Northern Rockies and Great Plains Regional Carbon Sequestration Partnership:

Montana State University-Bozeman
Boise State University
South Dakota School of Mines and Technology
Texas A&M University
University of Idaho

Idaho National Engineering and Environmental Laboratory
Los Alamos National Laboratory

EnTech Strategies and New Directions
National Carbon Offset Coalition

Inland Northwest Regional Alliance
State of Montana, Governor's Office
Nez Perce Tribe
The Confederated Salish and Kootenai Tribes
Energy companies and other coalitions

DOE Regional Carbon Sequestration Partnership Meeting

Hyatt Regency, Pittsburgh Airport

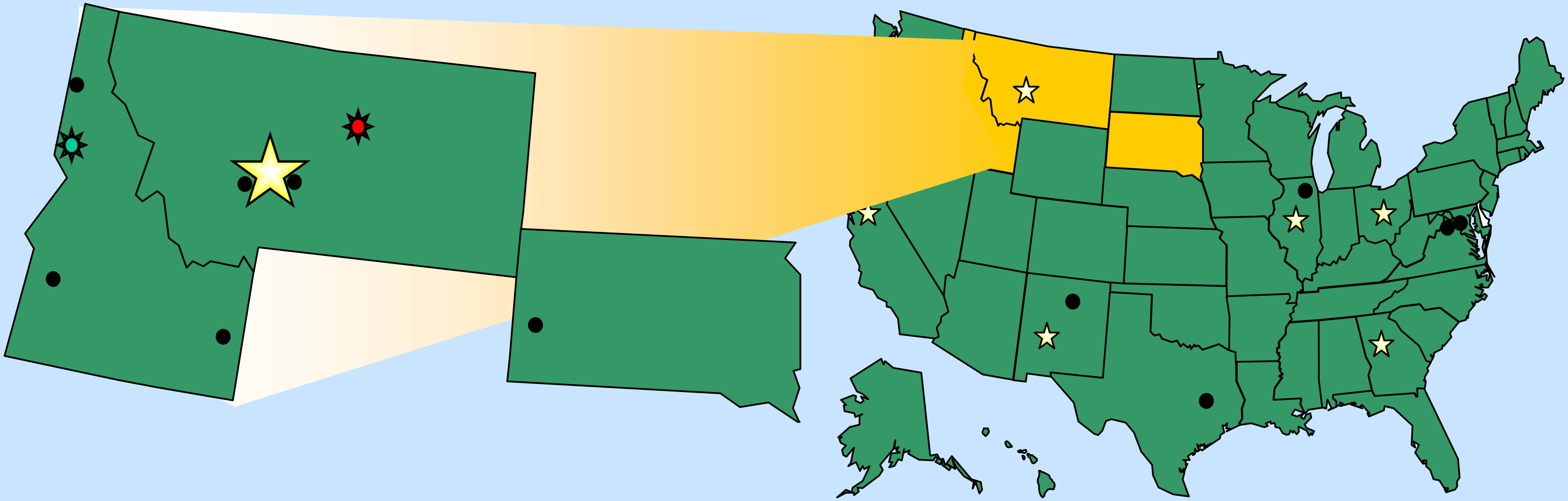
November 3-4, 2003

Dr. Susan M. Capalbo

scapalbo@montana.edu

www.climate.montana.edu

Northern Rockies & Great Plains Carbon Sequestration Partnership



Region Covered:
Montana
Idaho
South Dakota

Partners:

- **Montana State University**
- **Boise State University**
- **South Dakota School of Mines and Technology**
- **Texas A&M**
- **University of Idaho**
- **The Sampson Group**
- **New Directions NALLC**
- **Environmental Financial Products**
- **Nez Perce Tribe**
- **The Confederated Salish andKootenai Tribes**
- **Idaho National Engineering and Environmental Laboratory**
- **Los Alamos National Laboratory**
- **Montana Governor's Carbon Sequestration Working Group**
- **National Carbon Offset Coalition**

Partnership Objectives

Provide *coordinated* disciplinary-based research, policy analysis, and outreach that focuses on mitigating GHG buildup through carbon sequestration alternatives

The Partnership will:

1) identify and catalogue sources of CO_2 and promising geologic and terrestrial storage sites;
2) develop a risk assessment and decision support framework to optimize the region's carbon storage;
3) enhance market-based, voluntary approaches to carbon storage;
4) identify and apply advanced GHG measurement technologies to improve verification protocols, support voluntary trading and stimulate economic development;
5) engage community leaders to define carbon sequestration implementation strategies and
6) create forums to inform and secure input from the public.

