loam over acid loamy sand till, meaning that the soil does not hold much water after rainfall or snowmelt. It forms over igneous, metamorphic, and volcanic rock that is more than 100 feet from the surface of the land, and the average depth to the aquifer is 20-50 feet (Figure 2; 4). These soils support lowland forests characterized by stands of aspen, paper birch, sugar maple, basswood, spruce, and fir with some white pine, red pine, and red oak.

The Dairyland Moraine also has well drained, sandy loam soils. It also forms over igneous, metamorphic, and volcanic bedrock that is that is 5-50 feet from the surface of the land, and the average depth to the aquifer is 0-20 feet (Figure 2; 4). These areas are more likely to be wet and support lowland and hydromesic (moderately wet) forest types classified by alder swamps, bogs, and other wet-tolerant species.

Dividing the classifications even further, the Amnicon and Dowling watershed becomes a rich mosaic of soil types (Figure 5; 6). They are mostly composed of sand and loam with some organic soils and some mucky areas (Figure 6).

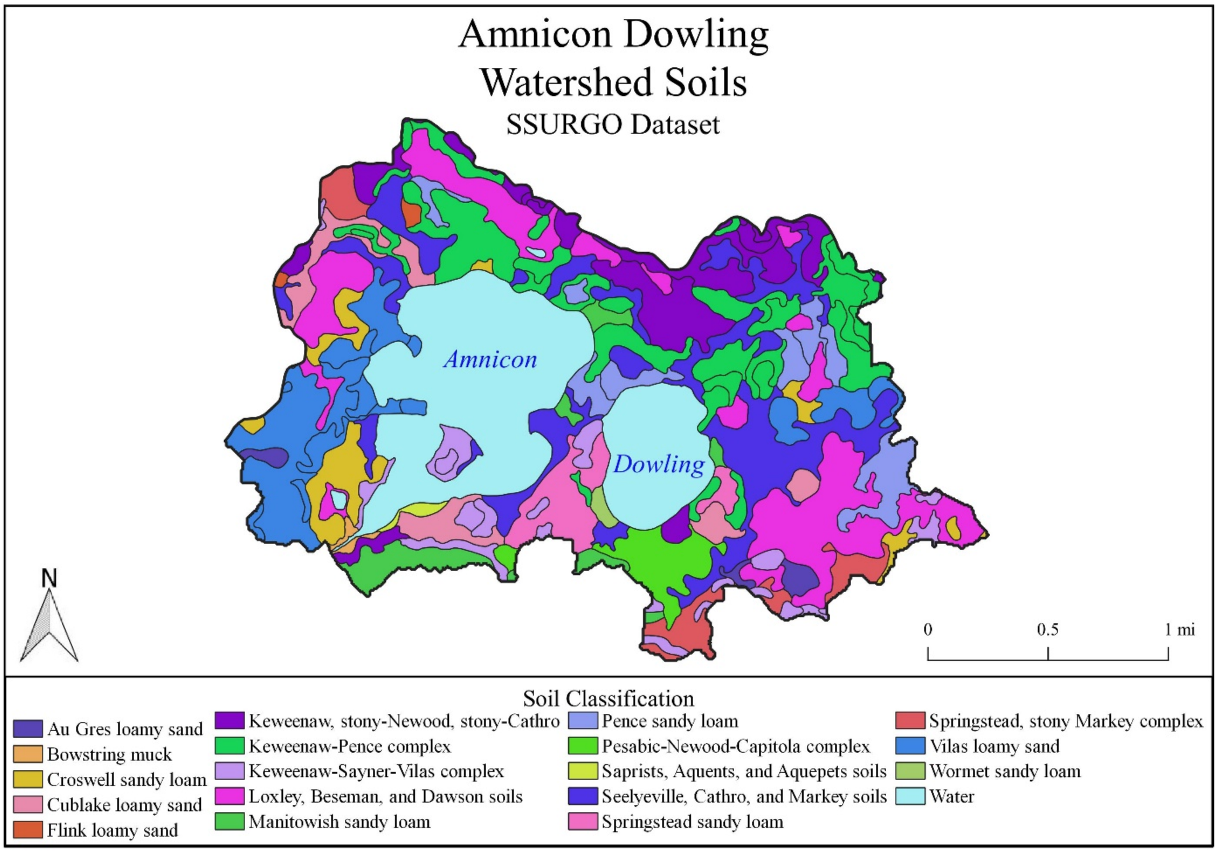
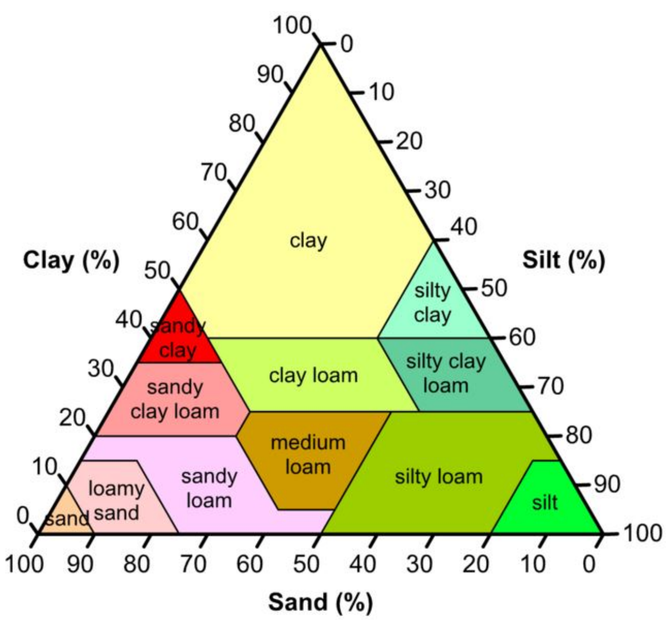


Figure 5. Amnicon Dowling watershed soils (SSURGO)



Loamy sand is comprised of 70-90% sand, 10-15% clay, 0-30% silt; sandy loam has 50-70% sand, 15-20% clay, 0-50% silt (see left). A soil complex is composed of two or more soil types, and muck is wet soils.

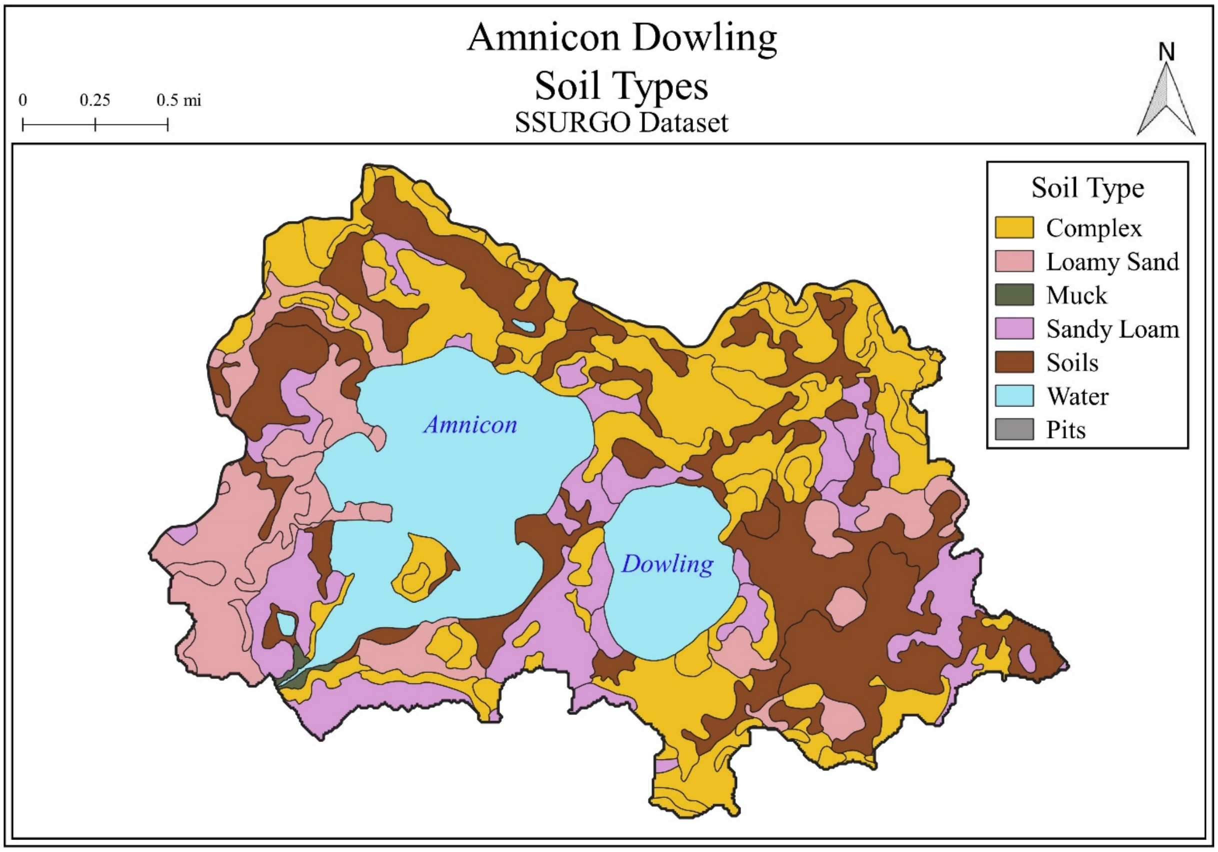


Figure 6. Amnicon Dowling watershed soil types (SSURGO)

Most areas with loamy sand or sandy loam are well drained, and areas with muck and soils are more poorly drained (Figure 7). This indicates that sandy areas are more likely to be dry and support trees, while mucky areas area likely to support wetlands and shrubby vegetation like alders. Both sandy and mucky areas are unlikely to easily support large-scale agriculture without substantial alterations to the composition of the soil and addition of nutrients.

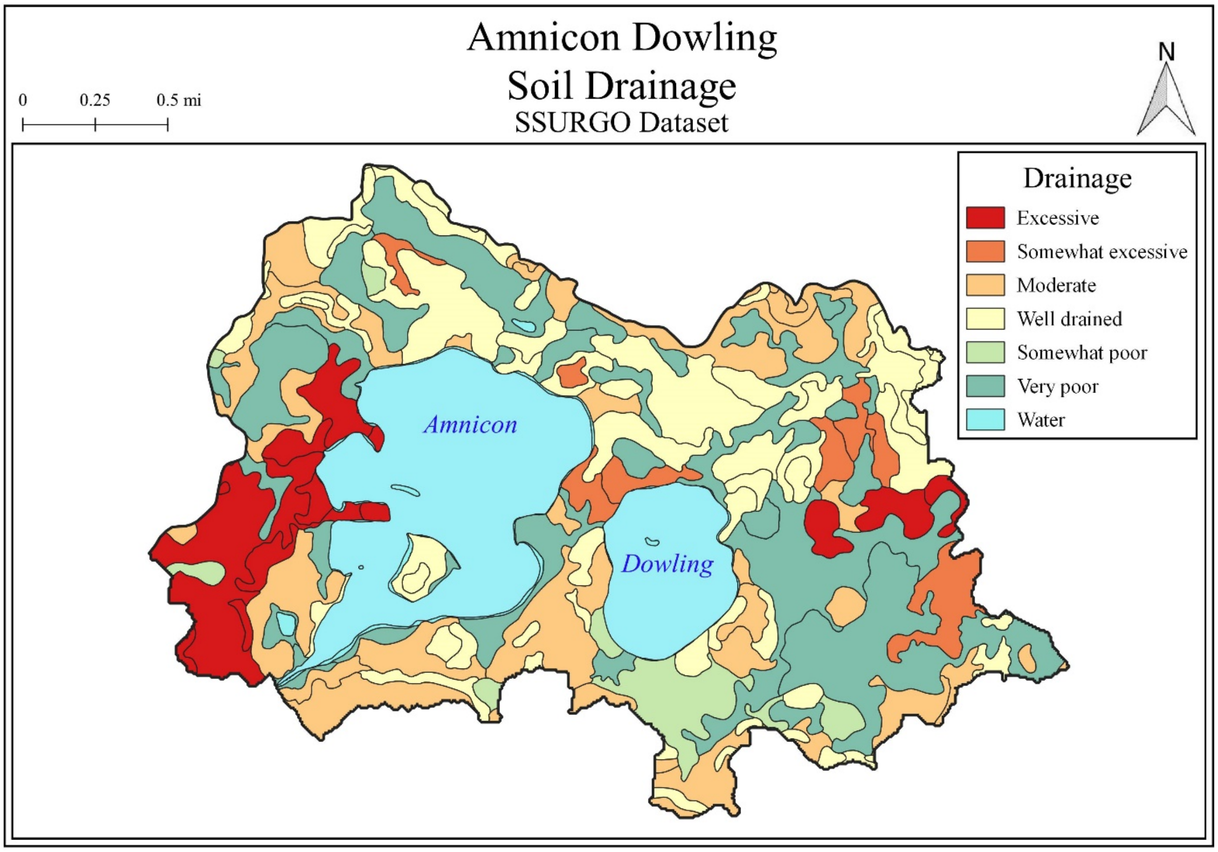


Figure 7. Amnicon Dowling watershed soil drainage (SSURGO)

Overall, these soils support lowland forests with some wetland areas. Tomatoes, peppers, green beans, cucumbers, onions, carrots, and lettuce would grow well here. These soils have fine material and can be easily eroded when left bare during large rain events or sudden snow melt. However, the soils in the watershed are also fairly permeable, and vegetative cover would hold them in place.

It is recommended that exposed soils should be limited around the lakes where the soil can be washed into the lake. Plant native plants where possible and cover gardens so that spring snowmelt does not wash soil into the lakes.

For more information on the Pattison Moraine: https://dnr.wi.gov/topic/landscapes/documents/LTAData/212Kb01_rpt.pdf

For more information on the Dairyland Moraine: https://dnr.wi.gov/topic/landscapes/documents/LTAData/212Kb02_rpt.pdf

For more information on SSURGO datasets: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/office/ssr12/tr/?cid=nrcs142p2_010596

WATER QUALITY

Trophic Status

Trophic state and **water quality** are often used synonymously; however, they are not the same. Trophic state describes the biological condition of a lake using a scale – **Trophic State Index** (TSI) – that is based on **water clarity**, **total phosphorus**, and **chlorophyll-*a*** (Carlson 1977). Water quality is typically based on a perception of the lake, which may be subjective for different lake users. People who use the lake for primarily swimming usually classify lakes with clear water as having better water quality while the same lake might be classified as having poor water quality by a fisherman because the low productivity limits fish growth.

By combining data for water clarity, phosphorus, and chlorophyll-*a* in Dowling Lake, the trophic state as determined by Carlson's Trophic Status Index (1977) is able to be determined (Figure TSI; Figure TSIGraph). **Eutrophic lakes** typically have large amounts of aquatic plant growth, higher nutrient concentrations, low water clarity due to algae blooms, and oxygen-depleted bottom waters. On the other end of the spectrum, **oligotrophic lakes** are nutrient-poor, have clear and cold water, and oxygen throughout the water column continually. **Mesotrophic lakes** fall in the middle and have intermediate nutrient levels, occasional algal blooms, and may experience bottom water oxygen depletion in the summer. Measures of water quality in Dowling consistently show that Dowling is EUTROPHIC (Red circles in Figure TSI represent Dowling Lake ranges).

The process of a lake moving from oligotrophic to eutrophic is natural. After the last glaciers left behind Dowling Lake, it may have been deeper, nutrient-poor, and oligotrophic for a time. As the lake aged and the climate became warmer, the more plants grew in and around the lake, and it likely become more mesotrophic. With more aging, more plants, and more nutrients being added to the lake (possibly as a result of human activities) present-day Dowling Lake is shallow, warm, has algal blooms, low water clarity, and occasional algal blooms. Into the future, the natural course of the lake is to become even more eutrophic and to continue filling in until it becomes a wetland and then eventually dry land. This process takes place over many thousands of years, but **eutrophication** (becoming more eutrophic) can be exacerbated by human activities in the watershed, in the **riparian** (area near the edge of the lake), and within the lake itself. Poor agricultural practices, large amounts of development, improper treatment of waste and yard trimmings, removing native vegetation, starting up boat motors in shallow water, and many more practices can increase the rate of eutrophication in a lake faster than it would occur without any human activity.

TSI	Chlorophyll-a (ug/L)	Secchi Depth (ft)	Total Phosphorus (ug/L)	Classification	Attributes	Fisheries and Recreation
<30	<0.95	>26	<6	ULTRAOLIGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water, cold water	oxygen-sensitive, cold water fish species in deep lakes
30-40	0.95 -2.6	13 - 26	6 - 12	OLIGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water except possibly in shallow lakes, cold water	oxygen-sensitive, cold water fish species in deep lakes only
40-50	2.6 - 7.3	6.5 - 13	12 - 24	MESOTROPHIC	water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer	walleye may dominate
50-60	7.3 - 20	3 - 6.5	24 - 48	EUTROPHIC	decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident	warm-water fisheries (pike, perch, bass, etc.)
60-70	20 - 56	1.5 - 3	48 - 96	EUTROPHIC	blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible	thick aquatic vegetation and algal scums may discourage swimming and boating
70-80	56 - 155	0.75 - 1.5	96 - 192	HYPEREUTROPHIC	heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight)	summer fish kills possible, rough fish dominant
>80	>155	<0.75	192 - 384	HYPEREUTROPHIC	Algal scums, few plants	

Figure TSI. TSI scores for Dowling Lake

Circled values indicate the values and corresponding TSI scores for Dowling from data collected by citizen volunteers. This figure is adapted from Carlson and Simpson (1996) with information from the WDNR and publicly available CLMN data.

