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A New Energy Future for Montana, Idaho, South Dakota, Wyoming, the Pacific Northwest and the Nation

Terrestrial Carbon Sequestration

2006

REGIONAL CARBON SEQUESTRATION PARTNERSHIPS ANNUAL REVIEW MEETING

National Energy Technology Laboratory

Pittsburgh, PA

October 3-4, 2006

Susan Capalbo
John Talbott
David Brown

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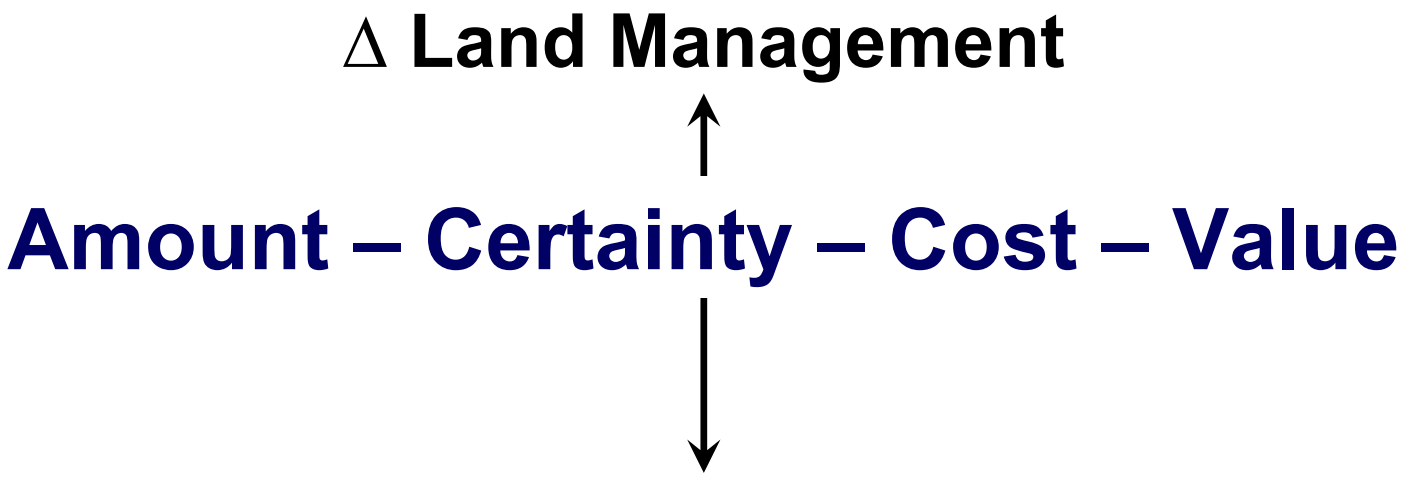
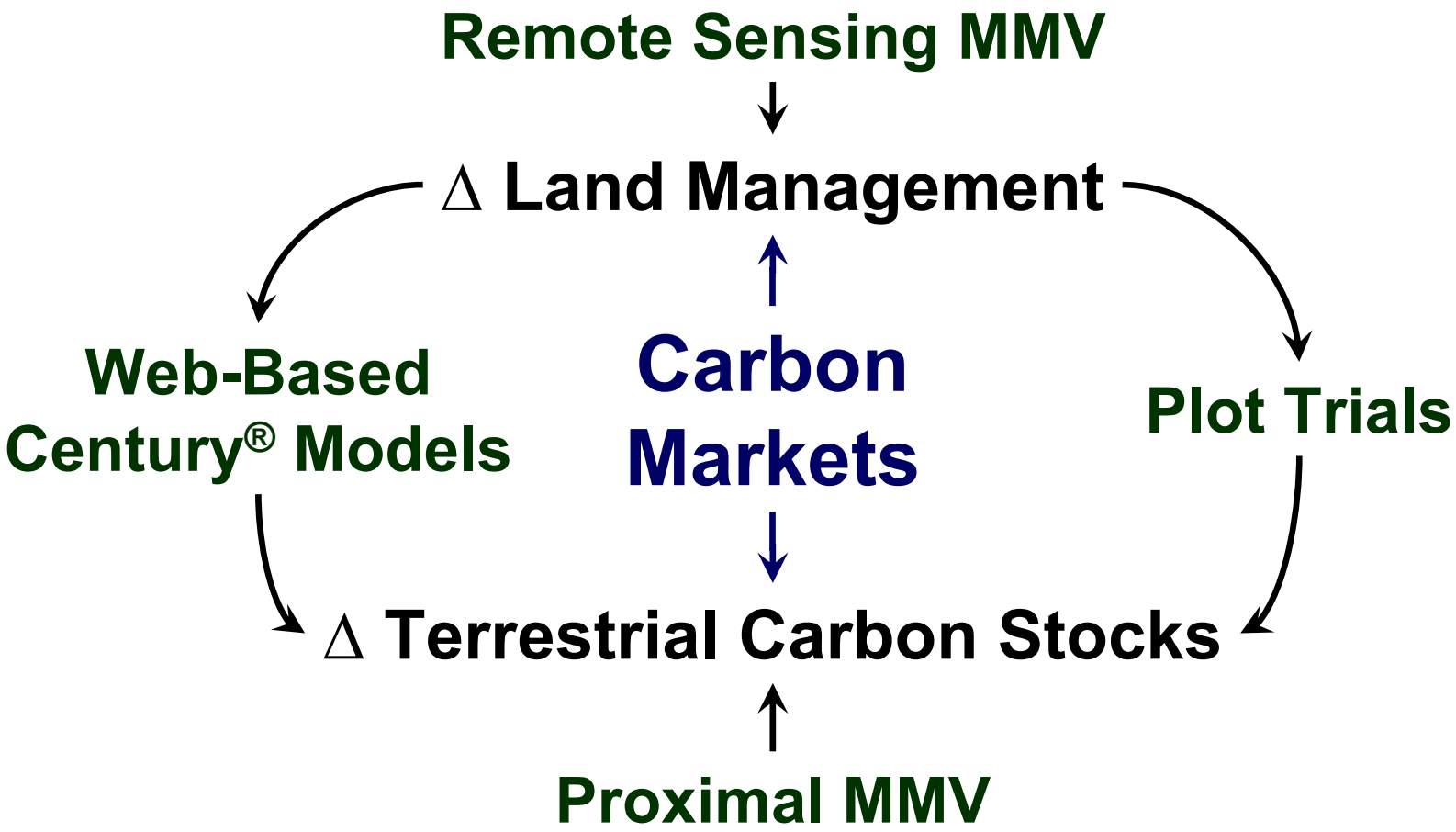
Terrestrial Carbon Sequestration Design



