Application of remote sensing based tillage mapping technique in Upper White River watershed

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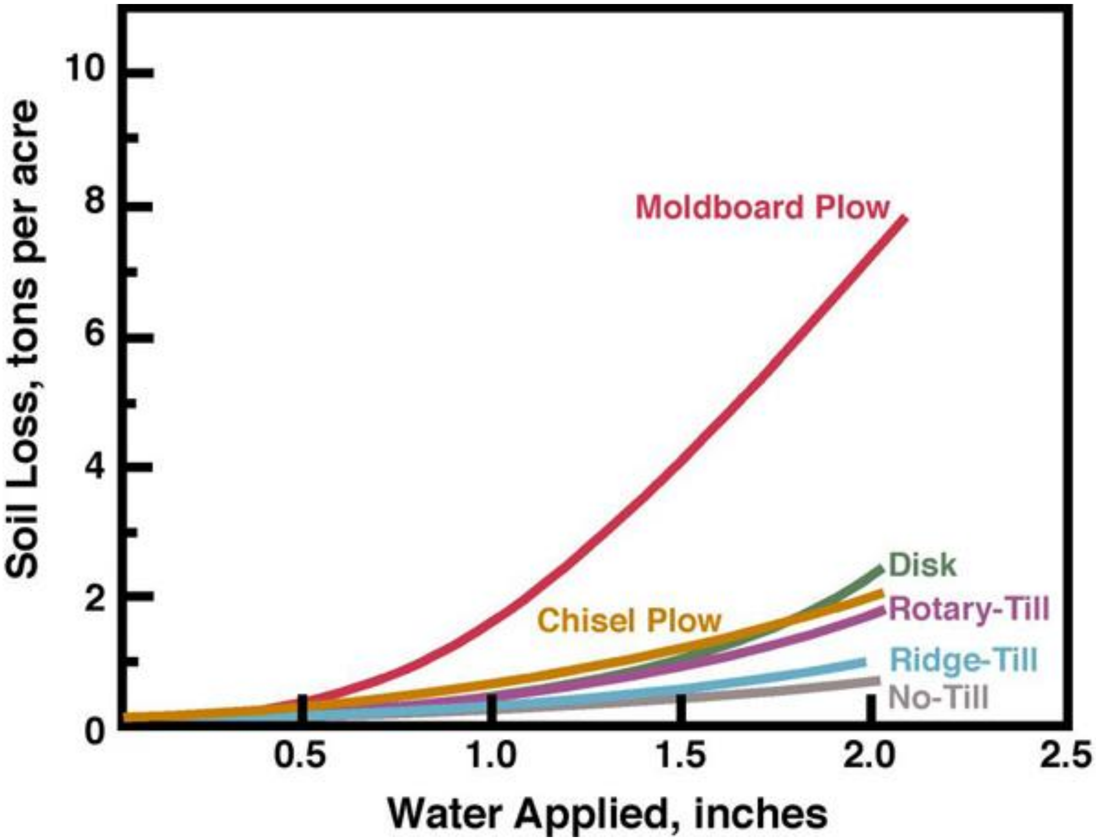
Soil loss under various tillage practices



Source : www.ianrpubs.unl.edu

Estimated annual soil and nutrient losses under various tillage practices

Practice	Soil erosion / Sediment yield (t/ac/yr)	Total water and soil losses (lb/ac) N	P
Moldboard plow	15	55.6	21.0
No till	1.0	9.7	3.1

