

Designing for Scientists

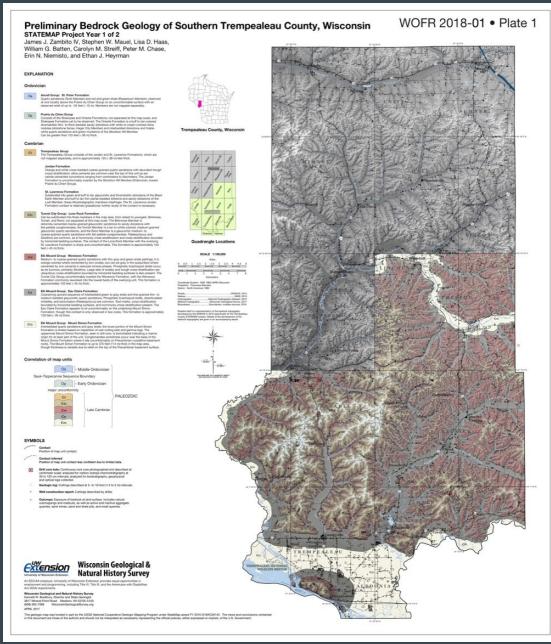
Caroline Rose

Wisconsin Geological and Natural History Survey

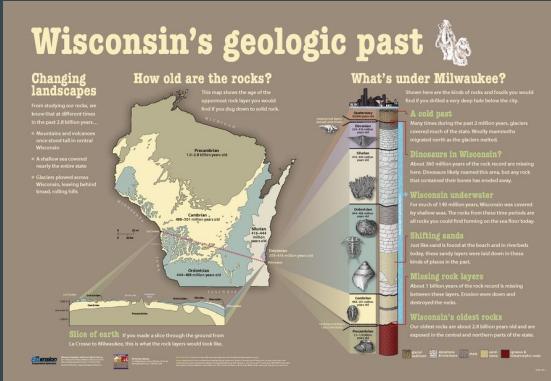
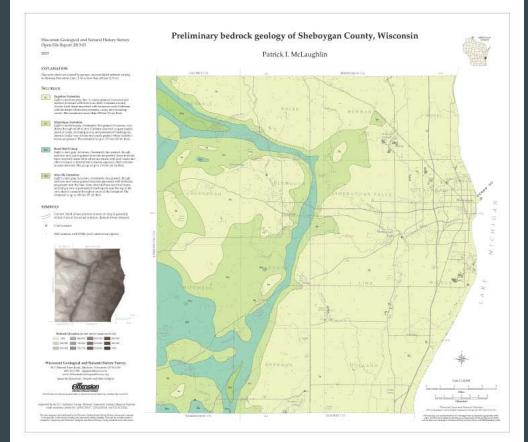
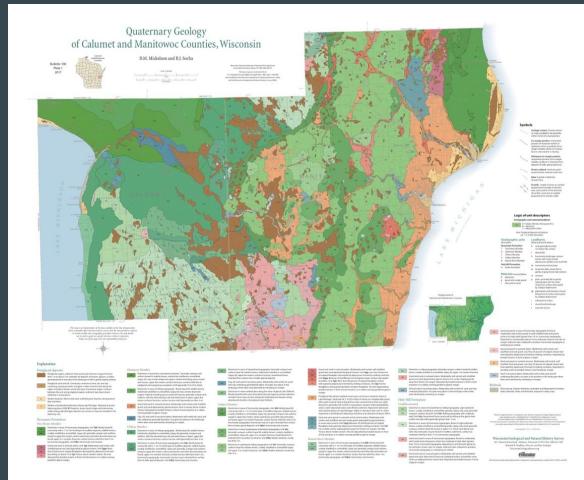
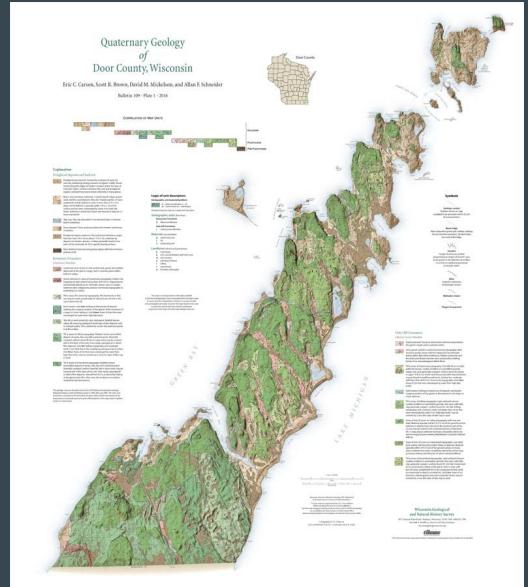
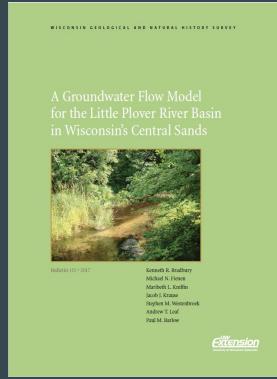
caroline.rose@wgnhs.uwex.edu

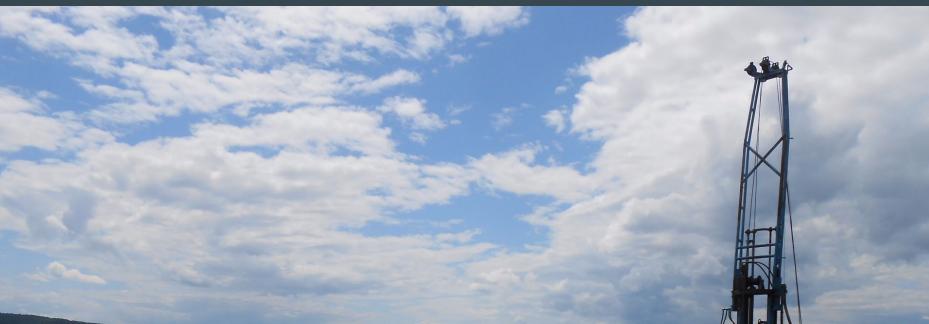
@cmrRose

github.com/cmrRose/talks

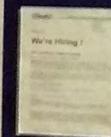
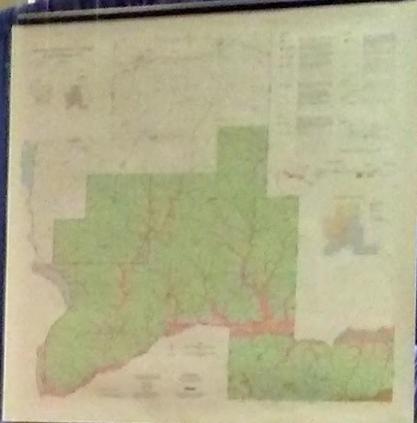
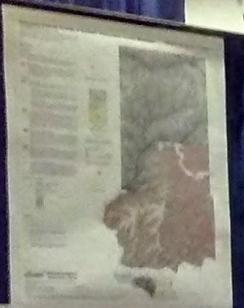


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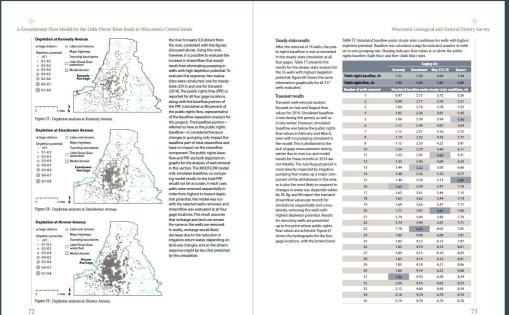
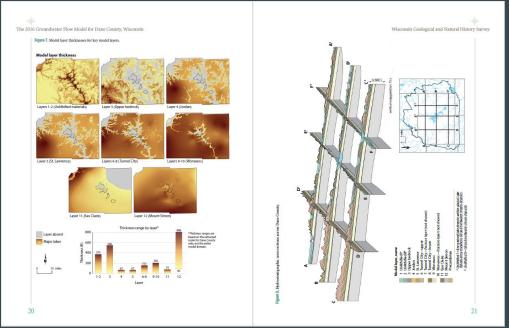
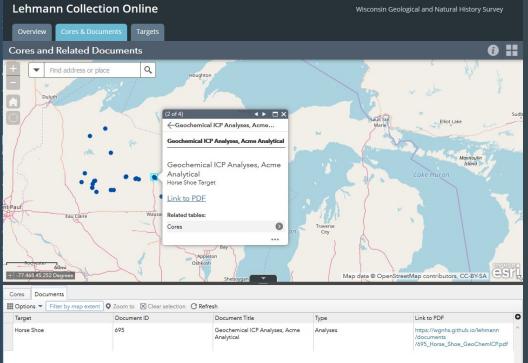
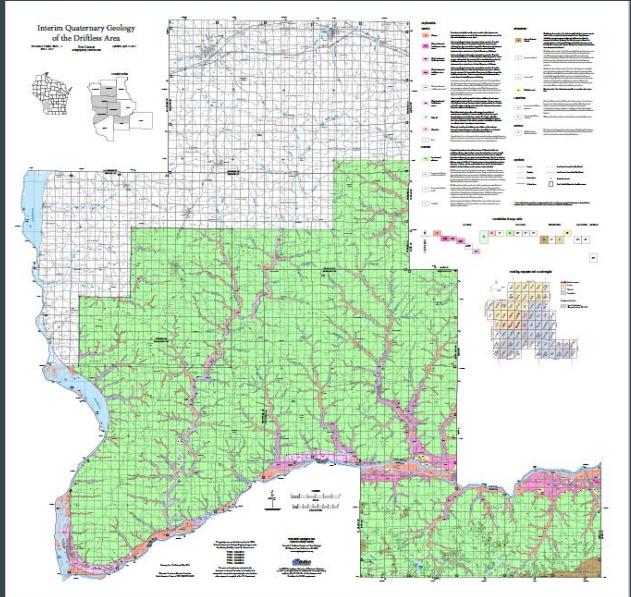
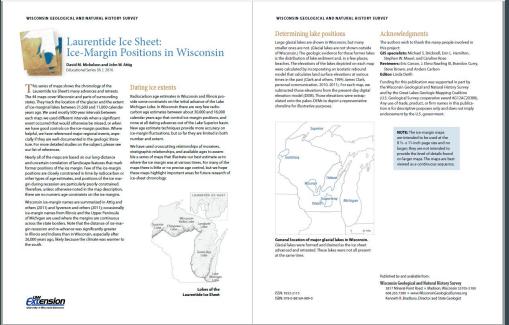
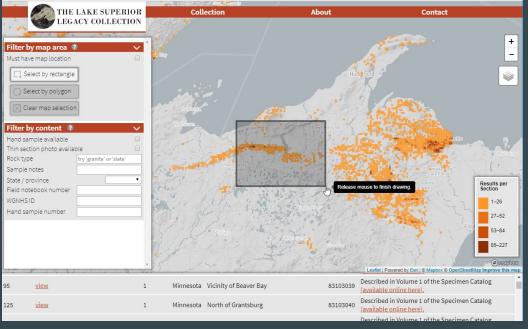
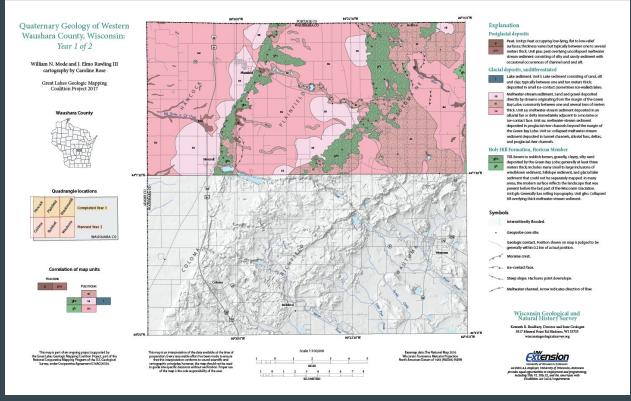
WI Geological & Natural History Survey



See

Put Your

on the



A Groundwater Flow Model for the Little Plover River Basin in Wisconsin's Central Sands



Bulletin 111 • 2012

Kenneth R. Bradford
Michael J. Flenniken
Mark E. Howell
Jacob L. Knuth
Stephen M. Weller
Andrew T. Leaf
Paul M. Barkow

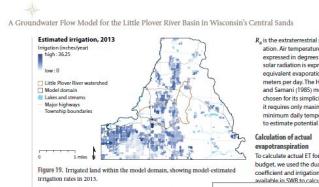


Figure 19. Irrigated land within the model domain, showing model-estimated irrigation rates in 2013.

Hydrologic groups



Figure 20. Hydrologic and groups in the SWB model domain.

Calculation of potential evapotranspiration

The SWB model calculates potential ET in one of five ways chosen by the user: (1) the Hargreaves method for potential ET using the Hargreaves and Samani (1985) method, which estimates potential ET based on maximum and minimum air temperatures and solar radiation (equation 5);

$$ET_p = 0.0133(K_f + 17.797(T_m - T_{min})^{\frac{1}{2}})$$

22

where:
 K_f is an empirical coefficient used to adjust for "virtual" net ET (0.95) coastal region.
 T_m is the average daily temperature (°C).
 T_{min} and T_{max} are the mid-day maximum and minimum daily temperature (°C).

(These are percentages from an equation)

Methodology

The example simulates the impact of a new high-capacity irrigation well along the northern boundary of the Little Plover River (fig. 51). This translates to an average daily discharge of the new well of 500 gallons per minute per day (174 gallons per minute, gpm).

We simulated the groundwater and surface-water system using steady-state pumping using both the steady-state and transient models with three scenarios:

existing well elsewhere in the model); (2) overall discharge from the well is 500 gallons per minute (gpm); and (3) no change in the magnitude of large-capacity irrigation wells in the model domain. This hopefully represents the range of possible growing seasons, with 28 percent of the area receiving irrigation in August and 14 percent in August.

Simulated steady-state drawdown, with and without irrigation return



Figure 51. Simulated steady-state drawdown with and without irrigation return for a hypothetical new well. (Source: see text)

62



1 Change in irrigation methods
Soil moisture on the control year simulation minus the soil moisture on the current year. The negative value is obtained when water is being removed from the soil layer. The change is measured in millimeters by a soil thickness capacity.

calculator water budget
Nash and Sutcliffe (1970);
Droogendijk and Broekhoff (2004);
and Vossen and others (1985).

Land use

Land use is a critical component of the SWB approach because it defines the control year. The 2013 USGS National Land Cover Database (NLCD 2013) land-use database identifies 23 land-use categories represented with high-capacity wells (fig. 19).

Land use types were separated into two categories: non-irrigated land use and irrigated land. The seven most prevalent land uses are: forest, field crops, grass/pasture, sweet corn, potatoes, soybeans, and other annual crops. Figure 18 shows the spatial distribution of land use in the model domain in 2013. 26 percent of the land area in the model domain is sand and gravel surface sediments greater than 50 feet thick, which is the depth of the study area. The Wisconsin Department of Natural Resources (R. Small, DNR, personal communication, 2012) reported that this region consists of sandy outwash and eolian sediments deposited in a large glacial trough, part of the drift of the Pliocene Epoch, around 11,700 years ago in Wisconsin. These sandy soils have an important shallow aquifer that supplies water for major row crops, vegetable packaging industries, cranberry production, and dairy and hog production communities. The aquifer is approximately 100 feet thick and lies on less than 10 percent of the region includes more than 80 lakes and more than 600 miles of headwater streams (Kraft and others, 2012). The aquifer is an important recreational and ecological resource. Irrigated land, which includes all land irrigated after 1950, currently covers about 183,000 acres. Irrigation supports production of corn, hay, carrots, snap beans, and other vegetables. The main source of the irrigation water is groundwater pumping from relatively shallow wells located within the sandy aquifer. The number of wells has increased every year for the past several decades.