Terrestrial Carbon Sequestration Design



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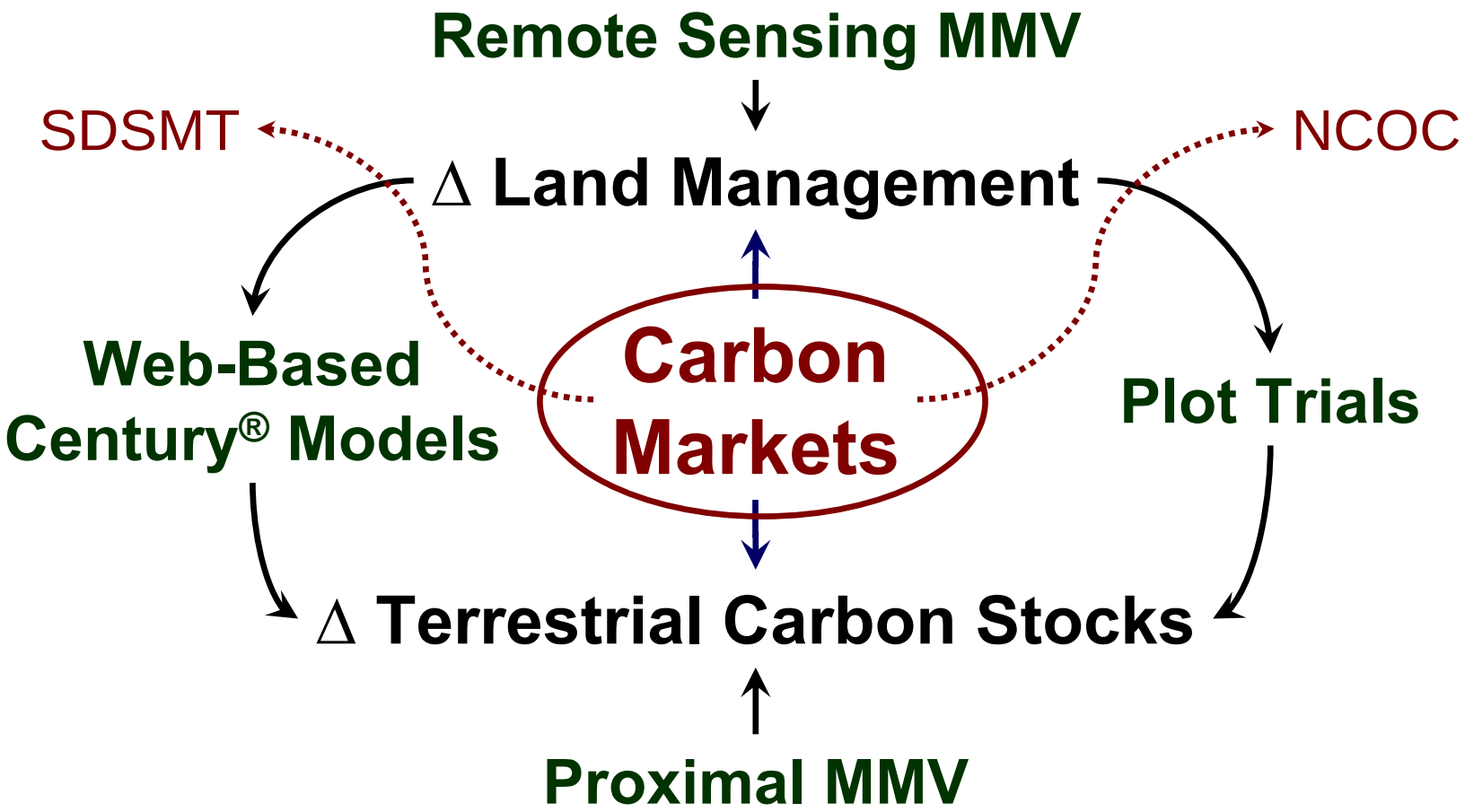
Terrestrial Carbon Sequestration Design



SDSMT Objectives & Achievements

- Spatial databases for 4 Big Sky states
  - Soil, climate, default historical land management
  - More states to be added
- Three complete farmer applications
  - One application fully quantified
    - 62,000+ MTCO2-e; 10,000 acres; 2001-2005
  - Two in process, planned pilot sale of all three
  - Planned outreach to farmers in more Big Sky states

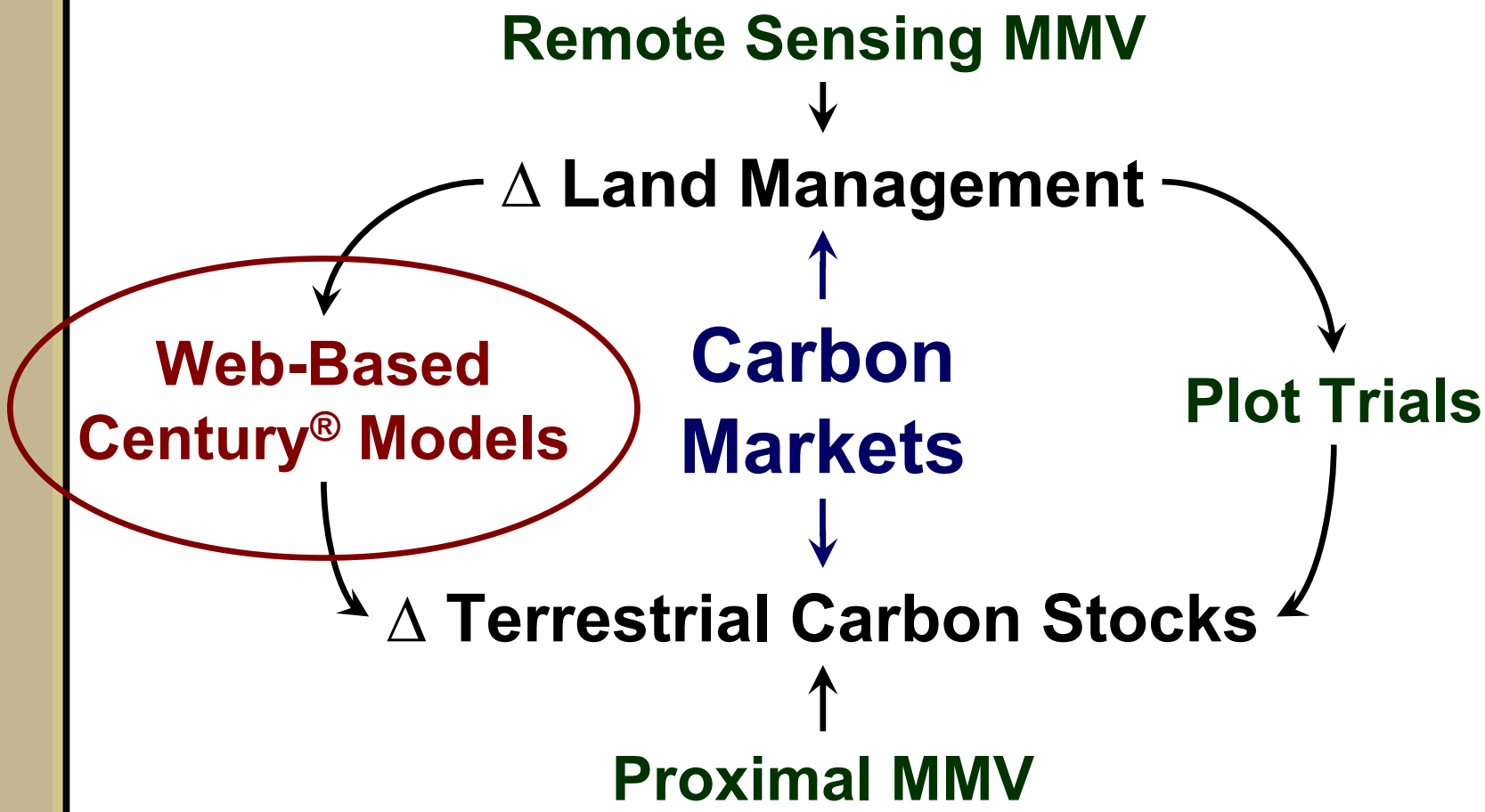
Ted Dodge, Emily Tafoya
& Neil Sampson, NCOC

NCOC Objectives & Achievements

- Listing Agreements
  - 16 landowners; 12,434 acres; 6,838 MTCO2-e/yr
  - 1 Tribe; 5,216 acres; 4,822 MTCO2-e/yr
- Market (CCX) listing and contracting
  - 4,822 MTCO2-e/yr accepted by CCX market
  - *25,000 MTCO2-e/yr carbon offset portfolios (2007)*
  - *Contracting & registration of pilot projects (2008)*
- Project planning handbook & portfolio standards (www.ncoc.us), contractual documents in testing

Ted Dodge, Emily Tafoya
& Neil Sampson, NCOC

Terrestrial Carbon Sequestration Design



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Web-based Century® Models (6.0)

- Estimate soil C sequestration
- Required Inputs
  - Cropping/management history
  - Climate & soil data
  - *Farmer input vs. Expert input?*
- Uncertainties
  - Inputs
  - Model

