Palmer Amaranth Risk Analysis in Iowa

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Advisors: Professors Clint Meyer, John Pauley, and Brady Spangenberg

Outline

- History and biology of Palmer amaranth
- Palmer Project outreach
- Demographic model
- Geographic model
- Synthesis model
- Economic impact study
- Future work

The Palmer Project

SIMPSON COLLEGE

Agriculture makes up 33% of Iowa's economy.

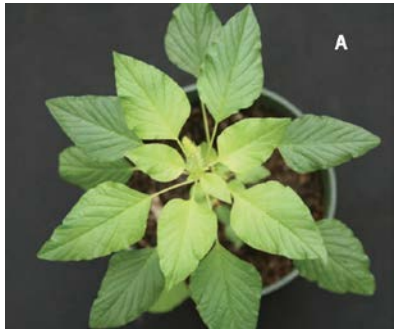
-Iowa Agricultural Statistics Bulletin, 2014

Project began in May 2015

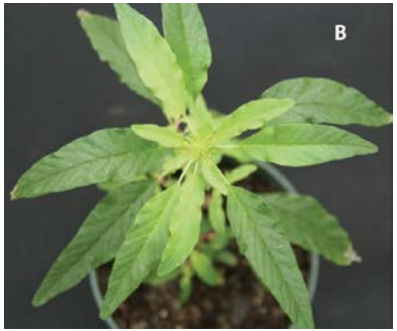
- Predictive analytics
- Qualitative, sociological research
- Educational outreach
- Curricular innovation

Biology of Palmer

- Closely related to waterhemp
  - Same genus
  - Similar appearance
- Dioecious
  - Develops herbicide resistance rapidly
- Grows 2-3 inches a day
  - 8 feet tall
- Germinates from May to September
- Prolific seed production
  - 500,000 - over 1 million



Palmer

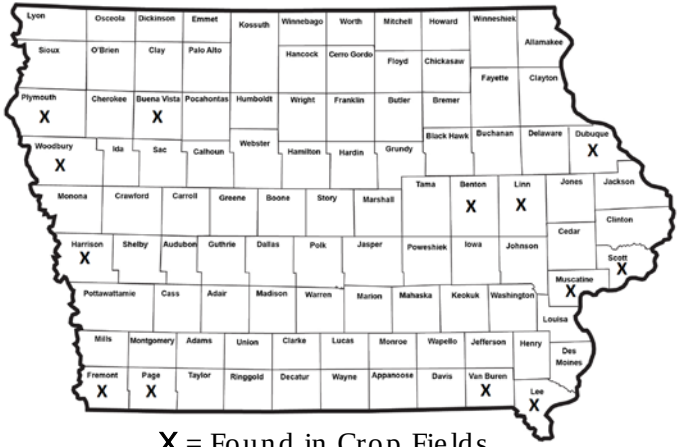


Waterhemp

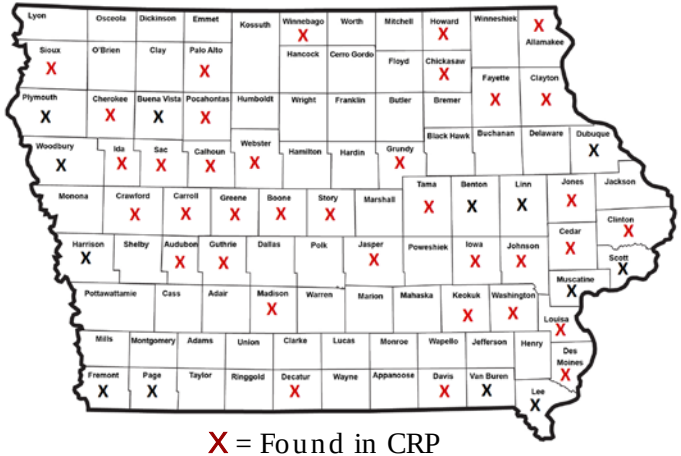
History of Palmer

- Major agricultural weed in the late 1990's in the Southern Great Plains
- Resistance to several herbicides, including glyphosate, dicamba and atrazine
- No new herbicide modes of action being developed
- Recently discovered in CRP seed, causing major dispersal

2016



2017



ISU Extension, 2016, 2017

Palmer Amaranth is in Kansas

Modeling Objectives

- What is the risk of Palmer infesting any particular area in Iowa?
- Three types of data
  - GIS Maps
  - County Data Information
  - Interviews
- Two characteristic maps
  - Demographic map
  - Geographic map
- Final synthesis of the two maps
  - Considers risk from both maps to create a final risk model

Predictions

- Higher risk in the southern counties
  - Less productive soil
- Higher risk near waterways
  - Increased animal traffic
- Higher risk near edge of state
  - Dispersal from neighboring states

Demographic Model

- Characters
  - Diverse Herbicide Programs
  - Ditch Maintenance
  - Owning Equipment
  - Cleanliness of Equipment
  - Community Collaboration
  - Add 1+ Crop
  - Awareness of Superweed
- Attributes
  - Average Expense
  - Primary Occupation
  - CRP Acres
  - Percent Owned
  - Average Farm Size
  - Average Income
  - Average Age

1		County Rank
2	Osceola County	0.784
3	Buena Vista County	0.819
4	Emmet County	0.819
5	Sioux County	0.83
6	Monona County	0.841
7	Pocahontas County	0.844
8	Hamilton County	0.846
9	O'Brien County	0.855
10	Crawford County	0.867
11	Ida County	0.868

1		County Rank
91	Jefferson County	1.085
92	Marion County	1.091
93	Decatur County	1.091
94	Winneshiek County	1.095
95	Wayne County	1.097
96	Davis County	1.107
97	Lucas County	1.113
98	Clarke County	1.116
99	Monroe County	1.133
100	Warren County	1.15

