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Remote sensing crop residue for improved watershed management

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Outline

- **Why?**
  - Renewed interest in crop residue
  - Model needs
  - Measurement issues
  - CAI and other indices
  - Objective
- **How?**
- **Then and What?**
  - Discriminating soil from crop residue
  - CAI performance
- **So What?**
  - Summary and implications
- **Acknowledgement**

Why?

- Renewed interest in crop residue
  1. Soil and water conservation
  2. Soil carbon sequestration
  3. Feedstock for biofuel production
- Different outcome on the field

Use in Watershed Models

- Crop residue affects the following parameters
  1. Sediment transport
  2. Surface runoff velocity and volume
  3. Snow accumulation and melt
  4. Nutrient loading
  5. Temperature (?)

- BASINS, SWAT

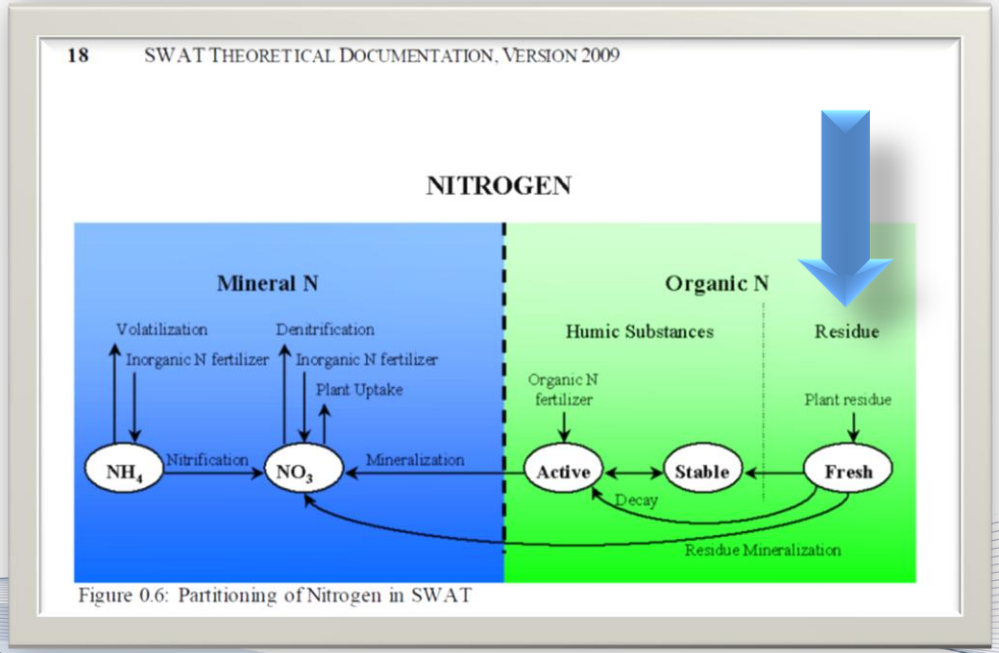
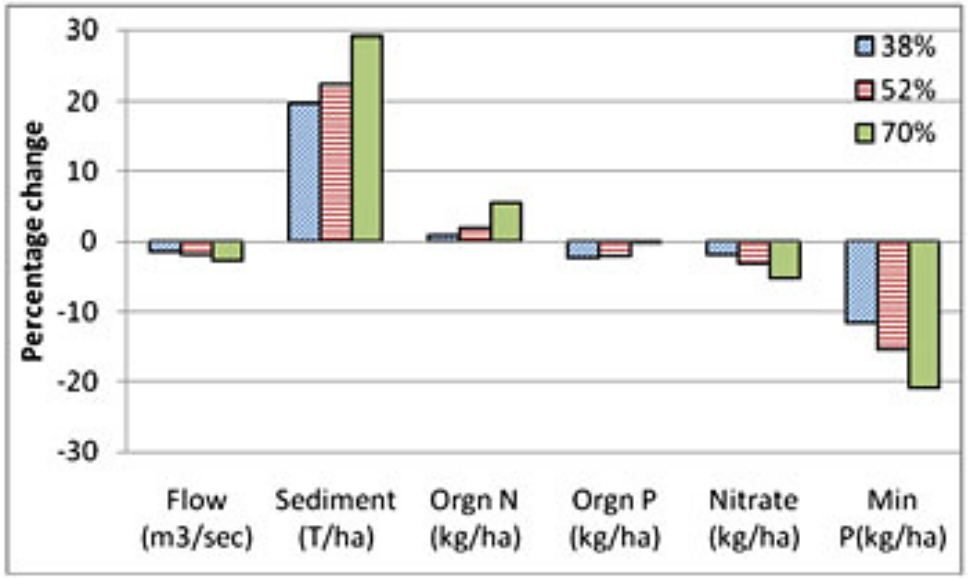


