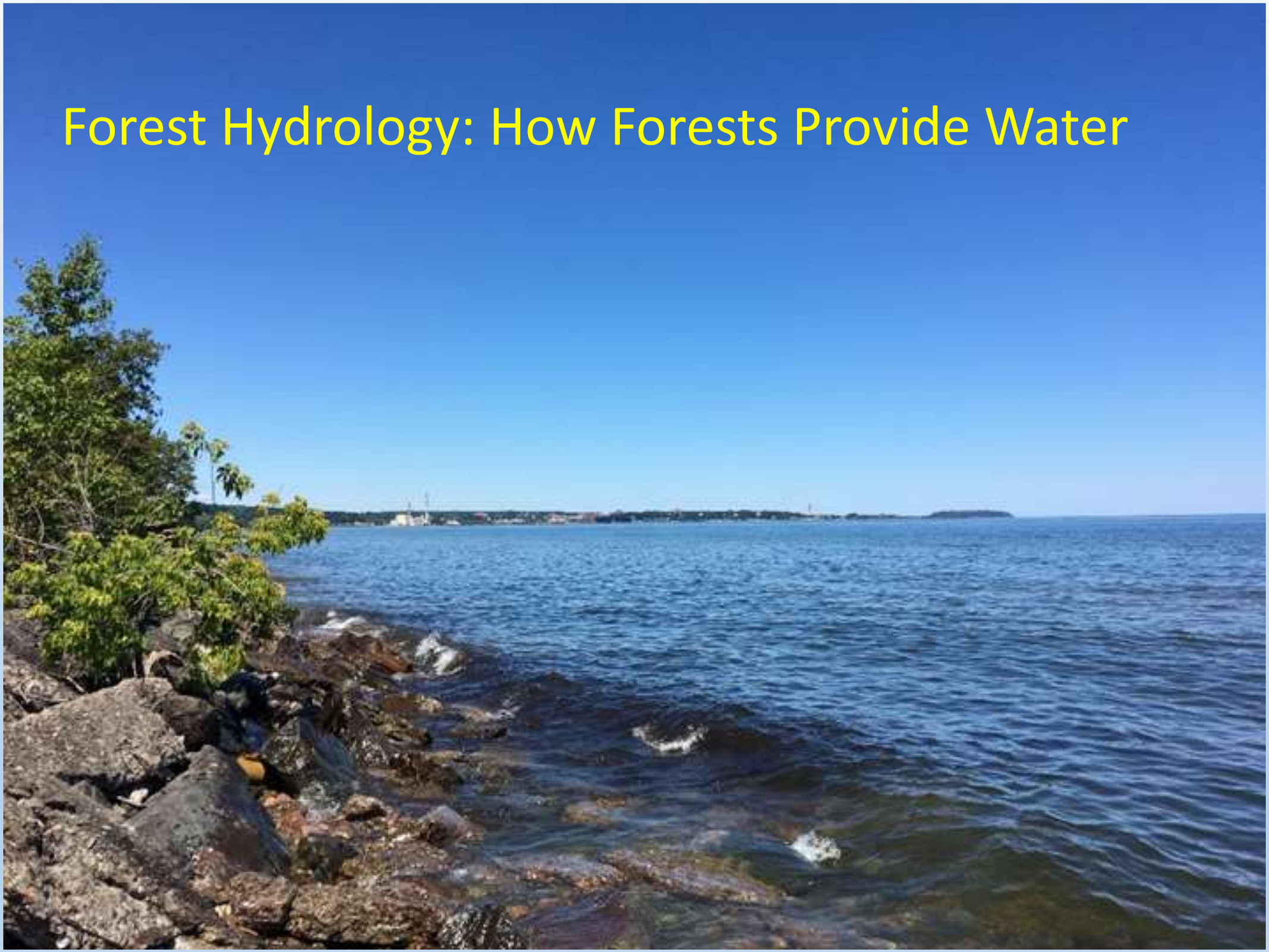
Forest Hydrology: How Forests Provide Water



97.5%
Oceans & Seas

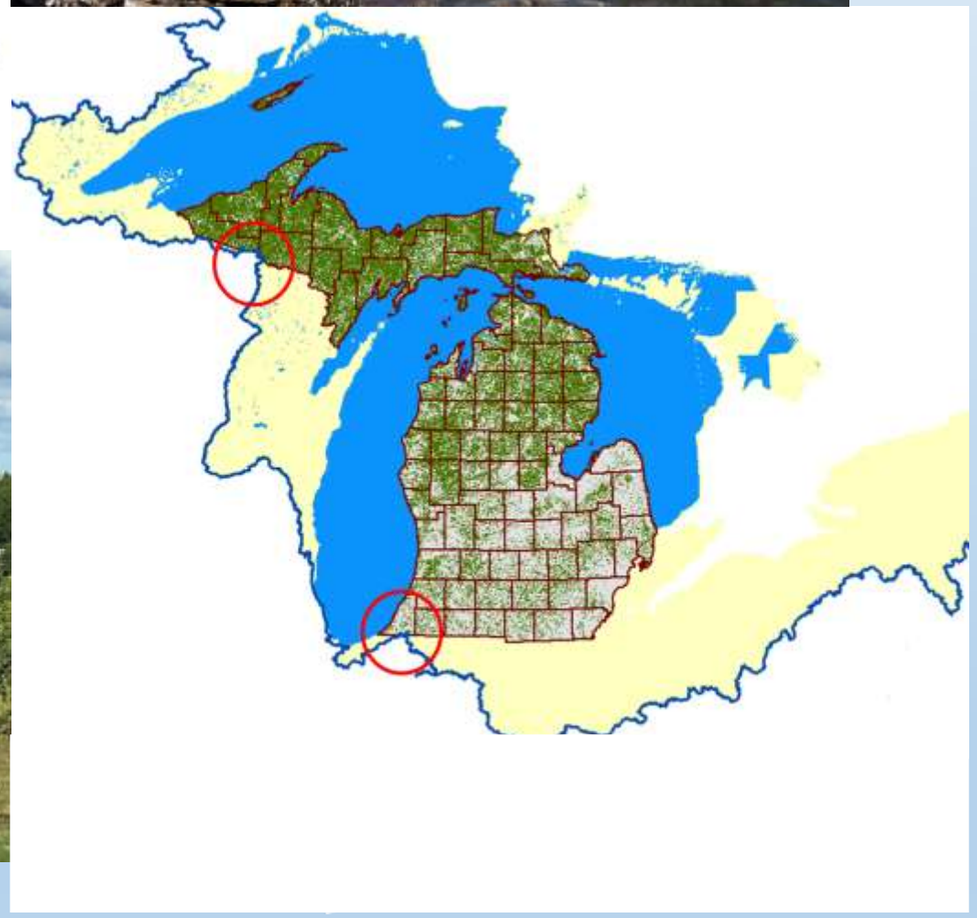
1.73%
Glaciers & Icecaps

0.77%
Total
Fresh Water

0.0008%
Available &
Renewable
Fresh
Water

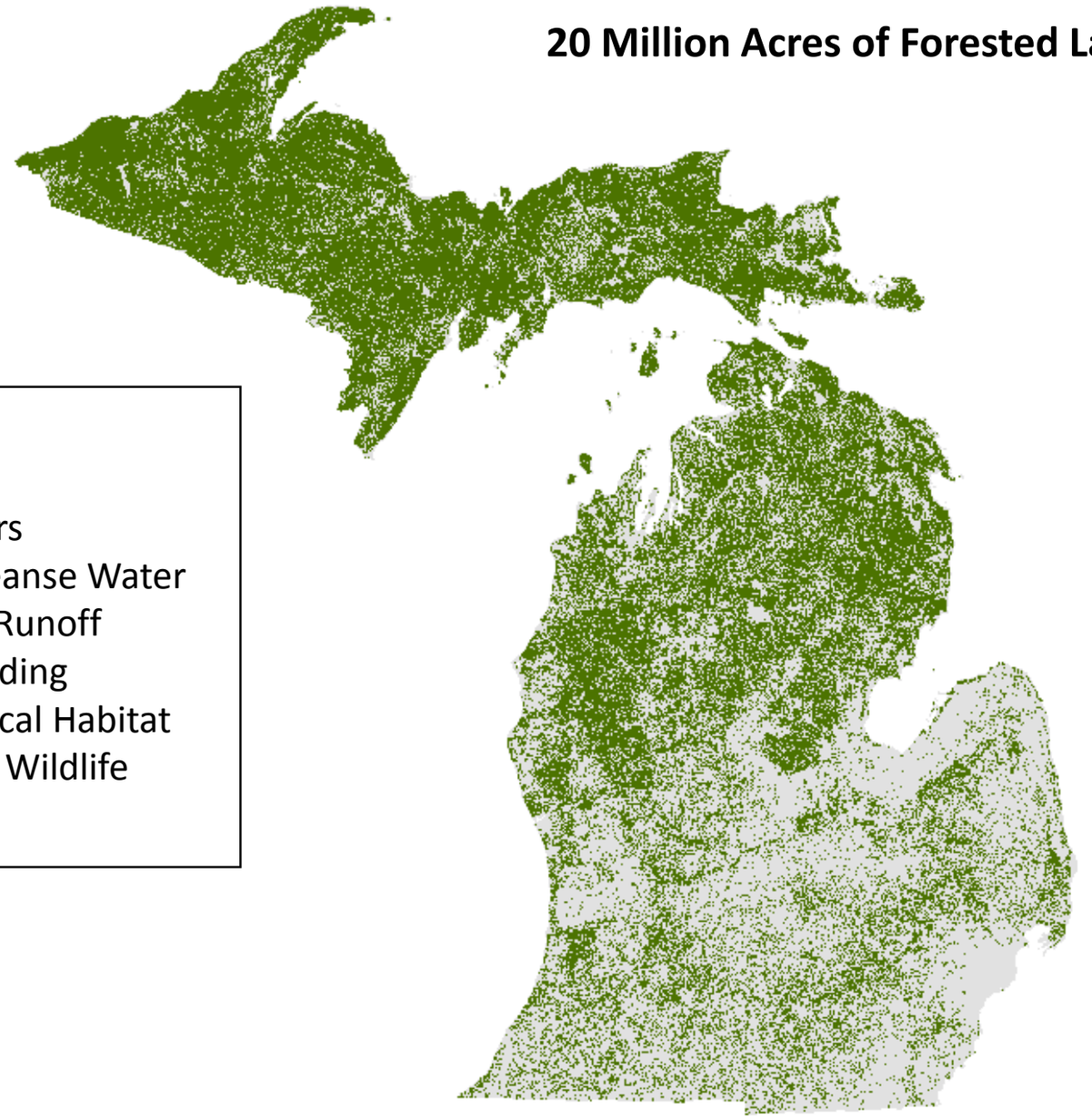
Forest Service. 2000. Water &the Forest Service. United States Department of Agriculture. Forest Service. Washington Office. FS-660. 26 pgs.