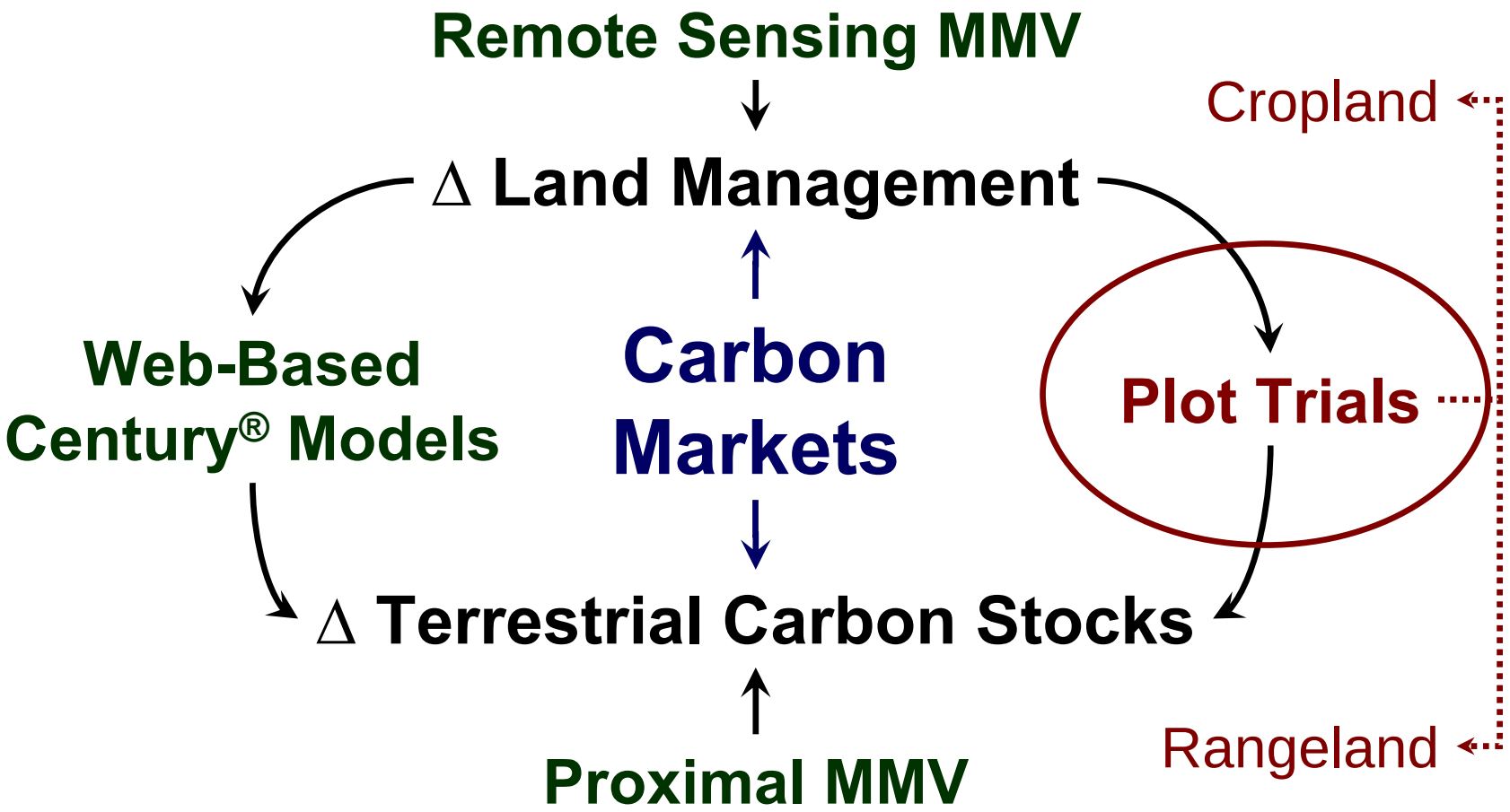
Comet (6.1)

- Developed by US Gov't Agencies
- Planned use by MSU and NCOC
  - *Ross Bricklemyer (MSU) & Ted Dodge (NCOC)*

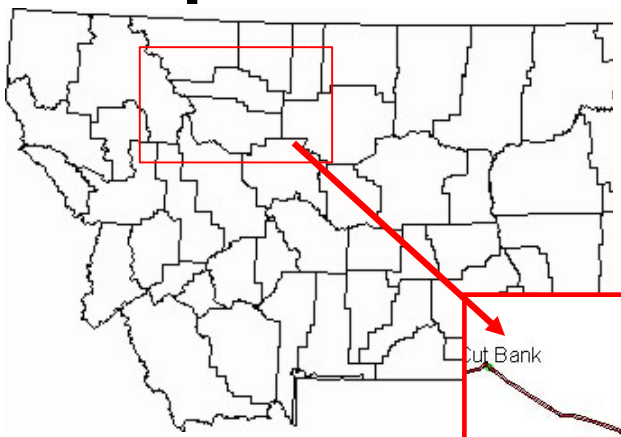
C-Lock® (6.2)

- Developed & used by South Dakota School of Mines & Technology (SDSMT)
  - *Pat Zimmerman & Karen Updegraff*

Terrestrial Carbon Sequestration Design

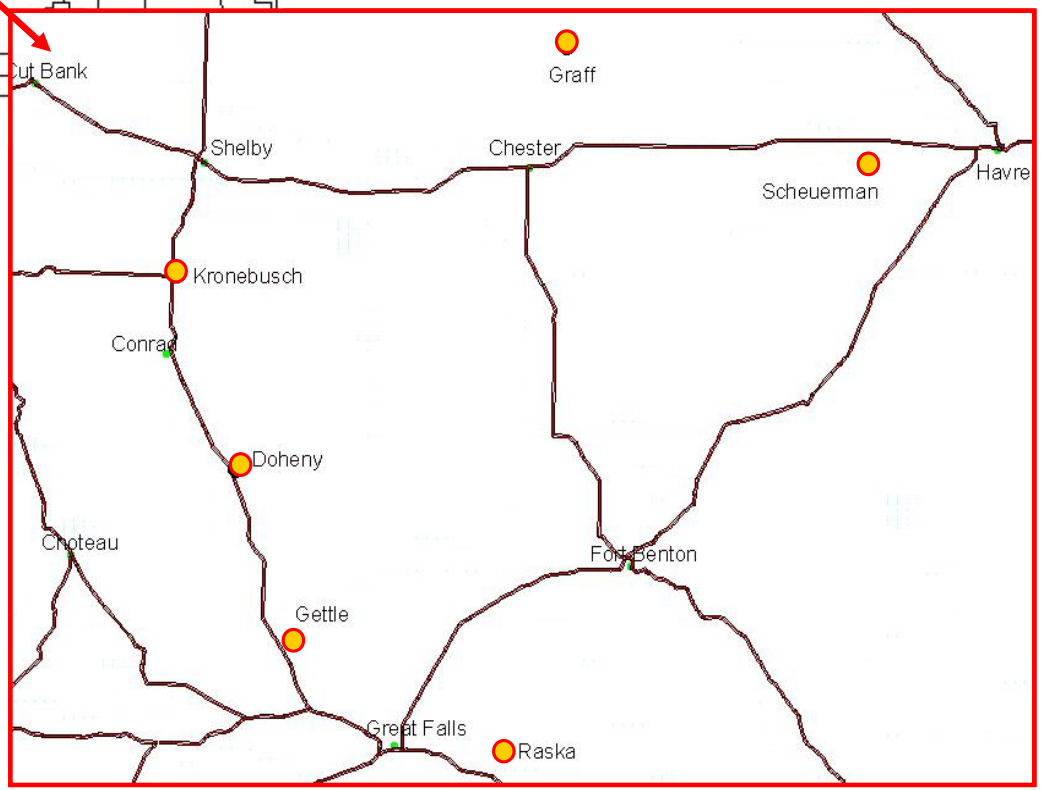


Cropland Controlled Test Sites



Treatments:

- Till vs. no-till
- Wheat-fallow vs. wheat-lentil



Ross Bricklemyer & Perry Miller, MSU

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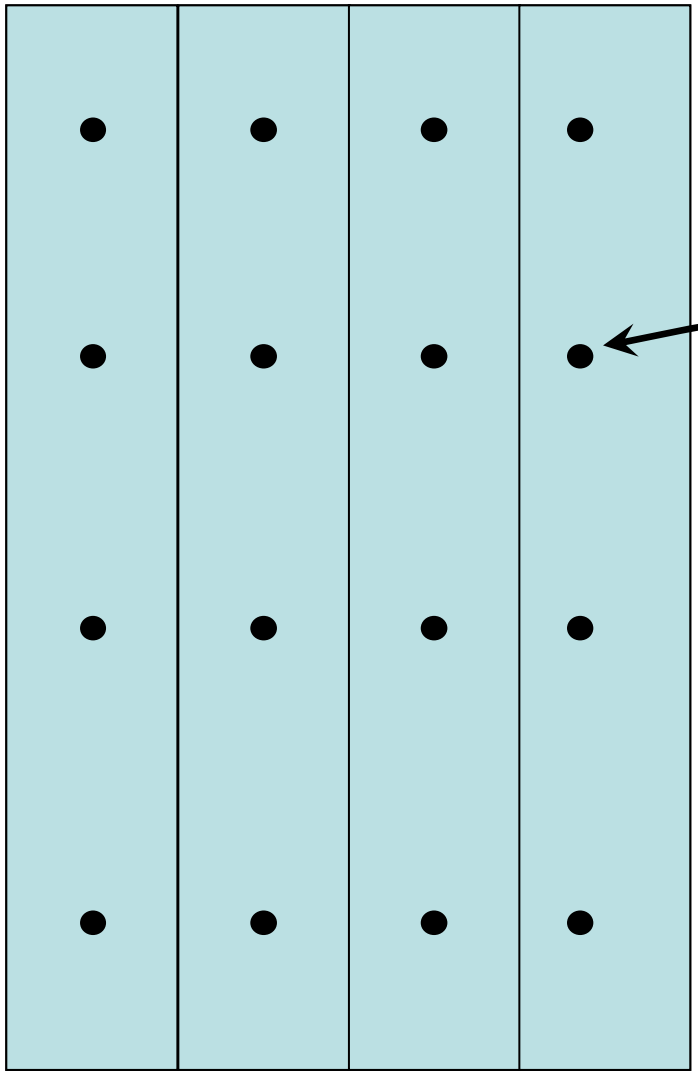
Cropland Controlled Sites