Figure 0.6: Partitioning of Nitrogen in SWAT

Simulated watershed scale impacts of corn stover removal for biofuel on hydrology and water quality

- Used SWAT model
- Three corn stover removal rates (38%, 52% and 70%)
- Results:
  - Stream flow, nitrate and mineral phosphorus loading were reduced
  - Sediment and organic nitrogen loading were increased at the watershed outlet



Cibin, R., Chaubey, I. and Engel, B. (2011), Simulated watershed scale impacts of corn stover removal for biofuel on hydrology and water quality. Hydrological Processes.

Why?

- Currently, there is no government (or private entity) program that monitors crop residue in the field
- There is a need for objective, accurate, and economical estimate of the crop residue on a timely basis

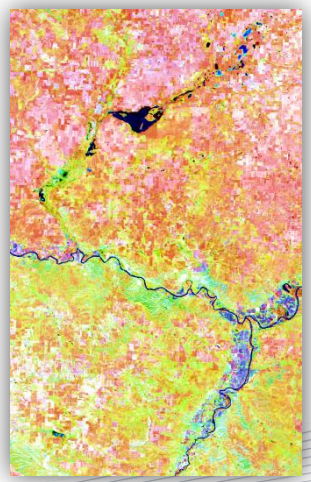
Measuring crop residue

- Transect line method (NRCS and Laflen et al. 1981)
- Meter stick method
- Photo comparison (NRCS)
- Photographic / grid-point method
- Calculation method (based on secondary info)
- “Windshield observation” estimate (CTIC)

The greatest challenge is when the crop residue is almost the same color as the soil

Remote sensing methods

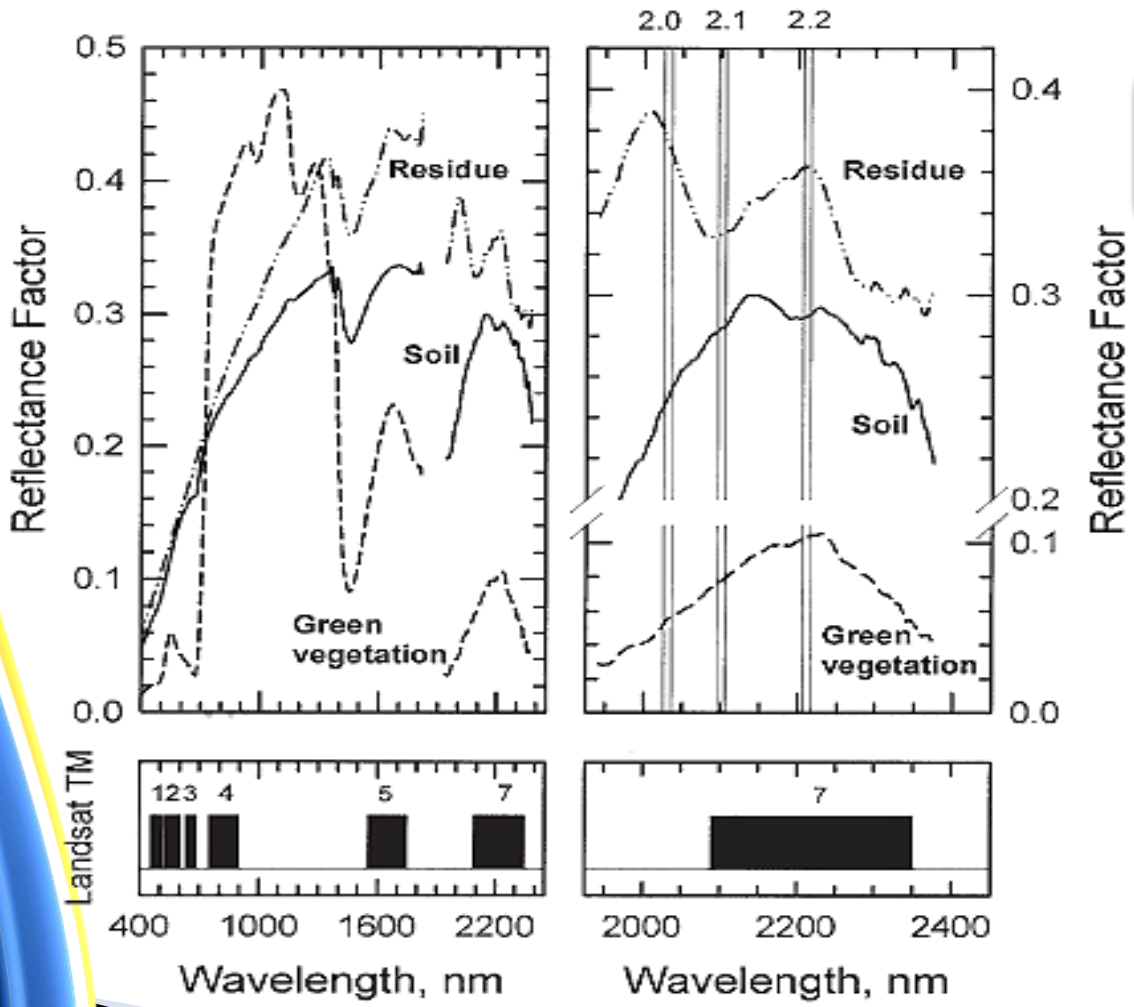
- Reflectance-band height indices
  - CAI – cellulose absorption index
  - LCA – lignin-cellulose absorption index
- Broadband spectral normalized difference indices
  - NDTI – normalized differential tillage index
  - NDSVI – normalized differential senescent vegetation index
  - NDI5 – normalized differential index 5
- Spectral angle indices
  - MSACRI – modified soil adjusted residue index
  - CRIM – crop residue index multiband