Credit: Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE



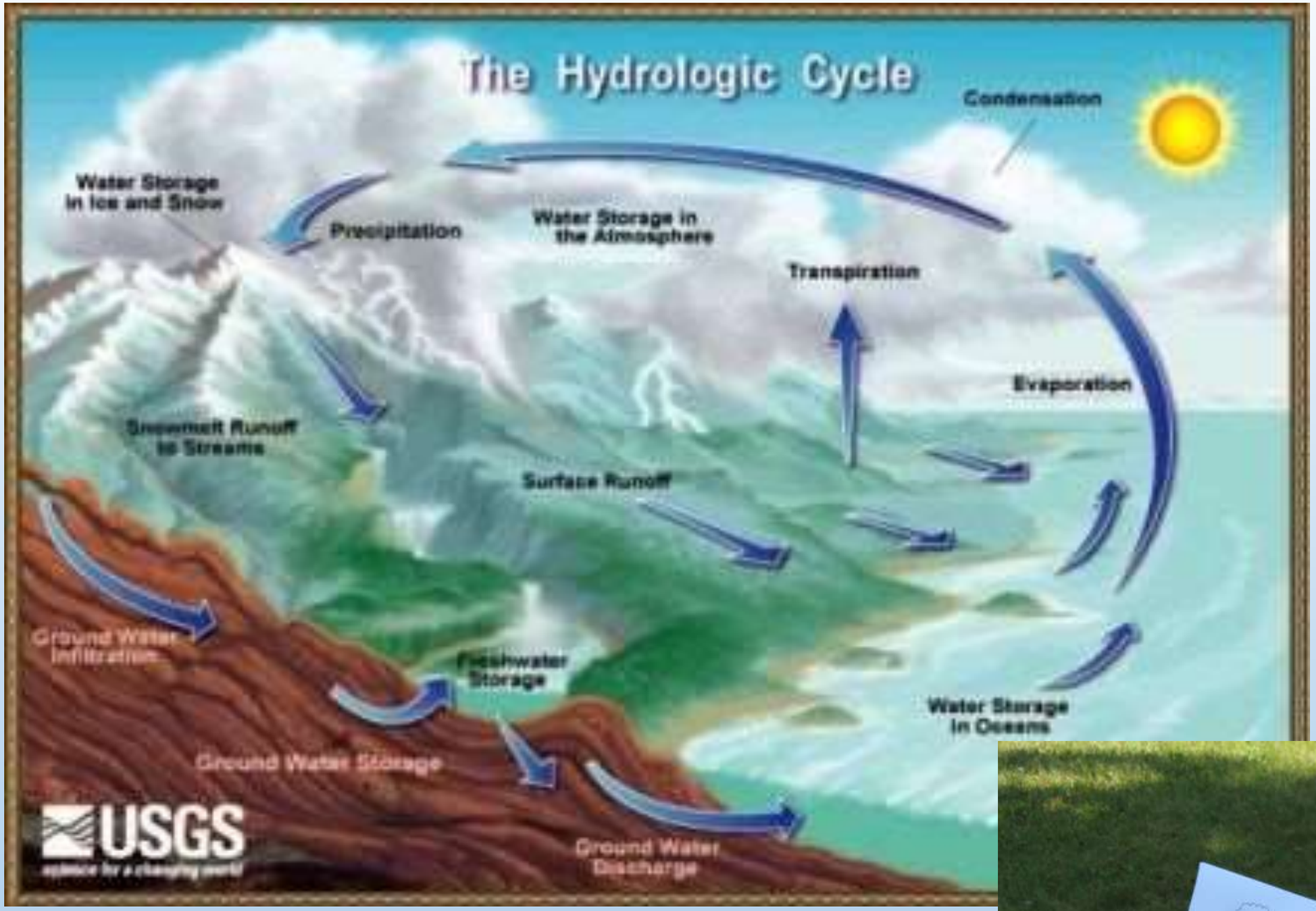
Great Lakes Information Network. 2017. downloaded on 10/3/2017 from http://www.great-lakes.net/teach/geog/intro/intro_2.html

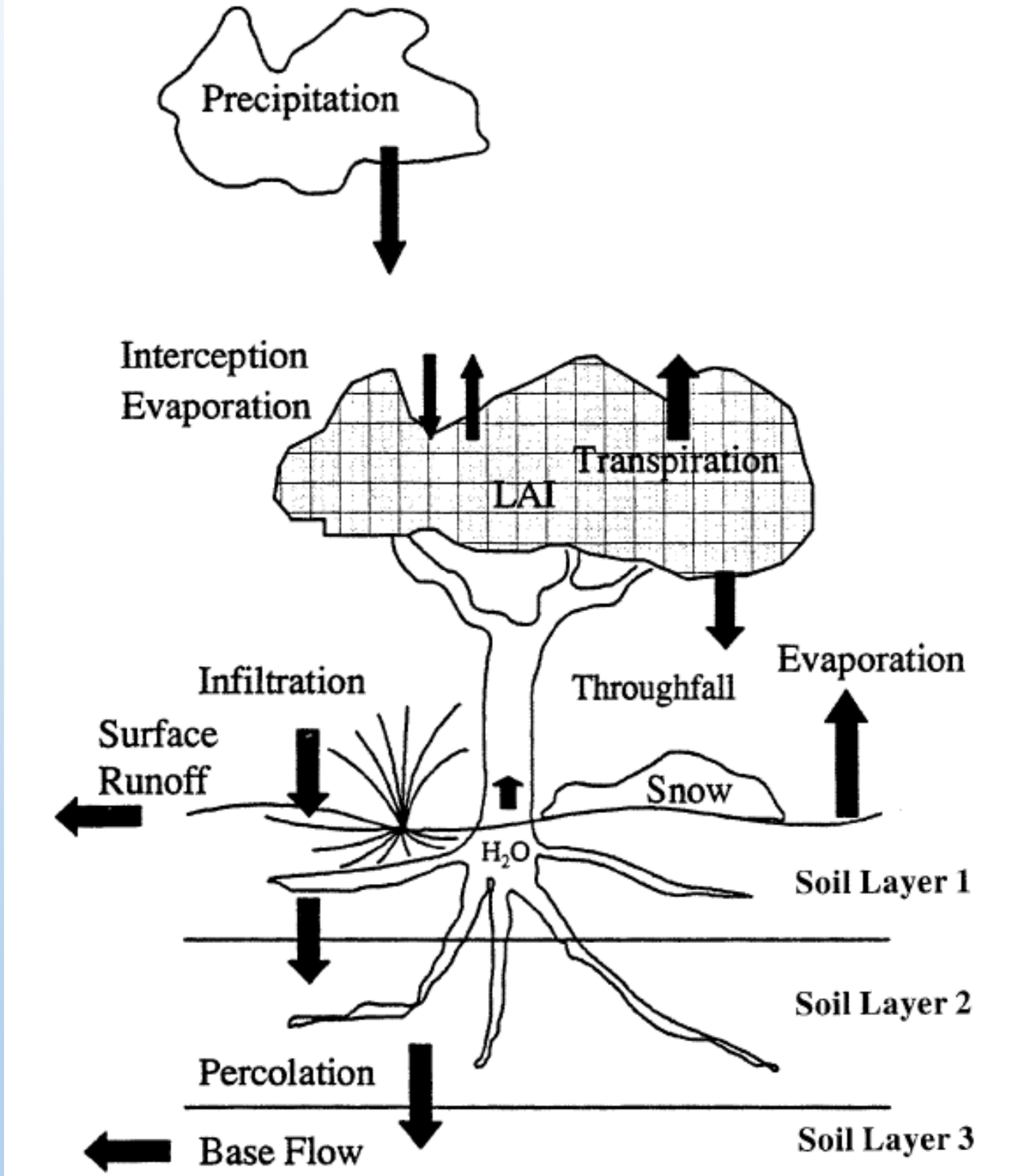
20 Million Acres of Forested Land in MI



- Absorb Rain
- Refill Aquifers
- Cool and Cleanse Water
- Slow Storm Runoff
- Reduce Flooding
- Provide Critical Habitat For Fish and Wildlife

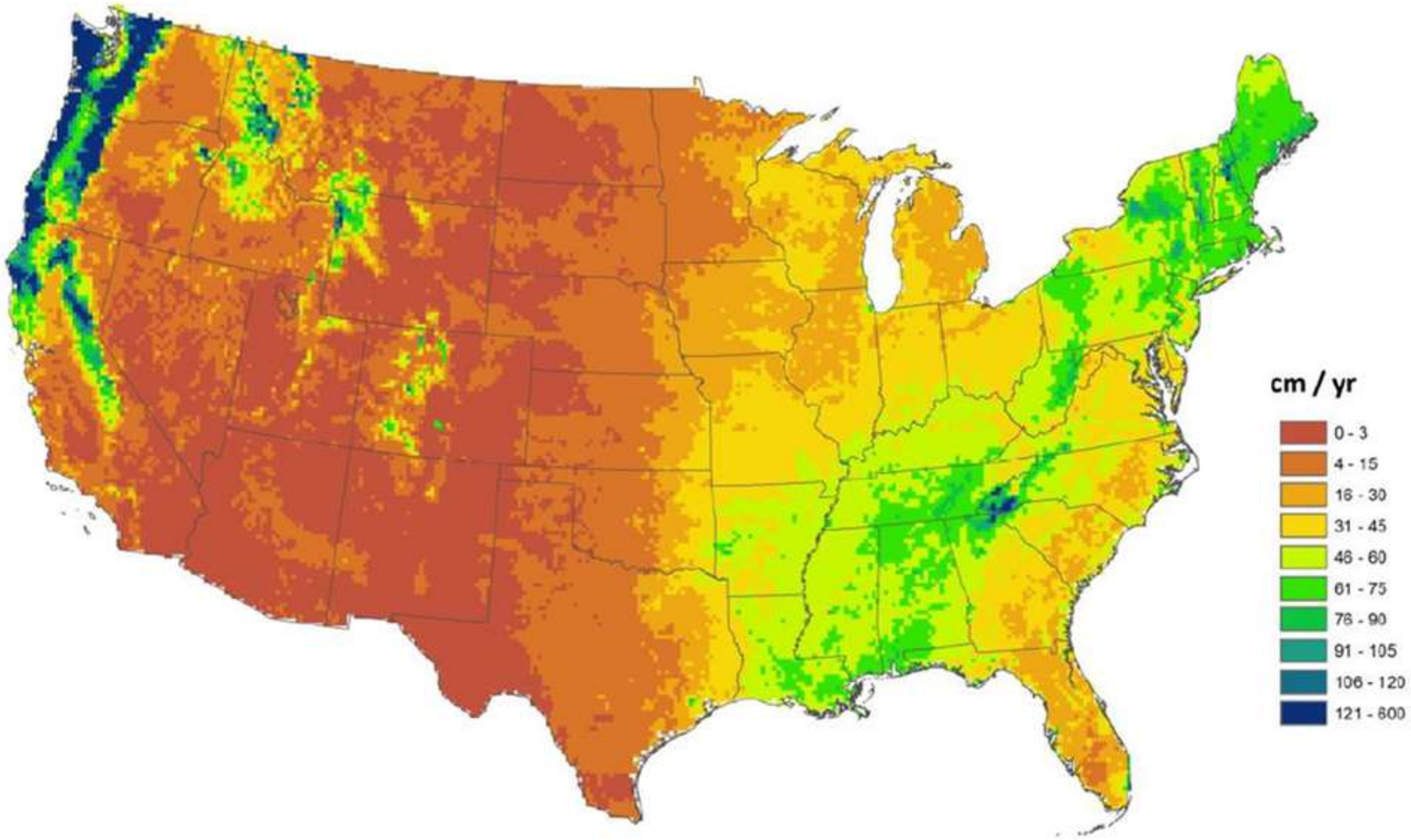
NRCS. 2017. National land Cover Dataset (NLCD) by State, downloaded from https://datagateway.nrcs.usda.gov on 10/3/2017


The Hydrologic Cycle
Condensation
Water Storage
in Ice and Snow
Precipitation
Water Storage in
the Atmosphere
Transpiration
Evaporation
Snowmelt Runoff
to Streams
Surface Runoff
Ground Water
Infiltration
Freshwater
Storage
Water Storage
in Oceans
Ground Water Storage
Ground Water
Discharge
USGS

