Conservation Success Index: Driftless Area Brown Trout

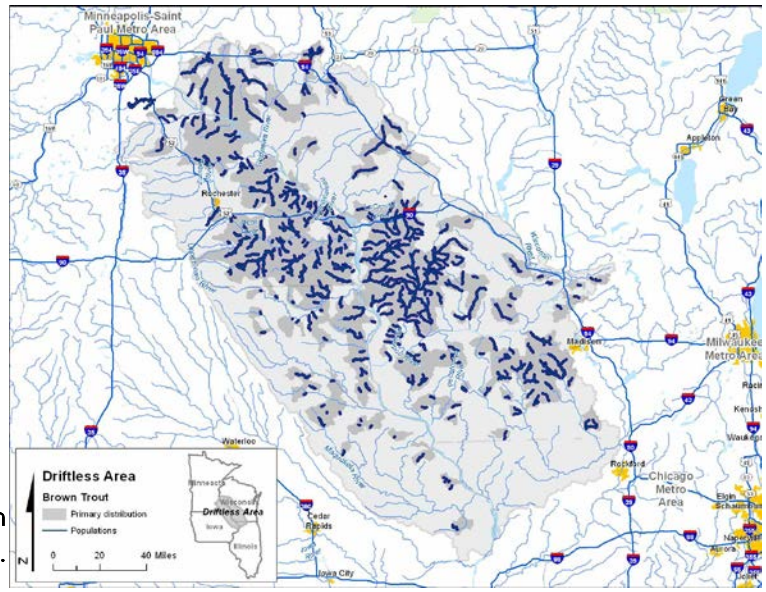
SALMO TRUTTA

Rev. 1.1 - 8/2011

SPECIES SUMMARY

The Wisconsinian glaciation that retreated 10 to 12 thousand years ago left behind silt, sand, gravel and boulders – called glacial drift – across much of the Upper Midwest. However, glaciers during that time bypassed the area known today as the Driftless Area in southeastern Minnesota, southwestern Wisconsin, northwestern Illinois, and northeastern Iowa. The term Driftless is a misnomer, though, because the area does contain glacial drift from glaciations prior to the Wisconsinian glaciation. History aside, the limestone bluffs, river valleys, and spring streams that characterize the Driftless Area lead to an expansive network of coldwater streams.

Driftless Area Map



An angler pursues wary trout in newly restored Bishops Branch, Wisconsin. Photo by Jeff Hastings.

Brook trout are the only trout native to the Driftless Area. However, brown trout were stocked into Driftless Area streams in the late 1800's. While brown trout stocking continues throughout the area, many populations have become naturalized and now reproduce in the wild. Wild brown trout populations now provide anglers with quality angling opportunities, including the potential for trophy fish.

In the mid-1800's European settlers began clearing the oak-savanna landscape. They harvested trees for firewood and grazed livestock on valley slopes. These land-clearing activities lead to severe hillside erosion, flash floods, and large quantities of sediment in valley floors and streams. By the 1930's the Driftless Area trout streams had become warm, shallow, and silt-laden. The lack of vegetation resulted in more surface runoff, leading to more flash floods and streambank erosion and less groundwater recharge.

Since the 1930's many efforts have been made to improve farming practices and reduce runoff and soil erosion, and stream habitat has improved substantially. Today, several efforts are underway to protect the Driftless Area landscape and improve trout habitat.

The Driftless Area Restoration Effort (DARE) partnership is spearheaded by Trout Unlimited and directed towards protecting, restoring, and enhancing Driftless Area watersheds, coldwater resources, and trout streams.

The Driftless Area Initiative is a multi-state partnership aimed at restoring and enhancing ecology and economy of the Driftless Area.

Driftless Area streams can produce big trout. Joe Chadwick caught this 30+ inch brown trout from an undisclosed Driftless Area stream. Photo by Len Harris.

Streambank erosion prior to restoration on Big Spring Branch, Wisconsin. Photo by Nohr Chapter of Trout Unlimited.

Big Spring Branch, Wisconsin, after streambank stabilization and bank contouring restoration. Photo by Nohr Chapter of Trout Unlimited.

Trout Unlimited Chapters have been instrumental in restoring Driftless Area streams. For example, the Nohr Chapter of Trout Unlimited worked with the Elliott Donnelley Chapter, TU DARE, and other project partners to restore over three miles of stream in Big Spring Branch, Iowa and Grand counties, Wisconsin. The project included streambank stabilization and shaping and installing cross-channel logs, vortex weirs, boulders, rootwads, and logs to improve habitat for fish, reptiles, and amphibians. Critical to the project was a voluntary stream buffer implemented by the landowner.

Our CSI analysis was based on information from the Minnesota, Wisconsin, Iowa, and Illinois Departments of Natural Resources, and the Driftless Area Initiative. A complete list of data sources can be found under the Rule Sets and Data Sources link.

Key CSI Findings

- Population abundance is often moderate to high
- Populations occupy habitat extents ranging from small stream segments to entire watersheds
- Many subwatersheds are stocked with brown trout
- Brown trout populations range from having balanced population structure to being recruitment limited or having few spawning adults

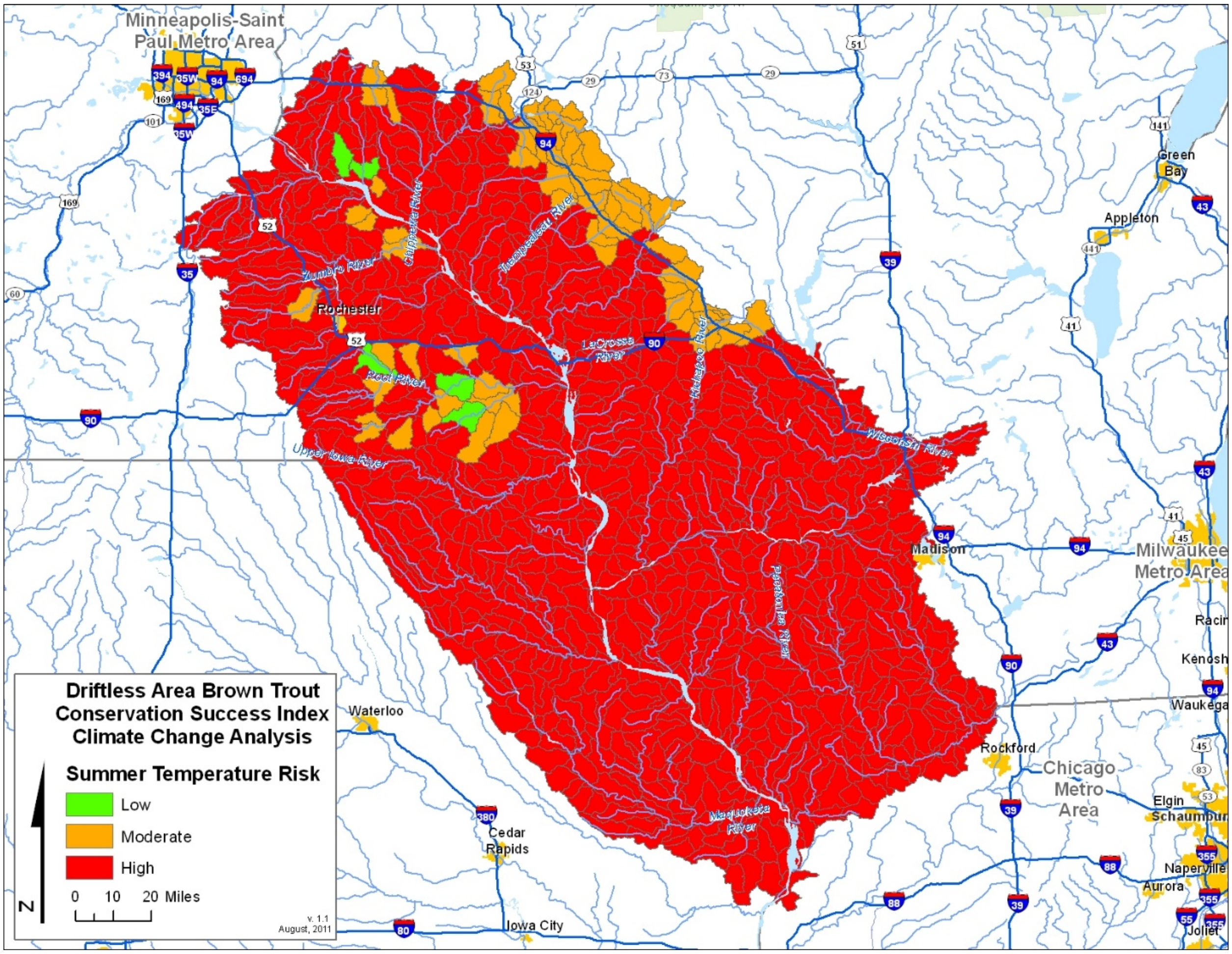
- Much of the Driftless Area natural land cover has been converted for human use
- Over 1,800 miles of stream habitat in 227 subwatersheds are listed as having impaired water quality by the EPA (303d listed).
- Since most lands have already been converted, there is little risk of lands being converted in the future
- Most subwatersheds have low risk due to future energy development
- Climate warming poses a high risk to many Driftless Areas trout populations, except those that inhabit spring streams.
- The extensive road network and accessible streams poses a high risk for invasive species introductions.

