Parcel Environmental Benefit Assessment Tool

Expanded Documentation

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Table of Contents

Key Scoring Concepts

Indices

Our environmental benefit metrics are presented in the form of indices. An index is useful for conveying prioritization within a defined area (i.e., the state of Minnesota), because the highest value can be mapped to 1 and the lowest to 0 while still maintaining the relative distributions of priority within (e.g., 0.8 is much higher priority than 0.2).

Indices were also important when we wanted to use multiple datasets to inform prioritization. For example, in our lake recreation metric we indexed the sub-scores for phosphorus sensitivity, amenities, and social media based visitation. This allowed us to perform a weighted sum of components that were originally in different units. We calculated indices by subtracting the lowest observed value from every value in the dataset and then dividing each value by the range observed in the dataset. As an example, imagine our soil carbon data were composed of 5 observations:

Original data (Mg/ha)	Indexed value
23	0
176	1
40	0.11
105	0.54
92	0.45

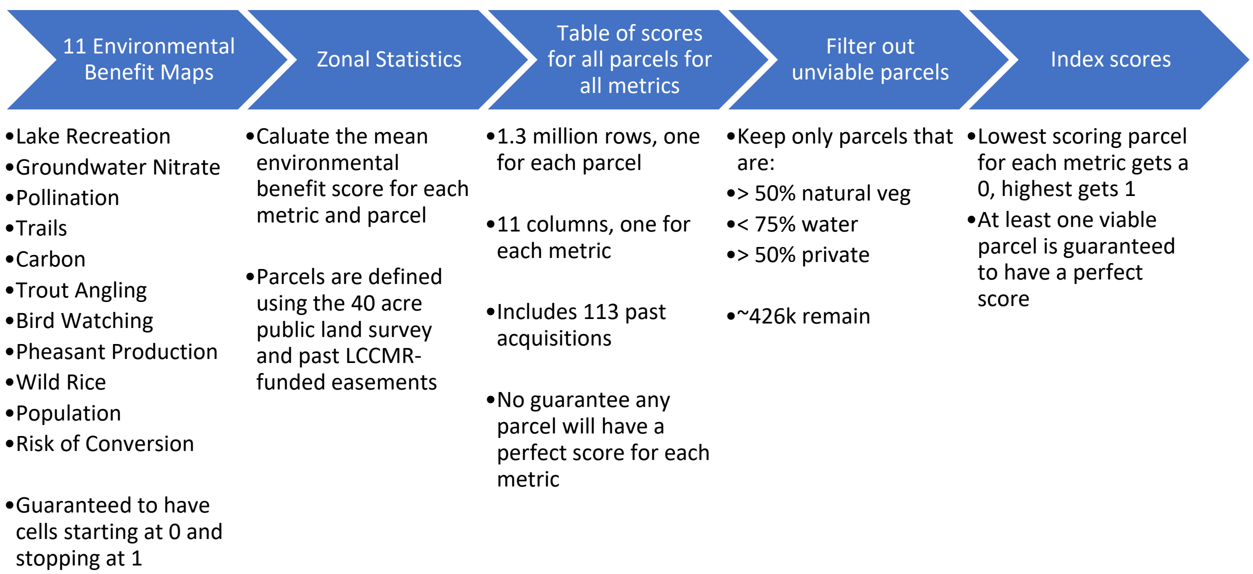
Endpoints

Endpoints are a geographic area where an environmental benefit is produced. Some services, such a soil carbon, are produced almost everywhere, and do not have specific endpoints. Others, such as drinking water protection from nitrate contamination, are only produced only in the recharge area for a wellhead. Our environmental benefit metrics are statewide maps, but if the service is specific to an endpoint, the scores outside of the endpoint are zero. The definition of the endpoint is provided in the metric documentation below.

Base Scores

Many of our metrics provide prioritization between and within endpoints. To represent the scarcity of endpoint based metrics relative to those that are produced broadly, we assign a base score to any land that is with the endpoint of metrics for wild rice, lake recreation, trout angling, trails, and groundwater nitrate. Endpoint base scores were also used to refine prioritization in the pollination metrics. We did not perform further prioritization on endpoints in the wild rice or trails metrics, therefore their base scores are 1. For the remaining metrics, we selected a base score of 0.2 to ensure land in an endpoint stood out against land that does not contribute to that service, but also reserved enough of the total possible score to prioritize between and within endpoints.

Flow chart



Parcel Data Preparation

Parcel Data

We used 40 acre public land survey parcels as an approximation for the scale that land management decisions are made. They are intended as an approximation of management boundaries; they do not capture sub-division and other changes over time. Specifically, we used plsown_fortypy3.shp, which is the version modified to better match the MNDNR Land Records. We further modified it by removing three polygons that represented large lakes (GM_CH = '4000000000099', '11000000000099', and '48000000000099'). We then split apart (with an operation commonly known as also known as ‘explode’) multi-part polygons and assigned all parcels a new unique identifier.

Viable Parcel Criteria

Due to sub-division and management changes, our parcel data may not align with all management or ownership boundaries. We used thresholds to determine if they should be included in the ‘viable’ comparison set. We included parcels that were > 50% natural vegetation, < 75% water, > 50% privately held.

To calculate the proportion of each land cover in each parcel, we performed zonal statistics using the University of Minnesota’s Minnesota Land Cover Classification and Impervious Surface Area by Landsat and Lidar: 2013 update - Version 2. We grouped the continuous measurement of imperviousness into three categories to facilitate analysis as categorical data. Although newer land cover maps are available from the Cropland Data Layer, these are optimized for crop detection, rather than non-agricultural land covers. The U of M data is also higher resolution and uses modern object-based classification techniques. It was the preferred land cover map in this analysis unless crop specific information was required.

To create a comparison set of viable parcels we excluded publicly held land. We also excluded land that was privately held but was already protected with a conservation easement, or by a private conservation NGO. We performed zonal statics on a raster containing several merged layers of ownership data to get the proportion each parcel that is privately held. The datasets and assumptions we used to define public land are described below, and implemented in the script define_viable_parcels.py.

Data layer: Natural Resources Conservation Service Easements

URL: available from the Geospatial Data Gateway

Additional processing: We only included the subset of permanent easements.

Data layer: State Surface Interests Administered by MNDNR or by Counties

URL: https://gisdata.mn.gov/dataset/plan-stateland-dnrcounty

Additional processing: This layer does not contain the exact boundaries of parcels, but rather records what proportion of a PLS 40 acre parcel is held by the state. Some records were missing data for the proportion of the parcel that is held by the state, but did have the absolute area. We calculated the proportion for all parcels using the value for absolute area of the state and the GIS calculated area of the parcel. Our analysis is conducted at the PLS 40 acre level, so we defined publicly held as those with greater than 50% held by the state. We excluded any interests that were not matched at the forty/glot level because they could not be mapped precisely enough for this analysis and there were very few interests not matched at this level. We applied this processing to two layers in the state surface interests layer; land held in fee-title and permanent conservation easements.

Data layer: GAP Stewardship 2008

URL: ftp://gdrs.dnr.state.mn.us/gdrs/data/pub/us_mn_state_dnr/plan_gap_stewardship_2008.zip

Additional processing: We used a subset which included parcels where the 'OWNER_DESC' attribute was equal to: county, federal, other public, or private conservancy.

Data layer: Protected Areas Database of the United States (PAD-US) version 1.4

URL: https://gapanalysis.usgs.gov/padus/data/download/

Additional processing: We used a subset which included only land that had a protection status of 1 or 2, which corresponds to land managed for biodiversity. We also excluded the category as 'Designation' because it can include private unprotected land.

Data layer: State Funded Conservation Easements (RIM Reserve)

URL: https://gisdata.mn.gov/dataset/bdry-bwsr-rim-cons-easements

Additional processing: We used a subset which included only permanent easements. We also excluded the category ‘ACUB’ (Army Compatible Use Buffer) because these easements prevent development, but not agriculture.

Due to uncertainty in land cover and ownership maps, we do not exclude any land from the underlying environmental benefits that are used to score a proposed acquisition. It is the responsibility of the user to propose parcels that are undeveloped and not already protected.

Past Acquisitions Data Preparation

Identifying Data Inconsistencies

Spatial and cost data were provided by the LCCMR, with recent entries acquisitions manually updated with information available on the LCCMR website. While recent LCCMR acquisitions have relatively consistent data, acquisitions prior to 2010 sometimes had inconsistencies that needed to be addressed before inclusion in the past acquisitions comparison data. We cannot include any acquisition that does not have spatial data of the boundaries available, which was not typical prior to 2007. Inconsistencies fell into two main categories; spatial data, and contributions to the total project costs. The source data and code used to identify inconsistencies and apply other corrections is available in the script past_acquisitions_prep.py in the expanded base data.

We identified inconsistencies in spatial data by calculating the area of each of the provided parcel boundaries and comparing it to the reported size of the acquisition. Differences typically occurred when multiple parcels were lumped together in one data source but not the other, or when a point was converted to a small polygon instead of the complete boundaries of a parcel. When the reported and calculated sizes were notably different, the acquisition was excluded.

To identify manual corrections in cost data, we compared ‘enrtfdollars’/’totalfundsdollars’ to ‘enrtfpercent’. ‘enrtfdollars’ is the expenditures from the Environment and Natural Resources Trust Fund (ENRTF), ’totalfundsdollars’ is the total cost of the project which includes funding from all sources, and ‘enrtfpercent’ is the proportion of the total costs paid by the ENRTF. If the breakdown of organization contributions and the total cost were consistently reported, these values should be the same. If the difference was less than +/- 2 it was assumed to be due to rounding and was ignored. For larger differences, the larger of either ‘totalfundsdollars’ or the sum of all funding sources (i.e., ‘enrtfdollars’, ‘othersfdollars’, ‘fedfundsdollars’, ‘reglocaldollars’, ‘npfundsdollars’, bargaindollars, otherfundsdollars, and related professional costs), was used as the total project cost which was in turn used to calculate a new ‘enrtfpercent’. To be consistent in our calculations and maximize use of the most reliable data (i.e., the expenditures of the ENRTF) we divided the ‘enrtfdollars’ by ‘enrtfpercent’ to give the total project costs. Other errors such as recording percentages as a fraction of 1 or not calculating the percentage were also corrected.

Adjusting for Inflation

We adjusted the costs of past acquisitions to 2016 dollars using the Consumer Price Index from the Bureau of Labor Statistics.

Excluded Parcels

To be consistent with our metrics designed for conservation easement prioritization, we excluded fee-title acquisitions from the past acquisitions comparison set. We also excluded agricultural easements from Rural Advantage and short term “3rd crop” easements, as they have already been converted to agriculture.

After filtering out inconsistencies, adjusting for inflation, and excluding inappropriate comparisons, 97 conservation easement acquisitions remained. Their scores and price per acre can be viewed in the scatter plots in the metric descriptions below. Note that for display purposes two acquisitions with costs above $31,000 an acre are not shown, however, those values are included in the mean ROI comparison metrics.

Risk of Conversion

Overview

We calculated risk of conversion by modeling the probability that a location will convert from natural land to developed land. This is a preliminary metric based on new, ongoing research at the University of Minnesota (see Hyejin et al., 2018[1] for more details). To determine which grid-cells have the highest risk of conversion, the metric combines coarse-scale projections of land-use change from the Intergovernmental Policy Platform on Biodiversity and Ecosystem Services and the Land-Use Harmonization project (LUH) with fine-scale data on conversion probability based on physical suitability, adjacency to existing land-use types and conversion constraints for each grid-cell.

High priority parcel description

Endpoint: Statewide

A high priority parcel:

- has a high probability of converting to agriculture or human development
- is near existing agriculture or development
- is in a 30 km^2 gridcell projected to have high expansion of cropland or human development
- has high suitability for agricultural expansion (in terms of potential yield) or human development (physically suitable location)

Data sources

Land-use, land-cover data from the European Space Agency's Climate Change Initiative

https://www.esa-landcover-cci.org/

Coarse land-use, land-cover projections based on Shared Socioeconomic Pathways

Defined by the Intergovernmental Science/Policy Platform on Biodiversity and Ecosystem Services, provided by the Land-Use Harmonization project (available at

[1] Kim, HyeJin, et al. "A protocol for an intercomparison of biodiversity and ecosystem services models using harmonized land-use and climate scenarios." *bioRxiv* (2018): 300632.

http://luh.umd.edu/data.shtml, based on the RCP7.0, SSP3 states.nc file http://gsweb1vh2.umd.edu/LUH2/LUH2_v2f/AIM/multiple-states_input4MIPs_landState_ScenarioMIP_UofMD-AIM-ssp370-2-1-f_gn_2015-2100.nc

Climate data from Worldclim version 2.0

http://worldclim.org/version2

Soil data from ISRIC

https://soilgrids.org/#!/?layer=TAXNWRB_250m&vector=1

Digital elevation map from Hydrosheds
https://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=3dirb

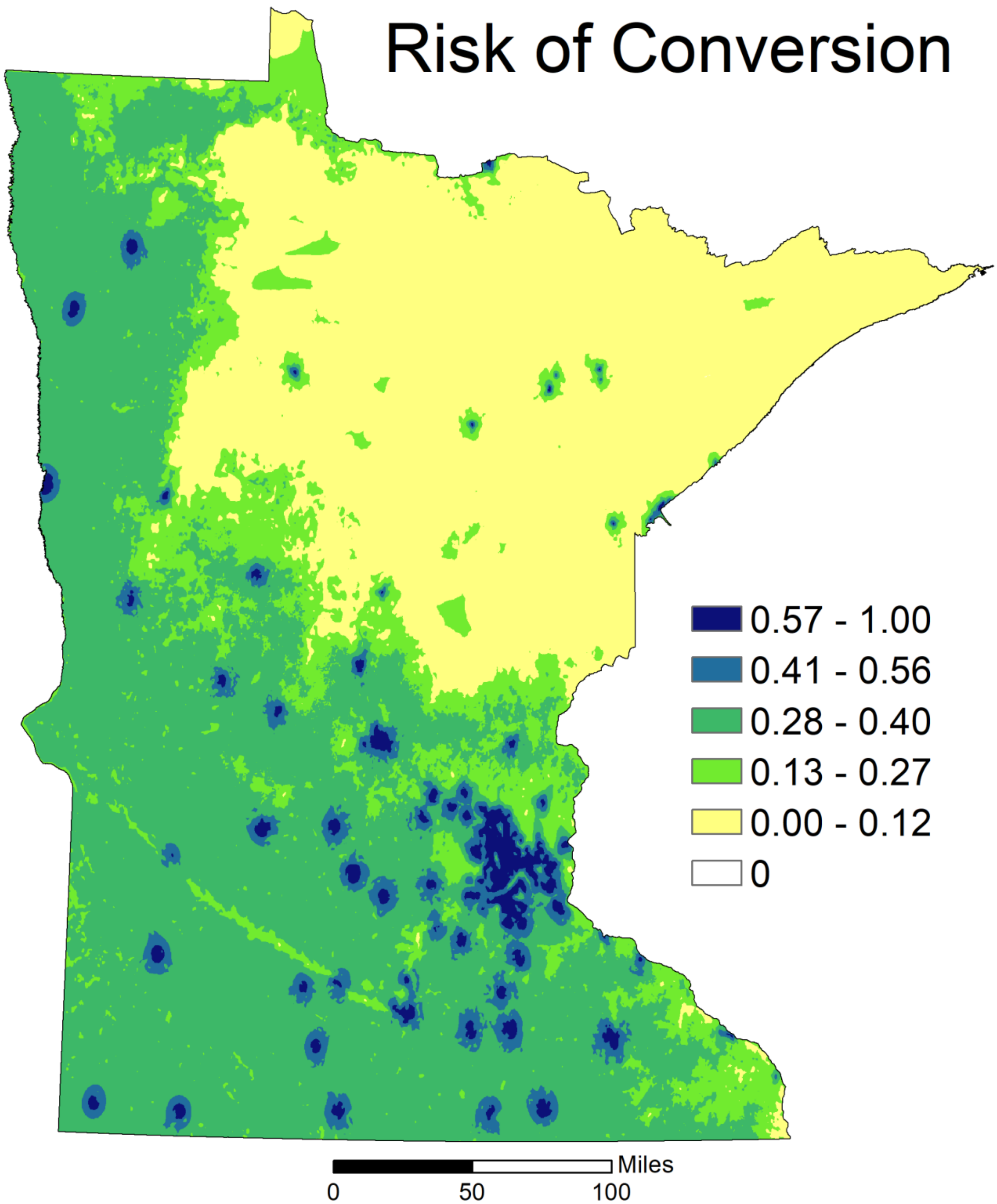
Crop suitability from the Food and Agriculture Organization of the United Nations Global Agro-Ecological Zones project