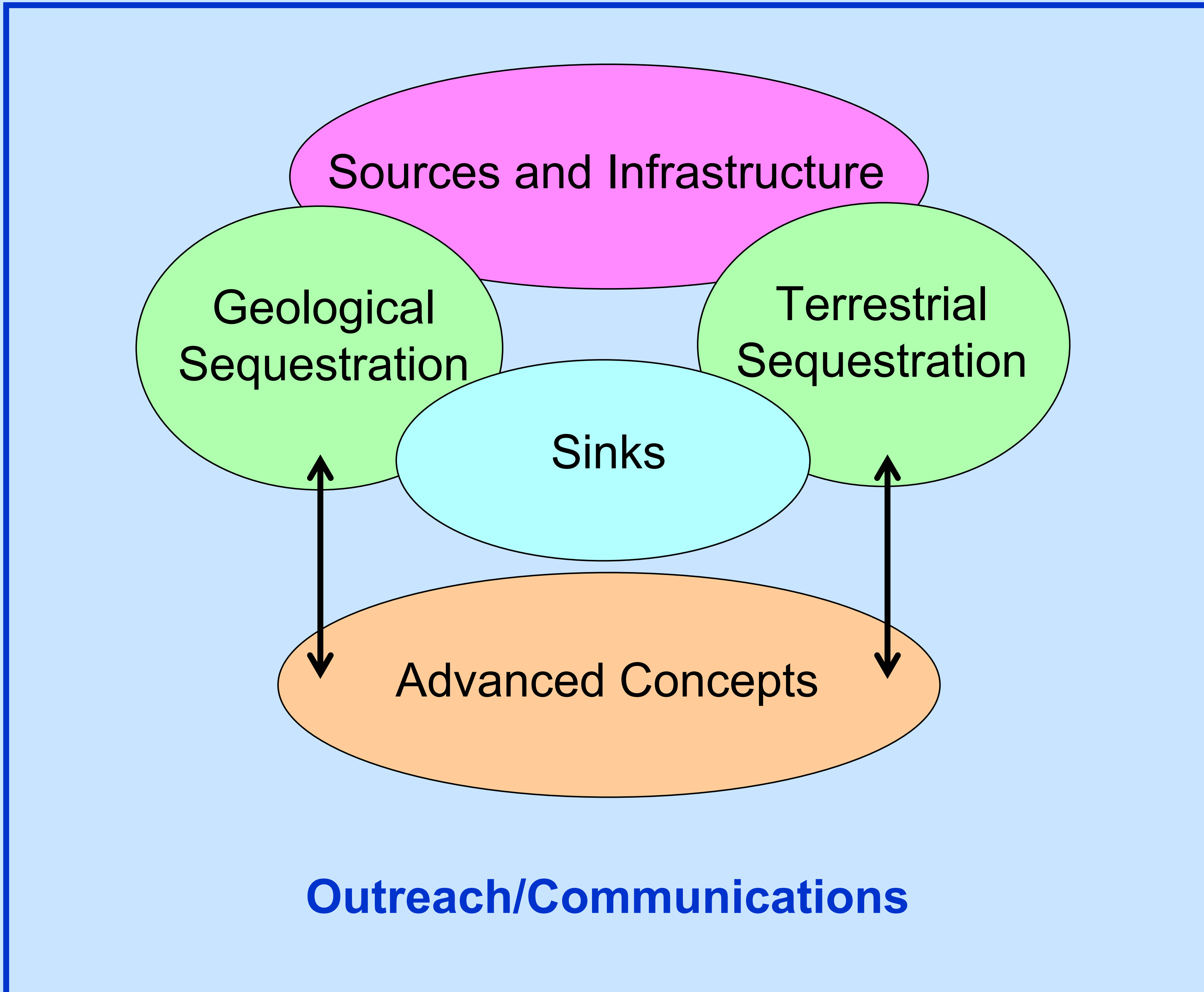
Partnership reflects extensive expertise and experience in carbon sequestration research

- Engineers, physical/biological scientists, economists, policy analysts, policy leaders, communications specialists
- Strong Capabilities in
  - GIS systems
  - geological sequestration technologies and assessment
  - terrestrial sequestration technologies and soil C measurement
  - Designing frameworks for understanding economic, environmental, and risk tradeoffs with alternative sequestration sinks
  - Market-based trading for carbon
- Broad understanding and hands-on experience with technical, economic, and market issues related to carbon sequestration trading
- Strong skills and experience in communications and outreach that uniquely coalesce around carbon sequestration and involves many stakeholders including tribal nations

Organization of the Partnership

Focus areas:

- Sources and Infrastructure (GIS based)
- Geological Sequestration
- Terrestrial Sequestration
- Advanced Concepts
- Outreach and Education


Sources and Infrastructure
Geological Sequestration
Terrestrial Sequestration
Sinks
Advanced Concepts
Outreach/Communications

Organization of the Partnership (cont)

Leadership team

- Susan Capalbo (MSU) PI
- John Antle, (MSU) terrestrial sequestration
- Dick Benson (LANL) advanced concepts
- David Shropshire (INEEL) geological and GIS
- Robert Smith (UI) geological sequestration
- Pamela Tomski (EnTech) outreach and education
- Patrick Zimmerman (SDSMT) terrestrial sequestration/GIS

Steering Committee

- includes representation from all collaborators

Sources and Infrastructure

- Characterize the region relative to sources and transportation infrastructure
- Industrial and agricultural sources

  Fossil fuel power plants, industrial plants, agricultural sources (feedlots)
- Look at all three major GHGs
- Archive the information in a GIS database

Coordinated effort: INEEL, LANL, SDSMT, MSU

Geologic Sequestration

Understand the behavior of CO_2 when stored in geological formations

Provide information on the potential magnitude/location of the geological sinks in the region

- ***University of Idaho***
  - ***Bob Smith (technical coordinator)***
- ***Boise State University***
  - ***Warren Barrash***
  - ***Bill Clement***
- ***Idaho National Engineering and Environmental Laboratory***
  - ***David Shropshire (program coordinator)***
  - ***Randy Lee***
  - ***Travis McLing***
- ***Los Alamos National Laboratory***
  - ***Rajesh Pawar***

