Key Topics for Today’s Discussion:

• Assessment of Current Nutrient Situation
  – Crop yields vs. removal, movement of nutrients, nutrient forms

• Nitrogen-Related Topics
  – Crop uptake vs. carryover nitrogen
  – Considerations for whole crop harvest
  – Fate of carryover nitrogen through the next crop
  – Nitrogen testing options
  – Residual nitrogen following soybeans

• Lime, Phosphorus, and Potassium Considerations
  – Crop removal considerations
  – Nutrient cycling and soil test differences in drought conditions

• Managing Cover Crops
If You Are Having Audio Trouble

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We appreciate the support of the sponsor for today’s webinar:
Managing Nutrients After the Drought

Today’s slides, links to additional resources at:
https://www.agronomy.org/education/managing-nutrients-drought-resources
Today’s Panel Members

Jim Camberato, PhD
Purdue University

John Grove, PhD
University of Kentucky

Antonio Mallarino, PhD
Iowa State University

Scott Murrell, PhD
International Plant Nutrition Institute
Managing Nutrients After the Drought

Mike Plumer, MS
University of Illinois Extension (retired)

Bruce Erickson, PhD
Agronomic Education Manager
American Society of Agronomy
Adjunct Asst. Professor, Purdue University
Managing Nutrients After the Drought

We Welcome Your Questions and Comments:

– Type in the question queue
– Please be as brief as possible
– Indicate which panel member to ask if you have a preference
– Indicate your location, if relevant to question
Overview of the 2012 Drought

T. Scott Murrell
U.S. Northcentral Director
U.S. Drought Monitor

September 18, 2012
Valid 7 a.m. EDT

Intensity:
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:
- S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically >6 months (e.g. hydrology, ecology)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

Released Thursday, September 20, 2012
Author: David Simneral, Western Regional Climate Center
Percent of U.S. area (contiguous 48 states) in various drought intensity classifications

<table>
<thead>
<tr>
<th>Period</th>
<th>Date</th>
<th>None</th>
<th>Dry to moderate</th>
<th>Severe to exceptional</th>
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</thead>
<tbody>
<tr>
<td>One year ago</td>
<td>9/13/2011</td>
<td>55.36</td>
<td>20.54</td>
<td>24.10</td>
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<td>3 months ago</td>
<td>6/19/2012</td>
<td>31.22</td>
<td>44.51</td>
<td>24.27</td>
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<tr>
<td>Current</td>
<td>9/18/2012</td>
<td>21.85</td>
<td>37.08</td>
<td>41.07</td>
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</table>

### Impacts of 2012 drought on agriculture

<table>
<thead>
<tr>
<th>Crop</th>
<th>Average U.S. yield to date</th>
<th>Comparison to 2011 average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>122.8</td>
<td>-24.4</td>
</tr>
<tr>
<td>Soybean</td>
<td>35.3</td>
<td>-6.2</td>
</tr>
</tbody>
</table>

Other impacts:
- Increased hay thefts
- Increased selling of cattle
- Many counties designated as Primary Natural Disaster Areas
- Increased competition for water use

Reduced yield results in reduced nutrient removal for a given harvested portion

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<tr>
<th></th>
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<tbody>
<tr>
<td>Corn</td>
<td>Illinois</td>
<td>132</td>
<td>73</td>
<td>45</td>
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<td></td>
<td>Indiana</td>
<td>135</td>
<td>83</td>
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<td></td>
<td>Iowa</td>
<td>130</td>
<td>84</td>
<td>35</td>
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<tr>
<td>Soybean</td>
<td>Illinois</td>
<td>38.0</td>
<td>27.0</td>
<td>29.0</td>
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<td>Indiana</td>
<td>40.0</td>
<td>27.5</td>
<td>31.3</td>
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<tr>
<td></td>
<td>Iowa</td>
<td>43.5</td>
<td>31.0</td>
<td>28.7</td>
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</table>
A change in harvested portion changes nutrient removal

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Harvested portion</th>
<th>Yield</th>
<th>Nutrient removal**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Planned</td>
<td>Corn grain</td>
<td>150 bu/acre</td>
<td>100</td>
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<tr>
<td>Actual</td>
<td>Corn silage with barren ears*</td>
<td>10.8 tons/acre</td>
<td>70</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td></td>
<td>-30</td>
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</tbody>
</table>

*Assumes corn stover corresponding to 150 bu/acre grain crop, no grain formed, a harvest index of 0.5, and a moisture content of 67% (wet basis).