http://www.fao.org/nr/gaez/en/

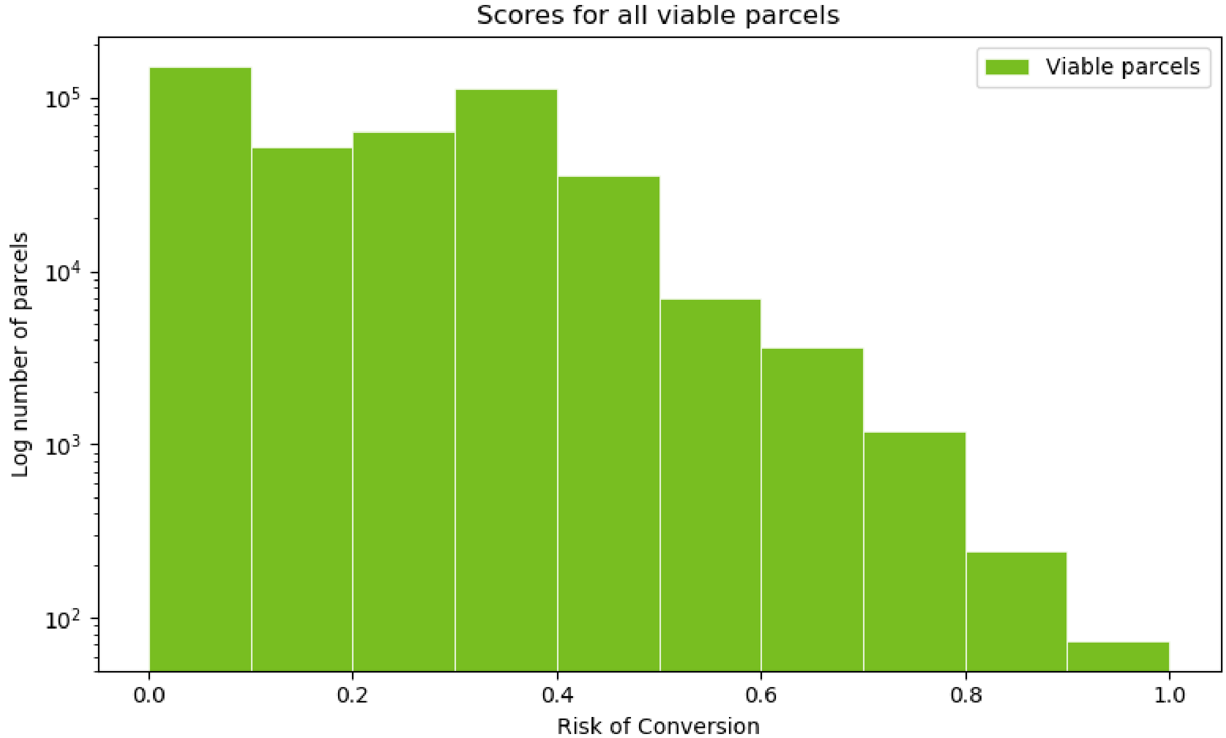
Data preparation

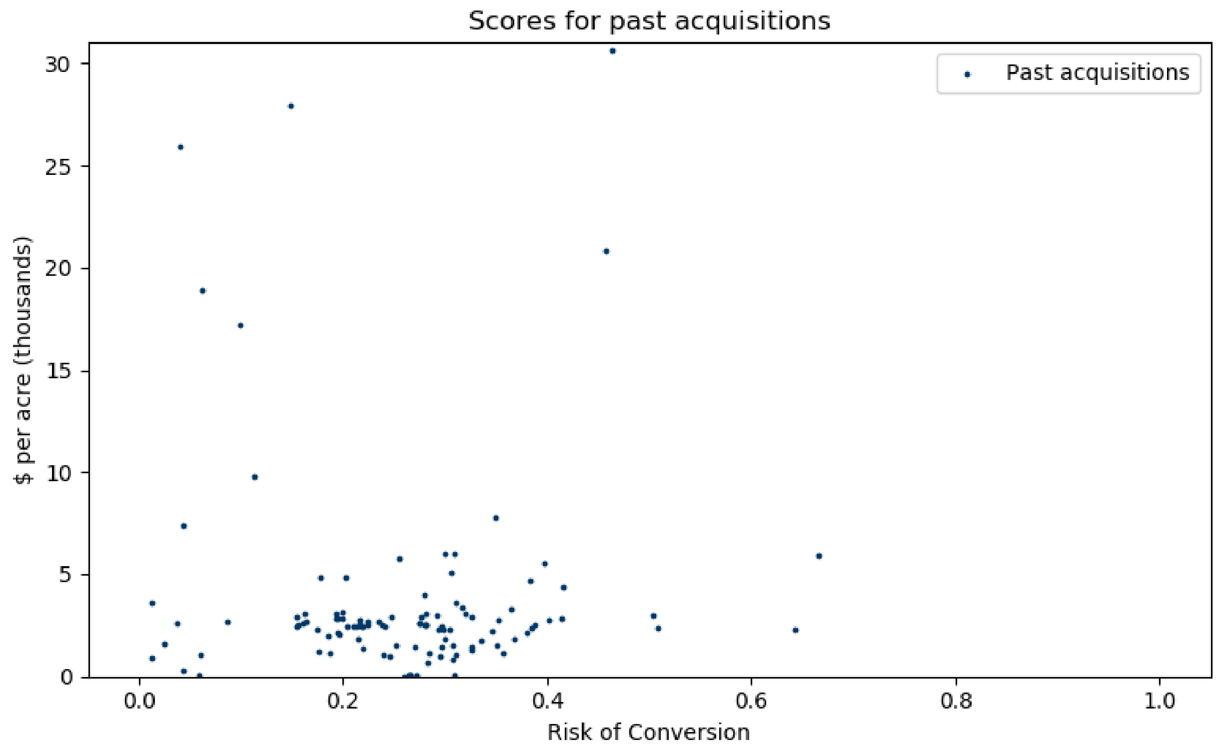
Soil data for organic carbon content, digital elevation data and land-use, land-cover were combined via log-normalized, equal weighted sum-product to produce a proxy of land-suitability. The DEM data were processed further to calculate topographic roughness indicator and topographic ruggedness indicator for physical suitability. Crop suitability was from GAEZ and was also log-normalized and included via equal-weighted sum-product for the cropland-specific risk of expansion. Adjacency suitability was calculated for agriculture and urban expansion separately for each other LULC class in the ESACCI data based on expert calibration to best match observed predictions in the prior time-series of ESACCI LULC data. The physical suitability was log-normal multiplied by adjacency suitability to get overall suitability, which was then multiplied by the projected changes in the LUH data to get weighted adjacency suitability, which was then log-normalized. The risk of conversion metric is the weighted sum of the risk of conversion to agriculture and risk of conversion to urban, where the weight is determined by the proportion that each of those land covers expanded in MN according to coarse global projections from the Land-Use Harmonization project.

Map


Risk of Conversion
0.57 - 1.00
0.41 - 0.56
0.28 - 0.40
0.13 - 0.27
0.00 - 0.12
0
Miles
0
50
100

Score distributions





Nearby Population

Overview

The nearby population metric represents the proportion of the state's population that can easily access the benefits of a proposed acquisition. We assumed nearby population to be the people residing within a radius of 50 miles from each parcel. This distance is based on the US National Tourism Resources Review Commission's definition of a "day trip". The population within 50 miles was calculated using the EPA's 30 meter population map. Higher scoring parcels are those with higher nearby population.

High priority parcel description

Endpoint: Statewide

A high priority parcel:

- has a high proportion of the state's population within 50 miles

Data sources

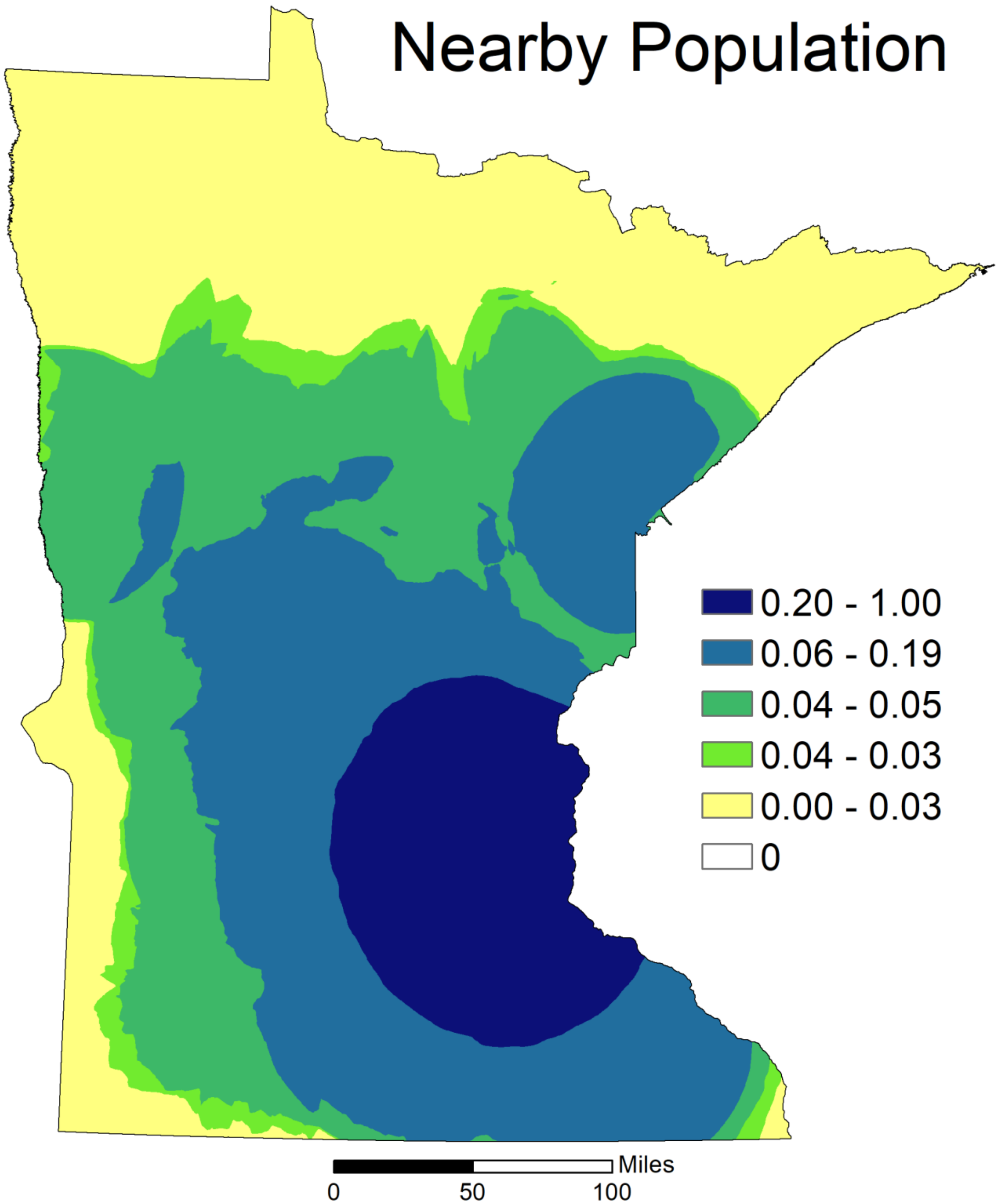
Dasymetric Allocation of Population Raster

ftp://newftp.epa.gov/epadatacommons/ORD/EnviroAtlas/dasymetric_us_20160208.zip

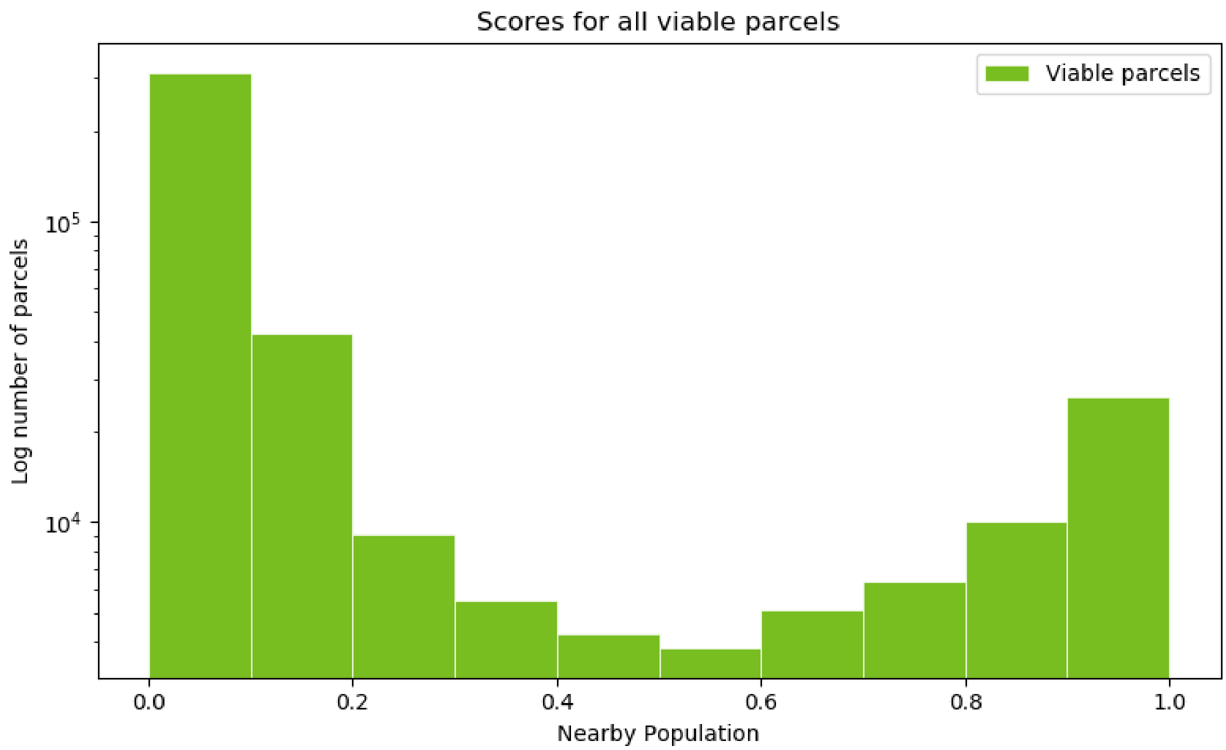
Data preparation

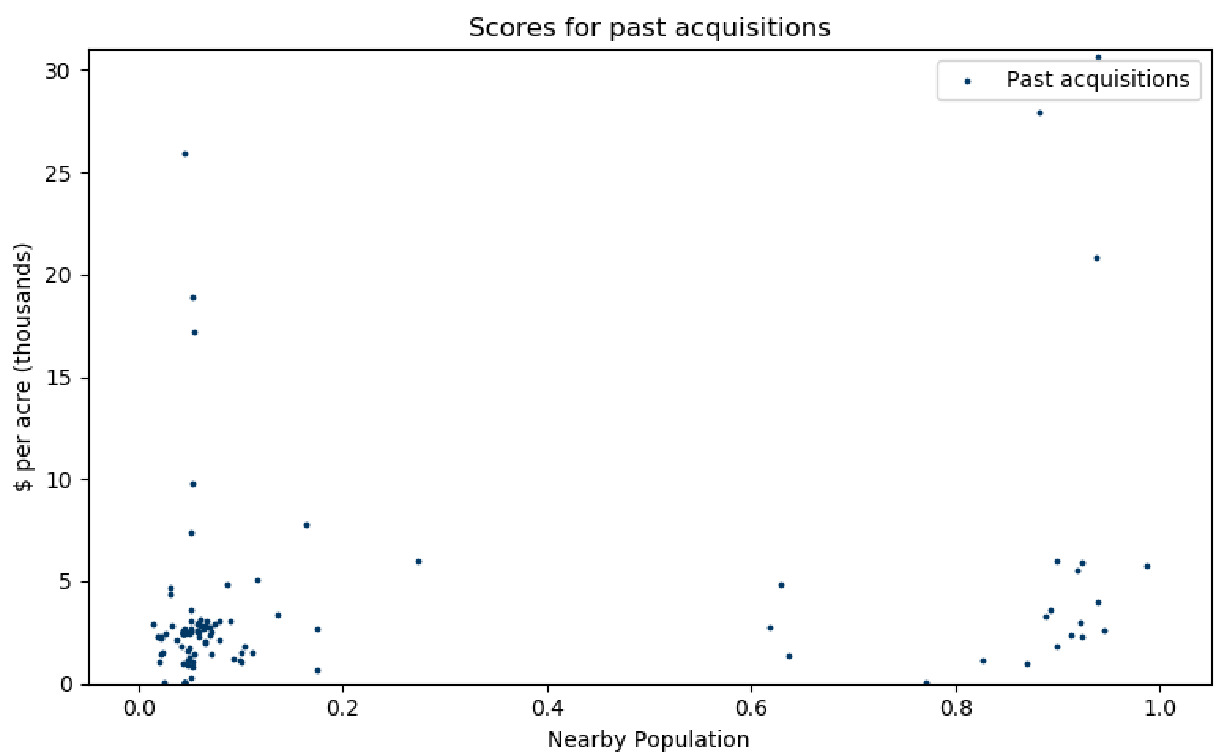
We clipped the EPA's national dasymetric allocation map to the extent of Minnesota and then used ArcGIS focal statistics to calculate the sum of all of the cells within 50 miles of each cell. We selected 50 miles based on the US National Tourism Resources Review Commission's definition of a "day trip" (National Tourism Resources Review Commission, 1973). We divided the population within 50 miles of a cell by the total population of the state (i.e. the sum of all cells in the population map) to produce a map of the proportion of the population of the state within 50 miles of each cell and indexed the result to a zero to one scale.

Map


Nearby Population
0.20 - 1.00
0.06 - 0.19
0.04 - 0.05
0.04 - 0.03
0.00 - 0.03
0
Miles
0
50
100

Score distributions





Soil Carbon

Overview

Carbon stored in the soil can be emitted to the atmosphere when land is developed. We created the soil carbon metric by multiplying the bulk density and percent carbon maps published in Ramcharan (2017). Soil carbon storage benefits are provided throughout the state, but some regions have much higher concentrations of soil carbon than others. For example, north central Minnesota has some of the highest concentrations of soil carbon in the state, often more than 15 times greater than soil in southern Minnesota. High scoring parcels are in carbon-rich areas.