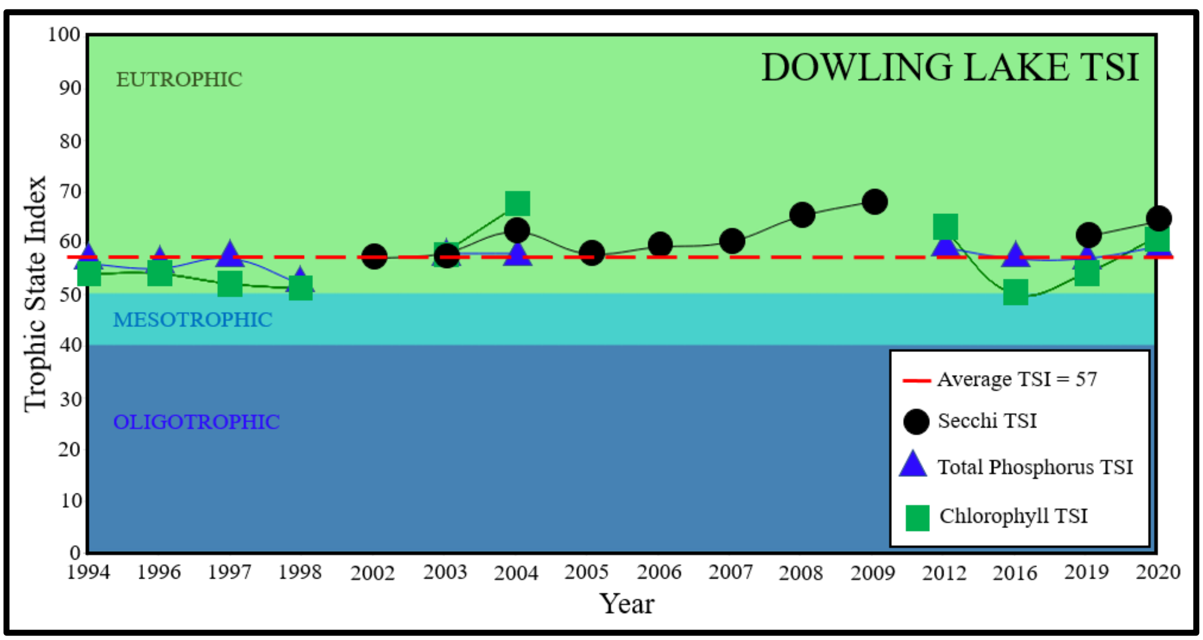


Figure TSIGraph. Dowling Lake Deep Hole TSI scores

Water Clarity

Water clarity is depth to which light can penetrate into the water. It affects algae – the base of the food web – by limiting the depth algae can grow, which in turn affects the rest of the food web and has implications for algal blooms. It also affects macrophytes (aquatic plants) by limiting their depth as well. Most life in lakes occurs in the littoral zone, which is the area where light can reach all the way to the bottom. Thus, water clarity has the potential to affect many aspects of aquatic life.

Water clarity also affects recreation and human enjoyment of lakes. Murky, cloudy water is aesthetically unappealing and can even be hazardous in some situations. Increased water clarity is shown to increase recreational enjoyment for recreators and is linked to higher property values (Angradi et al 2018; Ng & Mohammad 2017).

In Dowling Lake, water clarity is naturally limited by the dark, tannin-stained waters that give the lake its 'root beer' coloring. Tannins are created as water passes through peat soils and decaying vegetation, and the water that flows into Dowling comes directly from tannin-rich woody wetlands and peaty organic soils.

Water clarity can be reliably measured using a Secchi disk. The disk is 8 inches in diameter and divided into alternating black and white quarters. Lowered into the water on a marked rope, the depth at which the disk disappears from sight is representative of water clarity. Volunteers have been periodically monitoring water quality and water clarity at the Deep Hole site (Station ID: 163091) on Dowling following WDNR Citizen Lake Monitoring Network (CLMN) protocol from 1976 to present (Figure Secchi). The average Secchi depth on Dowling is 3.4 feet but has ranged from 1.3-7.7 feet (Figure Secchi). These values fall within EUTROPHIC ranges based on the 1977 Carlson Trophic Status Index (Figure TSI; Figure Secchi).

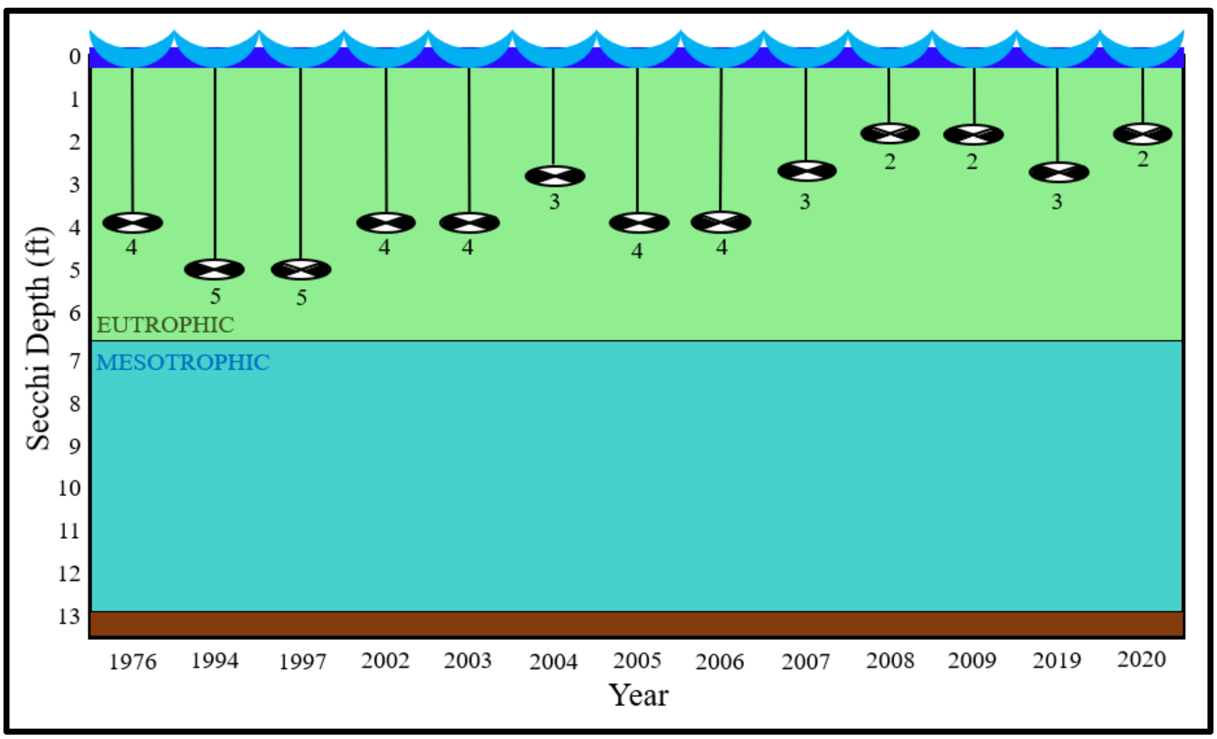


Figure Secchi. Average summer Secchi disk readings per year on Dowling Lake

Total Phosphorus

Phosphorus is an important nutrient for plant growth and is often the limiting nutrient for plant production in Wisconsin lakes. Naturally, phosphorus is derived in low quantities from sediment and bedrock and is an essential component to lakes. However, when too much phosphorus is washed into lakes or added from other sources like agricultural fertilizers, leaky septic systems, soil erosion, pet waste, or mishandled yard trimmings, there can be a dramatic increase in plant and algae growth.

In lake like Dowling that is shallow and naturally productive, phosphorus can come from within the lake itself. This is internal loading. As phosphorus enters a lake, it is taken up by algae and some of it is locked away in tissue as it bioaccumulates up the food chain. Ultimately, most phosphorus becomes trapped in the sediment as dead organisms like phytoplankton (algae) sink to the bottom. This source of phosphorus can be easily resuspended into the water column by wind and waves. Additionally, as aquatic plants senesce (die back) in the fall, a large sudden influx of phosphorus can be released within the lake resulting in an algal bloom.

In Dowling, citizen volunteers have been monitoring total phosphorus levels at the Deep Hole since 1974 (1974, 1996-98, 2003-05, 2012, 2016, 2019-20). The CLMN data has shown that total phosphorus levels at the deep hole have ranged from 20 ug/L to 74 ug/L with an average of 40.3 ug/L. These values are consistently in the EUTROPHIC range (Figure TP). Monitoring at the outlet of Dowling in 2020, 2019, 2004, and 2003 has shown average total phosphorus levels of 52, 44, 57, and 38 ug/L, respectively. These values are also consistent with EUTROPHIC values, indicating that not all nutrients are being taken up by organisms before the water leaves Dowling and that water from Dowling that enters Amnicon Lake is contributing high levels of phosphorus.

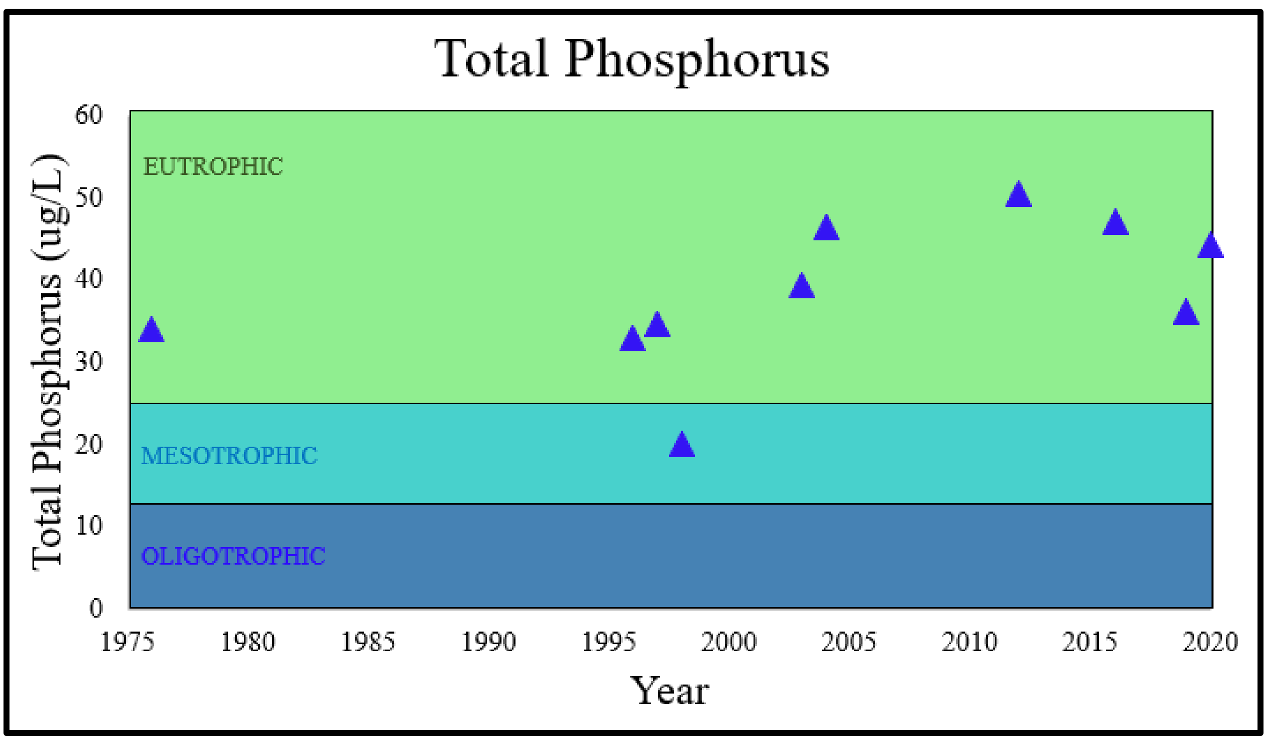


Figure TP. Average summer total phosphorous per year on Dowling at the Deep Hole site

Chlorophyll-a

Chlorophyll-*a* is the green pigment found in plants and algae that allows plants to photosynthesize. Concentrations of chlorophyll-*a* can be measured and used as an approximation of algal biomass in a lake. Algae is an important part of the food web, and algae produces oxygen (a crucial need for aquatic life) as a byproduct of **photosynthesis** (converting light into energy). However, too much algae can overwhelm a lake by preventing light from penetrating into the water and limiting plant growth, and it can cause a reduction in oxygen levels when the algae dies and the process of decomposition uses significant amounts of oxygen.

In Dowling Lake, high levels of phosphorus and warm, shallow waters are conducive to promoting algal blooms. Blooms can occur rapidly and are often recognized as a green-colored scum on the surface of the water. Some blooms of cyanobacteria can be detrimental to human and animal health when toxins are released into the water – these are harmful algal blooms (HAB).

Concentrations of chlorophyll-*a* greater than about 10 µg/L are considered indicative of eutrophic conditions and concentrations 20 µg/L or higher are associated with algal blooms. For trophic state classification, preference is given to the chlorophyll a trophic state index (TSICHL) because it is the most accurate at predicting algal biomass.

CLMN data at the Deep Hole site for chlorophyll-*a* is available for 1994, 1996, 1997, 2003-04, 2012, 2016, and 2019-20. The chlorophyll data ranges from 2.79 ug/L to 111 ug/L with an average of 20.20 ug/L in summer months. These values are consistent with being EUTROPHIC (Figure Chlorophyll). A nearshore algal bloom was monitored in 2012 and a chlorophyll value of 36.9 ug/L was reported.

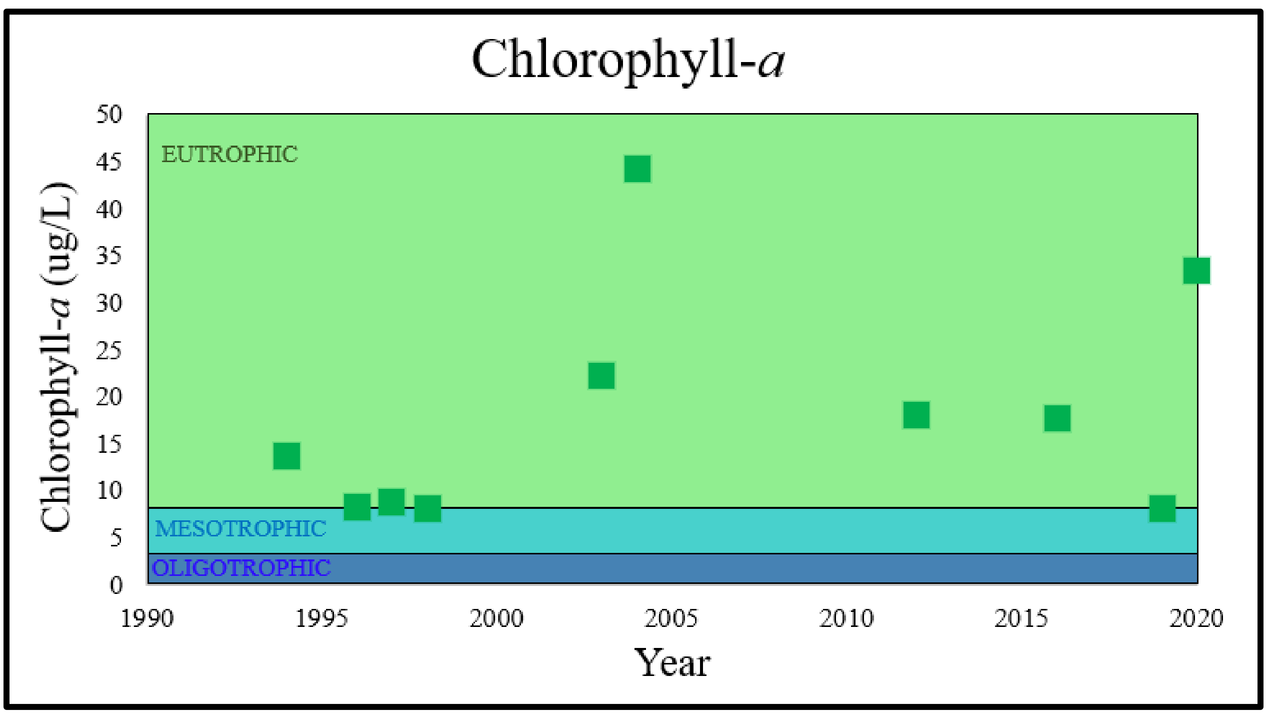


Figure Chlorophyll. Average summer chlorophyll-*a* on Dowling at the Deep Hole site

Stratification

In some lakes, layers of water can become separated based on temperature – this is **thermal stratification**. It can often be noticed when swimming and you feel a sudden drop in temperature near your feet while the surface stays warm. This happens because of two essential facts:

(1) The density of water depends on its temperature. Cold water is more dense than warm water, which is why the water near a swimmer's feet is usually the coldest. Water is at its most dense at 4°C (39.2°F).

(2) Liquids of different densities often are not easily mixed. The greater the difference in density, the harder it is to mix the two layers.

In lakes, thermal stratification occurs when the water near the surface gets heated by the sun – usually in lake spring or early summer. As the water warms, it becomes less dense and remains at the surface while the cooler, more dense water stays trapped below. This process forms three layers: the warm surface waters are called the **epilimnion**, the cold bottom waters are the **hypolimnion**, and where the two layers meet in the middle is the **metalimnion**. Within the metalimnion there is a point where there is the greatest difference in temperature (and therefore density) between the epilimnion and the hypolimnion, this is the **thermocline** (Figure Stratification).

The epilimnion interacts with the wind and sunlight, so it becomes the warmest and contains the most dissolved oxygen. Though dissolved oxygen doesn't play a direct role in lake stratification and turnover, it is important for all the aquatic organisms in a lake that require oxygen to survive.

The hypolimnion often remains around 4°C throughout the year, rarely gets any direct warmth from the sun and is isolated from the air at the surface of the lake. The hypolimnion contains the lowest amount of dissolved oxygen and can often become anoxic (zero dissolved oxygen) while the lake is thermally stratified.

