WHAT IS TILLAGE

THE PHYSICAL MANIPULATION OF THE SOIL FOR THE PURPOSES OF:

- Management of previous crop residues
- Control of competing vegetation
- Incorporation of amendments
- Preparation of a seedbed
SOIL PROPERTIES AFFECTED BY TILLAGE

- Crop residue cover
- Soil test measurements
- Nutrient availability
- Structure and aggregate stability
- Water relationships
- Temperature
- Strength
SURFACE CROP RESIDUE INTERACTS WITH OTHER FACTORS

- Impact on erosion
- Cooler soils
- Conserves moisture
- Affects soil physical properties
- Affects carbon and nutrient cycling
TILLAGE EFFECT EROSION ON CLEAN-TILLED GROUND, DANE CO., WIS.
CROP MANAGEMENT EFFECT
EROSION ON CORN SILAGE
GROUND SHAWANO CO., WIS.
TILLAGE INTENSITY IN WISCONSIN VARIES BY CROP

CTIC, 2002
EFFECT ON SOIL TEST

- Nutrients “stratify” in long-term no-till
  - Surface acidification
  - Soil sampling concerns
  - Benefit to P and K banding
  - Banded fertilizer response more likely in no-till
SOIL TEST STRATIFICATION FOLLOWING FIVE YEARS OF TILLAGE MANAGEMENT, ARLINGTON, WIS.

Wolkowski, 2003 (Corn/soybean rotation)
REDUCED TILLAGE IS MORE RESPONSIVE TO BANDING

- Positional availability
  - Surface vs. sub-surface
  - Wheel track vs. non-wheel track effects on root distribution
- Reduced P and K fixation by the soil
- Reduced K uptake from zones of poor aeration
FERTILIZER PLACEMENT AFFECTS CORN ROOT DISTRIBUTION (0-15 IN.)

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Fert. placement</th>
<th>Row</th>
<th>Untracked Inter-row</th>
<th>Tracked Inter-row</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH ROW</td>
<td></td>
<td>17.1</td>
<td>3.0</td>
<td>0.8</td>
</tr>
<tr>
<td>CH INTER-ROW</td>
<td></td>
<td>12.0</td>
<td>4.4</td>
<td>1.4</td>
</tr>
<tr>
<td>NT ROW</td>
<td></td>
<td>19.8</td>
<td>2.5</td>
<td>0.8</td>
</tr>
<tr>
<td>NT INTER-ROW</td>
<td></td>
<td>10.8</td>
<td>6.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Kaspar et al., 1991
EFFECT OF ROTATION, TILLAGE, AND FERTILIZER ON CORN K CONCENTRATION 45 DAP, ARLINGTON, WIS.

<table>
<thead>
<tr>
<th></th>
<th>CC</th>
<th>SbC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CH</td>
<td>ST</td>
</tr>
<tr>
<td>NONE</td>
<td>2.23</td>
<td>2.37</td>
</tr>
<tr>
<td>BDCT</td>
<td>2.35</td>
<td>2.19</td>
</tr>
<tr>
<td>2 x 2</td>
<td>2.85</td>
<td>3.26</td>
</tr>
</tbody>
</table>

Wolkowski, 2003
CORN RESPONSE TO STARTER: PLANTING DATE AND TILLAGE

BUNDY AND WIDEN, 1991 (3 YR. AVG.)
LOWER N AVAILABILITY IN REDUCED TILLAGE SYSTEMS

No-till/reduced tillage:

- Lower and slower mineralization
- Greater immobilization
- Volatilization of ammonia from surface urea and urea-containing materials
- Potential for increased denitrification
- Higher supplemental N rate for >50% corn residue recommended (30 lb N/a)
CONTINUOUS NO-TILL CORN TYPICALLY HAS LOWER N UPTAKE

