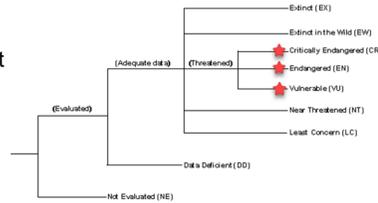
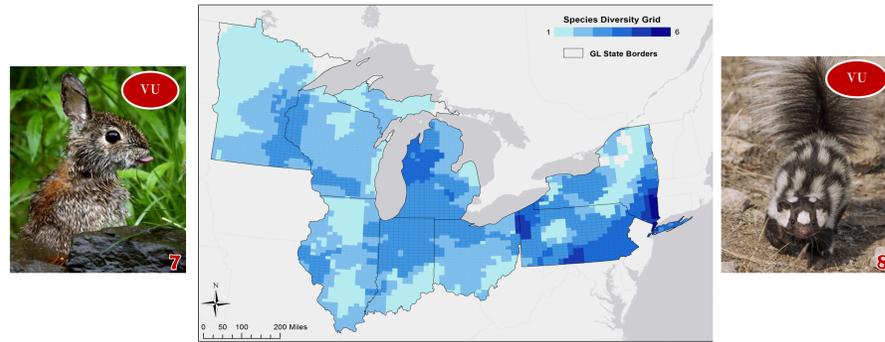


### INTRODUCTION

The International Union for Conservation of Nature (IUCN)'s Red List is a list of species across the globe at risk of extinction and assigns a code to each animal, ranging from least concern to extinct. Three of these categories can be grouped together as threatened: critically endangered (CR), endangered (EN), and vulnerable (VU). Animals are classified as such based on a scheme involving variables like habitat status, threats, stresses, and ecosystem services. Within the Great Lakes region of the United States, there are six reptile species and two mammal species which fall into these categories:



1. *Clemmys guttata*, the spotted turtle
2. *Macrochelys temminckii*, the alligator snapping turtle
3. *Emydoidea blandingii*, Blanding's turtle
4. *Glyptemys insculpta*, the wood turtle
5. *Glyptemys muhlenbergii*, the bog turtle
6. *Terrapene carolina*, the Eastern box turtle
7. *Sylvilagus transitionalis*, the New England cottontail
8. *Spilogale putorius*, the Eastern spotted skunk



**Figure 1.** Threatened reptile and mammal species diversity in great lakes states. All eight species never overlap but almost all of the study area is home to at least one.

One of the potential risks to already threatened species is environmental pollution in the form of toxic chemicals. The EPA collects data across various industry sectors on the release of harmful chemicals into the environment, known as the Toxic Release Inventory (TRI). One subset of chemicals the EPA monitors are known as Persistent Bioaccumulative Toxic (PBT) chemicals, which are particularly significant in terms of ecosystem effects because of their 1) resistance to degradation (persistence), 2) ability to build up in body tissue (bioaccumulation), and 3) often carcinogenic or otherwise harmful effects on living organisms (toxicity)<sup>1</sup>. The EPA separates releases into two categories: dioxin/dioxin-like compounds, and other PBT releases. These other chemicals fall into the categories of lead compounds, mercury compounds, polycyclic aromatic compounds (PACs), and various types of organochlorines used as pesticides, insecticides, and herbicides<sup>1</sup>. The EPA has various reporting thresholds for these 16 chemicals and four chemical compound categories dependent upon their toxicity. These chemicals are very significant in the field of conservation biology; one notable example is DDT, a commercial pesticide which nearly wiped out important raptor species in the US. DDT has since been banned, but the chemicals in this group have certainly filled its role. These toxins can take effect in both terrestrial and aquatic habitats. Although the analyses included in this project are limited to the land surface, the study area includes significant aquatic ecosystems as well. The goal of this project is to assess the risk level across states bordering the Great Lakes due to PBT releases, particularly in the context of threatened species.

