Soil organic matter and climate change adaptation and mitigation:

Can we have our cake and eat it too?

Keith Paustian

Department of Soil and Crop Sciences
Natural Resource Ecology Laboratory
Colorado State University

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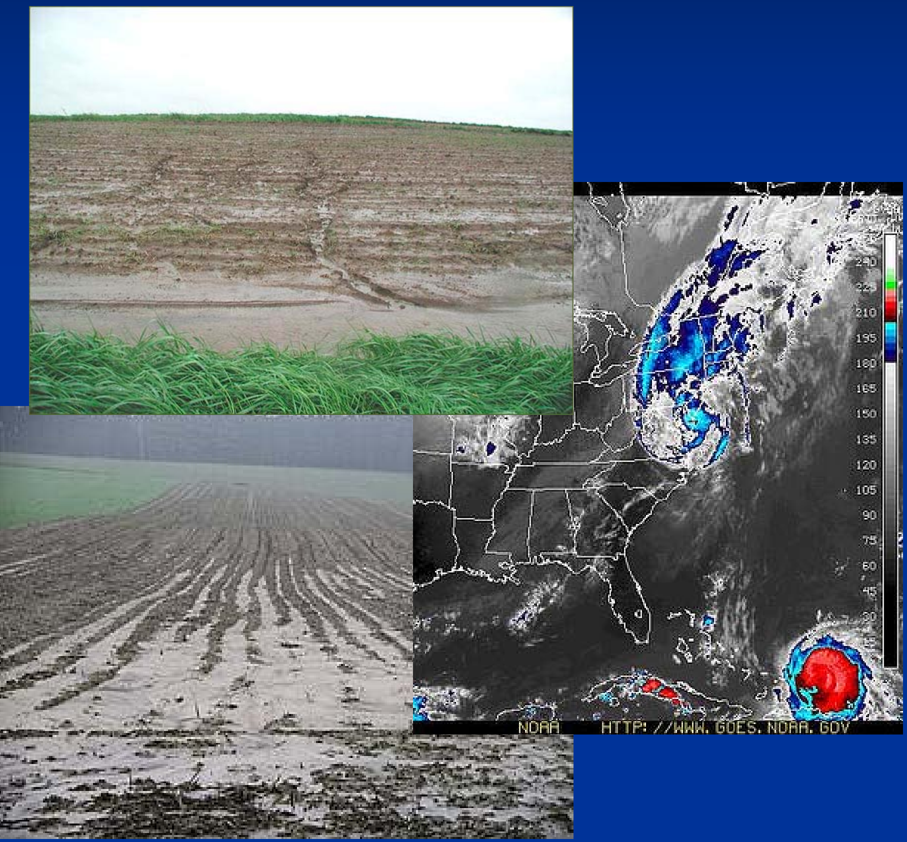
The value of soil organic matter

- Soil Fertility
- Nutrient cycling
- Infiltration
- Water-holding capacity
- Cation exchange
- Aeration
- Tilth
- Structure
- Detoxification
- Soil biodiversity

Soils rich in organic matter are better able to withstand climate stresses



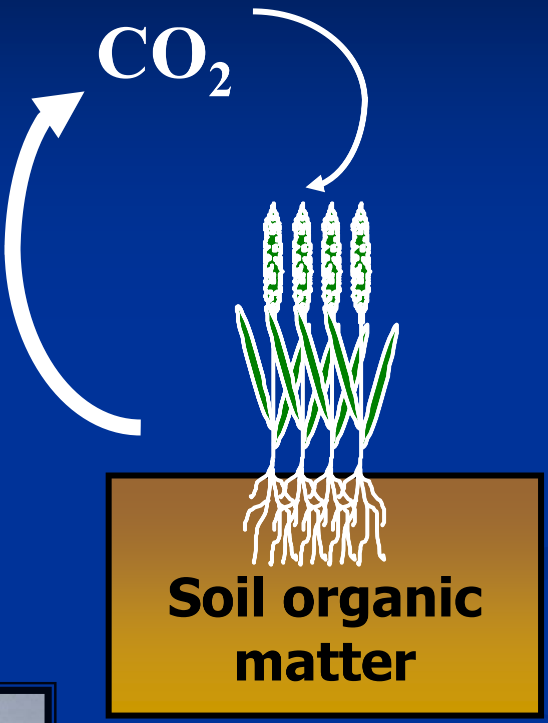
Extreme events

Drought

Depleting Soil Organic Matter

Erosion

Intensive tillage



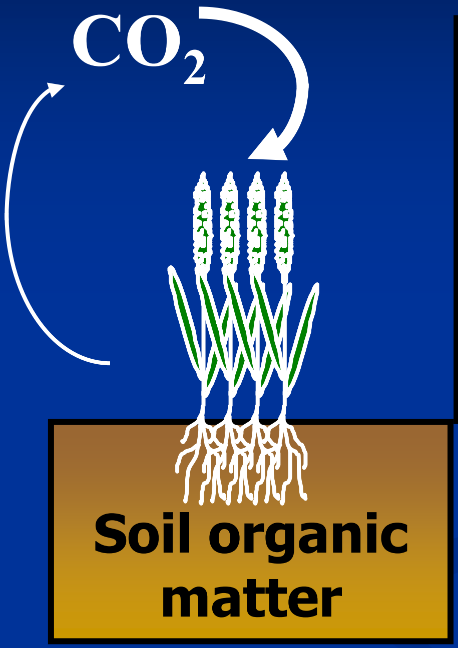
Deforestation

Low Productivity

Rebuilding Soil Organic Matter

Conservation buffers

Conservation tillage



Cover crops

Improved rotations

Agroforestry

Having our cake and eating it too

Engaging agriculture in mitigating CO_2 through rebuilding soil organic matter will strengthen adaptation and resilience of agricultural systems to climate change.