Source : www.epa.gov/msbasin/

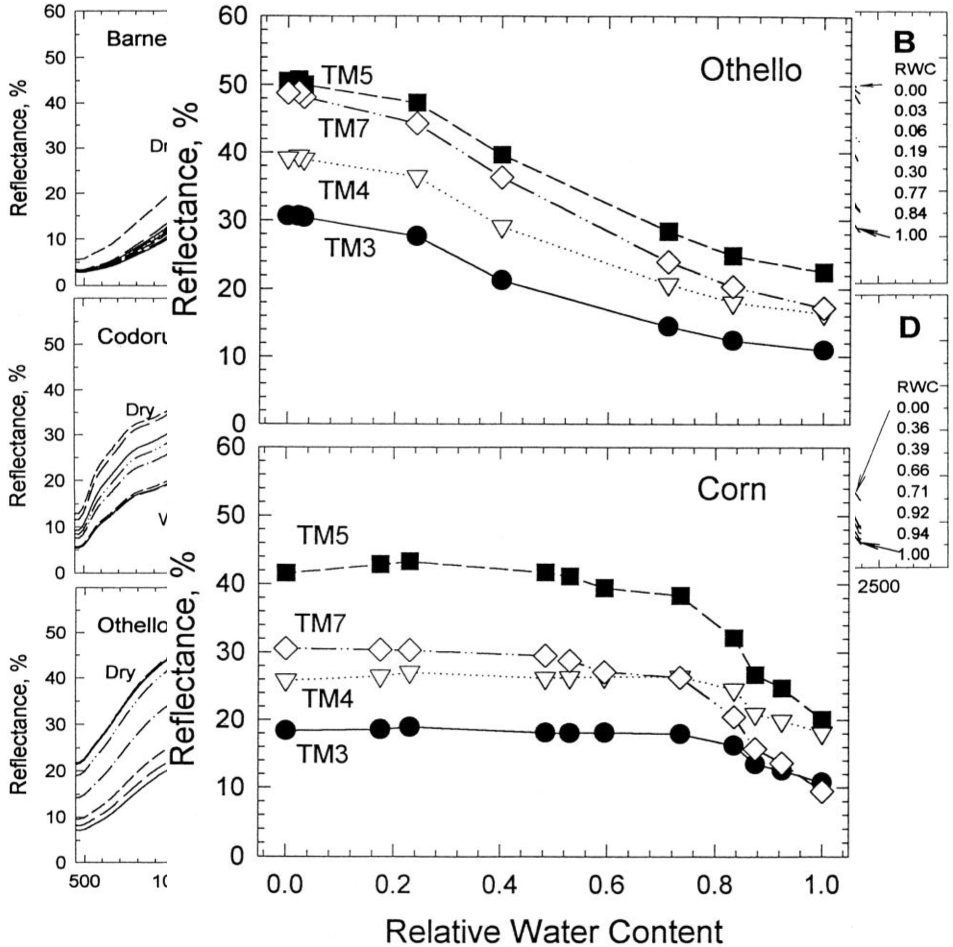
Practice	Eroded soil (t/ha)	Total N (5% OM)	Total P (5% OM)	Total K (5% OM)
Conventional Till	141	296	2.5	266
Mulch Tilled	88	47	0.4	34
No Till	1.7	14	0.1	9

Source : Comia et al., 1994

Objective

- Mapping tillage practices using Landsat Thematic Mapper (TM) data and logistical regression models for the Upper White River watershed