High priority parcel description

Endpoint: Statewide

A high priority parcel is:

- has a high average soil organic carbon content

Data sources

Soil Properties and Class 100m Grids United States (Ramcharan et al., 2017a)

https://doi.org/10.18113/S1KW2H

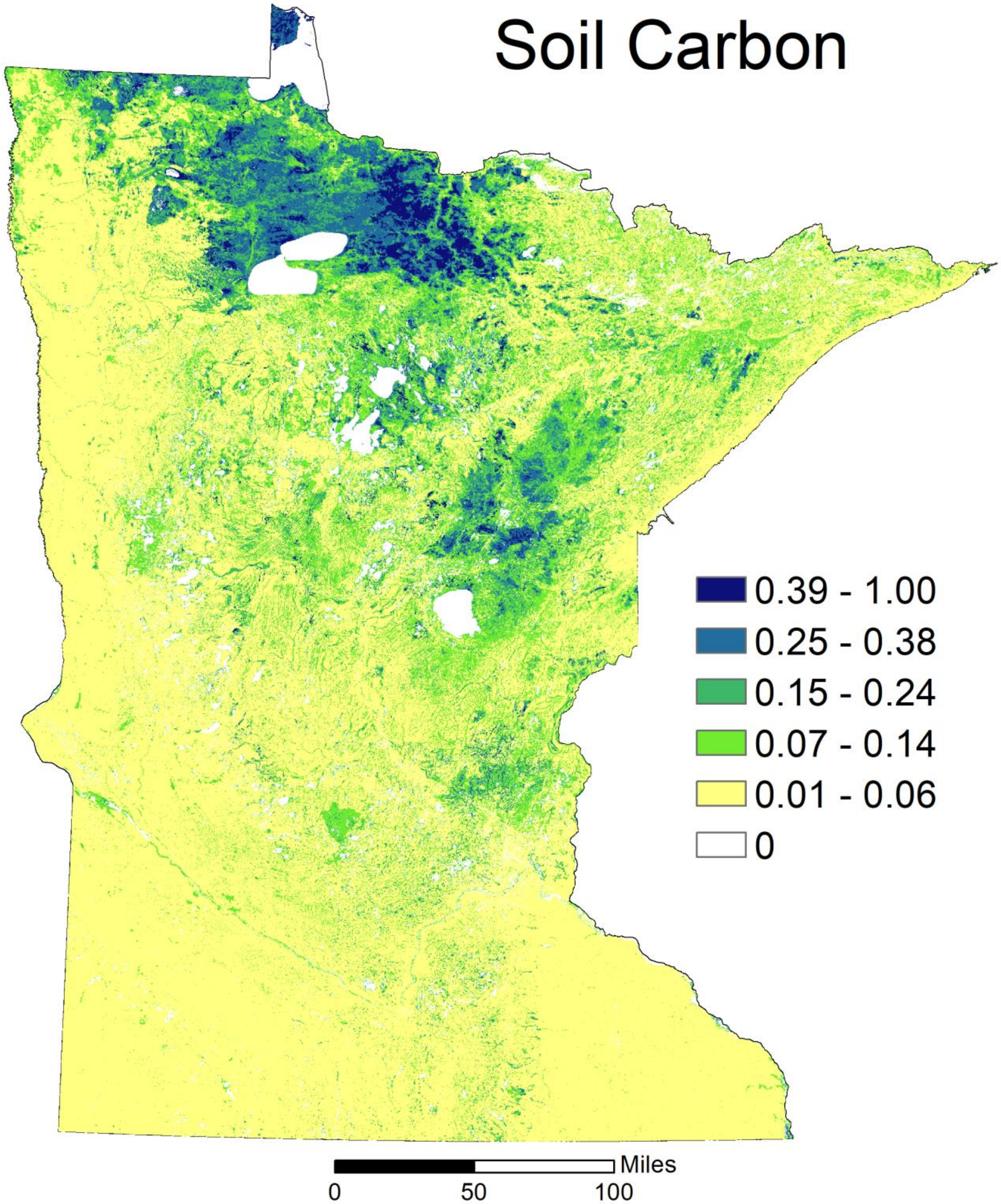
bd_M_sl6_100m.tif, bd_M_sl5_100m.tif, bd_M_sl4_100m.tif, bd_M_sl3_100m.tif, bd_M_sl2_100m.tif, bd_M_sl1_100m.tif, soc_M_sl6_100m.tif, soc_M_sl5_100m.tif, soc_M_sl4_100m.tif, soc_M_sl3_100m.tif, soc_M_sl2_100m.tif, soc_M_sl1_100m.tif

Data preparation

We used maps depicting estimates of bulk density and soil organic carbon percentage at six depths to calculate the metric tons of carbon stored per hectare throughout the state to a depth of one meter (Ramcharan et al., 2017b). The source maps provided estimates at depths of 0, 5, 15, 30, 60, and 100 cm. We created the script carbon.py to combine the source layers and produce our carbon metric.

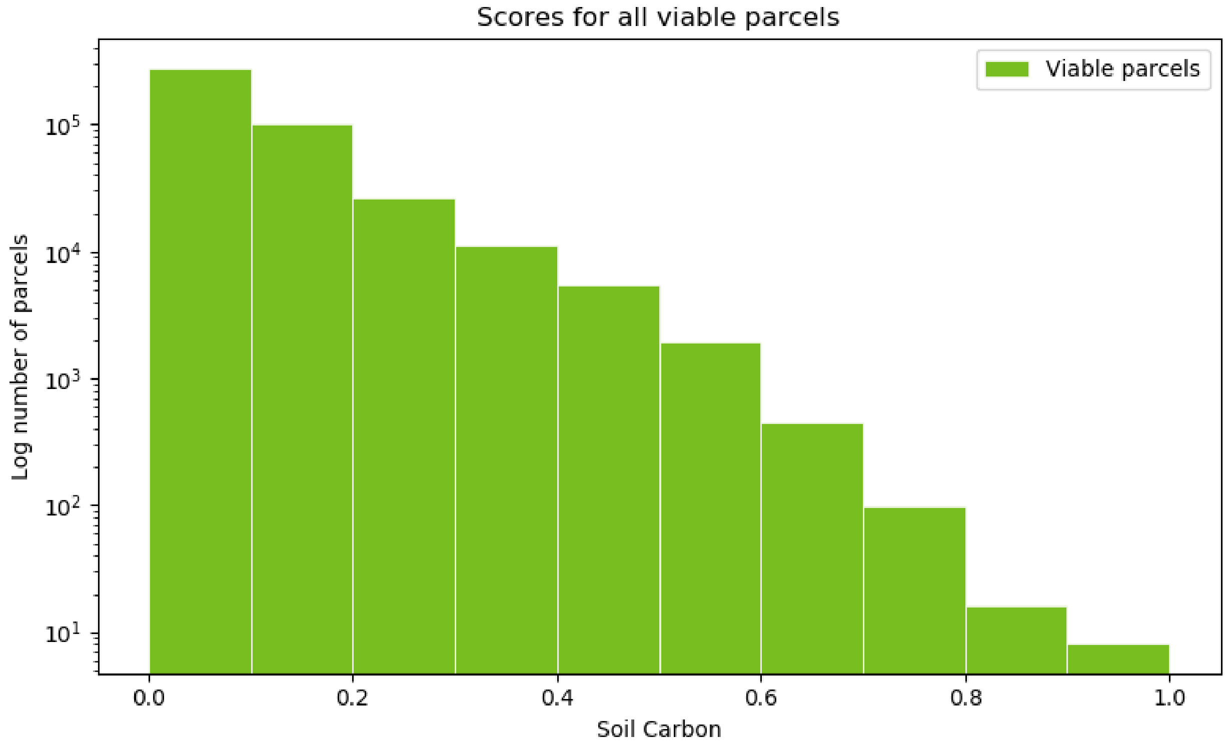
First, the 12 original national maps are aligned, clipped, and projected. Their no data value is set to 0, and they are multiplied by 0.001 because the values in the source data are multiplied by 1000 to facilitate distribution as integer files rather than much larger float files. For both bulk density and soil organic carbon maps we took the average of adjacent depth ranges to estimate the value of soil between them (i.e., averaging sl2 and sl3, or sl3 and sl4). Each bulk density layer is multiplied by its corresponding soil organic carbon percentage layer to estimate the amount of carbon in the soil. Each layer is multiplied by the portion of the depth profile it represents (e.g., 30-40cm, is multiplied by 0.1) and summed to estimate the total carbon in one meter of soil.

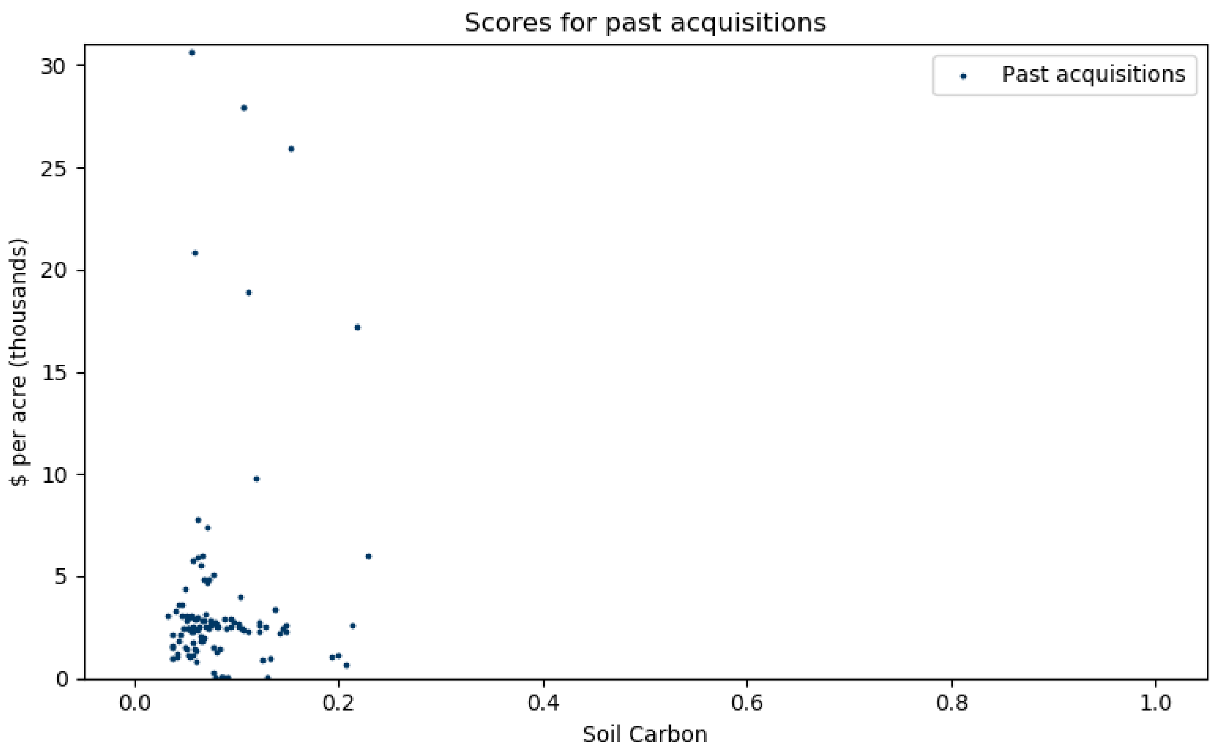
Map



Soil Carbon
0.39 - 1.00
0.25 - 0.38
0.15 - 0.24
0.07 - 0.14
0.01 - 0.06
0
Miles
0
50
100

Score distributions





Pollination

Overview

Pollinated crops benefit from having an abundant supply of pollinators nearby. This metric uses the output from the InVEST pollination model along with the cropland data layer. The InVEST pollination model uses data on land cover and the foraging habits of bees to produce a bee abundance index. The model output used in this metric is described in Koh (2016). We used the cropland data layers from 2014 to 2017 to identify where pollinated crops such as sunflowers and apples are produced, and buffered these fields by the foraging distance of bees. Consistent with the base score used in other metrics, we assigned a value of 0.2 to land in proximity to pollinated crops. The metric is the sum of the pollinator abundance index and the presence/absence of pollinated crops. High scoring parcels are those that have high relative pollinator abundance and are in close proximity to pollinator-dependent crops.

High priority parcel description

Endpoint: Supplied statewide, with demand concentrated in close proximity to pollinator-dependent crops.

A high priority parcel:

- has land cover and a neighborhood land cover configuration that supports high relative pollinator abundance
- has crops that benefit from insect based pollination within the travel distance of a typical pollinator

Data sources

USDA NASS Cropland Data Layer (CDL) 2014, 2015, 2016, and 2017

https://gisdata.mn.gov/dataset/agri-cropland-data-layer-2014

https://gisdata.mn.gov/dataset/agri-cropland-data-layer-2015 https://gisdata.mn.gov/dataset/agri-cropland-data-layer-2016

https://gisdata.mn.gov/dataset/agri-cropland-data-layer-2017

Invest Pollination Model

http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/croppollination.html

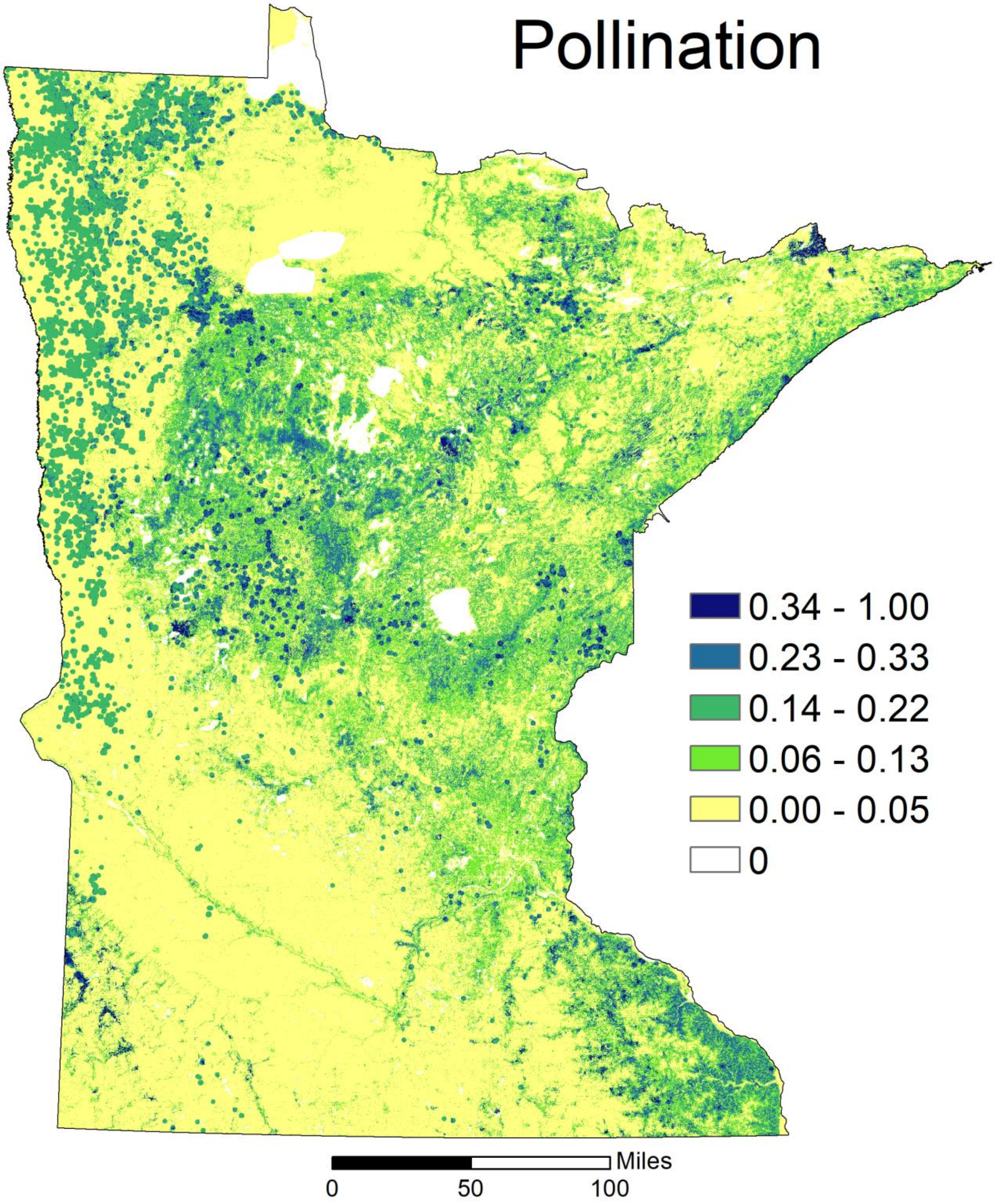
Availability note: the model output used for this metric was originally published in (Koh et al., 2016), (see Figure 1 A), and is available in the expanded base data.

Data preparation

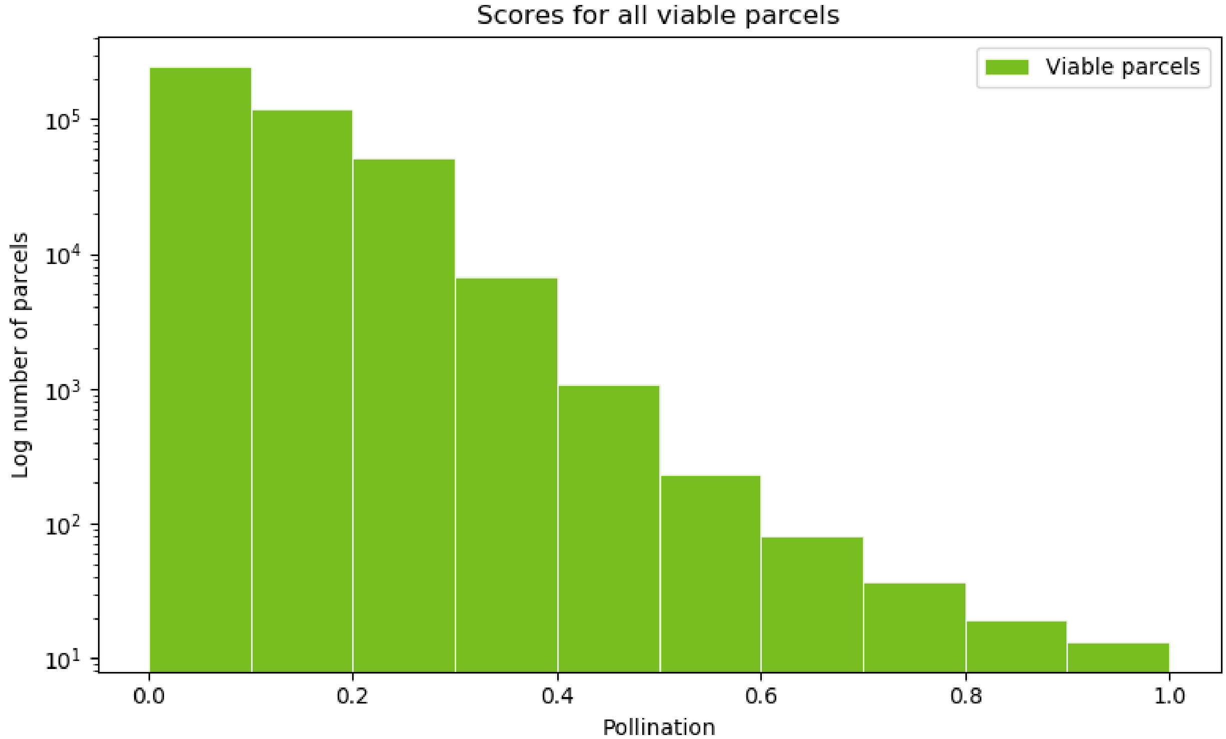
We reclassified the CDL to one for pollinated crops and zero for all other values. The vast majority of pollinated crops in Minnesota are sunflower, but the complete list of CDL codes for pollinated crops we used is in pollination.py. We created a binary map of pollinated crops for each year 2014 through 2017 to capture fields that in are in rotation with crops that are not pollinator-dependent. We used ArcGIS to perform a focal statistics 5x5 majority operation to remove likely erroneous cells that were not a part of a larger field. After filtering, we merged the four years into a single raster and buffered the fields by 1340m to represent the foraging distance of honey bees. Similar to the base score used in other metrics, we assigned all land within the buffer of pollinated crops (i.e., the pollination demand endpoint) a value of 0.2.

