Incorporating Environmental Public Health Indicators into Cumulative Risk Scores to Track the Disparate Burden of Pesticide Exposure in Wisconsin

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Overview

- *Provide* the background on the importance of pesticide exposure as an issue in Wisconsin
- *Describe* available data and their relevance to indicator development
- *Illustrate* Wisconsin's approach to exploring pesticide exposure and risk estimates
- *Offer* future research directions, including identifying the role of pesticides in priority health endpoints (childhood cancer)

Background

- Agricultural picture of Wisconsin
  - Wisconsin leads the nation:
    - Snap beans, cranberries, canning beets, and corn for silage
  - Central Wisconsin known for vegetable production
    - Third in the nation for carrots, potatoes, sweet corn for processing, and green peas for processing
  - An integral part of Wisconsin's economy
    - 12 percent of workforce relies on it directly for their job

Background

- Wisconsin crops (ranked greatest to least)

Corn
Soybeans
Sweet Corn (processing)
Potatoes
Snap Beans (processing)
Green Peas (processing)
Cranberries
Sweet Corn (fresh market)
Apples
Cabbage (fresh market)
Cucumbers (processing)
Carrots
Cabbage (processing)
Tart Cherries
Onions
Strawberries

Have acreage information for top 6 crops -- comprising 99.2% of all crops grown in the state

Background

- Agricultural pesticide exposure is potentially high
  - Wisconsin farmers own 16 million acres of land – 44 percent of all land in the state
- Prior research has implicated agricultural pesticide exposure with childhood cancer
  - Occupational and in-home pesticide use
  - Residence on a farm
- Challenge:
  - Though a priority area in Wisconsin, data/measures for pesticide exposure are lacking

EPHT Indicators

HAZARDS

Annual tons used

Pounds applied

Patterns of use in agriculture, home, and garden

Number of worker and community complaints about possible pesticide exposure

Proportion of foods with residual pesticide levels that fail to meet safe consumption regulations and guidelines

EXPOSURE

95th percentile blood and urine concentration levels for biomarkers

HEALTH EFFECT

Incidence of pesticide-related poisonings and illnesses in pesticide workers

Number of non-occupational pesticide-related poisoning and illness

Number of pesticide-related poisoning and illness in children

EPHT Indicators

- Want a mechanism to evaluate the potential for pesticide exposure in Wisconsin
  - linking hazard information to personal exposure to health outcomes is the ultimate goal
- How can we move beyond the main core hazard indicator we have to develop a community risk score that can
  - guide future data collection
  - examine potential relationships with health outcomes of interest

EPHT Indicators in WI

- Level 1: Individual hazard or health outcome data presented by person, place, or time
  - e.g. acres of land used for corn production
- Level 2: Combined/integrated measures linking two different types of hazard/exposure or health outcome – lack good estimates of population exposure and/or dose
- Level 3 – Combined hazard, exposure, and health outcome measures or integrated risk-related measures that identify potential population exposure levels and population risk estimates

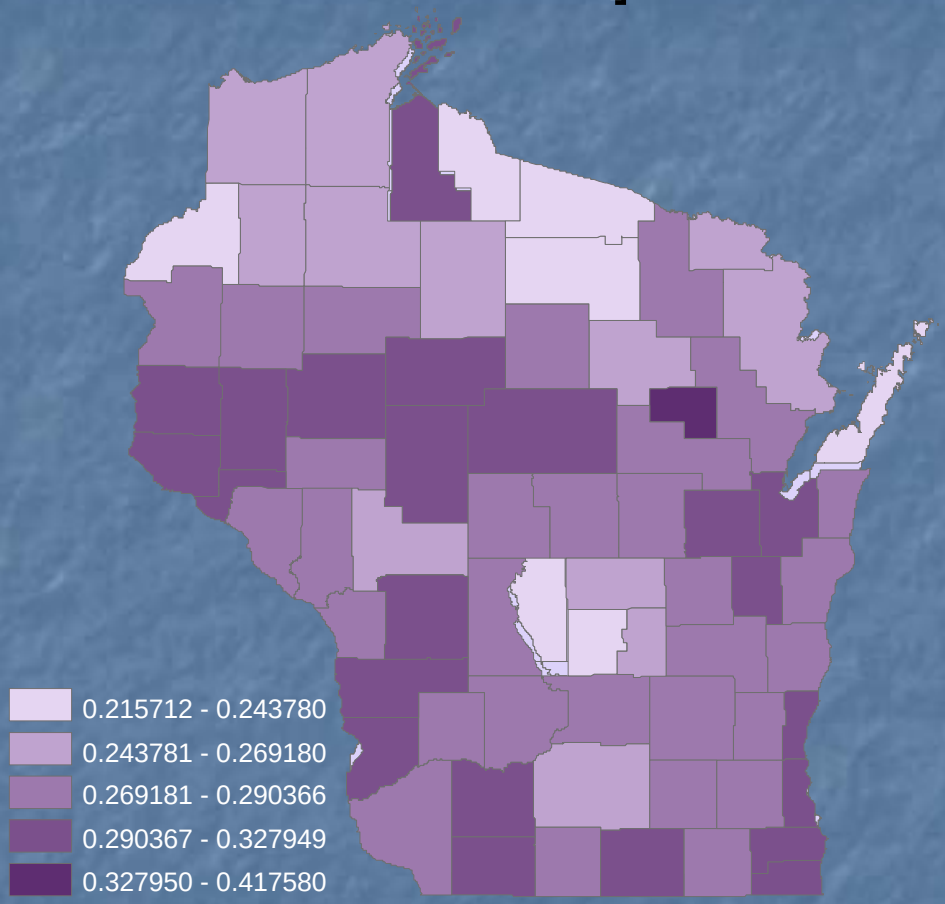
Available Data

- Health outcome and demographic information
  - US Census
    - Population at risk (childhood cancer example)
  - Cancer Registry
    - Childhood cancer incidence
- Crop information
  - National Agricultural Statistics Service
    - Crop information by county
  - Wisconsin Agricultural Statistics Service
    - Crop information: acres planted,percent of area applied, average number of applications/year, rate of application (based on sampled personal interview surveys)
- Agricultural chemical information
  - Environmental Protection Agency & California Prop 65
    - Toxicity/Carcinogenicity/Persistence
    - Identify the agricultural chemicals of interest