Throughout the summer, wind and waves cause the warming water in the epilimnion to mix deeper and deeper, slowly incorporating hypolimnetic water through the metalimnion. The ability of a lake to mix through wind turbulence is determined by the "stability" of thermal stratification. Stratification becomes increasingly stable with heating from the sun. The larger the difference in temperature (and density) between the epilimnion and the hypolimnion, the more stable the thermal stratification. Eventually, the epilimnion warms to the point where the difference in density between the epilimnion and hypolimnion (at the thermocline) is so large that wind and waves can no longer generate enough energy to incorporate hypolimnetic water.

As the summer turns to fall, the surface waters cool and sink, mixing the epilimnion down towards the hypolimnion and weakening the thermocline; as the temperatures and densities of the epilimnion and hypolimnion become more similar, the water currents and wind can once again mix water between the two layers (Figure Stratification). Eventually, the epilimnion cools until the entire lake is the same temperature (**isothermal**; Figure Stratification). This allows lake turnover to occur (Figure Stratification).

Lake turnover (or overturn) is a phenomenon whereby the entire volume of water in a lake is mixed by wind. This can only happen when the entire lake is the same temperature (and density), which in northwestern Wisconsin generally occurs two times per year — once in the spring after the ice melts, and once in the fall before ice forms.

Lake turnover is extremely important in freshwater lakes, as it is the event that is responsible for replenishing dissolved oxygen levels in the deepest lake waters. When the lakes are a uniform temperature and density, it takes relatively little wind energy to mix water deep into the lake. Wind moves highly oxygenated surface water to the lake bottom, forcing low oxygen water from the lake bottom up to the surface where it becomes saturated with oxygen. This is critical for aquatic organisms, as once the lakes freeze over for the winter, no new oxygen gets mixed into the lake from the atmosphere, and what is in the lake must last until ice goes off in the spring. Spring turnover is important for the same reason. Once thermal stratification sets up, hypolimnetic waters do not get mixed to the surface and whatever dissolved oxygen exists in the deepest parts of the lake is all that is available until lake turnover in the fall.

Dowling Lake is **polymictic** – the waters are so shallow (greatest depth is 13 feet and average depth is 7 feet) that the lake does not experience significant thermal stratification. The lake may occasionally stratify during periods of warm weather and calm wind, but heavy boat traffic and an increase in wind will cause the lake to become mixed once again.

CLMN data shows that the lake is most often not stratified with low levels of oxygen throughout the water column. This is likely a result of excessive algal growth caused by phosphorus and subsequent decomposition of the decaying material that uses up available oxygen. Dowling is also oriented north to south with its shortest **fetch** (distance that wind can blow across a lake) facing east and west, and because the prevailing wind is from the west, the lake is sheltered from most wind and not likely to experience mixing caused by wind.

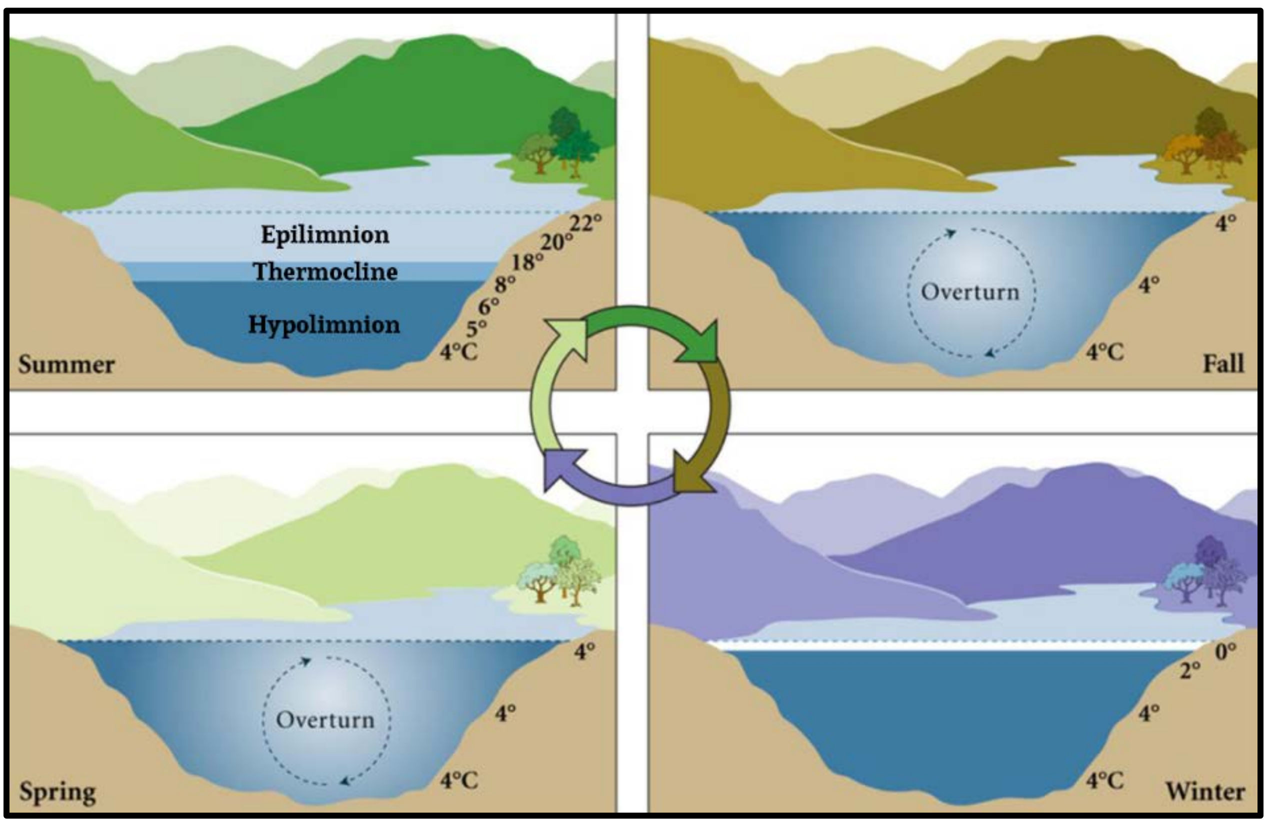


Figure Stratification. Annual mixing pattern of lakes from Young (2004)

AQUATIC VEGETATION

(From Endangered Resource Services, LLC High Density Plant Survey and Bed Mapping Report by Matthew Berg, 2016)

Dowling Lake has a very limited plant community in both density and distribution. Because of this, there were no areas anywhere on the lake that met the “bed” criteria where plants were likely causing a significant impairment to navigation that would have required multiple prop clears to travel through. During the 2016 survey, repeated random raking to establish the extent of the littoral zone never turned up submergent plants deeper than 5ft; apparently due to the poor water clarity. This was similar to the original point-intercept survey when we found plants at just 29 of 253 total points (11.5% of the entire lake and 29.9% of the then 7.0ft littoral zone) (Table 1) (Figure 3). Even when present, the majority of rake samples had just a few plants on the head. This was also similar to 2012 when the mean rake fullness was a low/moderate 1.52 (Figure 3).

Table 1: Aquatic Macrophyte P/I Survey Summary Statistics
Dowling Lake, Douglas County
August 3, 2012

Summary Statistics:

Total number of points sampled	253
Total number of sites with vegetation	29
Total number of sites shallower than the maximum depth of plants	97
Frequency of occurrence at sites shallower than maximum depth of plants	29.90
Simpson Diversity Index	0.88
Maximum depth of plants (ft)	7.0
Mean depth of plants (ft)	3.5
Median depth of plants (ft)	3.5
Average number of all species per site (shallower than max depth)	0.54
Average number of all species per site (veg. sites only)	1.79
Average number of native species per site (shallower than max depth)	0.54
Average number of native species per site (veg. sites only)	1.79
Species Richness	16
Species Richness (including visuals)	17
Species Richness (including visuals and boat survey)	33
Average rake fullness (veg. sites only)	1.52

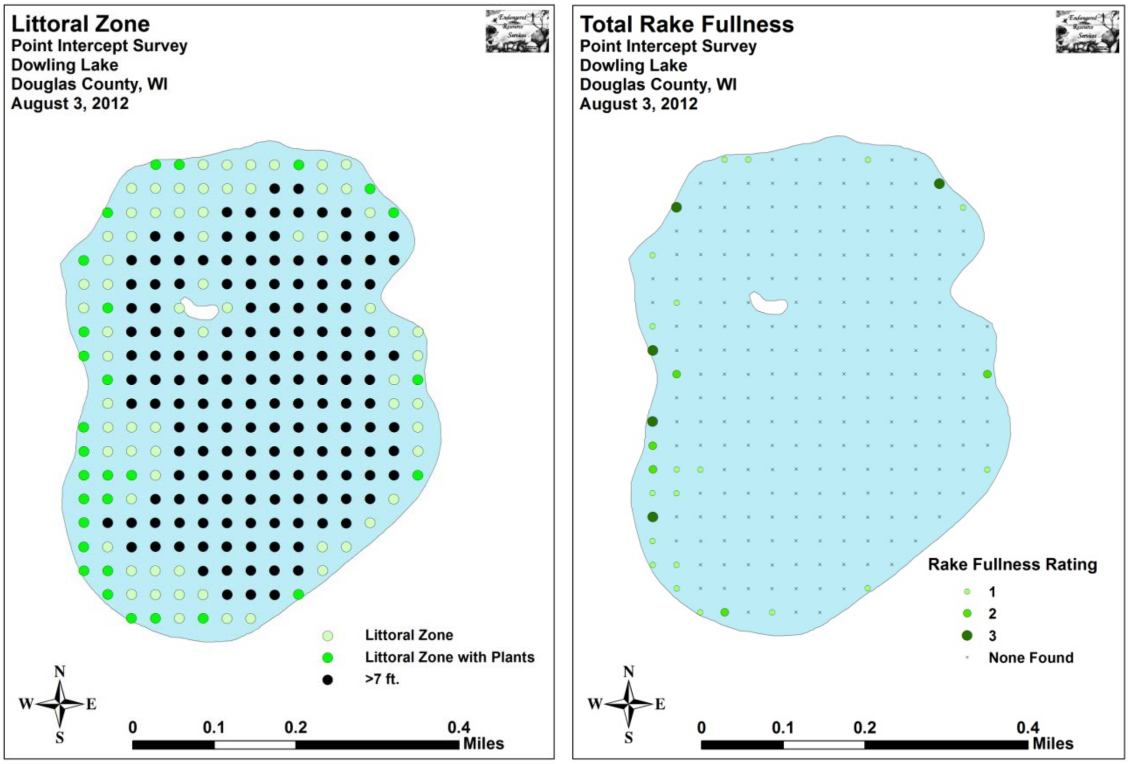


Figure 3: 2012 Littoral Zone and Total Rake Fullness

As in 2012, we did NOT find Northern wild rice present anywhere on the lake; however, we noted the overall emergent community continues to be both rich and diverse. With so few plants anywhere in the lake, these beds are likely important fish habitat; especially during spawning. Dominated by Hardstem bulrush (*Schoenoplectus acutus*), Creeping spikerush (*Eleocharis palustris*), and Pickerelweed (*Pontederia cordata*), the emergents seldom extended more than 10 meters from shore making it unlikely they would interfere with navigation (Figure 4). Even when docks occurred within the beds, regular boat traffic appeared to be keeping navigation channels open (Figure 5).

Figure 4: Typical Narrow Emergent Community

Figure 5: Regular Boat Traffic Maintaining Navigation Channels

The floating-leaf community tended to have low richness and diversity. Throughout much of the lake, scattered Watershield (*Brasenia schreberi*), Spatterdock (*Nuphar variegata*), and Floating-leaf bur-reed (*Sparganium fluctuans*) occurred as isolated clusters or in small patches that grew in a narrow band just beyond the emergents. The only exception to this was along the western shoreline where beds stretched a few 10's of meters to the east along shallow flats. Even here, boat traffic seemed to be having no problem keeping navigation channels open (Figure 6).

Figure 6: Densest Floating-leaf Area on the Western Shoreline

Aquatic Invasive Plant Species Survey

We did NOT find any evidence of Eurasian water-milfoil or Curly-leaf pondweed. However, we again found Purple loosestrife (*Lythrum salicaria*) scattered near the boat landing, on the north and west sides of the lake (Figure 7), and in ditches through low areas on roads around the lake. In 2012, we noted that every loosestrife plant we examined showed extensive damage from Galerucella beetle (*Galerucella* spp.) herbivory (Figure 8); unfortunately, in 2016, we saw no evidence of beetle damage.

Yellow iris (*Iris pseudacorus*), a species we didn't document in 2012, was present at seven locations scattered along the shoreline (Figure 9) (Appendix 1). It appeared to be spreading rapidly, and the worst areas occurred along the north and northeast shorelines (Figure 10).

The only other exotic species found on the lake was Reed canary grass (*Phalaris arundinacea*). This ubiquitous wetland species was present in limited numbers on the northeast shoreline and near the public boat landing. It was generally much less common than the native and very similar looking Bluejoint (*Calamagrostis canadensis*) (Figure 11).

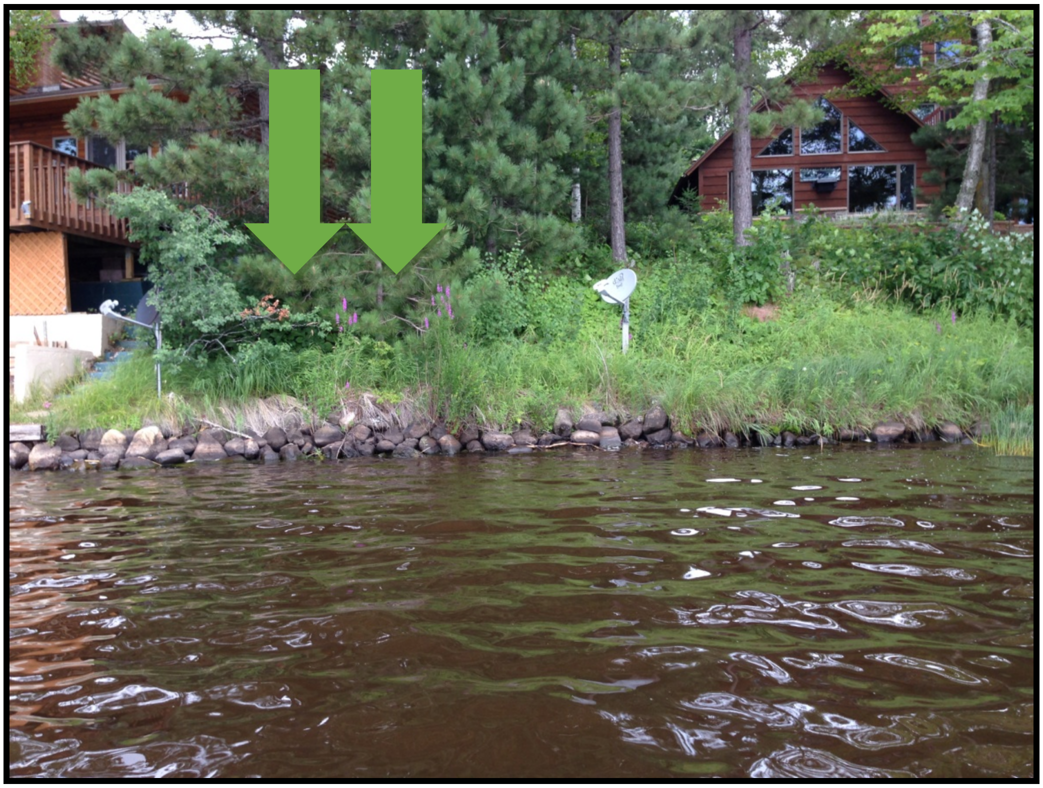


Figure 7: Purple Loosestrife Along the North Shore

Figure 8: Purple loosestrife and Galerucella Beetles

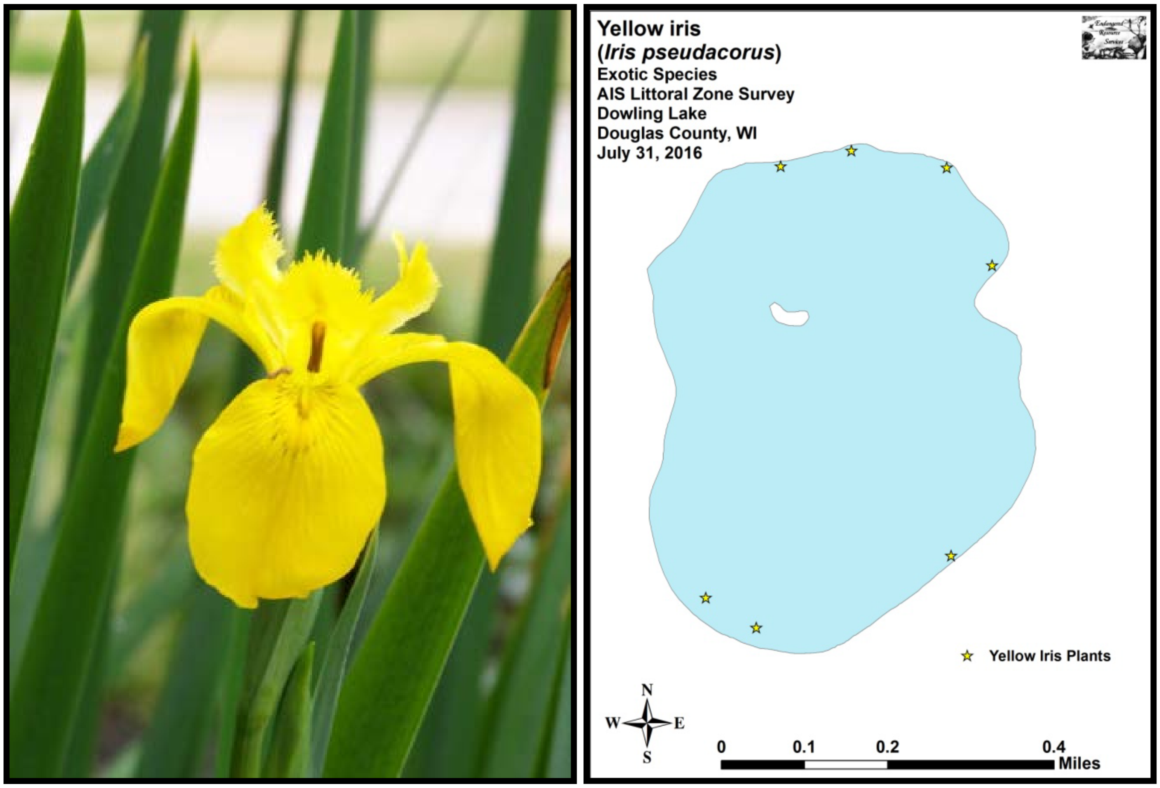


Figure 9: Yellow Iris Distribution 7/31/16

Figure 10: Dense Yellow Iris Along the Northeast Shoreline 7/31/16

Figure 11: Exotic Reed Canary Grass and Native Blue Joint Grass

FISH AND WILDLIFE

Fish

Dowling Lake supports a warm water fishery comprised of muskie, panfish species, largemouth bass, and walleye (WDNR 2021). Dowling has been stocked with a variety of species extending back to 1934 when walleyes, muskies, bass, and panfish were first stocked in the lake (Manz 2004). Walleyes and muskies were stocked annually from 1940-1970, and the stocking of muskies continued up until 1978 (Manz 2004). Fishery surveys in 1947, 1967, 1989, 1991, 2004, and 2012 have shown that walleye, muskies, and black crappie are common in the lake. A comprehensive fishery survey in 1977 also found that stocking muskies and walleye in Dowling was no longer necessary because of low growth rates, high population numbers, and natural reproduction (Manz 2004). The WDNR performed other fishery surveys on the lake in 1978 and 1982, and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) surveyed the lake in fall of 1989 and spring of 1991. The 1989 fall electrofishing survey and the 1991 spring walleye population estimate survey found sufficient numbers of walleyes of harvestable size (at least 15 inches; Manz 2004). A 2004 electrofishing study of Dowling Lake found the spawning population of walleyes in Dowling to be almost twice as high as other lakes in the area – 7.24/acre and 3.7/acre, respectively – and above the statewide goal of 3.0/acre (Manz, 2004). Stocking of walleyes has resumed in Dowling intermittently from 2010-2019.