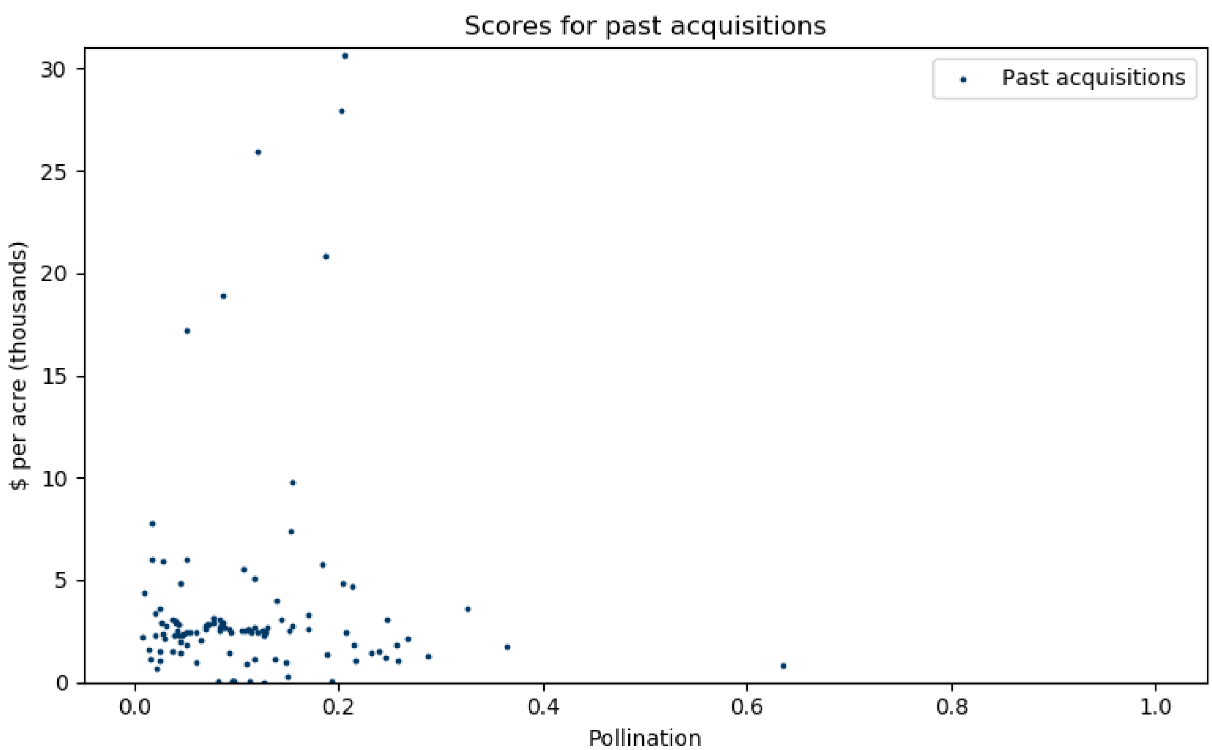
Because the pollination model output is in relative abundance, no further processing was applied except for re-indexing the data to zero to one. The resulting metric is the sum of the pollinator abundance index and the presence/absence of pollinated crops.

Map


Pollination
0.34 - 1.00
0.23 - 0.33
0.14 - 0.22
0.06 - 0.13
0.00 - 0.05
0
Miles
0
50
100

Score distributions





Pheasant Production

Overview

Abundant pheasant populations support pheasant hunters and related industries. Our metric is based on pheasant production models first published in Jorgensen (2014) and then refined in Wszola (2017). In brief, the metric uses relationships between the amount of grass, agriculture, small grains, trees and wetlands in one or five kilometer buffers around a proposed parcel to estimate relative pheasant abundance. Higher scores are given to parcels with greater potential pheasant abundance.

High priority parcel description

Endpoint: Pheasant range in Minnesota (southern half of the state)

A high priority parcel:

- has a high proportion of grassland within a 1km radius
- has a low proportion of trees within a 5 km radius
- has a low proportion of woody wetlands within a 1km radius
- has a moderate amount of agriculture within a 5 km radius
- has a moderate amount of small grains within a 5km radius

Data sources

USDA NASS Cropland Data Layer (CDL) 2017

https://gisdata.mn.gov/dataset/agri-cropland-data-layer-2017

Minnesota Pheasant Range

https://gisdata.mn.gov/dataset/env-pheasant-range-minnesota

Data preparation

Our metric is based on pheasant production models first published in (Jorgensen et al., 2014) and then refined in (Wszola et al., 2017). The model predicts pheasant abundance based on local and regional scale land cover composition. We adapted the model to use data available for Minnesota. First, we aggregated land covers categories in the 2017 cropland data layer to five categories used in the Wszola (2017) model; grassland, woodland, wetland, agriculture excluding small grains, and small grains. The reclassification tables and maps are available in the expanded base data.

The original model also found that Conservation Reserve Program (CRP) land within one kilometer was a strong predictor of pheasant abundance, however, spatial CRP data is not publicly available. Because we were unable to include this predictor, pheasant abundance may be underestimated by our metric in areas with a high proportion of CRP land.

After masking the inputs to the pheasant range in Minnesota, the final score is calculated as:

index of (exp(3.0666 +

(((-0.54781 * trees_5k) - (-0.54781 * 0.06301747)) / 0.053441) + (((0.131763 * (trees_5k^2)) - (0.131763 * 0.00682374)) / 0.00918277) +

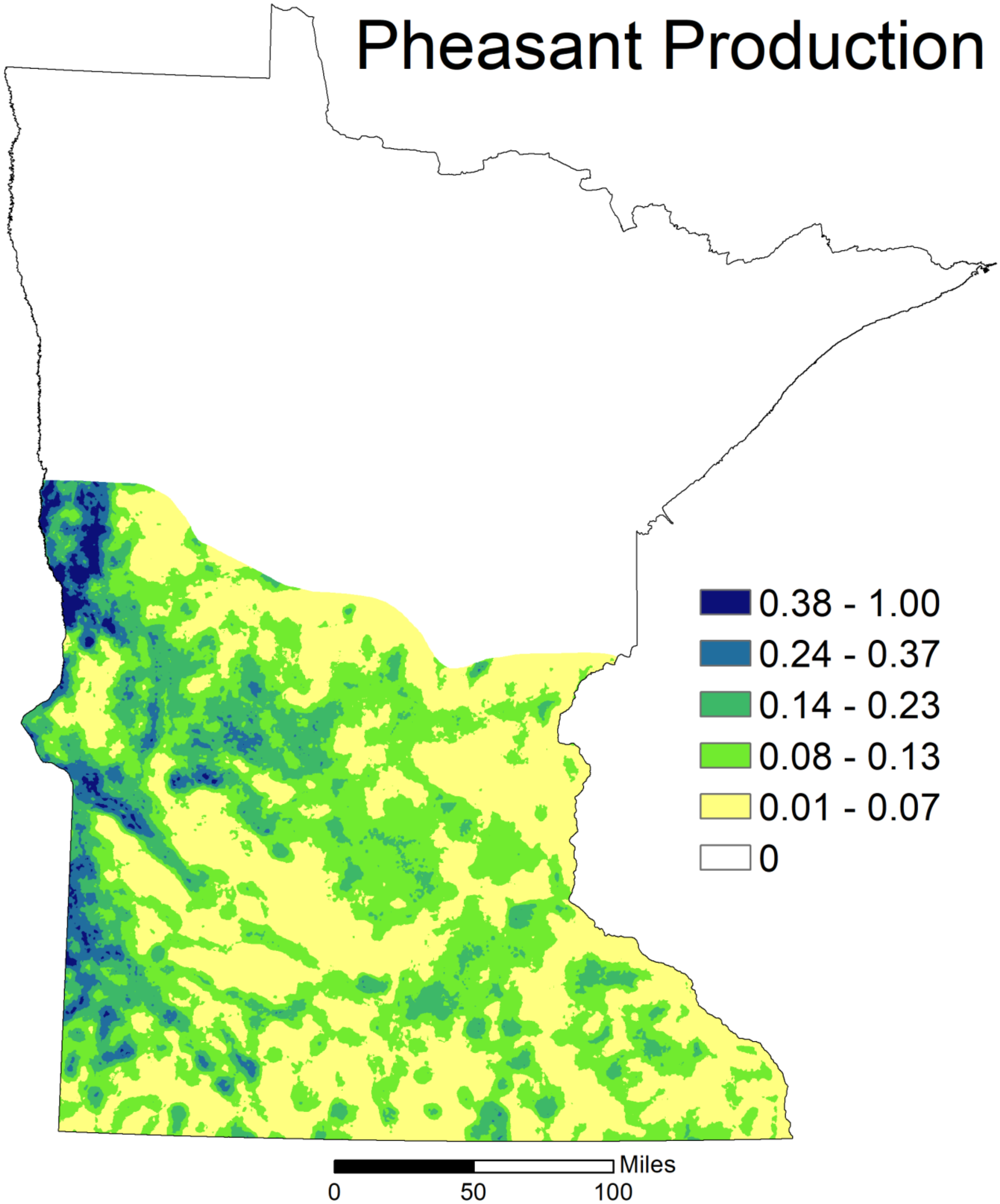
(((0.511138 * ag_5k) - (0.511138 * 0.25670848)) / 0.20208898) + (((-0.05282 * ag_5k^2) - (-0.05282 * 0.10669046)) / 0.16528966) + (-4.6611202 * ag_5k^3) +

(((0.133586 * grass_1k) - (0.133586 * 0.47500357)) / 0.21036192) +

(((0.451256 * sg_5k) - (0.451256 * 0.07708618)) / 0.06580207) + (((-0.04344 * sg_5k^2) - (-0.04344 * 0.01026702)) / 0.016885) + (-6.849455 * sg_5k^3) +

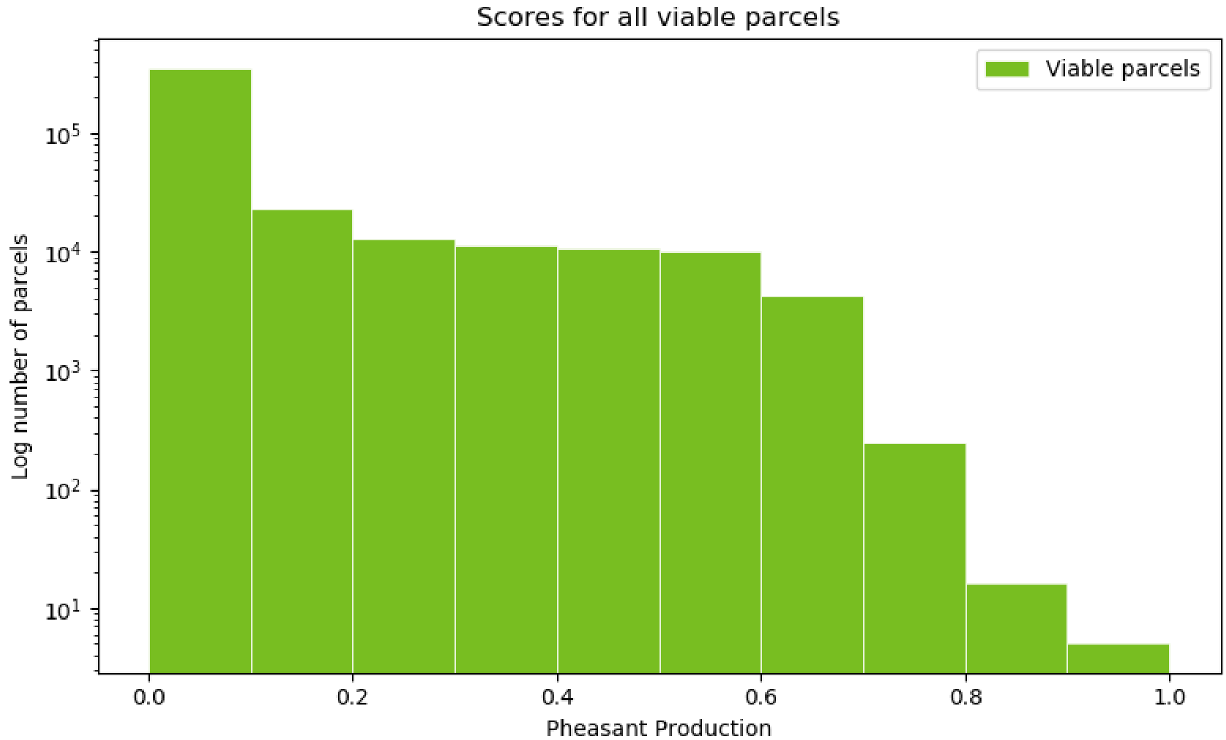
(((-0.10249 * wetland_1k) - (-0.10249 * 0.02997624)) / 0.07880755) - 0.15981))

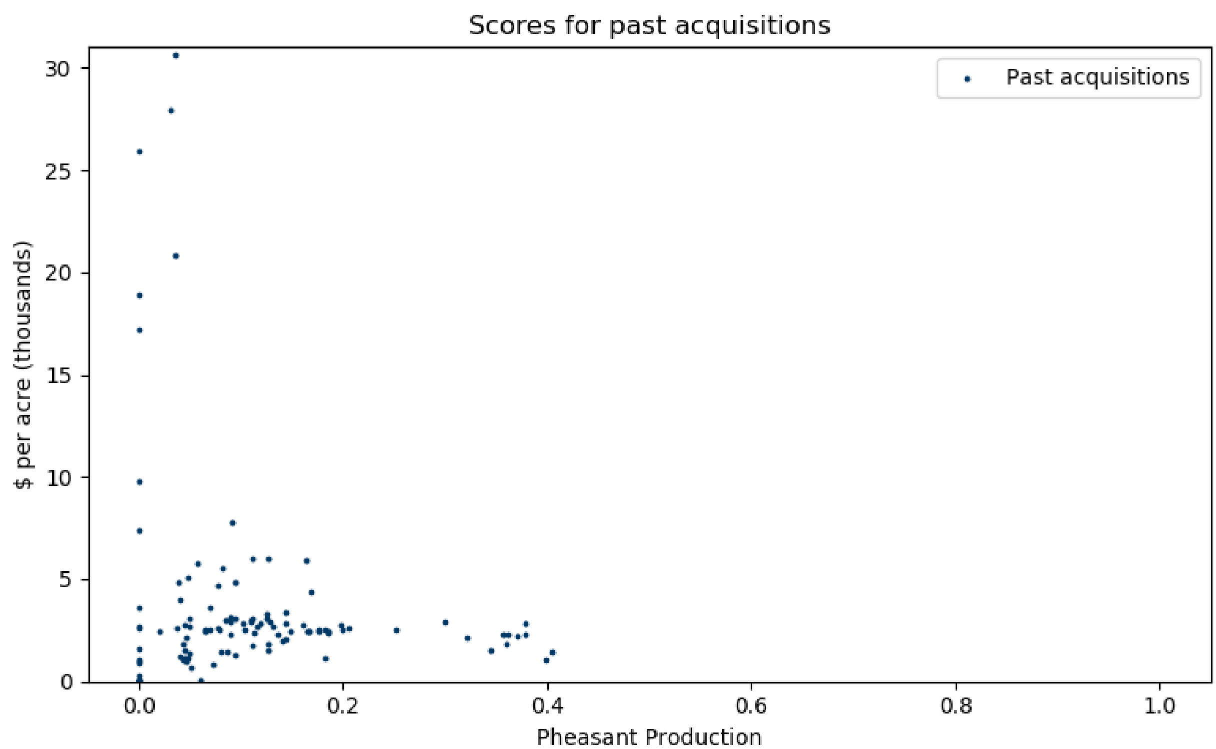
Map



Pheasant Production
0.38 - 1.00
0.24 - 0.37
0.14 - 0.23
0.08 - 0.13
0.01 - 0.07
0
Miles
0
50
100

Score distributions





Wild Rice

Overview

For this metric, we assume that acquisitions within the catchment of a wild rice site identified by the DNR have the potential to provide wild rice benefits, while parcel outside wild rice catchments do not. If a parcel is partially within a catchment, its score is equivalent to the proportion of the parcel's total area that is within the catchment. We do not differentiate among wild rice sites, nor does the metric account for the impact of management on wild rice habitat or water quality.

High priority parcel description

Endpoint: Catchment of wild rice sites

A high priority parcel:

- is entirely within the catchment of a wild rice site

Data sources

Wild rice sites

Availability note: The exact point location of wild rice sites is not posted publicly. Our metric identifies the catchments with wild rice within them, but we do not include the point data used to identify them.