Geologic Sequestration

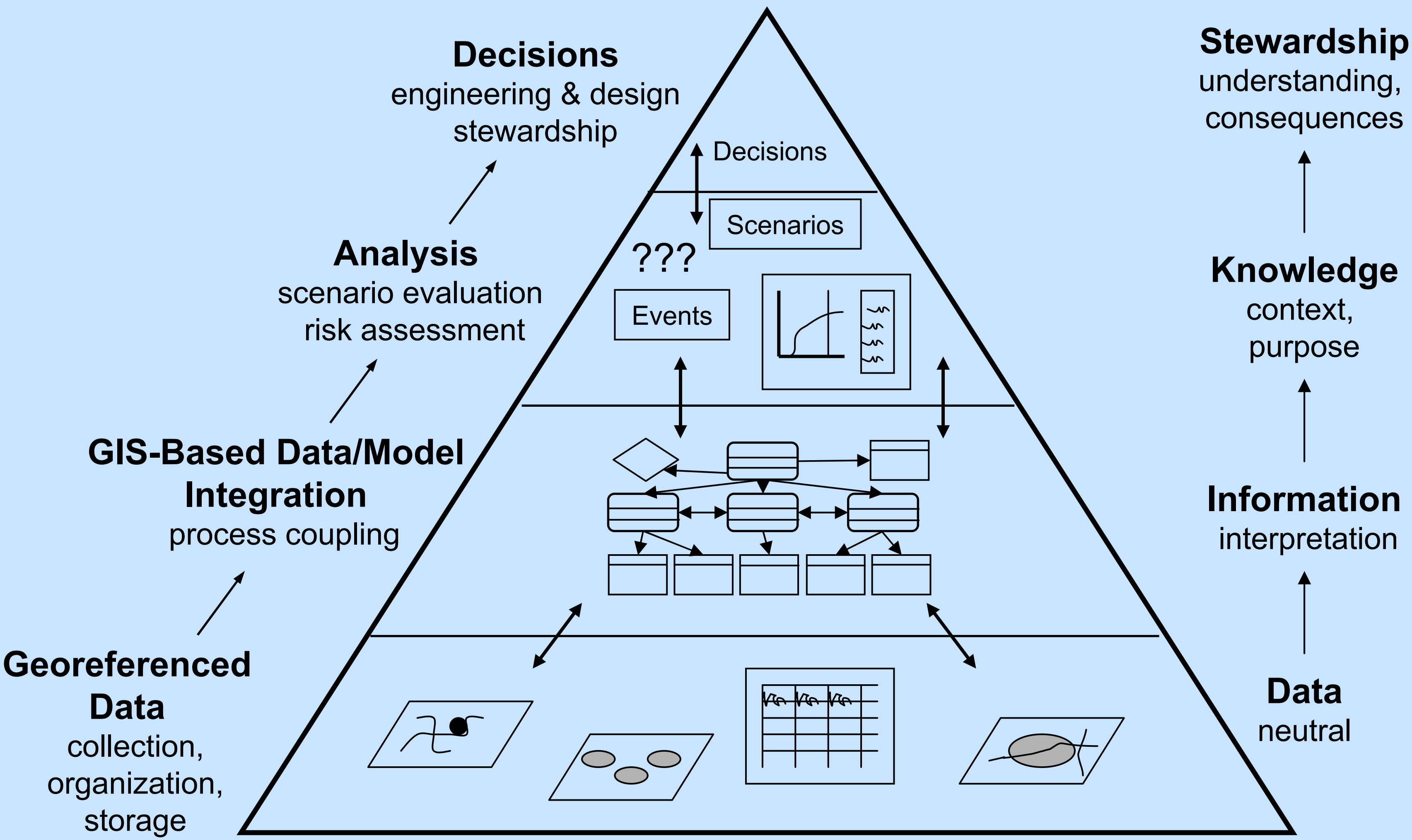
TASK 1: Development of GIS database structure

OBJECTIVE: Define and implement a standardized approach for storing geographic technical, infrastructure, and economic information

- **Design GIS Database**
  - **Establish list of contributors and their needs**
  - **Define end users and their requirements**
  - **Design system to be scalable for needs of Phase II and beyond**
  - **Establish common protocols (e.g., datum, terminology, data fields, metadata standards, etc.)**
  - **Define the rolls of the GIS groups (e.g., data development, system maintenance, data documentation, etc.)**
- **Build System**
  - **Gather and load existing information**
  - **Provide products that meet the needs of the larger partnership**

LEAD INSTITUTION: INEEL

Spatial Decision Support System



Geologic Sequestration

TASK 2: Assessment of Mineralization Trapping Potential

OBJECTIVE: Define the contribution of reservoir weathering reactions to the sequestration of CO_2 in regional traps

Mineral Trapping of CO_2 in Geologic Reservoirs

- **Characterize the ability of geologic terrain in the study area to facilitate the mineralization of CO_2 into stable mineral phases.**
- **Weathering of silicates in aquifer host rocks via the following simplified reaction consumes 2 moles of CO_2 for every mole of calcite precipitated.**

$$CaSiO_{3(s)} + CO_2 + 3H_2O = Ca^{2+} + 2HCO_3^- + H_4SiO_4$$

leads to

$$Ca^{2+} + 2HCO_3^- = CaCO_{3(s)} + CO_{2(aq)} + H_2O$$

LEAD INSTITUTION: INEEL

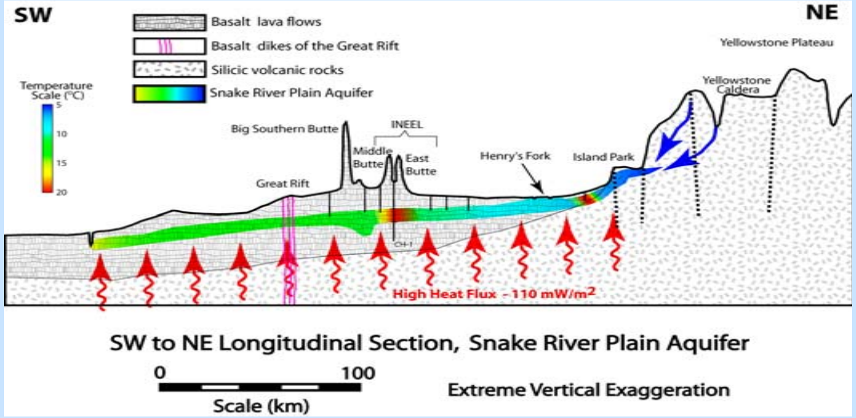
Geologic Sequestration

TASK 3: Assessment of Solubility Trapping Potential

OBJECTIVE: Define the contribution of deep geologic fluids (formation water and hydrocarbons) to the sequestration of CO_2 in regional traps