Demographic Model

- Information was gathered on relationships between characters and attributes
- Each character/attribute pair was given a score
  - Character/attribute potential risk score
- The characters were ranked based on greatest to least impact on mitigating Palmer infestations

Risk Score: 1.2-0.8
1.2: very unlikely
1.1: unlikely
1: neutral
0.9: likely
0.8: very likely

Character	Rank
Diverse Herbicide Program	1.7
Ditch Maintenance	1.6
Owning Equipment	1.5
Cleanliness of Machinery	1.4
Collaboration	1.3
Add 1+ Crop	1.2
Awareness of Superweeds	1.1

Demographic Model

Risk Score: 1.2-0.8
1.2: very unlikely
1.1: unlikely
1: neutral
0.9: likely
0.8: very likely

Spreadsheet for scores

- Top = Characters (Diverse herbicide program, ditch maintenance, etc.)
- Side = Attributes (Small farm, large farm, etc.)

	(1.7) Diverse Herbicide Program	(1.6) Ditch Maintenence	(1.5) Owning Equipment	(1.4) Cleanliness of Machinery	(1.3) Collaboration	(1.2) Add 1+ Crop	(1.1) Awareness of Superweeds	Total Attribute Score	Overall Attribute Rank
Attribute 1	0.9	0.9	1.1	1.1	0.8	1.1	0.9	9.51	0.970
Neutral	1	1	1	1	1	1	1	9.8	1.000

$$S_{attribute} = c_1(r_1) + \ldots + c_i(r_i)$$

$r =$ Risk Score
$c =$ Character Rank
$S =$ Total Attribute Score

Example with Attribute 1: $1.7(0.9) + 1.6(0.9) + 1.5(1.1) + 1.4(1.1) + 1.3(0.8) + 1.2(1.1) + 1.1(0.9) = 9.51$

Overall Attribute Rank = Total Attribute Score ÷ Neutral Attribute Score

- Neutral Attribute Score = ***9.8***
- From previous example: Overall Attribute Rank = 9.51/9.8 = ***0.970***

Demographic Model

- All county attribute data were collected from Ag Census data
- We ranked each attribute based on its potential to mitigate Palmer
- Each data point per county was given a rank as well, corresponding to the 0.6 - 1.4 scoring system

Risk Value

1 - 0.6
2 - 0.7
3 - 0.8
4 - 0.9
5 - 1
6 - 1.1
7 - 1.2
8 - 1.3
9 - 1.4

Attribute	Weight
Average Expense	1.7
Primary Occupation	1.6
CRP	1.5
Percent Owned	1.4
Average Farm Size	1.3
Average Income	1.2
Average Age	1.1