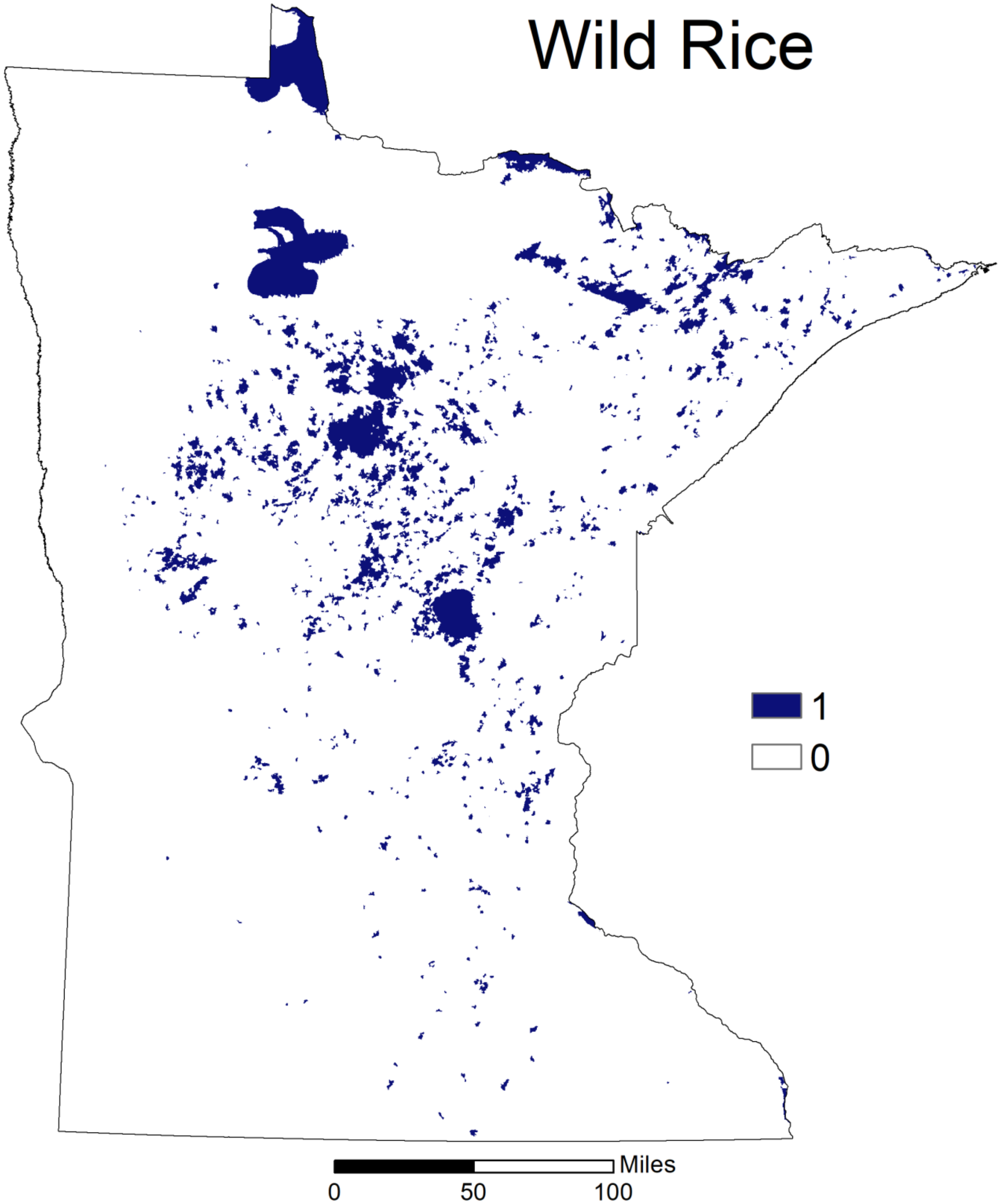
MNDNR Level 09 - DNR AutoCatchments

https://gisdata.mn.gov/dataset/geos-dnr-watersheds

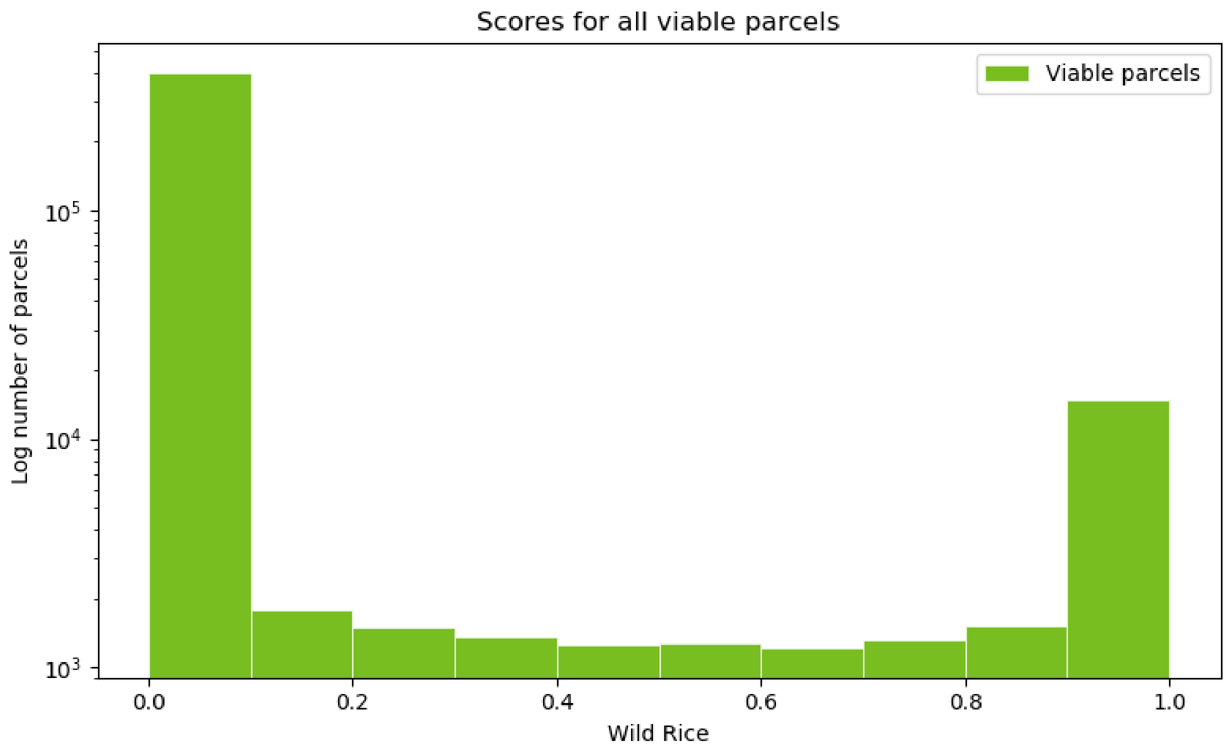
Data preparation

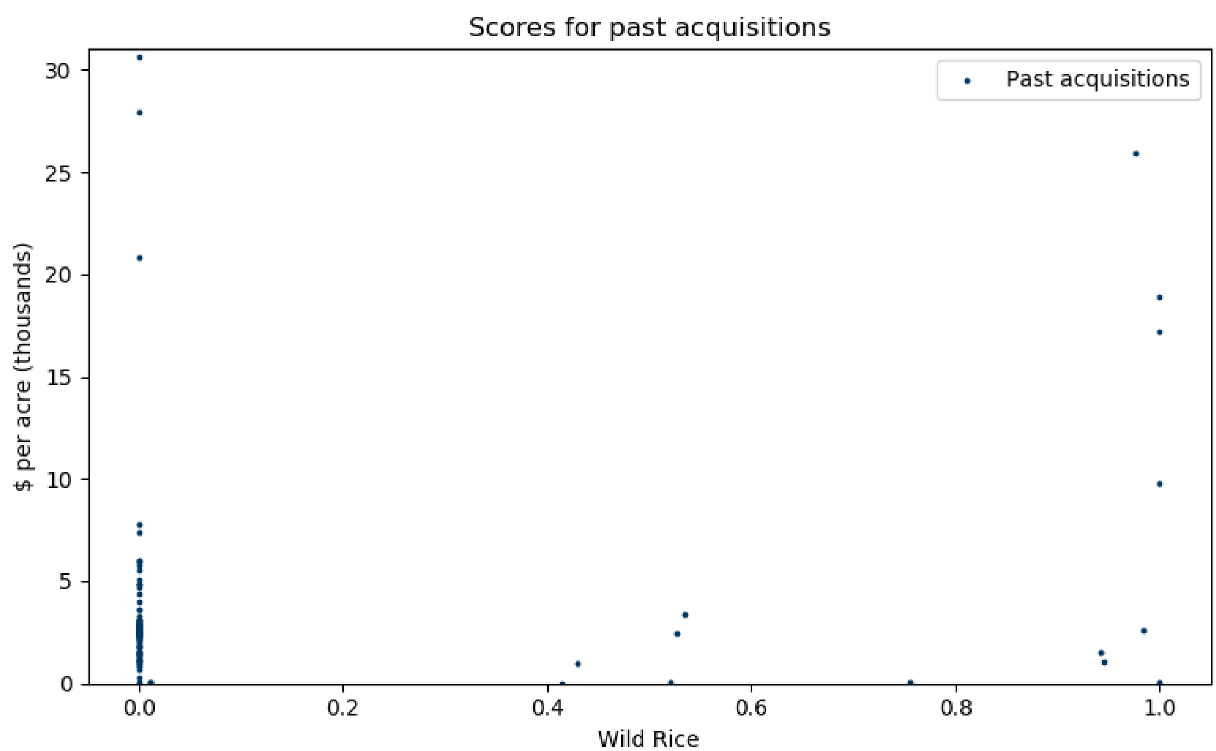
This metric is intended to quickly assess if a parcel has the potential to protect wild rice production, and does not prioritize between sites or assess the magnitude of the impact. We used a spatial join operation to select all catchments with a wild rice site within them and assigned them a value of one, everywhere else received a value of zero. If a parcel is partially within a catchment, its score is equivalent to the proportion of the parcel's total area that is within the catchment.

Map



Score distributions





Lake Recreation

Overview

The lake recreation metric prioritizes protection of land that influences the water quality of lakes important for public recreation. It applies to the catchments of lakes with a publicly accessible water access site. Parcels outside of these catchments receive a score of zero for lake recreation. Among lakes with public access, prioritization is based on three attributes; the sensitivity of the lake's clarity to additional phosphorus runoff, the public amenities (i.e., restrooms, boat launches, docks) of the lake, and lake visitation. Catchments with publicly accessible lakes receive a minimum score of 0.2. The rest of the score is equally divided between a physical measure of the lake's sensitivity to phosphorus, and measures of the social benefit of the lake as measured by proxies for visitation. High scoring parcels are those that are within a catchment of a publicly-accessible lake highly sensitive to additional phosphorus, which has public amenities and high scores for lake visitation.

High priority parcel description

Endpoint: Land that is in the catchment of lakes that have public, no cost water access sites as identified in the DNR water access sites database.

A high priority parcel is in the catchment of a publicly accessible lake that:

- is in danger of becoming impaired with more phosphorus loading
- has high visitation
- has amenities (i.e., restrooms, boat launches, docks) that enable and improve recreation experiences

Data sources

Lakes of Phosphorus Sensitivity Significance

https://gisdata.mn.gov/dataset/env-lakes-phosphorus-sensitivity

Availability note: the metric is based on LPSS scores which are presented only in aggregated classes in the public version of this dataset.

Natural Capital Project Recreation Model

http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/recreation.html

The output from the model is available in the expanded base data.

Public Water Access Sites in Minnesota

https://gisdata.mn.gov/dataset/loc-water-access-sites

MNDNR Watershed Suite - Level 09 autocatchments and autolakes

https://gisdata.mn.gov/dataset/geos-dnr-watersheds

MNDNR Hydrography - Lakes and Open Water

https://gisdata.mn.gov/dataset/water-dnr-hydrography

Data preparation

Identifying public lakes:

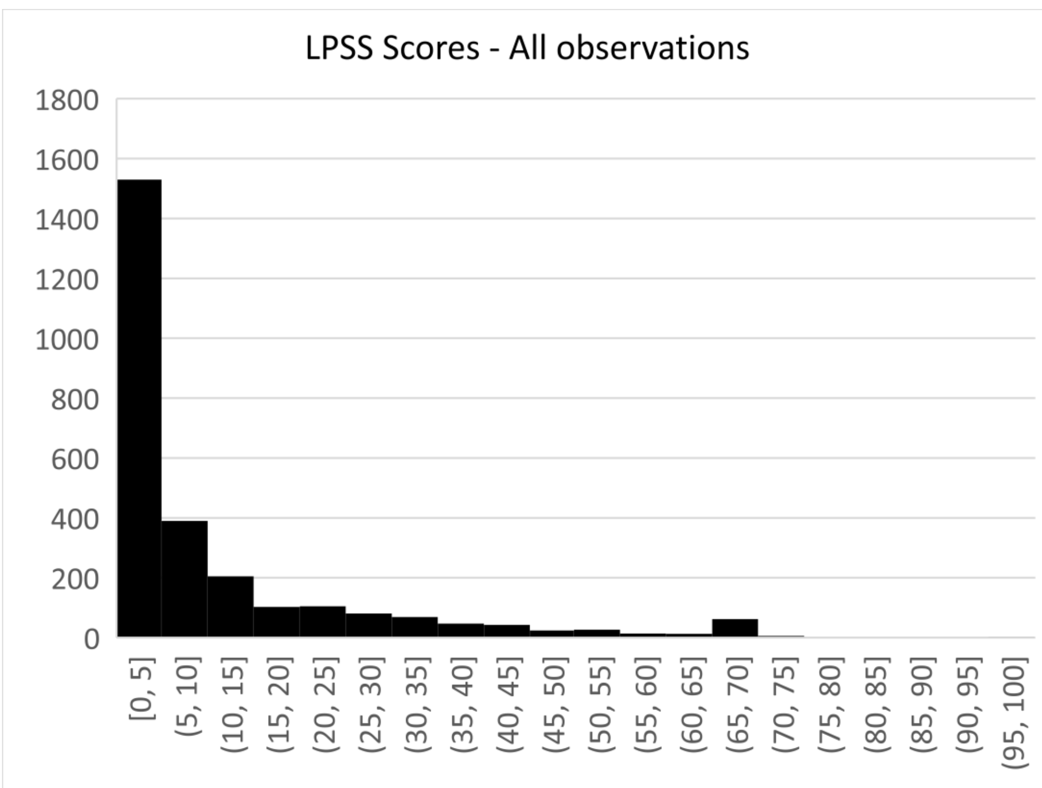
The lake recreation metric applies to the catchments of publicly accessible lakes. While the surface of a lake is public if any public land (e.g., roads, parks) touches its riparian area, the location of these lakes is not readily available to the public, and the physical access may be very difficult. We defined public lakes as those with free, open to the public, water access sites in the DNR's Parks and Trails authoritative database. We used two sources to define lakes; DNR Watershed Suite level 09 autolakes and DNR Hydrography database lakes and open water. We primarily used the level 09 autolakes layer because it aligned best with the autocatchments layer, however it does not include reservoirs or gravel pits, both of which are used for recreation. To include those water bodies we extracted them from the DNR Hydrography database and merged them with the autolakes layer.

Due to inconsistencies between data sources, joining the water access points to lakes and catchments required several manual corrections. We identified a set of manual corrections by comparing the results of an attribute join between the water access points layer and our merged lakes layer on 'dowlknum'. For access points with a 'dowlknum' but no match we use aerial imagery and the lakes and open water layer to identify a match or removed it if applicable. We also used a spatial join between the lakes and open water layer and the access points layer to identify points that had the incorrect ‘dowlknum’ assigned. Manual changes are identified and performed in the script lake_rec_prep.py.

Lakes of Phosphorus Sensitivity Significance:

Because the Lakes of Phosphorus Sensitivity Significance (LPSS) layer is already an index, no further processing was applied except for re-indexing the data to zero to one. The formulation of this index is described in documentation linked to on the Minnesota Geospatial Commons dataset page.

We joined the phosphors sensitivity significance scores to our public lakes layer by ‘dowlknum’. The Lakes of Phosphorus Sensitivity Significance layer is regularly updated as new observations are added, but it is not complete for all lakes with public access sites. Of the 1964 lakes with public access sites, 372 did not have a corresponding phosphorus sensitivity significance score. To include this data source, we used the median value of the data set for the missing observations. Values in the dataset ranged from 0 to 100, with a median of 3.5 and a mean of 10.7. Over 71% of the values where in the range 0-10.



Social media-based visitation data:

We used our public lakes layer as the input to the InVEST Recreation model. We used the index of the log of all photo-user-days between 2005 and 2014 to score lakes by visitation, and applied the score to any catchments a lake intersects (typically one).

Lake amenities:

While the presence of geotagged photos on lakes is a good indicator of higher levels of visitation, many lake recreationist do not publicly share geotagged photos, and thus many lakes have 0 photo-user-days. To supplement social media-based visitation data, we used amenities at the lake recorded in the Public Water Access Sites database. Previous research has indicated that these amenities are correlated with higher visitation (Keeler et al., 2015).

Specifically we consider whether or not a lake has a dock, trailer launch site, and toilets. In previous surveys of Minnesota lake recreationists (e.g. MNDNR 2002), sufficient parking is also an important consideration. While we have data on the amount of parking at most access sites, we do not have data on whether or not it is typically enough and therefore do not include this information in our metric. The amenity component is the weighted sum of three amenities, where a lake receives 1 * the amenity value weight if that amenity is present at a lake, regardless of the quantity. If it is absent the lake receives 0 * the amenity value weight.

When selecting weights for individual amenities, we reviewed five DNR surveys of lake recreationists from different regions throughout the state (MNDNR, 2011, 2009, 2007, 2006, 2002). Unfortunately, the ways in which questions were asked about amenities cannot be directly mapped to preference weights. The weights used are primarily based on a question that was asked in two surveys (MNDNR, 2011, 2009); “How important to public access users are the following items at public accesses?” Responses to this question rated docks and toilets similarly in both surveys. However this question did not ask about trailer launches. In other surveys (MNDNR, 2007), when trailer launch sites were limited, it was generally rated highly on the question “Which of the following improvements do you feel are needed at this launch sites?” Note that a lake is still considered publicly accessible if it does not have a trailer launch site, but does have a carry-in access site. Given that survey questions did not show clear differences in preference for the three amenities we considered, we opted to weight them equally. For example, a lake with a dock, and trailer launch would receive and amenity component score of 0.67.

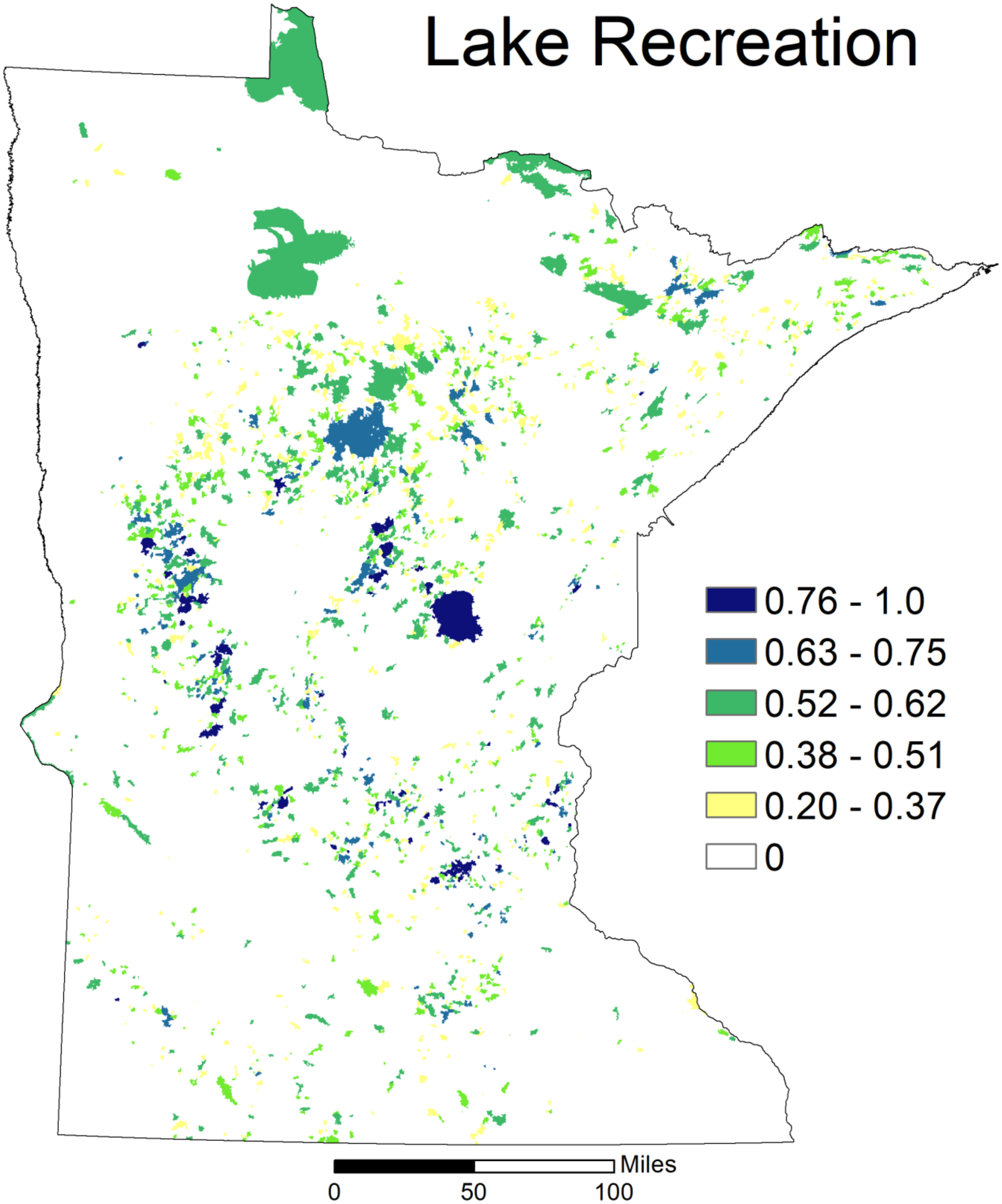
Metric formulation:

When formulating the lake recreation metric, all land in the catchment of a publicly accessible lake received a minimum score of 0.2. The remainder of the score was split between the biophysical measure of the phosphors sensitivity score (0.5), and the social demand represented by social media based visitation and investment in amenities. Given the more comprehensive data on amenities, we weighted it at 0.4 and the social media based visitation at 0.1.