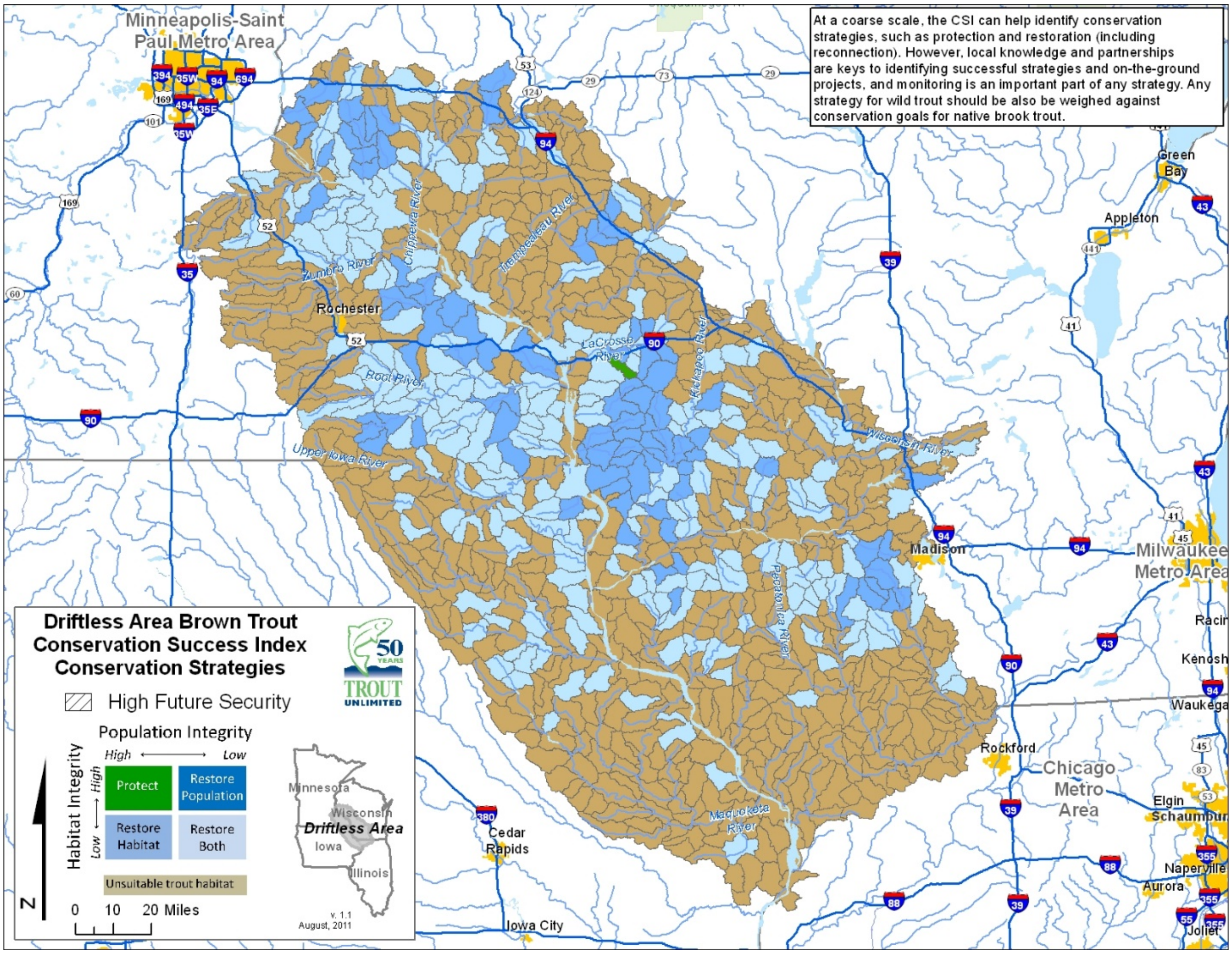
Prepared by Dan Dauwalter, 1/2011

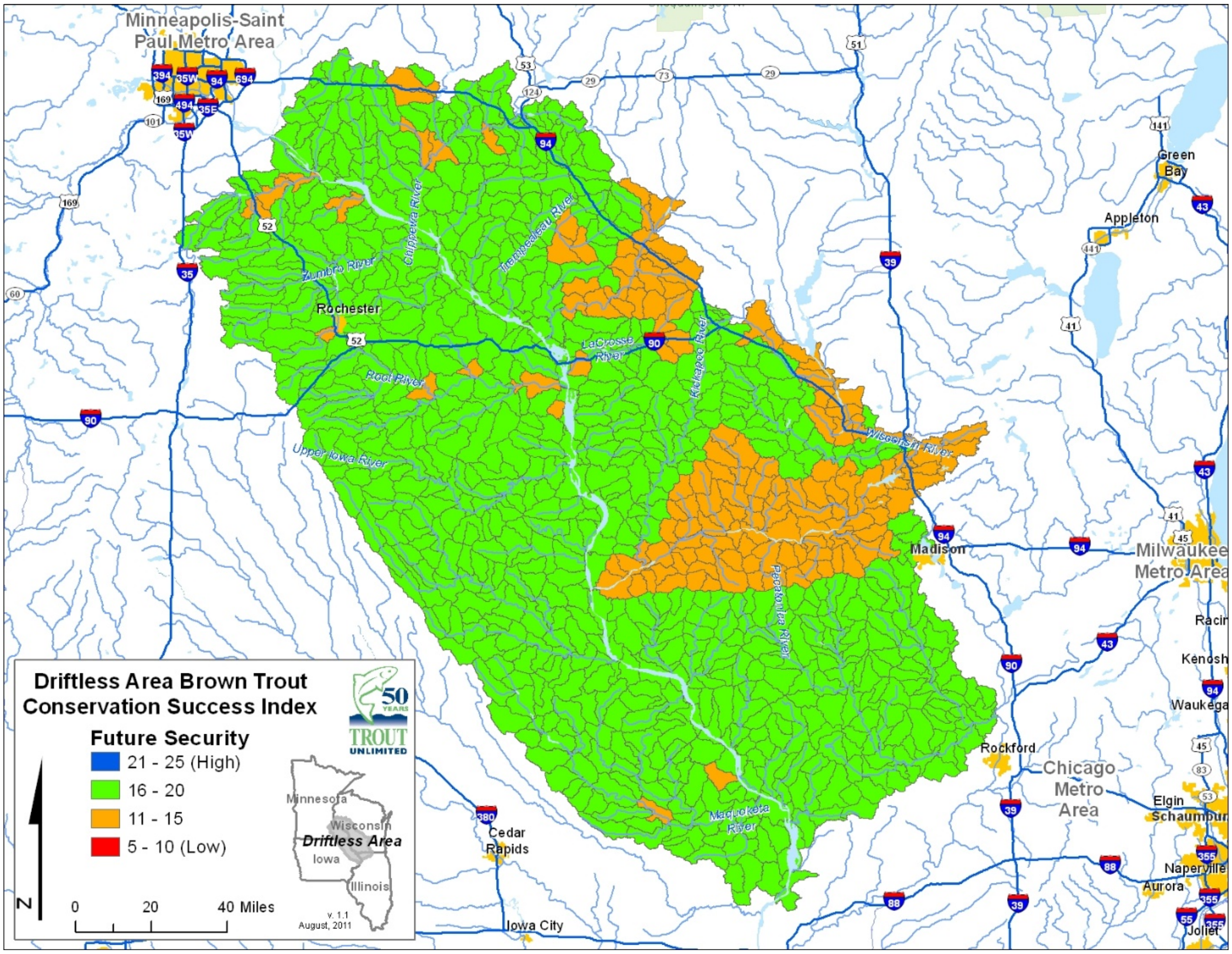
Table 1. CSI scoring result summary for Driftless Area brown trout. Population Integrity indicators were scored only for currently occupied habitat (305 subwatersheds), while Habitat Integrity and Future Security indicators were scored for all 819 subwatersheds in the Driftless Area. All indicators are scored from 1 (poorest) to 5 (best): see detailed methods for scoring Driftless Area brook trout.

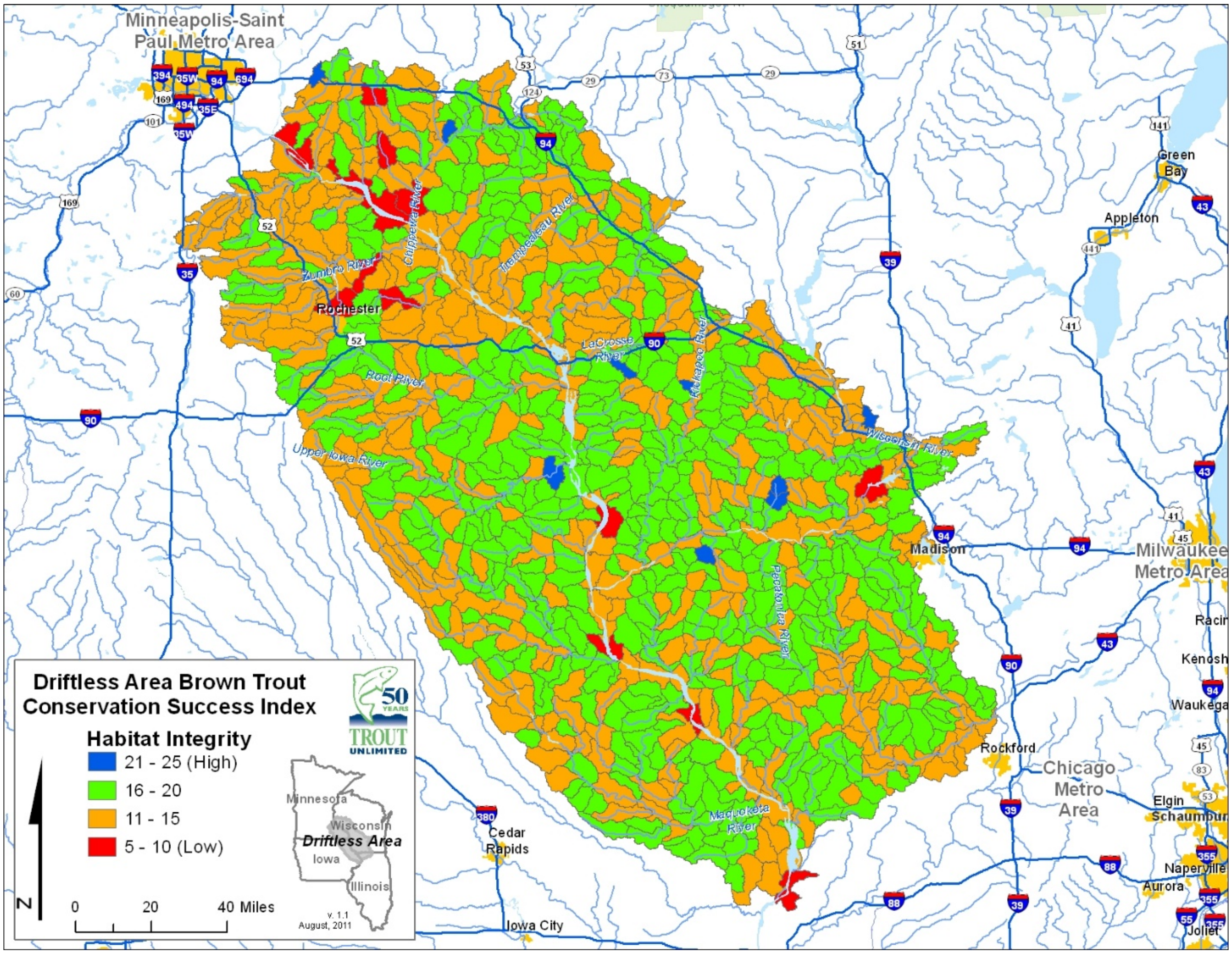
		Number of Subwatersheds Receiving Scores					**Total Subwatersheds Scored**
	CSI Indicator	**1**	**2**	**3**	**4**	**5**	
Population Integrity	Population Density	5	29	146	61	64	305
	Habitat extent	84	64	38	33	86	305
	Management emphasis	69	17	23	89	107	305
	Disease vulnerability	0	0	0	0	305	305
	Population size structure	18	17	134	39	97	305
Habitat Integrity	Riparian condition	19	114	395	243	48	819
	Watershed connectivity	45	320	369	77	8	819
	Watershed conditions	219	348	233	15	4	819
	Water quality	178	23	107	47	464	819
	Flow regime	28	59	60	149	523	819