Reflectance curve



Source: Daughtry et al., 2004

Reflectance [illegible] wavelength bands

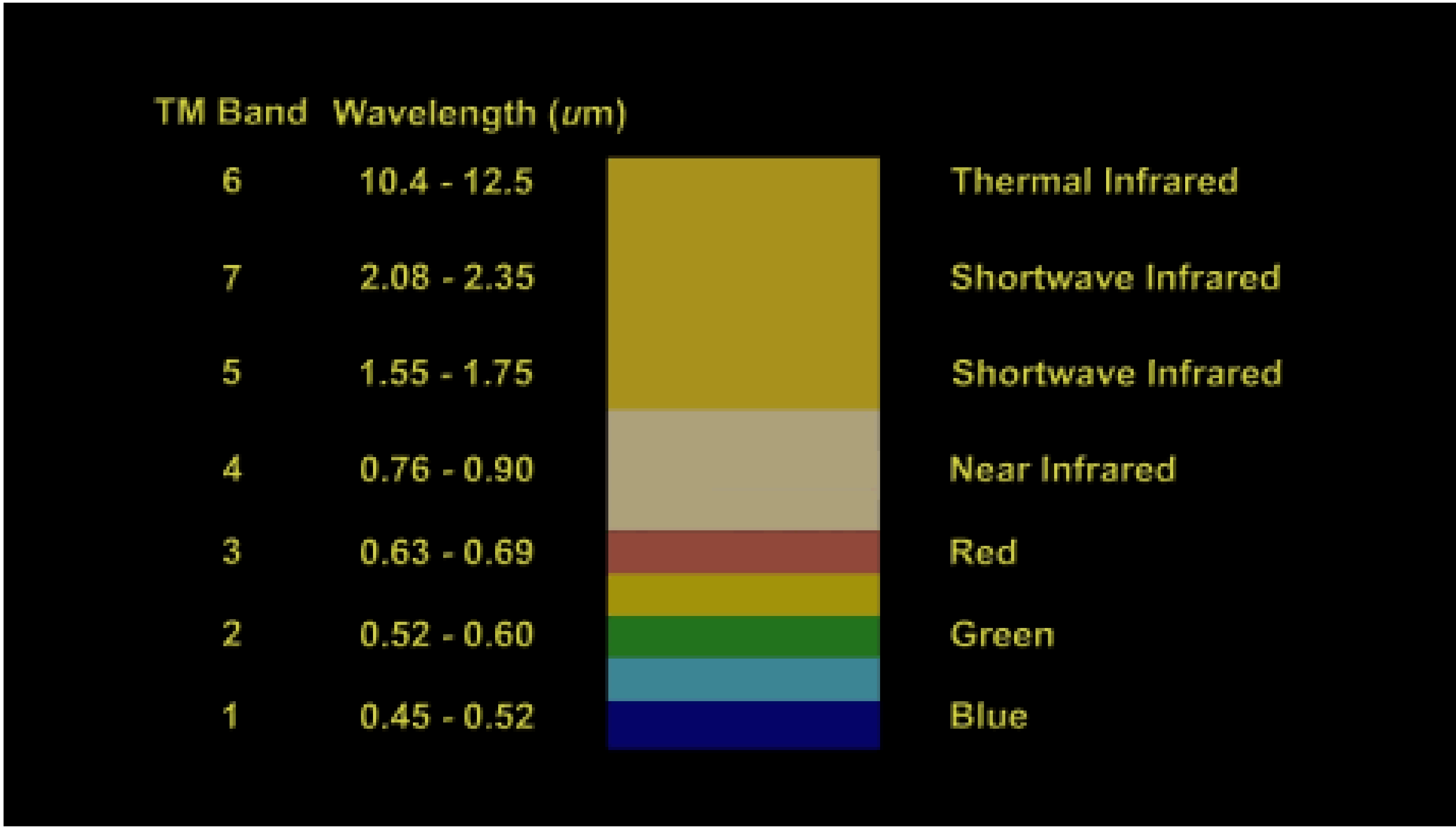
Satellite sensors

- Landsat MSS
- Landsat TM and ETM+
- NOAA - AVHRR
- SPOT
- IRS

Spectral resolution

- Refers to width of each band on the electromagnetic spectrum
  - Landsat TM sensor consists of 7 bands
    - TM Band 1 – Blue – 0.45 – 0.52 micro meters
    - TM Band 2 – Green– 0.52 – 0.60 micro meters
    - TM Band 3 – Red – 0.63 – 0.69 micro meters
    - TM Band 4 – NIR – 0.76 – 0.90 micro meters
    - TM Band 5 – MIR – 1.55 – 1.74 micro meters
    - TM Band 6 – TIR – 10.40 – 12.50 micro meters
    - TM Band 7 – MIR – 2.08 – 2.35 micro meters