Groundwater and surface water are well-connected in the Central Sands region, and concerns over the possible impacts of irrigated agriculture

on surface-water resources and groundwater levels first appeared in the mid-1960s and early 1970s (Holt, 1965; Weeks, 1969; Weeks and others, 1972). Irrigation use became more acute during the 2000s, with the occurrence of extensive droughts and subsequent low lakes and extrapolatively low groundwater levels. In response to this problem, the Wisconsin Geological and Natural History Survey (WGNHS) carried out several hydrogeologic studies in the Central Sands during the 1990s (Bradbury and others, 1992; Faust, 1985; Kraft and others, 2014) developed an extensive summary and synthesis report on groundwater in the region and summarized the results of numerous previous studies.

Introduction

Background

The region known as Wisconsin's Central Sands parts of several counties in central Wisconsin (fig. 1). This report defines the Central Sands as the contiguous area east of the Wisconsin River sand and gravel surface sediments greater than 50 feet thick, which is the depth of the study area. The Wisconsin Department of Natural Resources (R. Small, DNR, personal communication, 2012) reported that this region consists of sandy outwash and eolian sediments deposited in a large glacial trough, part of the drift of the Pliocene Epoch, around 11,700 years ago in Wisconsin. These sandy soils have an important shallow aquifer that supplies water for major row crops, vegetable packaging industries, cranberry production, and dairy and hog production communities. The aquifer is approximately 100 feet thick and lies on less than 10 percent of the region includes more than 80 lakes and more than 600 miles of headwater streams (Kraft and others, 2012). The aquifer is an important recreational and ecological resource. Irrigated land, which includes all land irrigated after 1950, currently covers about 183,000 acres. Irrigation supports production of corn, hay, carrots, snap beans, and other vegetables. The main source of the irrigation water is groundwater pumping from relatively shallow wells located within the sandy aquifer. The number of wells has increased every year for the past several decades.

Groundwater and surface water are well-connected in the Central Sands region, and concerns over the possible impacts of irrigated agriculture

Figure 1. Location of the Central Sands with the model domain and Little Plover River watershed.

3

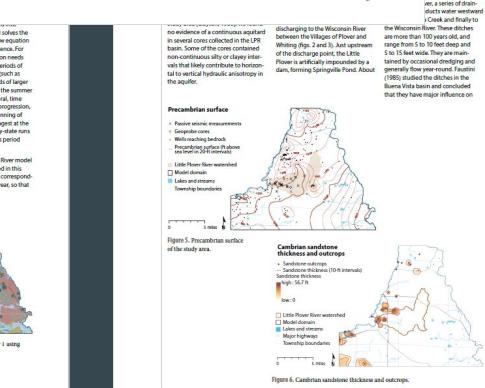


Figure 5. Provenance surface of the study area.

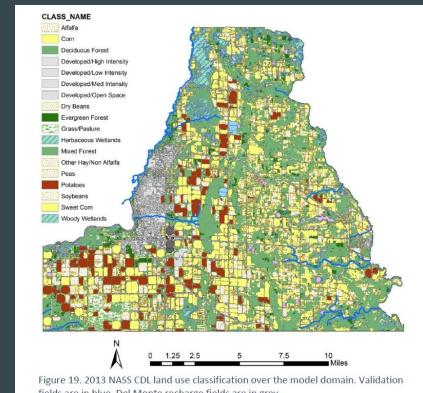
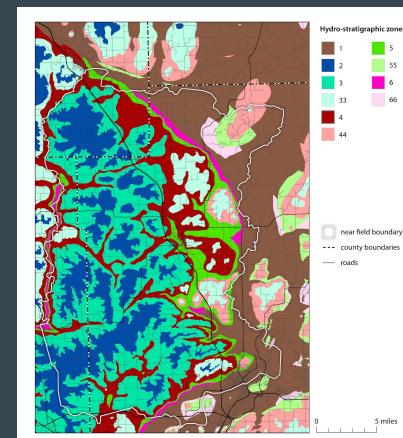
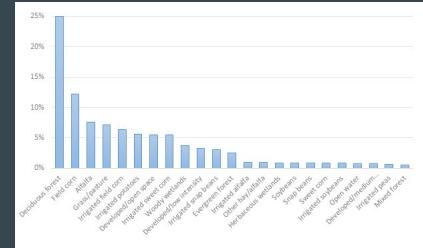
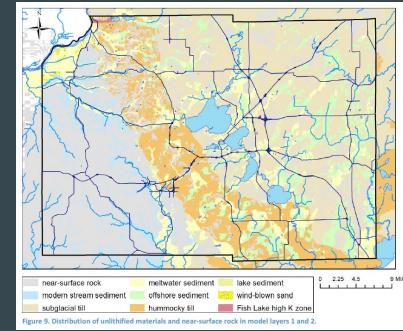
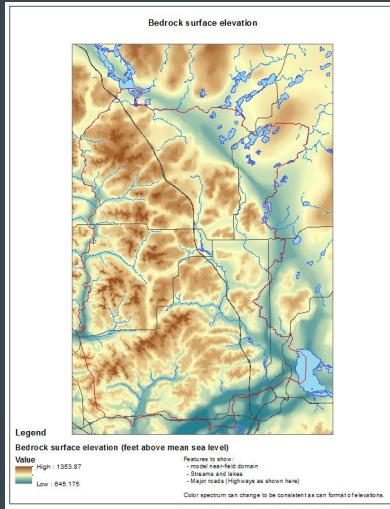
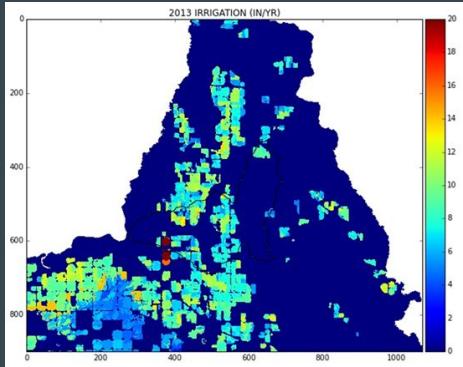
Figure 6. Cambrian sandstone thickness and outcrops.

38

8

design

to do or plan something with a
specific purpose or intention in mind



what should the reader understand about this data?

a sense of the
highs and lows?

areas of clustering
or dispersion?

identify specific
data values?

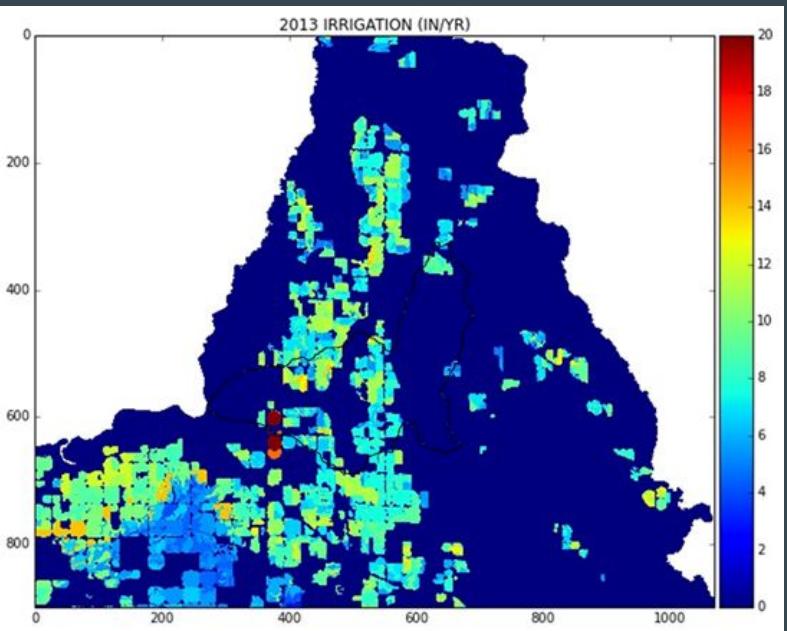
how?

- ① focus attention
- ② illustrate data structure
- ③ facilitate comparison

① focus attention

focus attention:

represent nothing with nothing

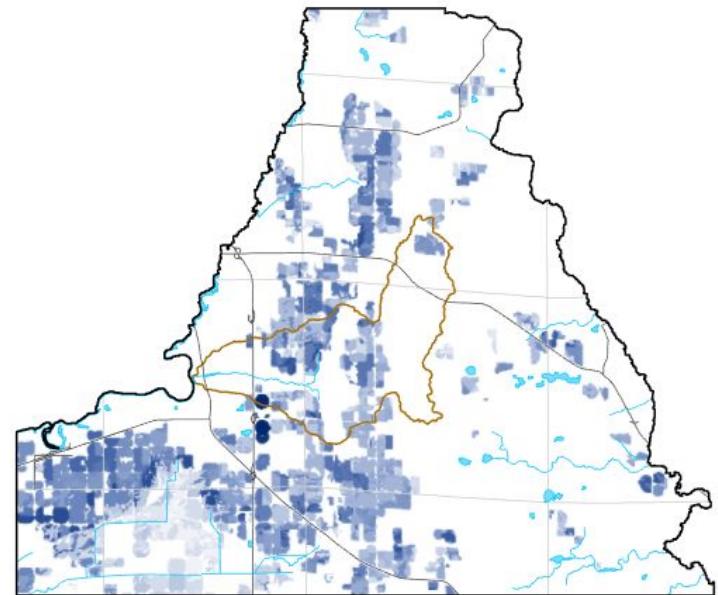


Irrigation (2013)

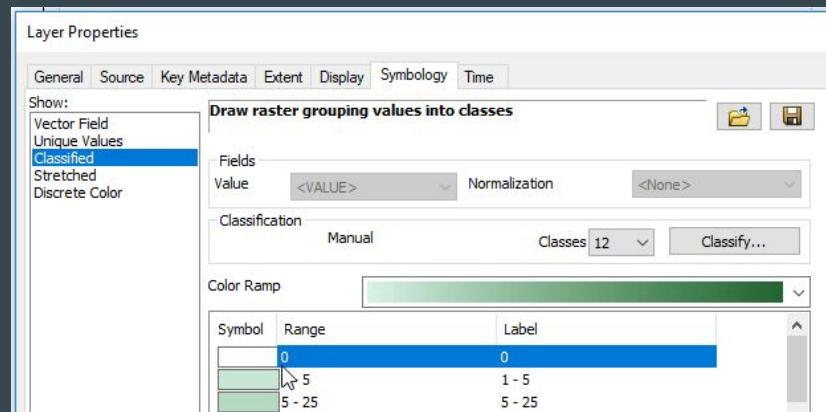
Irrigation (Inches/year)
high : 36.25
low : 0

- Little Plover River watershed
- Model domain
- Lakes and streams
- Major highways
- Township boundaries

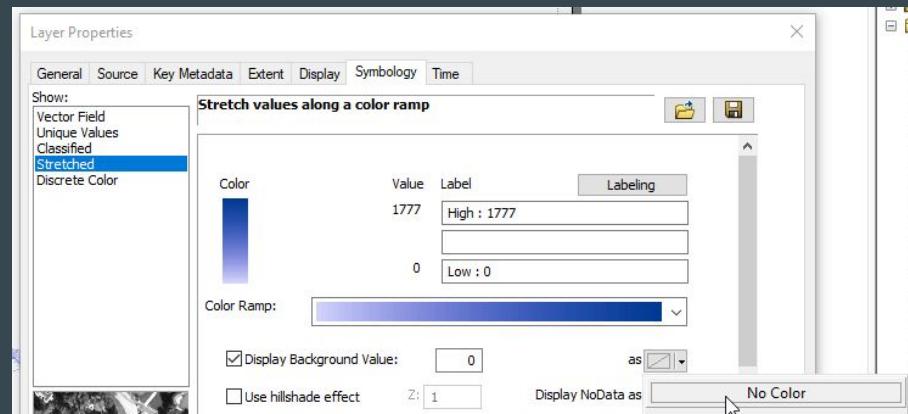
0 5 miles



Arcmap symbology



class set to background color

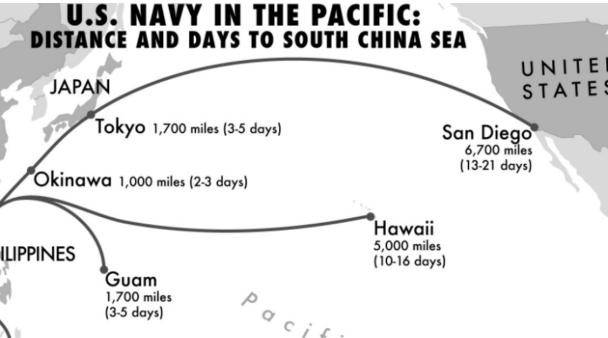
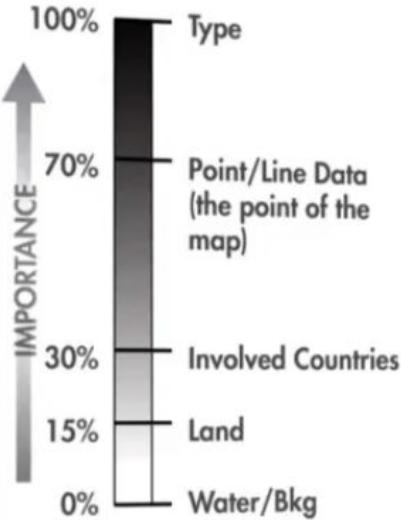
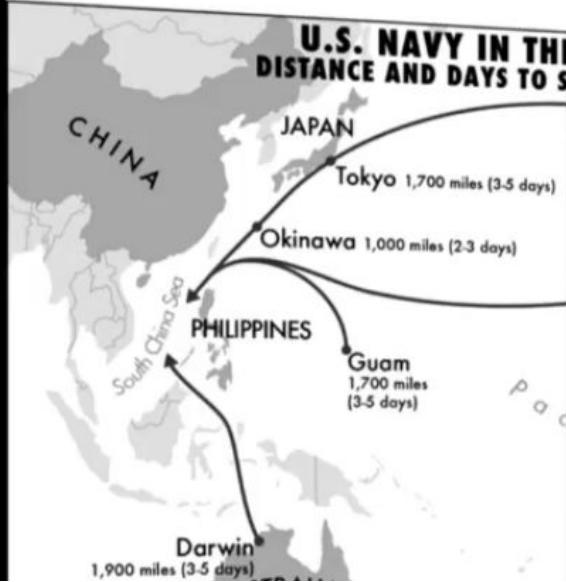


background value as no color

focus attention:

