The Iowa Nutrient Reduction Strategy
Farmer Survey Data

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CSSM

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Outline

1. Introduction
2. Data Analysis
3. Discussion
The water quality impacts of nutrients from agriculture are increasingly important to Iowans and Iowa agriculture.

- Corn and other crops are highly dependent on nitrogen and phosphorous. However, some are lost from field into waterways, where they degrade water quality in Iowa’s streams, lakes and other water bodies.
Some of those nutrients eventually flow into the Mississippi River and on the Gulf of Mexico, where they contribute to the formation of oxygen-depleted areas called hypoxic zones.

In short, the loss of the nitrogen and other nutrients from agricultural activities leads to economic and environmental costs in Iowa and beyond.
Background

In January 2015, ISU College of Agriculture and Life Sciences and the Iowa Department of Agriculture and Land Stewardship entered into a 28E agreement to develop and implement a farmer survey that will help stakeholders to measure progress towards the Iowa Nutrient Reduction Strategy (NRS): a science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico.
The survey will be implemented over a five-year period through an annual rotating longitudinal survey.

The survey will focus on three factors: 1) farmer knowledge, attitudes, and behavior regarding nutrient loss into waterways; 2) barriers to and facilitators of behavior change that reduces nutrient loss; and 3) change in these factors over time.
The sampling design is a five-year plan that surveys farmers within hydorologic unit code (HUC) 6 watersheds in a manner that will allow comparisons of farmers in HUC8 watersheds that have been identified as "priority watersheds" by the Iowa Water Quality Initiative to farmers in watersheds that have not received that designation.
**NRS Farmer Survey**

- In each subsequent year, a new HUC6 watershed will be added.
- The Iowa HUC6 watershed will be surveyed every year.

<table>
<thead>
<tr>
<th>Watershed #</th>
<th>HUC6 Watershed</th>
<th>Priority HUC8 Watershed(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1: Y1-5</td>
<td>Iowa</td>
<td>Middle Cedar</td>
</tr>
<tr>
<td>W2: Y1-2</td>
<td>Missouri-Little Sioux</td>
<td>Floyd</td>
</tr>
<tr>
<td>W3: Y2-3</td>
<td>Upper Mississippi-Maquoketa-Plum</td>
<td>Turkey</td>
</tr>
<tr>
<td>W4: Y3-4</td>
<td>Upper Mississippi-Skunk-Wapsi</td>
<td>South Skunk, Skunk</td>
</tr>
<tr>
<td>W5: Y4-5</td>
<td>Missouri-Nishnabotna</td>
<td>West, East Nishnabotna</td>
</tr>
<tr>
<td>W6: Y5</td>
<td>Des Moines</td>
<td>Boone, North Raccoon</td>
</tr>
</tbody>
</table>
NRS Farmer Survey

- Map of farmers’ locations for the Year 1 data
Objective

- The objective of the original survey is to provide direct estimates of farmer knowledge, attitude, and behavior regarding nutrient loss reduction, and estimate the change over time, at the state level.
- Due to the limited sample size, it is not possible to have good direct estimates at all HUC6 levels in all years.
- Based on the annual rotating longitudinal design, spatial and temporal dependence in the survey responses, we will develop model-assisted HUC6 level status.
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- Based on the annual rotating longitudinal design, spatial and temporal dependence in the survey responses, we will develop model-assisted HUC6 level status.
## Data Description

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>How knowledgeable?</td>
</tr>
<tr>
<td>NRS Source</td>
<td>What sources have you learned about the NRS?</td>
</tr>
<tr>
<td>Water Act</td>
<td>Related to watershed management activities group</td>
</tr>
<tr>
<td>Attitude</td>
<td>Attitude regarding the NRS</td>
</tr>
<tr>
<td>Behavior</td>
<td>if using or non-using each practice corresponding the NRS?</td>
</tr>
<tr>
<td>Barriers</td>
<td>The reason why you did not use a particular practice</td>
</tr>
<tr>
<td>Contact</td>
<td>About your contact with agencies, organizations and programs</td>
</tr>
</tbody>
</table>
## Data Description

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision Source</td>
<td>Information source on your decision on NRS practice</td>
</tr>
<tr>
<td>Barriers WQ</td>
<td>Potential barriers to water quality improvement in IA</td>
</tr>
<tr>
<td>Stratum</td>
<td>Four different HUC8s (11, 12, 21, 22)</td>
</tr>
<tr>
<td>Personal characteristics:</td>
<td>Gender, Age, Education, FarmlandAcres(Own/Rent), Livestock, Gross(Farm sales)</td>
</tr>
</tbody>
</table>
Data Description

Relation among variables
Data Description

- Relation among variables

- Correlation of HUC8 within HUC6

- Multivariate correlation

- HUC6 correlation

- Stratum11 Farmers
- Stratum12 Farmers

- Stratum21 Farmers
- Stratum22 Farmers

- Y:
  - Y1: Knowledge
  - Y2: Attitude
  - Y3: Behavior

- X: Covariates (Personal Characteristics)
Data Analysis

- Given only Year 1 data, our interest is
  1) to figure out what predictors contribute to farmers’ behavior regarding to the NRS
  2) to figure out which HUC8 used specific group of practices well and then other HUC8s may consider the predictors having significantly positive impact on good behaviors.
There are 20 practices that can reduce nutrient loss into waterways.

