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## *Technical and institutional requirements for reliable mapping, monitoring and forecasting of soil carbon*

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# The soil challenge

- A 75% increase in food production by 2050 with severe constraints:
  - water scarcity in key regions
  - finite arable land
  - yield plateaux for major crops
  - increasing cost of energy, nutrients and emissions
  - soil degradation
- Current systems of land use are being disrupted by changing climate



# Some big soil and land questions

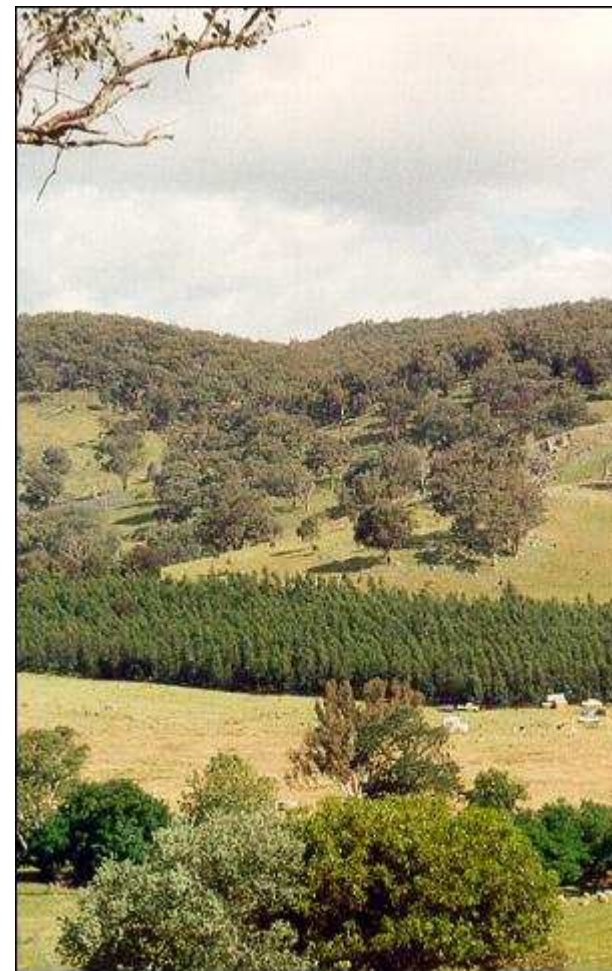
- What are the best options for storing carbon in terrestrial systems?
- Can we monitor and forecast the terrestrial carbon pool?
- How secure are farming systems and can they produce sufficient food at lower emission intensities?
- How serious are existing threats to ecosystem services (acidification, loss of biodiversity, soil erosion)?





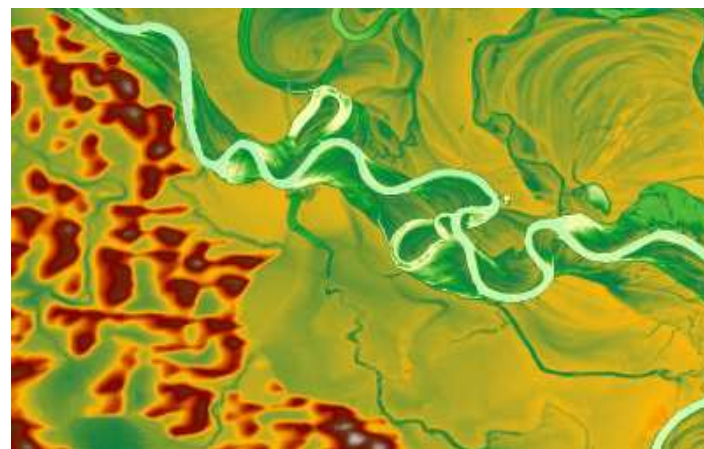
# Soil carbon

- Biosequestration potential is large in many parts of the world
  - Cleared grazing lands
  - Degraded cropping lands
- Practical and scientific complexities but they can be addressed
- Essential to have robust environmental observing and forecasting systems



# What primary biophysical data do we need?

- Observe and predict
  - Net primary productivity (e.g. crops, pastures, forests)
  - Water and energy balances
  - Cycling of carbon, nitrogen, phosphorous, and protons
  - Sediment and solute balances
- We can agree on the *primary* data
- Most spatial data are needed on a fine grid



# Requirement 1: Clear mandate

- Building the environmental information systems for monitoring and verification is a long-term task
- Market-failure leads to large under-investment in soil and land resource information
- Short-term project and program funding (<5yrs) does not deliver enduring environmental information systems
- Legally binding international conventions are valuable
- National legislation is essential (c.f. weather data)