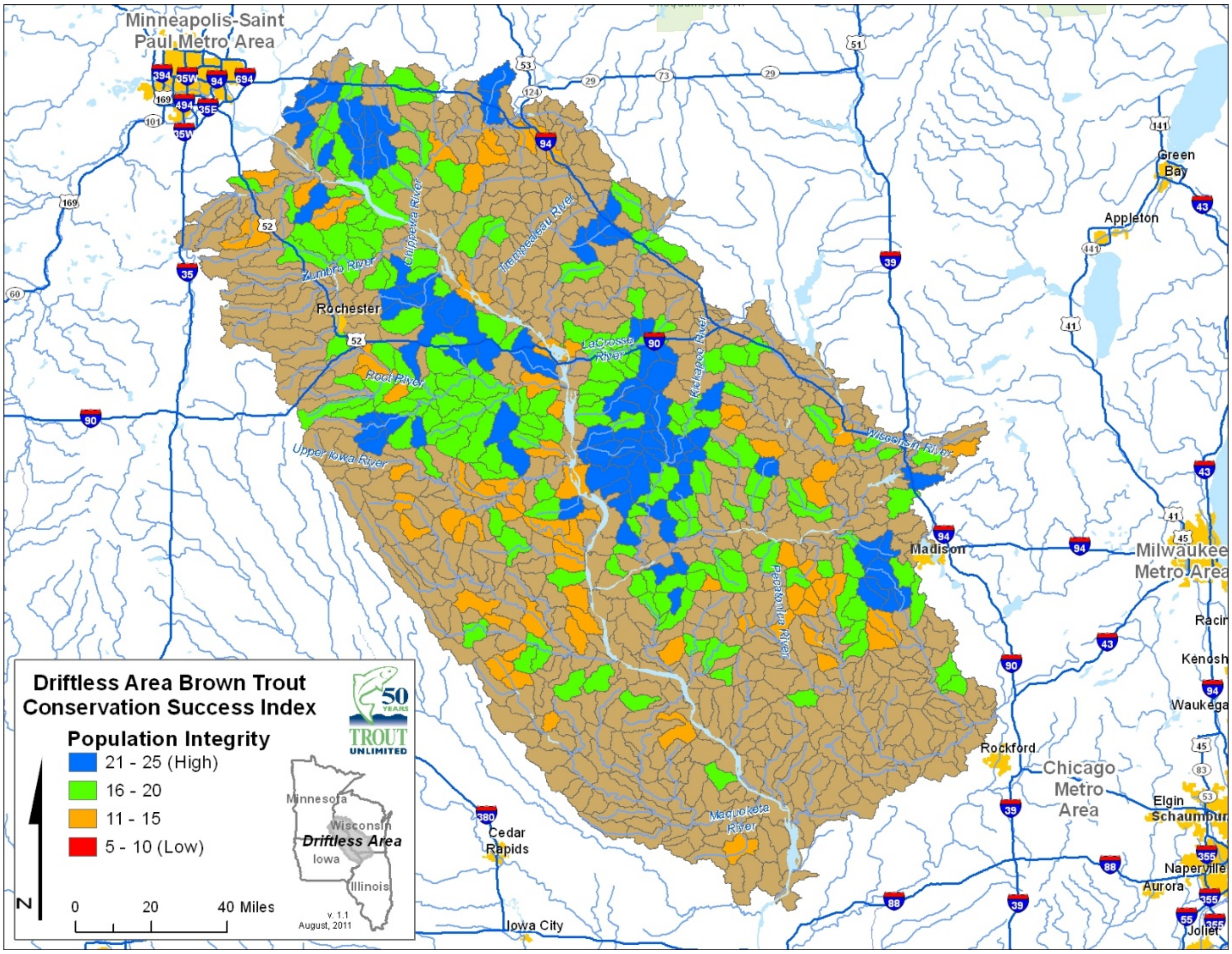
Future Security	Land conversion	4	9	22	168	616	819
	Resource extraction	14	210	234	286	75	819
	Energy development	84	0	2	12	721	819
	Climate change	751	0	63	5	0	819
	Introduced species	0	11	752	56	0	819

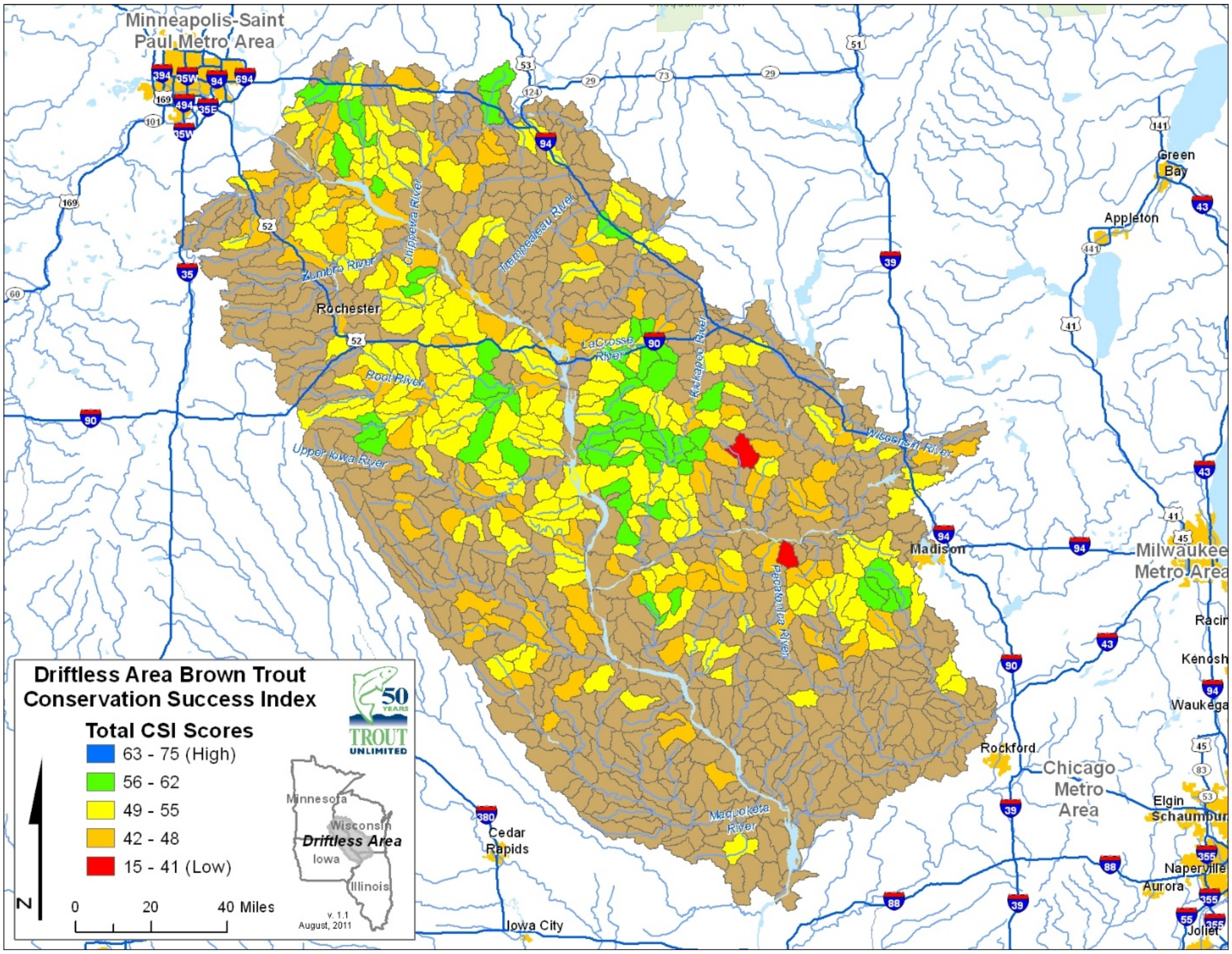

Driftless Area Brown Trout
Conservation Success Index
Climate Change Analysis
Summer Temperature Risk
Low
Moderate
High
0 10 20 Miles
N
v. 1.1
August, 2011
Minneapolis-Saint Paul Metro Area
Rochester
Madison
Milwaukee Metro Area
Chicago Metro Area
Rockford
Waterloo
Cedar Rapids
Iowa City
Green Bay
Appleton