Solubility Trapping

- **Characterize hydrochemical conditions of deep geologic basins in study area.**
  - **Water chemistry will be extracted from existing databases.**
- **Model CO_2 uptake potential of deep basin groundwaters using Geochemist Workbench**
- **Benchmark models with previously conducted laboratory studies.**



LEAD INSTITUTION: University of Idaho - Idaho Falls

Geologic Sequestration

TASK 4: Assessment of Hydrodynamic Trapping Potential

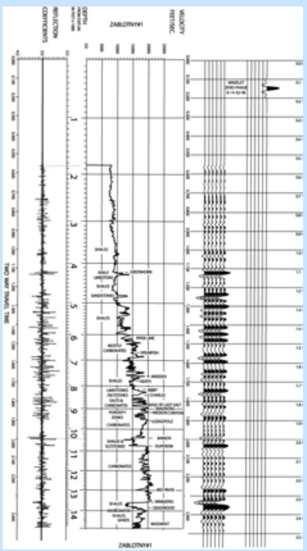
OBJECTIVE: Define the reservoir volumes and containment characteristics of regional traps for the sequestration of CO_2

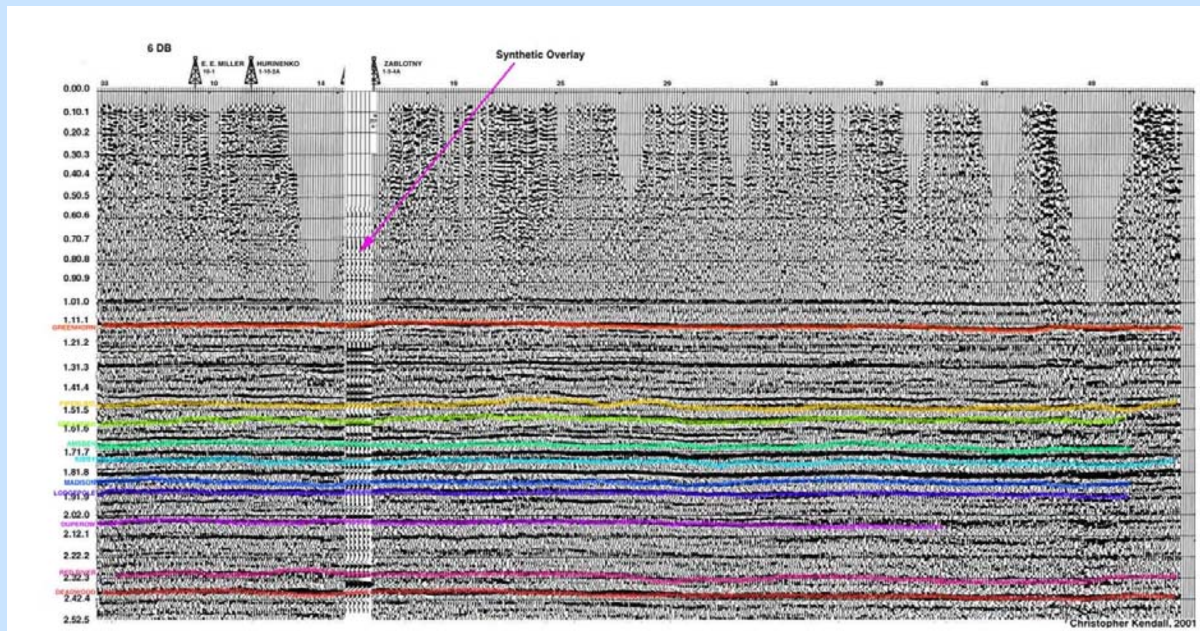
Assessment of Hydrodynamic Trapping Potential

- **Identify Federal and State inventories**
  - **Seismic reflection data and VSP**
  - **Well logs and core**
  - **Well tests**
- **Analyze data for potential sinks**
  - **Physical properties**
  - **Viability and storage capacity**

LEAD INSTITUTION: Boise State University

Assessment of Hydrodynamic Trapping Potential



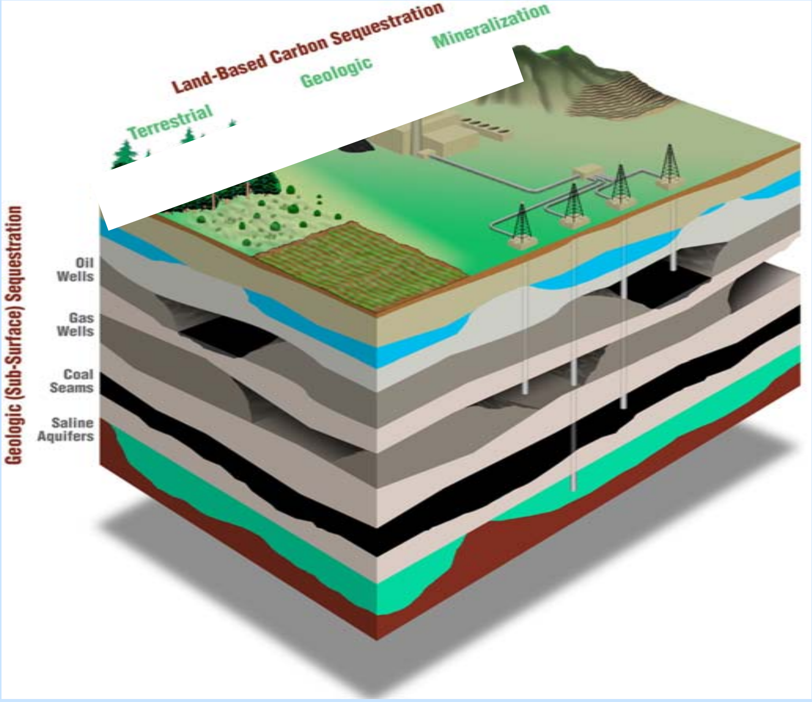


Geologic Sequestration

TASK 5: Assessment of Technical Feasibility and Offsetting Economic Benefits

OBJECTIVE: Define infrastructure requirements, costs, and off setting economic benefit for the sequestration of CO_2 in regional traps