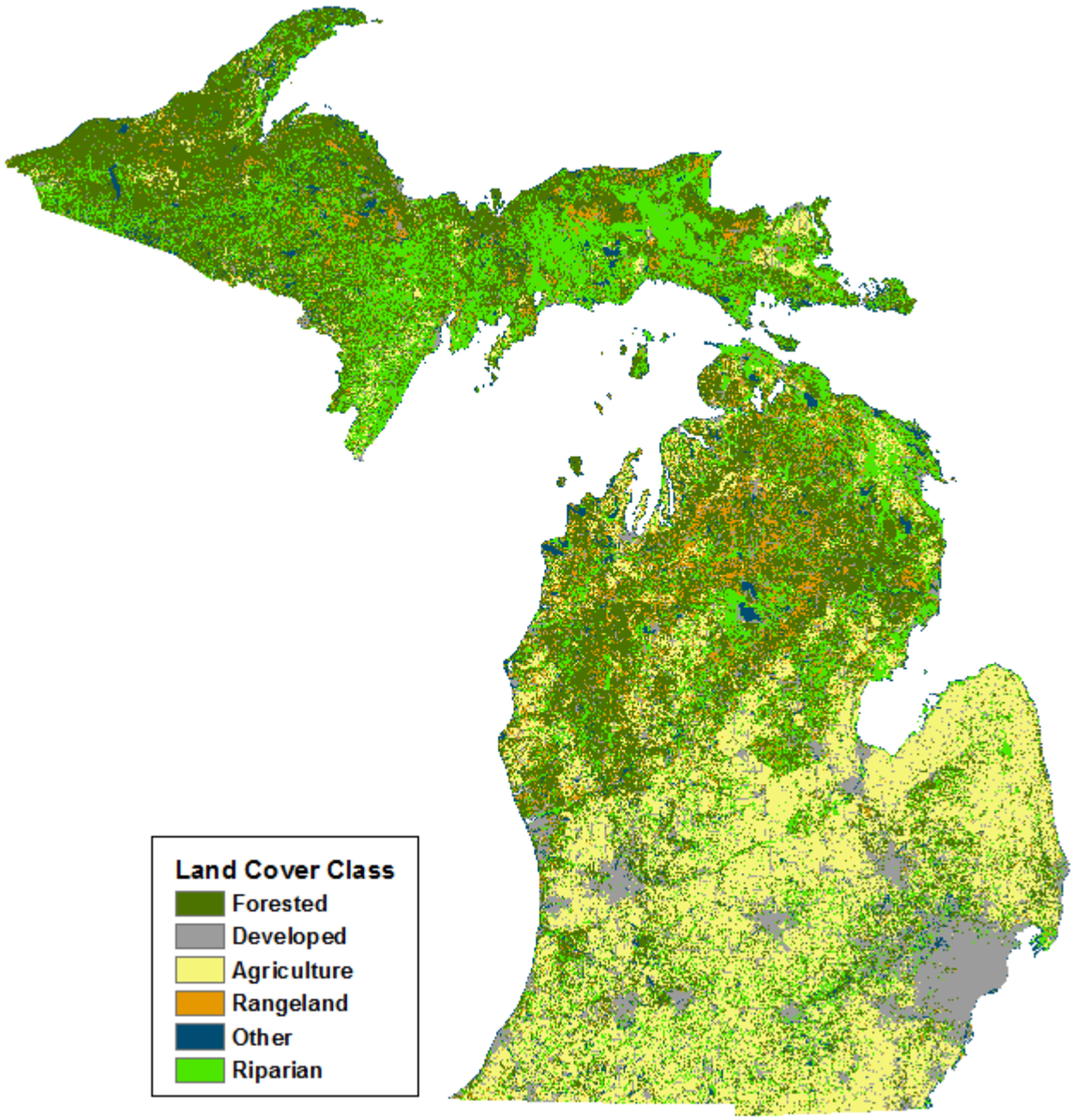


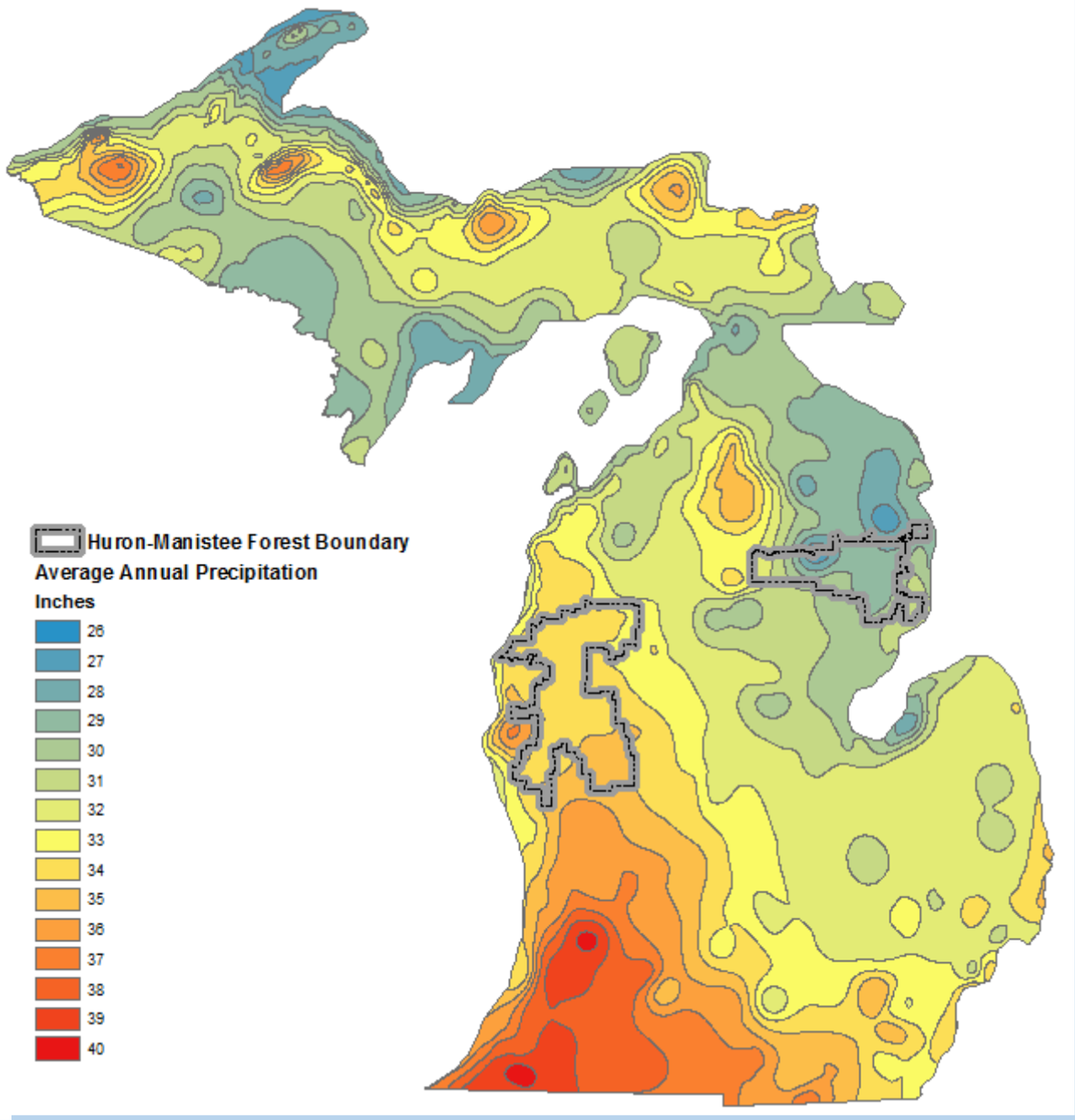
After R. P. Neilson. 1995. Ecological Applications (5)2, pp.362-385.

Figure 2. Mean annual water yield depth.



After Brown and Froemke. 2016. Rocky Mountain Research Station. USFS.





Mean annual water supply of Michigan by National Land Cover Data cover type (cubic miles)							
Land Cover Class	Forest	Range	Agriculture	Developed	Riparian	Other	Total
Annual Water Supply (miles^3)	3.7	0.6	2.7	1.1	2.0	0.3	10.4
Percent of Total	36	5	26	10	19	3	100
Cover Type Percent of Total State Area	35	6	26	10	19	4	
After Brown, Froemke, Mahat, and Ramirez. 2016. Rocky Mountain Research Station. U.S. Forest Service. Fort Collins Colorado							

After T.C. Brown. Rocky Mountain Research Station. https://www.fs.fed.us/rmrs/projects/estimating-contribution-forests-nations-water-supply

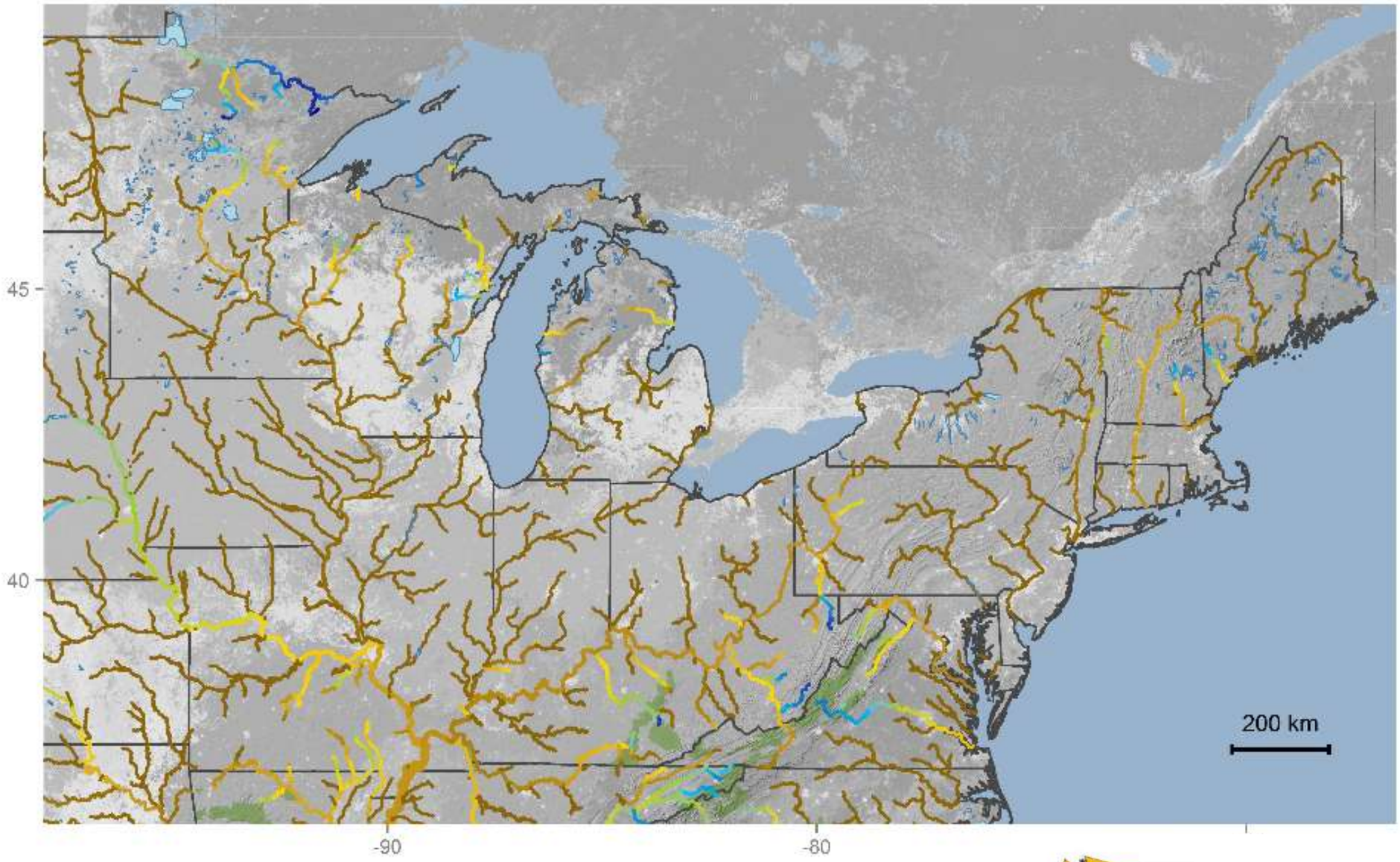
Table 1. Percent of land and water supply by land ownership type and region.