<table>
<thead>
<tr>
<th>Practices</th>
<th>Possible values</th>
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</thead>
<tbody>
<tr>
<td>A. Cover crops</td>
<td></td>
</tr>
<tr>
<td>B. No till (all yrs of rotation)</td>
<td></td>
</tr>
<tr>
<td>C. Intermittent no-till</td>
<td>1(Non-user) / 2(Potential user) / 3(User)</td>
</tr>
<tr>
<td>D. Strip tillage</td>
<td></td>
</tr>
<tr>
<td>T. Terraces</td>
<td></td>
</tr>
</tbody>
</table>
Data Analysis: Clustering

- In this case, we first cluster different practices into several groups which have similar predictors as follows.
  i) Fit a logistic regression model for each practice.
  ii) Construct a dataset with (practices) by (estimated coefficients of all covariates).
*Here, we put zero for non-significant coefficients.
  iii) Perform the k-means clustering analysis based on this dataset.
Data Analysis: Clustering

- Plot of the ratio of between SS to total SS for $k = 2, \ldots, 8$

<table>
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<tr>
<th># Clusters</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tr>
<td>Ratio</td>
<td>0.40</td>
<td>0.56</td>
<td>0.64</td>
<td>0.77</td>
<td>0.82</td>
<td>0.88</td>
<td>0.90</td>
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</table>
### Data Analysis: Logistic Regression

Logistic regression of using at least one practice for each cluster

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Practice</th>
<th>Significant Predictors</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>C, E, F, H, L, M</td>
<td>Gross(+)</td>
</tr>
</tbody>
</table>
| 2       | D, I     | MO.BigPM(−), MO.Floyd(−), Attitude(+)  
|         |          | Age(−), Gross(+) |
| 3       | S        | IA.LowerIA(+)  
|         |          | MO.BigPM(+), Know2(+),  
|         |          | Q8.OnFarmersNGO.Infl(−), Gross(+) |
| 4       | K, P     | IA.LowerIA(+)  
|         |          | Q3.WS.Group(+), Q8.Pub.Infl(+),  
|         |          | Q9.Landlord(+), TotalAcresFarmland(+), TotalAcresCrops(−) |
| 5       | A, N, O, Q | MO.BigPM(−), MO.Floyd(−),  
|         |          | Q3.WS.Group(+), TotalAcresFarmland(+), CS.TA.L5YRS(+)  
|         |          | Q8.infl.priv(−), Q9.econ(−), TotalAcresCrops(−), Livestock(−) |
| 6       | J        | MO.Floyd(+), Age(−), Livestock(−), Gross(+) |
| 7       | B, G, T  | IA.LowerIA(+), MO.BigPM(+), CS.TA.L5YRS(+) |
### Data Analysis: Logistic Regression

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<thead>
<tr>
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<th>cl.centers</th>
<th>D1</th>
<th>I1</th>
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<td>0.00</td>
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</table>
### Data Analysis: Logistic Regression

```r
> coef (out7.5)

<table>
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<tr>
<th></th>
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<th>cl.1.centers</th>
<th>A1</th>
<th>N1</th>
<th>O1</th>
<th>Q1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tbody>
</table>
```
Analysis: Logistic Regression

- The fitted probability of using at least one of practices in Cluster 1

- Cluster 1
  - C: Intermittent no-till
  - E: Conservation tillage excluding no-till and strip tillage
  - F: Tile, ditches, other drainage
  - H: Spring nitrogen
  - L: Nitrogen rate based on Corn N rate
  - M: Nitrogen stabilizer
Data Analysis: Logistic Regression

- The fitted probability of using at least one of practices in Cluster 2; BigPM(−), Floyd(−)

- Cluster 2
  - D: Strip tillage
  - I: Nitrogen rate based on Corn N rate calculator
Data Analysis: Logistic Regression

- The fitted probability of using at least one of practices in Cluster 3: BigPM (+), LowerIA (+)

- Cluster 3
  - S: Pond(s)/sedimentation basin(s)
Data Analysis: Logistic Regression

- The fitted probability of using at least one of practices in Cluster 4; LowerIA(+)

- Cluster 4
  - K: Variable rate N application
  - P: In-field buffer strips
Data Analysis: Logistic Regression

- The fitted probability of using at least one of practices in Cluster 5: BigPM(−), Floyd(−)

- Cluster 5
  - A: Cover crops
  - N: Cropland converted to perennial crops
  - O: Extended rotations
  - P: In-field buffer strips to filter nutrients and sediment

![Map showing the distribution of practices in Cluster 5]
Data Analysis: Logistic Regression

- The fitted probability of using at least one of practices in Cluster 6; Floyd(+)
The fitted probability of using at least one of practices in Cluster 7; BigPM(+) and LowerIA(+)
We did the k-means clustering analysis based on the estimated coefficients from single logistic regression models for each practice and then fit a logistic regression model for each cluster.

The next step is to re-cluster the 20 different practices based on domain background provided by agriculture department and apply the logistic regression models.

For the six structural practices (cropland converted to perennial crops, extended rotations and so on), we fit ordinal or multinomial logistic regression models.
Thank You