Fish species other than walleye and muskie known to be in the lake are largemouth bass, rock bass, pumpkinseed, black crappie, yellow bullhead, black bullhead, white sucker, tadpole madtom, johnny darter, fathead minnows, and golden, common, spottail, and blacknose shiners (Figure Foodweb). Largemouth bass and other panfish species (black crappie, bluegill, pumpkinseed, etc.) are known to be in relatively high numbers with adequate growth but few reaching significant size. Northern pike are not known to be in the lake.

Dowling's **food web** is ultimately driven by sunlight and photosynthesis that feeds the algae and plants at the bottom of the food web. **Zooplankton** (microscopic animals) eat the **phytoplankton** (algae), and in turn the zooplankton get eaten by **macroinvertebrates** (aquatic bugs insects like caddisfly larvae, dragonfly larvae, snails, and crayfish; Figure Foodweb). The macroinvertebrates are eaten by the next higher **trophic level** (the next hierarchy in the food web) that is mostly minnows, shiners, darters, suckers, fish larvae, and small (young of year) fish (Figure Foodweb). The small fish are eaten by bigger fish like largemouth bass (that can eat other adult fish) bluegill, pumpkinseeds, and black crappies that also eat larger zooplankton into adulthood (Figure Foodweb). The next trophic level are the **piscivores** (fish eaters) that primarily eat only other fish (Figure Foodweb). In Dowling, this would be walleye and muskies, although muskies are known to eat birds and mammals as well. Fish will ultimately eat just about anything that they can fit in their mouth – including other fish of the same species (cannibalism), their own young, a variety of other fish, **invertebrates** (aquatic and terrestrial bugs and insects), frogs, turtles, snakes, rodents, other small mammals, birds (ducklings especially), etc. In turn, fish of all sizes can be eaten by birds, otters, humans, etc. Food webs and trophic interactions are complex and often over simplified.

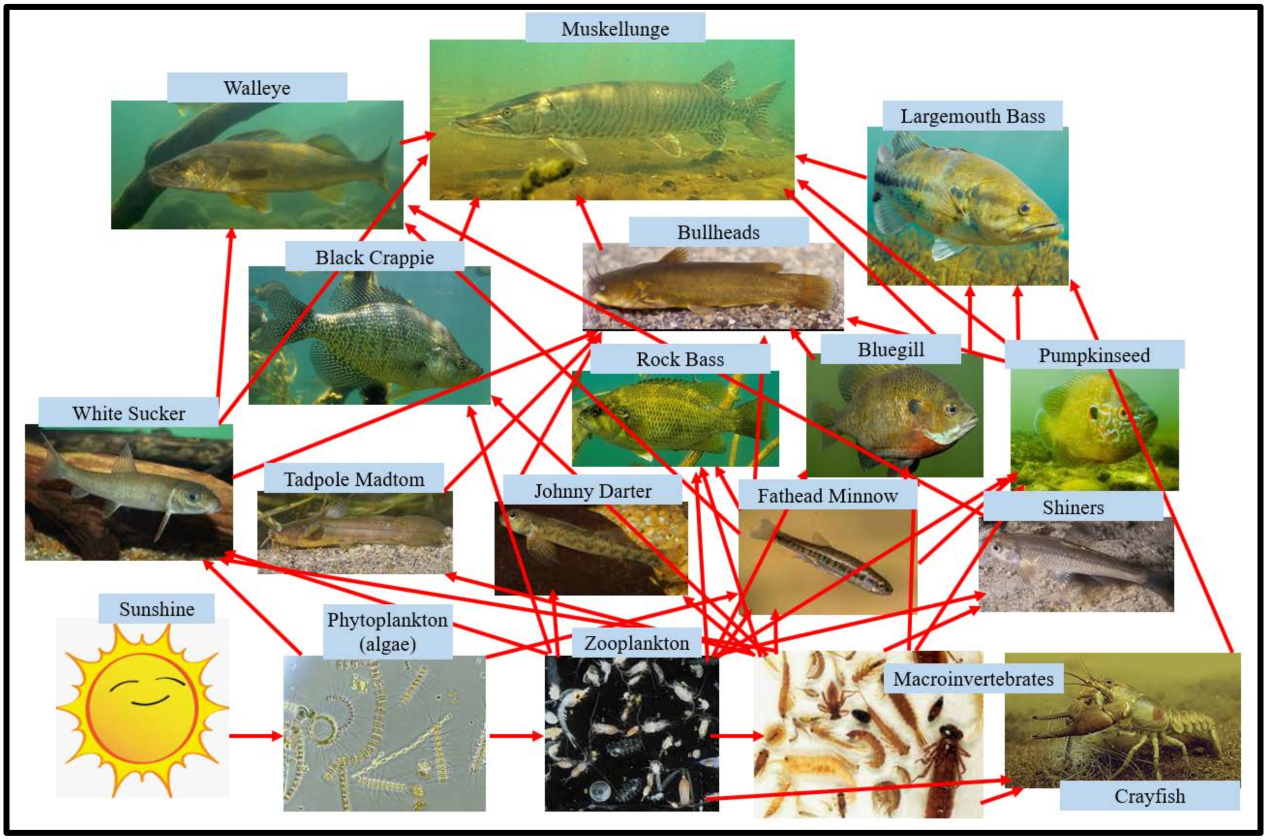


Figure Foodweb. Dowling Lake food web interactions

Wildlife

While no official wildlife surveys have been performed in the lake or in the drainage basin, many species are known to inhabit the watershed and the surrounding area, and it reasonable to assume that a variety of species can, and do, use Dowling Lake for a variety of purposes during their life cycles. The WDNR lists bald eagles, gray jays, Nashville warblers, bog copper butterflies, and bog fritillary butterflies as present in the watershed (WDNR 1992). The Wisconsin Natural Heritage Inventory (NHI) tracks 24 species of rare plants that have been documented in the Northwest Lowlands as of 2009. Of these, three are Wisconsin Endangered, six are Wisconsin Threatened, and 13 are Wisconsin Special Concern (WDNR 2015). White-tailed deer, moose American black bear, American beaver, North American river otter, fisher, bobcat, Ruffed Grouse, American Woodcock, Mallard, Wood Duck, and Ring-necked Duck are all important for hunting, trapping, and wildlife viewing and are known to use, or may possibly use, Dowling Lake for part of their life cycle or on a seasonal basis (WDNR 2015). See *The ecological landscapes of Wisconsin* Chapter 16 for more information at: https://dnr.wi.gov/topic/Landscapes/documents/1805Ch16.pdf#view=Fit

Rare and Endangered Species

The NHI program is part of an international network of programs that focus on rare plants and animals, natural communities, and other rare elements of nature. Each species has a state status including Special Concern, Threatened, or Endangered. It is important for lake managers to consider impacts to these valuable species, nearly all of which can be directly affected by aquatic plant management. Choosing the proper management techniques and the proper timing of management activities can greatly reduce or prevent negative impacts.

Five Special Concern species are listed for the area – the bald eagle, the Rocky Mountain sprinkled locust, the arctic fritillary, the Connecticut warbler, and the Forcipate emerald.

The NHI tracks examples of all types of Wisconsin's natural communities that are deemed significant because of their undisturbed condition, size, what occurs around them, or for other reasons. Natural communities listed for the area include: boreal forest, lake – soft bog, and northern wet forest.

The NHI also tracks other natural features that provide important habitat for certain plants and animals and are places where a catastrophic event could have an impact on a large number of common and/or rare species. A bird rookery is one such natural feature listed for the area.

A number of high value aquatic plant species listed in NR 107 including Potamogeton Richardsonii, Eleocharis spp., Scirpus spp. (also known as Schoenoplectus spp.), and Brasenia schreberi have been found in Dowling Lake. These plant species are known to offer important value to the aquatic ecosystem and any plant control activities in areas containing these high value species will be done in a manner which will not result in long-term or permanent changes to the plant community.

Education and Outreach

Many lakes suffering from advanced eutrophication can attribute much of the problem to area agriculture and the various issues associated with it including land use, farming practices, animal feedlots, manure spreading, etc. While other sources of nutrients may be impacting a given lake in an agricultural watershed, agriculture is by far the biggest. This is not the case with either Dowling or Amnicon lakes. As such, it is not so easy to “point a finger” at an offending party, because in most cases, the offending party is the one trying to point-the-finger. Every property owner on Dowling Lake is contributing to the decline of the lake. So, improving the lake has to start with the property owners.

While developing this plan, a volunteer on Dowling said something like the following. Because the lake’s water quality is so bad, the type of people who buy and own property on the lake care less about how what they do impacts the lake. While this may be an over-simplification and not likely entirely true, it does bring to bear that changing property owner and lake user attitudes is probably the one single, most important goal to achieve.

The main goal of the Education and Outreach Plan for Dowling Lake is to create public awareness of water quality issues and what contributes to them, increase public involvement in lake and watershed stewardship, and increase communication and coordination among stakeholders and partners.

Objectives

The following is a list of objectives related to the Education and Outreach goal

- Develop targeted educational and information materials to appropriate audiences in the lake and watershed and distribute through newsletters, brochures, website and Facebook posts, etc.
- Host workshops, meetings, and events that landowners can attend to learn more about BMPs that will help maintain or improve the lake.
- Solicit involvement and support from local businesses, schools, clubs, and other organizations.

Target Audience

Multiple audiences will be targeted through this education and outreach plan. Target audiences include but are not limited to property owners on and adjacent to Dowling Lake; businesses on or adjacent to Dowling Lake; lake users; real estate agencies; local clubs, organizations, and schools; ADLMD and other local government officials (Town of Summit, Town of Oak Creek), and Douglas County.

Property Owners

How property owners view and treat the lake, often called lake stewardship, is vital to maintaining the health of the lake. Lake stewardship can encompass many things including but not limited to how a property adjacent to the shore is managed, proper septic system maintenance, lighting along the shore, noise, being a good neighbor, responsible boat use, following fishing rules and regulations, and doing what is necessary to avoid spreading aquatic invasive species.

Lake stewardship will be promoted through lake organization meetings and publications. Many organizations create specific awards, brochures, or other materials promoting and/or recognizing good stewardship practices and the people who are practicing them.

People use lakes in different ways, and may have different goals for enjoyment of the lake. Discussing these goals in an open forum can help people understand each other's view points and vision for the lake. Additionally, gaining an understanding of general lake processes and ecology can help people understand what is happening in their lake. Determining the current condition of the lake can then provide a knowledge base that can be used to protect and restore the lake.

Lake Users

Lake users can be anybody with property on the lake or who comes to the lake for some purpose. While access is limited, Dowling Lake still gets it fair share of outside users for fishing, power boating, water skiing and tubing, and use of personal watercraft. A continued effort toward providing education and information regarding transport and introduction of AIS; safe and legal use of watercraft; and use of watercraft in a way that does not harm Dowling Lake helps protects the people of the lake and the overall health of the lake. Fishing is another popular activity on Dowling Lake, practiced by both property owners and outside lake users. Like other good lake stewardship practices, following fishing rules and regulations related to size and bag limits, proper handling of catch and release fish, draining livewells, and proper disposal of live bait will also help protect the health of the lake.

Real Estate

When ownership of a property changes due to sale, foreclosure, or by some other means, this is a good opportunity to approach the new owners with information about what they can do to make their new property more lake friendly. Being part of a lake district, each new property owner automatically pays extra taxes to support a healthy lake. Providing information to these new property owners about what their extra taxes are being used for may increase support for what the ADLMD does. Ultimately, taxes will be less and home/property values more when a lake is considered generally healthy with only minor issues. While mowed and manicured properties may sell better, a fact often noted by real estate agents, they are less healthy to the lake overall.

The ADLMD should be actively engaged in property sales around the lake. When a property exchanges hands, representatives of the ADLMD should be at the door immediately welcoming the new owner and passing on materials about how and what that property owner can do to maintain or improve the lake into the future.

Outside Resources

Douglas County Departments

<u>Land Conservation</u>

The Land Conservation Department's mission is to administer the Douglas County Land and Water Conservation Program to meet local priorities, conditions, and the needs of Douglas County land users through utilizing the Douglas County Land and Water Resource Management Plan as guidance and the State-funded, cost-share program for implementing conservation practices. The Land Conservation Department is responsible for administering programs such as: Aquatic Invasive Species Program; Environmental Reserve Fund; short-term, grant-funded programs; providing technical assistance for all types of conservation practices; implementing information and education programs; updating various soil and water resource inventories; and nurturing partnerships with other county, state, and federal agencies.

https://www.douglascountywi.org/305/Land-Conservation

Planning and Zoning

The Planning and Zoning Department's responsibility is: to protect the public interest and our natural resources by the administration of land use policies and ordinances emerging from comprehensive plans; to provide assistance to citizens, elected officials, and partners to guide decision-making; and to enhance staff capabilities, operational processes, and collaboration with County departments and outside agencies. The Planning and Zoning Department's responsibilities also include regulating shoreland development, lot size, building permits, impervious surface, POWTS, etc. around and adjacent to county water resources.

https://www.douglascountywi.org/327/Planning-Zoning

Forestry, Parks, and Recreation

The primary responsibilities of the Douglas County Forestry Department are to: 1) Provide stewardship to forest resources; 2) Develop and maintain recreational opportunities; and 3) Serve as an informational resource to the public. Management must balance local needs by integrating sound forestry and practices related to wildlife, fisheries, endangered resources, water quality, soil, and recreation. Forest resources are managed for environmental needs such as the protection of watersheds and rare plant and animal communities as well as the maintenance of plant and animal diversity. These same resources, however, also must provide for societal needs including recreational opportunities and production of raw materials for wood-using industries.

https://www.douglascountywi.org/211/Forestry-Parks-Recreation

Cooperative Extension

County-based Extension educators are University of Wisconsin faculty and staff who are experts in agriculture and agribusiness, community and economic development, natural resources, family living, and youth development. Extension county-based faculty and staff live and work with the people they serve in communities across the State. Extension specialists work on UW System campuses where they access current research and knowledge. Collaboration between county and campus faculty is the hallmark of Cooperative Extension in Wisconsin.

https://www.douglascountywi.org/205/Extension

State of Wisconsin

Center for Land Use Education

The Center for Land Use Education (CLUE) is a joint venture of the College of Natural Resources at the University of Wisconsin–Stevens Point and the University of Wisconsin–Madison Division of Extension. It is a focal point for land-use planning and management education. Through applied research, teaching and outreach, CLUE specialists and faculty support students, local government officials, communities and K-12 audiences on a variety of land and water topics including planning and zoning, land divisions, fragmentation, sustainability, bio- and renewable energy, food systems, shorelands and wetlands. By providing up-to-date and comprehensive training on planning and zoning tailored to address specific local needs, CLUE specialists are able to assist towns, villages, cities and counties in making sound land use decisions.

https://erc.cals.wisc.edu/programs/center-for-land-use-education/

Natural Resources Education Program

NRE Water Programming - Leading and facilitating water quality projects across the state.

Natural Resource Educators are providing leadership on nutrient reduction and water quality projects across the state. Key efforts include outreach to increase local capacity to reduce nonpoint source pollution in the Lower Fox, Wisconsin, St. Croix, Red Cedar and Rock River watersheds and the Lower Fox River Demo Farm Network initiative. Projects are carried out in collaboration with federal, state and local partners as well as producer-led watershed initiatives. The Demo Farm initiative works with farmers and their advisers to conduct on-farm demonstrations that measure and share the effectiveness of conservation practices to reduce erosion and sediment runoff, control phosphorus runoff and address other nonpoint sources of pollution.

NRE Forestry Programming - Engaging private woodland owners to encourage sustainable forest management.