Cellulose absorption index (CAI) method

- Developed by ARS Hydrology and Remote Sensing Laboratory (HRSL)
- Exploits the cellulose absorption feature at 2100 nm of the SWIR spectrum
- Robust application, but sensitive to moisture content and soil spectral signature
- Bare soil has negative index value, plant residue is positive index value

Cellulose absorption index (CAI) method



$$CAI = 0.5 (R_{2.0} + R_{2.2}) - R_{2.1}$$

Where $R_{2.0}$, $R_{2.1}$ and $R_{2.2}$ are the reflectance values at the 2000, 2100 and 2200 nm bands, respectively

Adapted from Daughtry et al. 2005

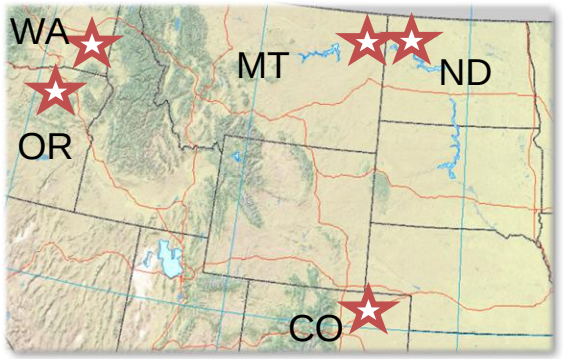
Objectives

Assess the applicability of CAI method in the Northern Great Plains region for measuring crop residue cover