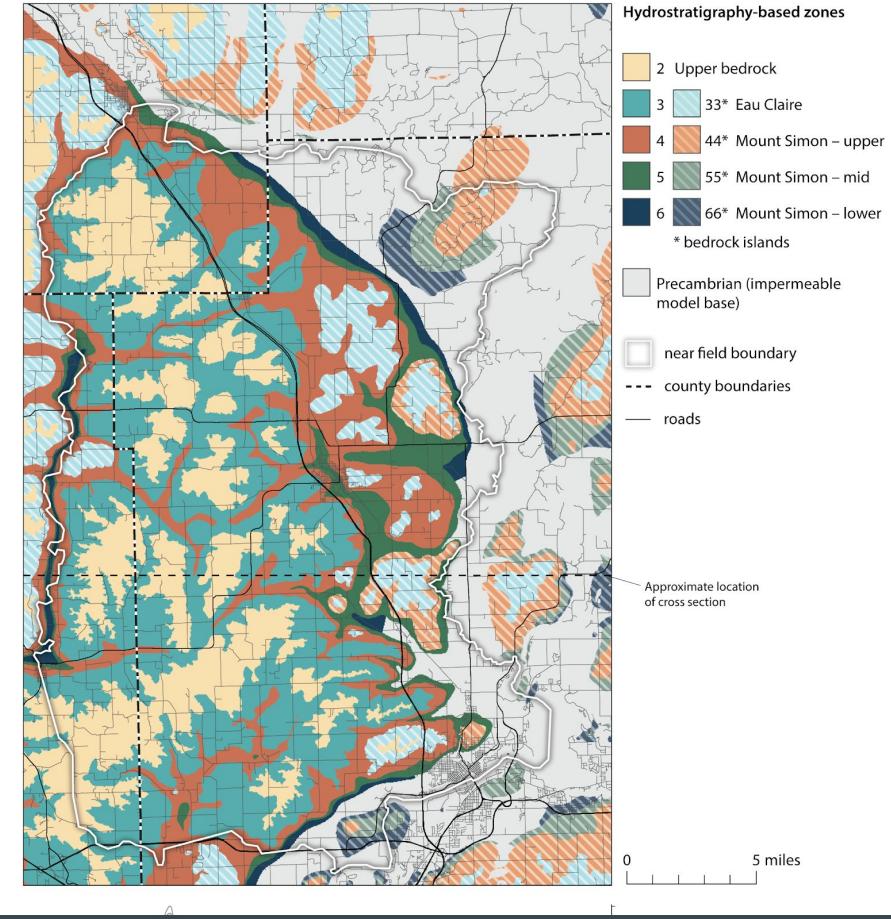
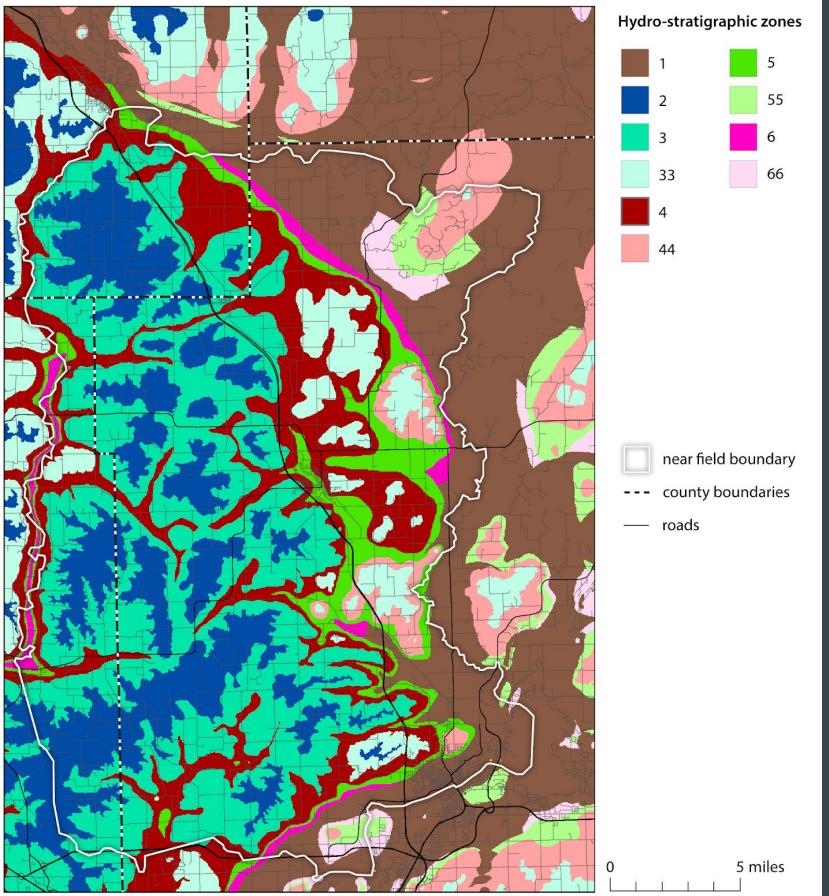
visual hierarchy

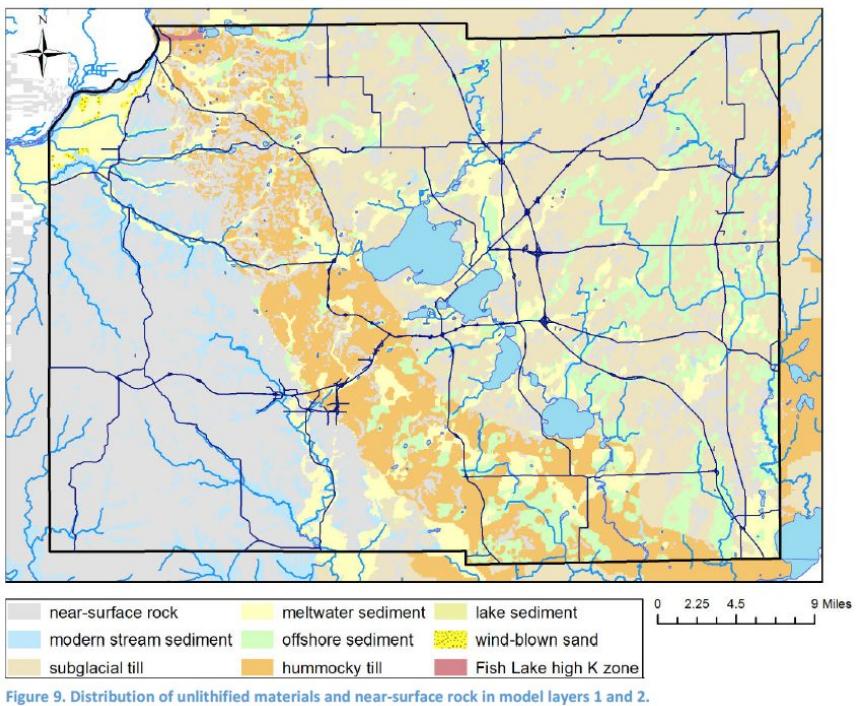
the arrangement or presentation of elements
in a way that implies importance



nacis

Soren Walljasper
NACIS 2017 (on youtube)





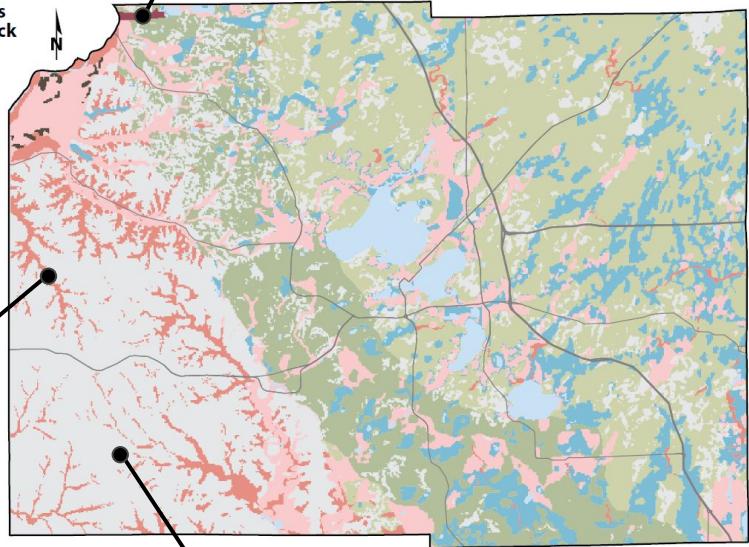
important
contrast

small features -
bold colors

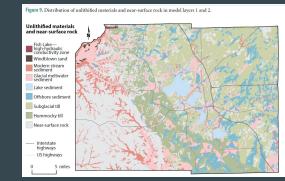
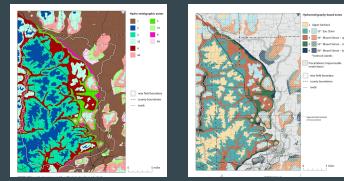
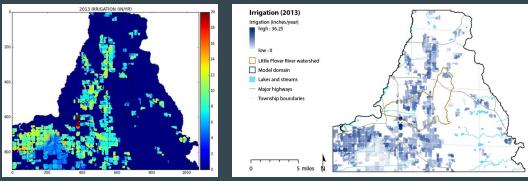
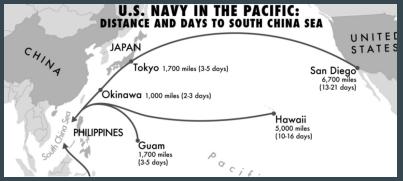
Figure 9. Distribution of un lithified materials and near-surface rock in model layers 1 and 2.

Unlithified materials and near-surface rock

- Fish Lake—high-hydraulic conductivity zone
 - Windblown sand
 - Modern stream sediment
 - Glacial meltwater sediment
 - Lake sediment
 - Offshore sediment
 - Subglacial till
 - Hummocky till
 - Near-surface rock
- Interstate highways
- US highways
- Scale: 0 5 miles



large features -
dull, neutral colors



zoom way out, or look at it from across the room

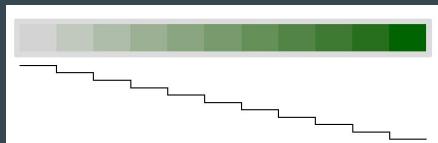
②

illustrate data structure

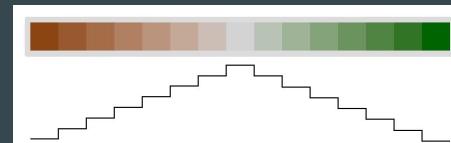
illustrate data structure:

color schemes

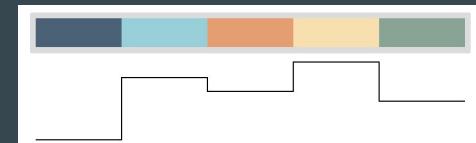
sequential



diverging



qualitative

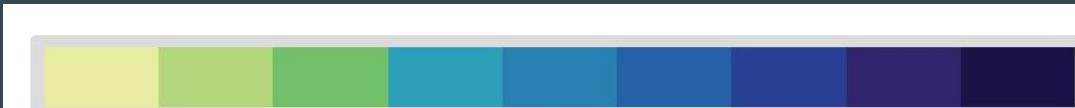


sequential

less of
something

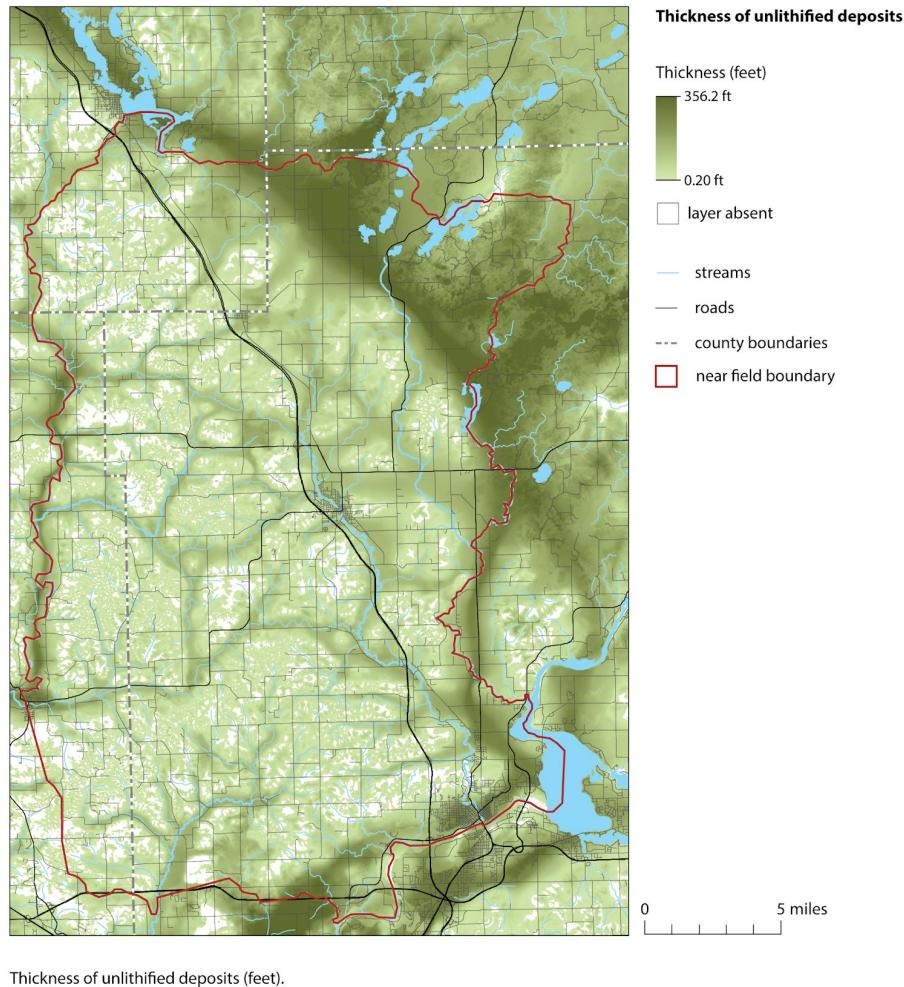


more of
something



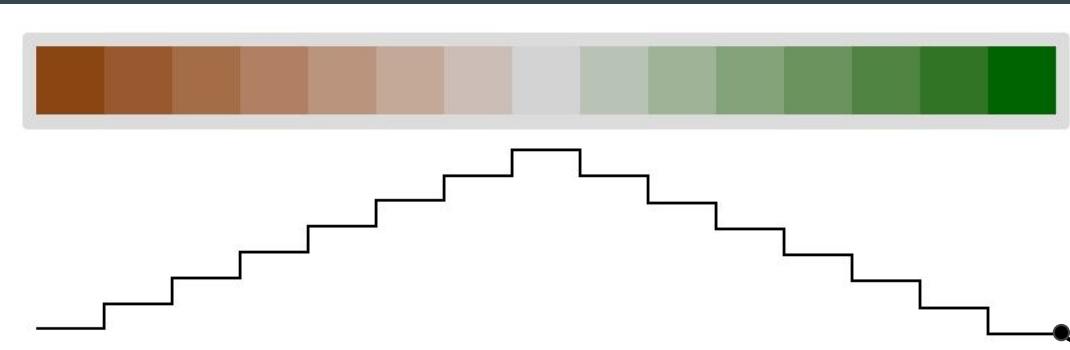
relative
lightness*

* see further reading at the end of this presentation for a comparison of lightness, brightness/value, and luminance



diverging

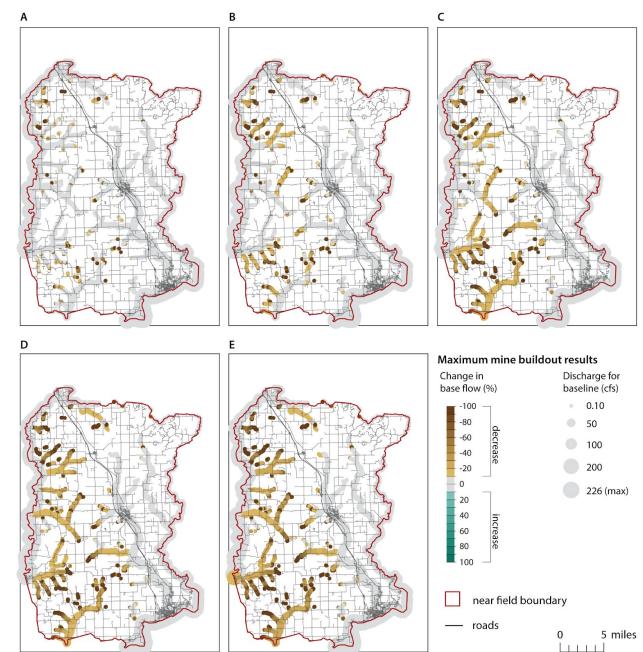
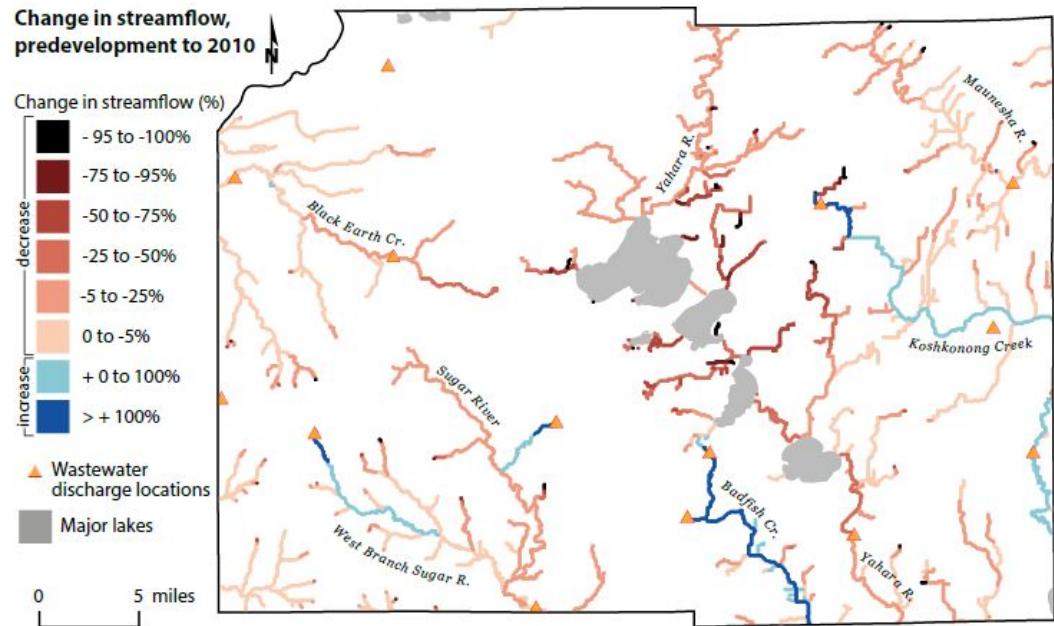
below a critical
midpoint