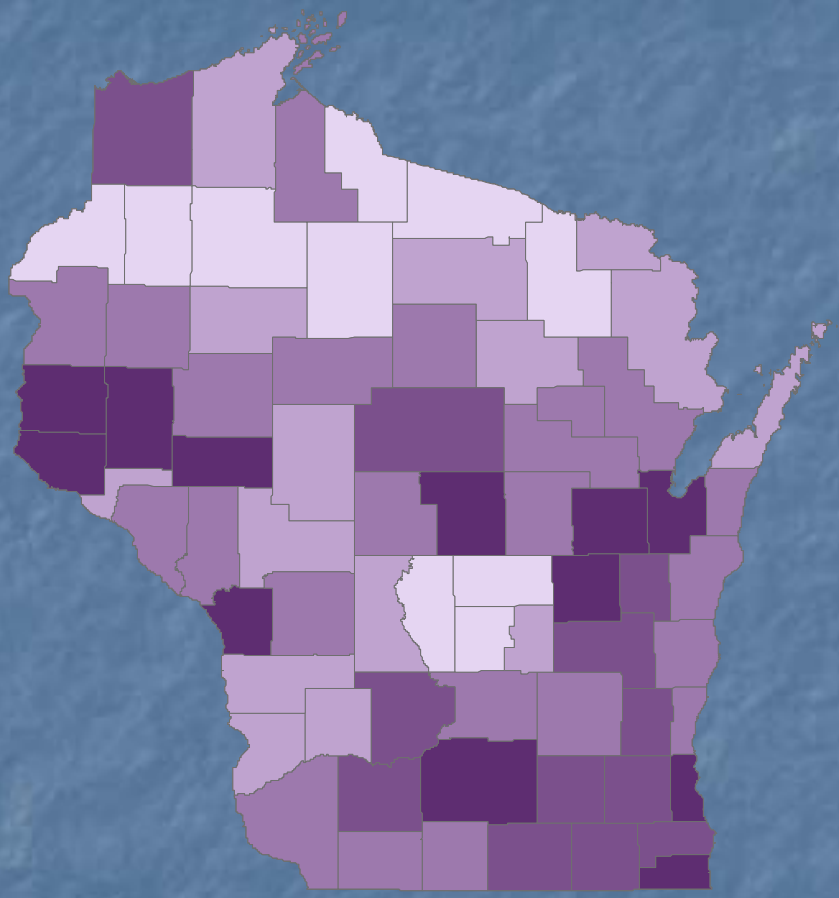
Methods

- Calculate population at risk (childhood cancer example)
  - Women of reproductive age
  - Children under the age of 18
- Childhood cancer incidence