At a coarse scale, the CSI can help identify conservation strategies, such as protection and restoration (including reconnection). However, local knowledge and partnerships are keys to identifying successful strategies and on-the-ground projects, and monitoring is an important part of any strategy. Any strategy for wild trout should be also be weighed against conservation goals for native brook trout.
Driftless Area Brown Trout
Conservation Success Index
Conservation Strategies
High Future Security
Population Integrity
High
Low
Habitat Integrity
High
Low
Protect
Restore Population
Restore Habitat
Restore Both
Unsuitable trout habitat
N
0 10 20 Miles
50 YEARS
TROUT UNLIMITED
Minnesota
Wisconsin
Driftless Area
Iowa
Illinois
v. 1.1
August, 2011
Minneapolis-Saint Paul Metro Area
Rochester
Zumbro River
Chippewa River
Trempealeau River
LaCrosse River
Kickapoo River
Root River
Upper Iowa River
Wisconsin River
Pecatonica River
Maquoketa River
Madison
Green Bay
Appleton
Milwaukee Metro Area
Racine
Kenosha
Waukegan
Rockford
Chicago Metro Area
Elgin
Schaumburg
Naperville
Aurora
Joliet
Cedar Rapids
Iowa City


Driftless Area Brown Trout
Conservation Success Index
Future Security
21 - 25 (High)
16 - 20
11 - 15
5 - 10 (Low)
N
0
20
40 Miles
Minnesota
Wisconsin
Driftless Area
Iowa
Illinois
v. 1.1
August, 2011
TROUT UNLIMITED
50 YEARS
Minneapolis-Saint Paul Metro Area
Rochester
Zumbro River
Chippewa River
Trempealeau River
LaCrosse River
Root River
Upper Iowa River
Kickapoo River
Wisconsin River
Pecatonica River
Maquoketa River
Madison
Milwaukee Metro Area
Green Bay
Appleton
Rockford
Chicago Metro Area
Cedar Rapids
Iowa City
Elgin
Naperville
Aurora
Joliet


Driftless Area Brown Trout
Conservation Success Index
Habitat Integrity
21 - 25 (High)
16 - 20
11 - 15
5 - 10 (Low)
N
0
20
40 Miles
Minnesota
Wisconsin
Driftless Area
Iowa
Illinois
v. 1.1
August, 2011
TROUT UNLIMITED
Minneapolis-Saint Paul Metro Area
Rochester
Zumbro River
Chippewa River
Trempealeau River
LaCrosse River
Kickapoo River
Root River
Upper Iowa River
Wisconsin River
Pecatonica River
Maquoketa River
Madison
Milwaukee Metro Area
Green Bay
Appleton
Racine
Kenosha
Waukegan
Rockford
Chicago Metro Area
Elgin
Schaumburg
Naperville
Aurora
Joliet
Cedar Rapids
Iowa City


Driftless Area Brown Trout
Conservation Success Index
Population Integrity
21 - 25 (High)
16 - 20
11 - 15
5 - 10 (Low)
N
0
20
40 Miles
Minnesota
Wisconsin
Driftless Area
Iowa
Illinois
v. 1.1
August, 2011
Minneapolis-Saint Paul Metro Area
Rochester
Zumbro River
Chippewa River
Trempealeau River
LaCrosse River
Kickapoo River
Root River
Upper Iowa River
Wisconsin River
Pecatonica River
Maquoketa River
Madison
Milwaukee Metro Area
Green Bay
Appleton
Rockford
Chicago Metro Area
Cedar Rapids
Iowa City
Elgin
Schaumburg
Naperville
Aurora
Joliet
Kenosha
Waukega
Racin



Driftless Area Brown Trout
Conservation Success Index
Total CSI Scores
63 - 75 (High)
56 - 62
49 - 55
42 - 48
15 - 41 (Low)
TROUT UNLIMITED
Minnesota
Wisconsin
Driftless Area
Iowa
Illinois
v. 1.1
August, 2011
0 20 40 Miles
N
Minneapolis-Saint Paul Metro Area
Rochester
Madison
Milwaukee Metro Area
Chicago Metro Area
Cedar Rapids
Iowa City
Rockford
Green Bay
Appleton
Elgin
Naperville
Aurora
Zumbro River
Chippewa River
Trempealeau River
LaCrosse River
Kickapoo River
Root River
Upper Iowa River
Wisconsin River
Pecatonica River
Maquoketa River

v1.0 - Jan, 2011

Conservation Success Index: Driftless Area Brown Trout Subwatershed Scoring and Rule Set

Introduction:

The CSI is an aggregate index typically comprised of four different component groups: Range-wide Condition; Population Integrity; Habitat Integrity; and Future Security. However, for non-native wild trout there is no historical range, and, therefore, there is no Range-wide Condition group of indicators in a CSI developed for wild trout. Only Population Integrity, Habitat Integrity, and Future Security groups are used. Each CSI group has five indicators that describe a specific component of each group. Each indicator is scored from 1 to 5 for each subwatershed, with a score of 1 indicating poor condition and a score of 5 indicating good condition. Indicator scores are then added to obtain the subwatershed condition for a Group, and Group scores are added for a CSI score for a subwatershed (Figure 1). CSI scores can then be summarized to obtain the general condition within the current distribution of wild trout.

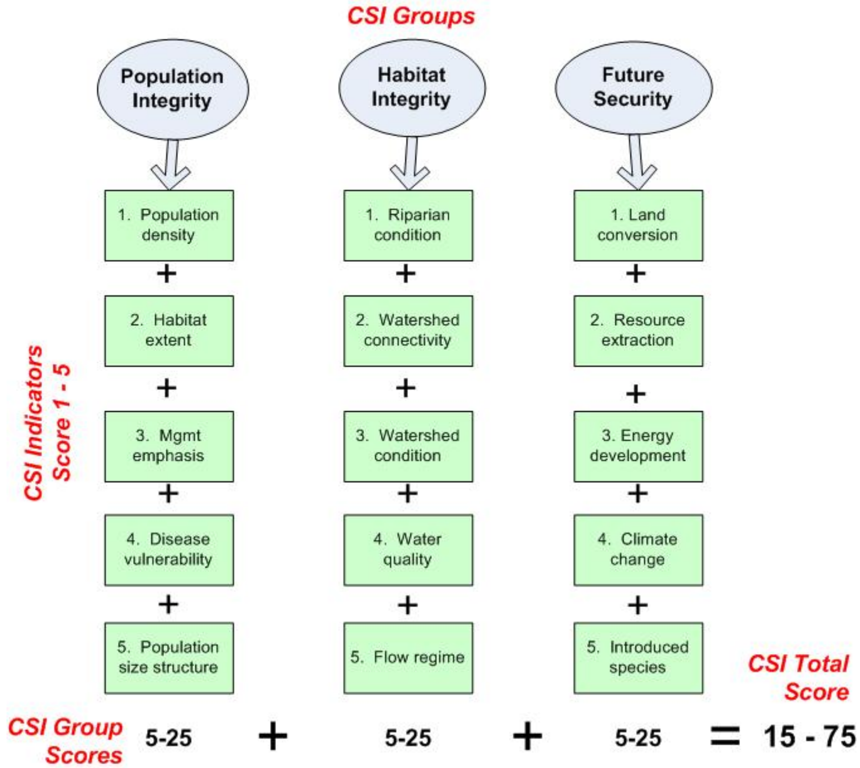


Figure 1. For a wild trout CSI, each subwatershed is scored from 1 to 5 using 15 indicators within three main groups. Indicator scores are added per group to obtain an overall group score. Group scores are then added to obtain a composite CSI score for each subwatershed.