- **Compile Infrastructure Information into GIS Database**
- **Determine Storage Capacity**
  - **Oil/Gas Reservoirs**
  - **Aquifers**
  - **Coalbed Methane Reservoirs**
- **Long-Term Storage Capability**
- **Evaluate Infrastructure Needs and Associated Costs**
- **Determine Sequestration Benefits**
- **Evaluate Geologic Sinks**

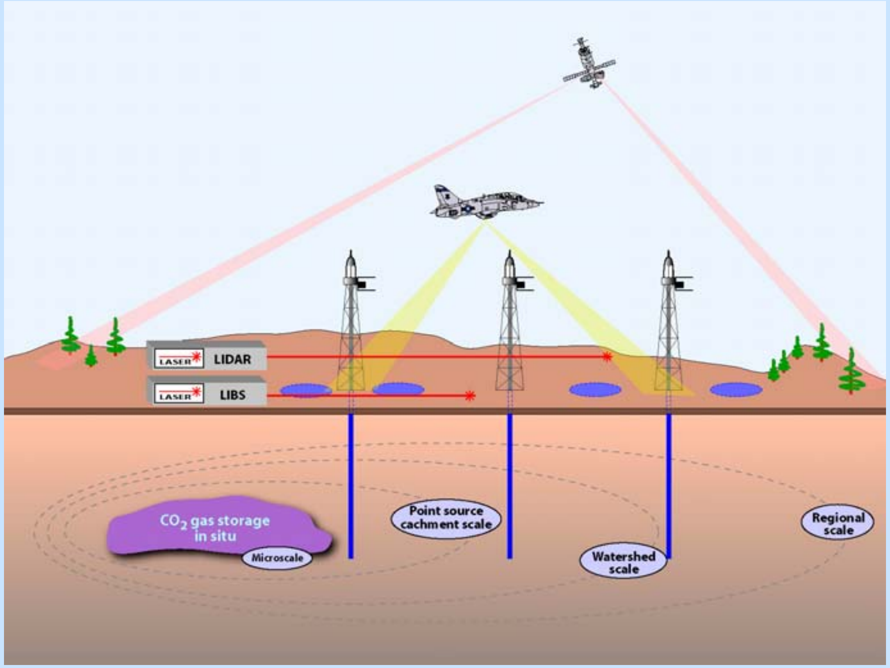


LEAD INSTITUTION: Los Alamos National Laboratory

Integrated MMV Concept

LANL Lead in Measurement, Monitoring and Verification

- Measurement, Monitoring and Verification (MMV)
  - Integrated MMV Diagnostics Assessment
  - Gap Analysis
- MMV of Sequestration
  - Cost Effectiveness
  - Risk Analysis
- MMV Deployment Plan
  - Local Manufacturing and Maintenance



Terrestrial Sequestration

Understand the ecosystem impacts and long term effectiveness

Cost-competitive, economic vs technical potential

Quantification and measurement of soil C

- ***Montana State University***
  - ***Susan Capalbo, John Antle***
  - ***Perry Miller, Rick Engel***
- ***South Dakota School of Mines and Technology***
  - ***Pat Zimmerman, Karen Updegraff, Bill Capehart***
- ***Texas A&M University***
  - ***Jerry Stuth, Jay Angerer***
- ***National Carbon Offset Coalition***
  - ***Ted Dodge***

Ecosystems that offer opportunities for soil C sequestration in the region:

-- agricultural lands (croplands, grasslands, range lands)

-- wetlands (management of soil C pools, limit conversion)

-- forested lands and agroforested areas

-- degraded lands

Where should/would soil C be sequestered?

• **soil scientists: *should be* where potential ΔC highest…e.g., on most degraded lands?**

• **economists: *would be* where $\Delta\pi/\Delta$C lowest! (opportunity cost)**

Key Point: $\Delta\pi$ and ΔC are correlated, so its not obvious where the ratio is lowest, must look at both biophysical and economic factors

Terrestrial Sequestration

TASK 1: Coordinating the GIS database with the geological sequestration efforts

OBJECTIVE: To integrate soil, climate, and management data as well as GHG source data into a single standardized GIS database

TASK 2: Evaluate terrestrial sequestration potential in regional ecosystems and assess long term effectiveness and costs

OBJECTIVE: Examine both the technical and economic potential for soil C sequestration

TASK 3: Assess existing conservation programs for sequestration potential

OBJECTIVE: Examine the connections between existing agricultural policies which affect land use and policies which provide incentives for additional soil C sequestration

TASK 4: Monitoring and measurement

OBJECTIVE: Development of monitoring technologies and verification schemes, needed for carbon emissions trading and other policies

Two frameworks for quantifying soil C sequestration potential:

-- C-lock (SDSMT)

-- Integrated biophysical/economic assessment framework (MSU)

The South Dakota Carbon Sequestration Project

•Funding provided by Governor William Janklow currently serving as the lone U.S. Congressional Representative from South Dakota and the State of South Dakota (BOR) and NSF EPSCoR

--The C-lock program is administered by the Institute of Atmospheric Sciences at SDSMT