Demographic Model

$$R_{county} = \frac{(r_1)(a_1)(c_1) + \ldots + (r_i)(a_i)(c_i)}{R_{neutral}}$$

$r =$ Risk Value

$a =$ Attribute Rank

$c =$ Attribute Weight

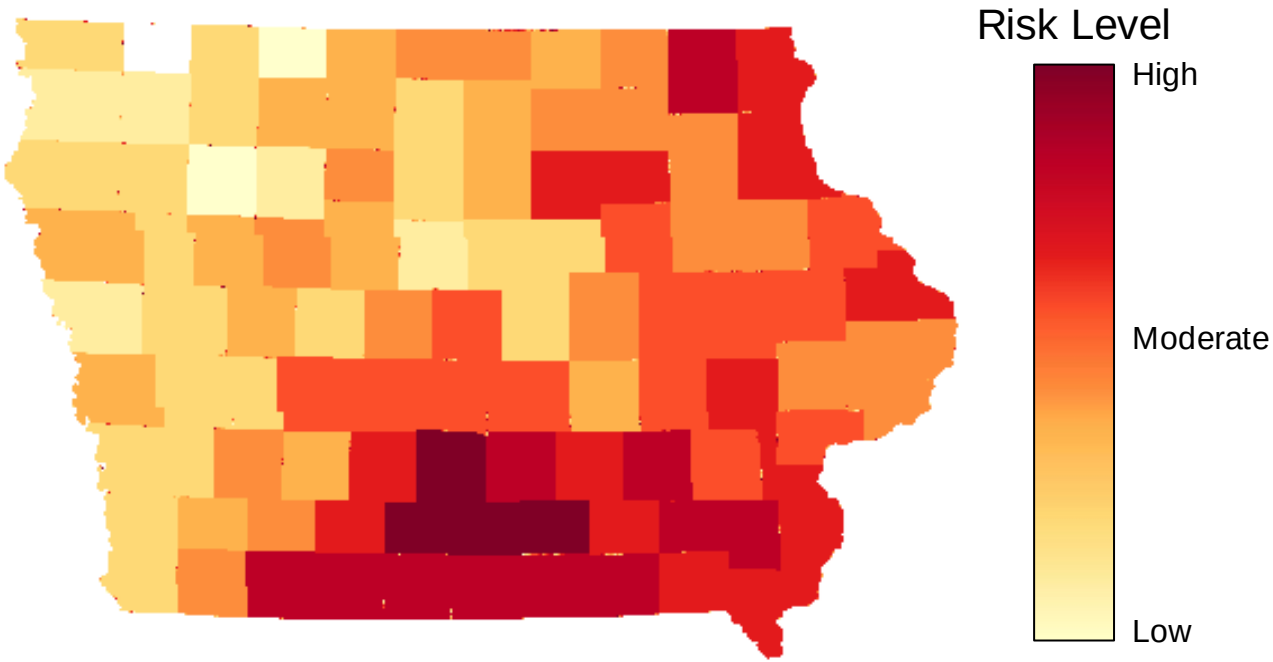
$R_{county} =$ County Rank

1 - 0.6
2 - 0.7
3 - 0.8
4 - 0.9
5 - 1
6 - 1.1
7 - 1.2
8 - 1.3
9 - 1.4

	Average Expense		Primary Occupation		CRP Acres		Percent Owned		Average Farm Size		Average Income		Average Age		Overall County Rank	County Rank
	1.7		1.6		1.5		1.4		1.3		1.2		1.1			
Osceola County	0.9	1	0.6	0.89	0.6	1	1.2	0.95	0.9	0.89	0.7	1	0.9	0.93	7.68	0.78
Buena Vista County	1	1	0.7	0.89	0.7	1	1.2	0.95	0.9	0.89	0.6	1	0.9	0.93	8.02	0.82
Emmet County	1	1	0.8	0.89	0.6	1	1.1	0.95	0.8	0.89	0.9	1	0.8	0.93	8.03	0.82
Sioux County	0.6	1	0.8	0.89	0.6	1	1.2	0.95	1.2	0.97	0.7	1	1.1	0.93	8.13	0.83

$R = r \times a \times c$

Demographic Risk Map



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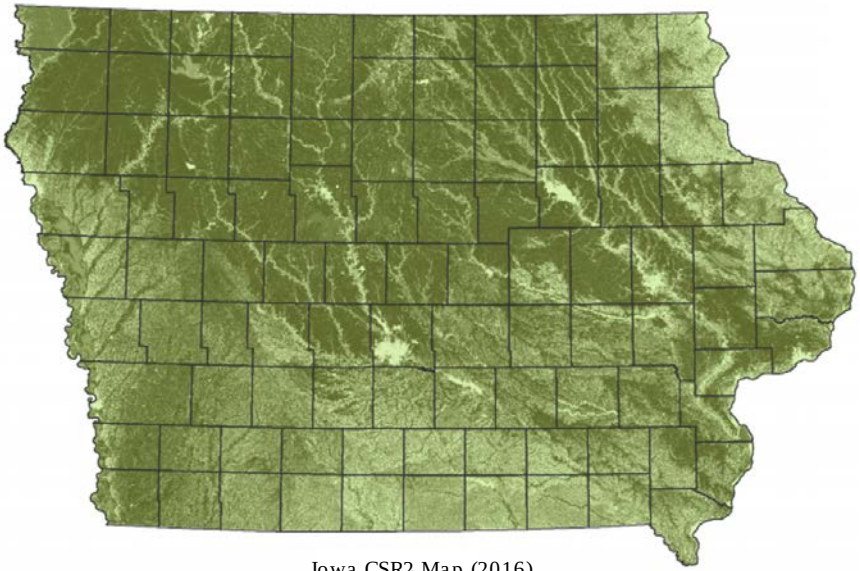
Geographic Model

- Palmer risk based on natural conditions that cannot be changed
- 5 GIS maps from USDA Geospatial Data Gateway
  - Corn Suitability Rating (CSR2)
  - Average Maximum Temperature
  - Elevation
  - Average Yearly Rainfall
  - Average Wind Potential
- ≈325,000 data points

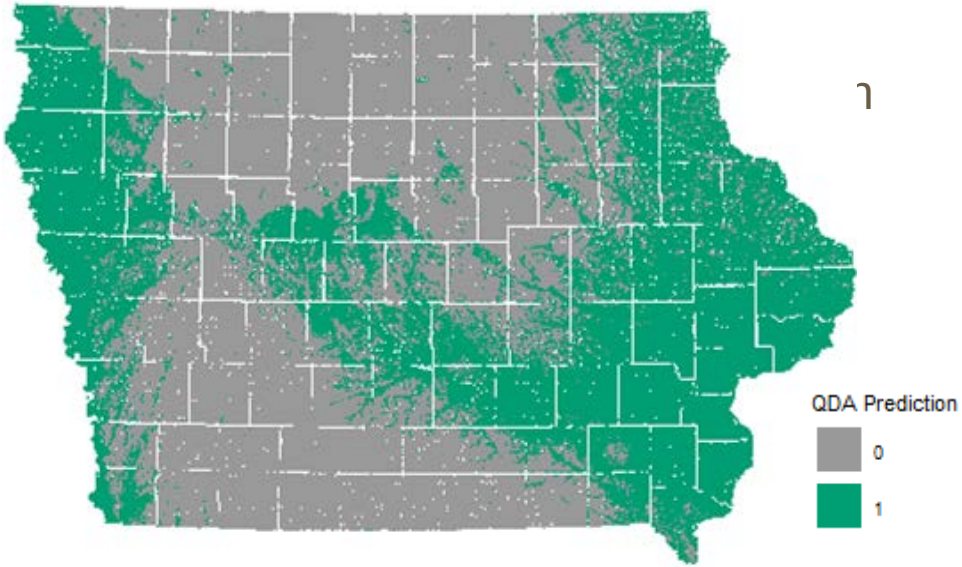


Iowa CSR2 Map (2016)

"Corn Suitability Ratings & Soil Interpretations." Iowa State University Extension and Outreach. 2016. Accessed July 20, 2017.