CSI Groups and Indicators

The CSI for wild trout consists of three main groups of indicators:

1. Population integrity
2. Habitat integrity
3. Future security

Below is an overview of each CSI group and the indicators within each group. Each section contains the indicator scoring rules, the rational for the indicator, and the data sources used for the indicator.

Brown trout population data:

The current distribution of brown trout in the Driftless Area was defined by regional biologists of the Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, Iowa Department of Natural Resources, and Illinois Department of Natural Resources, and also brown trout data from the Wisconsin, Iowa, and Minnesota Departments of Natural Resources. Maps and descriptions of brown trout distribution and fisheries from the Minnesota DNR (http://www.dnr.state.mn.us/fishing/trout_streams/south_mn_maps.html) and Iowa DNR (http://www.iowadnr.gov/fish/fishing/trout/troutstr.html) were also used.

Population Integrity: *Indicators for the integrity of populations*.

Overview:

1. Population density
2. Habitat extent
3. Management emphasis
4. Disease vulnerability
5. Population size structure

Indicator: 1. Population density.

Indicator Scoring:

Adult fish / mile	CSI Score
0	1
1 - 50	2
51 - 150, No recent data	3
151 - 400	4
>400	5

Explanation: Population density within each subwatershed.

Rationale: Small populations, particularly those below an effective size of 500 individuals, are more vulnerable to extirpation.[1;2]

Data Sources: Catch-per-effort data (N / mile) of adult brown trout (5 inches or longer) were obtained from Minnesota DNR, Wisconsin DNR, and Iowa DNR for 2007 to 2008. Catch-per-effort was adjusted using an average sampling efficiency (p = 0.7) to obtain unbiased adult density estimates (N / mile). Densities for each stream reach where data were collected were averaged per subwatershed; densities were not weighted per population extent because of high variation across sites and streams and the uncertainty associated with extrapolating catch-per-effort beyond sample sites. Scoring rules were based, in part, on Williams et al.[3].

Indicator: 2. Habitat extent.

Indicator Scoring:

Occupied habitat extent	CSI Score
< 6.2 mi (10 km) connected habitat	1
6.2 – 12.4 mi (10-20 km) connected habitat	2
12.4 – 18.6 mi (20-30 km) connected habitat	3
18.6 – 31.1 mi (30-50 km) connected habitat	4
> 31.1 mi (50 km) connected habitat	5

Explanation: Habitat extent is the amount of habitat occupied by a population.

Rationale: Populations occupying less habitat are more vulnerable to extirpation[4] as a result of small, localized disturbances.

Data Sources: Scores were based on the habitat extent of the contiguous populations identified by regional biologists from the Minnesota DNR, Wisconsin DNR, and Iowa DNR, but also brown trout data from the Wisconsin, Iowa, and Minnesota DNRs. Maps and descriptions of brown trout distribution and fisheries from the Minnesota DNR (http://www.dnr.state.mn.us/fishing/trout_streams/south_mn_maps.html) and Iowa DNR (http://www.iowadnr.gov/fish/fishing/trout/troutstr.html) were also used. Scoring rules were based, in part, on Williams et al.[3]

Indicator: 3. Management emphasis.

Indicator Scoring:

Primary management emphasis in subwatershed	CSI Score
Hatchery dependent (no natural reproduction)	1
Hatchery supported (some natural reproduction)	2
Wild trout fishery (uncertain self-sustainment)	3
Wild trout fishery (self-sustaining), supplemental stocking	4
Wild trout fishery (self-sustaining), no recent stocking	5

Explanation: Management emphasis for wild trout in the subwatershed.

Rationale: A wild trout fishery that is self-sustaining through natural reproduction reflects quality trout habitat. Although trout are often stocked to provide recreational opportunities for anglers, there is the potential for stocked fish to compete with wild fish for food and space, reduce growth,[5] and result in lower fitness.[6] Wild trout populations sustained by stocking have lower integrity, and populations existing solely as a result of stocking have low integrity.

Data Sources: Stocking information was obtained from the Wisconsin Department of Natural Resources stocking database, from the Iowa Department of Natural Resources fisheries database regarding the collection of stocked fish and stocking information from the Iowa DNR website (http://www.iowadnr.gov/fish/news/stockrep/trout.html). Stocking information was used in conjunction with the current distribution of self-reproducing brown trout populations in the Driftless Area as defined by state biologists and also brown trout data from state databases.

Indicator: 4. Disease vulnerability.

Indicator Scoring:

Disease Vulnerability	CSI Score
Disease present in population	1
Disease within 1 km of habitat	2
Disease within 25 km of habitat	3
Disease within 50 km of habitat	4
Disease not within 50 km of habitat	5

Explanation: The risk of each population to relevant diseases.

Rationale: Viral Hemorrhagic Septicemia (VHS) can cause local to large-scale mortality of fishes, and has the potential to impact naive populations of native salmonids.[7-9]

Data Sources: Information on distribution of VHS was based the US Geological Survey.

Indicator: 5. Population size structure.

Indicator Scoring:

Juvenile:Adult Ratio	PSD	No data	CSI Score
<0.25, or >15	<5, or >95		1
	5-15, or 85-95		2
0.25-1, or 5-15	15-25, or 75-85	No recent data	3
	25-35, or 65-75		4
1 - 5	35 - 65		5

Score Juvenile:Adult ratio if data are available

Explanation: Population size structure indicates the relative number of young fish to adult fish. Proportional Stock Density (PSD) is an index of population size structure that describes the percent of stock size fish that are of quality size: 100*(number 9 inches or greater / number 6 inches or greater). Low PSD values indicate high mortality whereas high values indicate poor recruitment.[10] The juvenile:adult ratio is the number of juveniles divided by the number of adults. Low ratios indicate poor recruitment whereas as high values indicate a high mortality.

Rationale: High PSD values or low juvenile:adult ratios indicate poor reproduction, poor recruitment, or the effect of stocking large fish. Low PSD values or high juvenile:adult ratios indicate excessive reproduction or low survival of adults.[10]

Data sources: PSD values were obtained from the Iowa Department of Natural Resources fisheries database or computed from the Wisconsin Department of Natural Resources fisheries database. Brown trout 6 inches or greater were considered to be of minimum Stock length and those 9 inches or greater were considered to be of minimum Quality length.[10] Juvenile:Adult ratios were computed from the Minnesota Department of Natural Resources data using catch-per-effort of recruits and adults.

***Habitat Integrity**: Indicators for the integrity of aquatic habitats.*

Overview:

1. Land stewardship
2. Watershed connectivity
3. Watershed conditions
4. Water quality
5. Flow regime

Indicator: 1. Riparian condition.