above a critical
midpoint

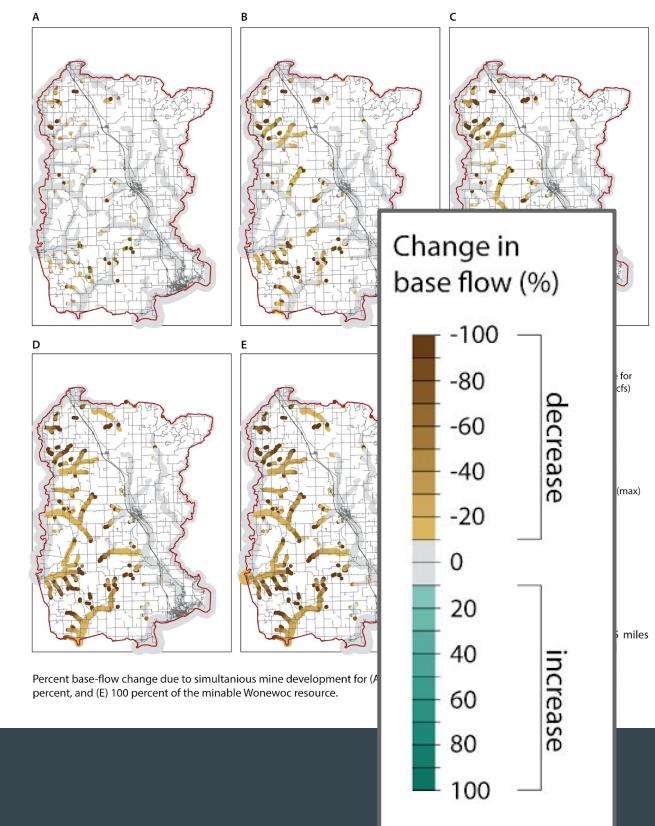
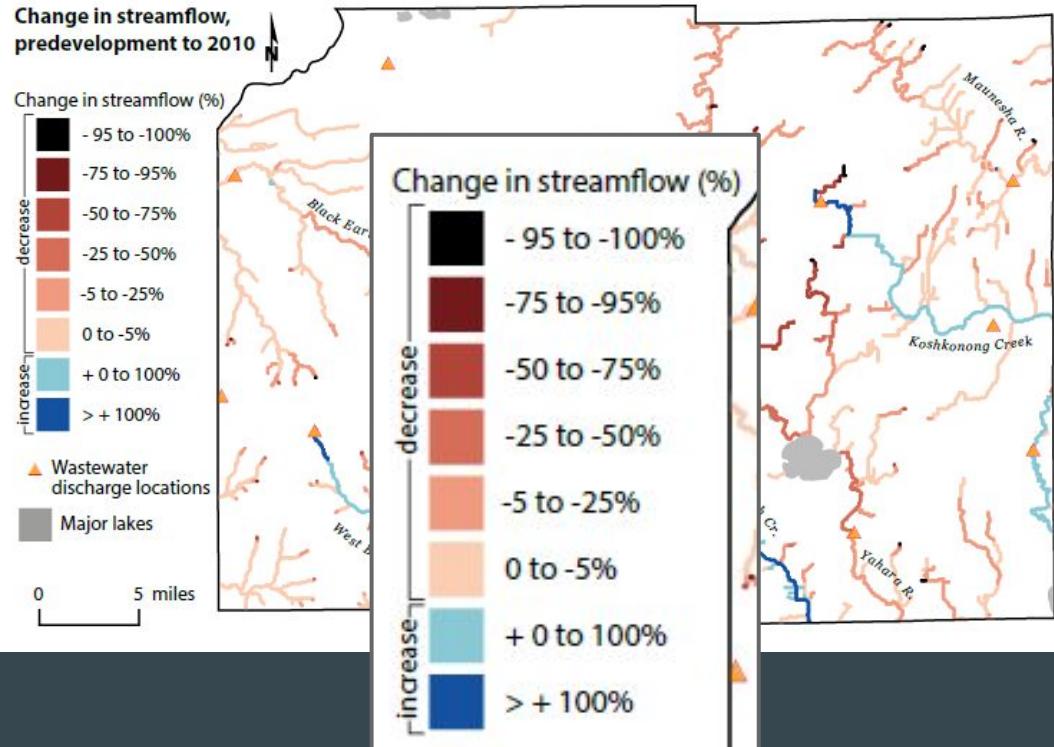
relative lightness

Figure 25. Comparison of changes in streamflow between predevelopment and 2010 conditions.

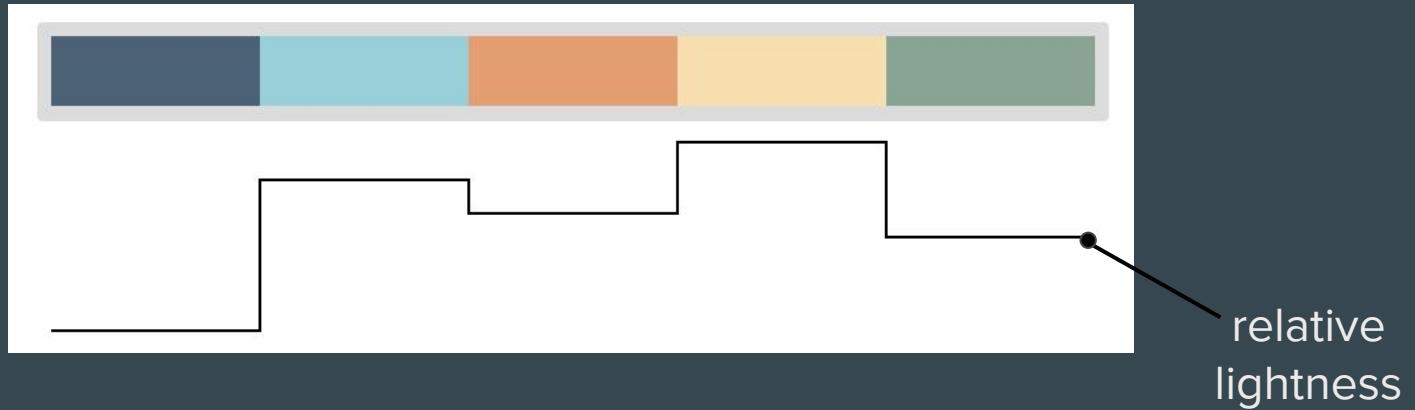


Percent base-flow change due to simultaneous mine development for (A) 10 percent, (B) 25 percent, (C) 50 percent, (D) 75 percent, and (E) 100 percent of the malleable Wonewoc resource.

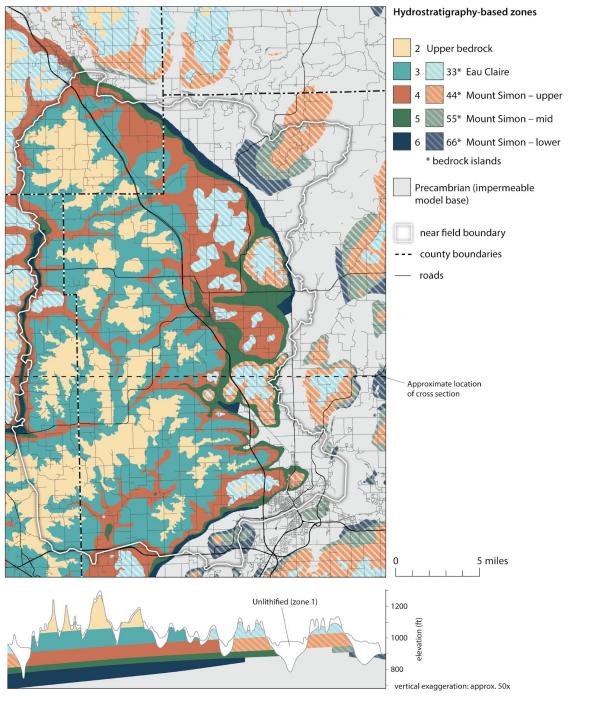
Figure 25. Comparison of changes in streamflow between predevelopment and 2010 conditions.



qualitative

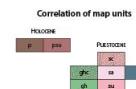


different, but no implied order

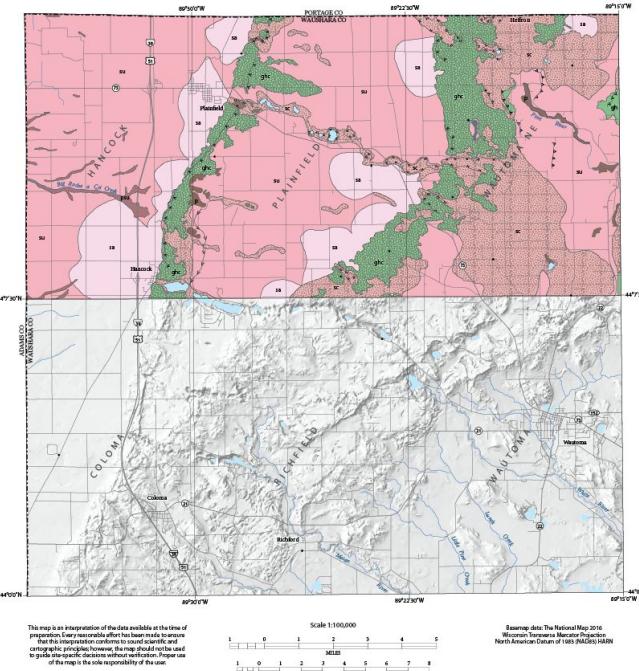


Quaternary Geology of Western Waushara County, Wisconsin: Year 1 of 2

William N. Mode and J. Elmo Rawling III
cartography by Caroline Rose
Great Lakes Geologic Mapping Coalition Project 2017



This map is part of an ongoing project supported by the Great Lakes Geologic Mapping Coalition Project, part of the National Geologic Mapping Program of the U.S. Geological Survey, under Cooperative Agreement G14AC0034.



Explanation

Postglacial deposits

P Post, till p Post occupying low-lying, flat to low-relief surfaces. Thickness varies but typically between one to several meters thick. Unit ps post overlying uncalibrated meltwater sediments. Unit pms post meltwater sand and gravel sediment with occasional occurrences of channel sand and silt.

Glacial deposits, undifferentiated

Lake sediment, Unit L Lake sediment consisting of sand, silt, and clay, typically between one and ten meters thick. Depositional environment is lake bottom. Unit sa lake sediment deposited directly by streams originating from the margin of the Green Bay Lobe, commonly between one and several tens of meters thick. Unit ta meltwater-stream sediment deposited in an alluvial plain. Unit ts meltwater-channel sediment deposited in proglacial meltwater channels beyond the margin of the Green Bay Lobe. Unit gh collapsed meltwater-channel sediment deposited in tunnel channels, channel bars, deltas, and proglacial river channels.

Holy Hill Formation, Horizon Member

gbc Till, brown to reddish brown, gravelly, clayey, silty, and deposited by the Green Bay lobe generally fill these depressions, including the Holy Hill area. Unit ghc till horizon of windblown sediment, tillite sediment, and glacial lake sediment that could not be separately mapped. In many areas, the Holy Hill surface is covered by glaciolacustrine sediments. Unit gh General has rolling topography. Unit ghs Collapsed till overlying thick meltwater-channel sediment.

Symbols

- Intermittently flooded.
- Geologic contact. Position shown on map is judged to be generally within 0.2 km of actual position.
- Moraine crest.
- Ice-contact face.
- Slope. Hatches point downslope.
- Meltwater channel. Arrow indicates direction of flow.

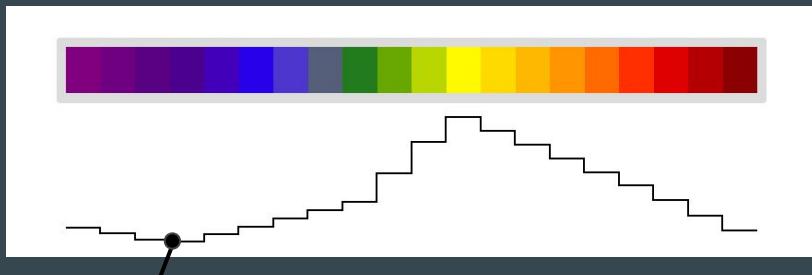
Wisconsin Geological and Natural History Survey

Kenneth R. Bradbury, Director and State Geologist
3811 Mineral Point Rd, Madison, WI 53705
www.wisconsingeology.org/wgnhs/

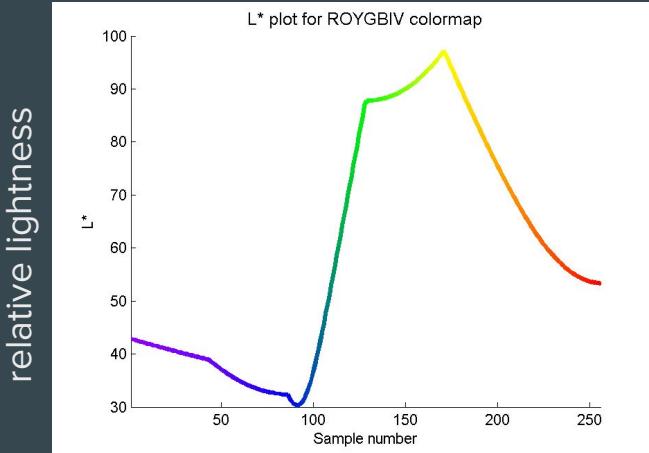


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spectral

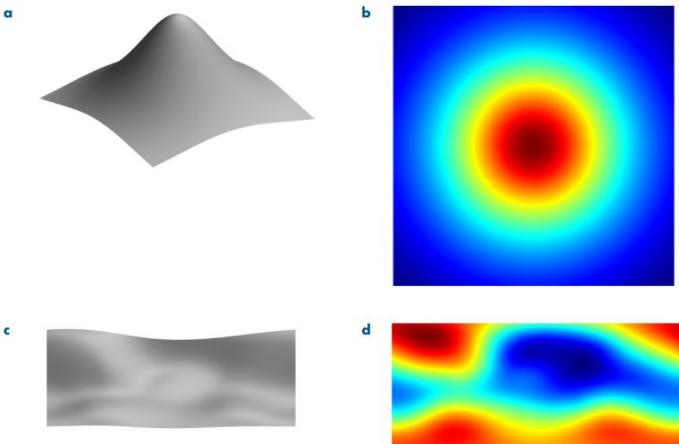


relative
lightness



"The Rainbow is Dead... Long Live the Rainbow!" by Matteo Niccoli

Figure 5. False bands caused by the rainbow color map for smooth data: a) Synthetic surface with a single peak; b) 2D visualization with rainbow color map; c) Earth's magnetic field intensity; d) 2D visualization with rainbow color map.