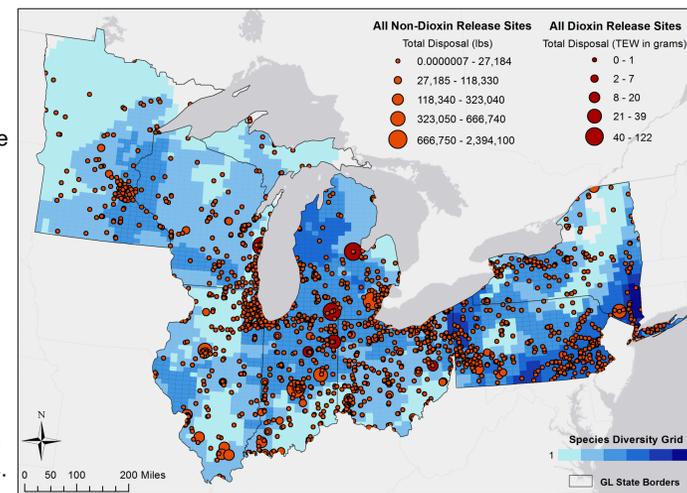
### Species Distribution

Reptile and mammal distributions were obtained from the IUCN Red List spatial data download. These datasets encompassed the whole globe, so they had to be cut down to the eight states selected for this project: Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan, Pennsylvania, and New York. A search within each dataset identified the threatened species. A "fishnet" grid was laid over the species ranges to be able to identify the diversity of each grid cell. Each species was separated from the mammal and reptile groupings into a new layer, then added to the "fishnet" grid so that each cell had information on the presence (or absence) of each species. These presences were added up to get the sum diversity for each cell, which ranged from one to six species (Figure 1).

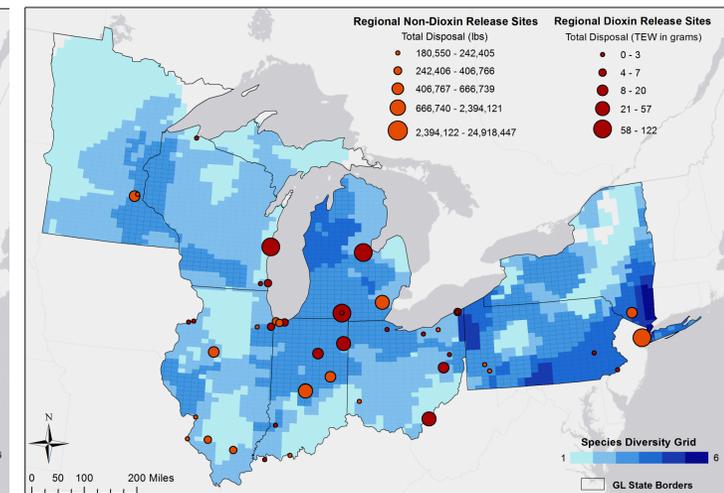
### PBT Chemical Releases

Using the EPA TRI explorer, 2015 releases were downloaded by facility for EPA Zone 5 (MI, WI, IL, IN, OH), PA, and NY. Additionally, the top 100 PBT releases in 2015 for the whole country were obtained. The top 100 release sites were cut down the great lakes region but also include a 10 km buffer around the relevant states in order to involve releases just beyond state borders. This layer is referred to in the maps as "regional" releases. The EPA separates dioxin and dioxin-like compounds from other PBT releases and offers both the net releases in pounds as well as Toxic Equivalency Weights (TEWs) for the dioxins. TEW is calculated using the relative toxicity of different components of these dioxin compounds<sup>1</sup>. These TEWs were used for subsequent dioxin analyses because they are a more accurate measure of risk, given that they qualify relative toxicity. As such, both the full in-state releases and clipped regional releases are separated into two categories: non-dioxin releases, reported in pounds, and dioxin and dioxin-like releases, reported as TEW in grams. A technique called inverse distance weighting (IDW) interpolation was used to predict the effect magnitude of each release site based on the quantity of PBT chemicals released at each site and proximity to other sites. IDW interpolations were made for all four release categories and each was re-classed on a scale of 1-10 because the range and unit of the values were different for each. The two interpolation maps shown were created by combining the two classes of PBT releases for each perspective, one showing the regions at risk from the major regional releases and the other showing the regions at risk from all the in state releases (Figures 4,5).