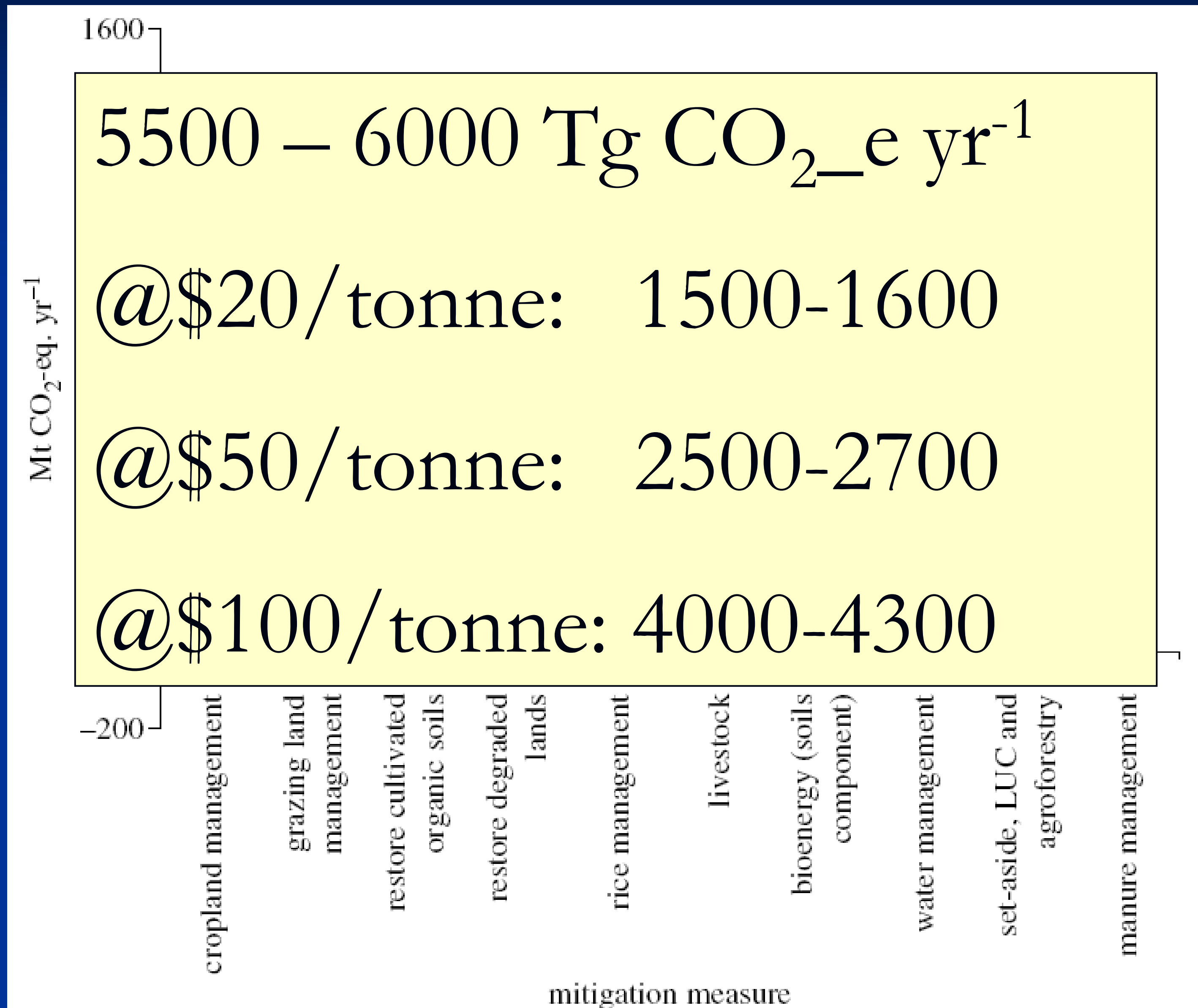
What and where are the potentials?

5500 – 6000 Tg CO_2_e yr^{-1}

@$20/tonne: 1500-1600

@$50/tonne: 2500-2700

@$100/tonne: 4000-4300



(Smith et al. 2008)

What are the perceived barriers to broad participation of land use activities in GHG mitigation?

- Concern about whether they will weaken efforts to reduce FF emissions.
- Concern about whether emission reductions will be ‘real’
  - Will they be additional ? (to BAU)
  - Will they be permanent?
  - Can they be effectively measured and monitored?

“We don’t know how to measure soil carbon!”

Anonymous UNFCCC-SUBSTA delegate (2000)

Soil C measurement – some facts

- The carbon (C) content of soil can be measured with a high degree of accuracy and precision.
  - Instrument error < 0.1%; Overall lab measurement error < 1-2%
- Equipment and protocols for soil sampling are well documented and have been applied throughout the world for decades.
- The general response of soil C stocks to environmental variables and management practices is relatively well known.
  - 100s of long-term field experiments globally
- Sophisticated models of soil carbon dynamics have existed for > 20 years and are increasingly deployed for research, management and policy applications.

Soil C measurements - some challenges

- Soil carbon contents can be highly variable within an individual field.
- Annual changes are usually small relative to existing C stocks, e.g.,
  - Typical C stocks 20-80 tonnes/ha
  - Typical C changes 0.1-1 tonnes/ha/yr
- Multiple factors (e.g. soil type, climate, previous land use) influence soil responses at a specific location.
- Field experimental measurements are lacking for many crop, soil, climate and management combinations.
- There are virtually no 'inventory' measurement systems for soil C (e.g. compare with forest biomass)

Thus, the challenge is NOT with measuring soil C *per se*, but rather designing an efficient cost-effective SAMPLING and soil C stock ESTIMATION system.