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Oshkosh</th>
<th></th>
<th>Janesville</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Earleaf N</td>
<td>Grain N</td>
<td>Yield</td>
<td>Earleaf N</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>bu/a</td>
<td>%</td>
</tr>
<tr>
<td>MB</td>
<td>2.92</td>
<td>1.57</td>
<td>159</td>
<td>3.10</td>
</tr>
<tr>
<td>CH</td>
<td>2.84</td>
<td>1.55</td>
<td>145</td>
<td>3.05</td>
</tr>
<tr>
<td>NT</td>
<td>2.76</td>
<td>1.55</td>
<td>146</td>
<td>2.98</td>
</tr>
</tbody>
</table>

*Bundy et al., 1992 (3 yr. avg.)*
SOIL C AND N DISTRIBUTION AFTER 12 YEARS OF CONTINUOUS CORN

Karlen et al., 1994
TILLAGE AND DENITRIFICATION

- Tillage affected loss:
  - MB = 10 lb/yr
  - CH = 14 lb/yr
  - NT = 22 lb/yr

- No-till
  - Lower air-filled porosity
  - Higher microbial denitrifier population
  - More surface organic carbon

Hilton et al., 1994 (all received 100 lb N/a)
Tillage has a profound effect on the soil physical condition.
EFFECTS OF LONG-TERM TILLAGE ON THE PLOW LAYER PORE SIZE DISTRIBUTION

Hill et al., 1985
EFFECTS OF TILLAGE MANAGEMENT ON MACRO-PORE (\ (>0.4 \ mm) \ CONTINUITY

Lancaster, Wis.; continuous corn (Logsdon et al., 1990)
AGGREGATE STABILITY

INFLUENCED BY
- Organic matter and organisms
- Texture
- Rotation
- Tillage

IMPORTANT FOR:
- Aeration
- Water relations
- Productivity
“HEALTHY” CORN ROOT MASS
## Tillage Effects on Soil (0-2 in.) Properties at Lancaster, Wis.

<table>
<thead>
<tr>
<th>TILLAGE</th>
<th>STAB. AGGR. %</th>
<th>TOTAL C g/kg</th>
<th>EARTH WORMS No./m²</th>
<th>RUNOFF Mg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>46</td>
<td>24</td>
<td>78</td>
<td>2.1</td>
</tr>
<tr>
<td>Chisel</td>
<td>34</td>
<td>16</td>
<td>52</td>
<td>--</td>
</tr>
<tr>
<td>Plow</td>
<td>36</td>
<td>11</td>
<td>53</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Karlen et al., 1994
WATER-STABLE AGGREGATE SIZE IN THE 0-3 IN. DEPTH AS AFFECTED BY ROTATION AND TILLAGE

Kladivko et al, 1986
EFFECT OF TILLAGE ON CRUST STRENGTH AFTER A HEAVY RAINFALL

STRENGTH (MPa)

UNGER, 1984
TILLAGE EFFECTS ON SOIL WATER RELATIONSHIPS

- No-till soils tend to have lower porosity and higher water content
- Considerable variability by soil type
- Continuous channels in no-till can increase infiltration rate
TILLAGE EFFECT ON INFILTRATION

- No-till maintains large pores
- Bare soil crusts
- Infiltration varies during season
- Wheel traffic influences infiltration

Ankeny et al., 1990
RELATIONSHIP BETWEEN SOIL MATRIC POTENTIAL AND VOLUMETRIC WATER CONTENT

Hill, 1990
TILLAGE EFFECTS ON SOIL TEMPERATURE

- Cooler temperatures associated with high residue
- Residue buffers temperature change
- Emergence and early growth affected
- No-till systems have been shown to be 5-10% less productive in Wisconsin
Soil temperature at 5 cm for a 3-d period starting at zero h on 2 June 1982 for 4 tillage treatments (Johnson & Lowery)
SOIL TEMPERATURE AFFECTED BY TILLAGE AND CROP RESIDUE

Effect on crop residue, Arlington, 1994

Effect on in-row soil temperature, Arlington, 1994

Wolkowski, 2000
EFFECT OF TILLAGE ON THE EARLY GROWTH OF CORN, ARLINGTON, WIS.

