Assessment of the Impacts of Terrestrial Vegetation on the Greenhouse Gas Budget at the Regional Level: Integrated Approach

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Far better an approximate answer to the right question, which is often vague, than the exact answer to the wrong question, which always be made precise

(Tukey, 1962)

Right questions?

- A need of a regional (national, continental) Terrestrial Biota *Full* Account of Major Biogeochemical Cycles (FABC)?
- A need of a *Verified* FABC?
- A need of transition to a *Certified* Account?
- Are we able to *formally* define a required level of uncertainties?

Prerequisites

- Full Carbon Account is the nucleus of the Terrestrial Biota Full Account of Major Biogeochemical Cycles (FABC)
- Landscape-ecosystem approach is the overall scientific basis of the FABC
- The FABC is a typical fuzzy system
- Assessment of uncertainties at all stages and for all modules of any verified FABC
- The FABC should be presented by an explicit spatial and temporal distribution of pools and fluxes by natural units of relevant size

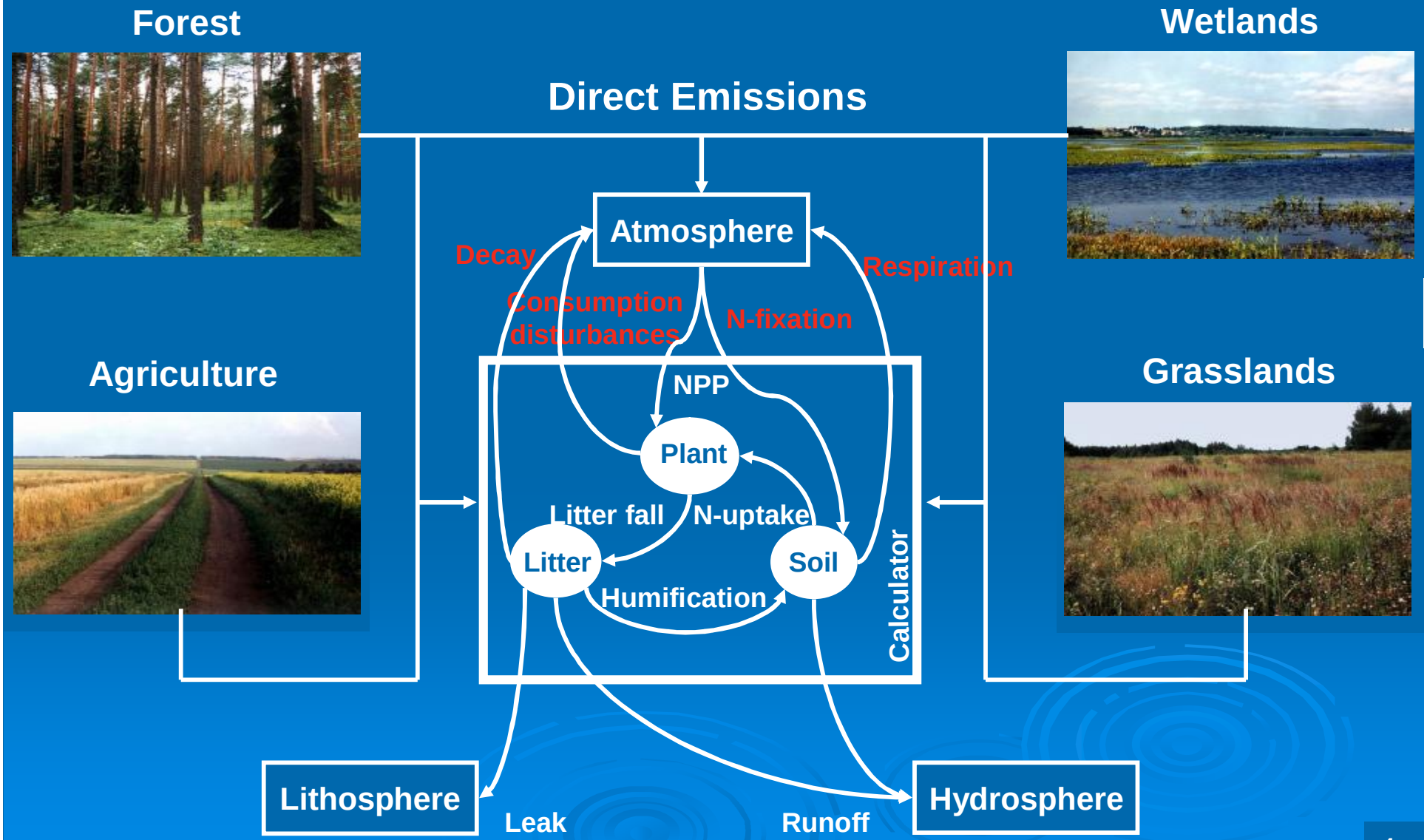
Prerequisites - continued

- Minimizing uncertainties is a major scientific goal of the FGGA
- Need of relevant combination of all available information sources
- Systems combining different methods in major alternatives – pool-based *and* flux-based, inventory *and* process-based
- Importance of temporal dimension
- Need of explicit algorithms
- Need of multi-side constraints