Final score:

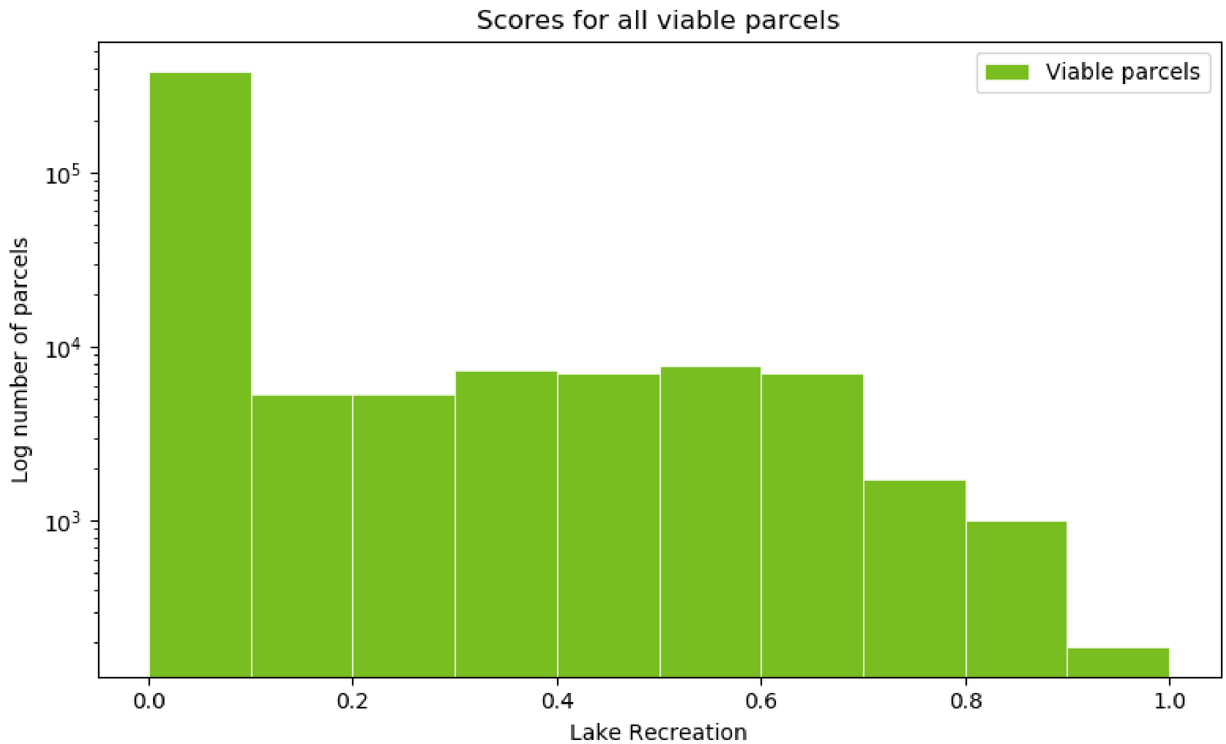
0.2 + 0.8 * (index of (0.5 * index of phosphorus sensitivity +
0.4 * index of amenity level +
0.1 * index of social media based visitation))

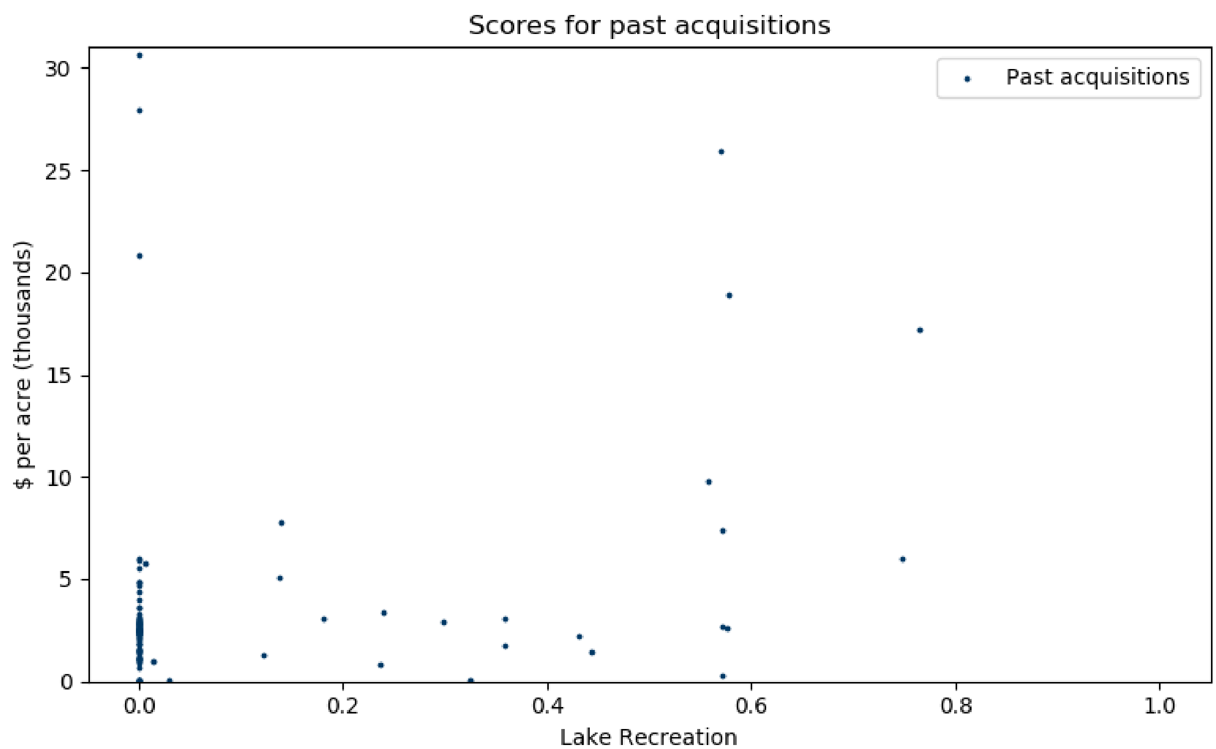
Map



Lake Recreation
0.76 - 1.0
0.63 - 0.75
0.52 - 0.62
0.38 - 0.51
0.20 - 0.37
0
Miles
0
50
100

Score distributions





Bird Watching

Overview

Our metric combines data on the location of important bird habitat with data on the behaviors of bird watchers. To define important bird habitat we relied on the Audubon Society's Important Bird Areas layer. To estimate the intensity and location of bird watching, we used the Cornell Lab of Ornithology's citizen science initiative, eBird. The eBird database allows bird watchers to report when and where they engaged in bird watching. We interpolated the data to create a statewide layer with high scores for bird watching hot spots and declining scores with low reported visits. To combine the habitat layer and the visitation layer we set the value for 'presence' in the Important Bird Areas data such that the average of all of the values in the map was equal to the average of all of the values in the eBird map, and then summed the two maps. High scores for bird watching are found on parcels that have both high reported visitation and are located in important bird habitat.

High priority parcel description

Endpoint: Statewide

A high priority parcel:

- is within an Audubon Society Important Bird Area
- is near a large number of unique observer entries in the eBird database

Data sources

Audubon Society Important Bird Areas

http://datazone.birdlife.org/site/requestgis

Availability note: GIS data are available by request only. See here to view the data in a web interface or pdf maps:

http://mn.audubon.org/conservation/minnesota-important-bird-areas

eBird database

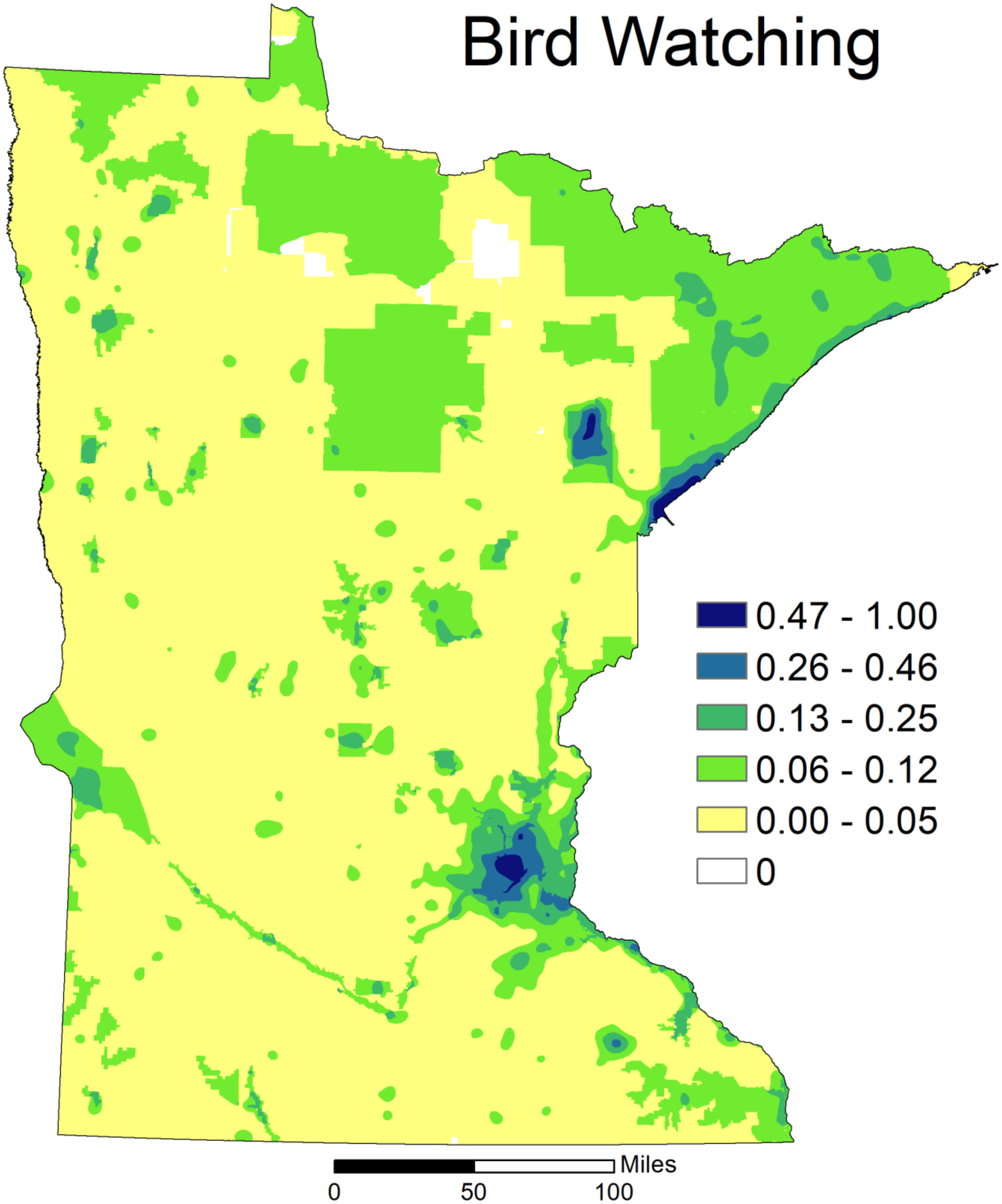
Availability note: data are available by request only:
https://ebird.org/ebird/data/download

Data preparation

We prepared the eBird data by grouping all entries by locality ID and assigning it the log of the sum of the number of unique observer-days between 2006 and 2016. This produced a map of point locations scored on their bird watching activity. We investigated several interpolation methods to extend this score to the habitat surrounding the points. Interpolation methods that extrapolate the values between points were rejected because the score at one location can have a disproportionate influence if there are no nearby points. Instead we opted for a gaussian blur that takes the value of a focal cell and assigns it to its neighbors following a gaussian distribution. When considering the distance of the effect we reviewed the home range of many bird species, and found that many occupy areas on the order of tens to hundreds of acres, but there was a very large range of values (Bowman, 2003; Schoener, 1968). We selected our raster resolution and gaussian parameters to concentrate most of the effect of a locality score in an area of a few hundred acres.

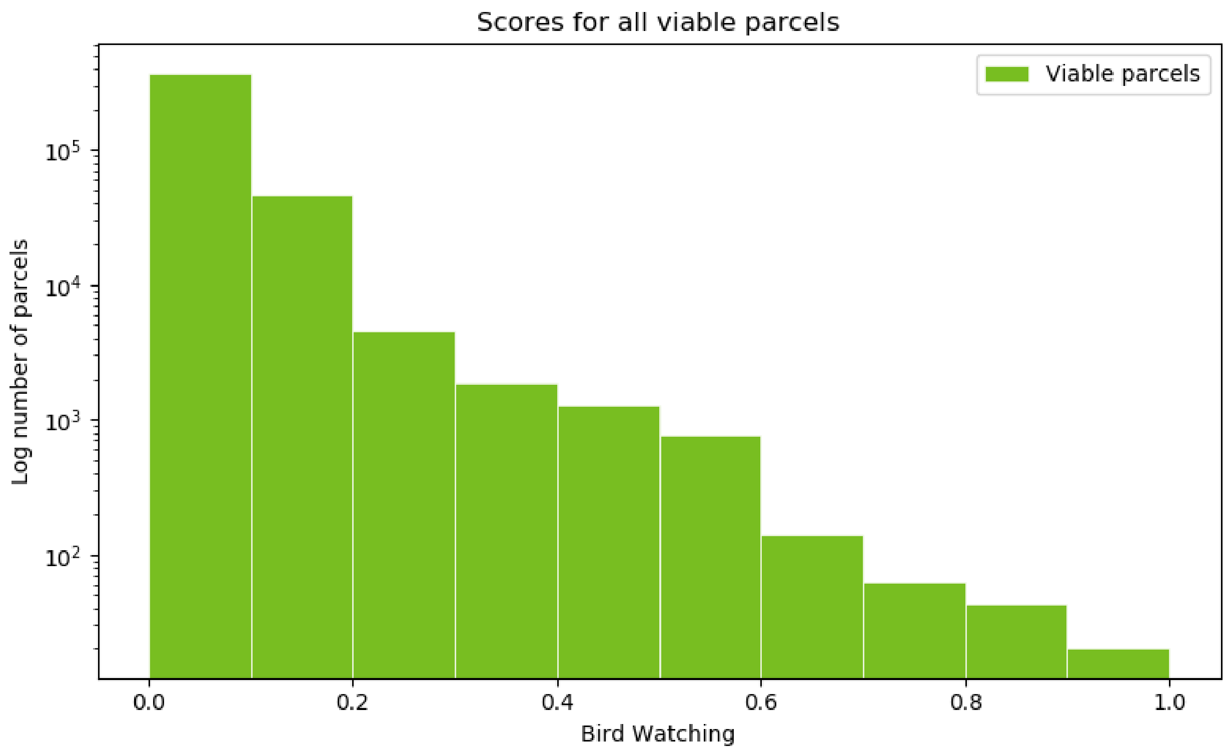
When combining the supply of habitat as defined by Important Bird Areas with the demand for bird watching as defined by the eBird data, we wanted to weight the two inputs similarly. However, this is challenging because one is continuous (with few values equal to one) and the other was binary (with many values equal to one). We set the value for ‘presence’ in the Important Bird Areas layers such that the average of all of the values in the map was equal to the average of all of the values in the eBird map, and then summed the two maps.

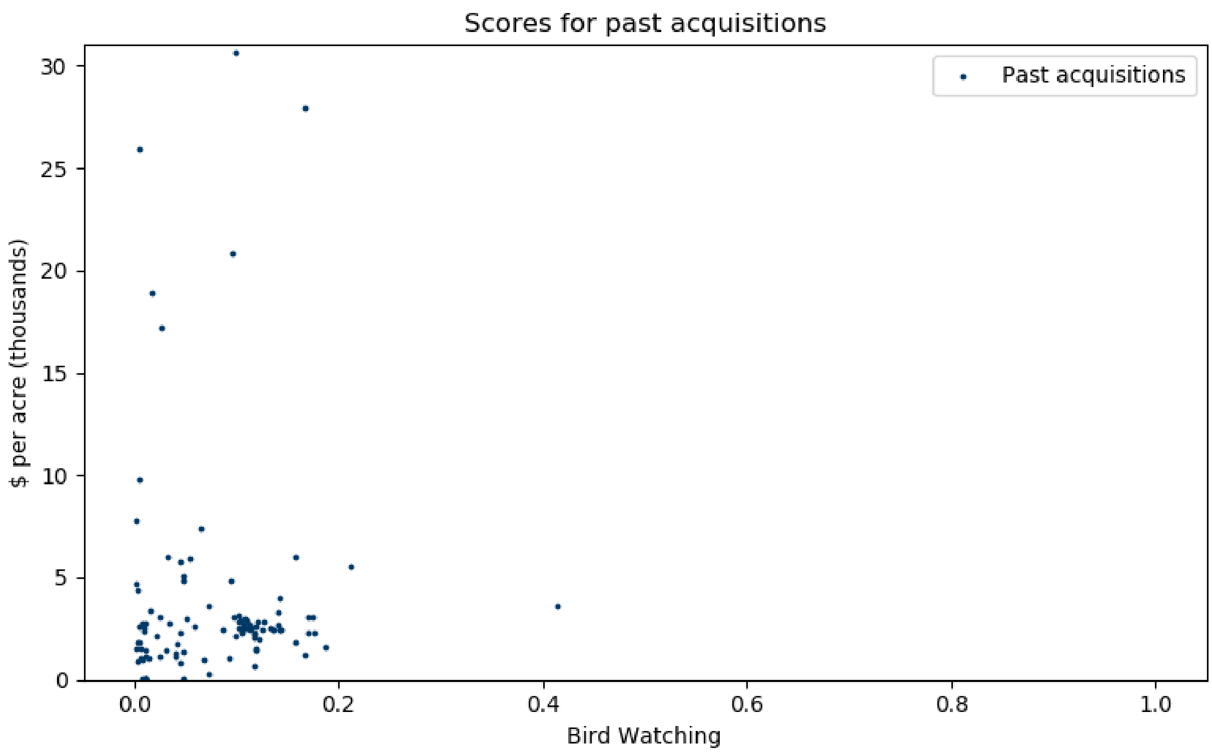
Map



Bird Watching
0.47 - 1.00
0.26 - 0.46
0.13 - 0.25
0.06 - 0.12
0.00 - 0.05
0
Miles
0
50
100

Score distributions





Recreation Trails

Overview

Trails in the state provide a wide range of recreation activities, such as hiking and biking on non-motorized trails, ATV and snowmobile used on motorized trails, and boating on water trails. Conservation of parcels via easements or acquisitions can protect the aesthetic experience around trails by providing scenic beauty and noise attenuation for trail users. Our metric scores parcels based on their proximity to existing recreational trails, as designated by the Minnesota DNR. A parcel's score is equivalent to the proportion of the parcel's total area that is within a 500 foot buffer of a trail, where higher scores are given to parcels with a greater proportion of their area in proximity to trails.