Geographic Model

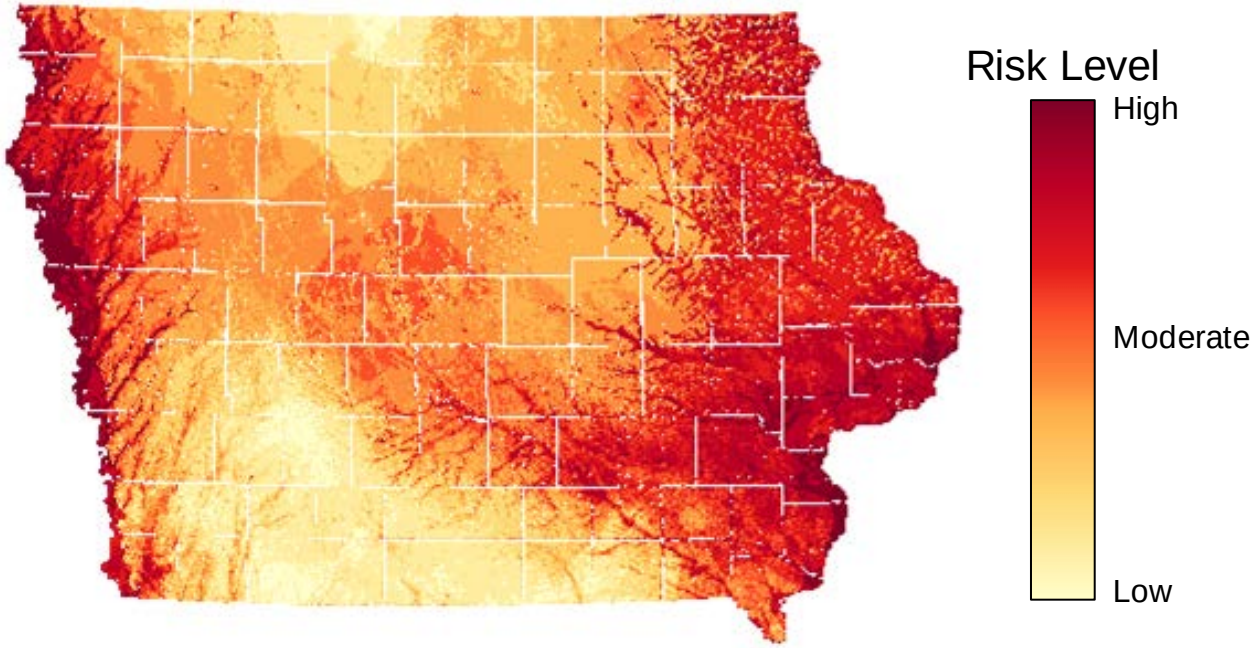
- Quadratic Discriminant Analysis (QDA) is a supervised machine learning method commonly used in classification problems
- We can “predict” which counties contain Palmer Amaranth based the geographic factors



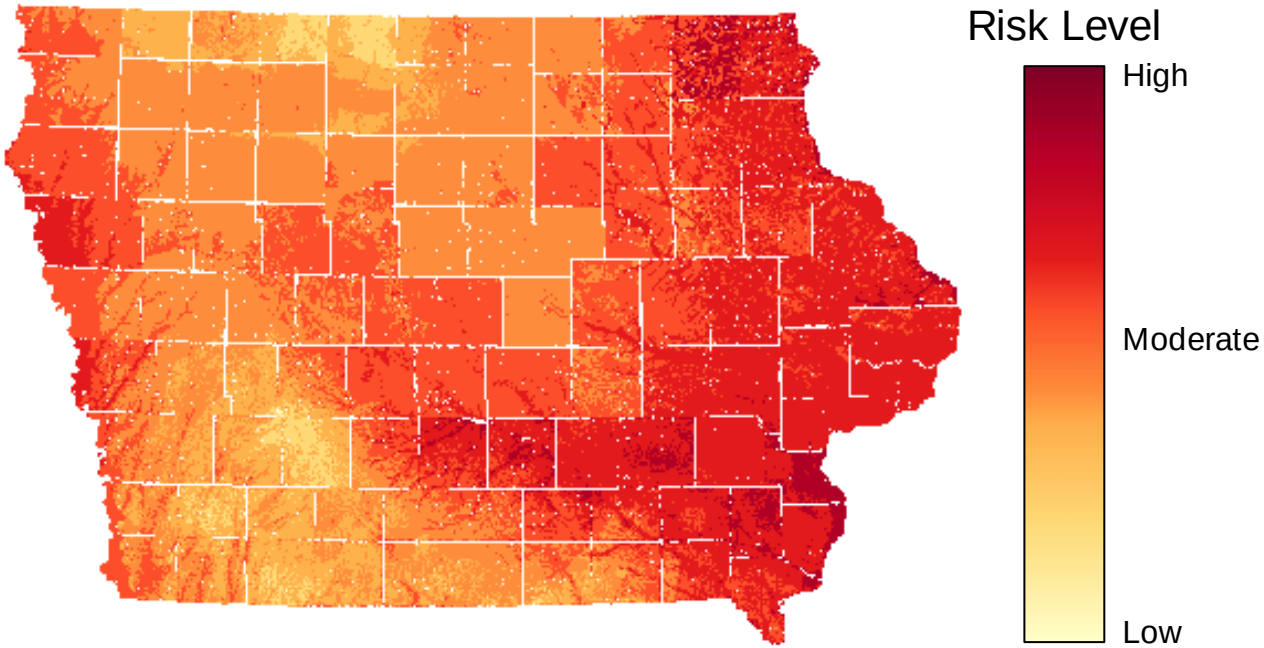
QDA classification of Palmer’s location in Iowa

Geographic Risk Map

$$Pr(palmer = 1|X = x)$$

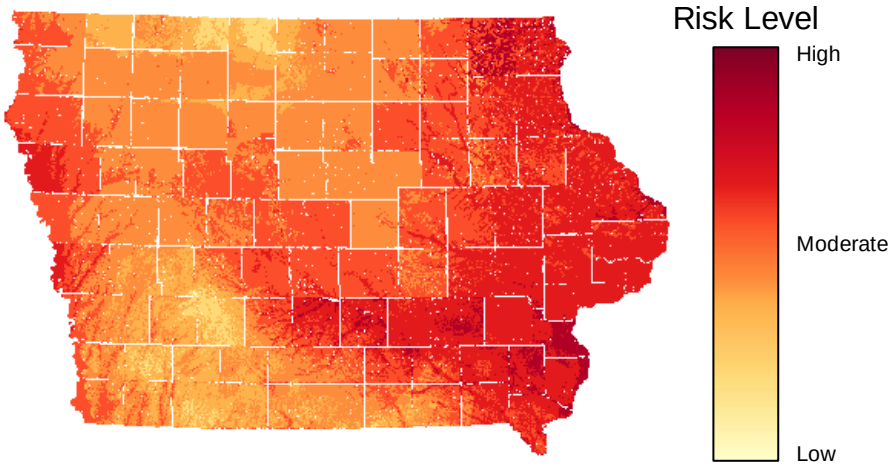


Final Risk Map Synthesis



Map Conclusions

- Higher risk on the edges of the state
- Higher risk along rivers and water bodies
- Less risk in extreme south central
- Less risk in north central