Landsat spectrum range

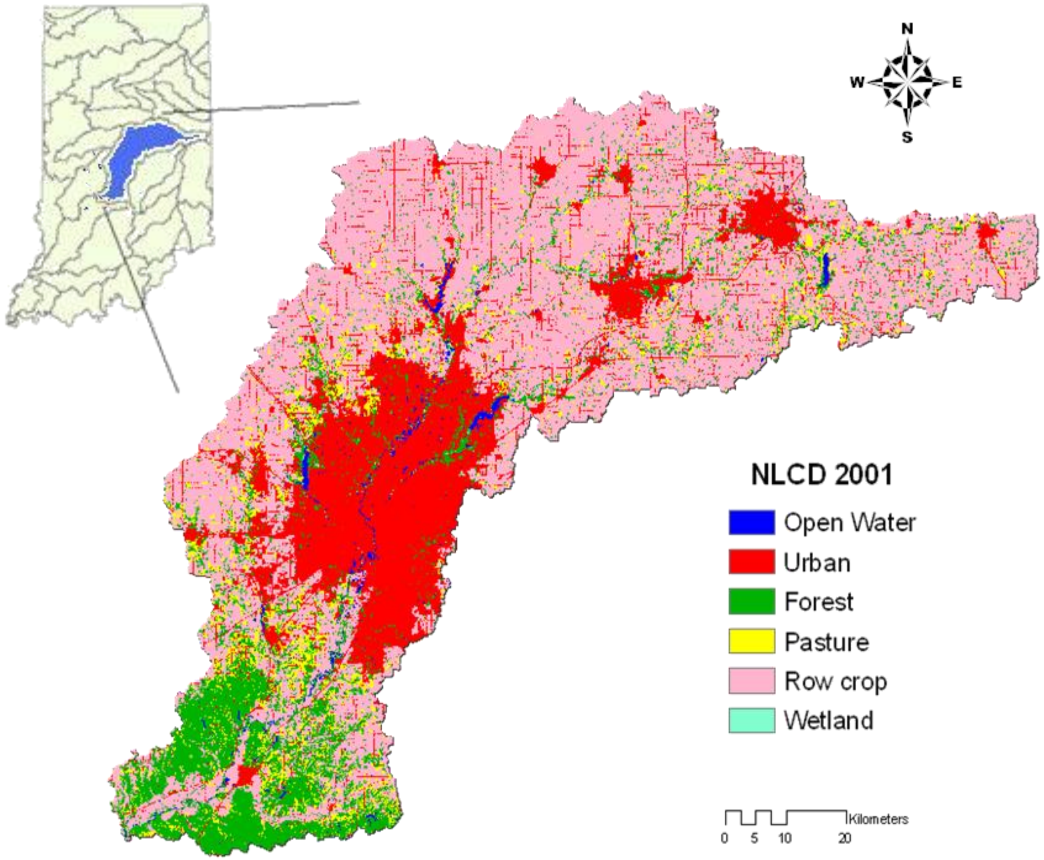


Source : http://svs.gsfc.nasa.gov/vis/

Radiometric and temporal resolutions

- Radiometric: refers to the dynamic range, or number of possible data values in each band. For example, Landsat TM sensor stores 8-bit image, i.e. data values range from 0 to 255.
- Temporal: refers to how often a sensor obtains imagery of a particular area. For example, Landsat TM can view the same area of the globe once every 16 days.