## Requirement 2: Skilled people

- Spatial prediction and monitoring of soil is technically complex
- Rebuild technical capability (c.f. 1970s)
- Field training and regional knowledge of landscapes is critical
- Small teams with modest and long-term funding are very effective





## Requirement 3: Compliance with agreed standards

- General consensus exists on methods for digital soil mapping but few formal standards yet
- Sufficient confidence to develop a Soil Carbon Offset Standard (e.g. project focussed)
- Measurement and verification protocols can also be developed
- Must balance confidence in the carbon offset with cost of verification





# Requirement 3: Measurement infrastructure

## International

- fine-resolution remote-sensing (time series, hyperspectral)
- digital elevation models
- spectroscopic calibration for soil carbon

## National

- comprehensive laboratory (chemistry, physics)
- remote sensing (e.g. gamma ray spectroscopy)

## Regional

- field crews
- proximal sensing units
- permanent monitoring sites

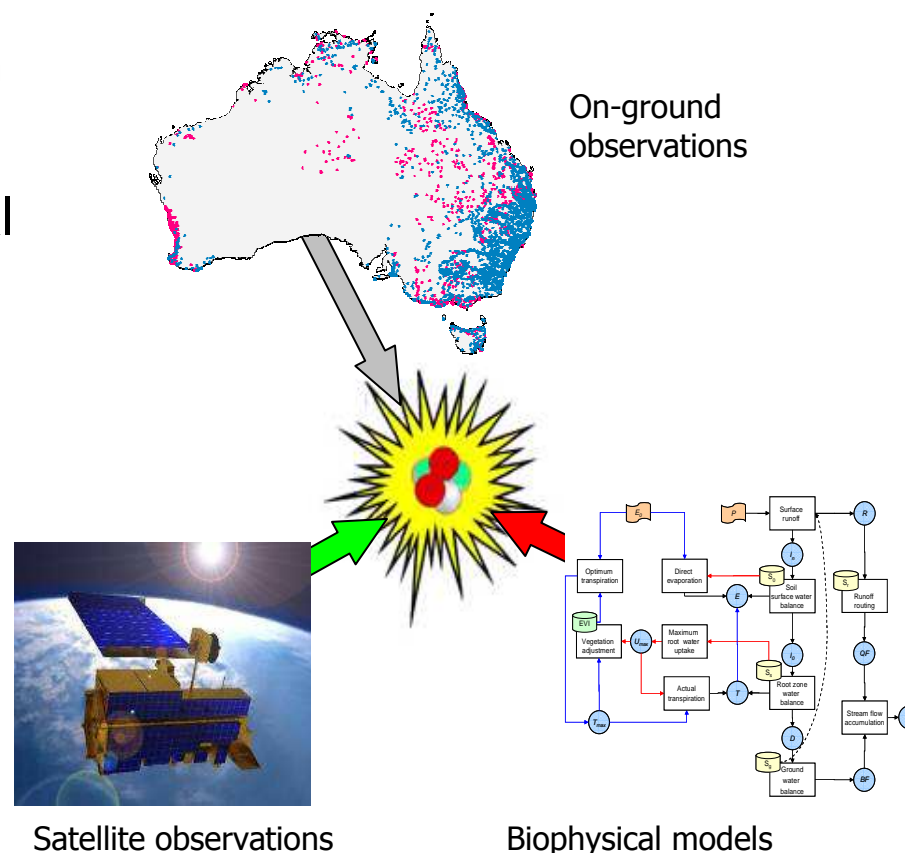
## Requirement 5: Excellent archives

- The challenges are long-term and will not go away
- Specimen archives are critical
  - calibrating of new techniques
  - constructing new time series
  - permanent baseline
- Data archives are the foundation
  - constructing new time series
  - increasing challenge because of the data deluge
  - essential for monitoring



## Requirement 6: Advanced data analysis

- Improve the confidence/cost ratio for soil carbon verification
- Model-data assimilation
  - Remote sensing and spatial data
  - Sensor networks
  - Simulation modelling
- Genuine opportunities to increase forecasting skill (e.g. carbon sequestration, crop production, net primary productivity)





# Requirement 7: Integration within GEOSS

- Soil information is essential for four of the nine societal benefit areas
- Mechanisms for data sharing and interoperability
- Economies of scale
- Essential for effective Earth system observation and forecasting



# Key tasks

- Establish the institutional and legislative framework for mapping, monitoring and forecasting soil condition
- Develop the Soil Carbon Offset Standard along with measurement and verification protocols
- Build the enduring capability (people, infrastructure and networks)
- Invest in the soil and environmental information systems