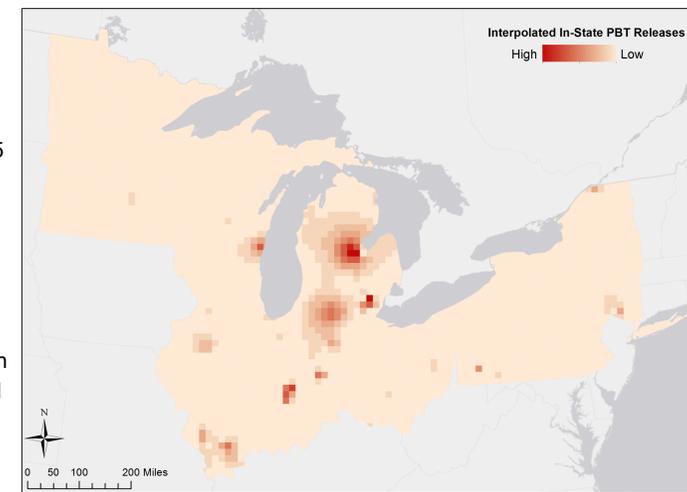
### METHODS



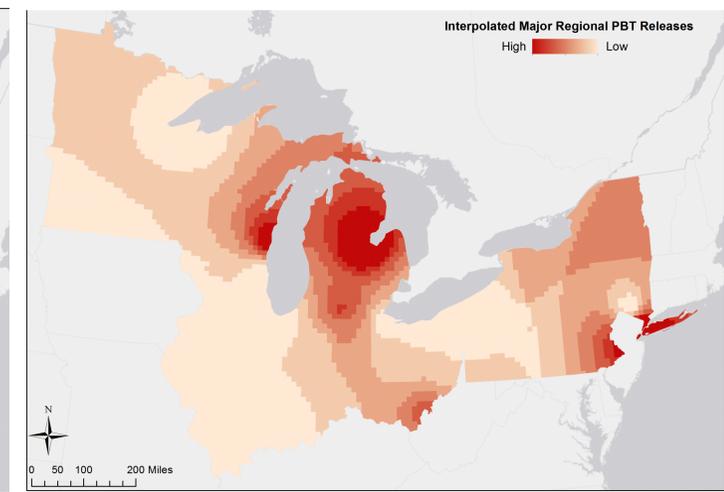
**Figure 2.** All in-state PBT chemical releases. There are a total of 2,460 non-dioxin and 241 dioxin release sites.



**Figure 3.** Major regional PBT chemical releases. Notable sites include a dioxin site on the southeast Ohio border and a very large non-dioxin site near Long Island.



**Figure 4.** IDW interpolation of Figure 2, or the potential spread of disposed chemicals dependent upon distance to other sites and magnitude of releases.



**Figure 5.** IDW interpolation of Figure 3, which found more areas of higher risk than Figure 4 because of how large all of the releases included are.

### RESULTS & CONCLUSIONS

There appears to be an alarming amount of PBT pollution throughout the great lakes states, which means the lakes themselves are being affected as well. The largest releases and most affected areas identified from the interpolations do not uniformly correlate with the areas most diversely populated with threatened species, but there are some areas where this is the case. The area around southern New York, particularly along the Connecticut border, is the most diverse. It is also in very close proximity to the largest non-dioxin PBT release in the whole area, at the northern border of New Jersey. Eastern Michigan is also identified as a hot-spot for PBT pollution and the risk spreads towards the western portion of lower peninsula, another diverse area.

While it is difficult to say how directly PBT chemicals are affecting threatened species, this type of pollution is extremely harmful to natural systems and organisms. These eight species are already at risk and this is just one of many factors that could lead to their demise. The issue is not just isolated to wildlife, however; PBT chemical releases have major implications for human, animal, and environmental health. The great lakes basin is home to more than 3,500 species of plants and animals and provides water for approximately 35 million people in the US and Canada<sup>2</sup>. Many of these compounds have been banned in Europe and some have even been banned in the US, prompting the question of why there are any releases even happening at all<sup>3</sup>. Health risks ranging from neurotoxicity to endocrine disruption to immunotoxicity are known effects of some of these chemicals, and yet there are still facilities disposing of thousands of pounds of them throughout these eight states<sup>3</sup>. This situation speaks to the importance of novel approaches to wildlife conservation, such as One Health, the idea that making improvements in human, animal, or environmental health can positively affect the others.

### RESOURCES

- Data Sources**
- IUCN Red List spatial data download
  - EPA TRI Explorer
  - Basemap: Tufts M Drive
- Cited Sources**
1. PBT Final Rule Summary, EPA.gov. Accessed December 16, 2016. <https://www.epa.gov/sites/production/files/documents/pbrule-sum.pdf>.
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  3. Stockholm Convention on Persistent Organic Pollutants (POPs) text as amended in 2011. Accessed December 15, 2016. <http://www.unep-pops.org/POPs-Convention/2011-English.pdf>.
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Cartographer: Annie Carter  
 GIS 101: Introduction To GIS  
 Projection: Albers  
 Projected Coordinate System: NAD 1983 Great Lakes Basin Albers