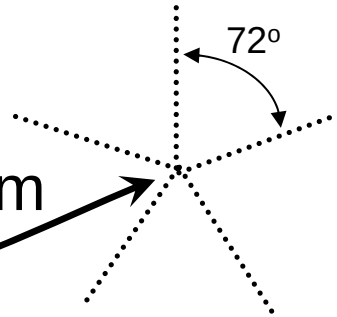


50 cm soil cores:

0-10,

10-20,

20-50 cm



5 m from center

2006 & 2008

Annually sample mature wheat biomass

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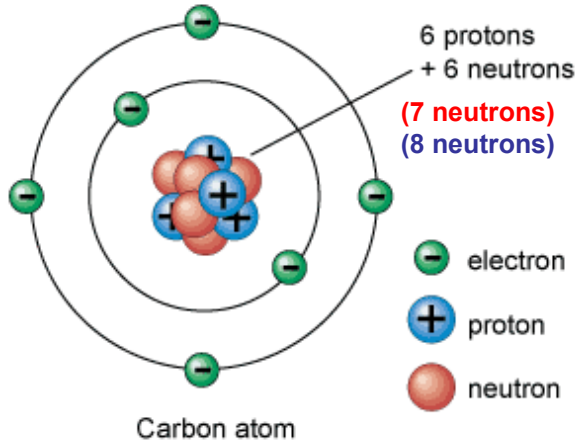
Isotope Detection of Carbon Flux and Storage

- Isotopes → Elements with varying number of neutrons
  (^{14}C, ^{13}C, ^{12}C, ^{15}N, ^{14}N)

- What are they used for?
  - ^{14}C = age of carbon (recalcitrant, new)
  - ^{13}C ^{14}C ^{15}N = source of C & N (soil, plant)
  - ^{13}C ^{15}N = health of vegetation



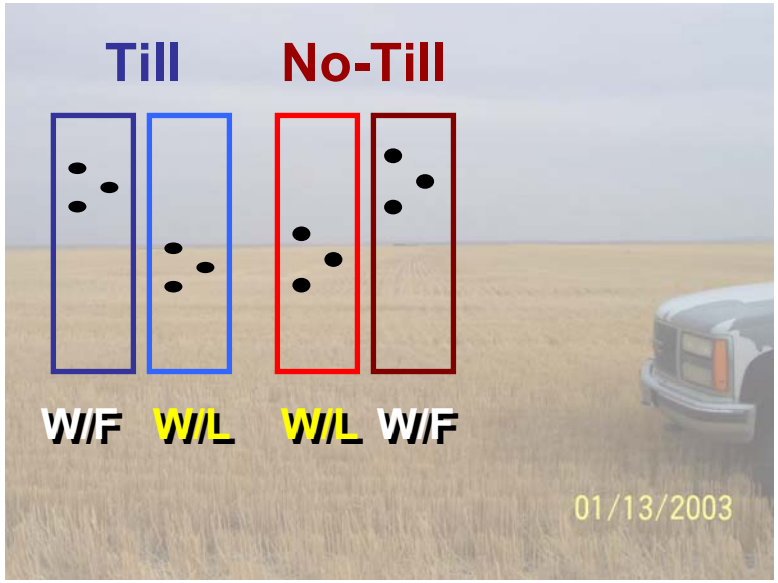
- What do you measure?
  - Pools = $^{14,13}C_{org}$ $^{15}N_{org}$ (soil or plant)
  - Flux = $^{14,13}CO_2$ (chambers), $^{14,13}C_{org}$ (leachate)

^{12}C = 98.9% in nature
^{13}C = 1.1% in nature
^{14}C = $10e^{-10}$ % in nature

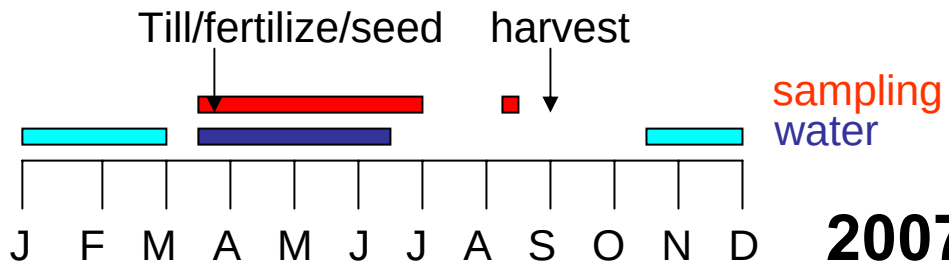
- How do you measure?
  - ^{14}C = Accelerator Mass Spectrometer (Irvine)
  - ^{13}C ^{15}N = Isotope Ratio Mass Spectrometer (Los Alamos)

Controlled Cropland Isotope Experiment

Gettle Farm (47.53°N, 111.21°W)