5 Year Temporal Model

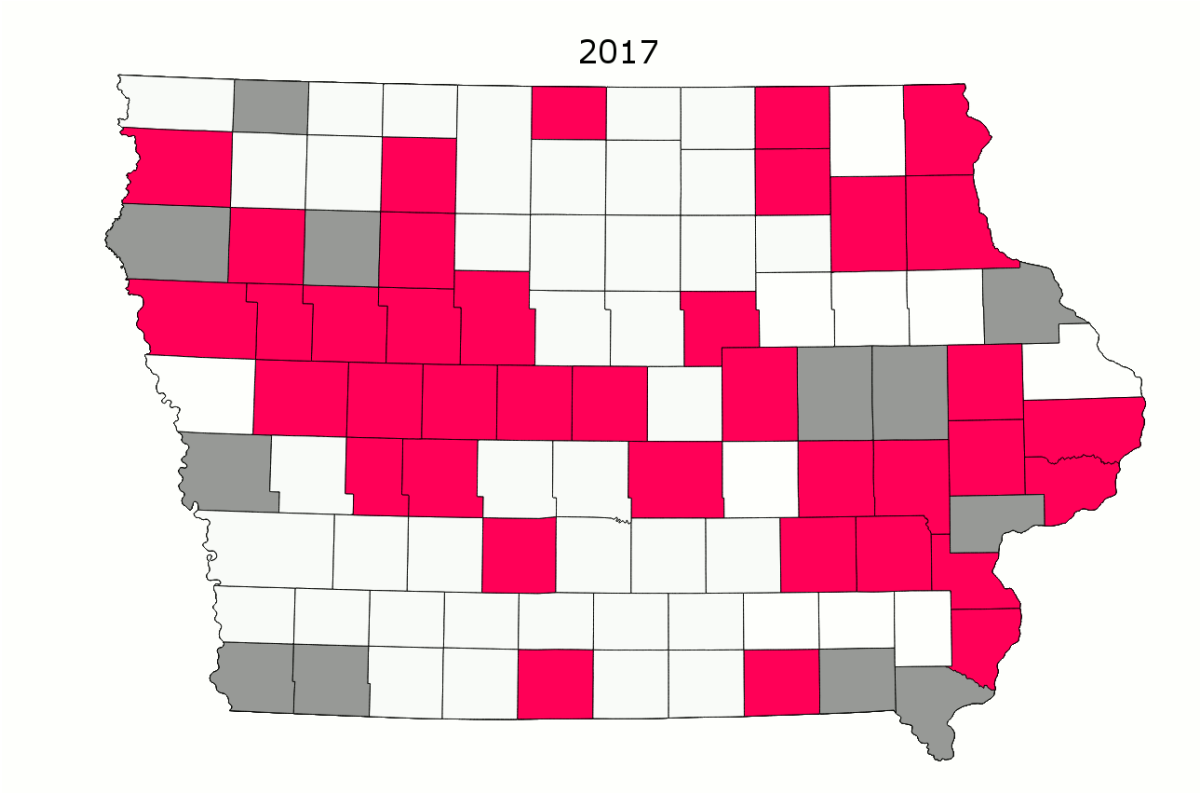
Prediction for future county infestations of Palmer amaranth

Infestation risk (based on our synthesis map) + Source of Palmer in county and bordering counties (Ag/CRP)

Determined a threshold above which a given county would become infested with Palmer

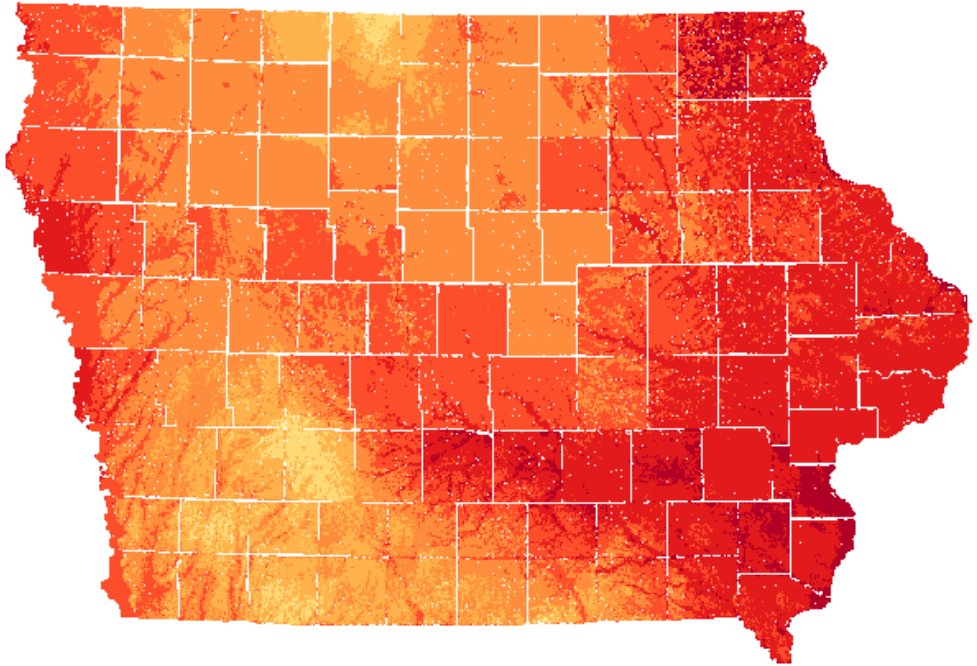
This was repeated from 2018-2022

5 Year Temporal Model



5 Year Temporal Model

2017



Future Model Objectives

- Obtain more accurate data detailing Palmer's location
  - Better testing, validation, and accuracy
  - Ground-truthing
- More detailed effects of CRP
  - Improve accuracy of risk map
- Create a custom Palmer risk assessment webtool
  - Producers input geographic and demographic scenarios to assess land risk
- Emergence Model
  - When and where is Palmer most likely to emerge?