Watershed



Upper White River Watershed

- 7043 km^2
- Land Use
  - 23% Urban
  - 55% Row crop

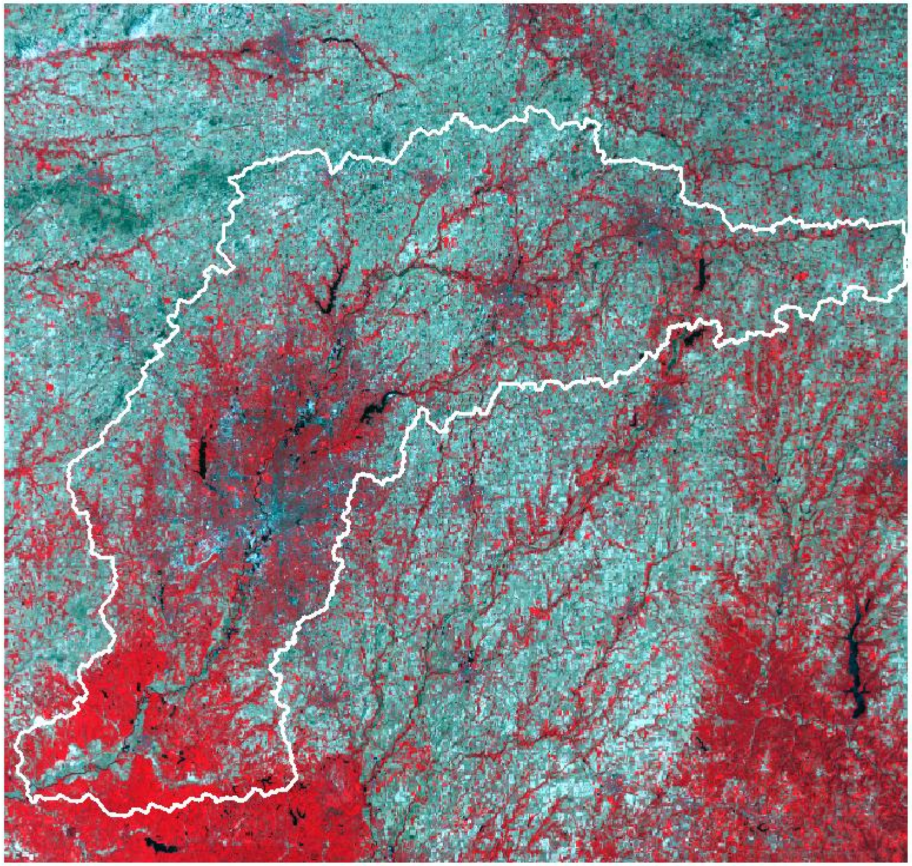
Materials and methods

- Tillage data collection
- Acquisition of satellite imagery
- Applying logistic regression models to determine tillage probability
- Accuracy assessment of tillage maps

Materials and methods

- Tillage data collection
  - Conventional and Conservational tillage percentage for corn at county level from Indiana State Department of Agricultural
- Satellite imagery
  - Two Landsat TM imagery
  - Mapping tillage practices - Preplanting season (May 8, 2003) (Source: www.indianaview.org)
- Mapping land use – Standing crop (July 25, 2003) (Source: Purdue Terrestrial Observatory)

Landsat TM imagery



Landsat TM imagery
May 8, 2003
Path 21 runs 32-33

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Materials and methods

- Logistical regression models
  - General expression: $\text{Logit}(p) = \ln\left(\frac{p}{1-p}\right) = \alpha + \beta X$
    - p – Tillage response probability
    - α – intercept
    - β – slope
    - X – Variable based on reflectance

$$p = \frac{e^{logit(p)}}{1 + e^{logit(p)}}$$

p value =0 100% conventional tillage
p value =1 100% conservational tillage

Materials and methods

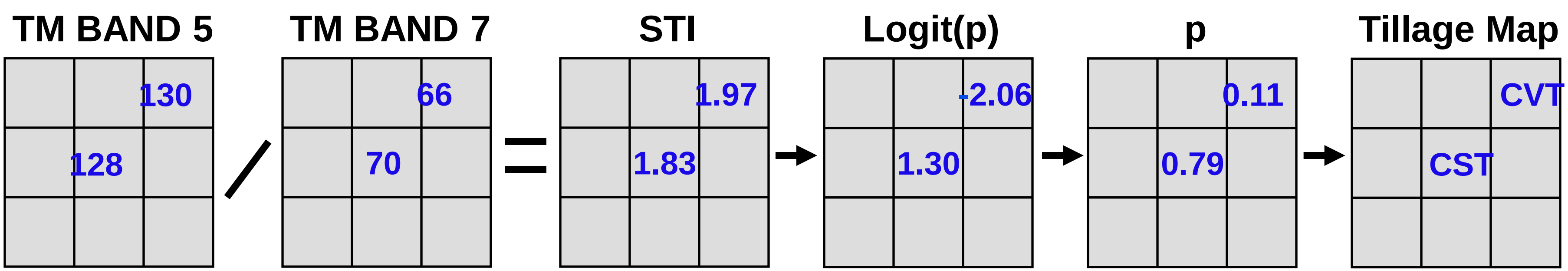
- **Logistic regression models**
  1. **Logit(p) = 10.215 – 0.072 * TM5**
  2. **Logit(p) = -19.404 + 29.949 * R15**
     - **where R15 = (TM1 / TM5)**
  3. **Logit(p) = 8.785 + 40.947 * M15**
     - **where M15 = (TM1 – TM5) / (TM1 + TM5)**
  4. **Logit(p) = 10.931 + 0.135 * D35**
     - **where D35 = TM3 - TM5**
  5. **Logit(p) = 45.218 – 23.998 * STI**
     - **where STI = TM5 / TM7**
  6. **Logit(p) = 30.464 – 99.483 * NDTI**
     - **where NDTI = (TM5 – TM7) / (TM5 + TM7)**

Source: Van Deventer et al. (1997)

Materials and methods

- How to identify tillage practices – An example

Logit(p) = 45.218 – 23.998 * STI   where STI = TM5 / TM7



Logit(p) = 45.218 – 23.998 * 1.83 = 1.30   p = e^Logit(p) / (1 + Logit(p)) = e^1.30 / (1 + e^1.30) = 0.79
Logit(p) = 45.218 – 23.998 * 1.97 = -2.06   p = e^Logit(p) / (1 + Logit(p)) = e^-2.06 / (1 + e^-2.06) = 0.11