Population at Risk



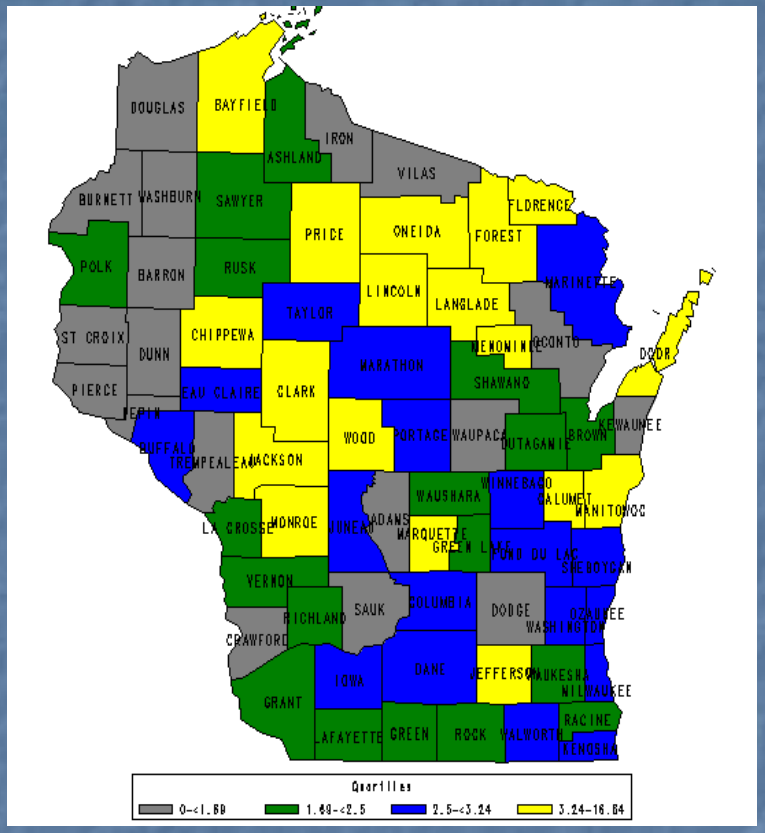
Percent Under 19



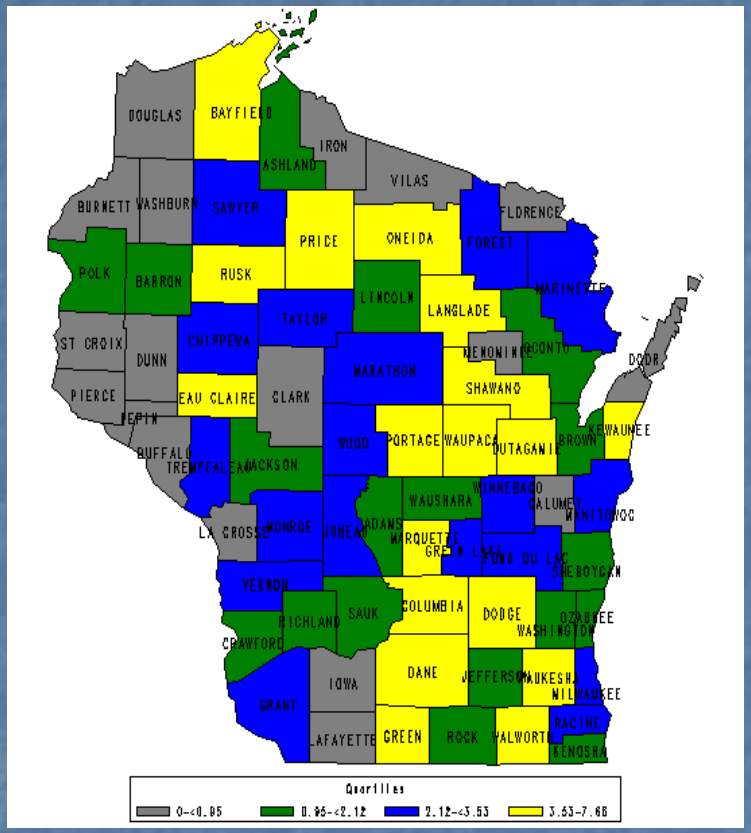
Percent Women 20-44

Population at Risk

- Approximately 250 cases annually



Brain



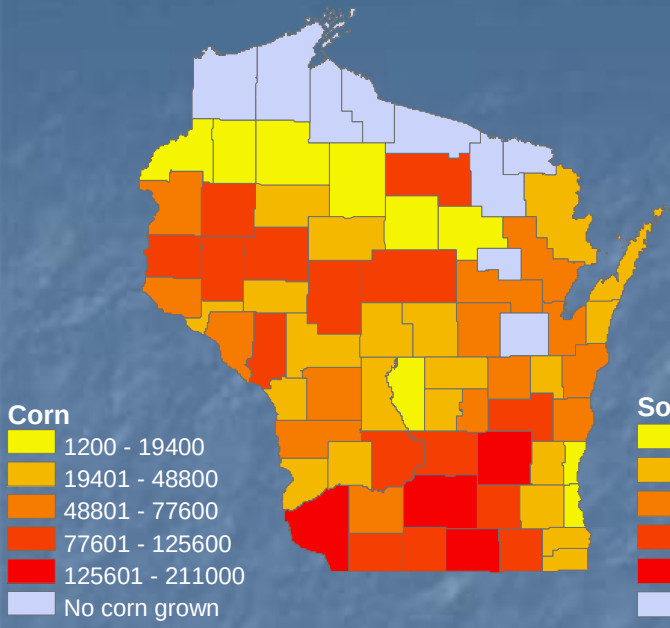
Lymphatic

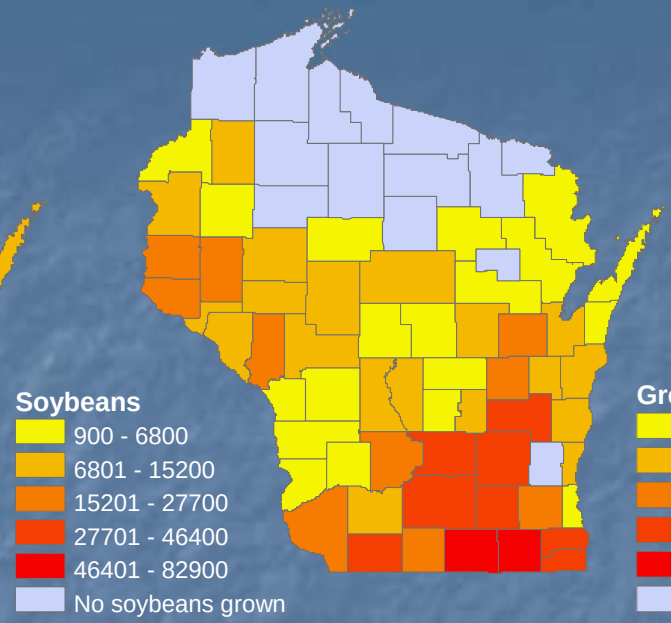
Childhood Cancer
Age Adjusted
1990-2000*