Economic Impact

Palmer amaranth interference in cotton

- Objectives
  - Establish a conservative model for potential yield lost due to Palmer amaranth infestation
  - Relate plants per acre to total yield loss number then to per acre revenue loss
  - Create a county case study that can be applied statewide and eventually to each individual acreage used in agriculture.

University of California, 2013

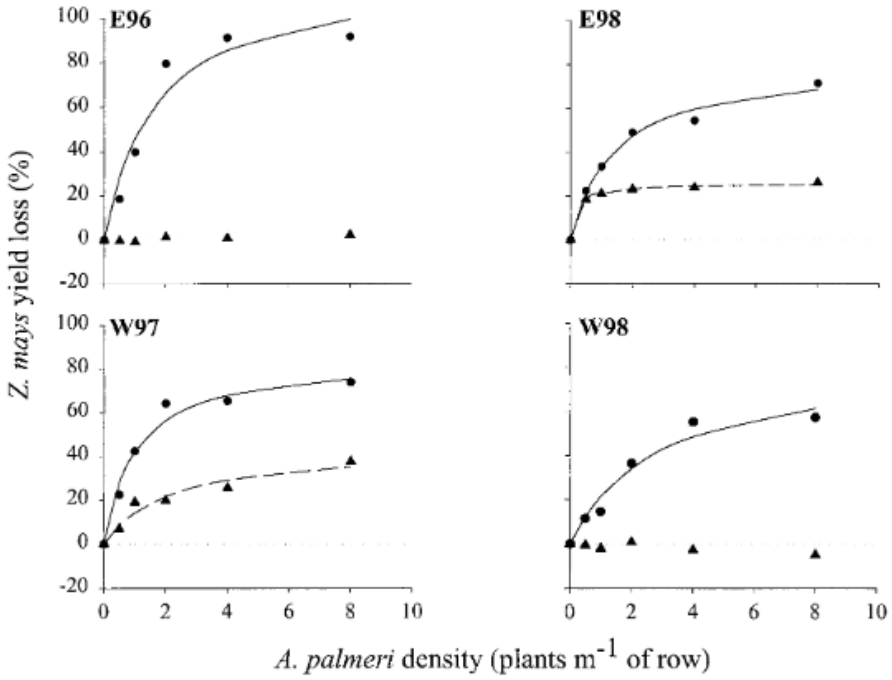
Economic Impact

Palmer and Yield Loss

Documented losses ranging from 11% to 91% & 17% to 68% yield losses in corn and soybeans, respectively

Figures to be used:
0.5 plants / m for Palmer infestation in corn

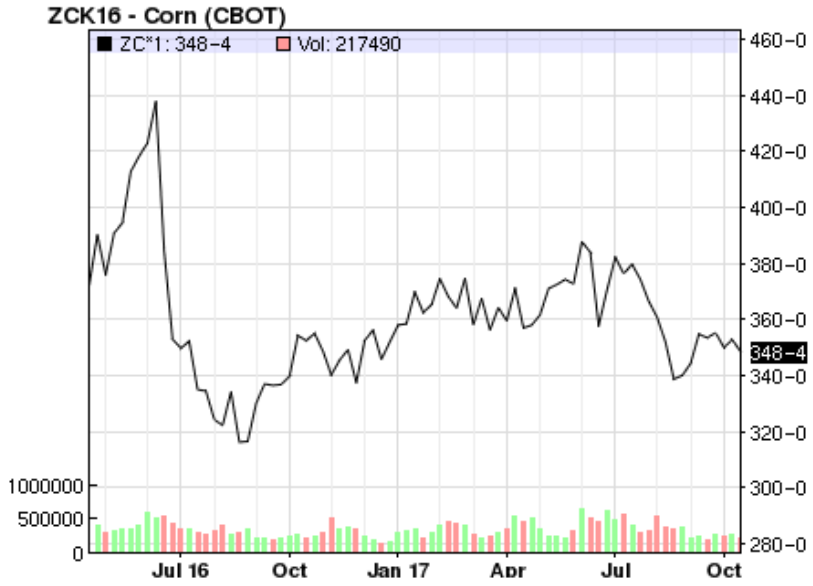
Conservative yield loss projection for minimally infested corn acreages = 11% yield loss

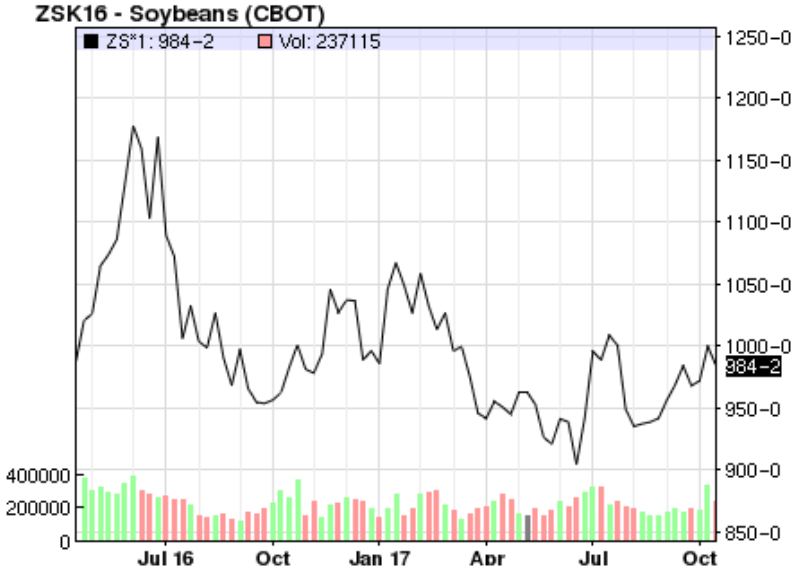


Rafael A. Massinga, Randall S. Currie, Michael J Horak, and John Boyer Jr., 2001

Economic Impact

Macroeconomic Climate: Yield projections at historic highs, prices near 10YR lows