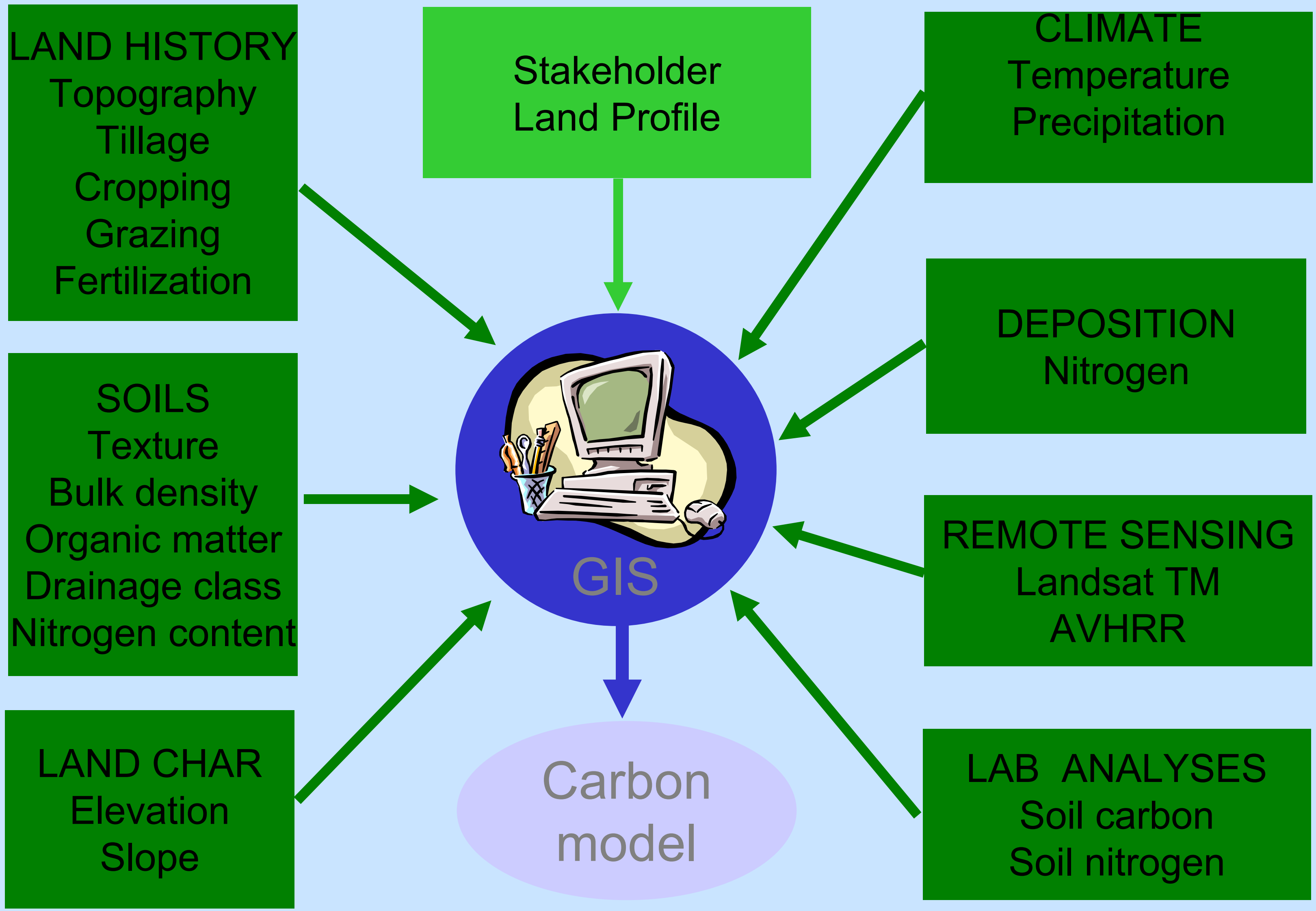
-- Two main goals:

Identify and assess Carbon Emission Reduction Credits (CERCs) for ag lands

Maximize the value of CERCs for producers through a system of validation and marketing

Issues considered in C-Lock:

- Establishment of Baseline
- Additionality, Surplus
- Permanence
- Leakage
- Ownership
- Verification