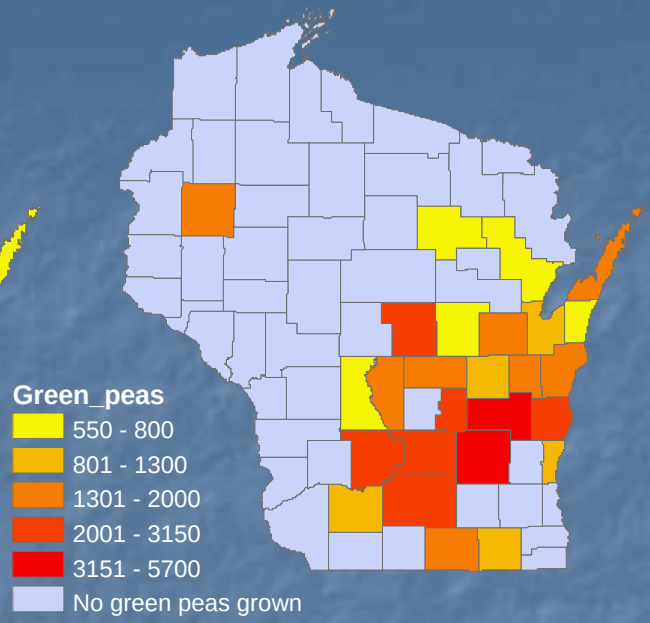
* Preliminary Data

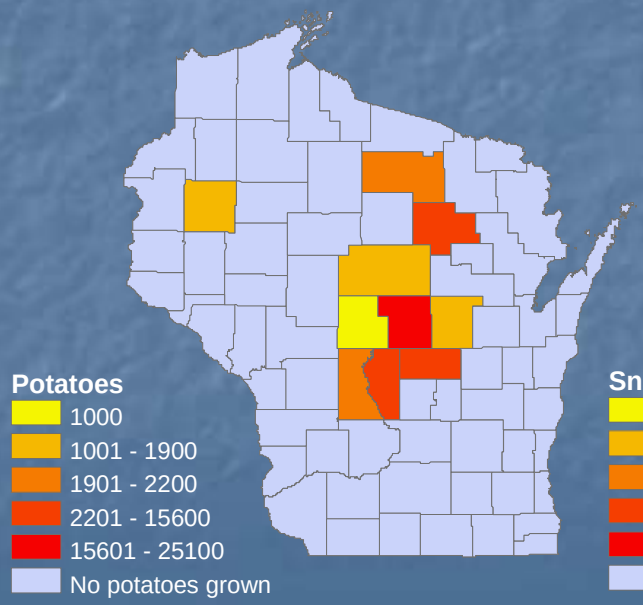
Methods

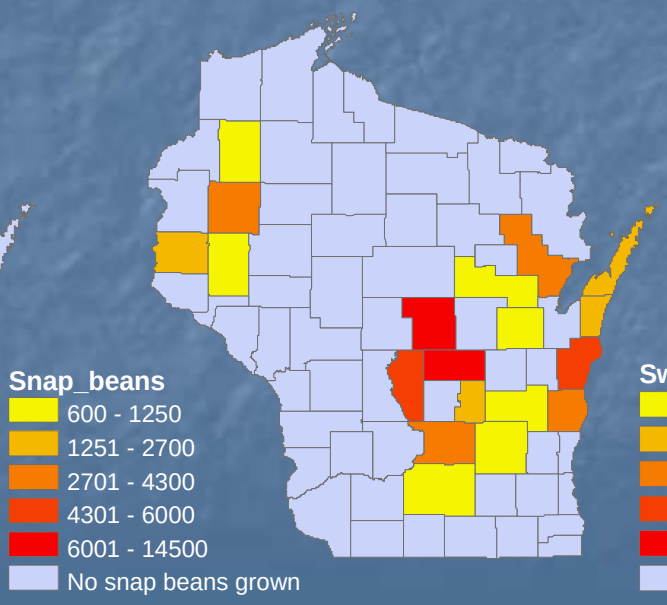
- National Agricultural Statistics Service (1996)
  - Crop information by county
- Wisconsin Agricultural Statistics Service (1996)
  - Agricultural chemical information
  - Percent of acreage applied, average number of applications/year, rate of application
  - Based on personal interview surveys (890 farms; RR=79%)

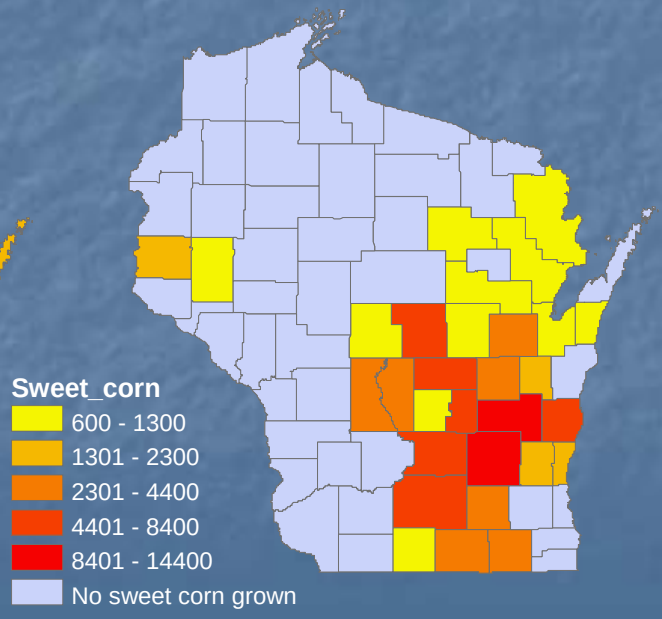

Corn
1200 - 19400
19401 - 48800
48801 - 77600
77601 - 125600
125601 - 211000
No corn grown


Soybeans
900 - 6800
6801 - 15200
15201 - 27700
27701 - 46400
46401 - 82900
No soybeans grown