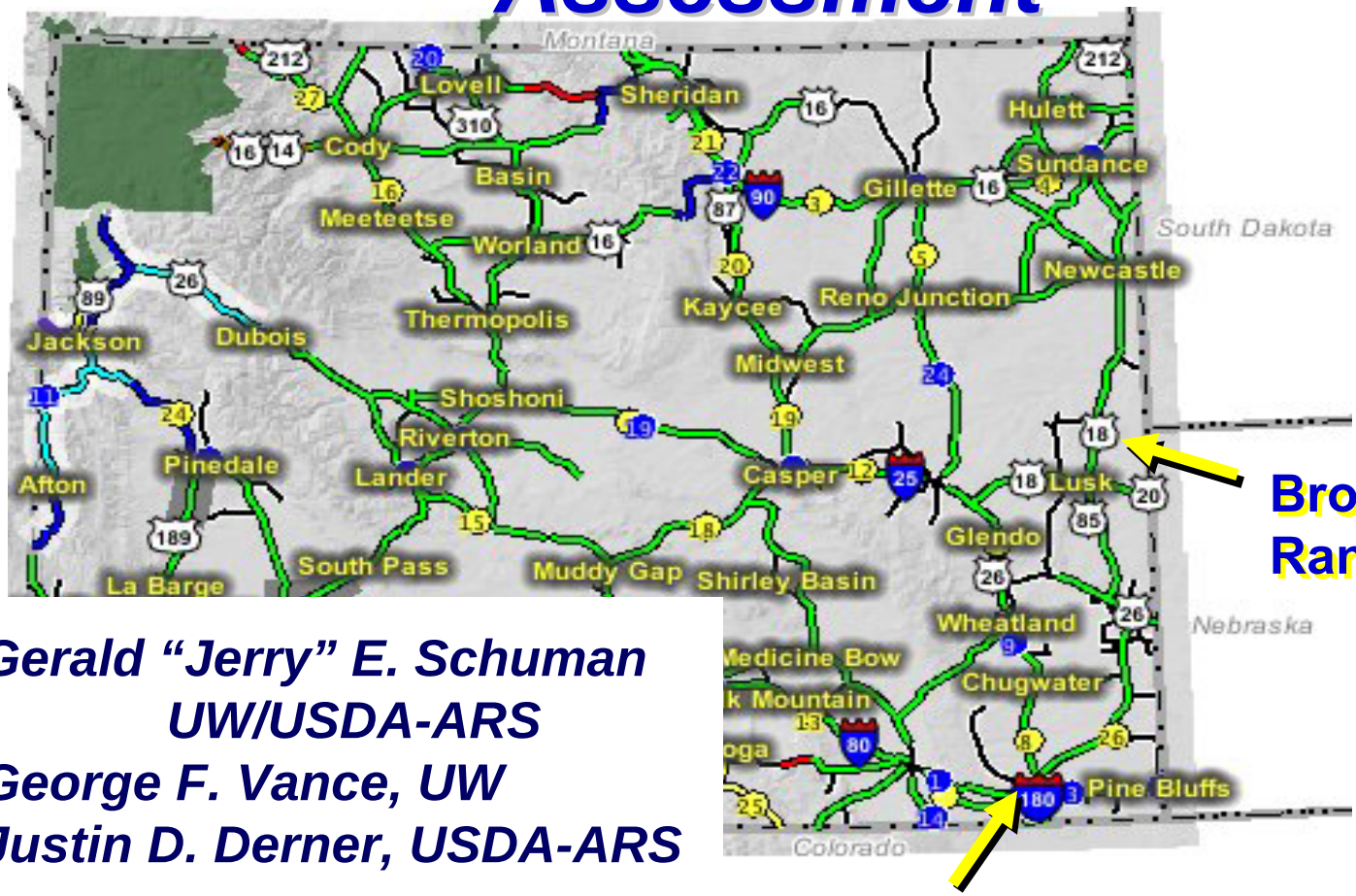


- **Measure C flux**
  - Chambers (gas)
  - Lysimeters (leachate)
- **Critical times**
  - Before/after till/seed
  - Before/after rain
- **C pools**
  - Soils and biomass
  - Pre-harvest



Malu Cisneros-Dozal &
Julianna Fessenden
Los Alamos National Lab

Rangeland Sequestration Potential Assessment



Gerald "Jerry" E. Schuman
UW/USDA-ARS
George F. Vance, UW
Justin D. Derner, USDA-ARS

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Grazing Intensity Study

- Initiated in 1982[a]
  - Northern mixed-grass prairie
- Assess the effects of grazing strategies
  - SOC, plant community, & animal performance
- SOC determined in 1993 and 2003
  - 50 m permanent transects, 10 m intervals
  - soil samples taken to a 60 cm depth

Grazing Treatments

120 day grazing season (mid-June to mid-October) with 250 kg yearling steers.

CL: Continuous light (5 steers/41 ha)
CH: Continuous heavy (5 steers/9 ha)
EX: Exclosure, no grazing by livestock

Browder Ranch Study

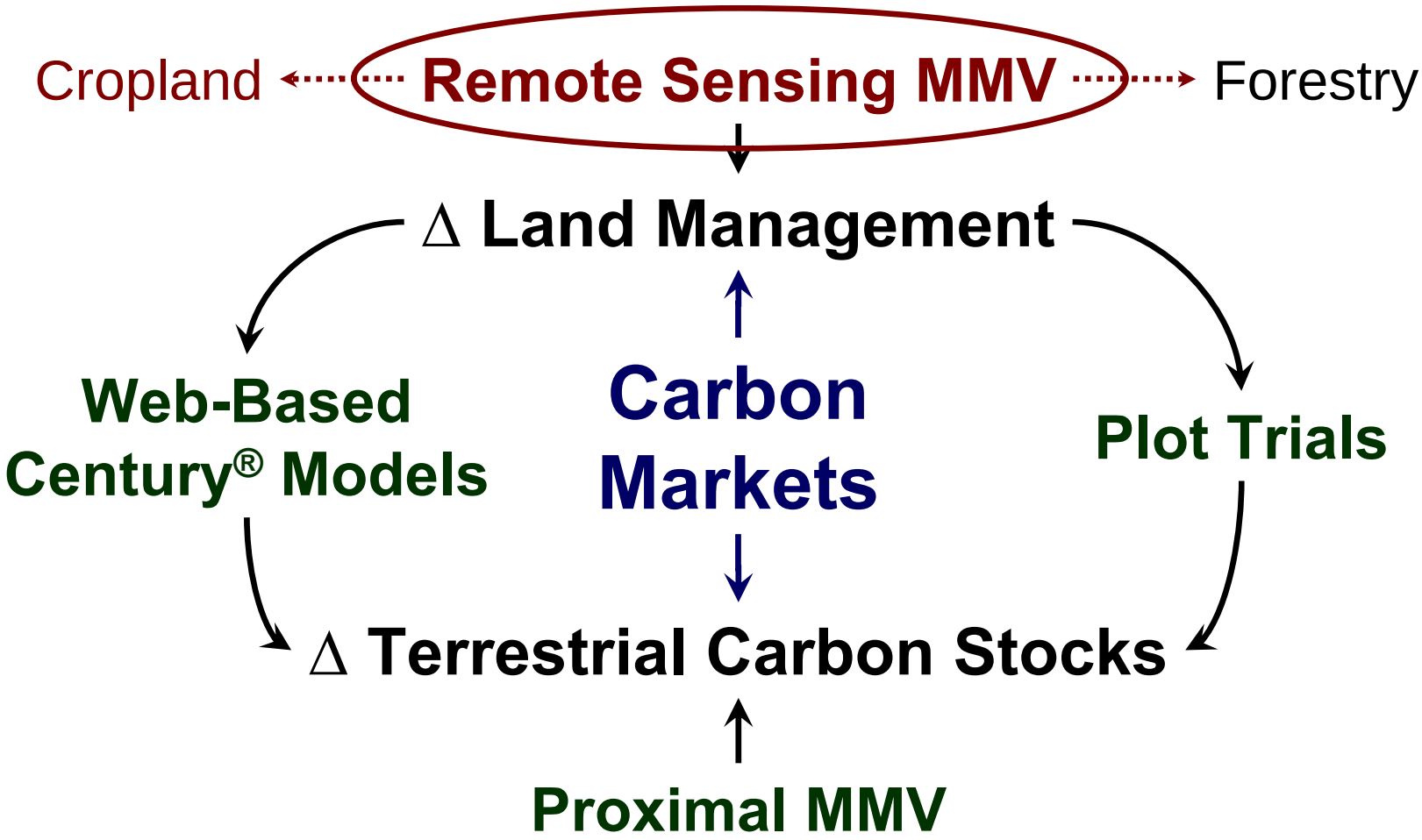
Formerly cropped areas

- Interseeding (grass & Alfalfa “falcata”)
- Herbicide treatment to control cheatgrass

Rangeland Soil Sampling Activities:

- **2006 → Grazing intensity**
  - established 1982
  - 4 treatments, 320 soil samples
- **2007 → Rangeland Improvements**
  - established 2003-04
  - 3 treatments, 120 soil samples
- **2009 → Grazing seasonality**
  - established 2003
  - 5 treatments, 160 soil samples
- **Vegetation C & forage quality for all**

Terrestrial Carbon Sequestration Design



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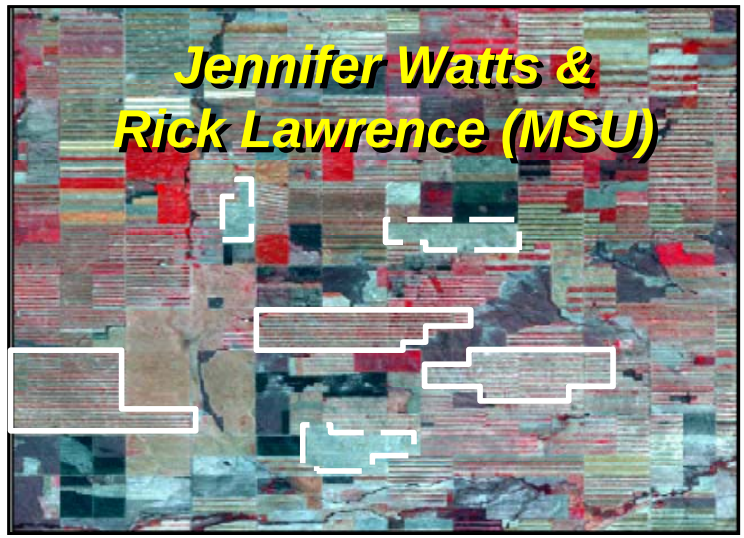
Remote Sensing MMV Objectives

- Map management practices in north central Montana
  - Tillage vs. no-till
  - Crop types & rotations
  - CRP



- Quantify adoption trends
  - Voluntary adoption trends for no-till
  - Current proportion of agriculture in alternative rotations