Managing Soil Nitrogen After The Drought

John H. Grove
University of Kentucky
Potential N carryover - With different N budgets

Change in residual soil N level

Application > removal
Application ≈ removal
Application < removal

Adapted from Murrell, 2012
Karlen et al. (1988) reported that a corn crop yielding about 310 bu/A took up about 345 lb N/A.

So, a good 225 bu/A corn crop will need at least 250 lb N/A from soil and fertilizer.

Producer provides 180 lb N/A, assuming the soil (organic matter) provides 70 lb N/A.

Understanding the problem:

Worst case - all vegetative material returned (destroyed the crop without grain/silage harvest).
How Much?

If corn stopped growing around R1-R2, then about 2/3 of N uptake has occurred.

Assuming total uptake = 250 lb N/A, that means 167 lb/A is in the standing crop with 83 lb/A remaining in the soil in the fall.

Fall soil N could be less (early N losses); could be more (more organic N mineralization).
Where Is That Carryover N?

➢ Worst Case:
  ➢ Stover/root N (167 lb N/A) lies on/near surface.
  ➢ Unused soil N (83 lb N/A) left in soil, near surface.

➢ Not Worst Case (some grain harvested):
  ➢ Grain removes 0.8 to 0.9 lb N/bushel (reduce carryover N pools, both soil and stover, equally).

➢ In What Form Is That Carryover N?
  ➢ Carryover stover/root N found as 'labile' organic N and nitrate-N.
  ➢ Carryover soil N largely nitrate-N.
What ‘Happens’ To Carryover N?

- Stover/root ‘labile’ organic N
  - Microbial immobilization (good)
  - Microbial mineralization (not good)
  - Outcome depends upon C:N ratio, available C and O₂, environmental conditions (T, H₂O).

- Stover/root nitrate N

- Soil nitrate N
  - Immobilization (good)
  - Denitrification (not great)
  - Leaching (not good)
What Do You Mean ‘Not Good’?

November to April nitrate-N in leachate water collected below corn rooting depth, as related to the amount of fall soil nitrate-N. N rate and manure treatments. No-tillage/no cover crop.

Stoddard et al. 2005
Residual nitrate in the fall soil profile tends to be higher after a droughty year.

Randall et al. 2003

\[ y = -1.6223x + 275.78 \]

\[ R^2 = 0.3592 \]

Adapted from Murrell, 2012
Nitrate leaching is related to the amount of early season rainfall - and also to fertilizer N management.

Randall et al. 2003 Adapted from Murrell, 2012

Flow-weighted NO$_3$-N in sub-surface tile drainage (mg L$^{-1}$)

Year, crop, and percent of 30-yr. average precipitation

- 1990 soybean (124%)
- 1991 corn (151%)
- 1992 soybean (114%)
- 1993 corn (155%)
- 1994 soybean (121%)

Month of the year

Randall et al. 2003  Adapted from Murrell, 2012
Dealing With Carryover N

Next spring – Dr. Camberato

This fall

Principles and options:
- Biologically immobilize as much labile or nitrate N as possible – reconnect C and N
- Minimize/slow oxidation of labile C
- Use cover crops (biological immobilization)

More on cover crops – Mr. Plumer
### Midwest Cover Crop Council

http://www.mccc.msu.edu

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<thead>
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<th>Nitrogen Scavenger</th>
<th>March 15</th>
<th>April 1</th>
<th>May 1</th>
<th>May 15</th>
<th>June 1</th>
<th>July 1</th>
<th>July 15</th>
<th>Aug 15</th>
<th>Aug 1</th>
<th>Sep 1</th>
<th>Sep 15</th>
<th>Oct 1</th>
<th>Oct 15</th>
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<th>Nov 15</th>
<th>Dec 1</th>
<th>Dec 15</th>
<th>Jan 1</th>
<th>Jan 15</th>
<th>Feb 1</th>
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Adapted from Murrell, 2012
Dealing With Carryover N