“Rainbow Color Map Critiques: An Overview and Annotated Bibliography” by Steve Eddins

SANFORD AND SELNICK

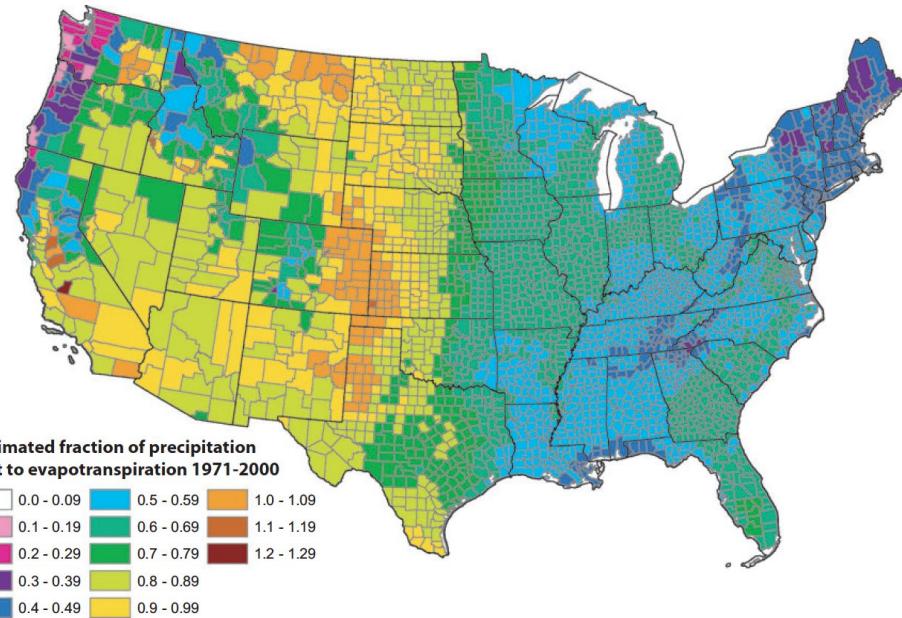
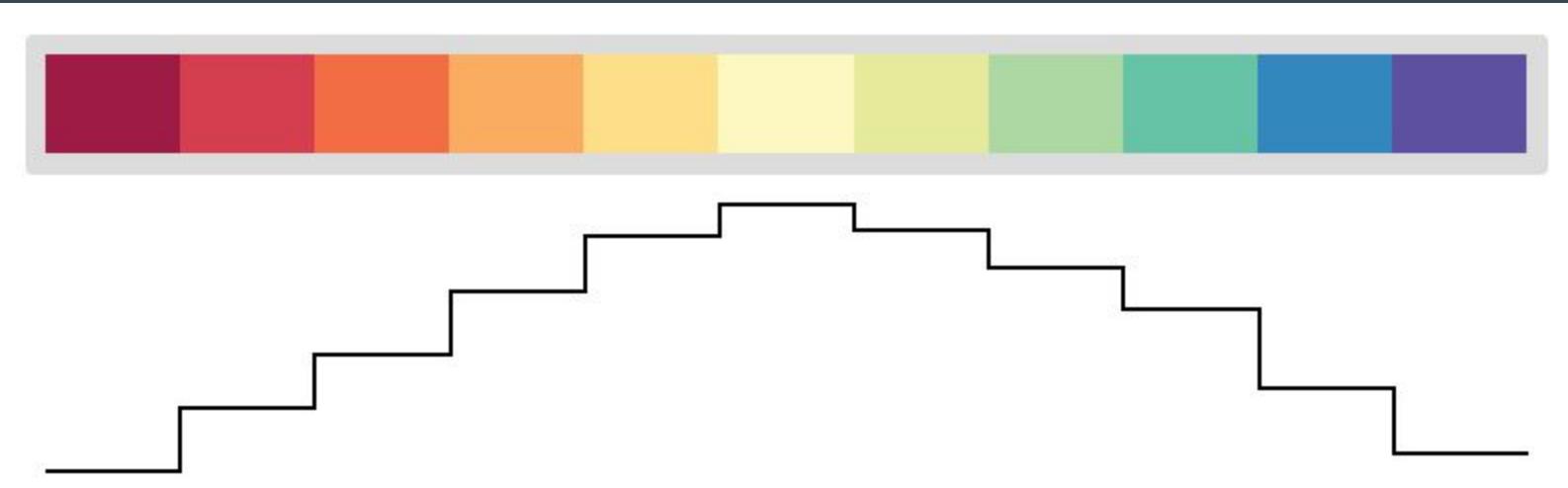
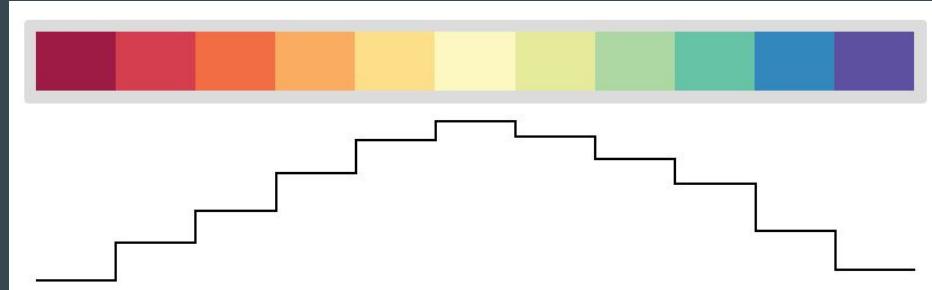


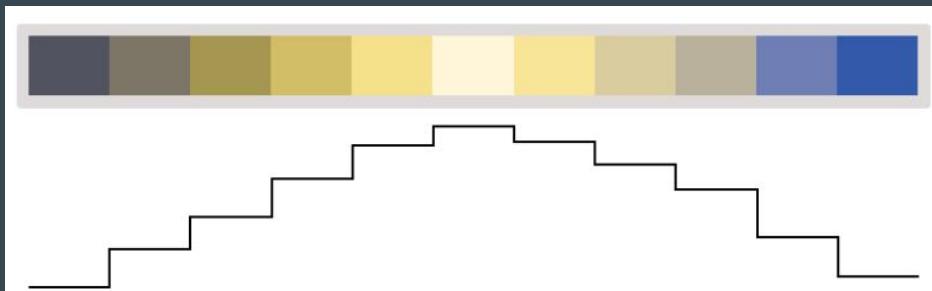
FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

“How The Rainbow Color Map Misleads” by Robert Kosara

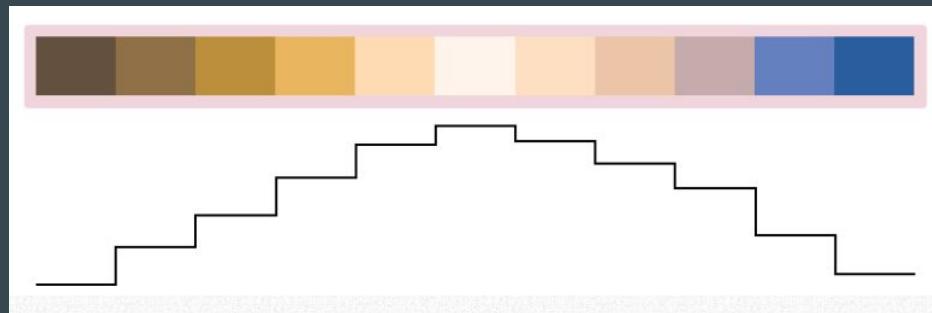




Protanopia

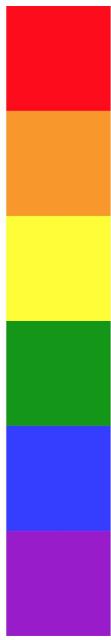


Deutanopia





CAUTION



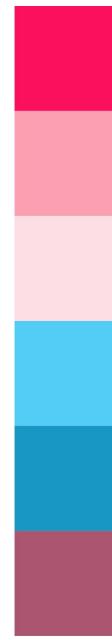
tritanomal



deuteranope



protanope



tritanope



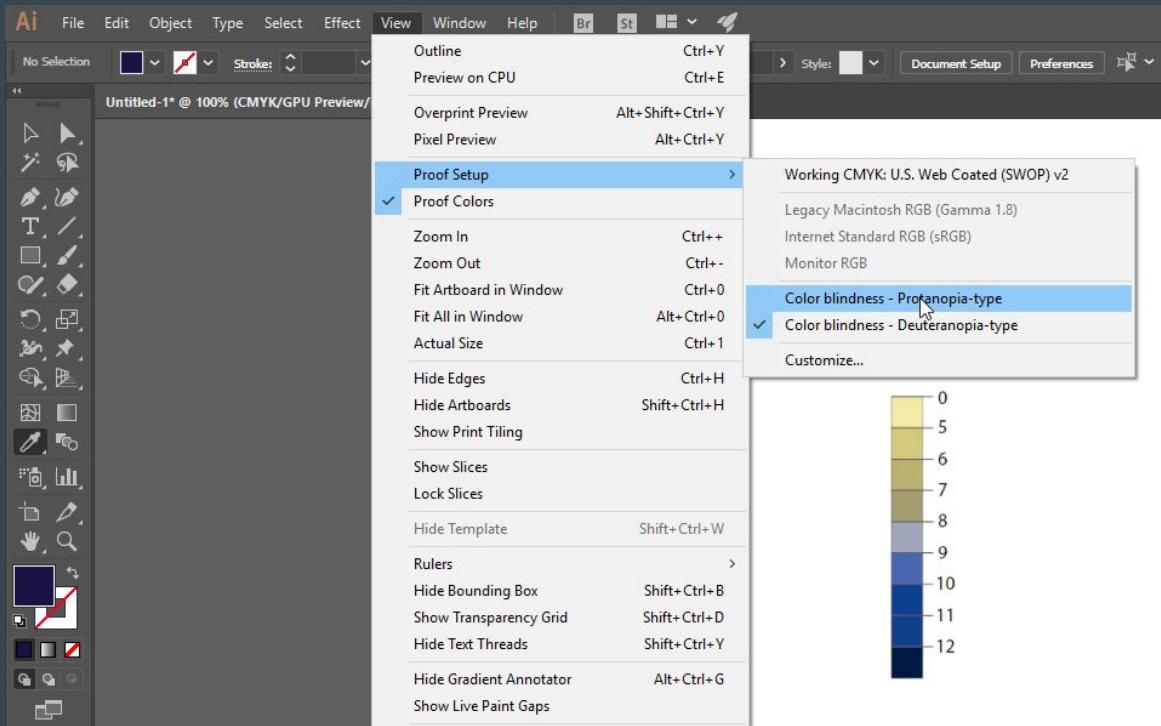
normal dichromat



dichromats

8% of men (1 in 12)

0.5% of women (1 in 200)



View > Proof Setup in Adobe Illustrator or Photoshop

Coblis — Color Blindness Simulator

If you are not suffering from a color vision deficiency it is very hard to imagine how it looks like to be colorblind. The Color BLindness Simulator can close this gap for you. Just play around with it and get a feeling of how it is to have a color vision handicap.

As all the calculations are made on your local machine, no images are uploaded to the server. Therefore you can use Images as big as you like, there are no restrictions. Be aware, there are some issues for the "Lens feature" on Edge and Internet Explorer. All others should support everything just fine.

So go ahead, choose an image through the upload functionality or just drag and drop your image in the center of our Color BLindness Simulator. It is also possible to zoom and move your images around using your mouse – try it out, I hope you like it.

Drag and drop or paste your file in the area below or: Dane-Fig9-Geology.png

Trichromatic view:	Anomalous Trichromacy:	Dichromatic view:	Monochromatic view:
<input type="radio"/> Normal	<input type="radio"/> Red-Weak/Protanomaly	<input type="radio"/> Red-Blind/Protanopia	<input type="radio"/> Monochromacy/Achromatopsia
<input checked="" type="radio"/> Green-Weak/Deutanomaly	<input type="radio"/> Green-Blind/Deutanopia	<input type="radio"/> Blue-Blind/Tritanomaly	<input type="radio"/> Blue Cone Monochromacy
<input type="radio"/> Blue-Weak/Tritanomaly	<input type="radio"/> Blue Cone Monochromacy		

Use lens to compare with normal view: No Lens Normal Lens Inverse Lens

Figure 9. Distribution of un lithified materials and near-surface rock in model layers 1 and 2.

Unlithified materials and near-surface rock

- Fish lake
- high-hydraulic
- Windblown sand
- Modern stream
- Glacial meltwater
- Lake sediment
- Lake sediment
- Offshore sediment
- Subglacial till
- Hummocky till
- Near-surface rock

Interstate highways US highways

0 5 miles

color-blindness.com/coblis-color-blindness-simulator/

tools for color schemes

colorbrewer2.org

Number of data classes: 3 ▾ [i](#) [how to use](#) | [updates](#) | [downloads](#) | [credits](#)

Nature of your data: [i](#)
 sequential diverging qualitative

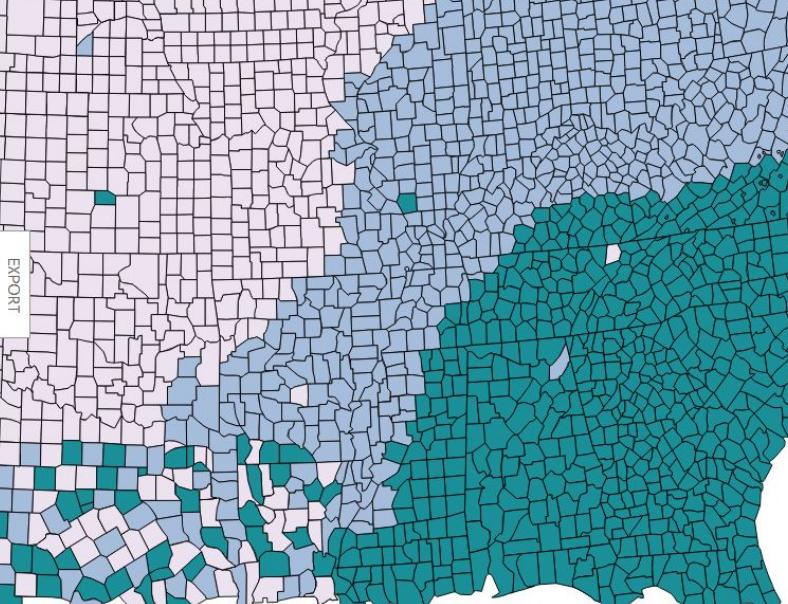
Pick a color scheme:
Multi-hue:  Single hue: 

Only show:
 colorblind safe
 print friendly
 photocopy safe

Context:
 roads
 cities
 borders

Background:
 solid color
 terrain

 color transparency

3-class PuBuGn

EXPORT 
HEX ▾ 
#ece2f0
#a6bddb
#1c9099

carto.com/cartocolors

SEQUENTIAL SCHEMES

Variations in lightness make these schemes ideal for mapping orderable or numeric data that progress from low to high using colors that range from light to dark (or vice versa).



DIVERGING SCHEMES

Highlight values above and below an interesting mid-point in quantitative data with these schemes. The middle color is assigned to the critical value with two sequential type palettes at either end assigned to values above or below.



QUALITATIVE SCHEMES

Demonstrate categorical differences in qualitative data with these color schemes that use different hues with consistent steps in lightness and saturation.