Remote Sensing MMV Methods

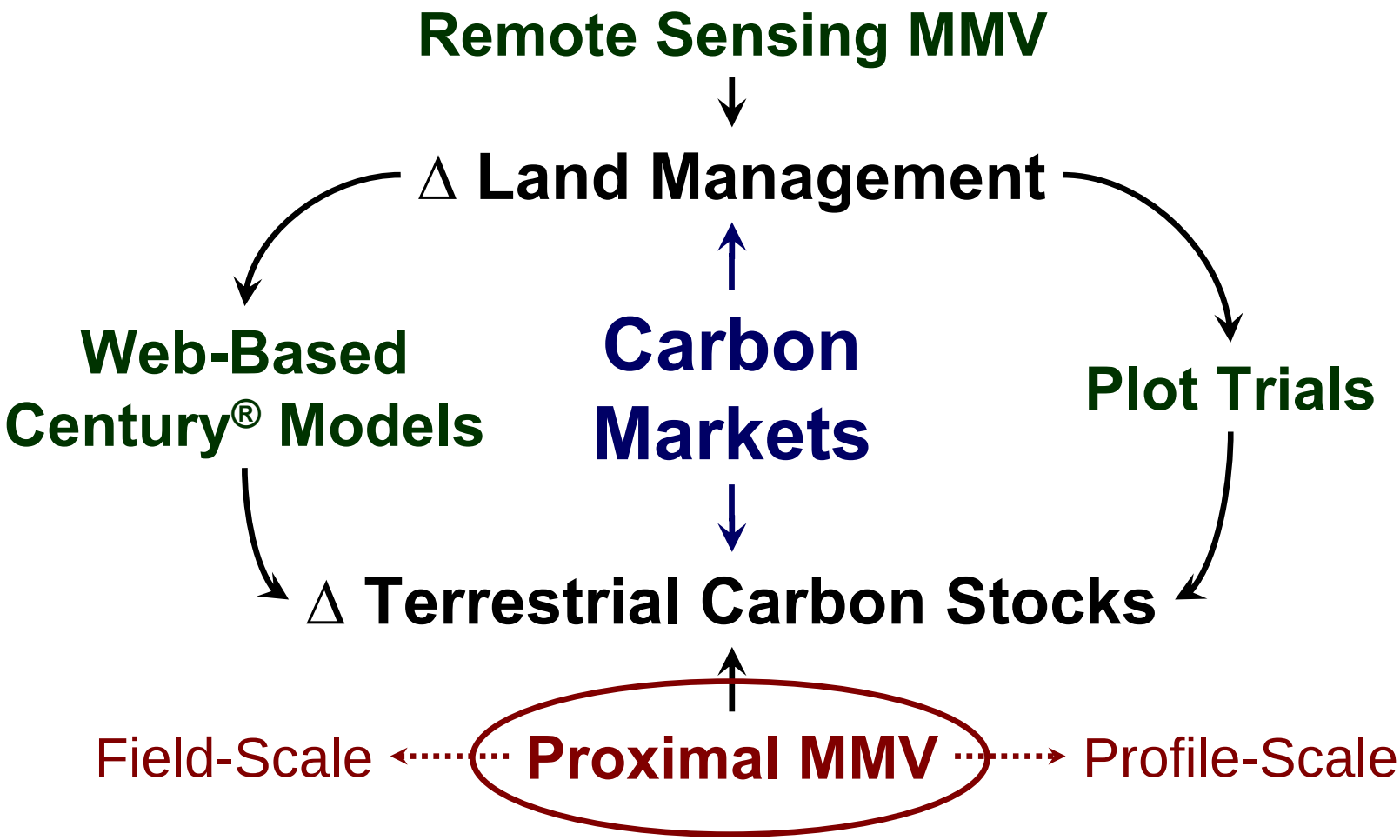
- Landsat TM imagery 2005, 2006, 2007
- Field data
  - NCOC enrolled sites
  - 500 random point locations
- ERDAS Imagine 9.0 & Definiens Pro 4.0
  - Image processing
  - Classification
  - Change detection

Remote Sensing MMV Results

- Regional maps of tillage, rotations, and CRP for 2005, 2006, and 2007
- Regional statistics for the COMET model
- Methodology for monitoring compliance with NCOC contracts

Expected by 2009

Terrestrial Carbon Sequestration Design

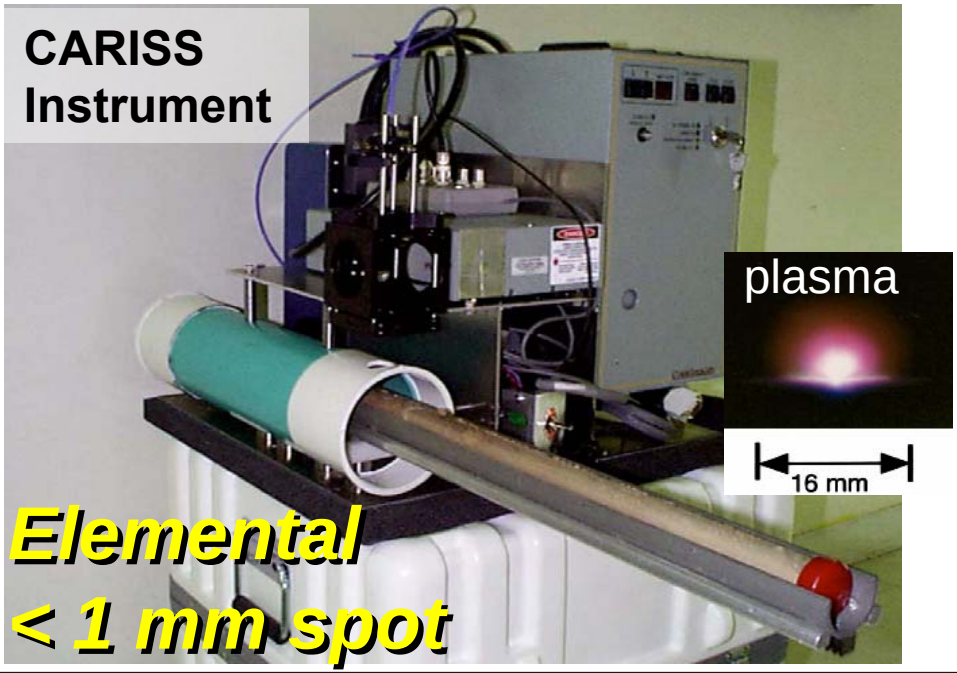


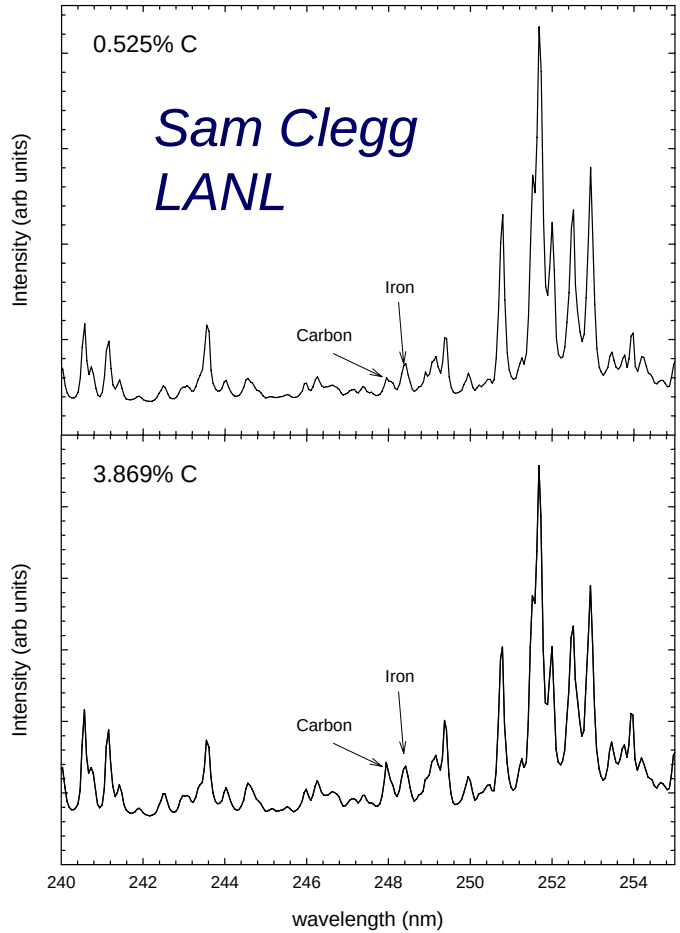
Proximal MMV Objectives

- Evaluate cost and information quality of multiple “cutting edge” soil sensing technologies
- Quantify soil carbon for 10 enrolled fields
  - “Field” → 40 acre
  - Total SOC per hectare 2006 & 2008
  - Spatial and depth distribution