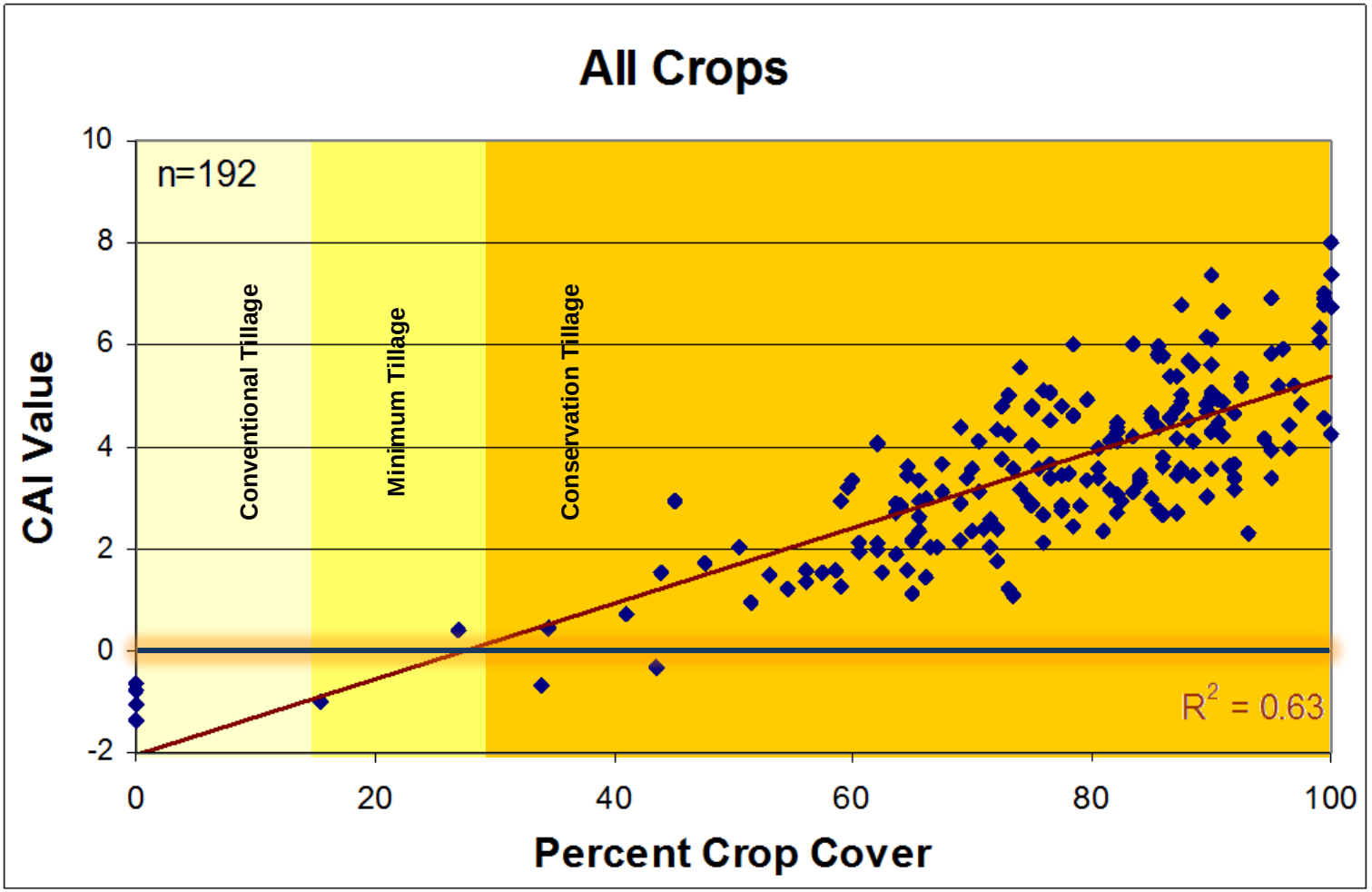
- Determine the correlation between CAI and percent crop residue cover
- Test how the correlation behaves against the major crop types
- Identify other parameters that influence the CAI values

How?

- Crops: Spring wheat, malting barley, durum, pea and fallow
- Field measurement
  - Reflectance of crop residue
  - Digital image of the field
  - Line transect method
  - Crop residue sampling
  - Soil moisture content
- Laboratory analysis
  - Residue weight
  - Grid-point analysis of images
  - Statistical analysis