ERC-based Natural Resources Educators and key partners are leading classes (Learn About Your Land and Your Land, Your Legacy) and other efforts to engage landowners in the sustainable management of Wisconsin's privately-owned forests. NREs create content for landowners on a variety of topics in publication, video, and website formats. Find out more about NRE's forestry programming at WoodlandInfo.org

https://erc.cals.wisc.edu/programs/regional-natural-resources-education-program/

Aquatic Invasive Species Outreach

Wisconsin's aquatic invasive species (AIS) program focuses on preventing the introduction of new invasive species to Wisconsin, containing the spread of invasives that are already in the state, and managing established populations when possible. In close cooperation with the Wisconsin Department of Natural Resources and Extension Lakes program, UW– Madison Division of Extension education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers and other water users the steps they should take to prevent transporting aquatic invasives to new waters. Efforts also address other potential mechanisms of introduction, including aquarium pet release and water gardening.

https://erc.cals.wisc.edu/programs/aquatic-invasive-species-outreach/

UW-Extension Lakes Program

Based at UW-Stevens Point, the Extension Lakes Program seeks to preserve Wisconsin's legacy of lakes through education, communication and collaboration. The program works with over 800 local lake associations and lake districts in Wisconsin, assisting them through education and capacity building. Lakes also partners with the Wisconsin DNR to coordinate a number of programs and projects to assist those concerned with the future of our lakes, including the Citizen Lake Monitoring Network, the Clean Boats, Clean Waters program and the Lake Leaders Institute. The *Lake Tides* newsletter reaches thousands of readers throughout the region.

https://erc.cals.wisc.edu/programs/extension-lakes-program/

Center for Watershed Science and Education

The Center for Watershed Science and Education supports watershed understanding and stewardship across and beyond the state of Wisconsin. The center includes specialists with expertise in groundwater, lakes, streams, water chemistry and analysis, and data science. The center helps individuals, organizations and private and public water resources professionals understand water quality and quantity in private wells, groundwater, lakes and rivers. Through their programming, center staff provide guidance on sampling and data collection, education on water quantity and quality, and interpretation and evaluation of monitoring results. The center also performs applied research and creates data visualization tools to improve watershed understanding.

Current research explores the movement of nitrate-nitrogen in soil and groundwater, the quantity and chemistry of groundwater, changes in lake water quality and the occurrence of pharmaceuticals and new pesticides in the water.

https://erc.cals.wisc.edu/programs/center-for-watershed-science-and-education/

Lake Superior Research Institute – UW Superior

The Lake Superior Research Institute (LSRI) was created in 1967 and formally recognized by the University of Wisconsin's Board of Regents in 1969. LSRI's mission is to conduct environmental research and provide services that directly benefit the people, industries, and natural resources of the Upper Midwest, the Great Lakes Region, and beyond; provide non-traditional learning and applied research opportunities for undergraduate students; and foster environmental education and outreach in the Twin Ports and surrounding communities.

Areas of expertise include: analytical chemistry; aquatic invasive species monitoring and outreach; benthic and zooplankton taxonomy; habitat restoration; microbiology; sediment and aquatic toxicology; quality assurance and data management; watershed management and planning; and wetland assessment and monitoring. Current research includes: aquatic and sediment toxicity testing, aquatic invasive species ecology, ballast water management system testing, beach monitoring and microbial source testing, biological monitoring and inventory of aquatic and terrestrial communities, endangered species management planning, habitat restoration, and mercury analysis in biota.

https://www.uwsuper.edu/lsri/index.cfm

Funding Sources

Douglas County Environmental Reserve Fund

A significant sum of money from the ATC came with that agreement to be used for environmental purposes as a way to mitigate environmental impacts of the new line. Douglas County combined some of this money with other sources to develop the Environmental Reserve Fund, administered by the Douglas County Land Conservation Committee (LCC) with oversight by the Administration Committee and County Board. The purpose of the fund is to make available modest amounts of money to small, Douglas County entities working on environmental issues; while earning interest, which will be applied to the principal, to continue the fund into the future.

https://www.douglascountywi.org/718/Environmental-Reserve-Fund

Wisconsin Department of Natural Resources Surface Water Grant Programs

Shoreland Improvement Project

In 2020, the LRPD began organizing a shoreland improvement education and implementation program based on the results of the 2018 SHA. The goal of the program is to help property owners understand how their property values benefit relative to better water quality through runoff reduction; healthier and more diverse habitat for fish and wildlife; and potentially improved natural aesthetics around the lake. This project has four phases to it. All four phases are expected to occur in each year of implementation.

The first phase of the project is to share with individual property owners the results of their evaluation during the 2018 SHA. Postings on the LRPD webpage and Facebook page, articles in LRPD newsletters, and one on one conversation with property owners, will encourage them to ask about their evaluation, review it with the LRPD, and ask questions about it.

During the second phase of the project, interested property owners will be invited to workshops to better understand their assessment results, learn more about possible improvement opportunities, and what resources exist to help them implement projects that will reduce runoff and improve habitat. These workshops would also include information on shoreline preservation methods (e.g. bio-logs, rip-rap, etc.) to prevent shoreland erosion.

The third phase is sponsoring actual workshops. The content of each year's workshop could vary but would be focused on why the LRPD sponsored this SHA of properties around the lake; review/explanation of the parameters used to score properties during the SHA; a review/explanation of individual property management recommendations made during the SHA; an introduction to the WDNR Healthy Lakes and Rivers Initiative and how it provides reimbursement for projects implemented to reduce runoff and improve shoreland habitat; options for reducing sediment runoff and habitat improvement that go beyond the management recommendations in the SHA; introduction to the Sauk County water quality improvement and lake protection program, eligible projects, and opportunities for reimbursement of expenditures for completed projects; and introduction of landscaper(s) and other businesses who could help assess properties for methods to reduce runoff and preserve shoreline and then possibly contract with property owners to perform the work.

The final phase of this activity is organizing property owners and projects and applying for grant funds on their behalf, and then providing support to complete identified projects.

It is expected that these activities will be carried out annually as long as there are still interested property owners. After five years, the SHA will be redone to determine the level of changes that have occurred.

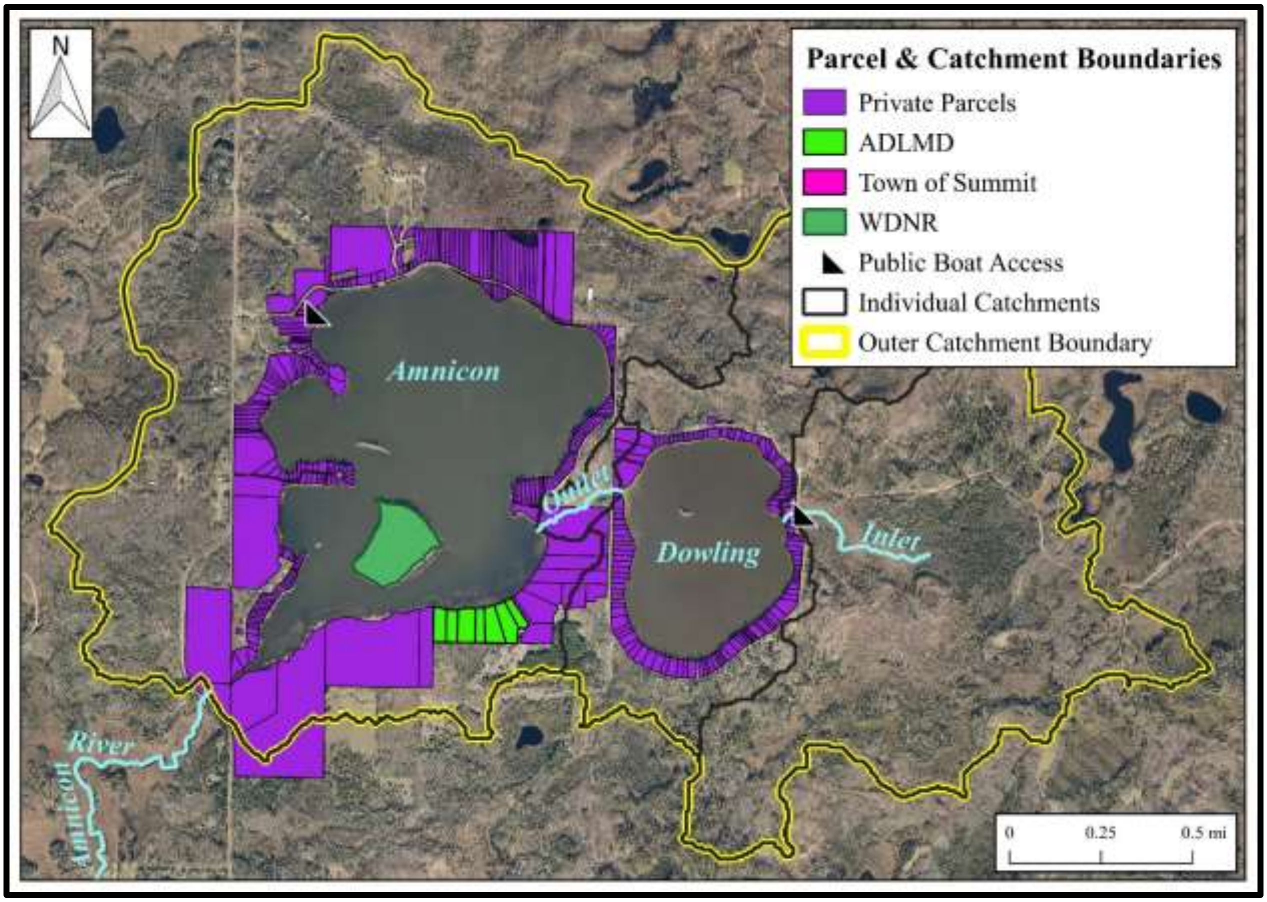


Figure 1. Parcel and catchment boundaries around Amnicon and Dowling Lakes.

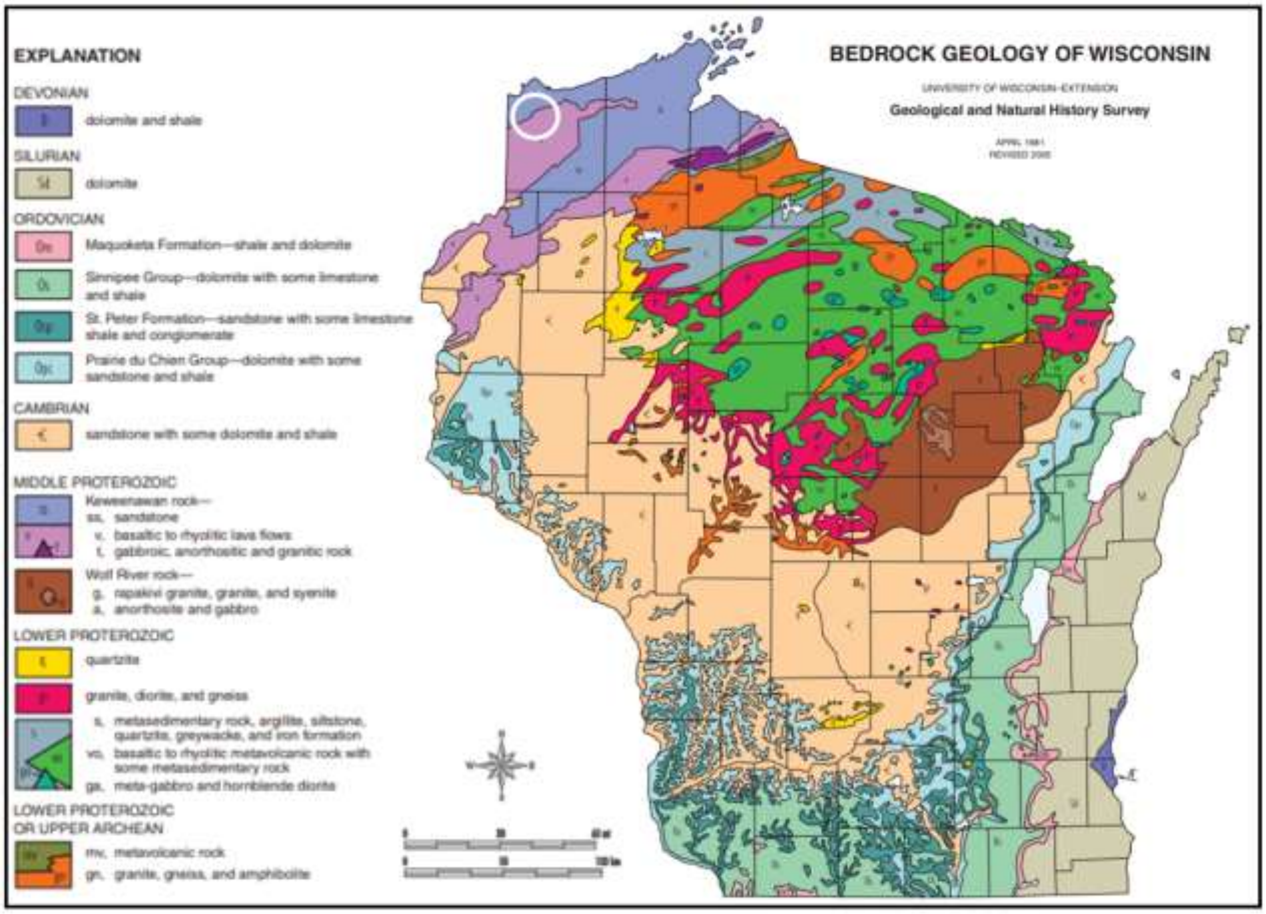


Figure 2. Wisconsin bedrock geology with Amnicon and Dowling Lakes circled in white (WDNR, 2005)

Figure 3. Glacial lobes of the Laurentide Ice Sheet that covered Wisconsin (UW-Extension, 2020)

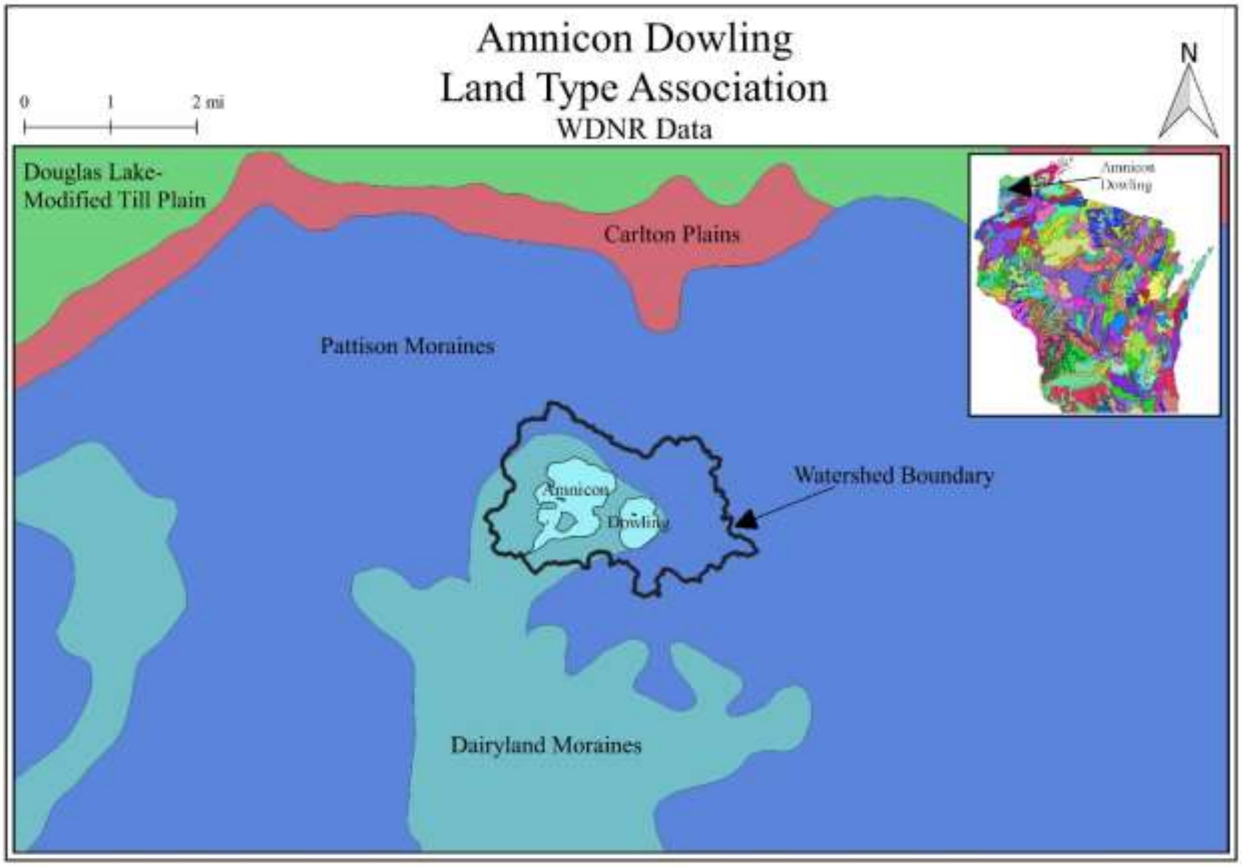


Figure 4. Land Type Associations of Amnicon and Dowling Lakes (WDNR, 2020)