High priority parcel description

Endpoint: 500 foot buffer of recreation trails

A high priority parcel:

- has a high proportion its area within 500 feet of state recreation trails

Data sources

Metro Region Trails

https://gisdata.mn.gov/dataset/us-mn-state-metc-trans-regional-trails-exst-plan

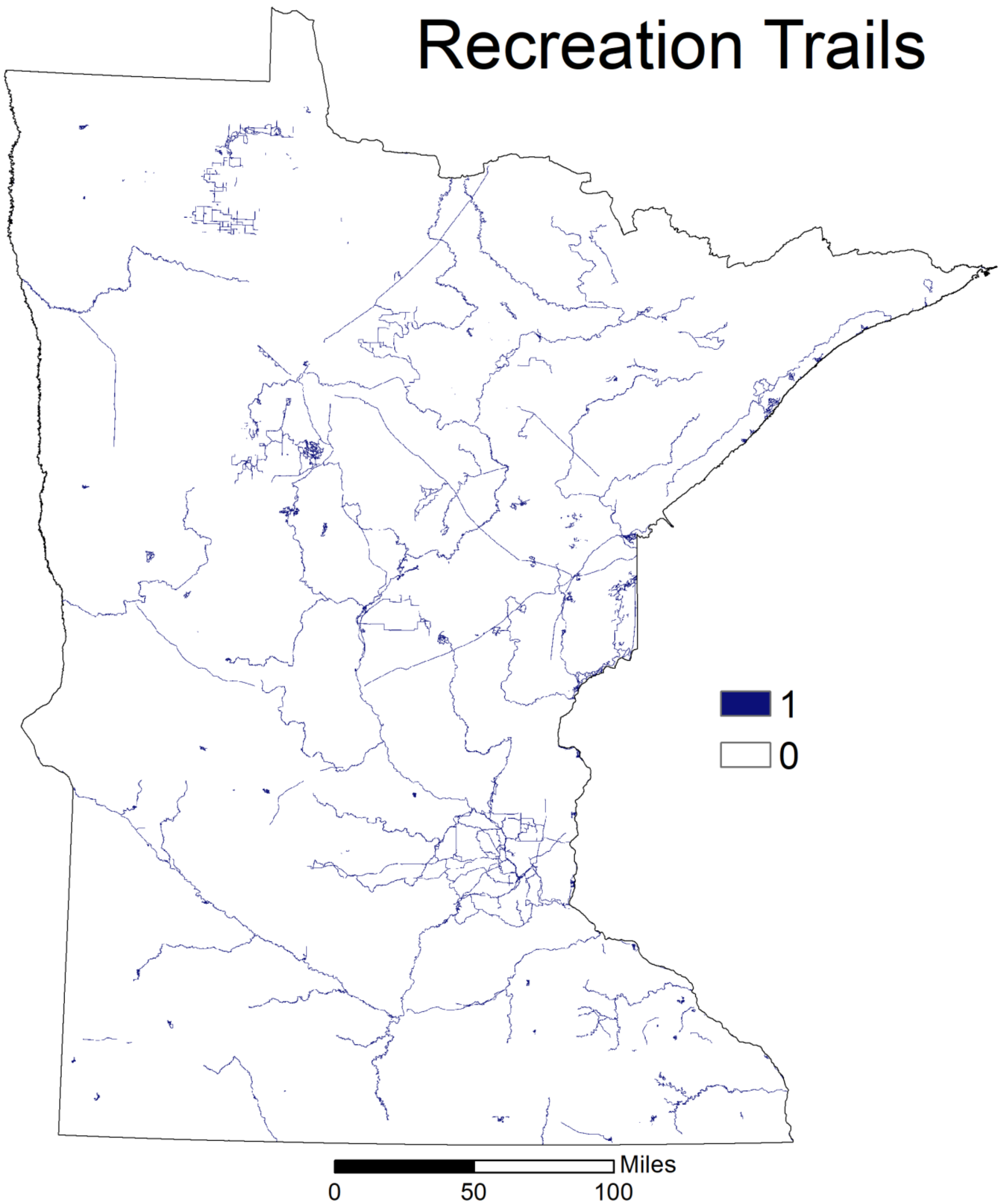
State Trails of Minnesota

https://gisdata.mn.gov/dataset/trans-state-trails-minnesota

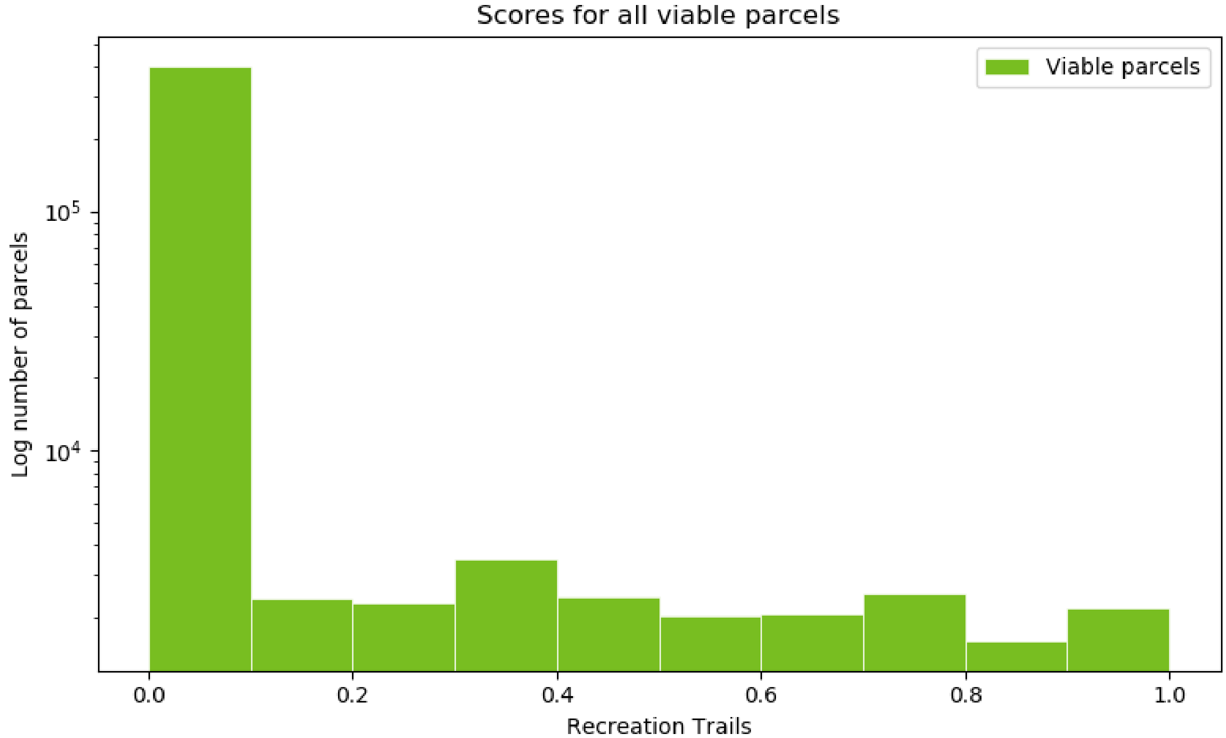
Data preparation

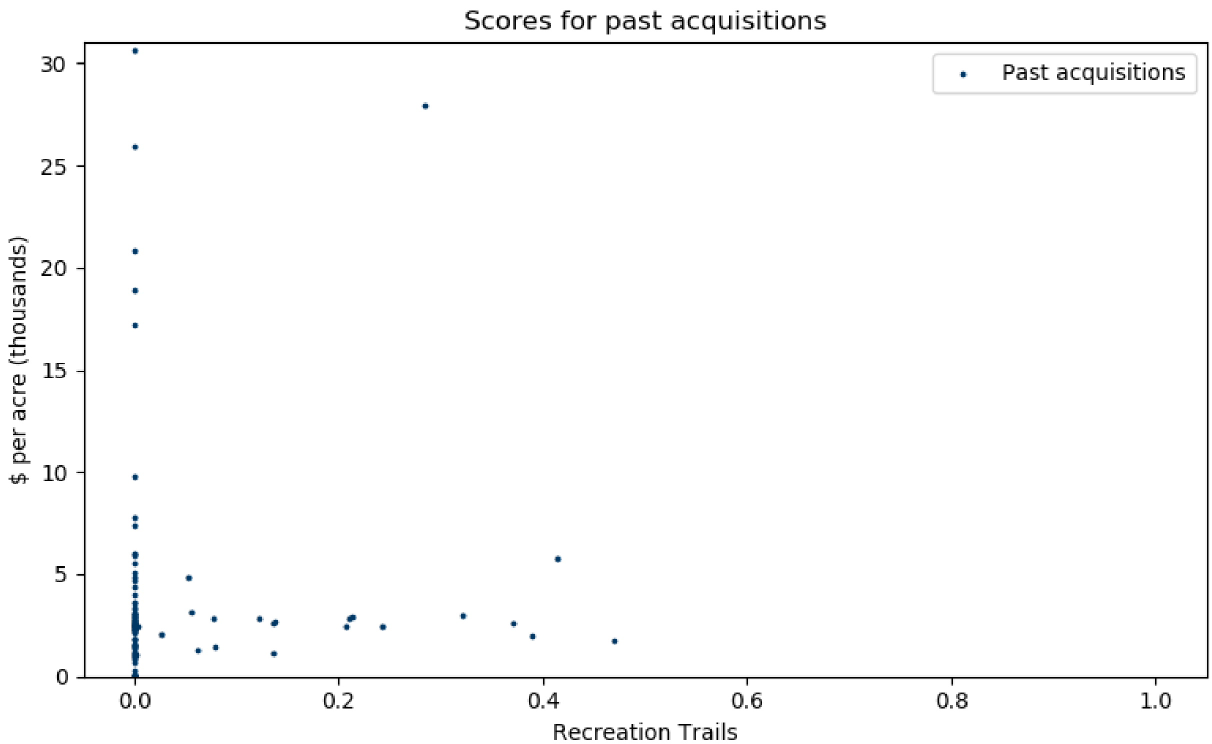
We merged the state and metro trail maps. We included all trails (i.e., motorized, non-motorized, and water), from the state trails database and proposed trails from the metro regional trails database. We selected a 500 foot buffer because beyond that noise attenuation benefits are not generated (Bentrup, 2008).

Map



Score distributions





Trout Angling

Overview

The trout angling metric applies to the catchments of legally designated trout streams, and prioritizes among them using social media based visitation data. If an acquisition is within 66 feet (the buffer size often used in Aquatic Management Area acquisitions), it receives a higher score. Catchments with a legally designated trout stream receive a minimum score of 0.2. The remainder of the score is the weighted sum of the proportion of the parcel within the buffer, and visitation, weighted at 0.6 and 0.4, respectively. High scoring parcels have a large proportion of their area in close proximity to a trout stream that has high scores for visitation.

High priority parcel description

Endpoint: Catchments of legally designated trout streams.

A high priority parcel:

- has a high proportion its area adjacent to a trout stream
- contributes to a trout stream with high visitation

Data sources

State Designated Trout Streams

https://gisdata.mn.gov/dataset/env-trout-stream-designations

Natural Capital Project Recreation Model

http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/recreation.html

The output from the model is available in the expanded base data.

MNDNR Level 09 - DNR AutoCatchments

https://gisdata.mn.gov/dataset/geos-dnr-watersheds

Data preparation

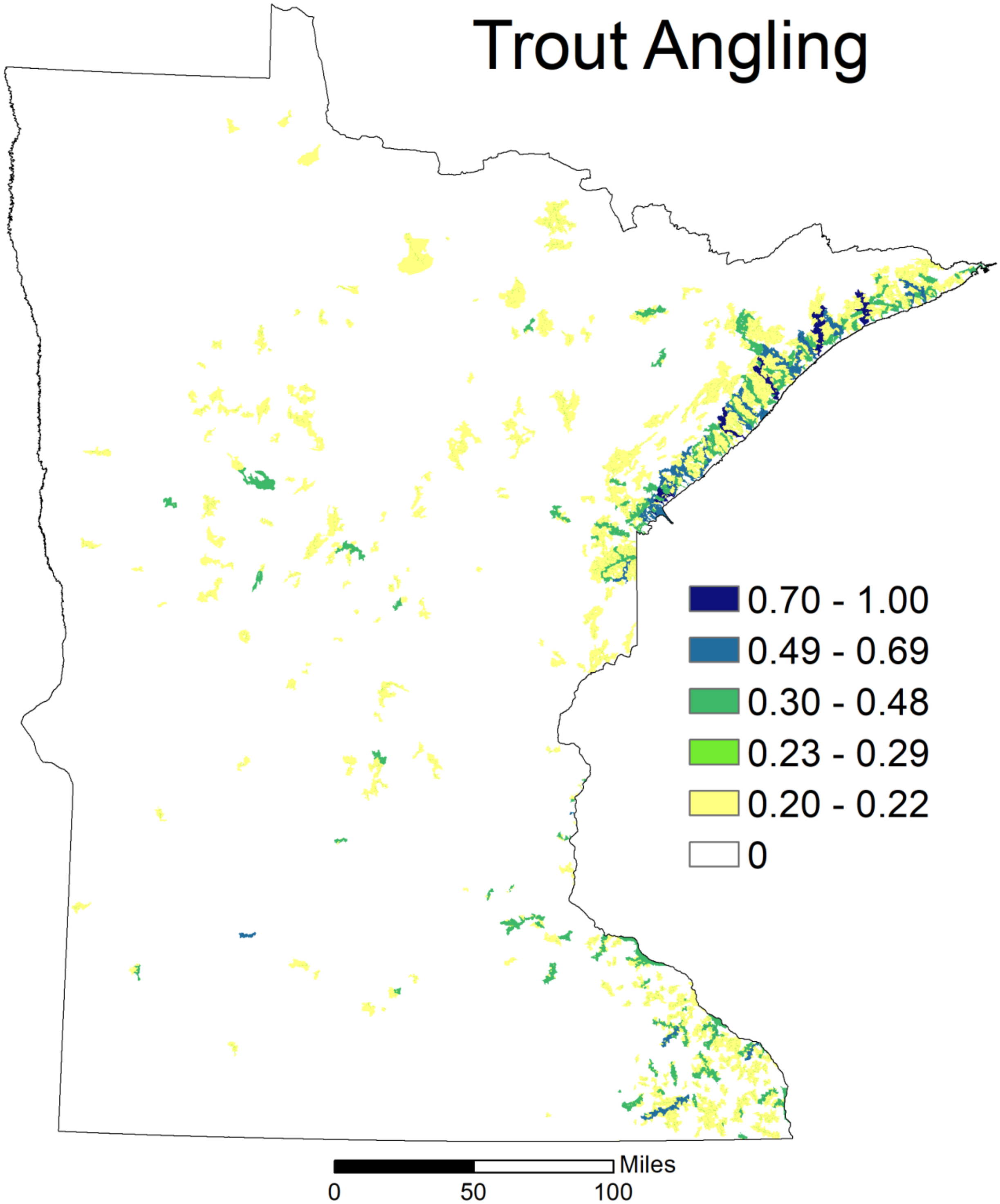
We first selected all MN DNR level 09 catchments that intersect a legally designated trout stream and assigned them a base score of 0.2. We then buffered the trout stream layer by 66 feet, which is the size frequently used in Aquatic Management Area acquisitions, and used it as the input to the InVEST Recreation model. We used the log of all photo-user-days between 2005 and 2014 to score trout streams by visitation, and applied the score of the stream to the catchment that it intersects. If more than one trout stream intersected a catchment, the higher score was assigned.

When constructing the metric, land in the catchment of a trout stream received a minimum score of 0.2. The remainder of the score was divided between being within the stream buffer, and the amount of visitation. We emphasized proximity to the stream by weighting it 0.6, and the visitation index 0.4.