Proximal MMV Techniques Profile-Scale

Laser Induced Breakdown Spectroscopy (LIBS)





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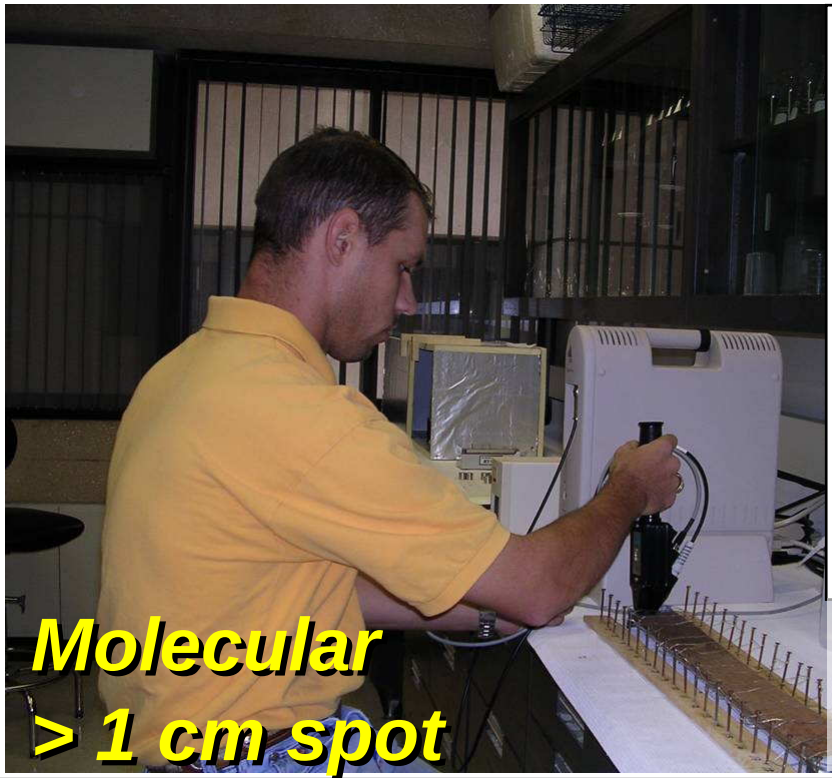
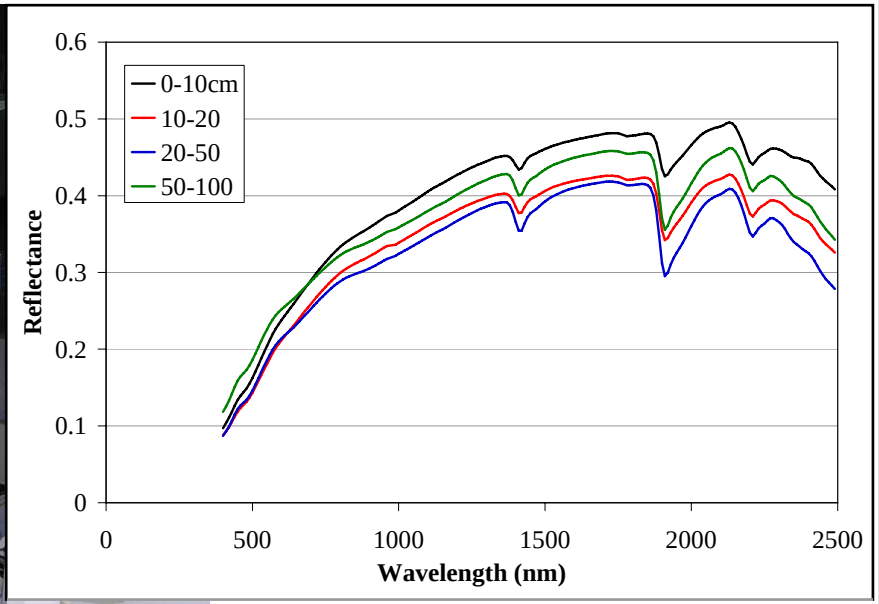
Proximal MMV Techniques
Profile-Scale

Visible & Near Infrared (VisNIR) Diffuse Reflectance Spectroscopy

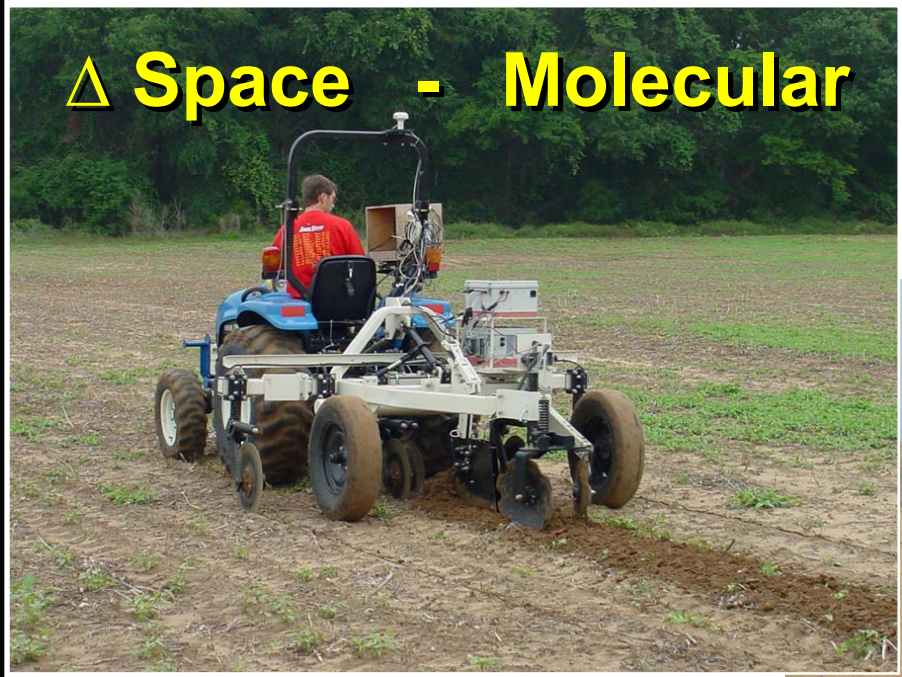
Ross Bricklemyer & David Brown, MSU





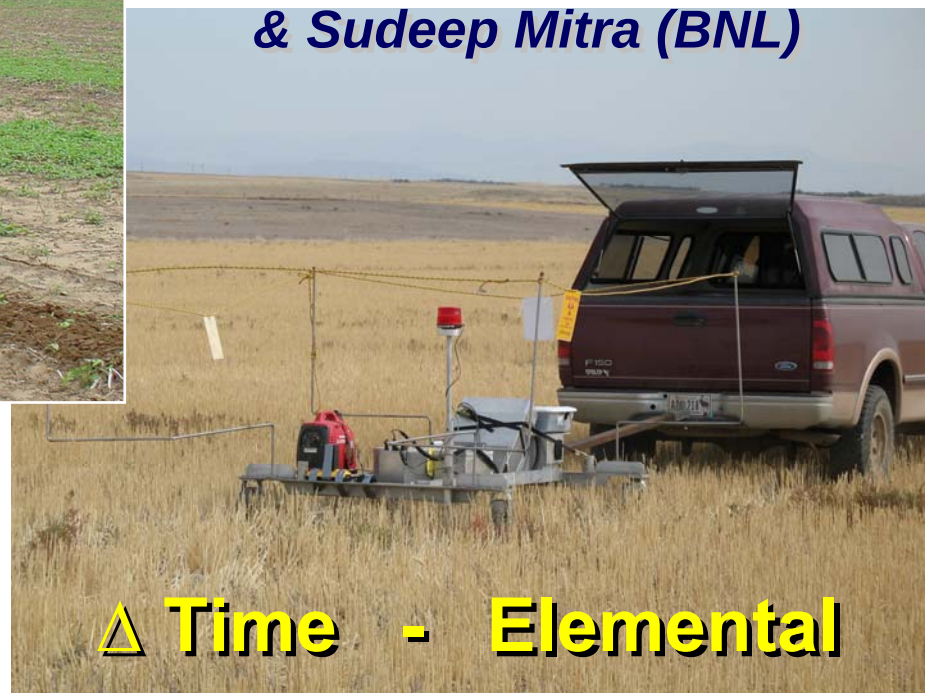
Semi-quantitative
SOC, SIC, clay, mineralogy