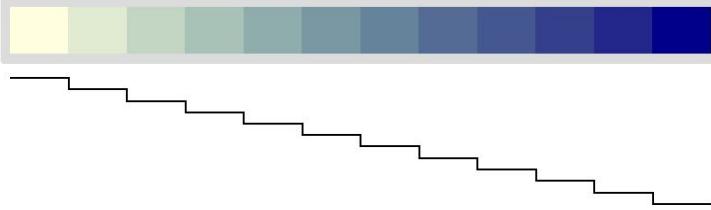


gka.github.io/palettes

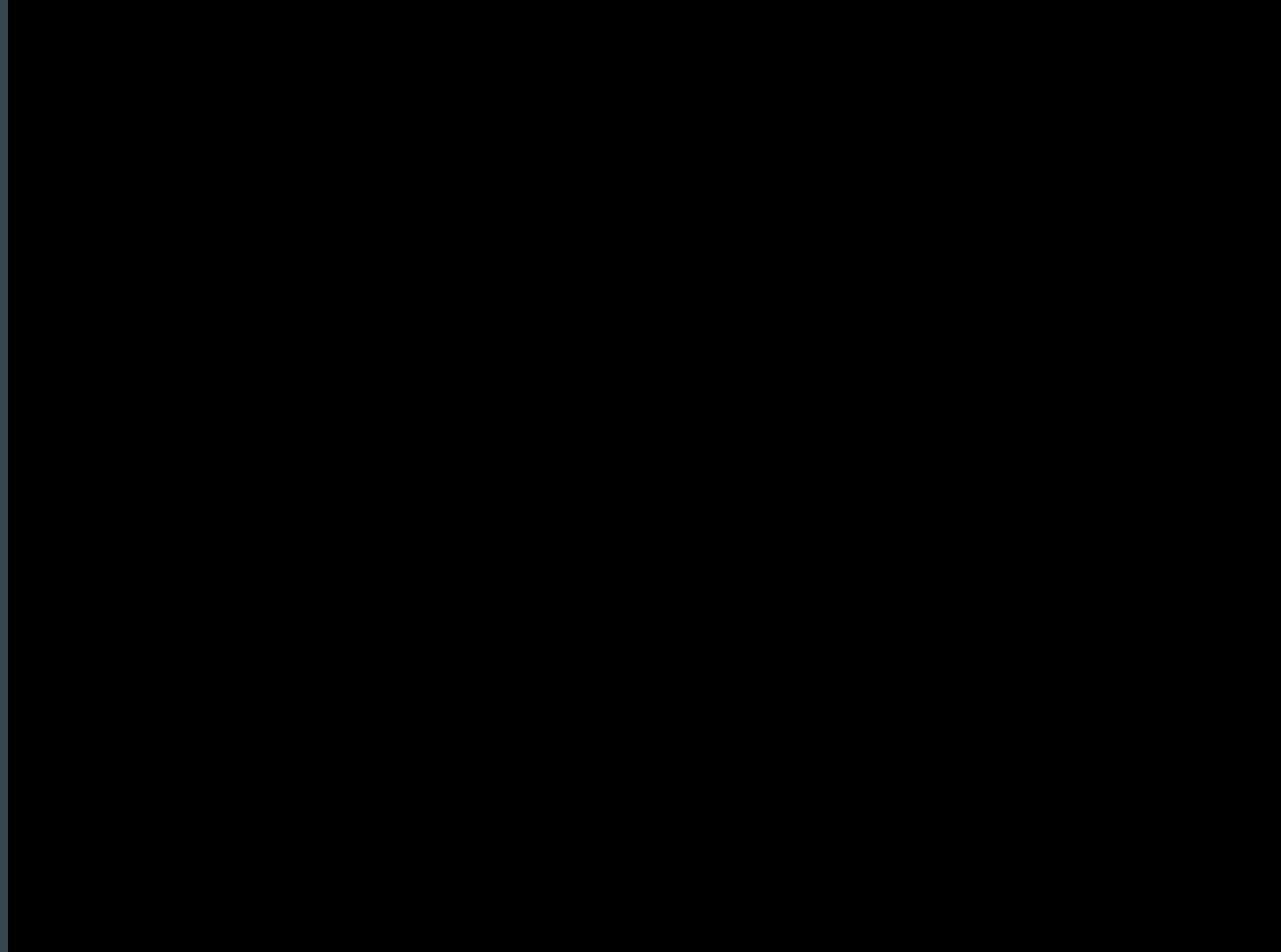
Chroma.js Color Scale Helper

This chroma.js-powered tool is here to help us mastering multi-hued, multi-stops color scales.

Enter named colors or hex codes: Step count:
 Bezier interpolation Correct lightness gradient

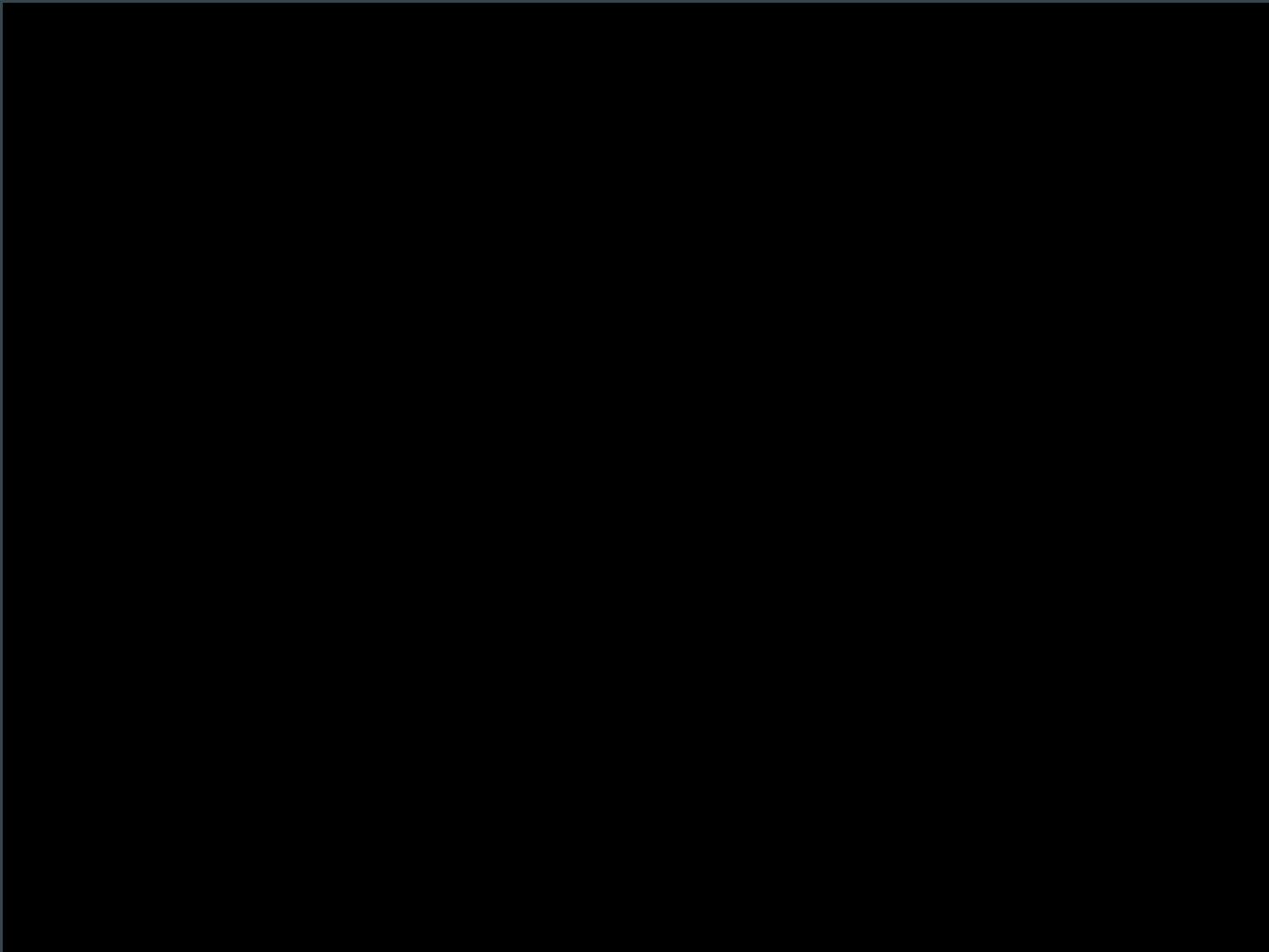


```
#ffffe0 #e0ebd1 #c3d6c4 #a8c2b8 #8fadad #7a98a4 #66839c #546c95 #455790 #35408d #23278b #00008b  
'#ffffe0','#e0ebd1','#c3d6c4','#a8c2b8','#8fadad','#7a98a4','#66839c','#546c95','#455790','#35408d','#23278b','#00008b'  
  
d3.scale.threshold()  
.range(['#ffffe0','#e0ebd1','#c3d6c4','#a8c2b8','#8fadad','#7a98a4','#66839c','#546c95','#455790','#35408d','#23278b','#00008b']);  
  
function palette(min, max) {  
    var d = (max-min)/12;  
    return d3.scale.threshold()  
.range(['#ffffe0','#e0ebd1','#c3d6c4','#a8c2b8','#8fadad','#7a98a4','#66839c','#546c95','#455790','#35408d','#23278b','#00008b']);  
    .domain([min+1*d,min+2*d,min+3*d,min+4*d,min+5*d,min+6*d,min+7*d,min+8*d,min+9*d,min+10*d,min+11*d,min+12*d]);  
}
```

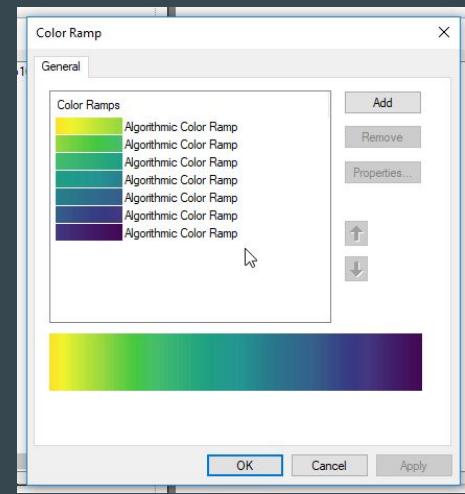
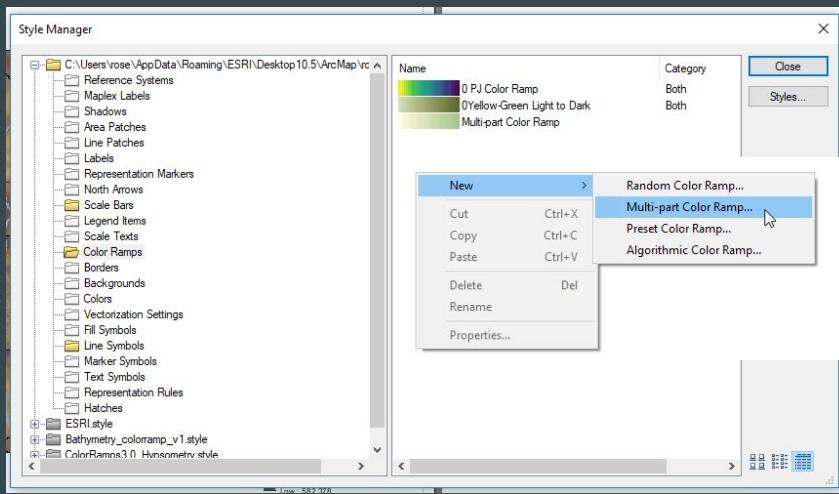
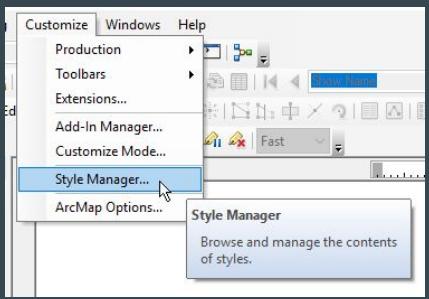


coolors.co/app

The screenshot shows the coolors.co/app web application interface. At the top, there is a navigation bar with the coolors logo, a Skillshare promotion for 2 months free, and links for Generate, Explore, iOS App, Add-on, Chrome Extension, More, Login, and Sign Up. Below the navigation bar, a message says "Press the spacebar to generate color schemes!". The main area features a color palette with five primary colors: a dark blue square on the left, followed by four horizontal bars in light green, orange, light blue, and yellow-orange. The orange bar has a small circular dot with the hex code "#9EB3A7" next to it, and a cursor is hovering over this dot. At the bottom of the palette, the hex codes for all five colors are displayed: #4A6176, #E59E72, #99CFD8, and #F8DFAF. The background of the page is a dark teal color.



ArcMap: Style Manager



illustrate data structure:

use other visualizations

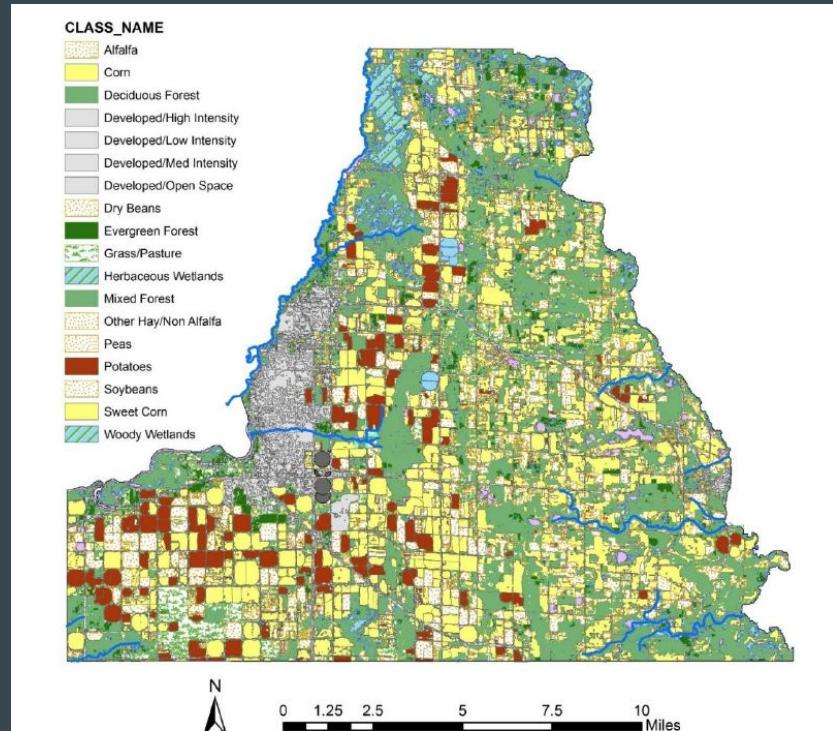
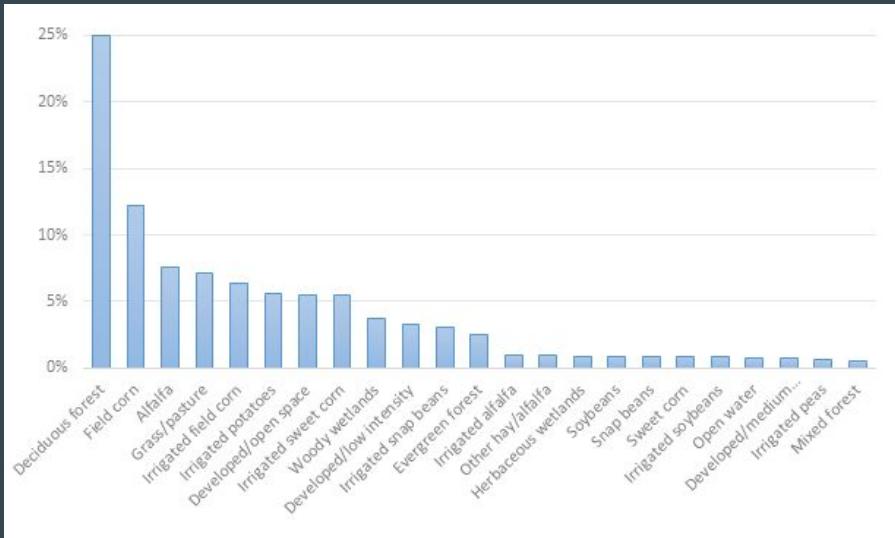


Figure 19. 2013 NASS CDL land use classification over the model domain. Validation fields are in blue. Del Monte recharge fields are in grey.