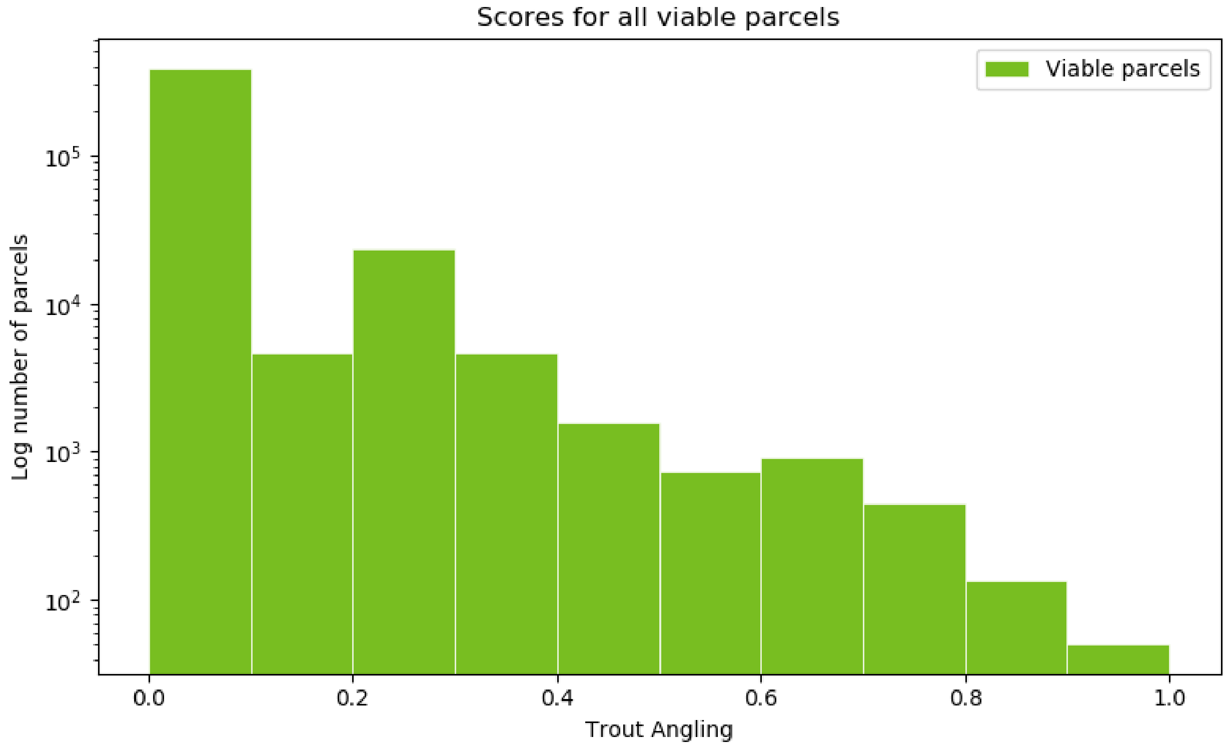
Final score:

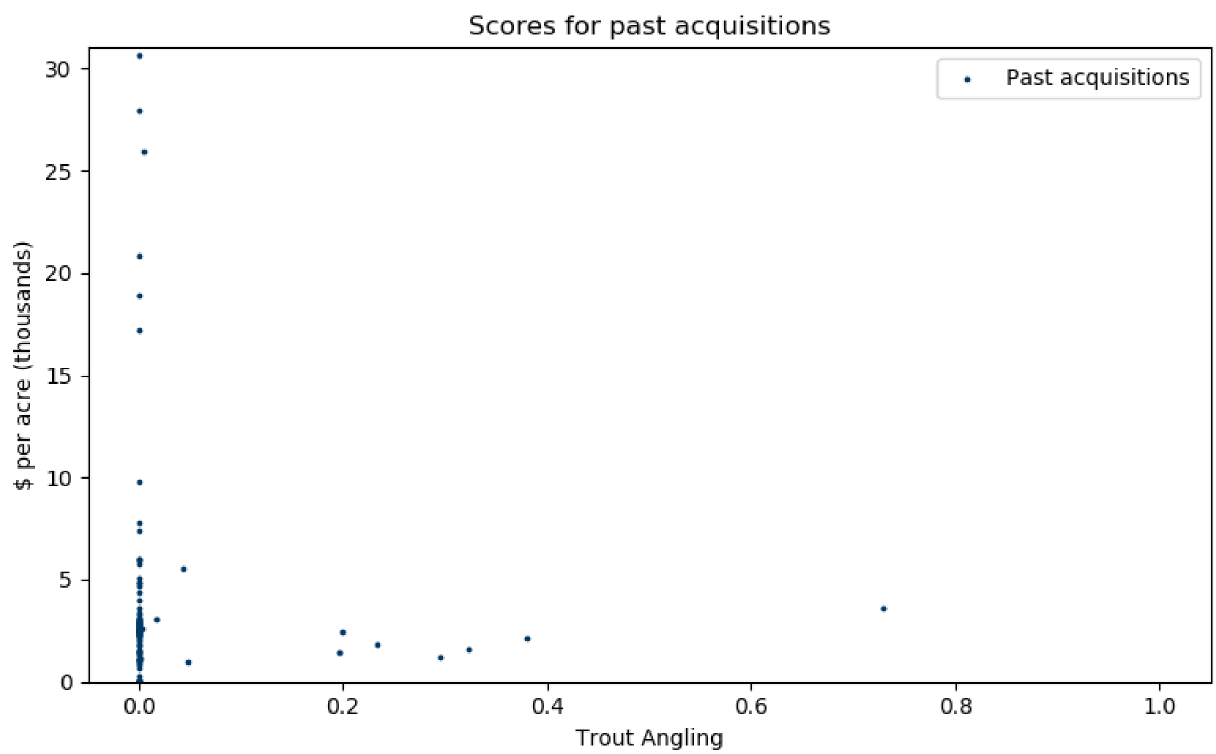
0.2 + 0.8 * index of ((0.6 * within stream buffer) + (0.4 * index of log photo user days))

Map


Trout Angling
0.70 - 1.00
0.49 - 0.69
0.30 - 0.48
0.23 - 0.29
0.20 - 0.22
0
Miles
0
50
100

Score distributions





Groundwater Nitrate

Overview

Nitrate in groundwater poses a threat to human health and increases water treatment costs, especially for rural communities. Our metric assumes that parcels located within identified Drinking Water Supply Management Areas (DWSMA) as mapped by the Minnesota Department of Health are more likely to contribute to drinking water protection than parcels outside DWSMAs. Parcels within DWSMAs receive a minimum score of 0.2, the remainder of the score is based on the amount of agriculture within the DWSMA (a proxy for threats to groundwater), and sensitivity of the geology to surface contamination. High priority parcels are within the boundary of a DWSMAs, have a high proportion of agricultural land cover, and are located in regions with soil and geologic characteristics that make groundwater more vulnerable to contamination.

High priority parcel description

Endpoint: Drinking Water Supply Management Areas (DWSMA)

A high priority parcel is within a DWSMA and:

- The DWSMA has a high proportion of its area in agriculture
- The DWSMA has a high proportion of its area on land with soil and geologic characteristics that make groundwater more vulnerable to contamination
- The agriculture is on land with soil and geologic characteristics that make groundwater more vulnerable to contamination
- The parcel is on land with soil and geologic characteristics that make groundwater more vulnerable to contamination

Data sources

Minnesota Land Cover Classification and Impervious Surface Area by Landsat and Lidar: 2013 update - Version 2

https://gisdata.mn.gov/dataset/base-landcover-minnesota

Drinking Water Supply Management Areas - Vulnerability

http://www.health.state.mn.us/divs/eh/water/swp/maps/index.htm

Data preparation

We used the Minnesota Department of Health's (MDH) Drinking Water Supply Management Areas (DWSMA) layer as the endpoint for the metric. All land in a DWSMA received a minimum score of 0.2, with higher scores assigned where groundwater was more at risk based on indices for overall nitrate loading, and groundwater vulnerability described below.

Nitrate Loading Index:

Drinking water supply management areas are sub-divided into five vulnerability classes by the MDH based on the geological characteristics that leave ground water vulnerable to surface contamination. For each of these units we calculated the proportion of it that has agriculture as a land cover and the proportion of the total area DWSMA it represents. We then calculated a weighted sum of the proportion of agriculture in each vulnerability class. Thus, if the weight for each class were 1, the end result would be the proportion of the DWSMA in agriculture. We weighted units with lower vulnerability classes lower because they have a less direct influence on groundwater. We created an index of the weighted sum of proportion of agriculture in every DWSMA to identify the DWMAs that have a high risk combination of nitrate loading on land with vulnerable geologic characteristics. The end result is an index prioritizing DWMAs based on the total nitrate load on their ground water. Because water from throughout the DWMA is aggregated at the well, this score applies evenly to the entire DWSMA.

Groundwater Vulnerability Index:

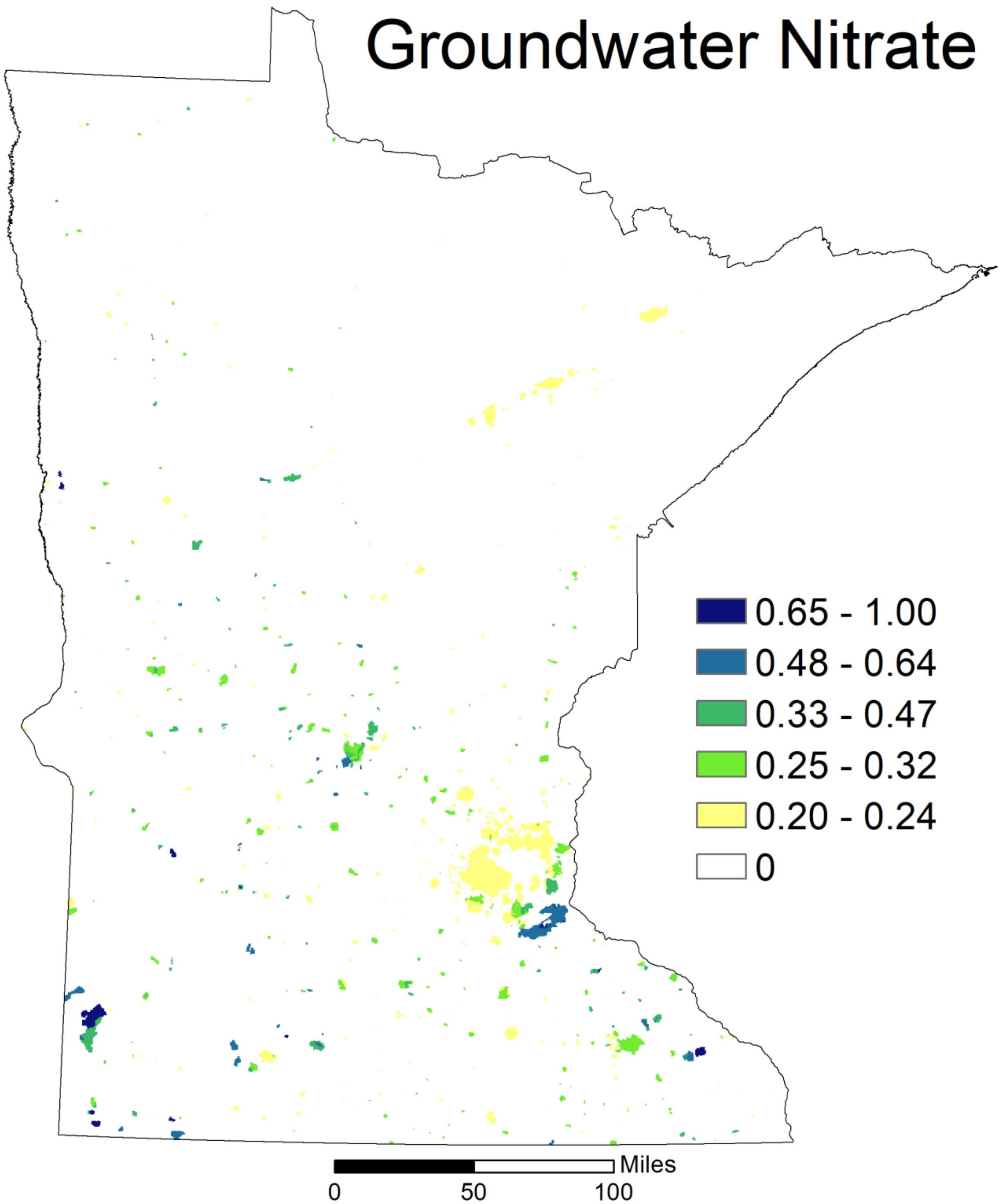
We further prioritized acquisitions within DWSMAs based on the vulnerability class of the land they were located on. Thus, parcels with a vulnerability class 'Very Low' in a DWSMA with a high nitrate loading index score may be lower priority than a parcel in a DWSMA with a lower nitrate loading index score if the parcel's groundwater vulnerability score is 'Very High'.

Nitrate Loading Index variables	Weight
% of DWSMA in agriculture and on very high vulnerability land (%_vh_ag)	1

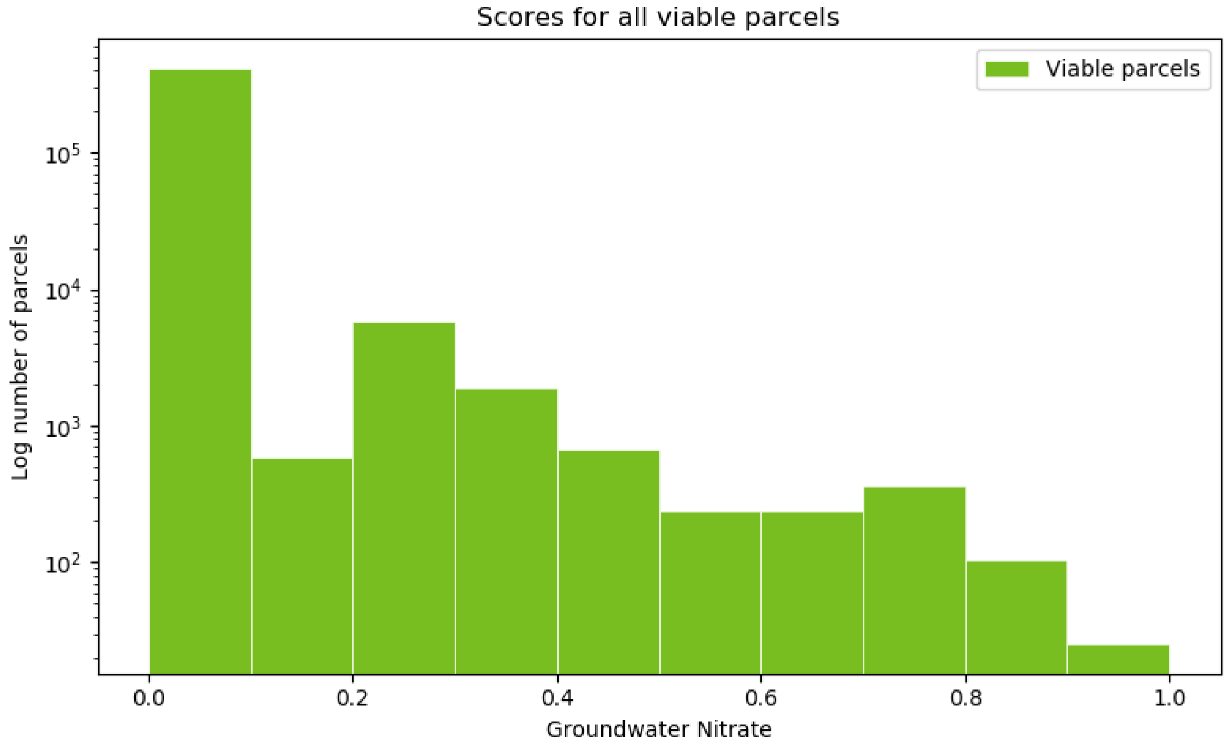
% of DWSMA in agriculture and on high vulnerability land (%_h_ag)	0.8
% of DWSMA in agriculture and on moderate vulnerability land (%_m_ag)	0.6
% of DWSMA in agriculture and on low vulnerability land (%_l_ag)	0.4
% of DWSMA in agriculture and on very low vulnerability land (%_vl_ag)	0.2
Groundwater Vulnerability Index variables	
Groundwater vulnerability of land of parcel is very high	1
Groundwater vulnerability of land of parcel is high	0.8
Groundwater vulnerability of land of parcel is moderate	0.6
Groundwater vulnerability of land of parcel is low	0.4
Groundwater vulnerability of land of parcel is very low	0.2
Base Score	0.2

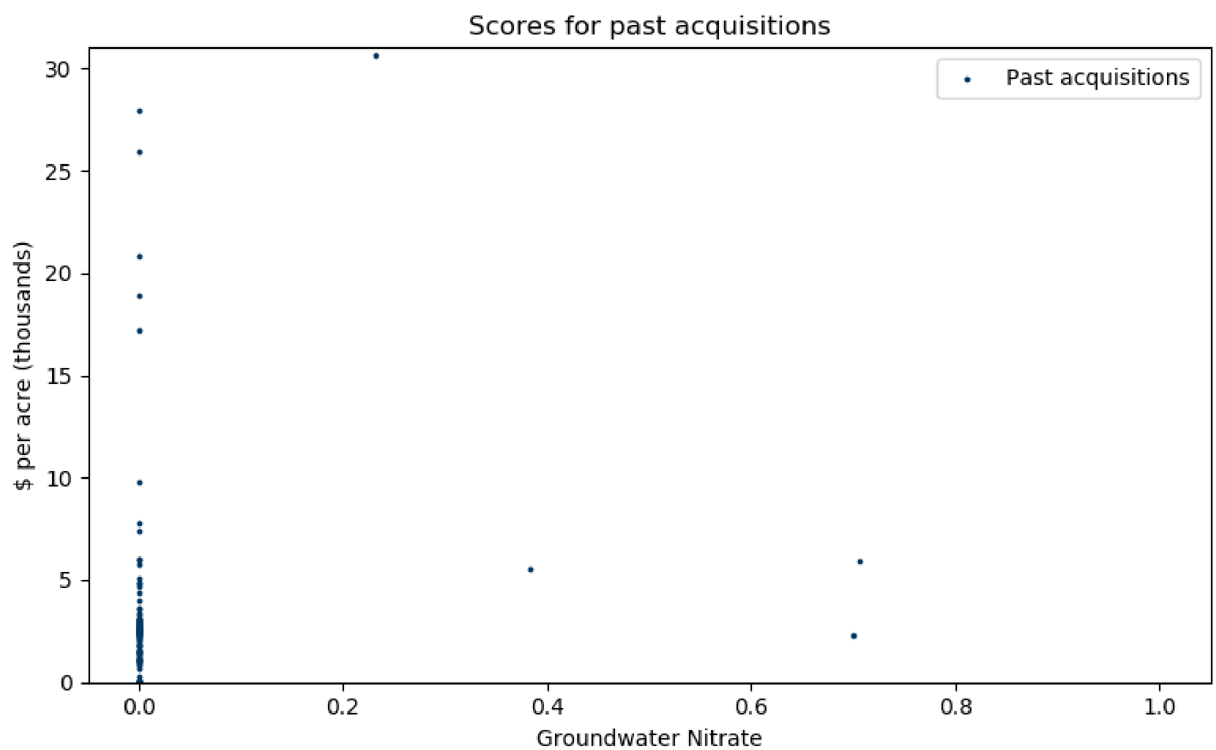
Final score:
0.2 + 0.8 * (Index of (weighted %_vh_ag' + weighted %_h_ag + weighted %_m_ag' + weighted %_l_ag' + weighted %_vl_ag) * groundwater vulnerability)

Map


Groundwater Nitrate
0.65 - 1.00
0.48 - 0.64
0.33 - 0.47
0.25 - 0.32
0.20 - 0.24
0
Miles
0
50
100

Score distributions





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