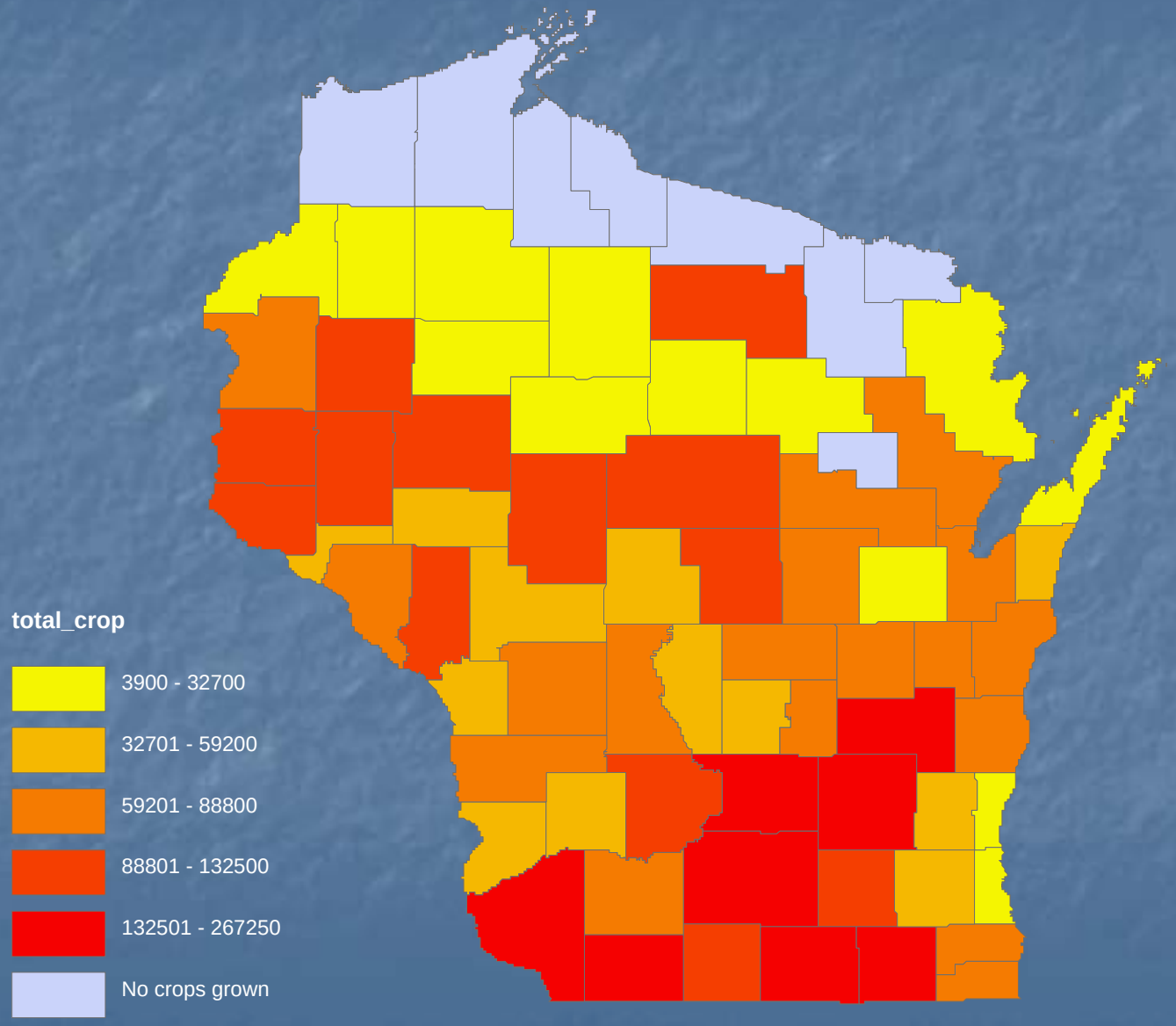

Green_peas
550 - 800
801 - 1300
1301 - 2000
2001 - 3150
3151 - 5700
No green peas grown


Potatoes
1000
1001 - 1900
1901 - 2200
2201 - 15600
15601 - 25100
No potatoes grown


Snap_beans
600 - 1250
1251 - 2700
2701 - 4300
4301 - 6000
6001 - 14500
No snap beans grown


Sweet_corn
600 - 1300
1301 - 2300
2301 - 4400
4401 - 8400
8401 - 14400
No sweet corn grown

Total Crops by County



Methods

- Narrow list of pesticides
  - Environmental Protection Agency – chemicals evaluated for carcinogenic potential
    - 112 Pesticides → 34 Pesticides
    - Classified as possible, probable, likely, or suggestive evidence of carcinogenicity
    - Of the 34 pesticides, 16 are applied to the six crops of interest
  - Environmental Protection Agency & California Prop 65
    - Toxicity/Carcinogenicity/Persistence
    - Identify the agricultural chemicals of interest