	E	S	M	P	W	All
			Percent of land*			
FS	2	7	6	2	21	11
BLM	0	0	0	0	23	9
NPS	0	1	0	0	3	1
Other fed.	1	2	1	1	4	2
S&P	97	90	93	96	50	76
			Percent of mean annual water supply			
FS	3	8	6	3	49	18
BLM	0	0	0	0	6	2
NPS	0	1	0	0	6	2
Other fed.	1	2	1	2	1	1
S&P	97	89	93	96	37	77

Table 2. Percent of land and water supply by NLCD cover type and region.

	E	S	M	P	W	All
			Percent of land			
Forest	58	44	25	8	23	26
Rangeland	4	9	3	49	62	37
Agriculture	17	23	52	33	8	23
Developed	11	9	9	5	3	6
Riparian	7	14	8	3	1	5
Other	3	3	3	2	3	3
			Percent of mean annual water supply			
Forest	60	46	28	19	58	46
Rangeland	4	8	3	31	30	14
Agriculture	15	22	50	35	4	22
Developed	11	9	10	8	3	8
Riparian	7	12	7	5	1	7
Other	3	3	2	2	4	3

Percent of Annual Streamflow from Forest Service Lands

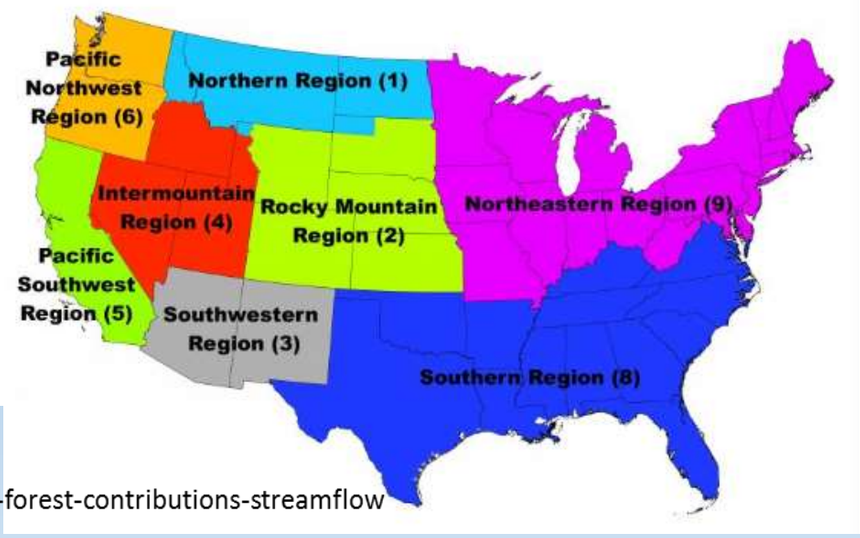


Percent Contributed
100%
75%
50%
25%
0%

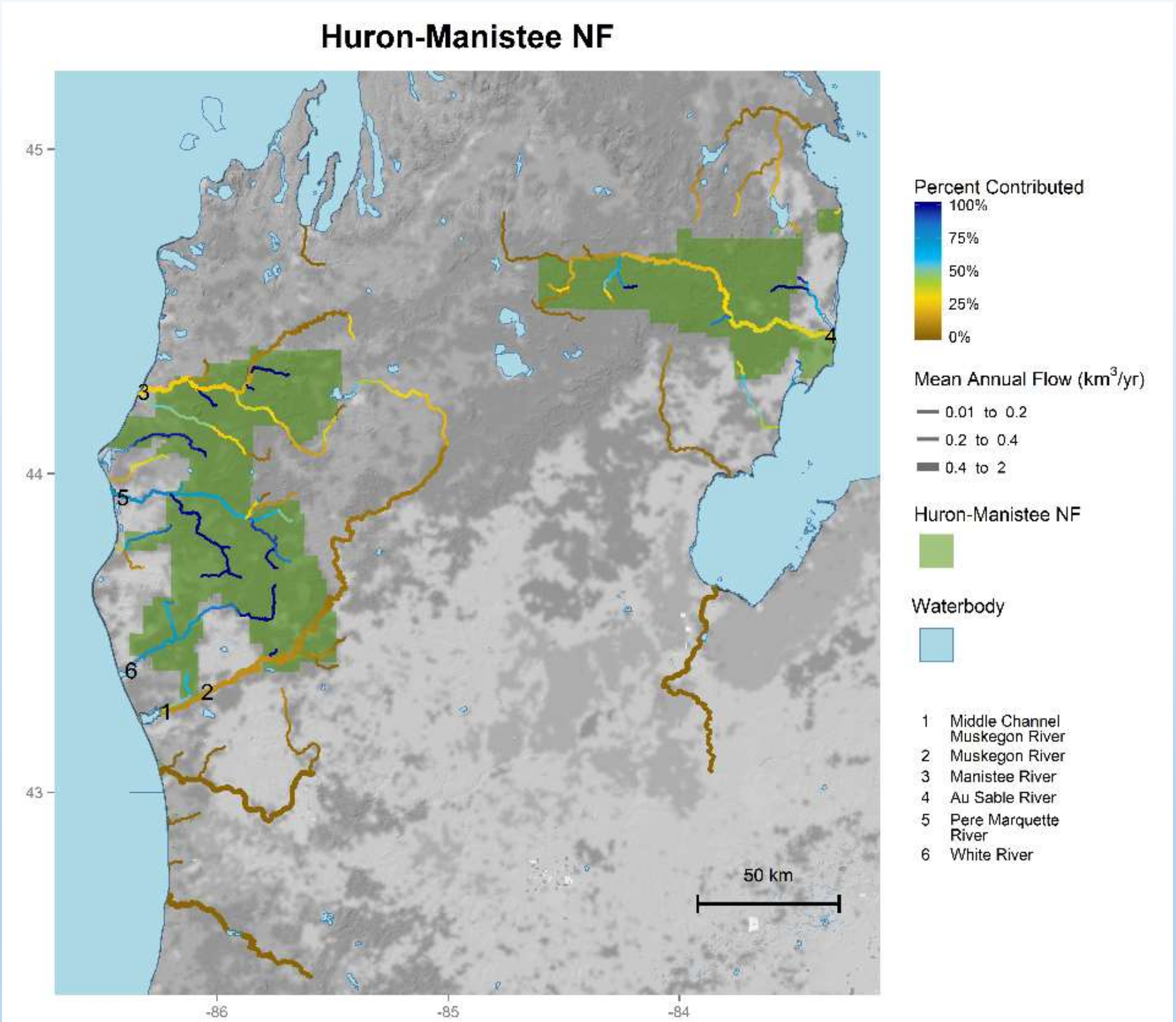
Mean Annual Flow (km /yr)
0.1 to 100
100 to 200
200 to 466

National Forest

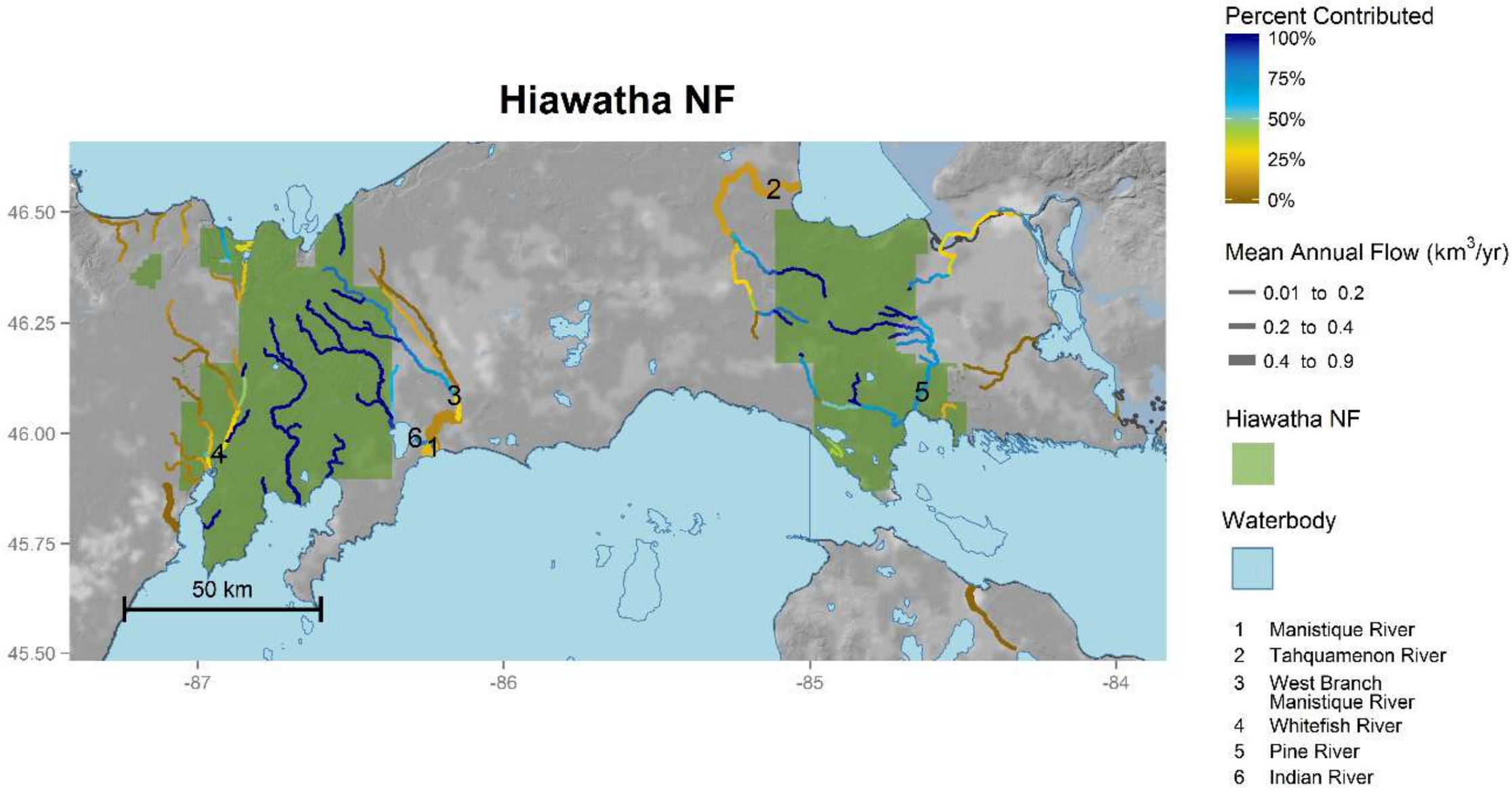
Waterbody



After Luce and Lute. 2016 Rocky Mountain Research Station. USFS. https://www.fs.fed.us/rmrs/projects/national-forest-contributions-streamflow