Measurement, Monitoring & Verification

- ~~Direct measurements on each farm~~
- Need 'practiced-based' approaches that:
  - integrate effects of multiple practices (e.g. rotation, tillage, N management) and land use history
  - are soil- and climate-specific
  - utilize direct measurements to produced unbiased estimates with known uncertainty

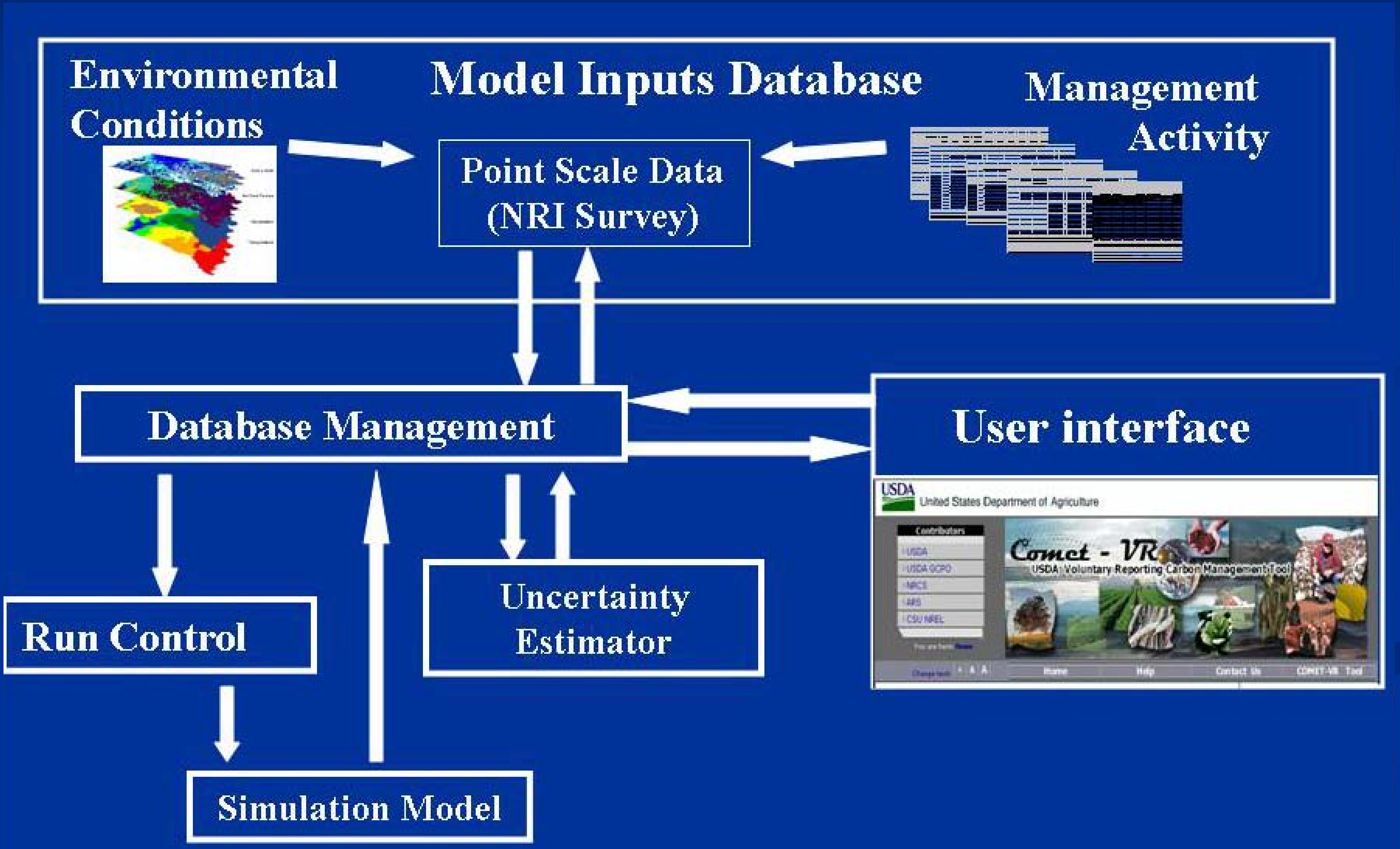
∴ Model-based systems supported by a coordinated measurement system

COMET-VR (CarbOn Management and Evaluation Tool – Voluntary Reporting)

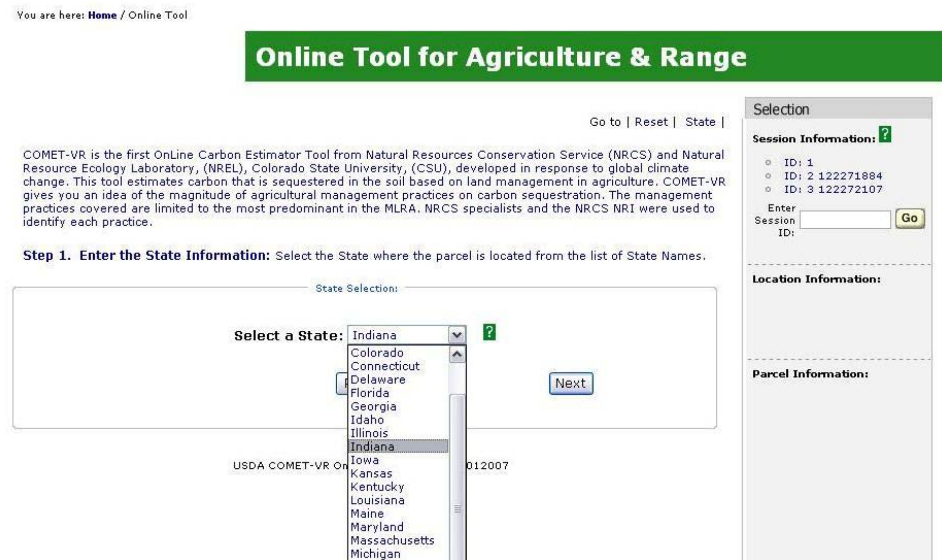
- First developed for **cropland/grassland soil C** & fuel use
- New version will include:
  - N_2O emissions
  - Agroforestry
  - Orchards and vineyards