Methods

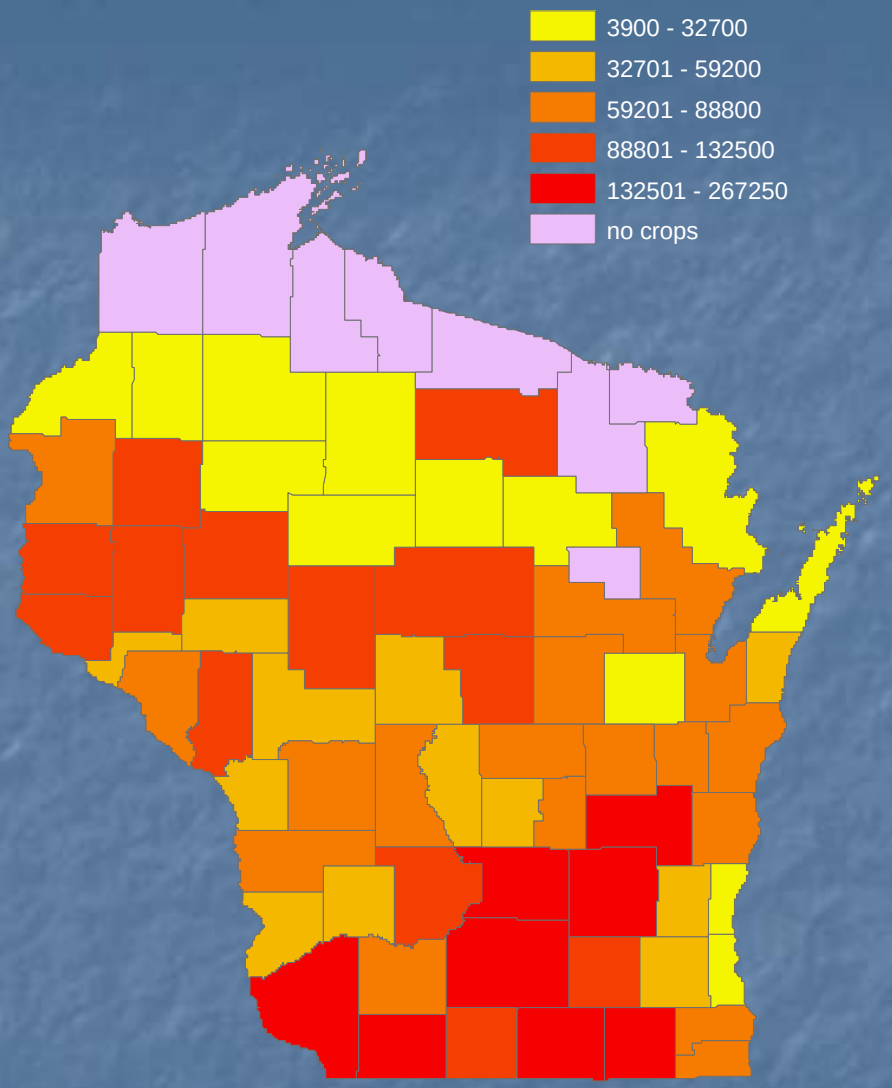
	CAS Number	Carcinogen
Herbicides		
Acetochlor	34256-82-1	Likely to be carcinogenic to humans (high doses), not likely to be carcinogenic to humans (low doses)
Alachlor	15972-60-8	Likely to be carcinogenic to humans (high doses), not likely to be carcinogenic to humans (low doses)
Bromoxynil	1689-84-5	Group C- Possible Human Carcinogen
Cyanazine	21725-46-2	Group C- Possible Human Carcinogen
Dimenthenamid	87674-68-8	Group C- Possible Human Carcinogen
Linuron		Group C- Possible Human Carcinogen
Metolachlor	51218-45-2	Group C- Possible Human Carcinogen
Pendimethalin	40487-42-1	Group C- Possible Human Carcinogen
Simazine	122-34-9	Group C- Possible Human Carcinogen
Insecticides		
Dimethoate	60-51-5	Group C- Possible Human Carcinogen
Piperonyl butoxid	51-03-6	Group C- Possible Human Carcinogen
Pyrethrins*	8003-34-7	Suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential
Fungicides		
Maneb	12427-38-2	Group B2--Probable Human Carcinogen
Thiophanate-methyl	23564-05-8	Likely to be carcinogenic to Humans
Triphenyltin hydroxode	76-87-9	Group B2--Probable Human Carcinogen
Metam-sodium	137-42-8	Group B2--Probable Human Carcinogen

Methods

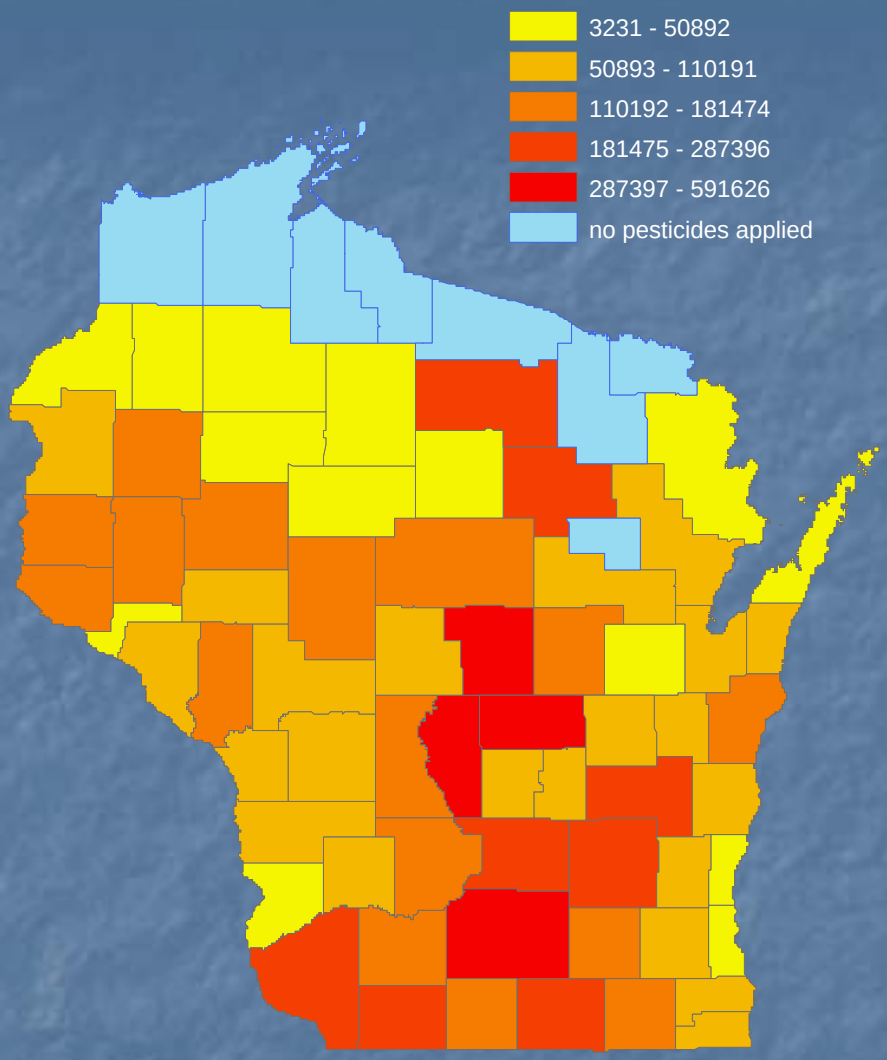
- Compute county-level estimates of pesticide usage