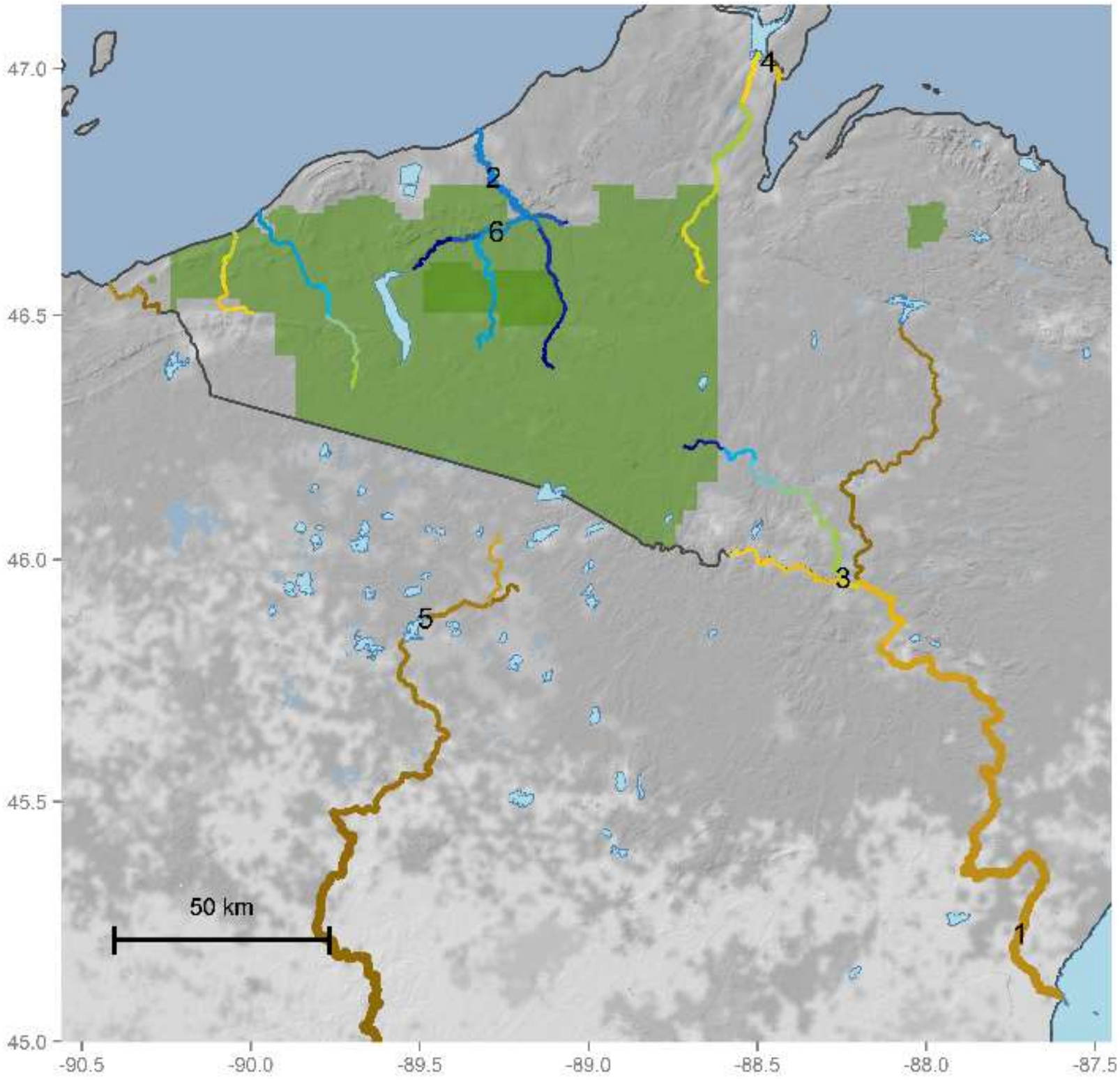


After Luce and Lute. 2016 Rocky Mountain Research Station. USFS. https://www.fs.fed.us/rmrs/projects/national-forest-contributions-streamflow



After Luce and Lute. 2016 Rocky Mountain Research Station. USFS. https://www.fs.fed.us/rmrs/projects/national-forest-contributions-streamflow

Ottawa NF



Percent Contributed

100%
75%
50%
25%
0%

Mean Annual Flow (km^3/yr)