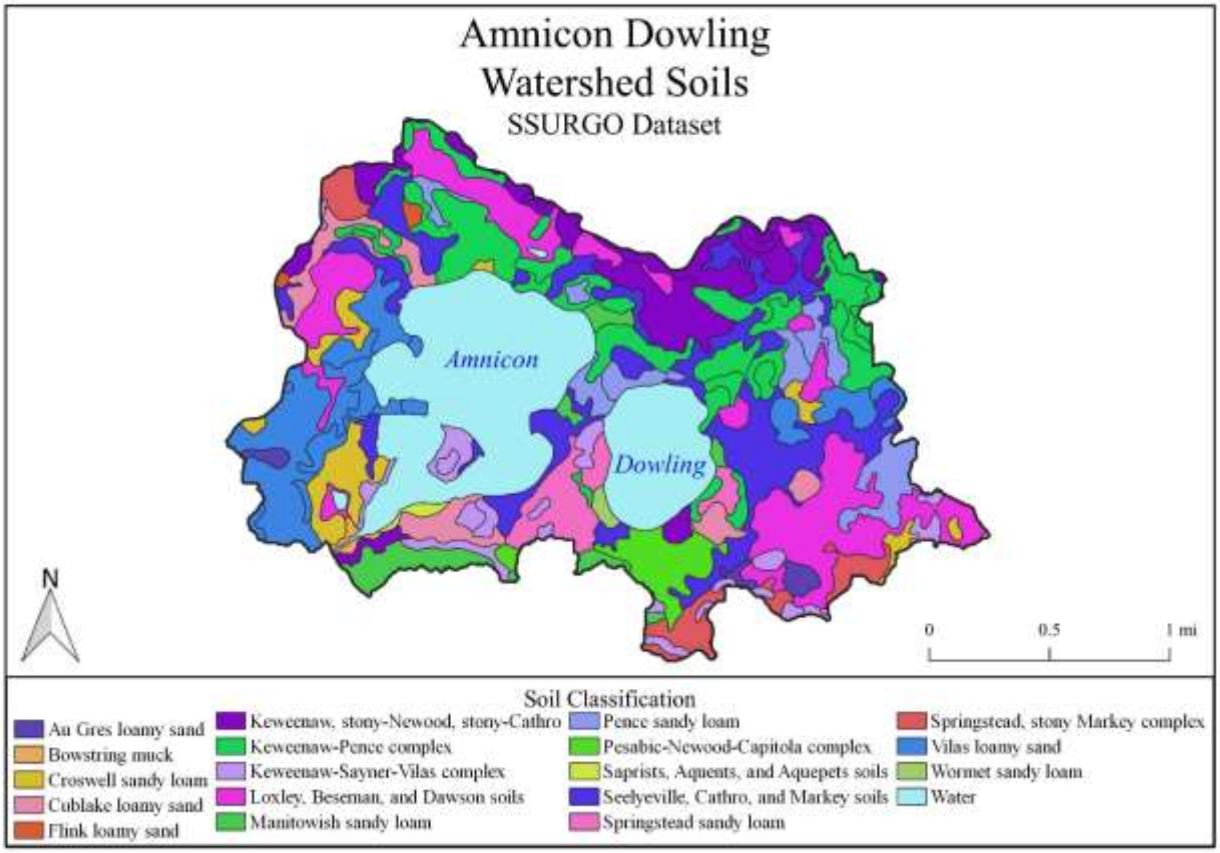


Figure 5. Amnicon Dowling watershed soils (SSURGO)

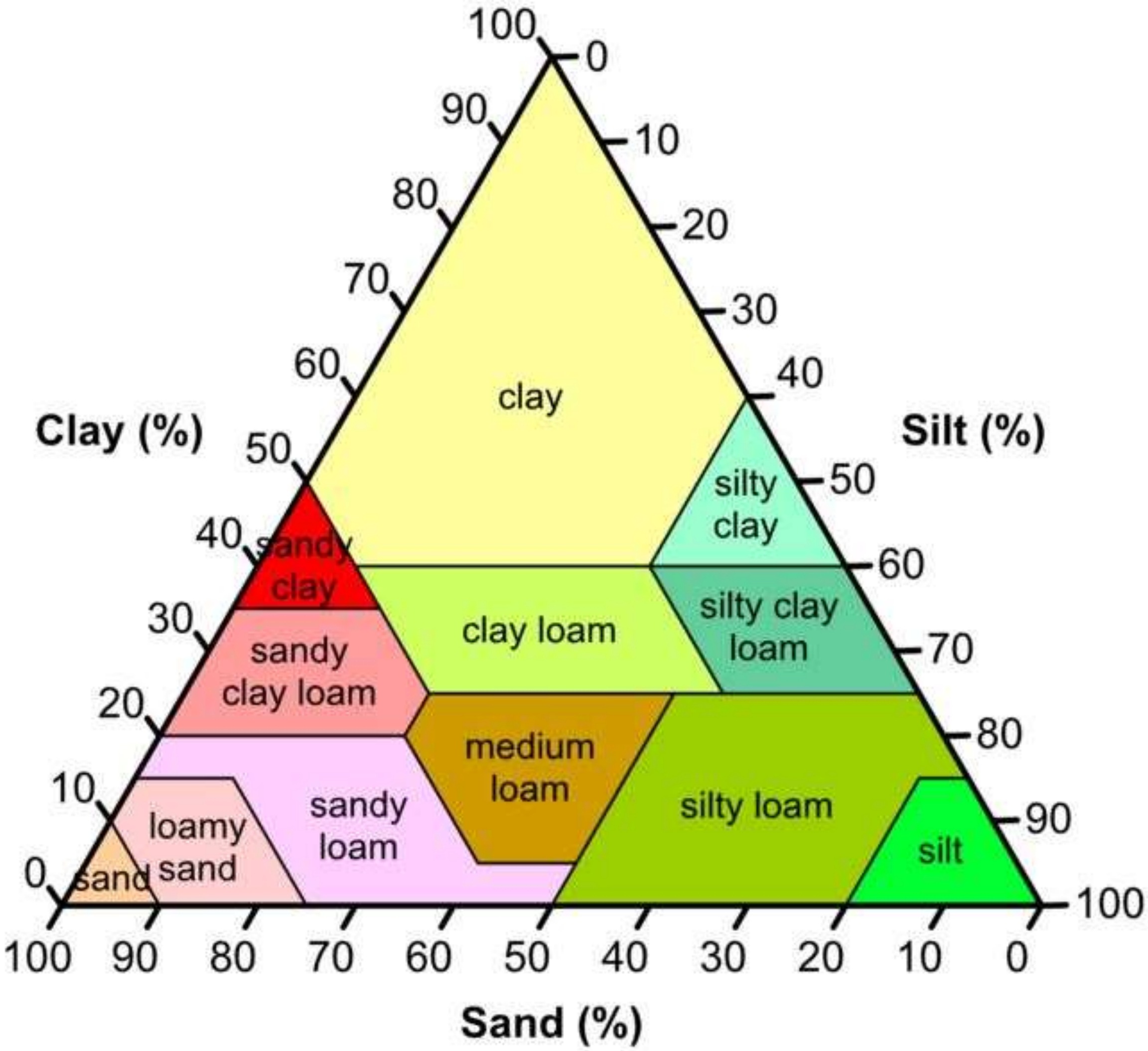


Figure 6. Soil composition and classification

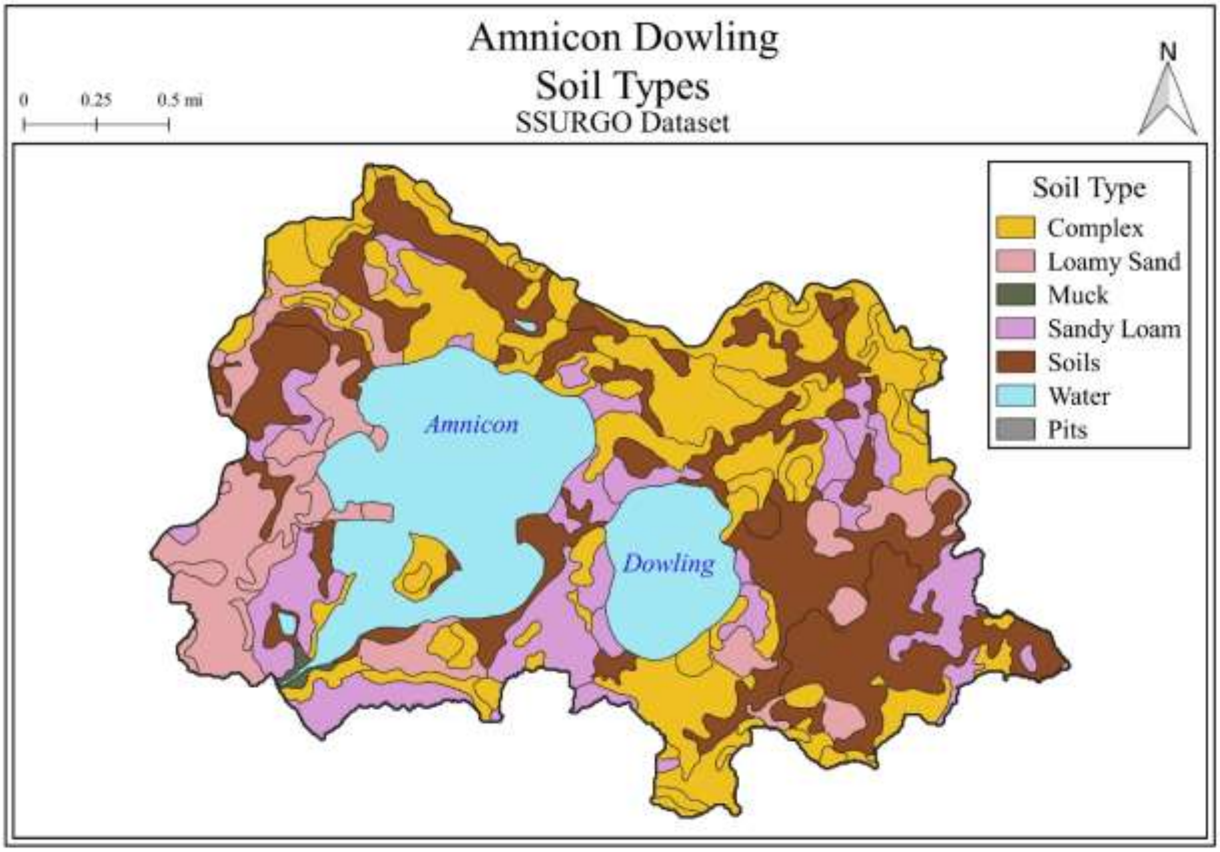


Figure 7. Amnicon Dowling watershed soil types (SSURGO)

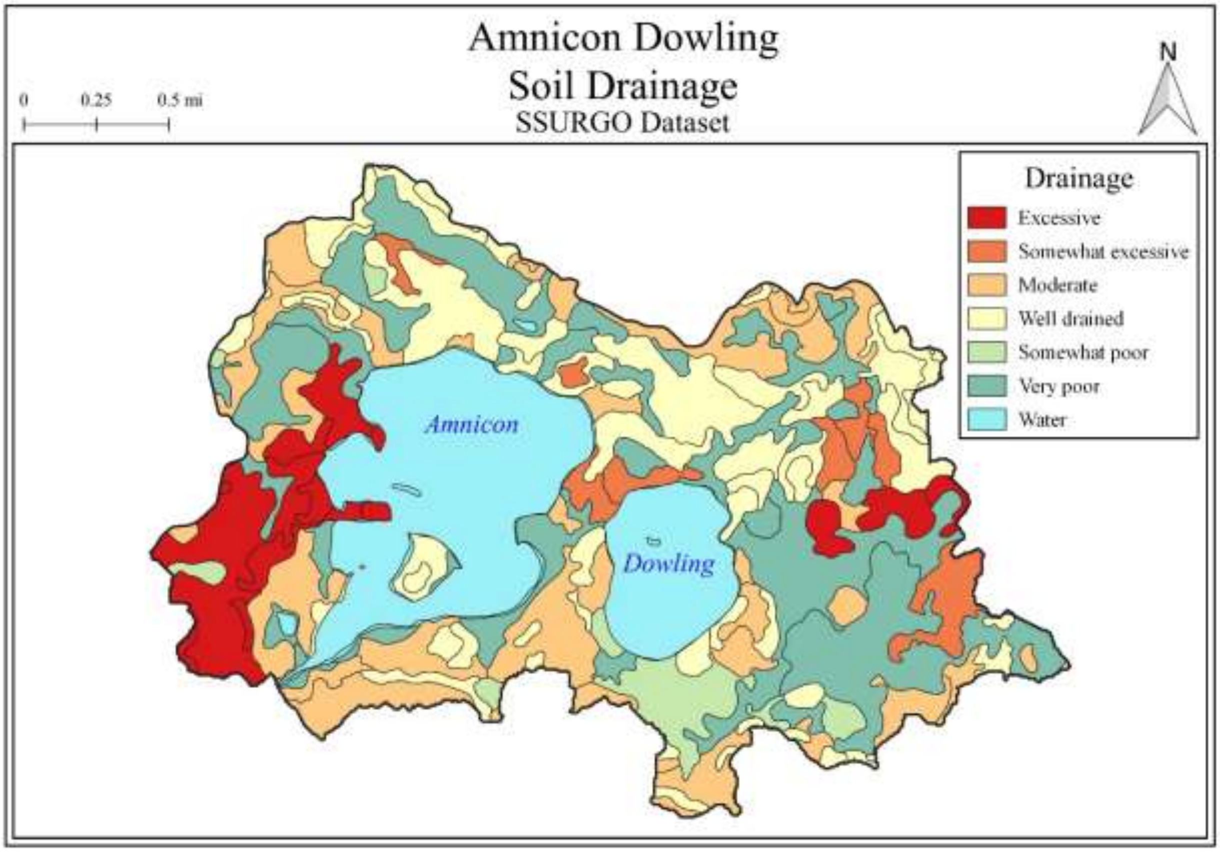


Figure 8. Amnicon Dowling watershed soil drainage (SSURGO)

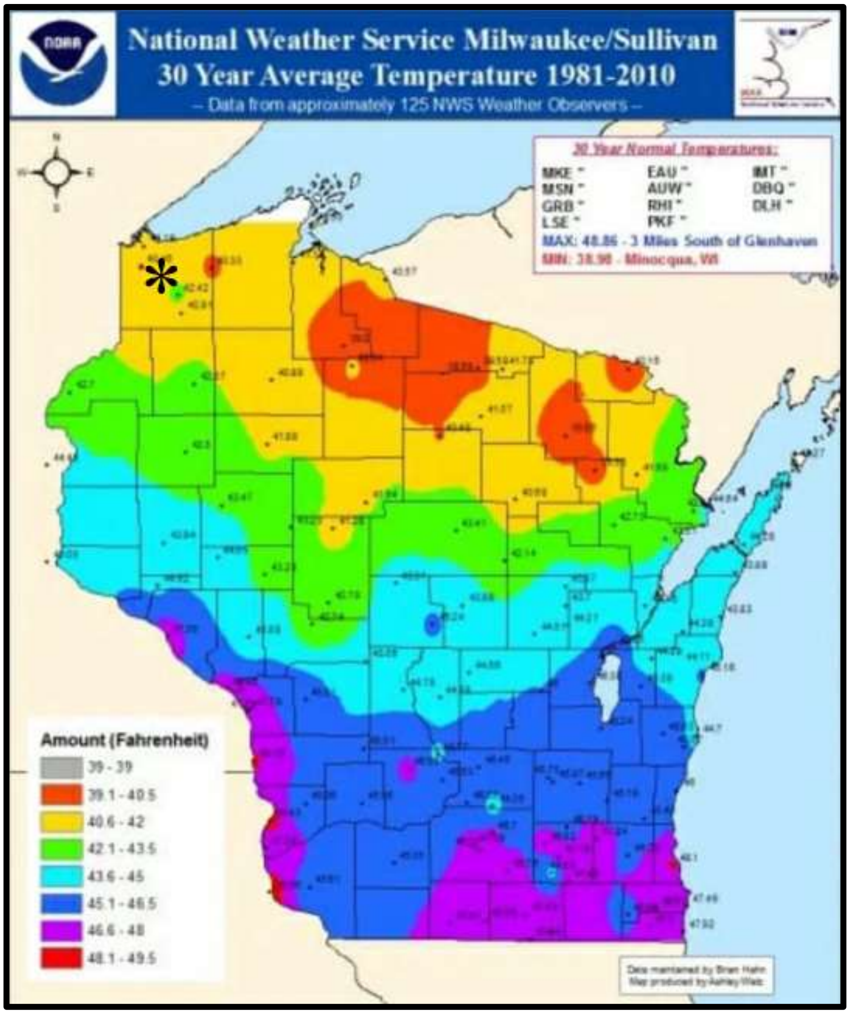


Figure 9. National weather service 30 year average temperatures in Wisconsin 1981-2010 (NOAA; *indicates Amnicon and Dowling Lakes)