CAI value against percent crop cover

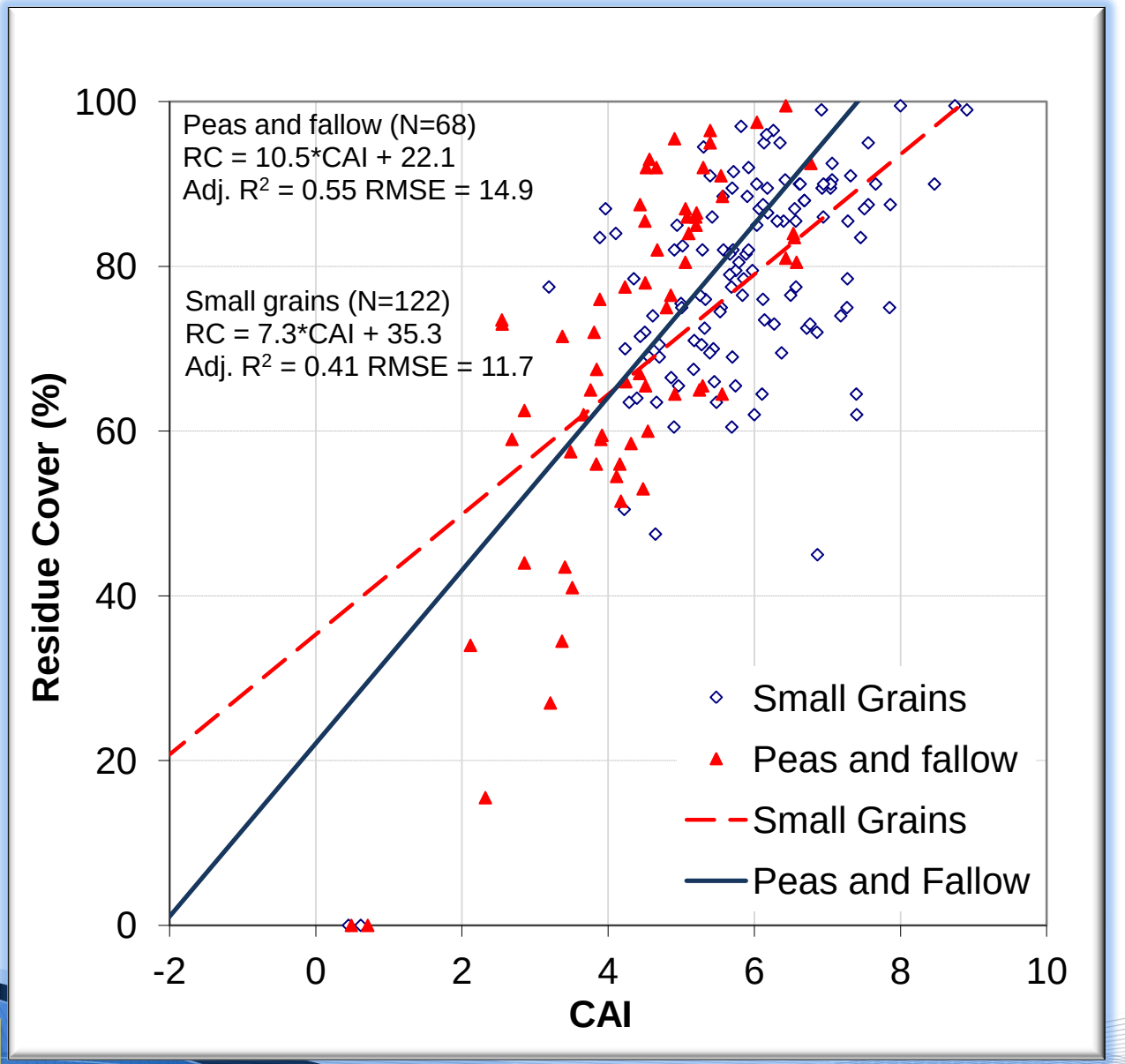


Correlation* of CAI and crop residue composition

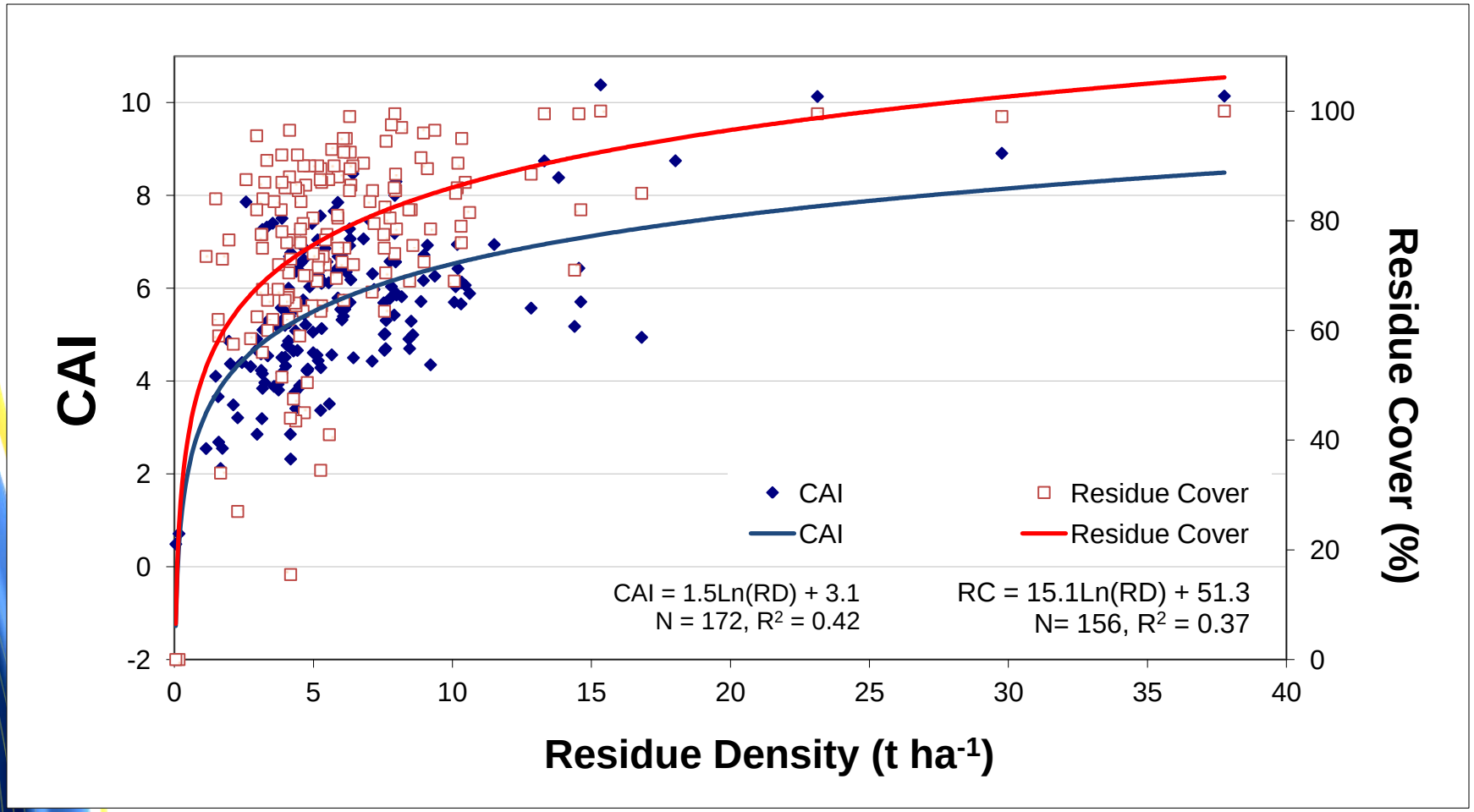
	Residue cover	Cellulose	Hemi-cellulose	Lignin	Total Fiber†	C:N Ratio	Residue Amount
CAI	0.62	0.38	0.63	-0.49	0.39	0.54	0.52
Residue cover	—	n.s.	0.38	n.s.	n.s.	n.s.	0.40
Cellulose	—	—	0.59	-0.69	0.72	0.60	n.s.
Hemicellulose	—	—	—	-0.78	0.61	0.66	0.30
Lignin	—	—	—	—	n.s.	-0.62	n.s.
Total Fiber†	—	—	—	—	—	0.49	n.s.
C:N Ratio	—	—	—	—	—	—	n.s.

* Pearson correlation coefficients
n.s. – not significant at α=0.05. Minimum significant value of Pearson correlation coefficient = 0.30.
† Total Fiber = Hemicellulose + Cellulose + Lignin

CAI value against percent cover by crop



CAI value against crop residue density



So what?

- CAI method could be effectively implemented in the NGP region for measuring crop residue cover
- For most crops, positive CAI value alone can distinguish fields practicing conservation tillage
- There is indication that CAI could measure crop residue amount
- Performance of CAI was affected by the type of crop rather than by location and soil type in the region

So what?

- Further study is needed to better understand the response of CAI and similar indices to other parameters (e.g. standing vs. laid stubbles)
- The incorporation of crop residue cover as (spatial data) input to watershed models could improve the reliability and accuracy of model results
- As the use for crop residue increase, the need to monitor and quantify this resource increases as well – remote sensing is a viable tool to tap

Acknowledgements

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Complete details of this study will be available on the May/June 2012 issue of Journal of Soil and Water Conservation