- Next spring - Dr. Camberato

- This fall
  - Principles and options:
    - Biologically immobilize as much labile or nitrate N as possible - reconnect C and N
    - Minimize/slow oxidation of labile C
    - Use cover crops (biological immobilization)
    - Minimize tillage (avoid accelerated oxidation)
      - Only the wettest, untiled, soils/fields - nitrate N more likely lost to denitrification than to leaching
We Welcome Your Questions and Comments:

- Type in the question queue
- Please be as brief as possible
- Indicate which panel member to ask if you have a preference
- Indicate your location, if relevant to question
Growing Season Rainfall, inches
Off-Season Precipitation, inches
Taking Stock of Nitrate Carryover

- Fall soil sampling – Western Corn Belt
- PrePlantNitrateTest (PPNT) – Central and Northern Corn Belt
- PreSidedressNitrateTest (PSNT) – Eastern Corn Belt
Western Corn Belt

Ex. - Nebraska

• 4’ soil sample in fall
• About 50% of the NO₃-N in a 4’ depth subtracted from the yield goal based N recommendation (if only 0-2’ sampled then 2-4’ estimated)

8 x NO₃-N ppm = lb/acre subtracted from rec.

Table IV. An example calculation of mean depth-weighted soil nitrate-nitrogen concentration across several soil depths.

<table>
<thead>
<tr>
<th>Soil layer, inches</th>
<th>Thickness, inches</th>
<th>Nitrate-N, ppm</th>
<th>Calculations for soil layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8</td>
<td>8</td>
<td>15</td>
<td>8 x 15 = 120</td>
</tr>
<tr>
<td>8-24</td>
<td>16</td>
<td>10</td>
<td>16 x 10 = 160</td>
</tr>
<tr>
<td>24-48</td>
<td>24</td>
<td>3</td>
<td>24 x 3 = 72</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>352</td>
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<tr>
<td>Weighted average ppm</td>
<td></td>
<td>352/48 = 7.3 ppm</td>
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</tbody>
</table>

Note: to convert from lb N/ac to ppm, the default soil density can be assumed to be 3.6 M lb soil/ac-ft.

Fertilizer Suggestions for Corn. Univ. of Nebraska, EC117, Shapiro et al., 2010.
Central and Northern Corn Belt

Ex. – Wisconsin

- 2’ soil sample in 1’ increments as soon as frost is out of ground
- NO$_3$-N greater than 50 lb/acre is subtracted from recommendation

Wisconsin's Preplant Soil Nitrate Test, A3512, Bundy et al., 1995.
Eastern Corn Belt

Ex. - Indiana

- 1’ soil sample after corn is planted (V4-V6, 6-12 inches tall)
- NO3-N determined is an index of the N to be released from organic N sources – soil OM, manure, legumes

<table>
<thead>
<tr>
<th>Soil NO3-N</th>
<th>Subtraction from standard N rec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ppm</td>
<td>lb/acre</td>
</tr>
<tr>
<td>0-10</td>
<td>No subtraction</td>
</tr>
<tr>
<td>11-15</td>
<td>-25</td>
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<tr>
<td>16-20</td>
<td>-45</td>
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<td>21-25</td>
<td>-90</td>
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<tr>
<td>&gt;25</td>
<td>No N rec.</td>
</tr>
</tbody>
</table>

The Pre-Sidedress Nitrate Test for Improving N Management in Corn, Purdue Univ. AY-314-W, Brouder and Mengel, 2000.
Soil Nitrate Testing

• Significant leftover NO$_3$-N may be available due to poor corn yield this past season
  – Routine sampling in West
  – Be prepared elsewhere to obtain soil samples if winter is normal to dry
  – Follow recommendations for sampling and sample interpretation in your states

• Keep samples cold for overnight delivery, spread thin on clean paper or plastic to air dry, or freeze
Will soybean N credits be affected for next year?