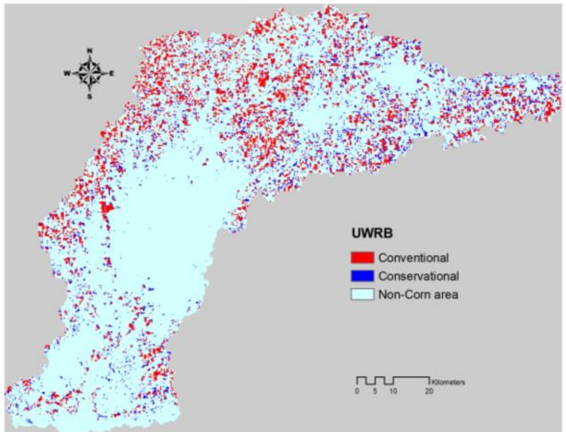
If **p <** cut point tillage probability – Conventional Tillage (CVT)
If **p >** cut point tillage probability – Conservation Tillage (CST)

Materials and methods

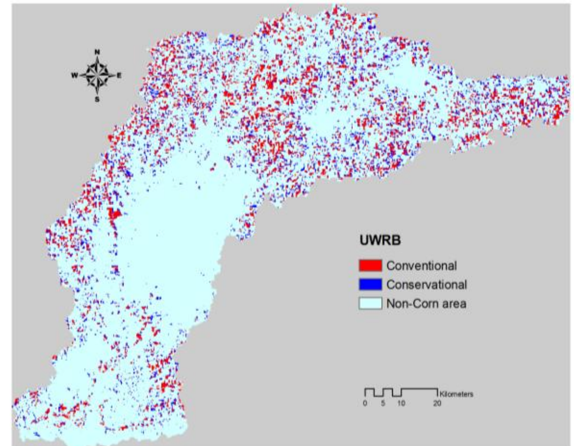
- Cut-off Tillage Probability

Model	Intercept	Slope	Cut-off Tillage Probability
TM5	10.215	-0.072	0.62
R15	-19.404	29.949	0.56
M15	8.785	40.947	0.56
D35	10.931	0.135	0.44
STI	45.218	-23.998	0.64
NDTI	30.464	-99.483	0.62