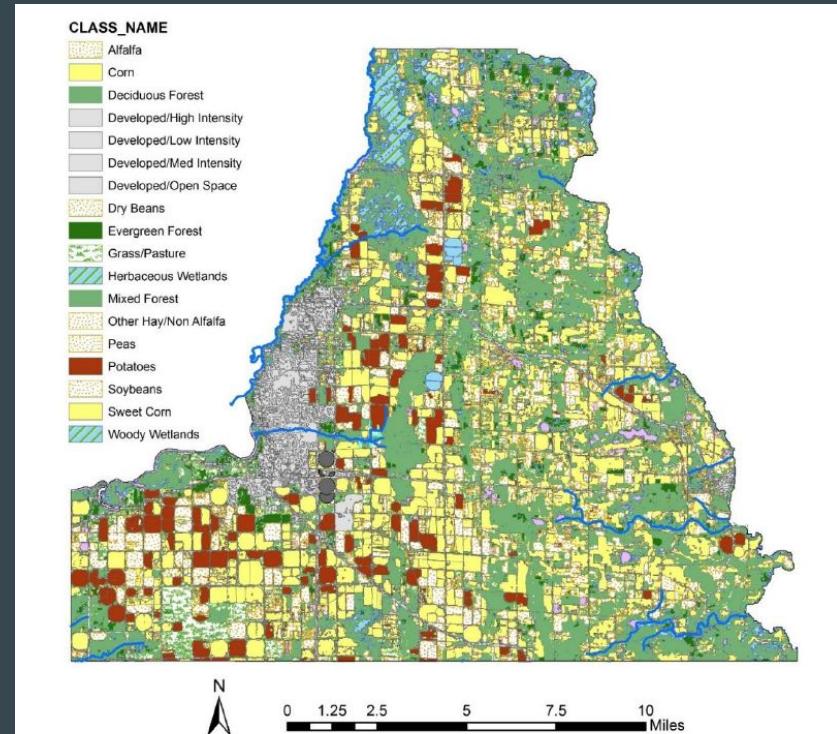
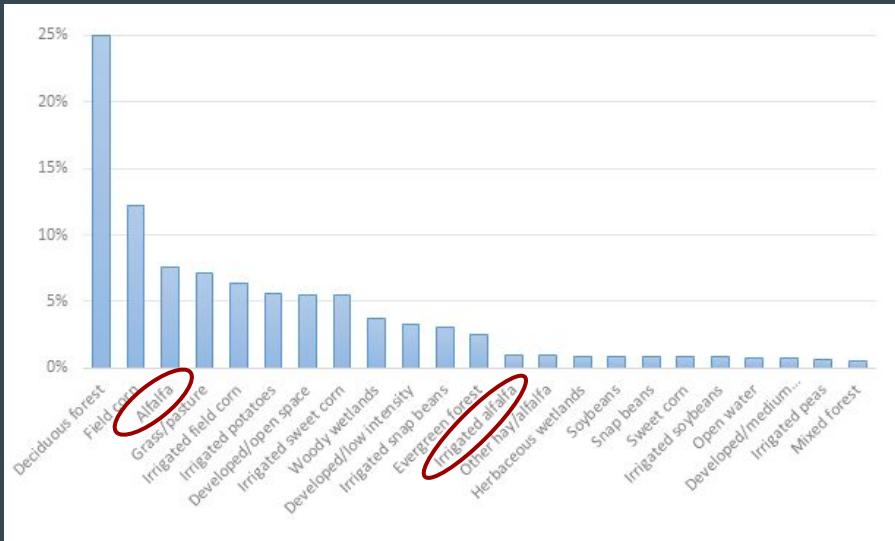
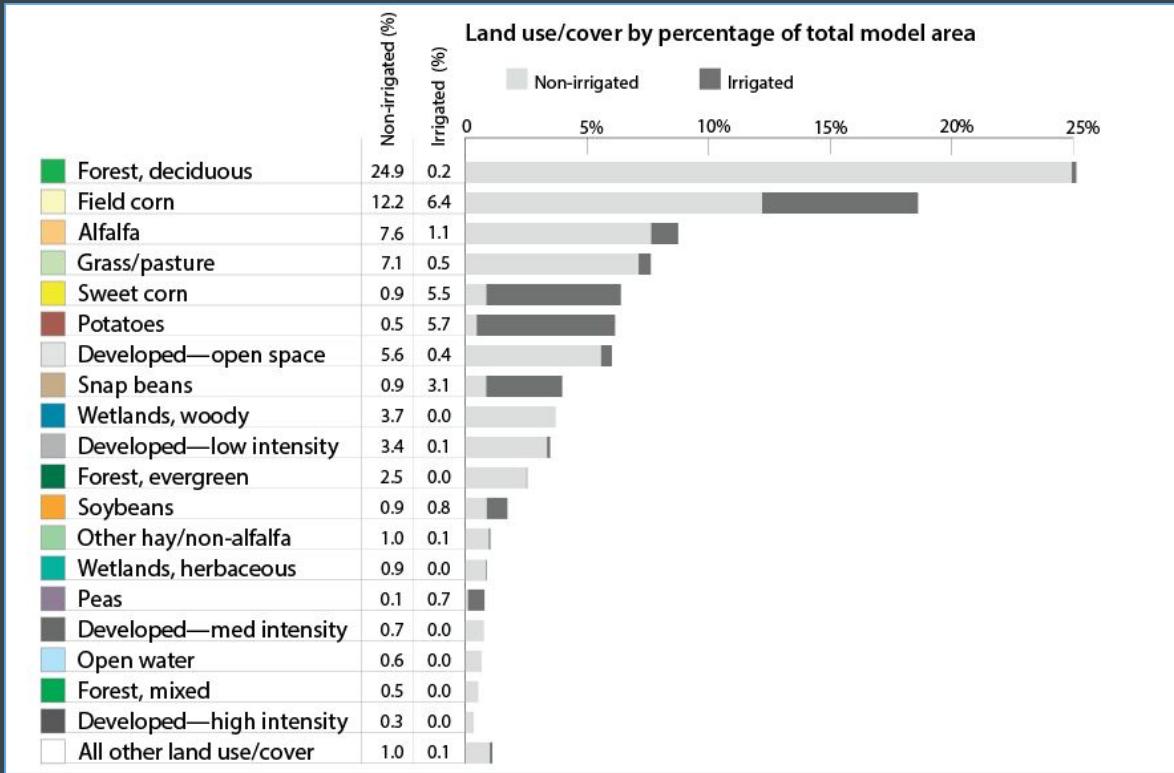
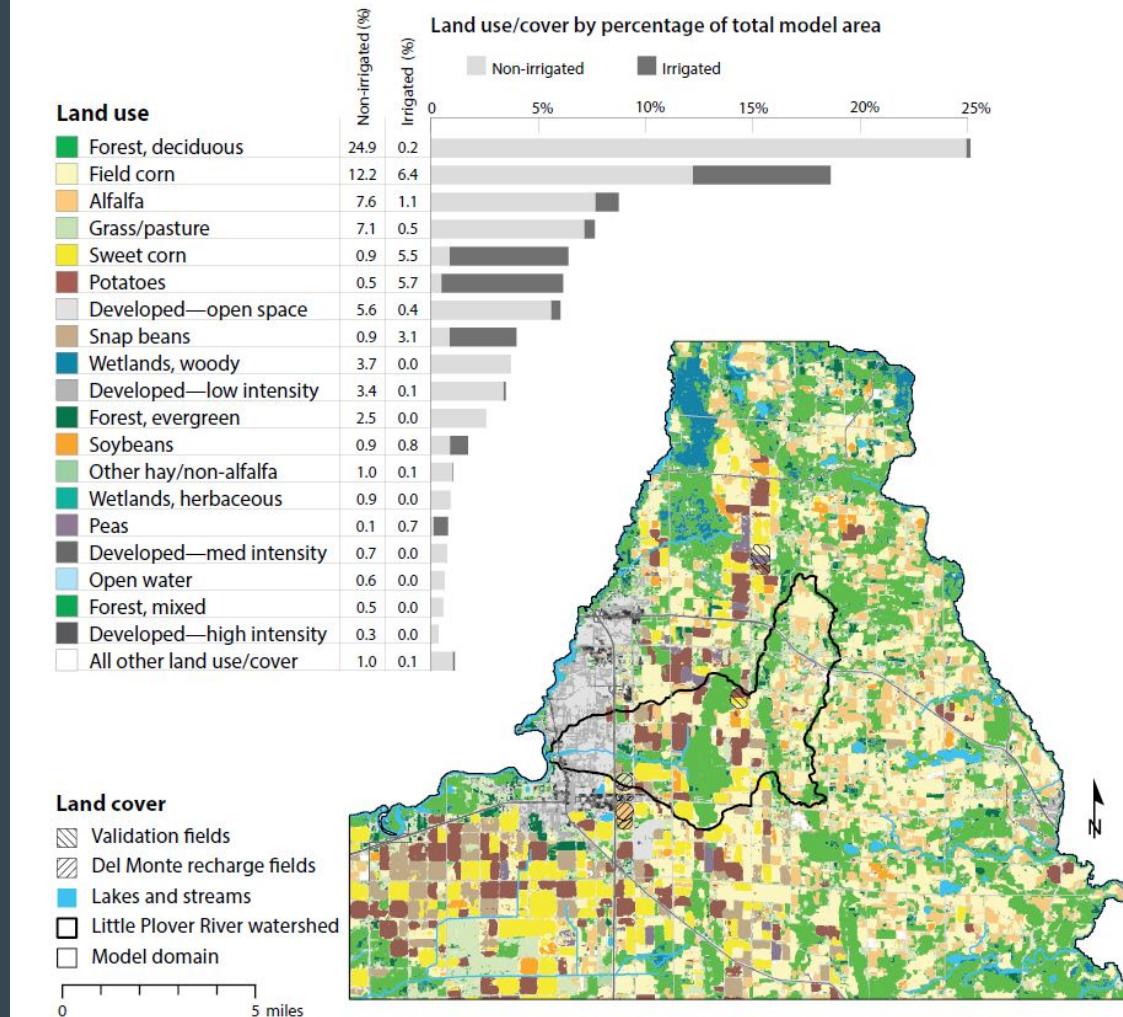
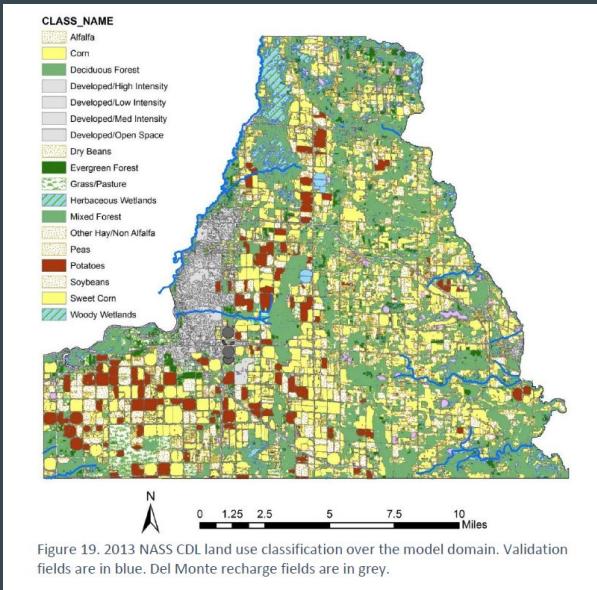
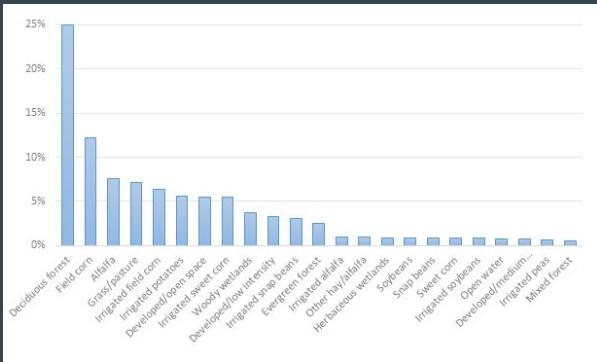
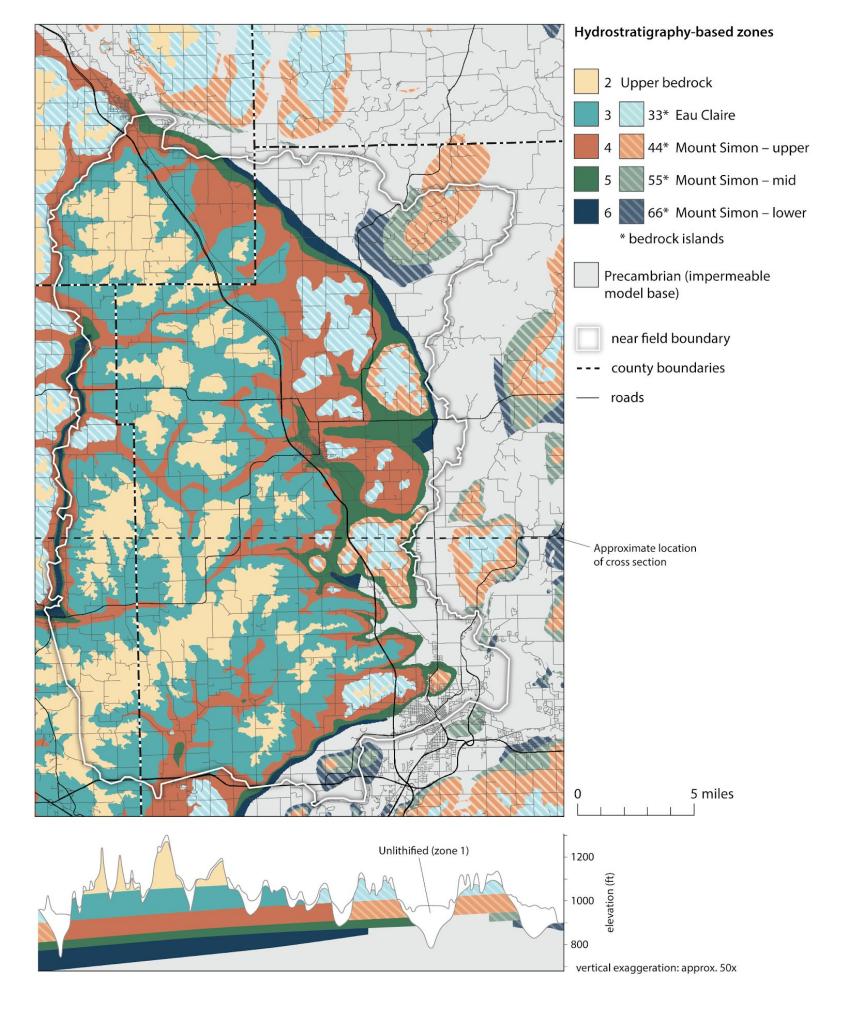


Figure 19. 2013 NASS CDL land use classification over the model domain. Validation fields are in blue. Del Monte recharge fields are in grey.