T. Scott Murrell
U.S. Northcentral Director
Crop effects on organic nitrogen content of soils

<table>
<thead>
<tr>
<th>Soil</th>
<th>Change in organic nitrogen content from May to Sept.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Corn 1997</td>
<td>Soybean 1998</td>
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<tr>
<td>Zenor</td>
<td></td>
<td>-9.17</td>
<td>27.1</td>
</tr>
<tr>
<td>Clarion 1</td>
<td></td>
<td>-9.86</td>
<td>22.4</td>
</tr>
<tr>
<td>Clarion 2</td>
<td></td>
<td>-16.5</td>
<td>17.5</td>
</tr>
<tr>
<td>Webster 1</td>
<td></td>
<td>-26.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Webster 2</td>
<td></td>
<td>-10.3</td>
<td>17.0</td>
</tr>
<tr>
<td>Webster 3</td>
<td></td>
<td>-12.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Webster 4</td>
<td></td>
<td>-13.9</td>
<td>10.3</td>
</tr>
<tr>
<td>Okoboji</td>
<td></td>
<td>-1.3</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Comparing C/N ratios of corn residue to soybean residue

<table>
<thead>
<tr>
<th>Crop</th>
<th>Fertility treatment</th>
<th>C/N ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(lb N/acre)</td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>100</td>
<td>90/1</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>57/1</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>45/1</td>
</tr>
<tr>
<td>Soybean</td>
<td>0</td>
<td>41/1</td>
</tr>
</tbody>
</table>

Contribution of soybean nodules to the N response of the following maize crop


After nodulating soybeans
After non-nodulating soybeans
After corn

1999 Weather conducive to corn production
Contribution of soybean nodules to the N response of the following maize crop


After nodulating soybeans
After non-nodulating soybeans
After corn

Dry weather during flowering
Taking the soybean N credit next year

• The N “credit” likely arises from:
  – Increase in a readily mineralizable organic N pool
  – Less immobilization of N due to lower C/N ratios of soybean residue compared to corn residue

• 2012 drought year:
  – For corn, yields were lower than planned for
    • N rates ended up being beyond those needed to maximize the low yields
    • C/N ratios are likely lower in corn residue this year
    • Corn residue will look more like soybean residue, so baseline for comparison shifts, making the soybean credit appear lower
  – For soybean, poorer nodulation could result in slightly lower N credits
  – Overall, N credit will likely be less, but overall N rates needed next year could also be less, due to higher residual nitrate and lower C/N ratios of corn stover
Managing Nutrients After the Drought

We Welcome Your Questions and Comments:

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- Indicate your location, if relevant to question
Major P and K issues due to drought

• Crop issues
  – Less than normal uptake and yield
  – Less removal with harvest
  – Very large yield and removal variability within and across fields

• Soil issues
  – Dry weather effect on recycling to soil
  – Dry soil effects on soil-test results
Yield level and P Removal

Yield of Corn and Soybean vs. Grain P Removal (lb P$_2$O$_5$/acre)

**Phosphorus Corn**

$Y = -0.2 + 0.27X$

$r^2 = 0.64$

**Phosphorus Soybean**

$Y = -5 + 0.78X$

$r^2 = 0.75$

Mallarino, Oltmans, et al., 2011

IOWA STATE UNIVERSITY
Extension and Outreach
Yield level and K Removal

Potassium Corn

\[ Y = 3.9 + 0.17X \]

\[ r^2 = 0.67 \]

Potassium Soybean

\[ Y = -9 + 1.35X \]

\[ r^2 = 0.81 \]

Mallarino, Oltmans, et al., 2011
Use suggested concentrations and yield estimates

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit of Yield</th>
<th>P₂O₅</th>
<th>K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>bu</td>
<td>0.375</td>
<td>0.30</td>
</tr>
<tr>
<td>Corn silage</td>
<td>bu grain equiv.</td>
<td>0.55</td>
<td>1.25</td>
</tr>
<tr>
<td>Corn silage</td>
<td>ton, 65% H₂O</td>
<td>3.50</td>
<td>8.0</td>
</tr>
<tr>
<td>Soybean</td>
<td>bu</td>
<td>0.80</td>
<td>1.5</td>
</tr>
<tr>
<td>Oat and straw</td>
<td>bu</td>
<td>0.40</td>
<td>1.0</td>
</tr>
<tr>
<td>Oat straw</td>
<td>ton</td>
<td>5.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Wheat</td>
<td>bu</td>
<td>0.60</td>
<td>0.30</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>ton</td>
<td>12.5</td>
<td>40.0</td>
</tr>
<tr>
<td>Red clover</td>
<td>ton</td>
<td>12.0</td>
<td>35.0</td>
</tr>
</tbody>
</table>

Adapted from PM 1688 publ.