Proximal MMV Techniques Field-Scale



Inelastic Neutron Scattering (INS)

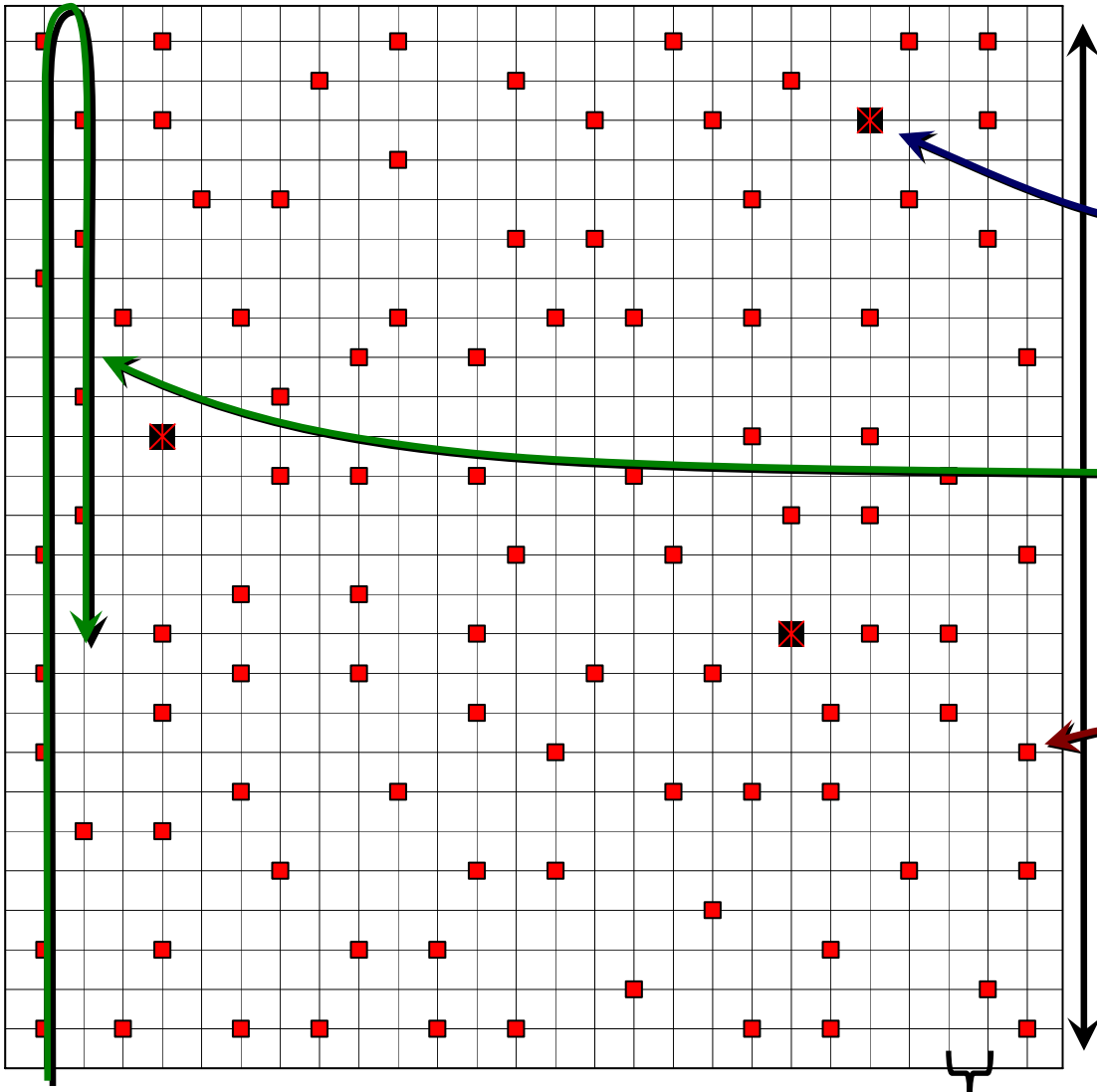
Lucian Wielopolski & Sudeep Mitra (BNL)



"On the Fly" VisNIR spectroscopy

Colin Christy Veris Technologies

Enrolled site proximal MMV sampling design



10 fields
2006 & 2008

INS
static points

"On the Fly"
INS & VisNIR

Soil Cores
100 x 0-10 cm
35+5 x 0-50 cm

390 m

15 x 15 m grid

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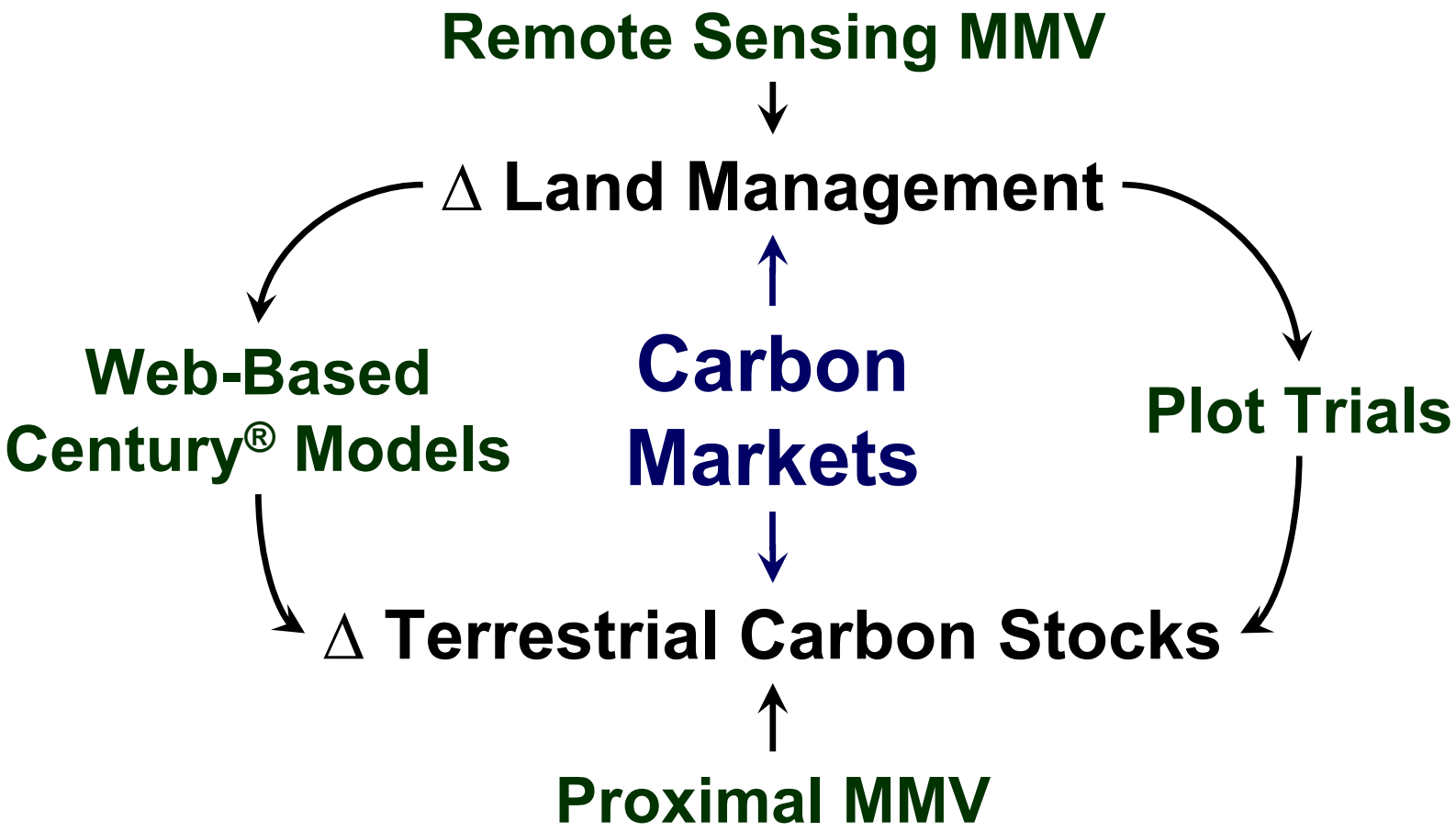

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