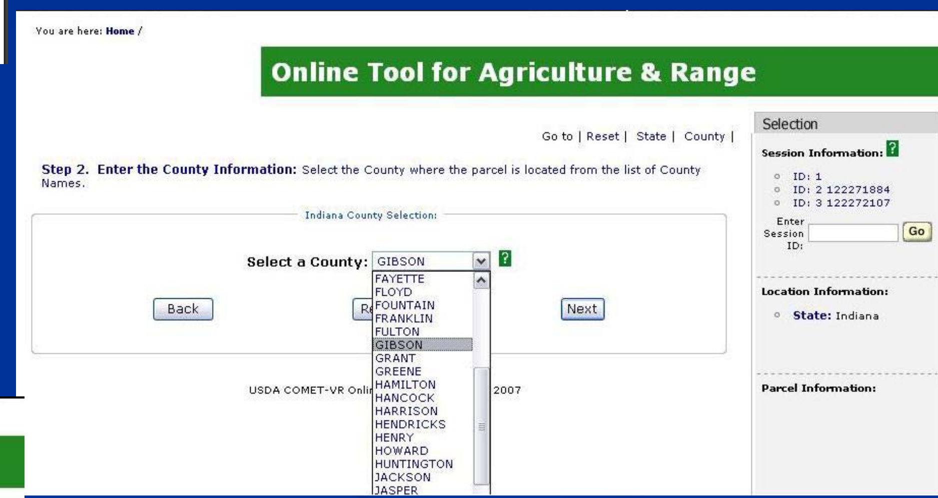
COMET-VR model

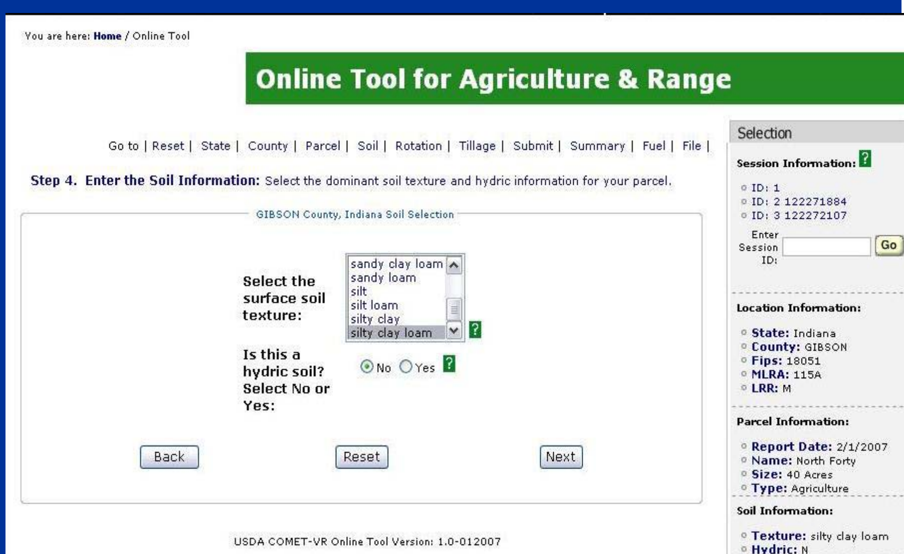
(www.cometvr.colostate.edu)