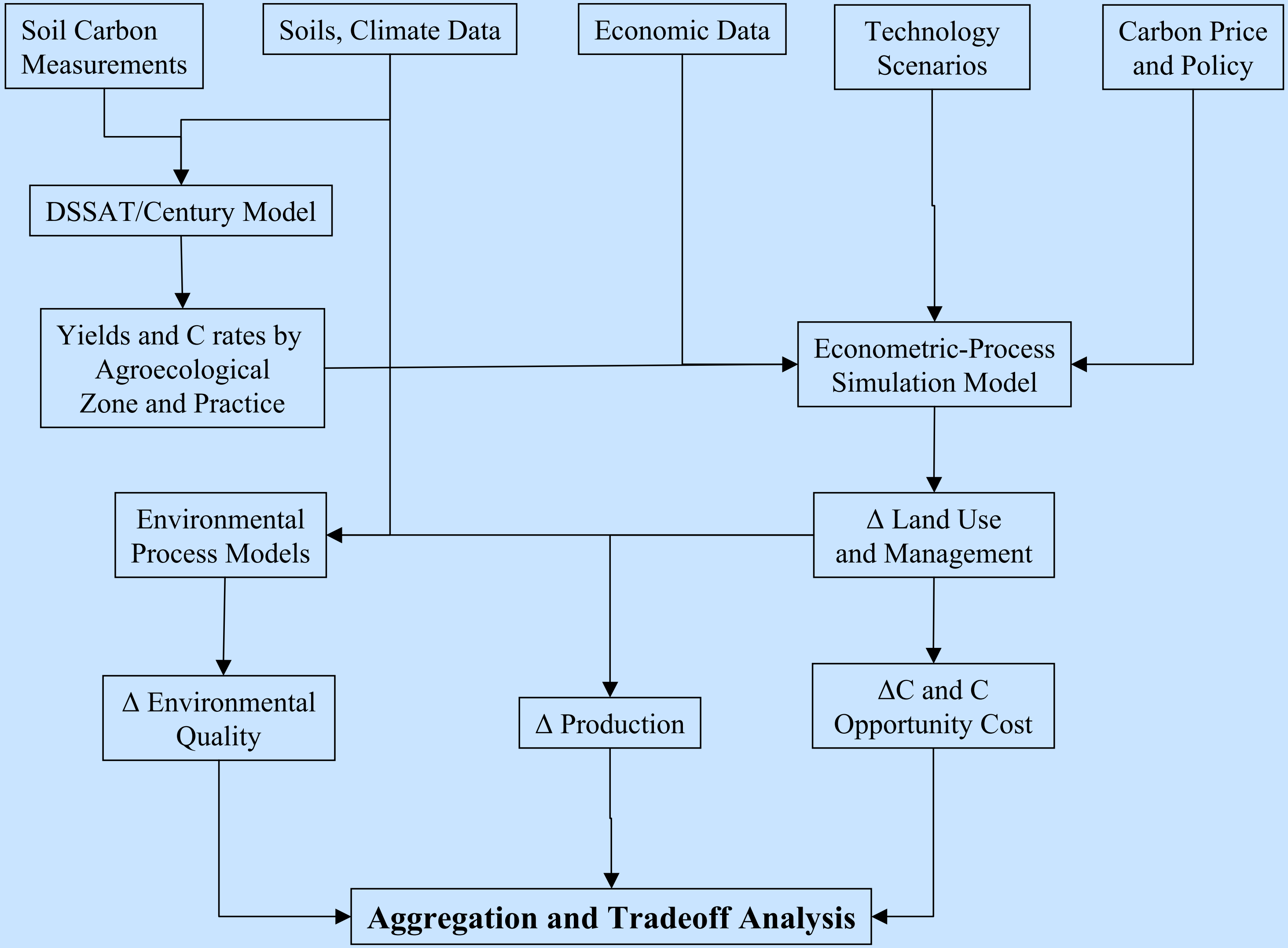

LAND HISTORY
Topography
Tillage
Cropping
Grazing
Fertilization
Stakeholder
Land Profile
CLIMATE
Temperature
Precipitation
DEPOSITION
Nitrogen
SOILS
Texture
Bulk density
Organic matter
Drainage class
Nitrogen content
GIS
REMOTE SENSING
Landsat TM
AVHRR
LAND CHAR
Elevation
Slope
Carbon
model
LAB ANALYSES
Soil carbon
Soil nitrogen

C-Lock provides:

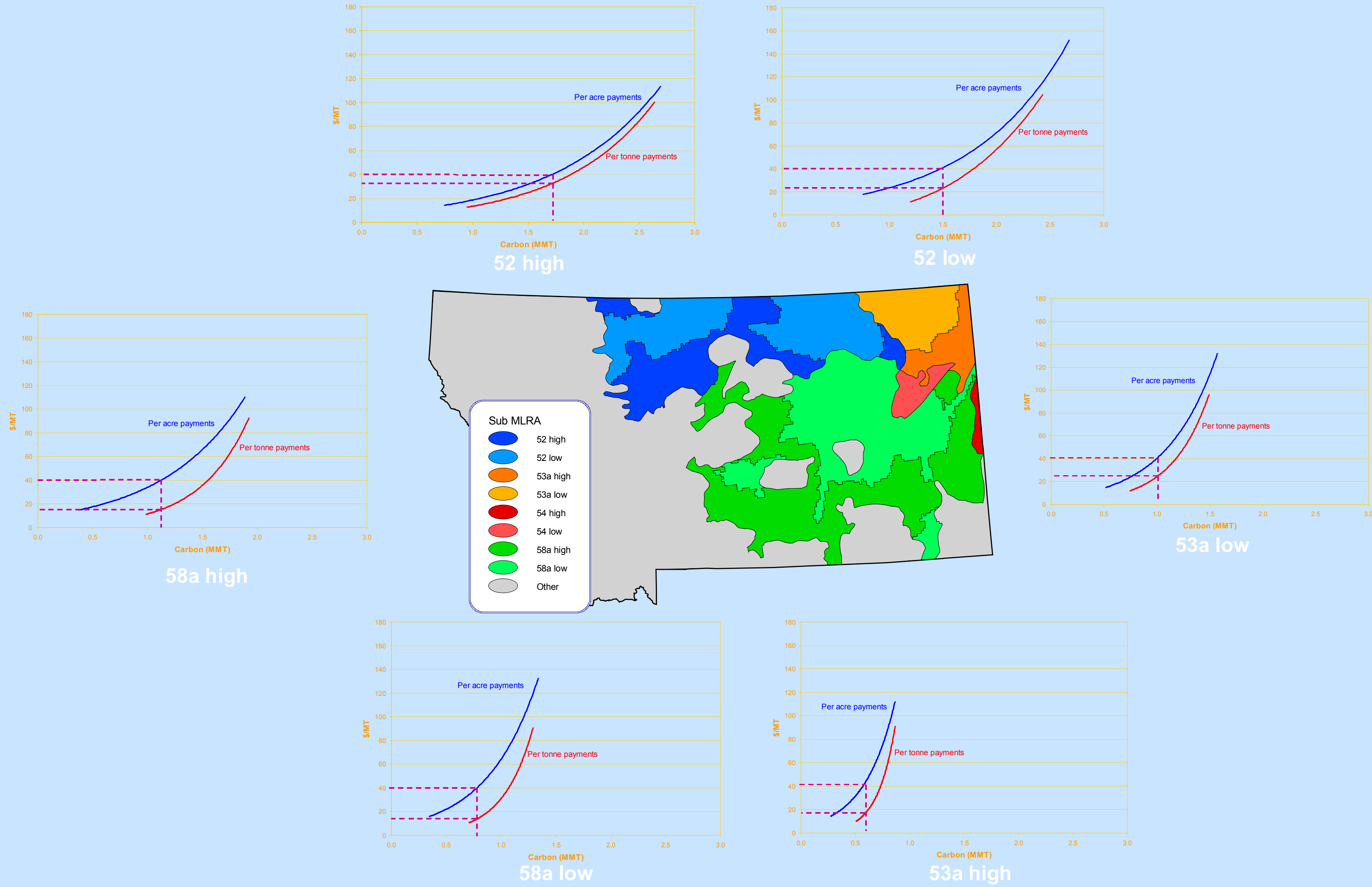
- Process to address and define uncertainties
- Emphasis on minimizes costs of sequestering soil C
- Flexible platform to interface regulations, science, and producer inputs and future changes
- Internet based system to enhance stakeholder interaction
- Provides online, near real-time estimation tools to help producers maximize sequestration potential
- Modules for forestry, manure management, landfills and erosion mitigation are under development for the partnership region