Indicator Scoring:

% Riparian Buffer Converted	Buffer Road Density (Road miles / Stream mile)	CSI Score
75 - 100%	0.5 – 1.0	1
50 – 75%	0.25 – 0.49	2
25 – 50%	0.24 - 0.10	3
10 – 25%	0.05 – 0.09	4
0 – 10%	0 – 0.04	5

Explanation: Percent riparian buffer (300 ft. buffer) that is converted from natural land cover (forest or grass), and roads within 150 ft of perennial streams in the subwatershed.

Rationale: Percent riparian buffer that is converted from natural vegetation is a remotely sensed measure of riparian conditions[11] that is often related to aquatic habitat conditions[12], and 300 ft. is a useful buffer width in which to measure riparian condition.[13] Roads along streams can also contribute large amounts of fine sediments that smother benthic invertebrates, embed spawning substrates, and increase turbidity.[14;15]

Data Sources: Riparian vegetation was determined using the National Land Cover Database[16] using Developed, Pasture/Hay, and Cultivated Crops land cover classes. Road density within a 150 ft buffer was computed using ESRI Tele Atlas North America, Inc. roads[17] and the National Hydrography Dataset Plus.[18]

Indicator: 2. Watershed connectivity.

Indicator Scoring:

Road-Stream crossings	CSI Score
>50	1
26-50	2
11-25	3
5-10	4
<5	5

Explanation: The number road-stream crossings of class 4 and higher roads and 1st and 2nd order streams in the subwatershed.

Rationale: Road-stream crossings on small streams can inhibit fish passage serve as an indication of stream connectivity, and the likelihood of fish passage problems increases with more road-stream crossings. Increased hydrologic connectivity provides more habitat area and better supports interactions with other populations, which increases the likelihood of persistence.[4]

Data Sources: Stream network and Strahler stream orders were based on the National Hydrography Dataset Plus.[18] Roads data was based on the ESRI Tele Atlas North America, Inc. roads[17], but only RTE_Class 4 and higher roads were used since major roads typically do not have fish passage problems.

Indicator: 3. Watershed condition.

Indicator Scoring:

% Row crop agriculture	% Impervious	Soil Erosion Risk	CSI Score

75-100%	≥30%	Highest (>4.5)	1
50-75%	20 – 29%	High (3.5 – 4.5)	2
20-50%	10 – 19%	Moderate (2.5 – 3.5)	3
5-20%	5 – 9%	Low (1.5 – 2.5)	4
0-5%	0 - 4%	Lowest (<1.5)	5

Score for worst case

Explanation: The percentage of land converted to agriculture and percentage of land that is impervious/urban, and soil erosion risk.

Rationale: Agricultural land can impact aquatic habitats by contributing nutrients and fine sediments, and deplete dissolved oxygen.[19] The amount of urban/impervious land cover has shown alter streamflows and degrade stream habitat and fish communities.[13;20] Erosive soils also contribute sediment to streams,[19] and the Driftless Area has a long history of soil erosion problems.

Data Sources: The National Land Cover Database[16] was used to identify cultivated crop agricultural lands (the Cultivated Crops classification). Percent urban/impervious was determined using National Land Cover Data[21] and Low, Medium, and High Intensity Developed land classes. Soil erosion risk was based on Soil Erosion Risk analysis conducted for the Driftless Area Initiative,[22] and is based on a Revised Universal Soil Loss Equation. Soil Erosion Risk has five classes: lowest risk, low risk, moderate risk, high risk, and highest risk, which were reclassified as 5, 4, 3, 2, 1, respectively, and were summarized by subwatershed.

Indicator: 4. Water quality.

Indicator Scoring:

Miles 303(d) Streams	Number Active Mines	NPDES Permits	CAFO Animal Units	CSI Score
>2	≥10	≥4	>10,000	1
1 – 2	7-9	3	5,000 – 10,000	2
0.5 - 1	4-6	2	1,000 – 5,000	3
0 – 0.5	1-3	1	>0 – 999	4
0	0	0	0	5

Score for worst case.

Explanation: The presence of 303(d) impaired streams, number of active mines, number of National Pollution Discharge Elimination System permits, and number of total animal units in registered concentrated (or confined) animal feeding operations (CAFOs).

Rationale: Decreases in water quality, including reduced dissolved oxygen, increased turbidity, increased temperature, and the presence of pollutants, reduces habitat suitability for salmonids. Mining activity can deteriorate water quality through leachates and sediments. NDPES permits indicate regulated point source discharges that can impair water quality.[23] Concentrated animal feeding operations indicate areas with high concentrations of livestock that can impair water quality.[24]

Data Sources: 303(d) impaired streams were obtained from the USEPA.[25] Active mines were identified by using the Mineral Resources Data System[26]. The number of NPDES permits (Permit Compliance System majors only) was determined using USEPA data.[27] The location of confined animal feeding operations and associated animal units were obtained from the Minnesota Pollution Control Agency,[28] Wisconsin Department of Natural Resources,[29] and Iowa Department of Natural Resources;[30] no data were available for Illinois.

Indicator: 5. Flow regime.

Indicator Scoring:

Ditches and Canals (miles)	Number of dams	Storage (acre-ft)/stream mile	CSI Score
≥20	≥5	≥2,500	1
10 – 19.9	3 – 4	1,000 – 2,499	2
5 – 9.9	2	250 – 999	3
1 – 4.9	1	1- 249	4
0 – 0.9	0	0	5

Score for worst case.

Explanation: Miles of canals and ditches, number of dams, acre-feet of reservoir storage per perennial stream mile.

Rationale: Natural flow regimes are critical to proper aquatic ecosystem function[31]. Canals, ditches, dams, and reservoirs alter streamflows. Reduced or altered flows reduce the capability of watersheds to support native biodiversity and salmonid populations.

Data Sources: The National Inventory of Dams[32] was the data source for dams and their storage capacity. Miles of canals and ditches is from the National Hydrography Dataset Plus[18], but some known errors in stream classification were corrected.

Future Security *Indicators for the future security of populations and aquatic habitats.*

Overview:

1. Land conversion
2. Resource extraction
3. Energy development
4. Climate change
5. Introduced species

Indicator: 1. Land conversion.

Indicator Scoring:

Land Vulnerable to Conversion	CSI Score
81 – 100%	1
61 – 80%	2
41 - 60%	3
21 - 40%	4
0 – 20%	5

Explanation: The potential for future land conversion was modeled as a function of slope, land ownership, roads, and urban areas. Land is considered vulnerable to conversion if the slope is less than 15%, it is in private ownership and not already converted, it is within 0.5 miles of a road, and within 5 miles of an urban center. Lands encumbered by a conservation easement are not available for conversion.

Rationale: Conversion of land from its natural condition will reduce aquatic habitat quality and availability[33].

Data Sources: Slope was computed from elevation data from the National Hydrography Dataset Plus[18]. Land cover was determined from the National Land Cover Database[16], and all land cover classes except developed areas, hay/pasture, and cultivated crops cover types were considered for potential conversion. Urban areas were determined using 2000 TIGER Census data[34], roads from the ESRI Tele Atlas North American / Geographic Data Technology dataset on roads[17], and land ownership using ESRI Tele Atlas North American / Geographic Data Technology dataset for parks[35] and managed areas identified by the Driftless Area Initiative[36].

Indicator: 2. Resource extraction.