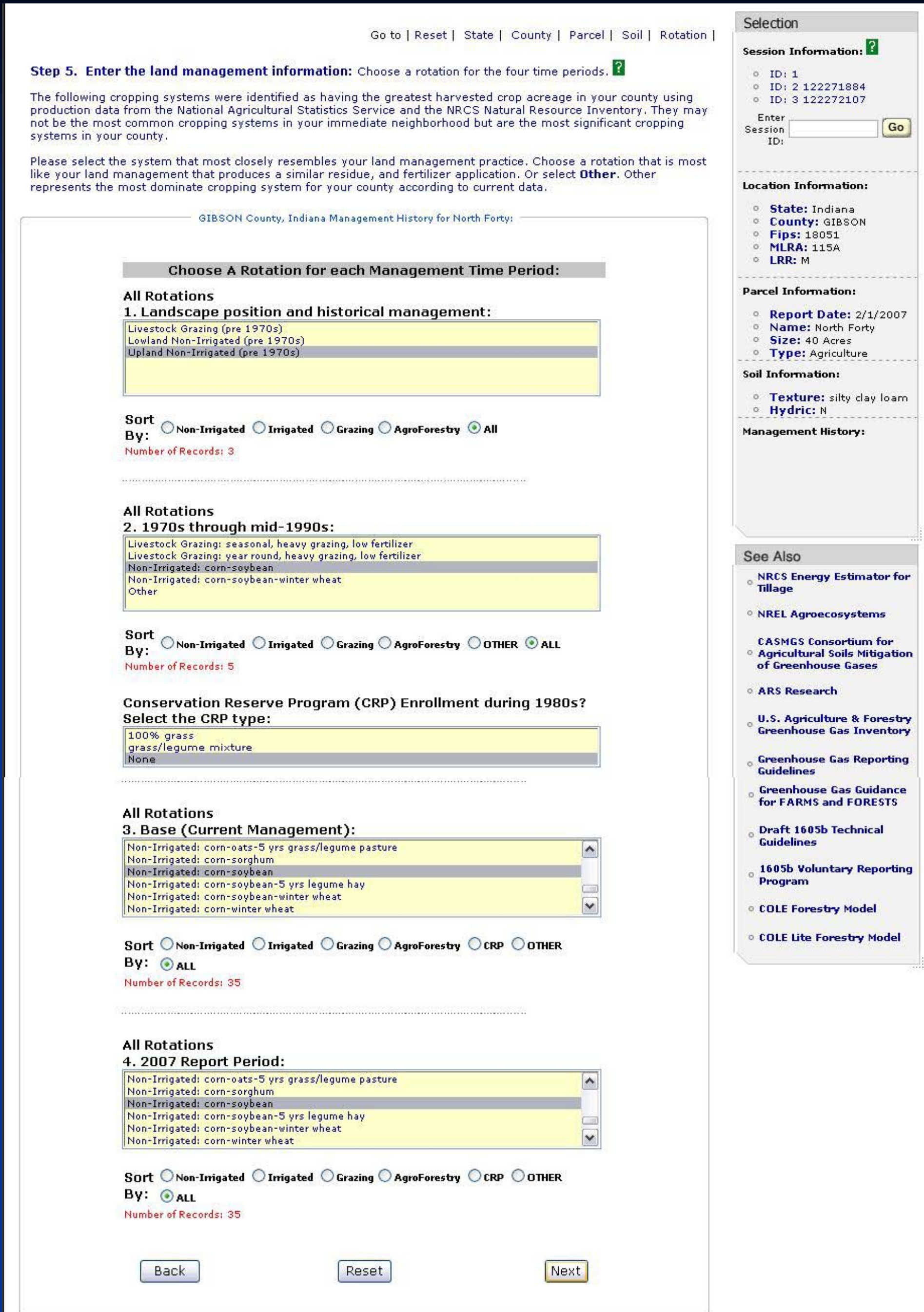
Select state and county





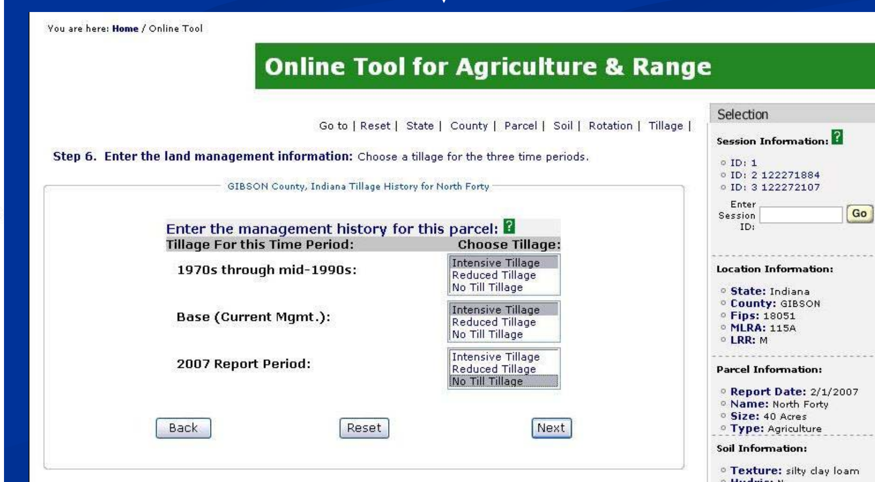


Select soil type and drainage condition



Select management sequences

Select tillage management sequence



Voluntary Reporting
Carbon Management Tool COMET-VR
Carbon Storage Report ?
Report Year: 2008
Session ID: 80747966

Parcel Description

Parcel Type:	Agriculture
Total Parcels for this Entity:	1
Parcel Name:	Parcel 1
Parcel Size:	100 Acres
Location:	GIBSON, Indiana
Soil:	Non-hydric loam

Parcel Management History

Historic:	Lowland Non-Irrigated (pre 1970s)
70s to 90s:	Non-Irrigated: corn-soybean; Intensive Tillage
Current:	Non-Irrigated: corn-soybean; Intensive Tillage
Report Period:	Non-Irrigated: corn-soybean; No Till Tillage

Predicted Change in Soil Carbon for the Parcel

Annual Change for 2008

	Carbon Change	Uncertainty ?		
		Avg Percent	Lower Bounds CI*	Upper Bounds CI*
Total Tons Carbon per year:	**15.27**	**30.16 %**	10.79	20.00
Total Tons CO2 Equivalent per year:	**56.00**	**30.16 %**	39.57	73.34

Values recorded in English units. One **ton** of carbon is equivalent to 3.667 **tons** of carbon dioxide.

Please report the **Large Bolded Values** on your 1605(b) report for carbon change and uncertainty. We are 95% confident that your average carbon change value is within (+-) 30.16 % of the modeled carbon change value shown on this report.

- **MLRA:** 115A
- **LRR:** M

Parcel Information:

- **Report Date:** 9/29/2008
- **Name:** Parcel 1
- **Size:** 100 Acres
- **Type:** Agriculture

Soil Information:

- **Texture:** loam
- **Hydric:** N

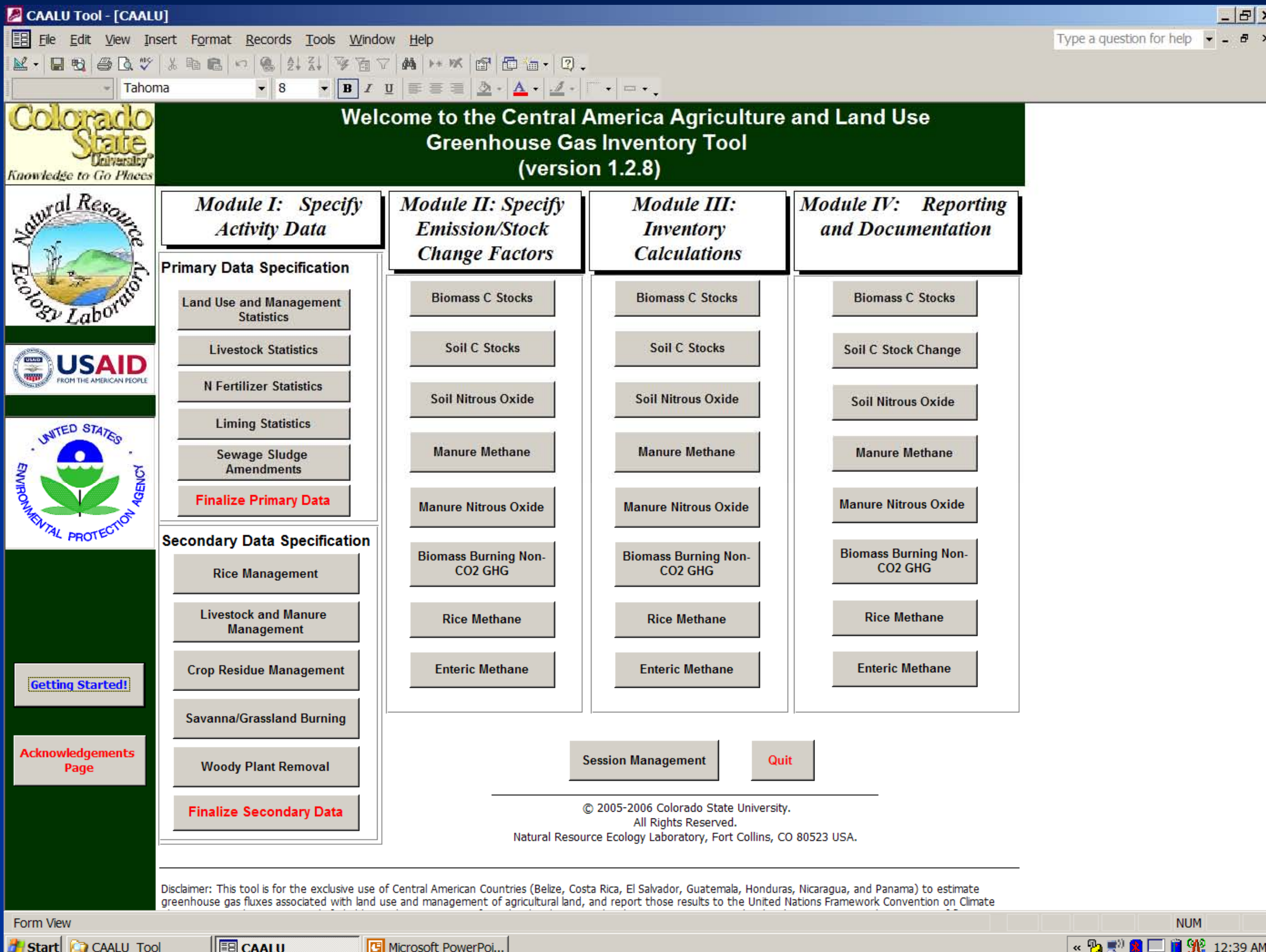
Management History:

- **Historic:** Lowland Non-Irrigated (pre 1970s)
- **70's - 90's:** Non-Irrigated: corn-soybean,Intensive Tillage, CRP: None
- **Current:** Non-Irrigated: corn-soybean,Intensive Tillage,
- **Report Period:** Non-Irrigated: corn-soybean,No Till Tillage,