Use yield monitors to estimate yield and removal variation within fields
Nutrient removal of drought-damaged corn harvested for silage (assuming no or little grain produced)

<table>
<thead>
<tr>
<th>Corn growth stage</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 (silking)</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>R2 (blister)</td>
<td>55</td>
<td>85</td>
</tr>
<tr>
<td>R3 (milk)</td>
<td>55</td>
<td>85</td>
</tr>
<tr>
<td>R4 (dough)</td>
<td>55</td>
<td>85</td>
</tr>
</tbody>
</table>

Calculations from Iowa State University publ. PMR 1009, Corn growth and development
Summary:

• Uncertain drought effects on crop P and K concentrations, and expected high variation
• Yield level drives amounts of P and K removed

• Use locally suggested average nutrient concentrations
• Measure yield level the best you can, use of yield monitors to estimate within-field yield and removal variation
K recycling and rainfall

Measurements from physiological maturity until early spring of the following year

Mallarino et al., 2012

Y = 10e^{-(75/(X+37))}
R^2 = 0.84
P < 0.01

Y = 22e^{-(148/(X+119))}
R^2 = 0.68
P < 0.01
K recycling and soil-test K change from fall to spring

\[ Y = 5.7 + 0.68X \]

\[ R^2 = 0.41 \]

\[ P < 0.01 \]

Mallarino et al., 2012
Exchangeable/Non-Exchangeable K Reactions

Uncertain but possible effect of drought due to limited equilibrium between pools:
- Likely less exchangeable K increase after harvest crops
- More K remains exchangeable when fertilizing dry soil

Effect of pre-plant K fertilization on soil-test K and non-exchangeable K after corn harvest

Mallarino et al., 2011
Summary

• Less P and K recycling and slower equilibrium between soil P and K pools equilibrium

• Unclear effects on P: Values may be perhaps 0 to 15% lower, but I would use the normal interpretations

• Much lower soil-test K results
  – Less K recycled from standing plant and residue
  – Slower replenishment of exchangeable K

• Late fall (after some rain) or spring soil sampling will provide more reliable results
Fall Drought and Soil pH

• Issue: Less leaching of soluble salts from topsoil
• pH values may be 0.1 to 0.3 units lower
  – Example: 5.7 to 5.9 instead of 6.0
• Little or no effects on Buffer pH used to calculate amounts of lime to apply
• A couple of inches of rain will be enough to restore normal conditions and pH test results
• If little rain continues, little movement of lime into soil in no-till or pastures
Cover Crop Considerations

Mike Plumer

University of Illinois Extension (retired)
Illinois KIC - Soil nitrate study 2012

• 10-25ppm in top 12” of soil
  – Max found 75ppm side dress track with UAN
  – Very little found below 12”

• Cover crops only way to stop nitrogen loss
Cover Crop
Picking up excess nitrogen from
Anhydrous tracks after corn

Protecting ground water by holding leftover nitrogen till spring
Nitrogen Uptake

- Continuous no-till
- Corn after Corn
- 200#N/a = 215 bu/A
- 3642#/A. annual ryegrass Jan. 6
- 84#/a of Nitrogen from ryegrass water leachable
- Leached out of ryegrass with 2” of water applied
Average annual flow-weighted nitrate-N concentration of drainage water for 2002-2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Control</th>
<th>Rye Cover Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>19.1</td>
<td>5.8</td>
</tr>
<tr>
<td>2003</td>
<td>24.7</td>
<td>11.8</td>
</tr>
<tr>
<td>2004</td>
<td>19.8</td>
<td>9.3</td>
</tr>
<tr>
<td>2005</td>
<td>21.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Avg.</td>
<td>21.3</td>
<td>8.7</td>
</tr>
</tbody>
</table>

U of Ill.
Recovering the nutrients

• Killing plants in vegetative stage of growth will recover nitrogen quickly:
  – Lack of lignin
  – Fragile cellulose
  – Good carbon:nitrogen ratio
    • Cereal rye  20:1
    • Ryegrass  15:1
    • Legumes  10:1
  – No-till system grass leaches out nitrogen with rainfall and surface decomposition
  – Tillage systems require microbial breakdown of plant which is quick at this stage of growth
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Managing Nutrients After the Drought

Today’s slides, links to additional resources at:
https://www.agronomy.org/education/managing-nutrients-drought-resources