NASDAQ Markets, 10/18/17

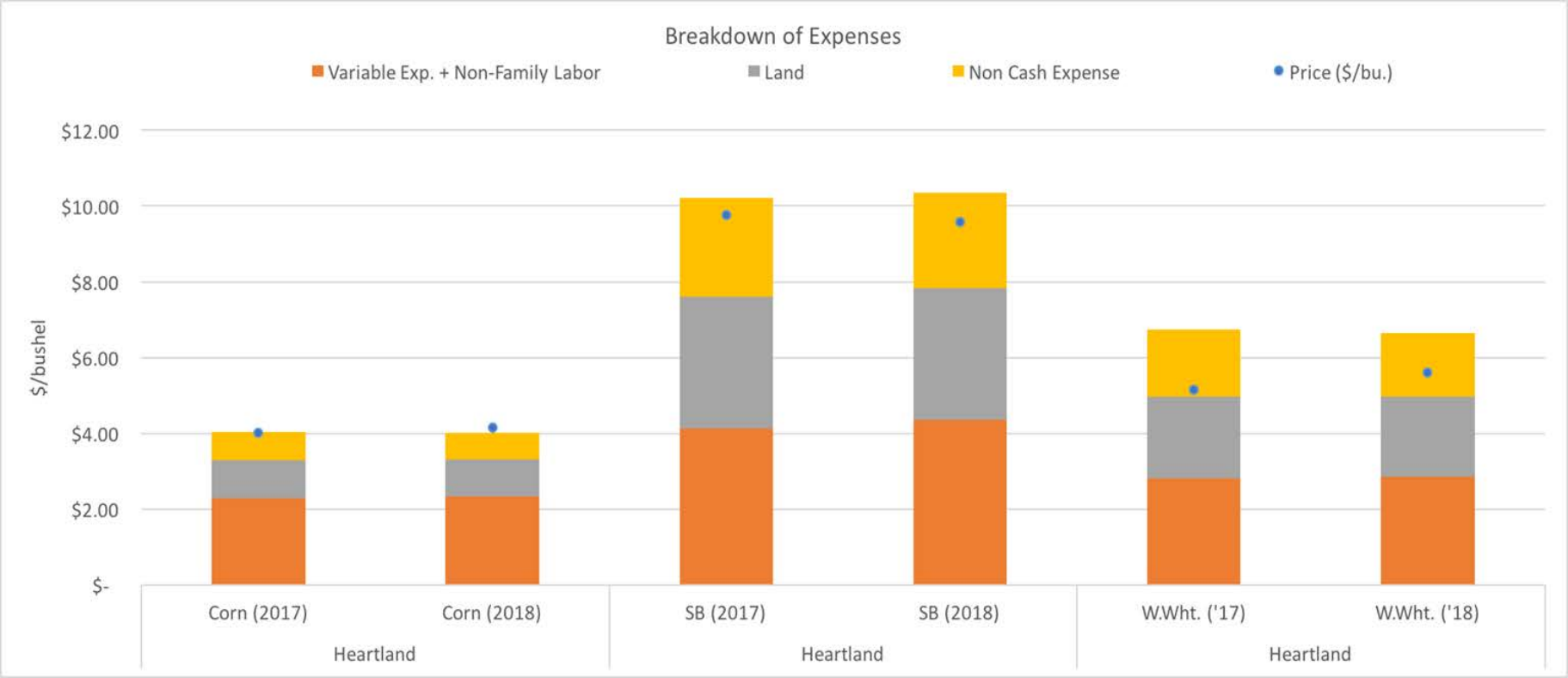
Economic Impact

Assumption: Microeconomic farm finance is sufficiently homogeneous geographically to model IA impact using American Enterprise Institute (AEI) Heartland projections

	Heartland		Heartland	
	Corn (2017)	Corn (2018)	SB (2017)	SB (2018)
Revenue				
Est. Yield (bu/acre) or (lb./acre)	175	177	50	50
Base Price ($/bu.) or ($/lb.)	3.99	4.14	9.68	9.5
Regional Price Adjustment ($/bu.)	0.02	0.02	0.07	0.07
Crop Revenue ($/acre)	701.75	736.32	487.5	478.5
Total Crop Nutrient Expense	$ 881	$ 917	$ 547	$ 538
Total Crop Protection Expense	49.43	53.42	29.45	35.34
Total Variable Costs	393	404	200	211
Contribution Margin (Revenue Less Variable Expenses)	309	332	288	268
Total Overheard (Fixed Expenses)	311.58	307.26	311.58	307.26
Earnings or (losses) from Operations	-$ 2.54	$ 24.59	-$ 23.64	-$ 39.29
Estimated Government Payments ($/acre)	$ -	$ -	$ -	$ -
Total Earnings or (Losses)	-$ 2.54	$ 24.59	-$ 23.64	-$ 39.29