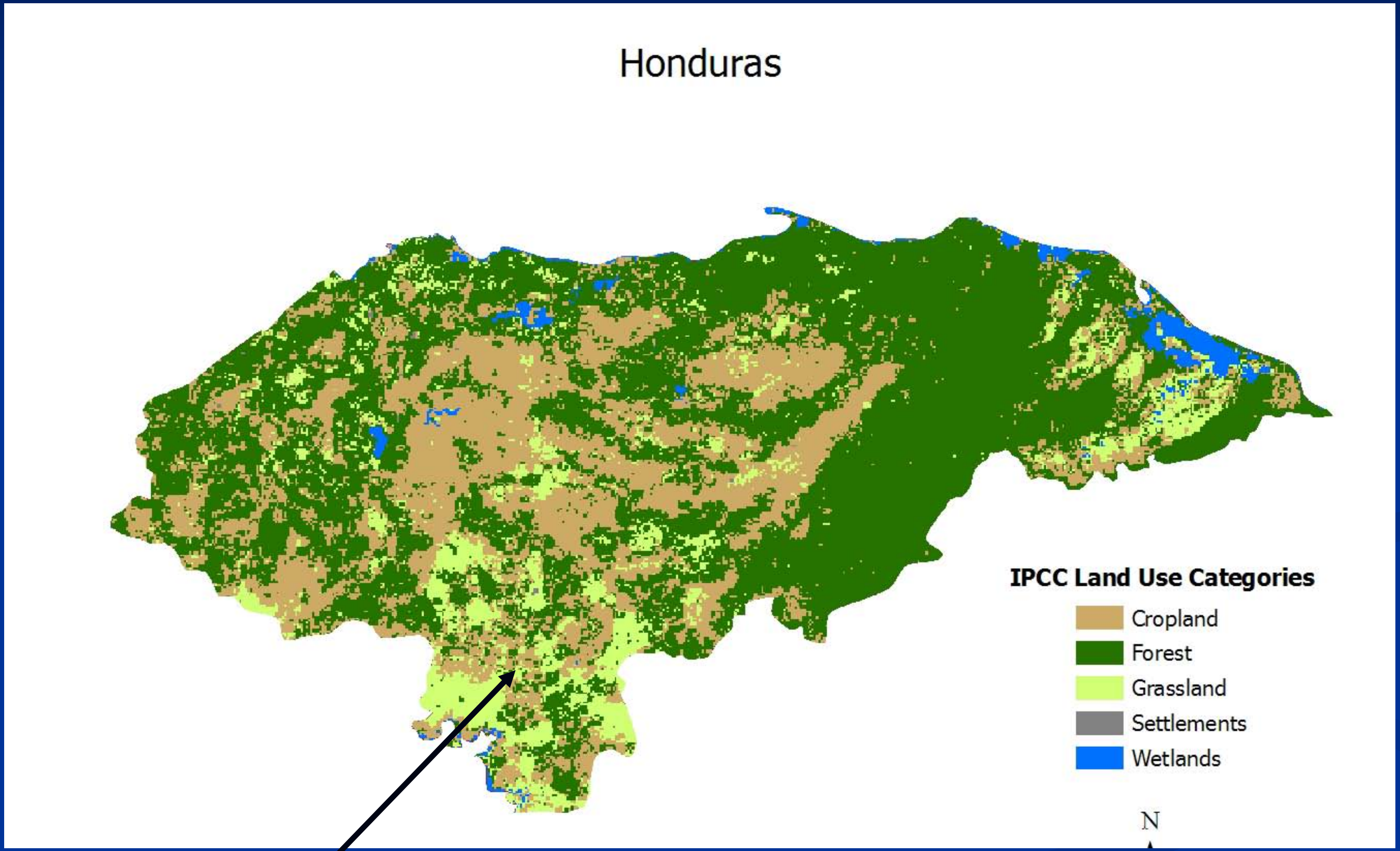
See Also

- NRCS Energy Estimator for Tillage
- NREL Agroecosystems
- CASMGS Consortium for Agricultural Soils Mitigation of Greenhouse Gases
- ARS Research
- U.S. Agriculture & Forestry Greenhouse Gas Inventory
- Greenhouse Gas Reporting Guidelines
- Greenhouse Gas Guidance for FARMS and FORESTS
- Draft 1605b Technical Guidelines
- 1605b Voluntary Reporting Program
- COLE Forestry Model
- COLE Lite Forestry Model