Total acres planted	X	% of area receiving pesticide application	X	average number of applications per year	X	application rate (lbs/acre)

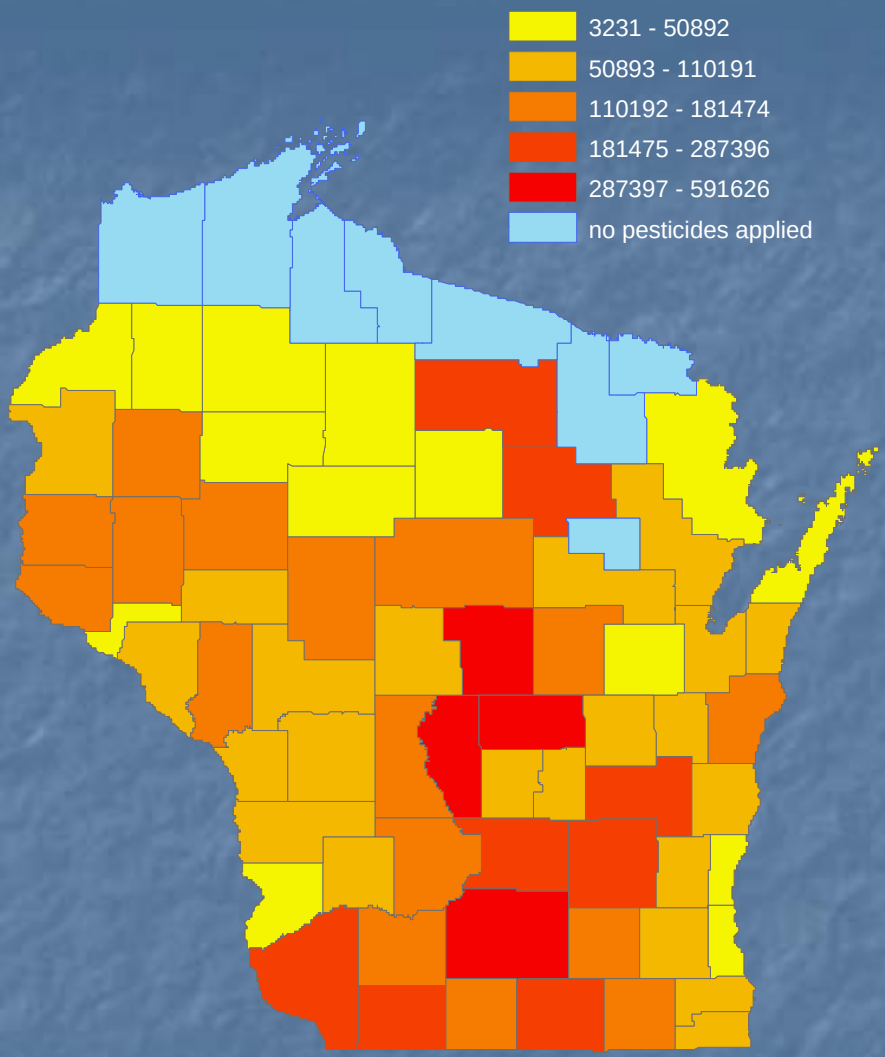
  - Assumes uniform distribution of agricultural chemicals
    - Tested assumption with corn/soybeans that have application information for five reporting districts in Wisconsin
  - For each of 72 counties, there is crop information for 6 of 16 crops (comprising 99% of all crops)



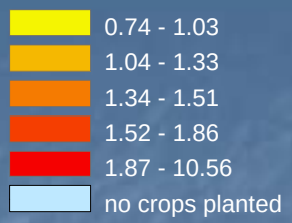
Total Crops
(acres)



Total Pesticides
(pounds)



Total Pesticides
(pounds)



Estimated Carcinogenic Pesticides
(pounds per acre)

Methods

- Integrate information into a hazard index*

$$\text{Risk Ranking} = \frac{\text{Application}}{\text{Rate}} \times \frac{\text{Toxicity}}{\text{Score}} \times \text{Persistence}^{**}\ \text{Score}$$

- Weight score by population at risk

*adapted from: Gunier, et al (2001); Valcke, et al (2005)

** will incorporate additional soil characteristics (e.g. adhesion, solubility)

Methods

- Moving beyond acreage as a proxy for exposure (level 1 indicator) –
  - Rate of application does not necessarily match acres planted or total pesticides applied
- Moving toward geographic variability in carcinogenic pesticide application (level 2 indicator)
- Will move to hazard score that incorporates pesticide information with persistence and toxicity -- approximating risk