AEI Crop Budget Estimates, Brent Gloy and David Widmar, 2017

Economic Impact



AEI Crop Budget Estimates, Brent Gloy and David Widmar, 2017

Economic Impact

County Case Study: Washington County

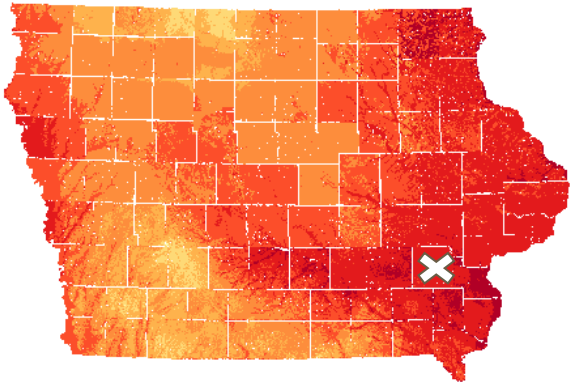
Average Risk Value: **0.9414179**
Average CSR2: **68**

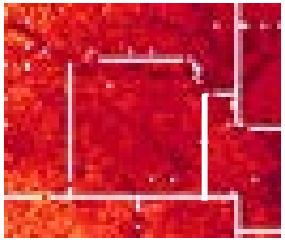
Projected Yield (bushels/acre) = **188.8**
Est. 2017 Revenue/Acre = **$50.00**

Projected Yield after conservative reduction from Palmer amaranth infestation of 0.5 plants m^{-1} = **168.03**
Est. 2017 Loss/Acre = **($31.00)**

Projected Corn Yield (bushels/acre)

$$Yield = (1.6 * CSR2) + 80$$





Sassman & Burras, Iowa CSR2 Weighted Means by County, May 2017

Cumulative Economic Impact

Average CSR2: **68.4**

Total 2017 Corn Production Acres: **13,700,007**

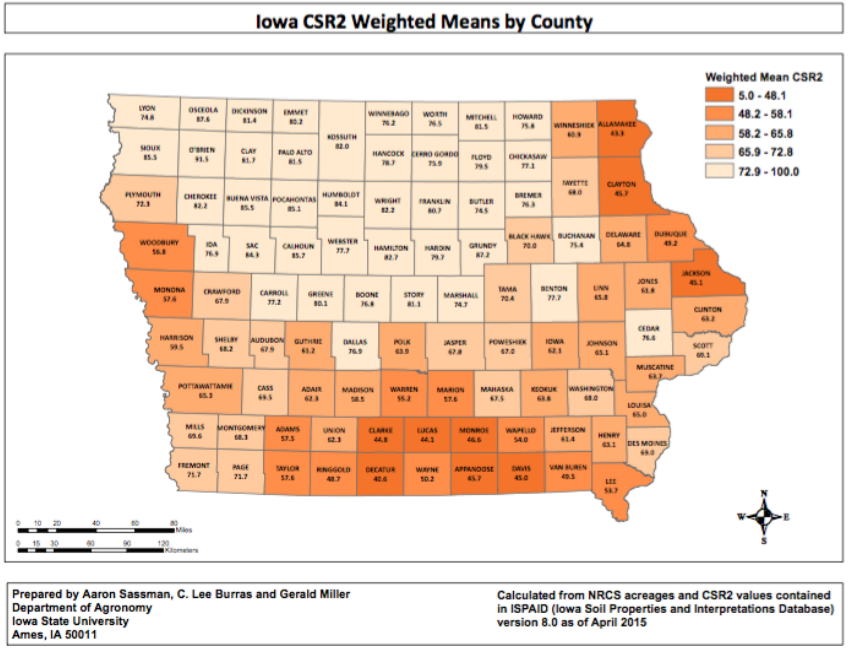
Current Price ($/Bushel): **3.48**

Projected Average Yield after conservative reduction from Palmer amaranth infestation of 0.5 plants m^{-1} = **168.65**

Est. Average Loss/Acre = **($41.78)**

Est. Average Post Palmer Loss/Acre = **($114.73)**

Cumulated Yearly Revenue Lost due to Conservative Palmer Infestation: **($1,368,979,431.85)**



Sassman & Burras, Iowa CSR2 Weighted Means by County, May 2017

Future Work on Economic Impact

- Establish potential yield figures for soybean production as a function of CSR2 or other geographic characteristics
- Find projected yield figures for Palmer infestations less dense than those examined by Massinga et al., 2001

Academic Consultants

- Meaghan Anderson - ISU Extension
- Josh Bruett - Agronomist, BB&P Feed and Grain
- Carolyn Dallinger - Professor of Sociology, Simpson College
- Mike Gunderson - Agro Economist, Purdue University
- Dr. Bob Hartzler- ISU Extension
- Mark Johnson - ISU Extension
- Jason Norsworthy - University of Arkansas
- Aaron Sassman - Agronomist, ISU
- Dr. Brady Spangenberg - Market Intelligence and Analytics, BASF Chemical; Visiting Scholar, Simpson College
- Amy Tlach - Iowa Soybean Association
- Murphy Waggoner - Professor of Mathematics, Simpson College

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- Ned and Mickey Burmeister
- Jay Simmons - President of Simpson College
- Kent Eaton - Academic Dean
- Bob Lane - Vice President of College Advancement
- Manda Gibson - Media Service Coordinator
- Sandy Condon - Administrative Assistant to Academic Dean
- Linda Sinclair - Administrative Assistant in Mary Berry

Future work and Recommendations

- Comprehensive Education & Outreach
  - Many stakeholders still are not aware of Palmer amaranth
- Our strategy has been to present at County Conservation Boards and Schools
- We have presented at Centerville High School, Appanoose County
- Our goal is to present to 20 more counties this year
  - Focusing on high risk areas
- Methods and analysis translate to other social and cultural problems
- Collaboration between industry, government, and education is effective in yielding comprehensive results

Palmer Amaranth Risk Analysis in Iowa

Summer Seminar Series

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