③

facilitate comparison

facilitate comparison:

consistent symbology

Simulated transient drawdown, with and without irrigation return

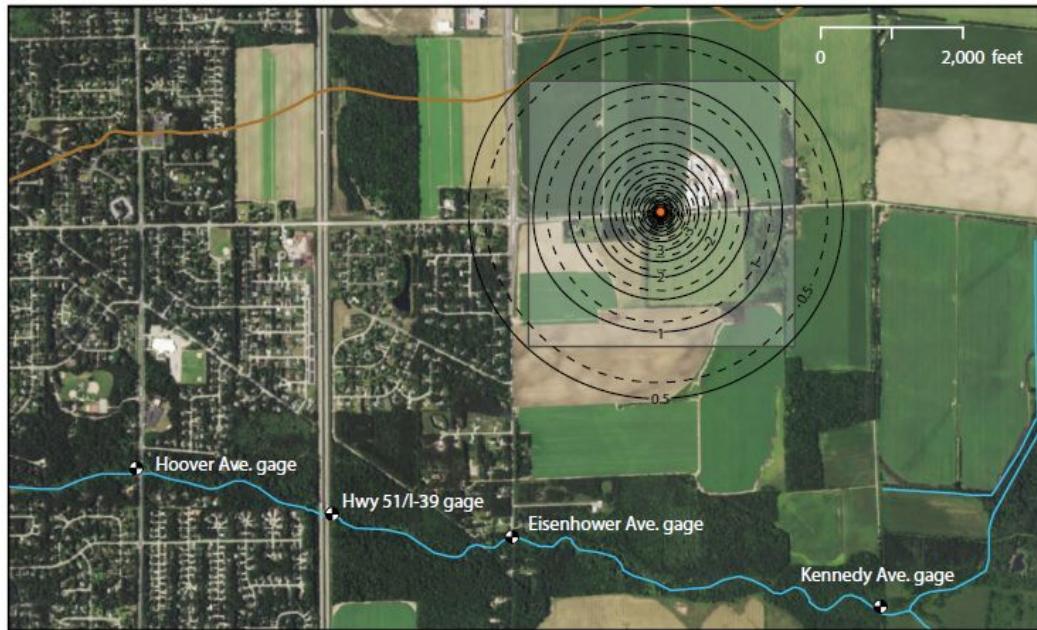
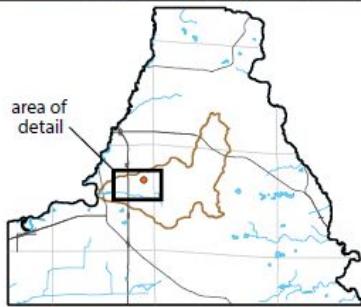


Figure 52. Simulated transient drawdown with and without irrigation return for a hypothetical new well. (Basemap source: Esri)



Cone of depression, with and without irrigation return

Without irrigation return



July



August



September

With irrigation return



Drawdown (in 0.5-ft intervals)

Steady state Transient

— With recharge
— Without recharge

● Hypothetical well

□ Area of added recharge from irrigation return

Figure 53. Expansion and contraction of cone of depression through time at the hypothetical new well, with (right) and without (left) irrigation return. (Basemap source: Esri)

facilitate comparison:

stretch to overall min/max

range of data
for this figure

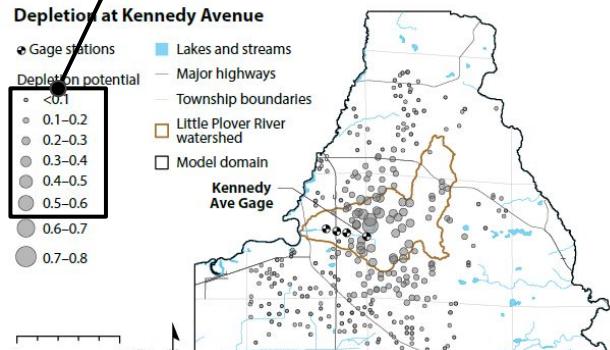


Figure 57. Depletion analysis at Kennedy Avenue.

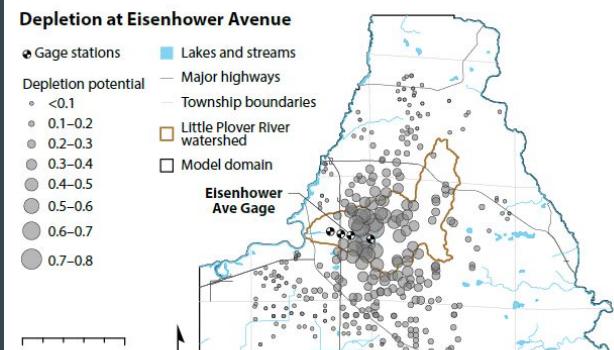


Figure 58. Depletion analysis at Eisenhower Avenue.

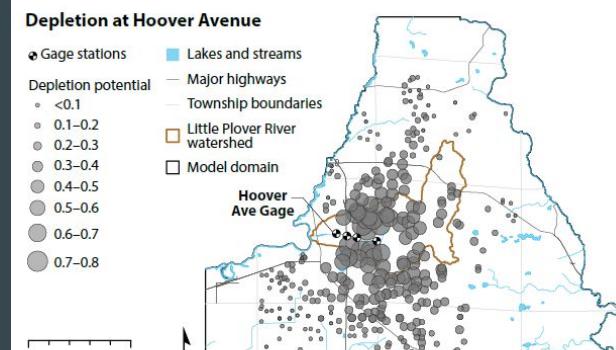


Figure 59. Depletion analysis at Hoover Avenue.

Water table,
predevelopment

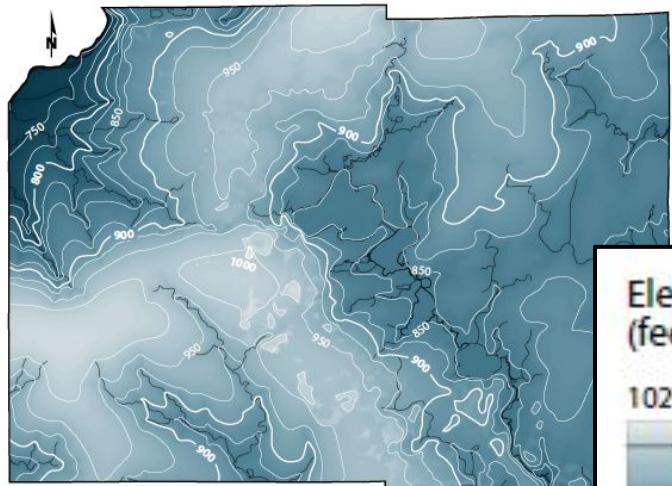
Elevation
(feet above sea level)

1020 ft max: 1020 ft

contour interval 25 ft

720 ft min: 720 ft

Major streams
and lake outlines



Water table,
2010

Well pumping rate
(mgd)

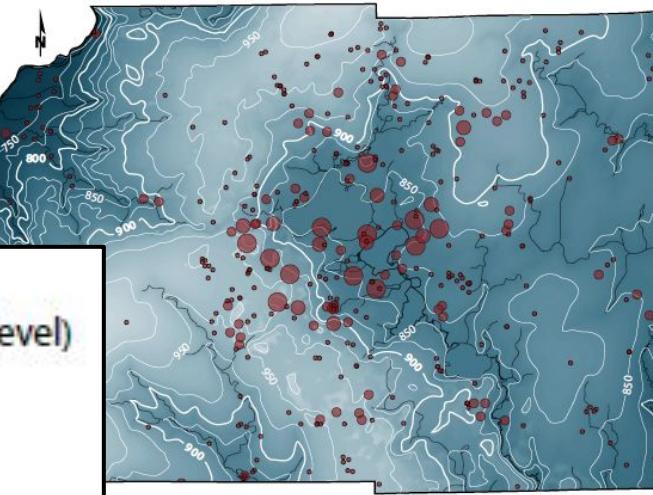
<0.1

0.1 - 0.5

0.5 - 1.0

>1.0

Elevation



Elevation (feet above sea level)

1020 ft

max: 985 ft

min: 730 ft

720 ft

Potentiometric surface,
Mount Simon (layer 12),
predevelopment

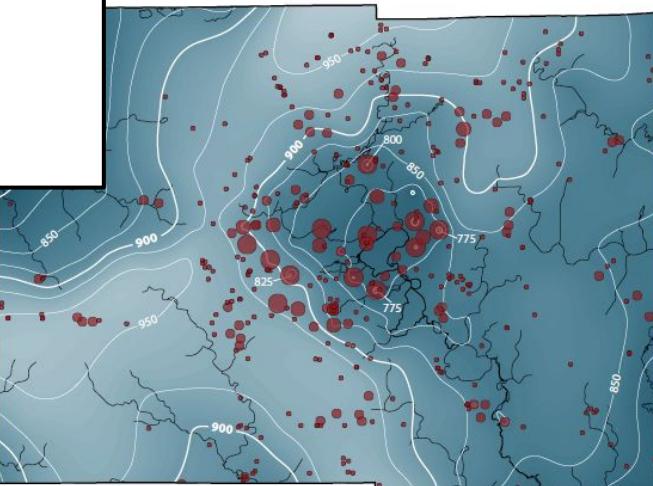
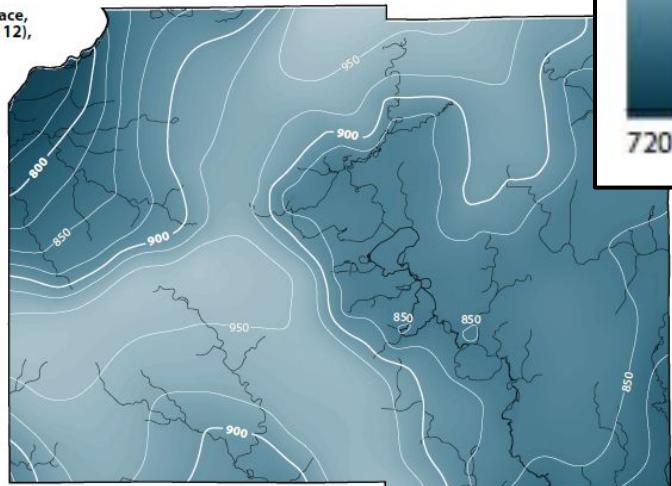
Elevation
(feet above sea level)

1020 ft max: 986 ft

contour interval 25 ft

720 ft min: 744 ft

Major streams
and lake outlines

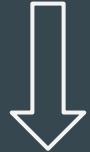


0 5 miles

0 5 miles

recap

what should the reader learn from this image?



design purpose

1

focus attention

represent nothing with nothing

create a visual hierarchy

②

illustrate data structure

choose color schemes to match data

use other visualizations

③

facilitate comparison

use consistent symbology for the same dataset

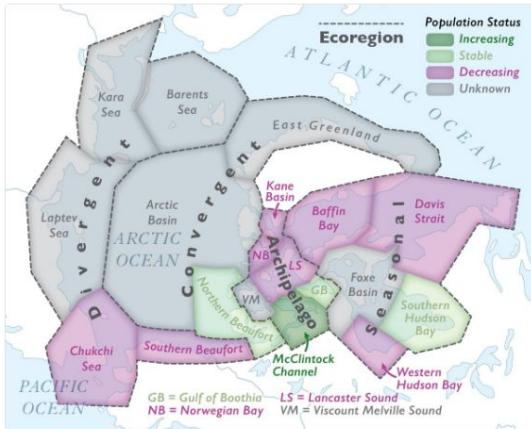
stretch different datasets to the same min/max

learn and share

Daniel P. Huffman
@pinakographos

Following

#PractiCarto 43: You can create a stronger association between a feature & its label by using the same or similar colors for each.



8:05 AM - 13 Jun 2017

12 Retweets 38 Likes



Hans van der Maarel @redgeographics · 30 Jun 2017

Text alignment along a path causing you grief? Try adding a thin space
#Practicarto

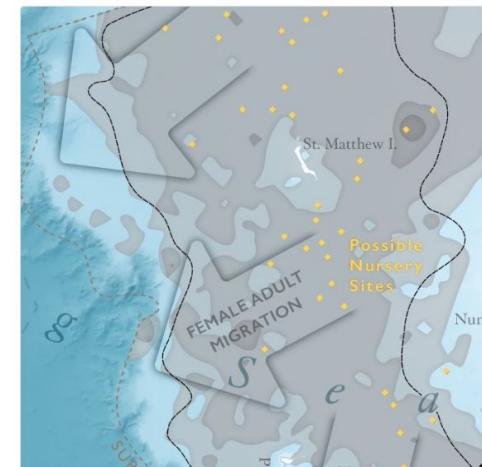


#practicarto

Daniel P. Huffman
@pinakographos

Following

#PractiCarto 46: You can layer data clearly by making good use of negative space, such as these invisible-but-shadowed arrows.



7:55 AM - 11 Jul 2017

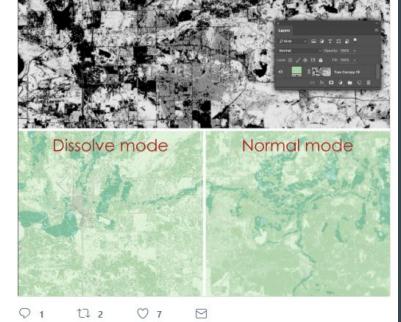
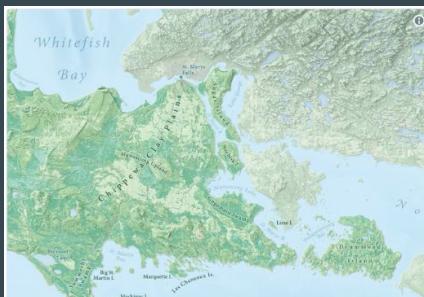
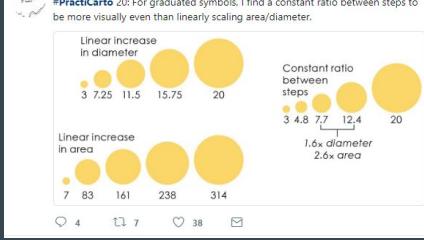
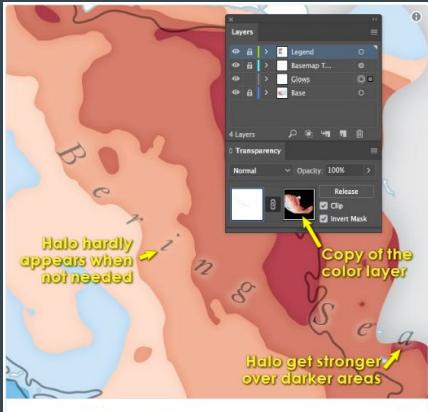
11 Retweets 55 Likes

#practicarto

Vanessa KW @run_for_funner Following

Making label halos slightly transparent often (not always) can really help with legibility - especially with data underneath. #practicarto

8:08 AM - 2 Nov 2017
5 Retweets 25 Likes

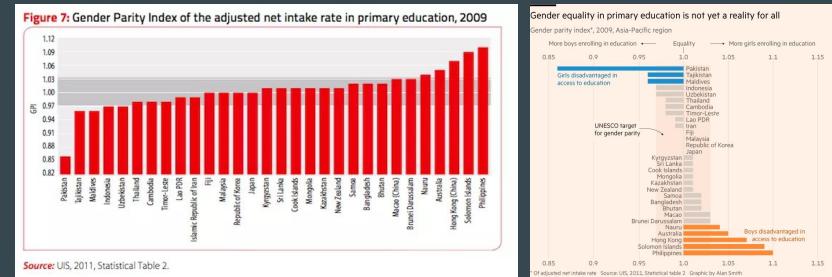


Further reading

“Design and Redesign in Data Visualization” by Fernanda Viégas & Martin Wattenberg
https://medium.com/@hint_fm/design-and-redesign-4ab77206cf9

“Data visualisation mistakes — and how to avoid them” by Alan Smith

<https://www.ft.com/content/3b59f690-d129-11e7-b781-794ce08b24dc>



Further reading

lisacharlotterost.github.io

“Why Do We Visualise Data?” by Lisa Charlotte Rost:

<https://lisacharlotterost.github.io/2017/03/10/why-do-we-visualize-data/>

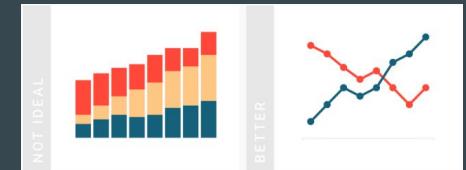
“What to consider when creating stacked column charts” by Lisa Charlotte Rost:

<https://blog.datawrapper.de/stacked-column-charts/>

“How The Rainbow Color Map Misleads” by Robert Kosara

<https://eagereyes.org/basics/rainbow-color-map>

“Anscombe's quartet” https://en.wikipedia.org/wiki/Anscombe%27s_quartet



Further reading

“Why Luminance Is The Key Component Of Color” by Stephen Bradley

<http://vanseodesign.com/web-design/color-luminance/>

“The Rainbow is Dead... Long Live the Rainbow!” by Matteo Niccoli

<https://mycarta.wordpress.com/2012/05/29/the-rainbow-is-dead-long-live-the-rainbow-series-outline/>

“Rainbow Color Map Critiques: An Overview and Annotated Bibliography” by Steve Eddins

https://www.mathworks.com/tagteam/81137_92238v00_RainbowColorMap_57312.pdf

“Perceptually Driven Visibility Optimization for Categorical Data Visualization” by Sungkil Lee, Mike Sips, and Hans-Peter Seidel

<http://ieeexplore.ieee.org/document/6365630/figures>

Thank you!

github.com/cmrRose/talks

caroline.rose@wgnhs.uwex.edu
@cmrRose