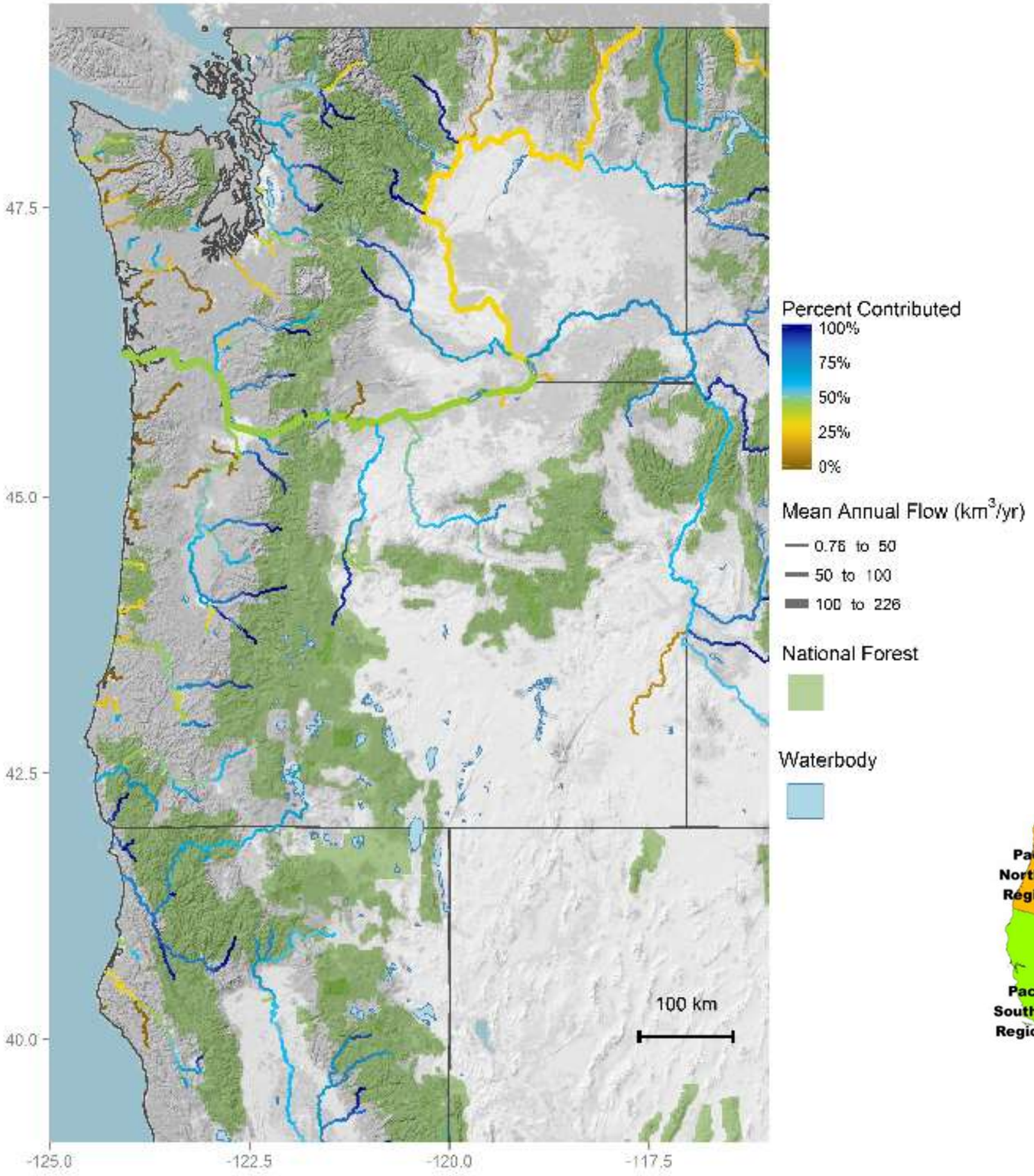
0.1 to 0.5
0.5 to 1
1 to 2

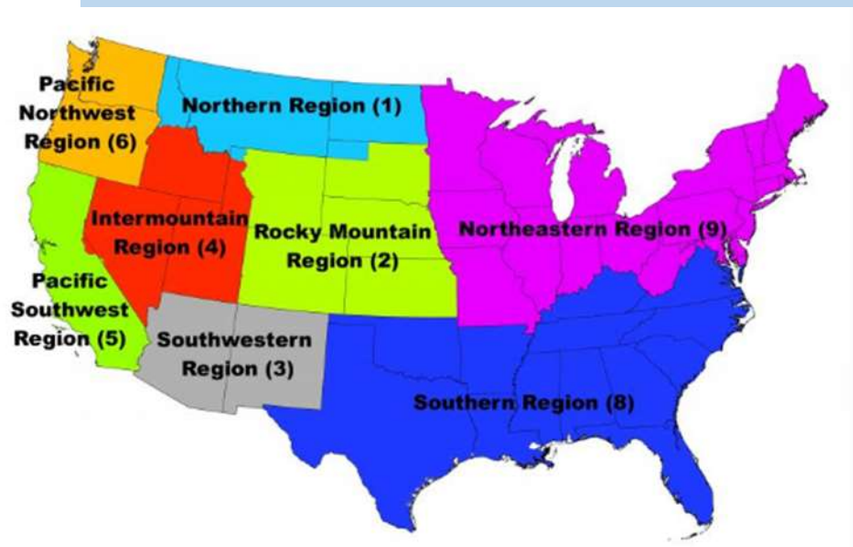
Ottawa NF

Waterbody

1 Menominee River
2 Ontonagon River
3 Brule River
4 Portage River
5 Wisconsin River
6 West Branch Ontonagon River

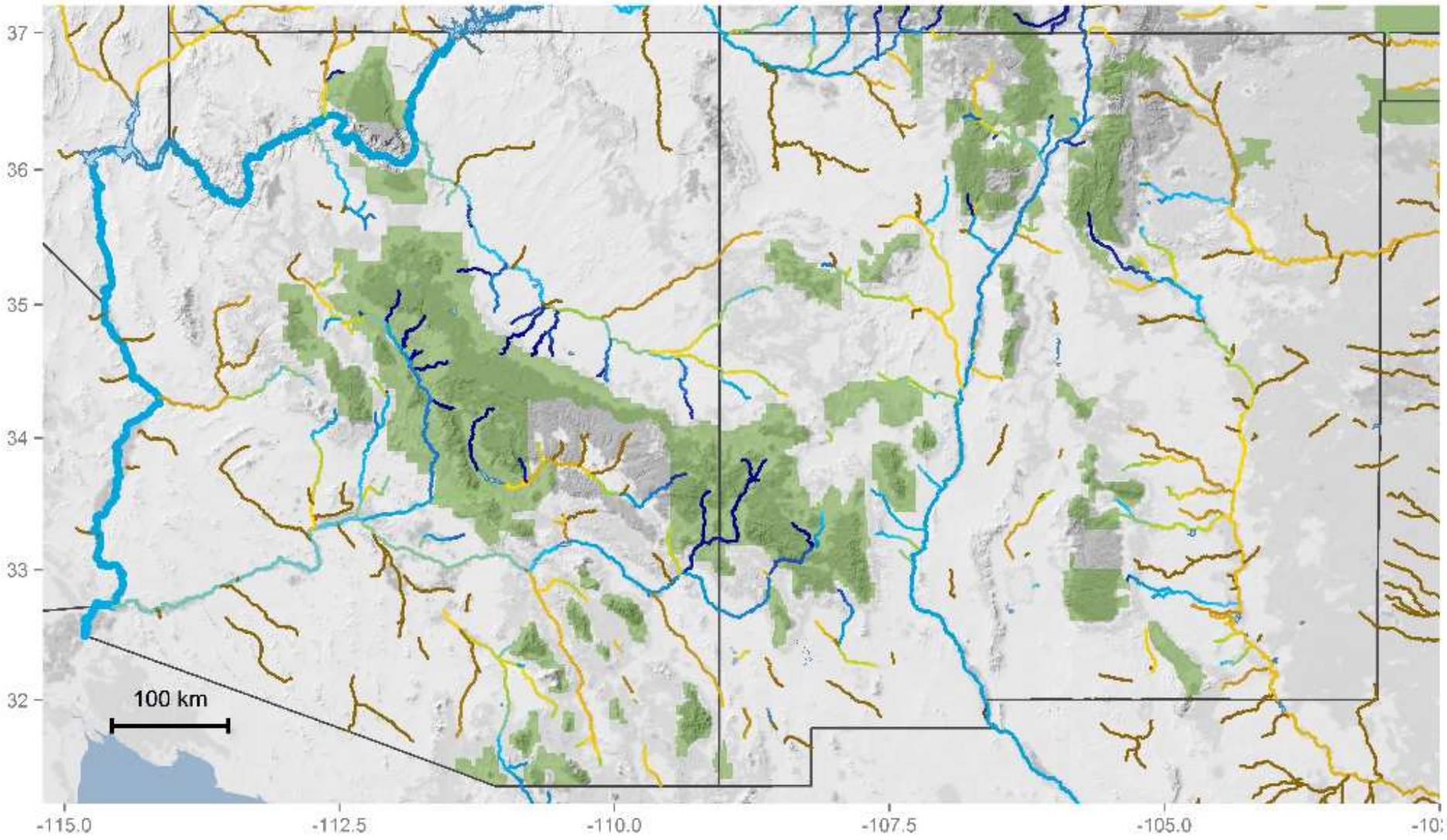
Percent of Annual Streamflow from Forest Service Lands





After Luce and Lute. 2016 Rocky Mountain Research Station. USFS. https://www.fs.fed.us/rmrs/projects/national-forest-contributions-streamflow

Percent of Annual Streamflow from Forest Service Lands



Percent Contributed

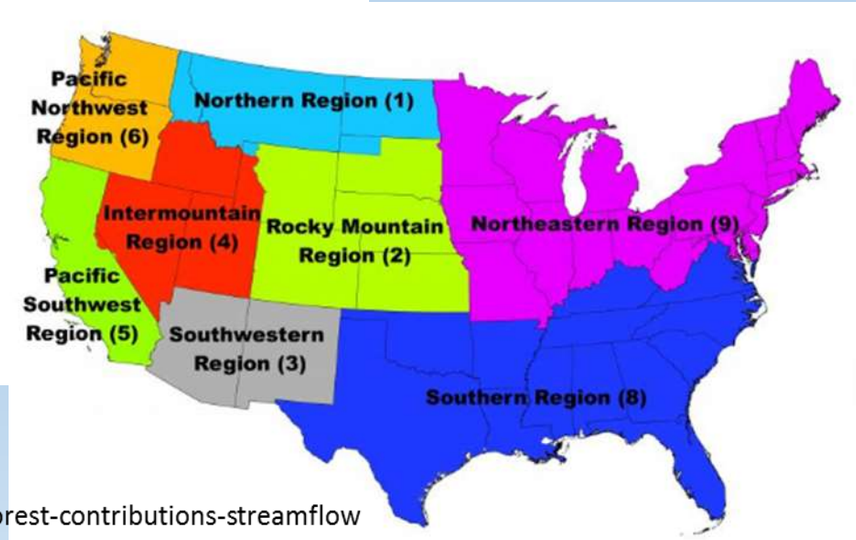
100%
75%
50%
25%
0%

Mean Annual Flow (km /yr)