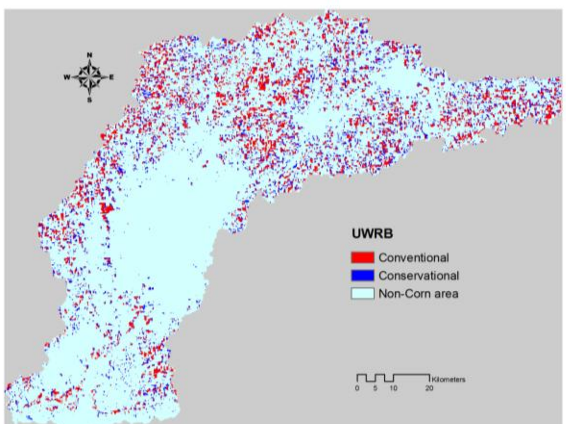
Models comparison



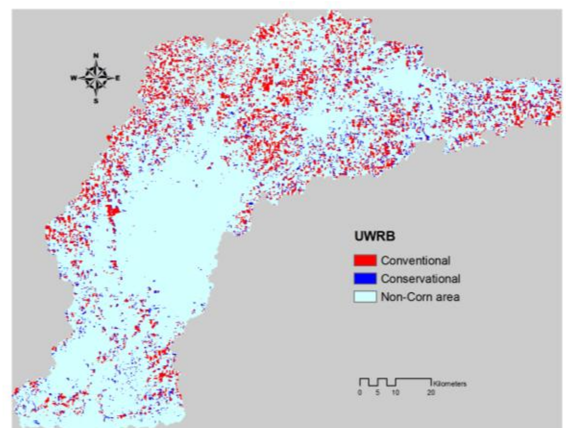
Model D35



Model M15

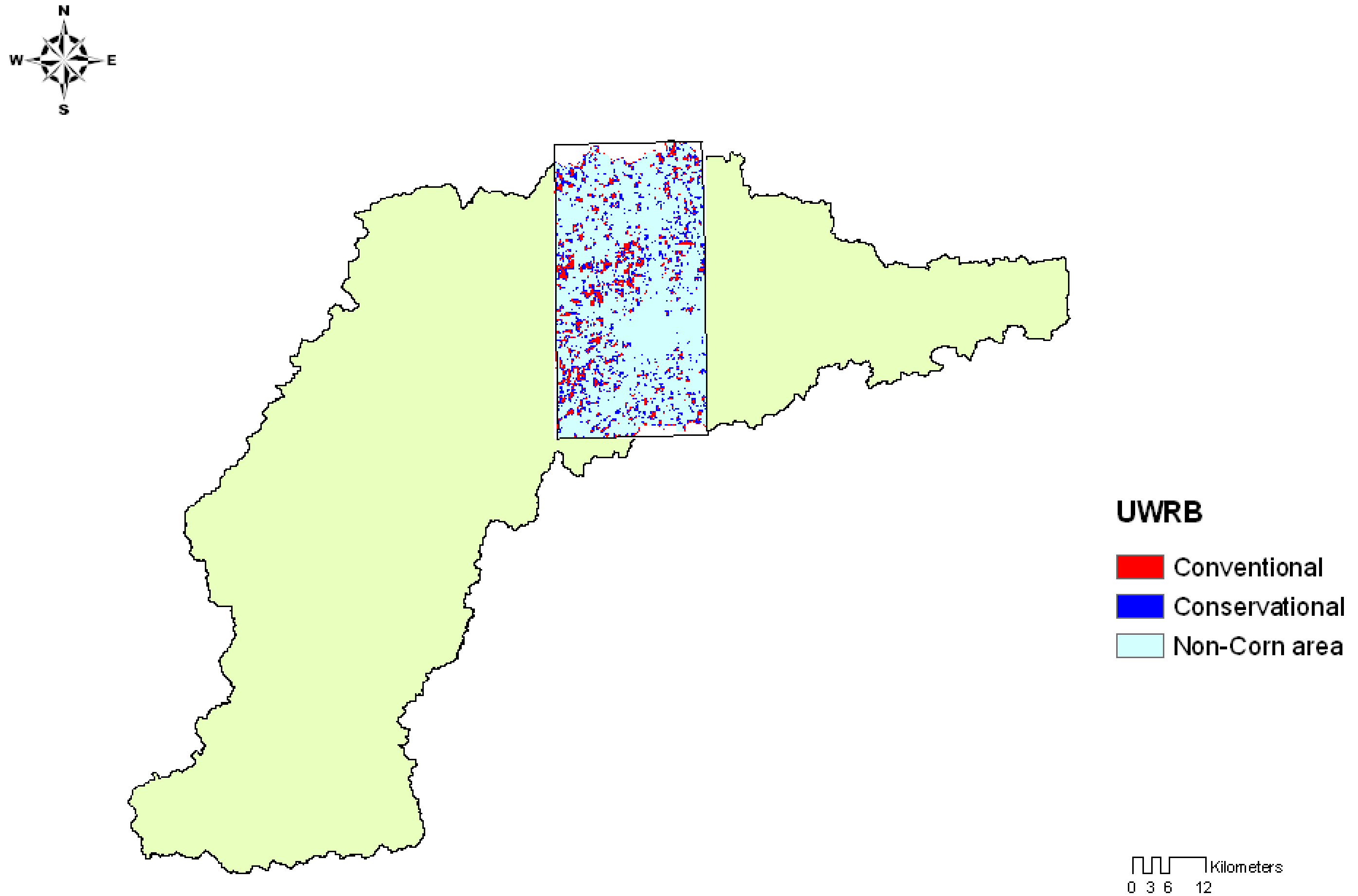


Model R15



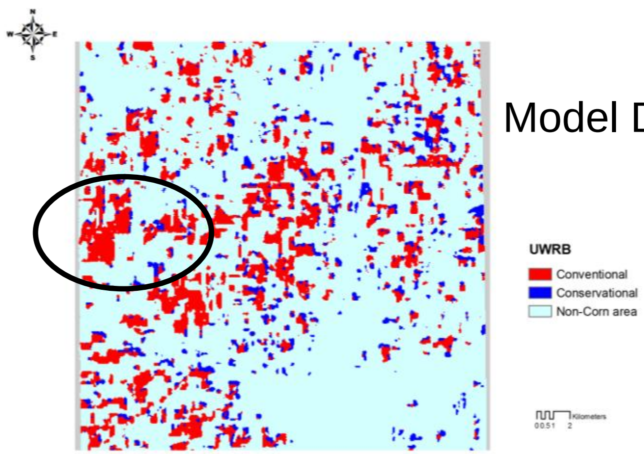
Model T5

Example: Madison county

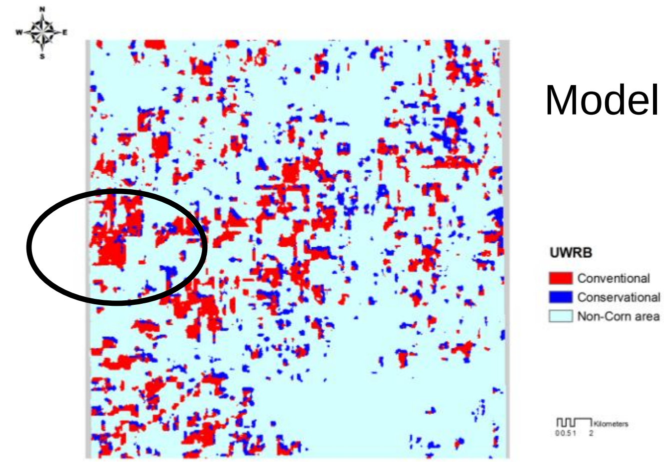


Model result

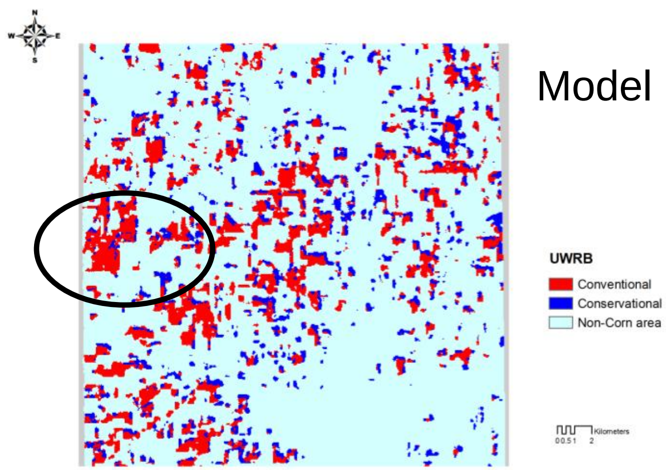
Model D35



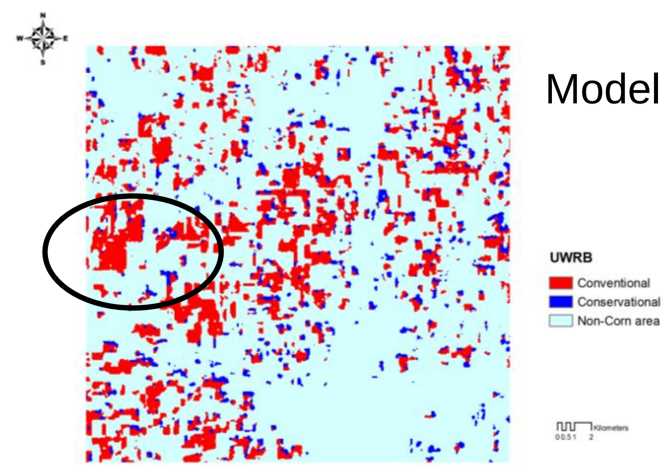
Model M15



Model R15



Model T5



Model accuracy

- Percentage conventional and conservational tillage under corn crop production from different logistic regression model and ISDA

	Models		ISDA data	
	Conventional	Conservational	Conventional	Conservational
Model R15	**59.1%**	40.9%	**56.3%**	**43.7%**
Model D35	67.4%	32.6%		
Model M15	**58.3%**	41.7%		
Model T5	73%	27%		

Conclusions

- Logistic regression models were easy to use and cost- and time-effective
- Regression models M15 provided a more accurate map
- This approach is promising for the rapid collection of tillage information on individual fields over large areas

Future research

- Development of new models to classify more than two tillage classes
- Use organic matter content as one of the variable in the regression model
- Use the regression model output to watershed modeling tools requiring specific information about tillage practice