<table>
<thead>
<tr>
<th>TILLAGE</th>
<th>EMERGENCE</th>
<th>V6</th>
<th>V12</th>
<th>SILKING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>plt/ft</td>
<td>----</td>
<td>----</td>
<td>%</td>
</tr>
<tr>
<td>Strip-till</td>
<td>1.6</td>
<td>1.1</td>
<td>28</td>
<td>62</td>
</tr>
<tr>
<td>Chisel</td>
<td>1.8</td>
<td>1.1</td>
<td>29</td>
<td>80</td>
</tr>
<tr>
<td>No-till</td>
<td>0.7</td>
<td>0.7</td>
<td>18</td>
<td>36</td>
</tr>
</tbody>
</table>

Wolkowski, 2000
STRIP TILLAGE OFFERS AN ALTERNATIVE TO FULL-WIDTH TILLAGE
STRIP TILLAGE OFFERS AN ALTERNATIVE TO FULL-WIDTH TILLAGE WITH CONSERVATION AND AGRONOMIC BENEFITS
TILLAGE EFFECTS ON SOIL STRENGTH

- Reduced tillage soils have higher surface bulk density
- Short-term response to occasional tillage
- Traffic management critical
- Subsoiling response is likely site dependent
EFFECT OF PERIODIC PLOWING ON SOIL BULK DENSITY (0-3 in.)

Pierce et al., 1994
TILLAGE INFLUENCES
RESISTANCE TO PENETRATION

- Lower penetration resistance in NT at depth compared to chisel and no-till

- Greater penetration resistance in wheel track

*Larney and Kladivko, 1989*
### Soil Physical Properties and Corn Yield as Affected by Tracked and Wheeled Vehicles

<table>
<thead>
<tr>
<th>TYPE</th>
<th>BULK DENSITY</th>
<th>HYDR. COND.</th>
<th>AIR-FILLED PORE SPACE</th>
<th>YIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/cc</td>
<td>uM/sec</td>
<td>%</td>
<td>Bu/a</td>
</tr>
<tr>
<td>Untracked Steel</td>
<td>1.28</td>
<td>26.0</td>
<td>17.8</td>
<td>166</td>
</tr>
<tr>
<td>Tracked</td>
<td>1.38</td>
<td>13.0</td>
<td>9.7</td>
<td>148</td>
</tr>
<tr>
<td>Steel-tracked</td>
<td>1.46</td>
<td>7.8</td>
<td>7.7</td>
<td>--</td>
</tr>
<tr>
<td>Rubber-tracked</td>
<td>1.50</td>
<td>2.7</td>
<td>4.7</td>
<td>139</td>
</tr>
<tr>
<td>Wheel-tracked</td>
<td>1.46</td>
<td>7.8</td>
<td>7.7</td>
<td>--</td>
</tr>
</tbody>
</table>

Brown et al., 1992
Given enough horsepower man can do some really dumb things
Compaction affects the soil
- structure
- porosity
- aeration
- strength

Plant growth affected
- root growth
- nutrient uptake
- water utilization
CORN AND SOYBEAN YIELD AS AFFECTED BY DEEP TILLAGE, MANITOWOC, WIS.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NT</td>
<td>30</td>
<td>213</td>
<td>57</td>
<td>176</td>
</tr>
<tr>
<td>VR</td>
<td>40</td>
<td>188</td>
<td>58</td>
<td>172</td>
</tr>
<tr>
<td>ZB</td>
<td>51*</td>
<td>226*</td>
<td>59</td>
<td>192*</td>
</tr>
</tbody>
</table>

Wolkowski (unpublished)
SUMMARY

- Tillage management can greatly modify soil properties related to soil quality and crop growth
- Tillage intensity will impact residue management and soil consolidation
- Many physical and chemical properties are affected
- High residue systems need “tweaking” in Wisconsin
- Better traffic and tillage management will enhance soil quality