CAALU/ALU – Integrated DSS for AFOLU

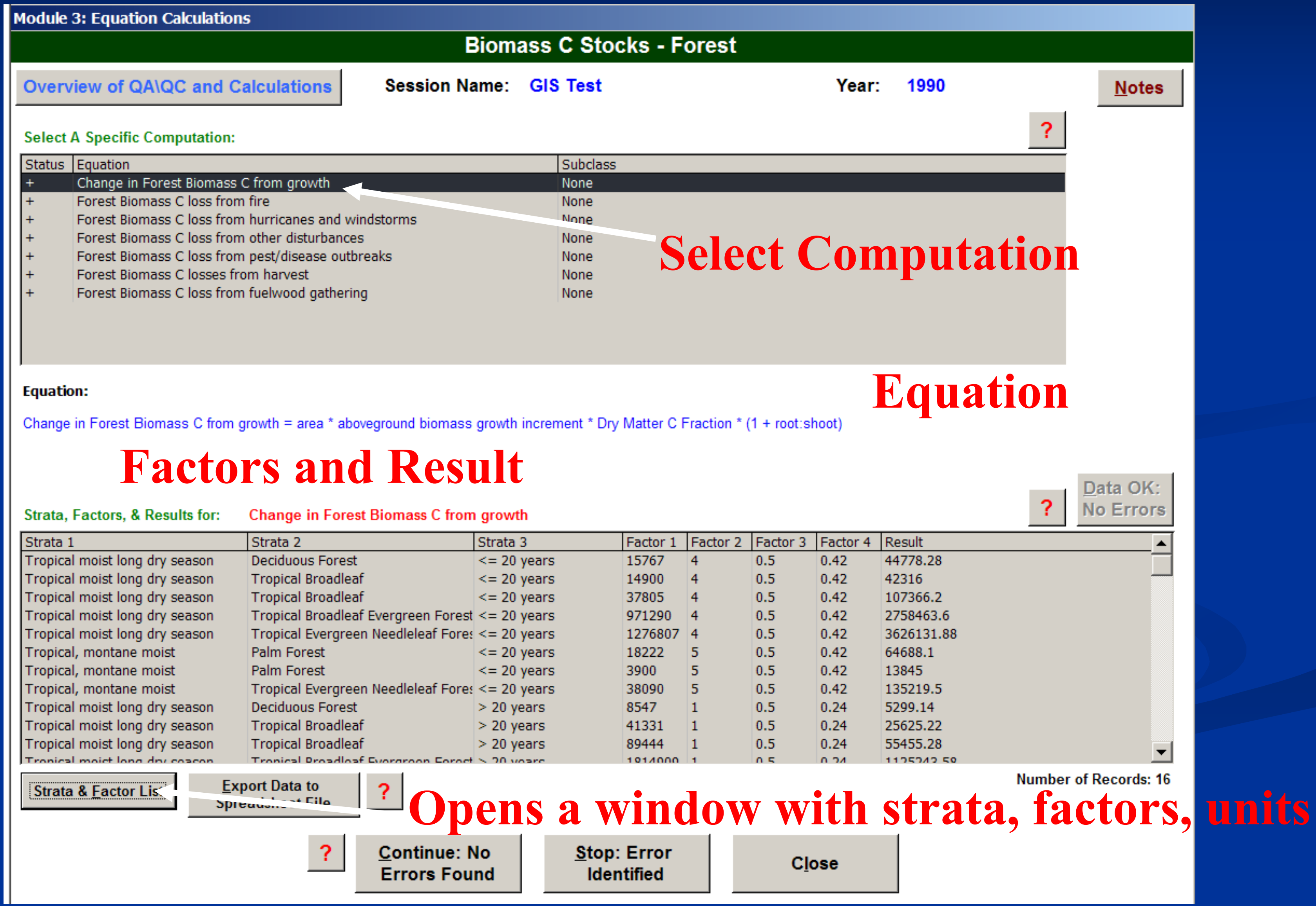


Integrates spatial data into assessment framework

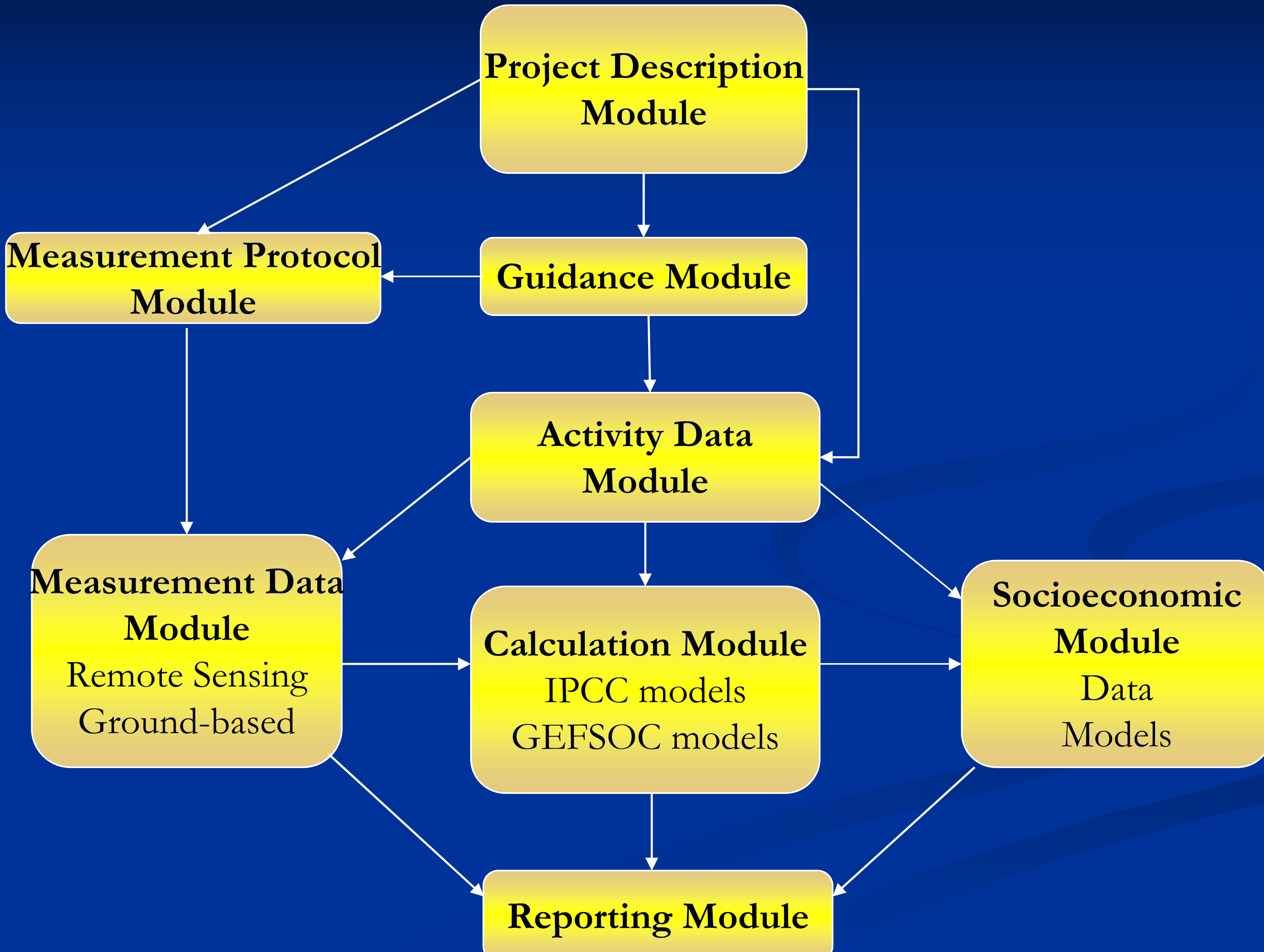


Land use areas from GIS data incorporated directly into program

Incorporates QA/QC, documentation, calculation and reporting functions



GEF-funded Carbon Benefits: Modelling, Measurement and Monitoring Project



Integrating soil measurements with model-based estimation systems

- Improving model-based systems requires integration with national- or regional scale measurement networks
- Should represent all major land use and management systems, climatic regions and soil types
- Should represent 'on-farm' conditions
- Needs to include data on land management practices
- Provide for precise re-measurement procedures and sampling protocols

Attributes of a measurement network

- Repeated measurements at permanent monitoring locations in farmer fields
  - 5-7 yr sampling intervals provides sufficient time for detectable changes
  - Remeasurement at permanent inventory plots reduces effects of spatial variability
  - Potential to leverage with soil mapping activities
  - Great advantages in pooling data from pilot projects, to reduce overall measurement.

Concluding remarks

- Improving soil organic matter stocks help buffer impacts of climate change.
- Inclusion of agriculture in GHG mitigation policies can provide impetus for achieving more sustainable practices.
- Acceptance of agricultural sinks require that they can pass the 'environmental integrity' test.
- While direct measurement at field-scale – for individual projects – is possible, in most cases it will not be practical, cost-effective, nor necessary.
- Integrated modelling-measurement systems can provide reliable, cost-effective quantification to support agricultural GHG mitigation policies.
- Efforts are needed to establish broad-scale, regional networks of soil C monitoring locations (via national efforts or 'data pooling' from pilot projects).