Indicator Scoring:

Forest management	CSI Score
51-100%	1
26 – 50%	2
11 – 25%	3
1 – 10%	4
0%	5

Explanation: Percentage of subwatershed available for industrial timber production (productive forest types only, minimum stand size of 40 acres) outside of protected areas. Protected lands were removed from availability and include: federal or state parks and monuments, national wildlife refuges, wild and scenic river designations, designated wilderness areas, inventoried roadless areas on federal lands, Research Natural Areas, Areas of Critical Environmental Concern, others areas of special protective designations, or private ownership designated for conservation purposes.

Rationale: Productive forest types have a higher likelihood of being managed for timber production than unproductive types, and, hence, logging poses a future risk to aquatic habitats and fishes[37].

Data Sources: Timber management potential identifies productive forest types using the existing vegetation type in the Landfire dataset.[38] Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas[39] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset[40].

Indicator: 3. Energy Development.

Indicator Scoring:

Leases or reserves	New Dams 4^{th}	New Dams 6^{th}	CSI Score
51-100%	≥0	≥1	1
26 – 50%	3		2
11 – 25%	2		3
1 – 10%	1		4
0%	0		5

Score for worst case

Explanation: The acreage of oil, gas, and coal reserves; geothermal or wind development areas; and the number of dam sites located for potential development outside of protected areas within each subbasin and subwatershed.

Rationale: Increased resource development will increase road densities, modify natural hydrology, and increase the likelihood of pollution to aquatic systems. Changes in natural flow regimes associated with dams are likely to reduce habitat suitability for salmonids.[41] If lands are protected then the watersheds will be less likely to be developed.

Data Sources: Average annual wind speeds (Wind Power Class 4 or higher [>7.0 m/s at 50-m] were obtained from different sources for for Iowa,[42] Minnesota,[43] Wisconsin,[44] and Illinois.[45] Geothermal potential was determined from the Geothermal Education Office.[46] Potential dam sites are based on Idaho National Laboratory (INL) hydropower potential data[47]. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas[39] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset[40].

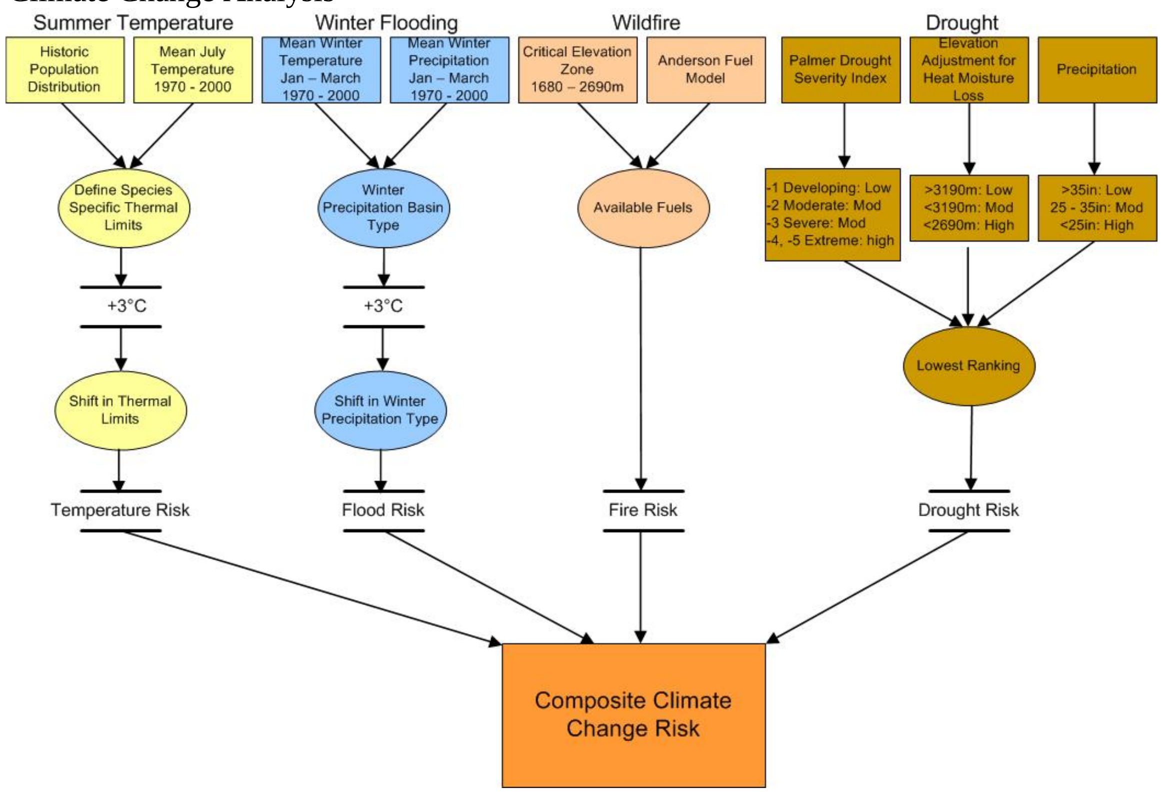
Indicator: 4. Climate change.

Indicator Scoring:

TU Climate Change Analysis	
Temperature Risk	**CSI Score**
High	1
	2
Moderate	3
	4
Low	5

Explanation: Climate change is based on the temperature portion of the TU Climate Change analysis. Increased summer temperature impacts temperature sensitive species

TU Climate Change Analysis



Rationale: Climate change is likely to threaten most salmonid populations because of warmer water temperatures. A 3°C increase in summer temperature has the potential to impact coldwater species occupying habitat at the edge of their thermal tolerance.
Climate change risks are further discussed by Williams et al.[48]

Data Sources: Temperature data were obtained from the PRISM Group.[49] The current The current distribution of brown trout in the Driftless Area was defined by regional biologists of the Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, Iowa Department of Natural Resources, and Illinois Department of Natural Resources, and also brown trout data from the Wisconsin, Iowa, and Minnesota Departments of Natural Resources and maps of brown trout distribution from the Minnesota Department of Natural Resources (http://www.dnr.state.mn.us/fishing/trout_streams/south_mn_maps.html).
The mean air temperature thresholds for determining temperature risk within the current range of brown trout are: Low Risk <22.5 C; Moderate Risk >22.5 and <24.5 C; High Risk >24.5 C. However, if there were 4 or more springs in the subwatershed then the risk was low, and if there were two or more springs in the subwatershed then the risk was lowered one category (e.g., from High to Moderate, or Moderate to Low). Data on springs was determine from the National Hydrography Dataset Plus.[18] There is a large amount of uncertainty associated with the Driftless Area climate change risks.

Indicator: 5. Introduced species.

Indicator Scoring:

Road Density (mi / mi^2)	CSI Score
> 4.7	1
3.7 – 4.7	2
2.7 – 3.7	3
1.7 – 2.7	4
<1.7	5

Explanation: Road density is the length of road per subwatershed area and represents the potential for future introduction of species not native to the basin.

Rationale: Introduced species are likely to negatively impact wild salmonid populations through predation, competition, hybridization, and the introduction of non-native parasites and pathogens.[50] In the absence of data on presence of non-native species, road density can be used as a surrogate for risk of non-native fish introductions by purpotrators.[51]

Data Sources: There is little information on species known to be injurious to wild brown trout populations; hence, risk to injurious introduced species is based solely on road density. Roads were obtained from ESRI, Tele Atlas North American / Geographic Data Technology dataset on roads.[17]

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