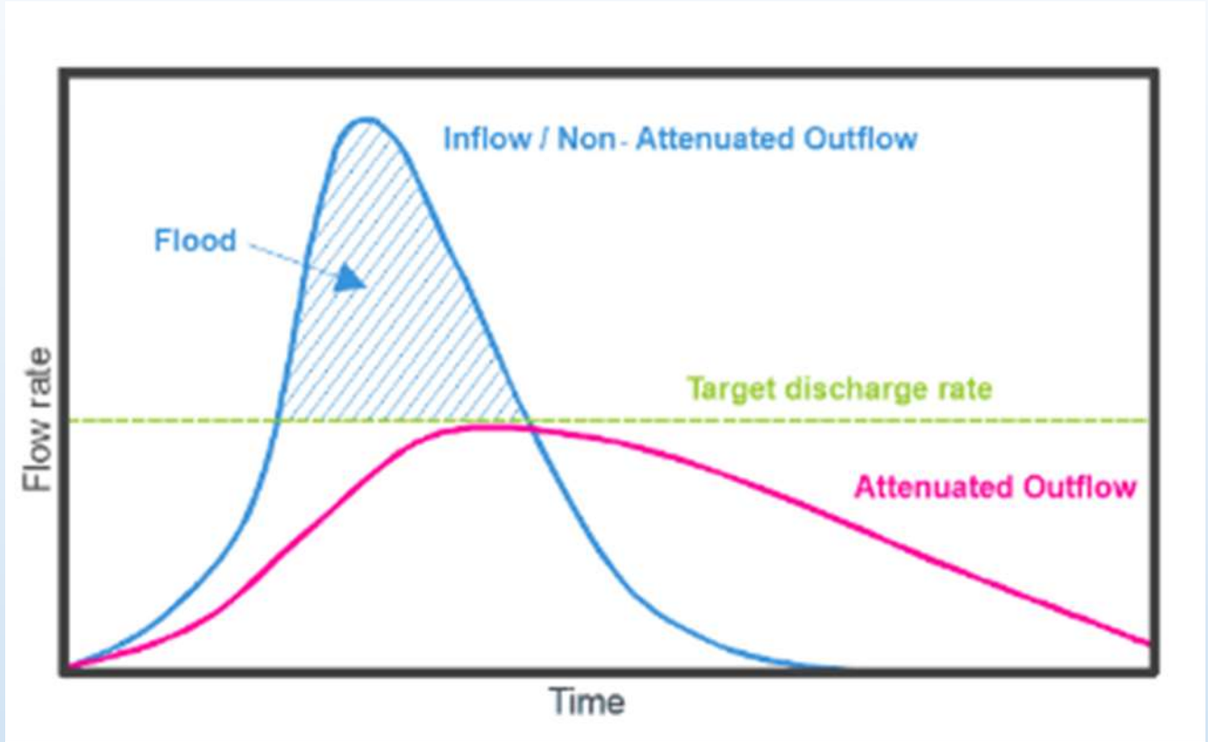
0.01 to 10
10 to 20
20 to 33

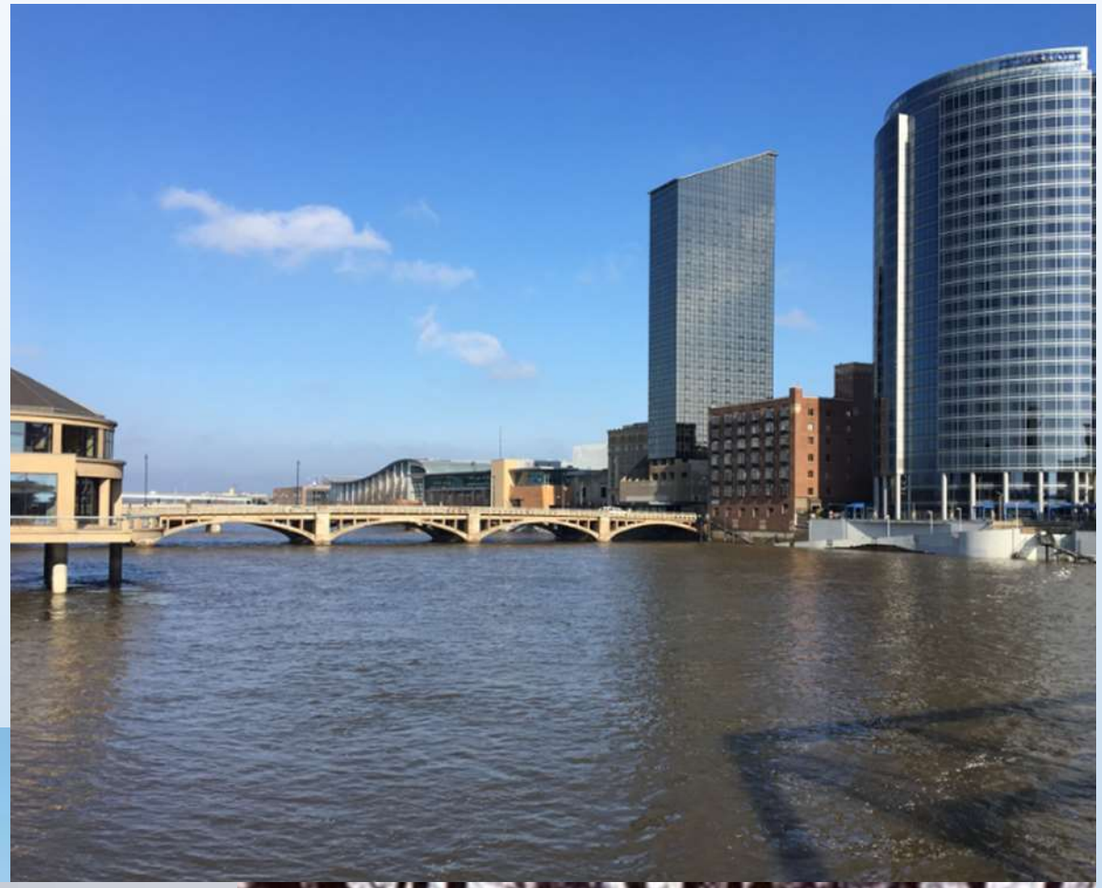
National Forest

Waterbody

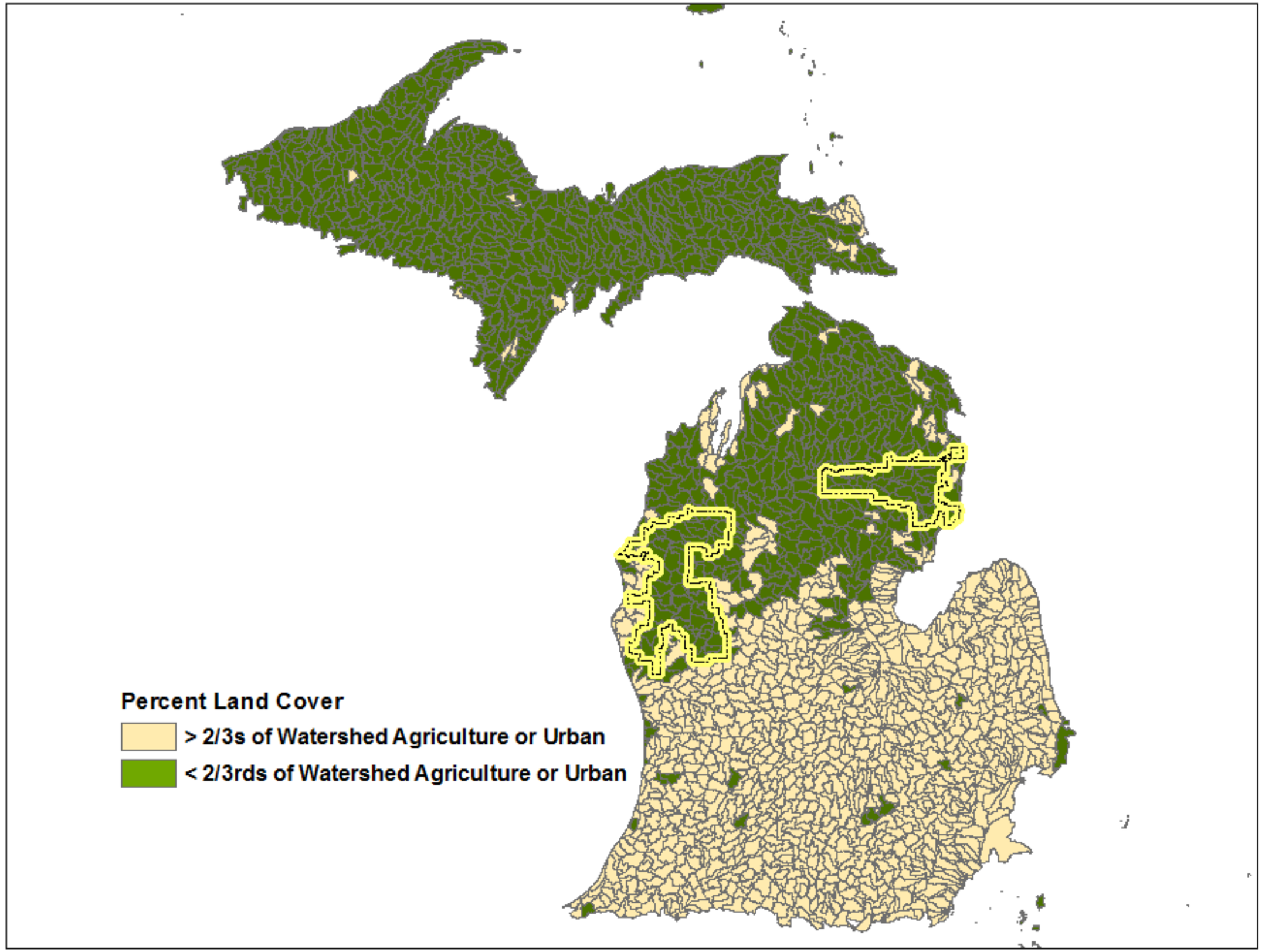


After Luce and Lute. 2016 Rocky Mountain Research Station. USFS. https://www.fs.fed.us/rmrs/projects/national-forest-contributions-streamflow

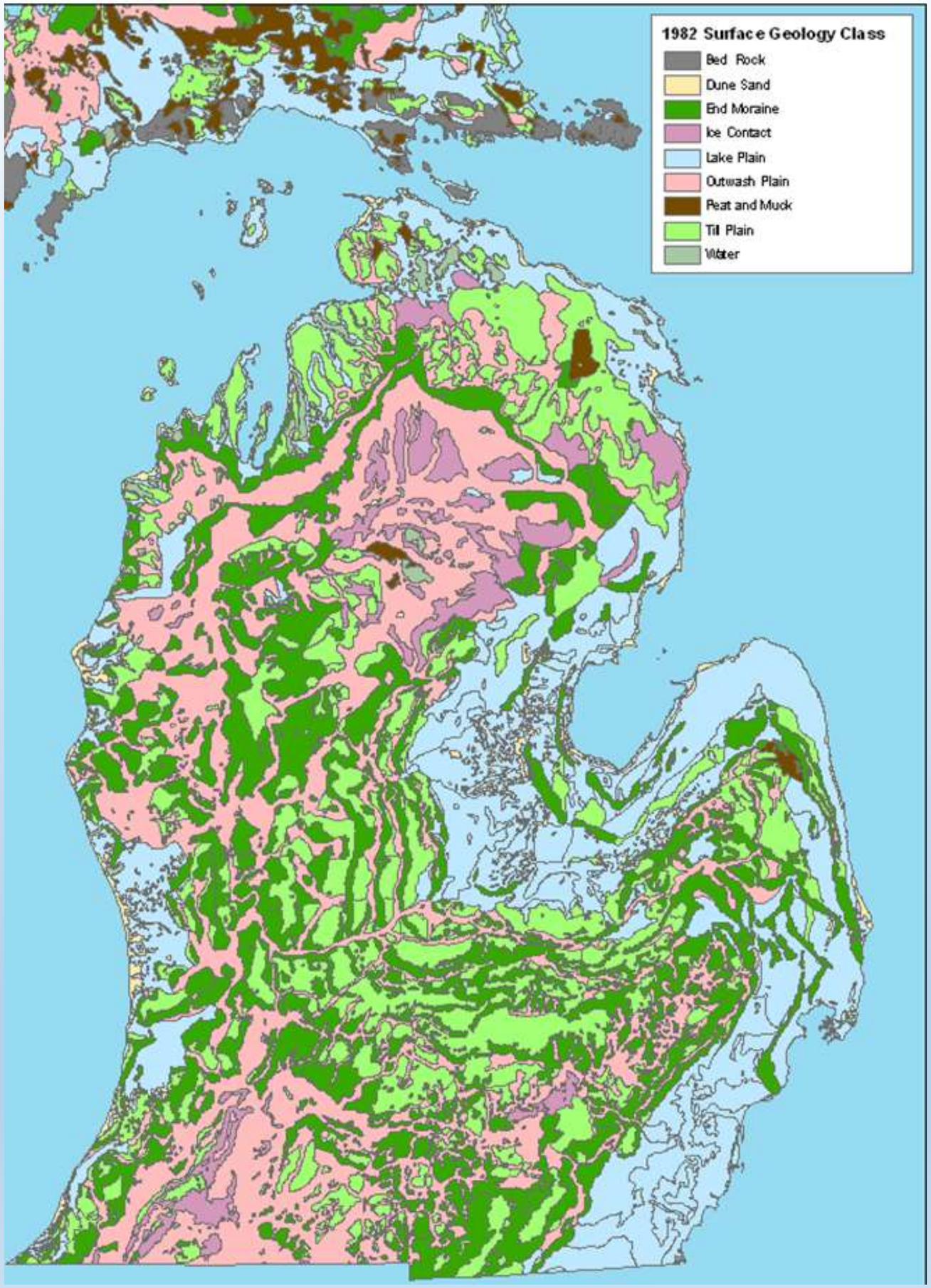

Inflow / Non - Attenuated Outflow
Flood
Target discharge rate
Attenuated Outflow
Flow rate
Time




HARTON
S FRANCIS


Percent Land Cover
> 2/3s of Watershed Agriculture or Urban
< 2/3rds of Watershed Agriculture or Urban

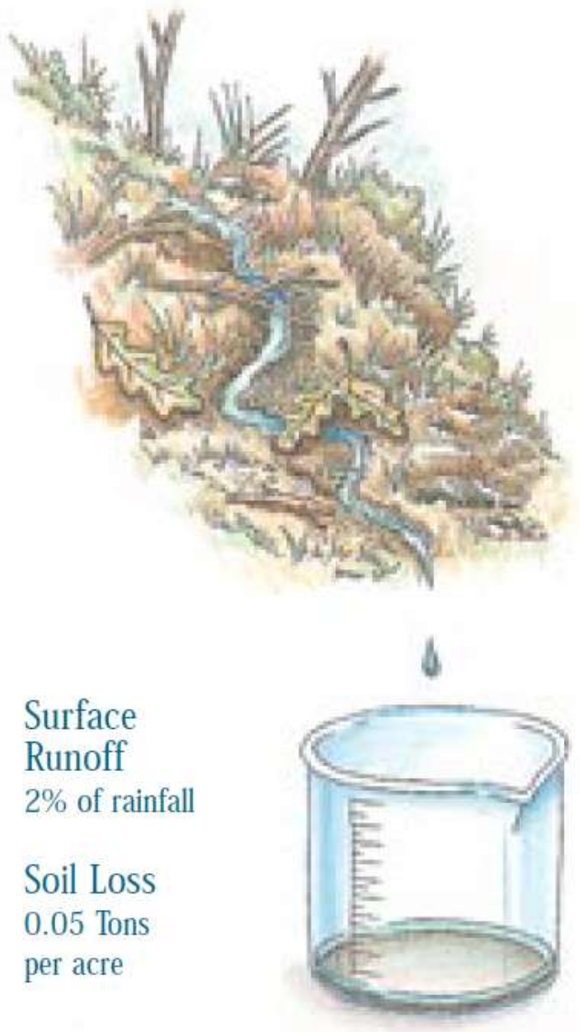
6-20 inches/hour Grayling Sands Permeability