Integrated Assessment Paradigm for Evaluating Terrestrial Sequestration Potential – Montana model

- Economic data $\Rightarrow$
  economic production models
- Soils & climate data $\Rightarrow$
  crop ecosystem models
- Output of crop ecosystem models $\Rightarrow$
  economic models and
  environmental process models
- Output of economic models $\Rightarrow$
  environmental process models



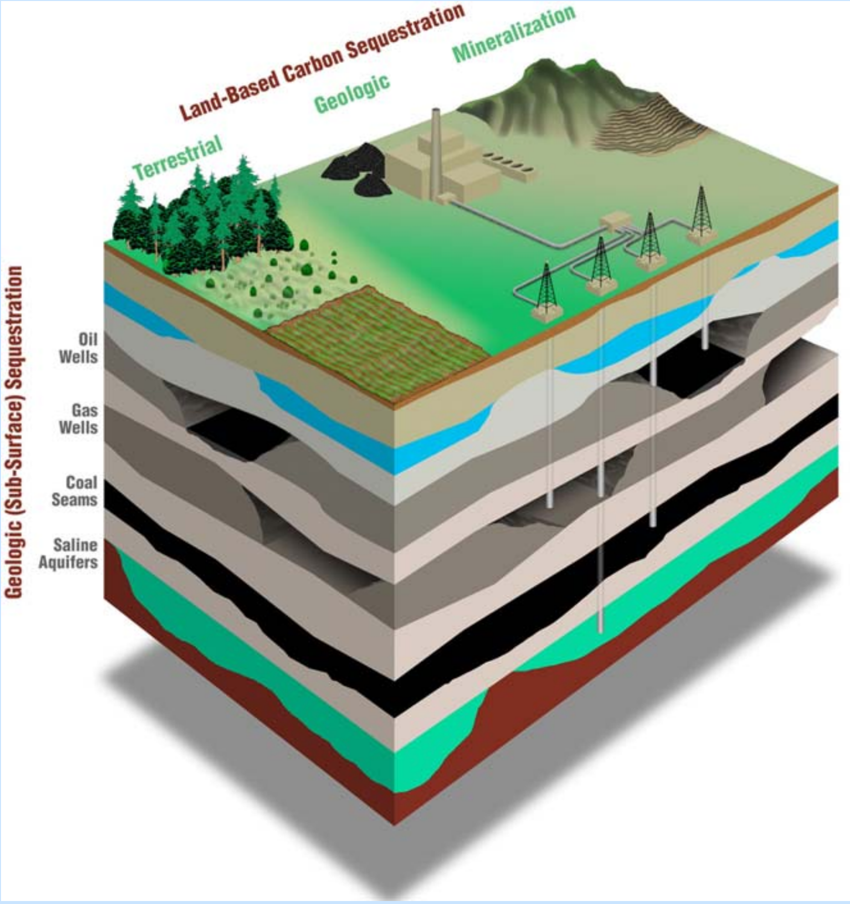
Terrestrial Carbon Sequestration Analysis



Marginal costs of sequestering additional soil C in selected areas of Montana

Advanced Concepts

- LANL Lead in Advanced Concepts
  - State of Sequestration and Gap Analysis (LANL Lead)
  - Common Evaluation of Various Sequestration Options (MSU Lead)
  - Identify Sequestration Guidelines (MSU Lead)
  - Sequestration Permit Issues (MSU Lead)
  - Revised 1605 B National Greenhouse Gas Registry
  - Cost Share Programs
  - Carbon Credit
  - Best Production Practices
- Mineralization Trapping
  - Engineered Mineralization Potential (LANL Lead)



Education and Outreach

Goals:

- **Increase awareness, understanding and acceptance**
- **Build advocacy**
- **Explore economic development opportunities**
- **Determine implementation barriers**
- **Establish networks of key constituencies**

EnTech Strategies, LLC
Pamela Tomski, ptomski@entech-strategies.com

Key Constituencies

- University Community
- Environmental NGOs and Professional Societies (ASME)
- Industry
- Farmers, Ranchers and Land Owners
- Native American Tribal Nations
- State Legislative and Regulatory Officials
- Congressional Delegations
- General Public

Education and Outreach

Tasks

- Outreach and Education Plan
- Partnership Listserve
- Brochure, Poster and Display
- Website
- Media Package and Campaign
- Community Roundtable Discussions
- Innovation Workshops
- Economic Development Workshop
- Capitol Hill Seminar for MT, ID, SD Delegations
- Carbon Sequestration Research Paper Competition (ASME)




Future meeting sites for the Northern Rockies and Great Plains Regional Partnership


What is a ton of carbon dioxide roughly equivalent to?

A. One cord of wood
B. 24 grass hay bales (the ones we used to buck)
C. One person’s one--two week atmospheric impact:
   - Fuel, waste decay, manufacturing, energy use
D. All of the above