Challenges

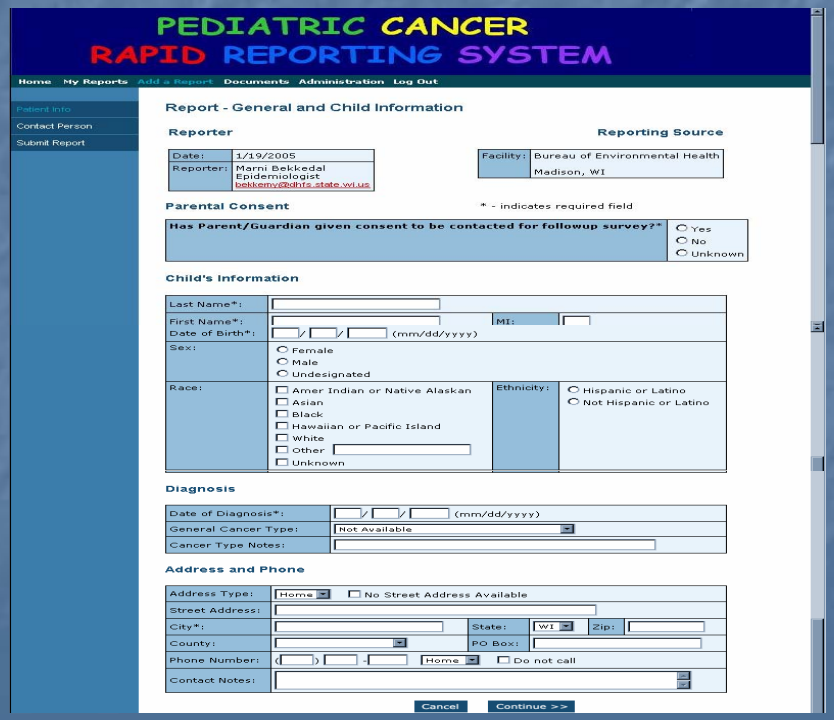
- Aggregated information (pesticide application rates may not be homogeneous across counties
  - i.e. the potential for ecologic fallacy
- Data limited to agricultural, outdoor chemical application (no indoor exposure)
- Lack occupational exposure information in Wisconsin
- Robust estimates of persistence (and in what)
  - What is the hypothesized exposure route?

Strengths

- Taking indicator measures that are readily available and deriving public health risk estimates
  - Integrating with other data sources
  - Still screening level, but can identify key gaps
  - Guide future hypothesis generation
    - Areas of greater interest -- the *potential* for higher risk of exposure
    - Childhood cancer example

Future Directions

- Integrate with cancer reporting system
- Develop a rapid case ascertainment method for childhood cancers



PEDIATRIC CANCER
RAPID REPORTING SYSTEM

Future Directions

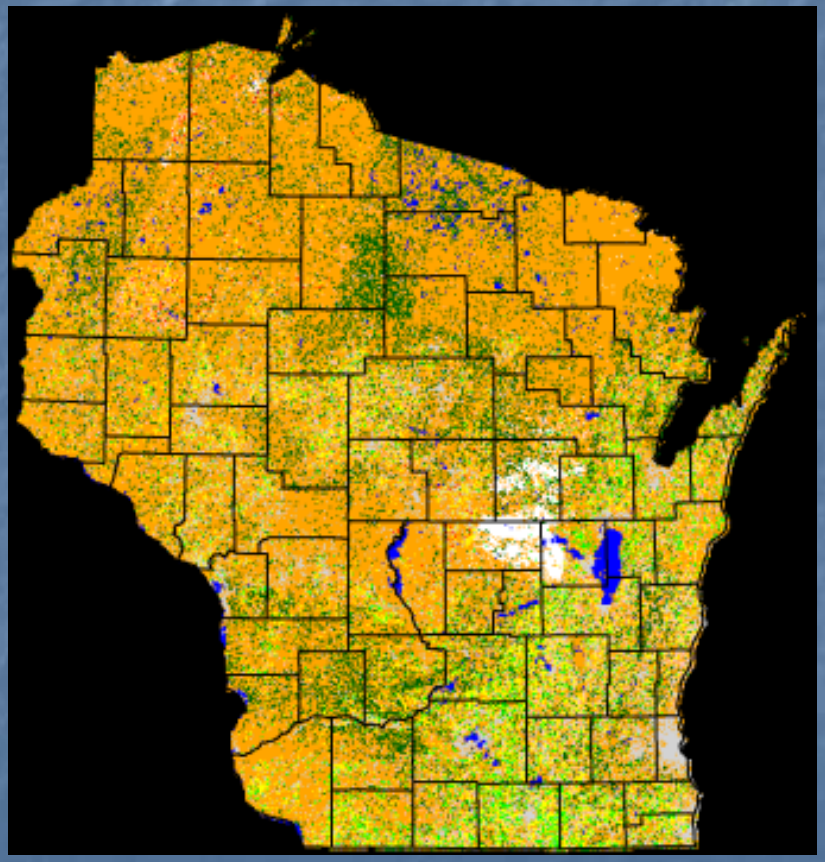
- Hospitals enter data
  - Patient name
  - Demographics
  - Current address
    - Critical for exposure assignment
  - Contact information
  - Diagnosis
- Data relayed to tracking database
  - Database is secure with role-based access
- Data aggregated for all hospitals in state
  - Hospitals can use to compare selves to state
  - Public Health can use for follow-back & further analysis

Future Directions

- Moving beyond ecologic data
  - Follow-back studies with childhood cancer
  - Linked birth/cancer registry records
  - Geocoding patient address
  - The potential for studies incorporating personal interviews
    - Allows for the examination of covariates
    - Best information available absent biomonitoring information

Future Directions

- Integrating satellite data
  - Comparing satellite with usage information to get a sense of under- or over-reporting
  - Cropland data layer
    - 30 x 30 meter resolution
    - Additional crops possible
- Exploring well water contamination
- Incorporating other health outcome datasets
  - e.g. poison control center data



Conclusions

- Project demonstrates linkage possibilities
- Incorporates GIS technology to examine trends
- Still screening level, but can identify geographic areas of particular interest for future data collection efforts/in depth analyses
- Strengths:
  - The ability to identify key gaps where additional information is needed
  - The ability to guide future hypothesis generation
  - The ability to guide policy management decisions
  - Puts environmental monitoring data in a public health context