Permeability of Clay is very low <0.06 inches/hour

GOOD Ground Cover

60-75% of ground covered
with plants and litter

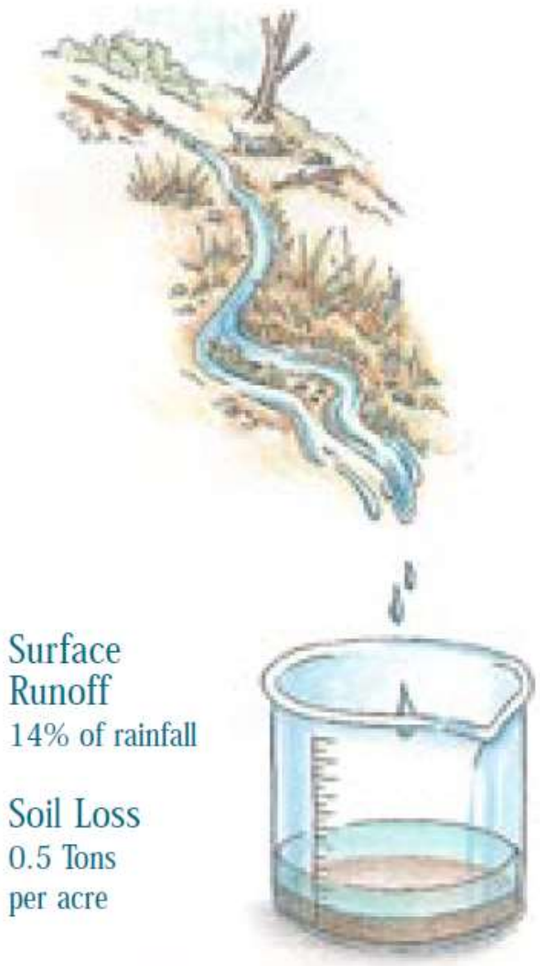


Surface Runoff
2% of rainfall

Soil Loss
0.05 Tons
per acre

FAIR Ground Cover

37% of ground covered
with plants and litter



Surface Runoff
14% of rainfall

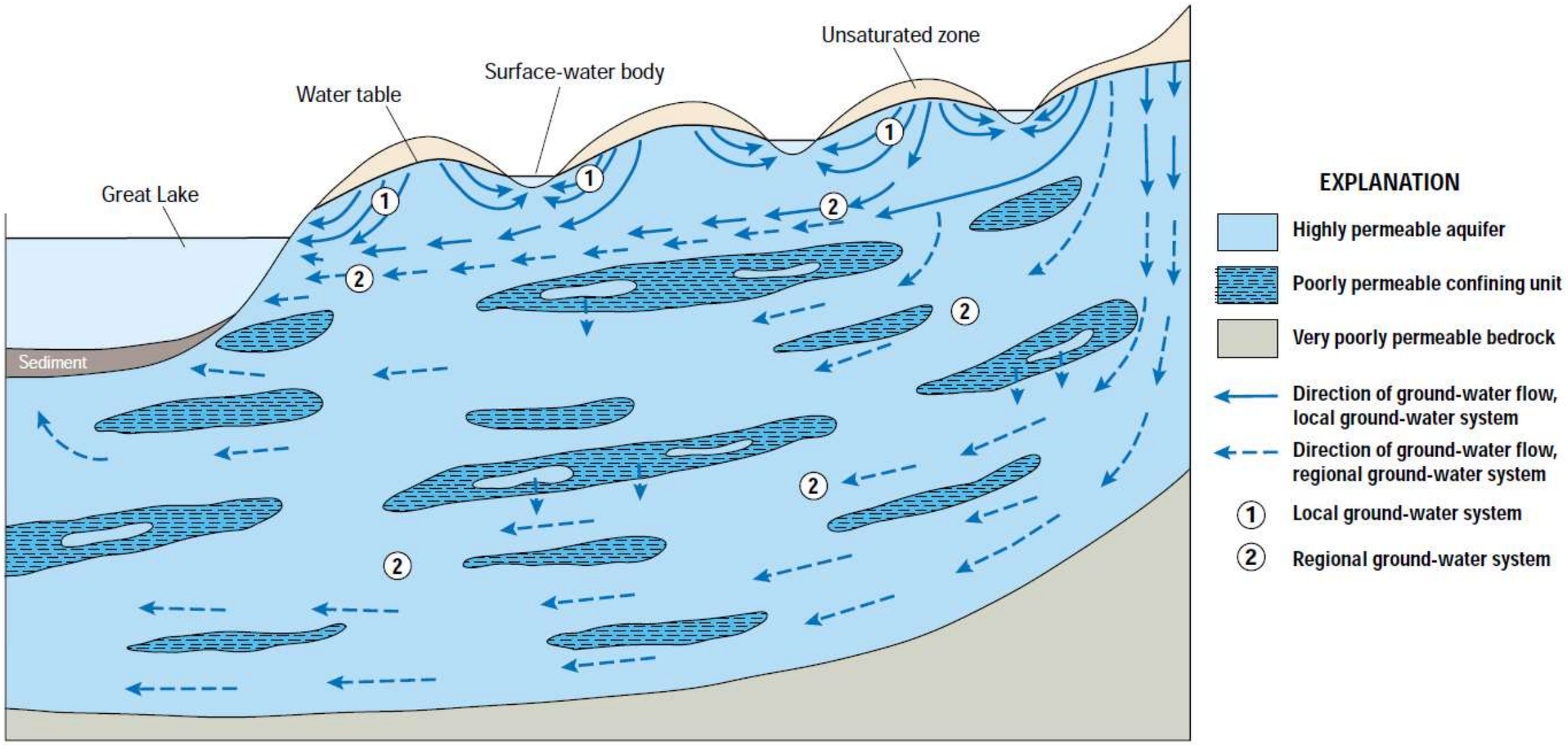
Soil Loss
0.5 Tons
per acre

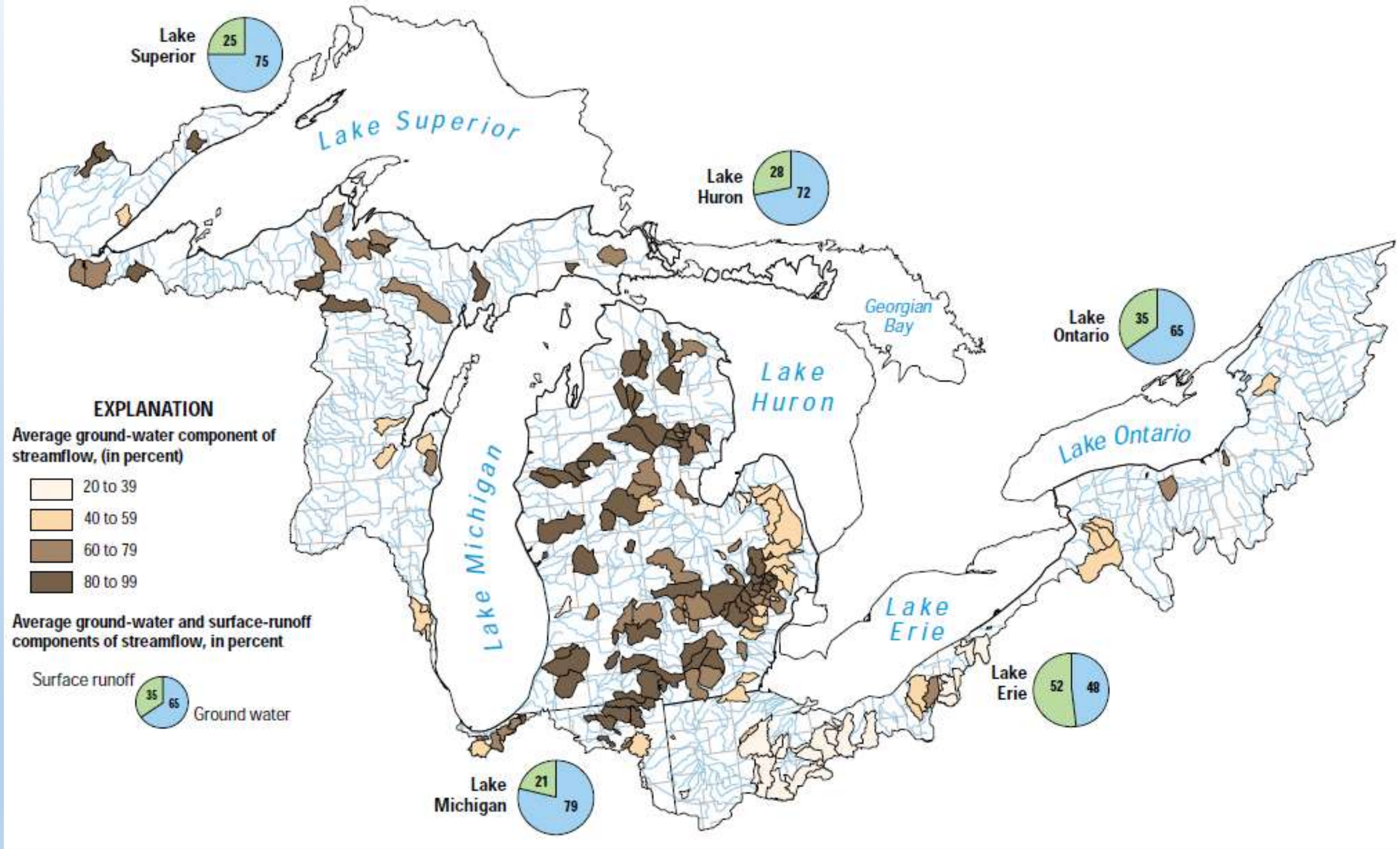
POOR Ground Cover

10% of ground covered
with plants and litter

Surface Runoff
73% of rainfall

Soil Loss
5.55 Tons
per acre


Unsaturated zone
Surface-water body
Water table
Great Lake
Sediment
1
2
EXPLANATION
Highly permeable aquifer
Poorly permeable confining unit
Very poorly permeable bedrock
Direction of ground-water flow, local ground-water system
Direction of ground-water flow, regional ground-water system
1 Local ground-water system
2 Regional ground-water system


Lake Superior
25
75
Lake Superior
Lake Huron
28
72
Georgian Bay
Lake Huron
Lake Ontario
35
65
Lake Ontario
Lake Michigan
Lake Erie
52
48
Lake Erie
Lake Michigan
21
79
EXPLANATION
Average ground-water component of streamflow, (in percent)
20 to 39
40 to 59
60 to 79
80 to 99
Average ground-water and surface-runoff components of streamflow, in percent
Surface runoff
35
65
Ground water

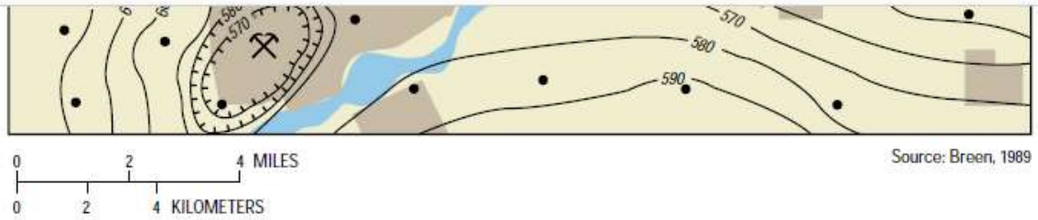


Figure 9. Potentiometric surface for the carbonate aquifer near Toledo, Ohio, July 1986.

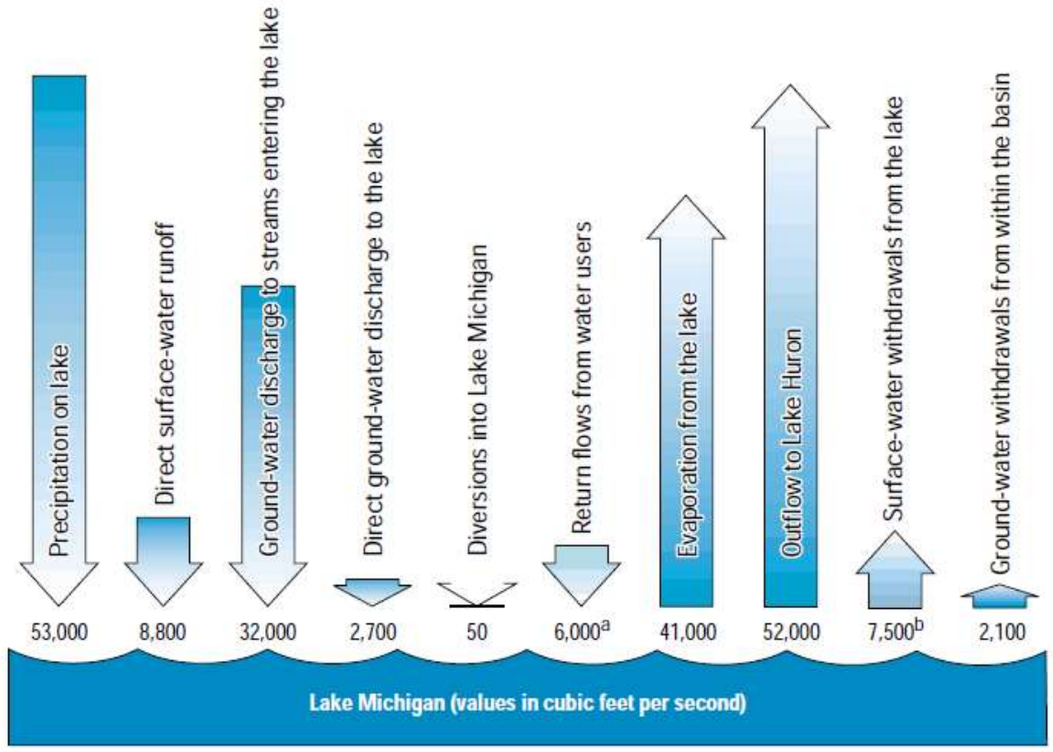


Figure 10. Approximate average water budget for Lake Michigan.

[a] Return flow is reduced by 3,200 ft^3/s that is diverted out of the basin at Chicago, Ill.

[b] Withdrawals for power plant cooling not included

water levels in wells as much as 35 feet below the average level of Lake Erie (fig. 9). In addition, pumping has induced water from Lake Erie into the ground-water system and intercepted water that would have discharged from the ground-water system to Lake Erie (Breen, 1989; Eberts and

Irrigation throughout the Great Lakes watershed

Irrigation is the largest consumptive use of water in the Great Lakes watershed, and ground-water sources contribute about half of the water used for irrigation. In areas