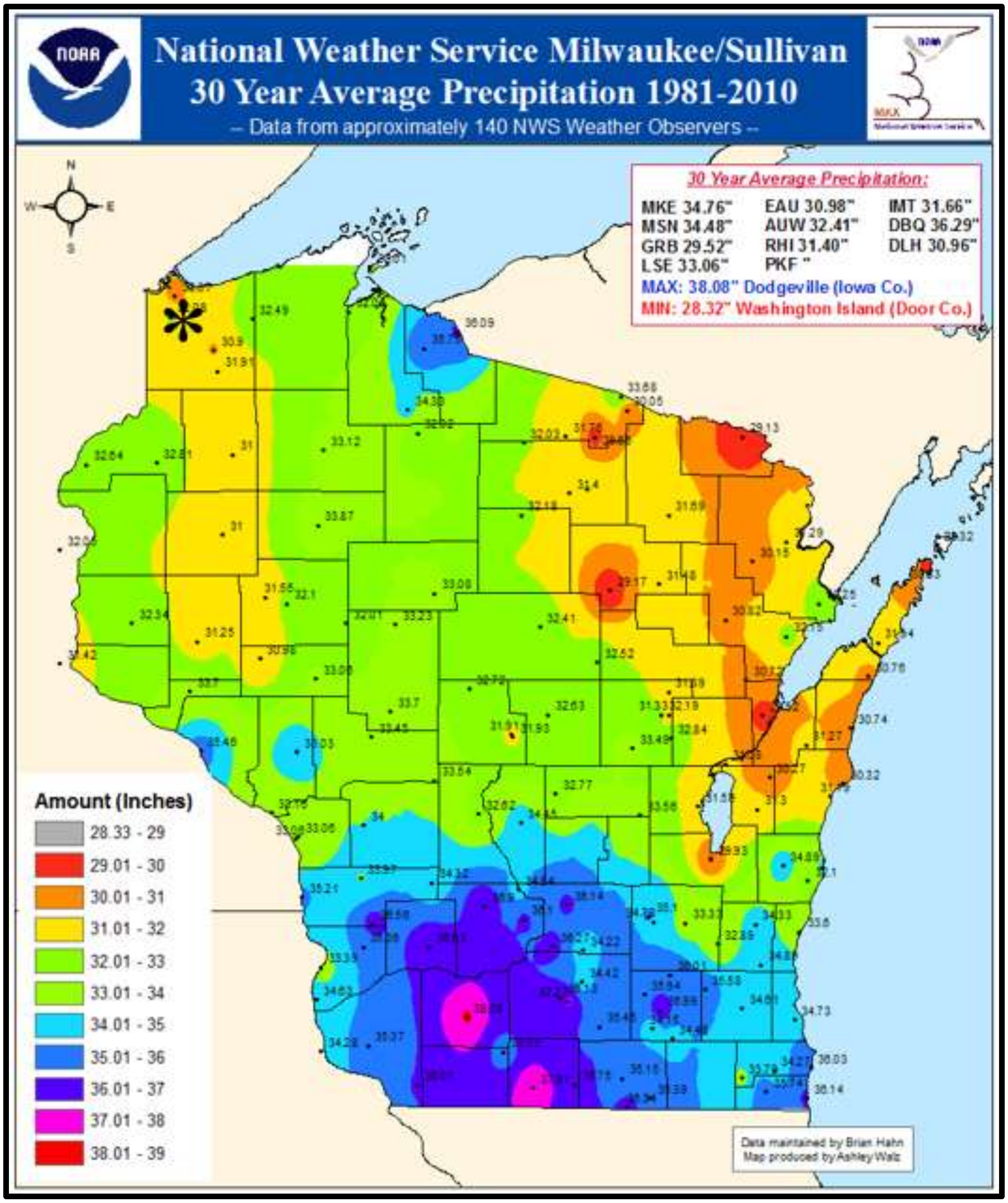


Figure 10. National weather service 30 year average precipitation in Wisconsin 1981-2010 (NOAA; *indicates Amnicon and Dowling Lakes)

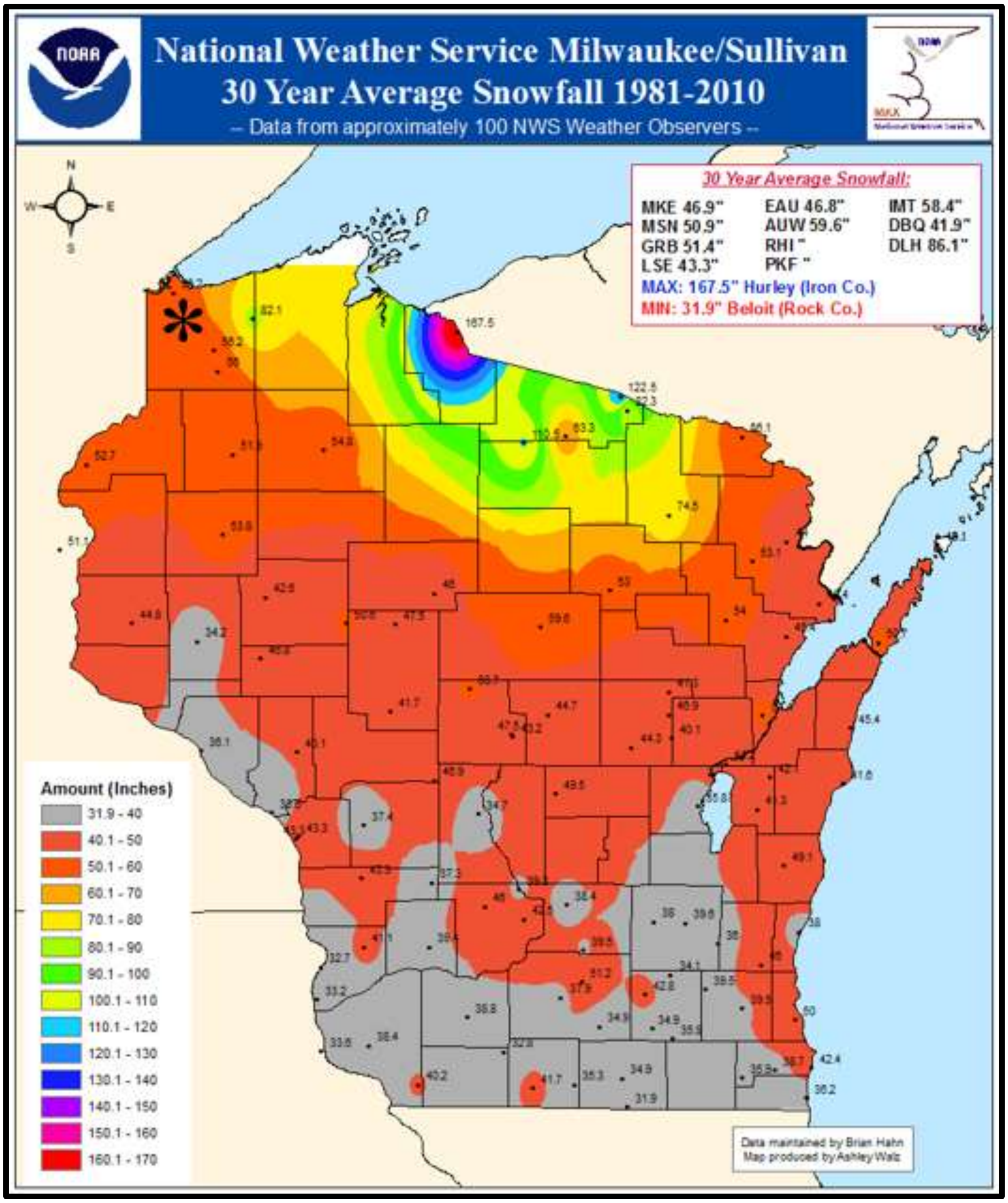


Figure 11. National weather service 30 year average snowfall in Wisconsin 1981-2010 (NOAA; *indicates Amnicon and Dowling Lakes)

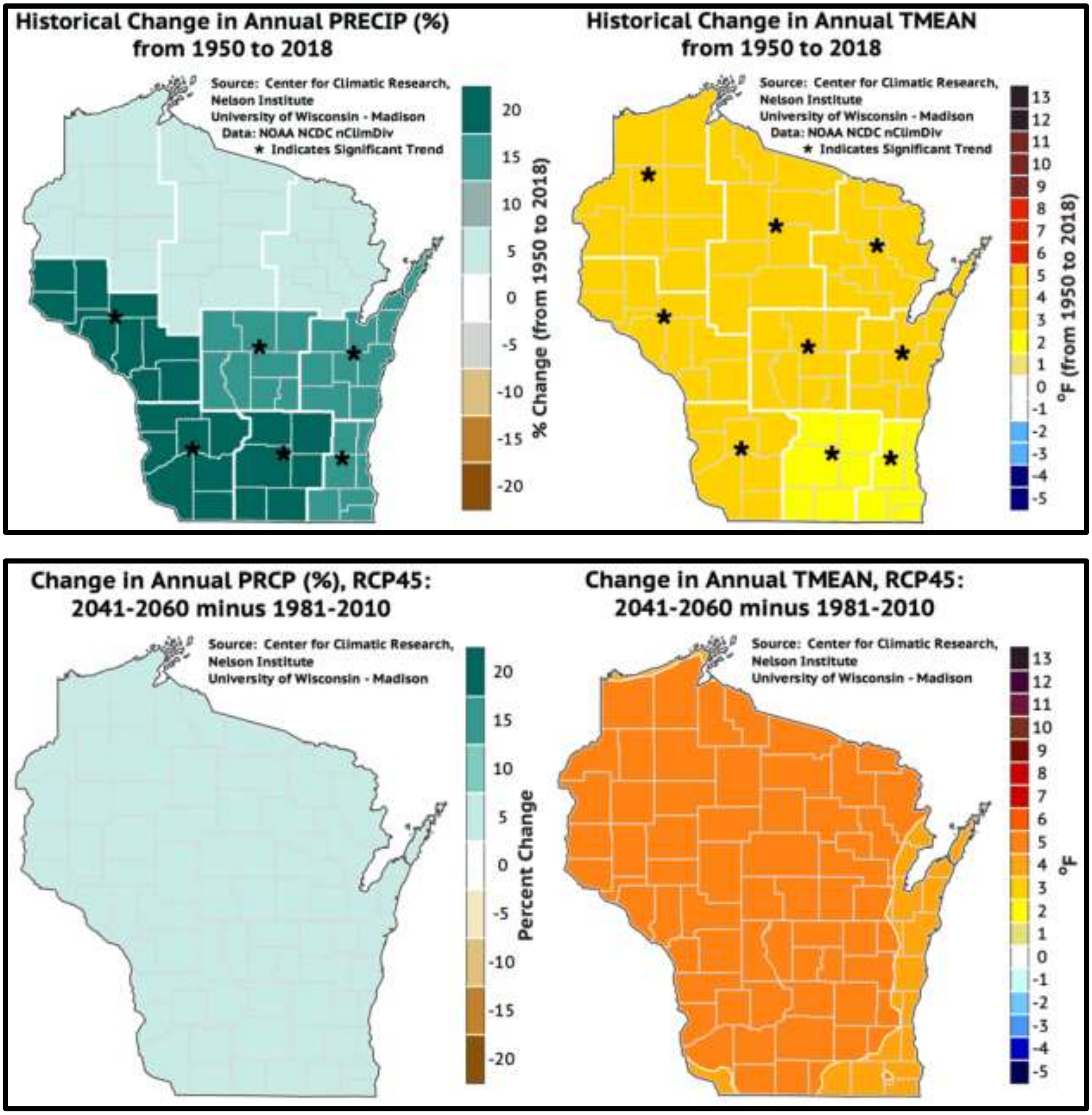


Figure 12. Historical change and predicted change in precipitation and temperature in Wisconsin (Center for Climatic Research, Nelson Institute)

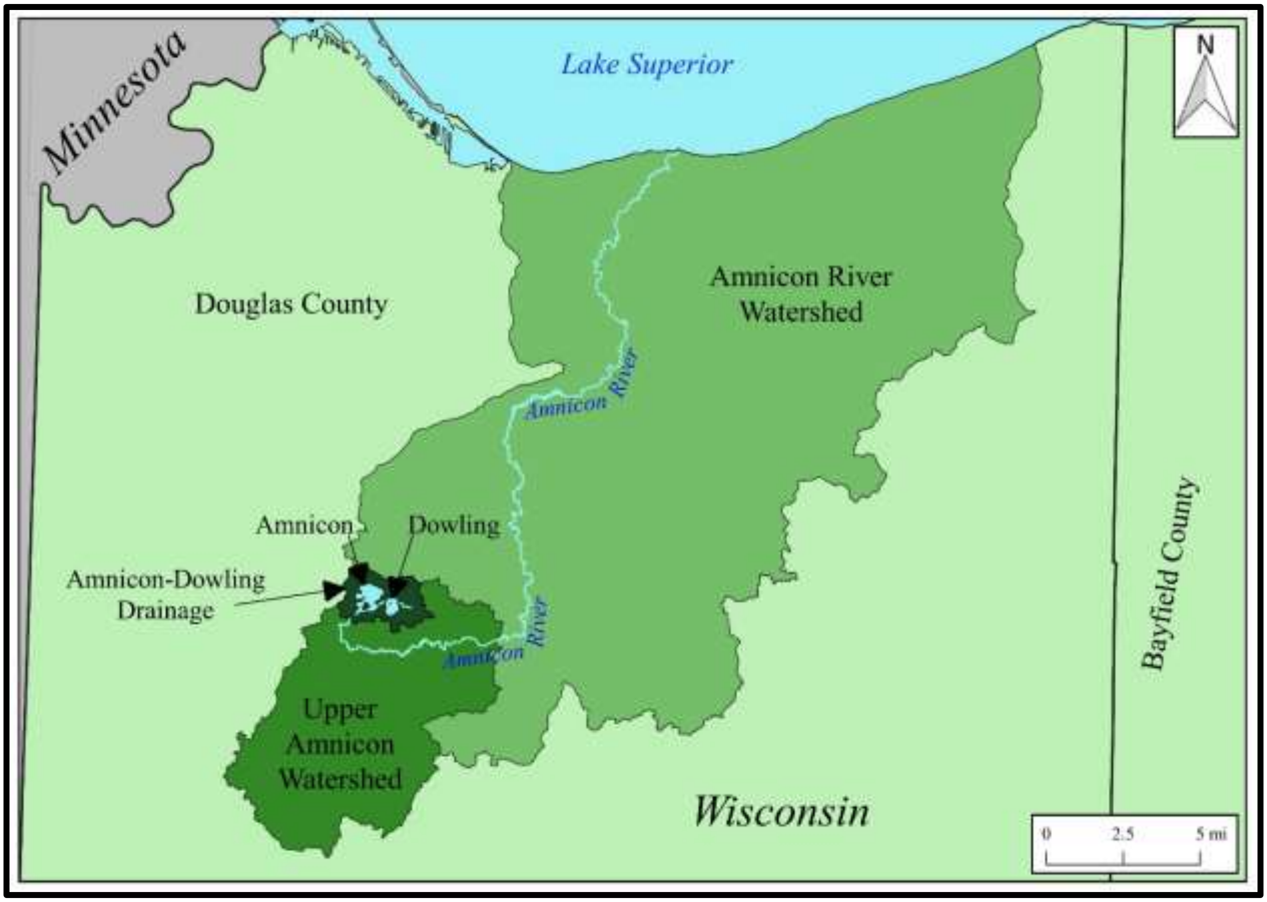


Figure 13. Amnicon and Dowling watersheds.

NLCD Land Cover Classification	Description
Open Water	areas of open water, generally with < 25% cover of vegetation or soil.
Developed, Open Space	areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for < 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings.
Developed, Low Intensity	areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.
Developed, Medium Intensity	areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50- 79% of the total cover. These areas most commonly include single-family housing units.
Developed, High Intensity	highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Deciduous Forest	areas dominated by trees generally > 5m tall, and > 20% of total vegetation cover. > 75% of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	areas dominated by trees generally > 5m tall, and > 20% of total vegetation cover. > 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	areas dominated by trees generally > 5m tall, and > 20% of total vegetation cover. Neither deciduous nor evergreen species are > 75% of total tree cover.
Shrub/Scrub	areas dominated by shrubs; < 5m tall with shrub canopy typically > 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Grassland/Herbaceous	areas dominated by graminoid or herbaceous vegetation, generally > 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Pasture/Hay	areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for > 20% of total vegetation
Woody Wetlands	areas where forest or shrubland vegetation accounts for > 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	areas where perennial herbaceous vegetation accounts for > 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Figure 14. NLCD land cover classification description (USGS, 2019)

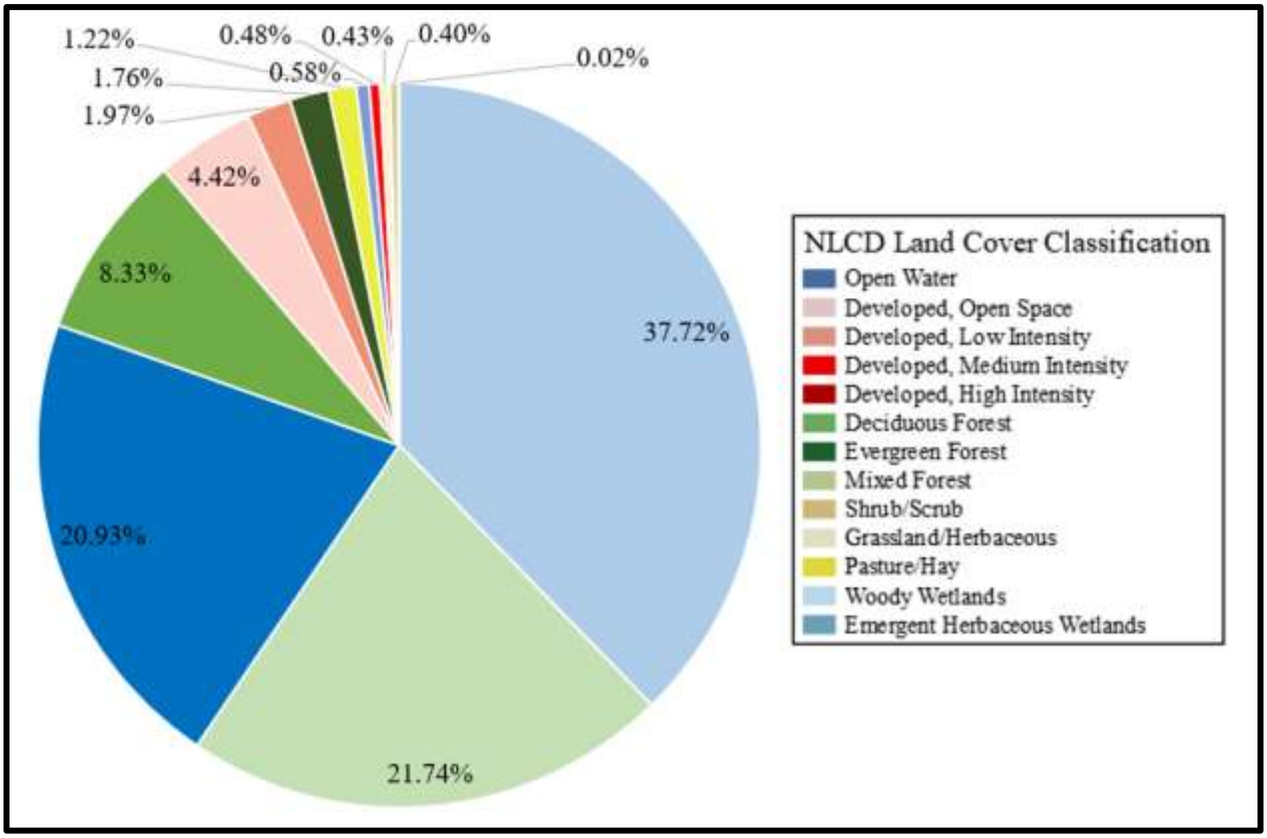


Figure 15. Amnicon-Dowling watershed land cover (NLCD, 2016)

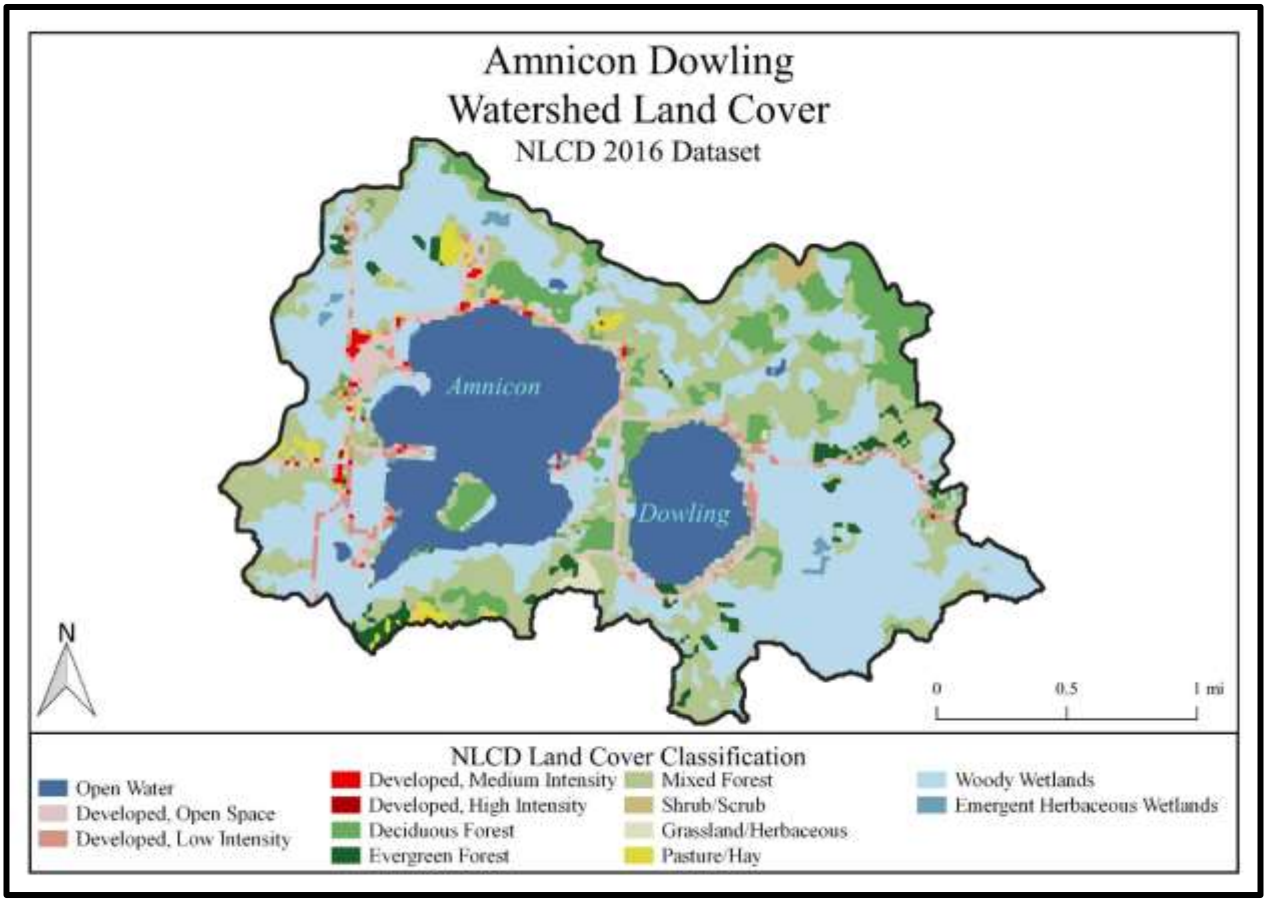


Figure 16. NLCD 2016 land cover of the Amnicon Dowling watershed area

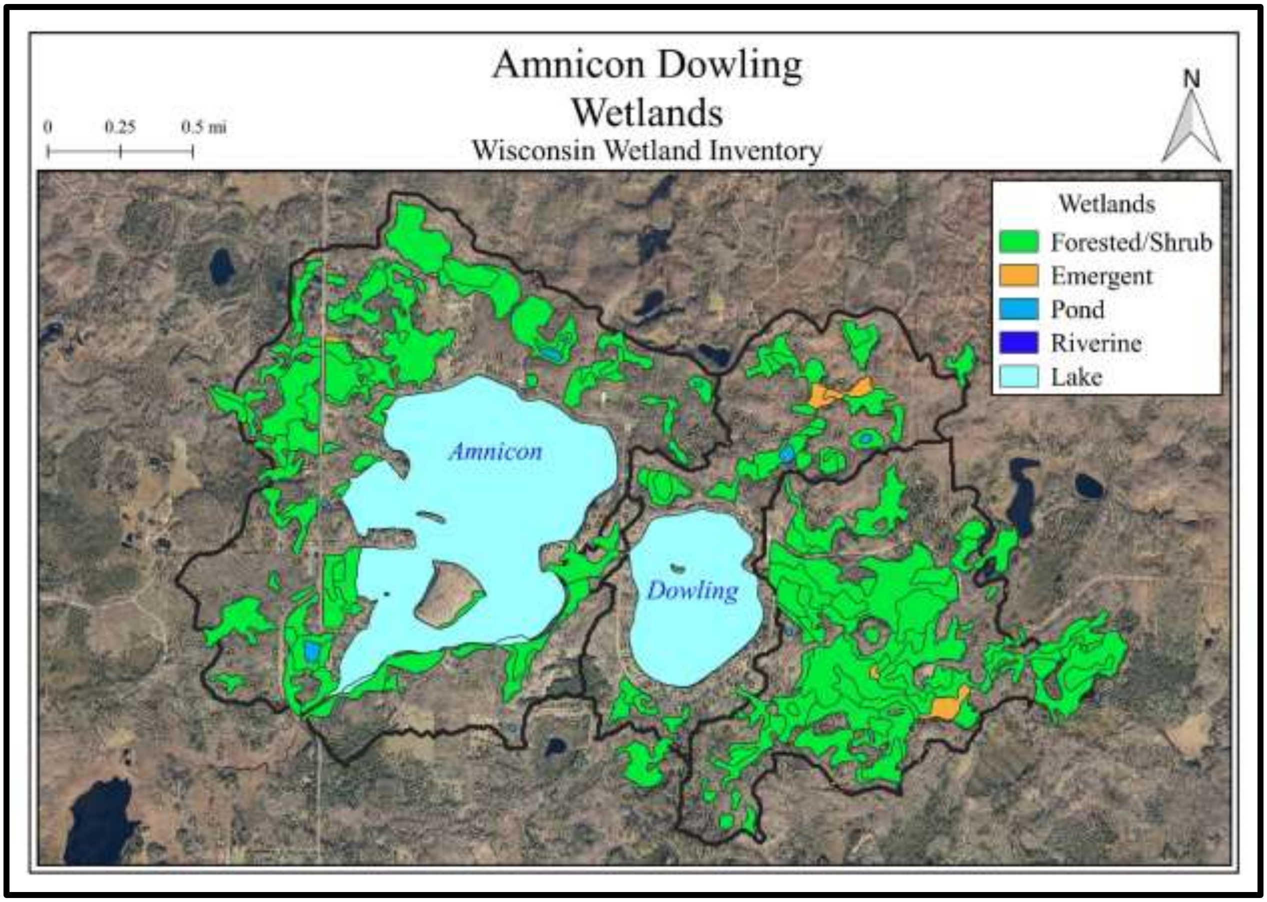


Figure 17. Wisconsin Wetland Inventory of wetlands in the Amnicon Dowling watershed area

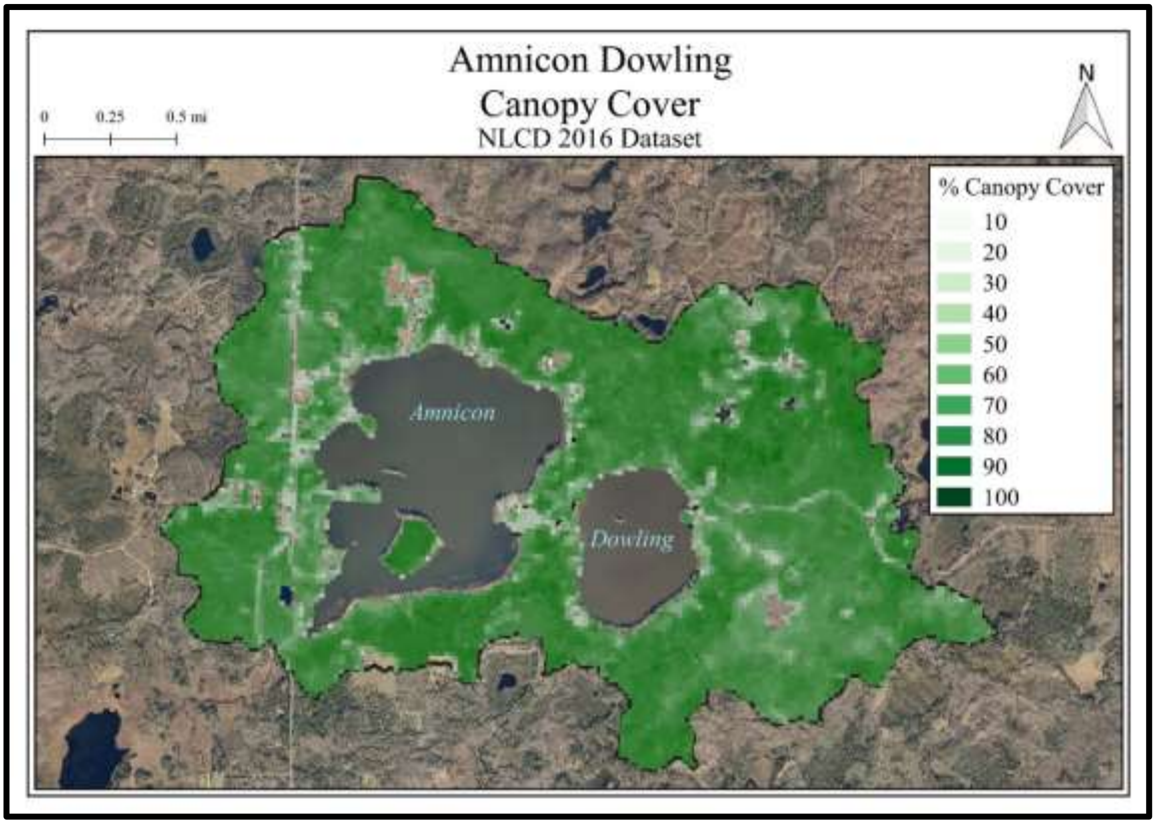


Figure 18. NLCD 2016 canopy cover of the Amnicon Dowling watershed

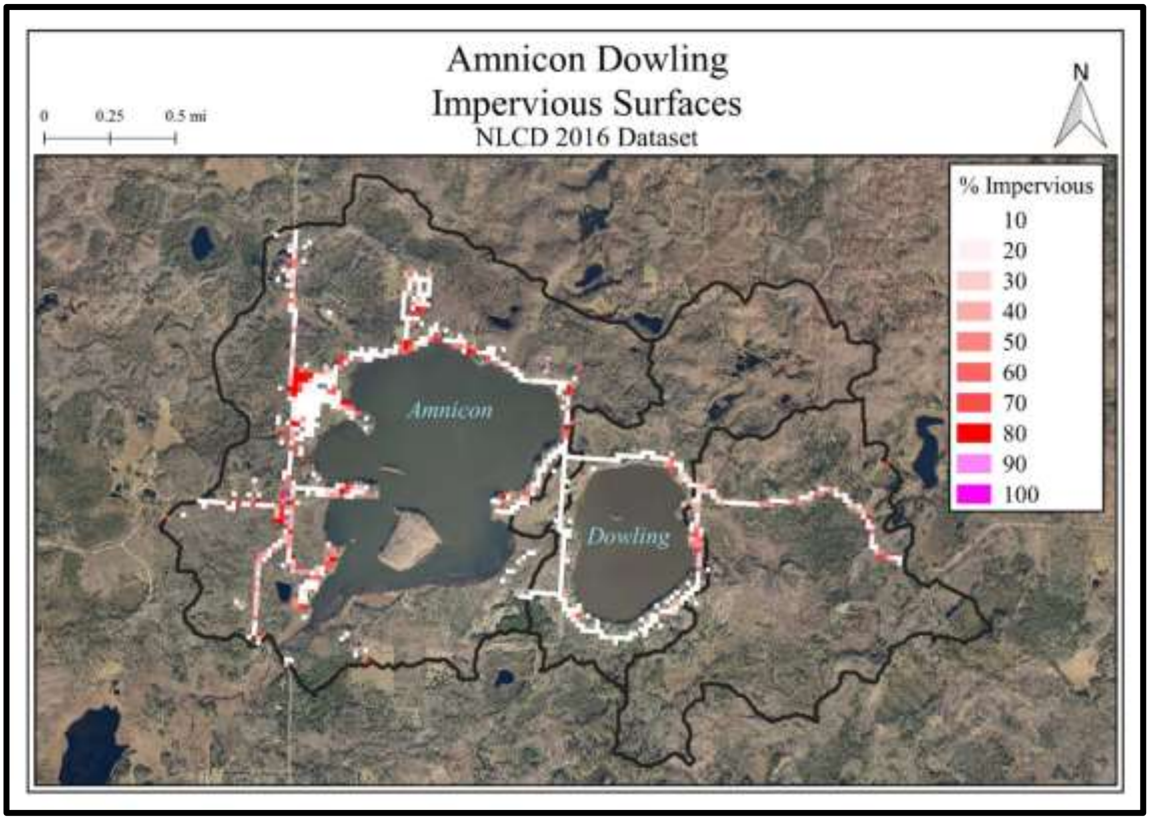


Figure 19. NLCD 2016 impervious surfaces of the Amnicon Dowling watershed

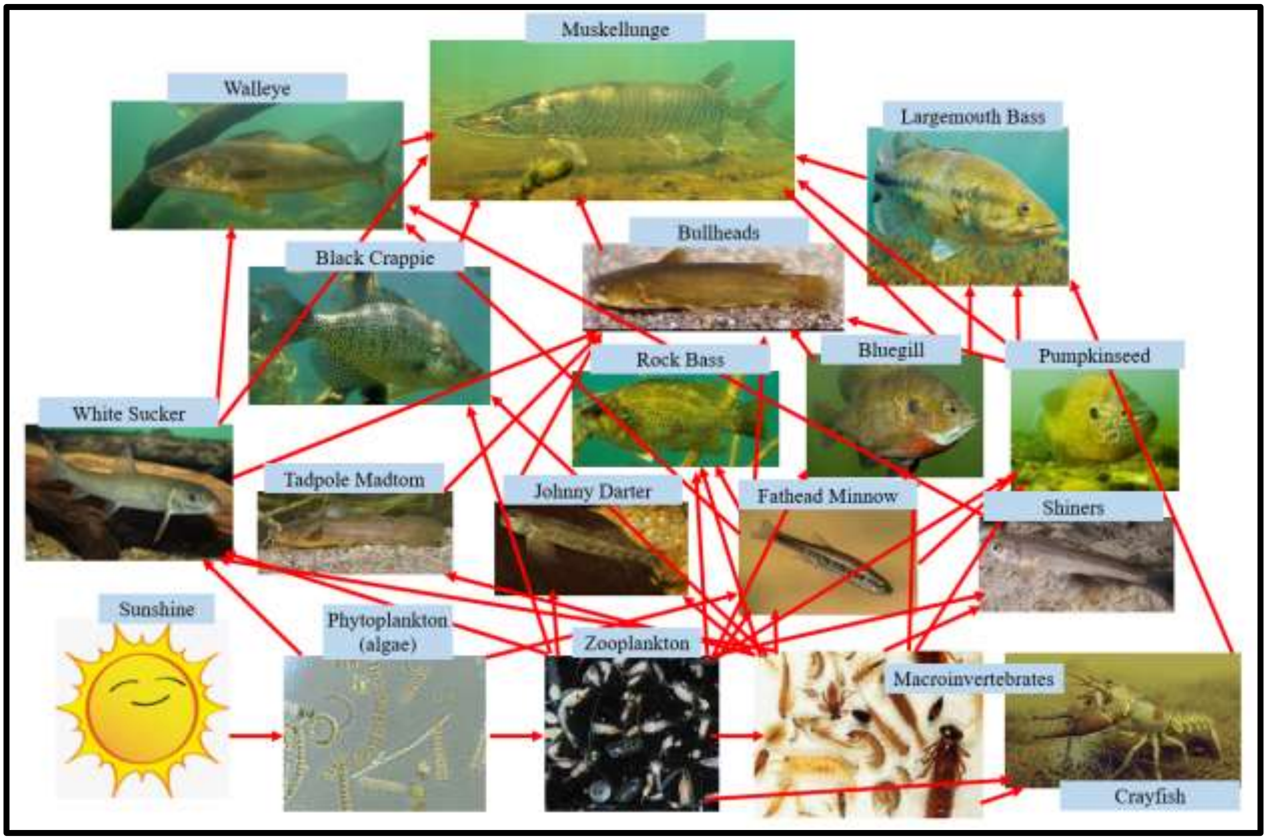


Figure 20. Dowling Lake potential food web interactions