Two major consequences

- There is no individual method or model which would be able to present sufficient information for comprehensive and reliable assessment of uncertainties of FABC based on only this method or model
- Integration in all aspects and multiple harmonizing intermediate and final results received by different methods

Core Model for Biogenic (CO_2, CH_4, N_2O) GHG Inventory



FCA-a nuclei of FABC

The FCA is presented as a relevant combination of a pool-based approach

$$dC/dt = dPh/dt + dD/dt + dSOC/dt,$$

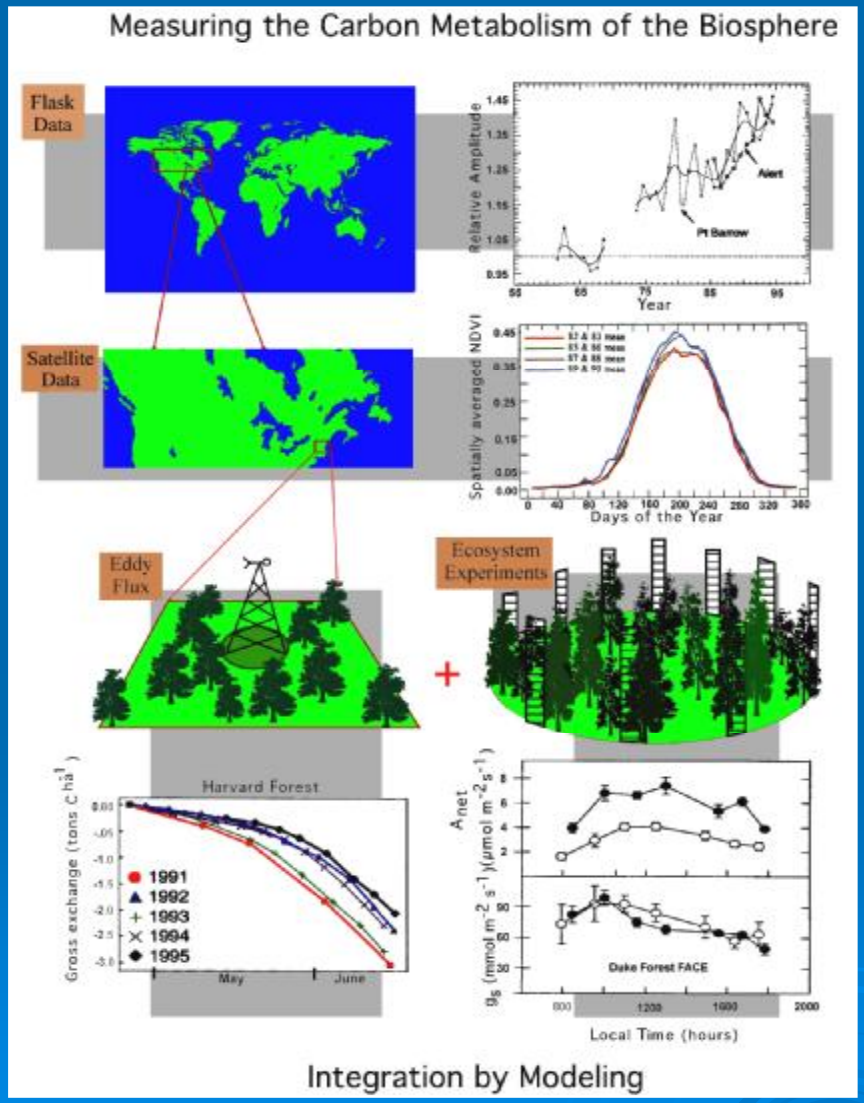
where Ph, D and SOC are pools of phytomass, dead organic matter and soil organic matter,

and a flux-based approach

$$NBP = NPP – HR- ANT – FHYD - FLIT,$$

where NBP and NPP are net biome and net primary production, HR – heterotrophic respiration, ANT – flux caused by disturbances and consumption, FHYD and FLIT- fluxes to hydrosphere and lithosphere, respectively

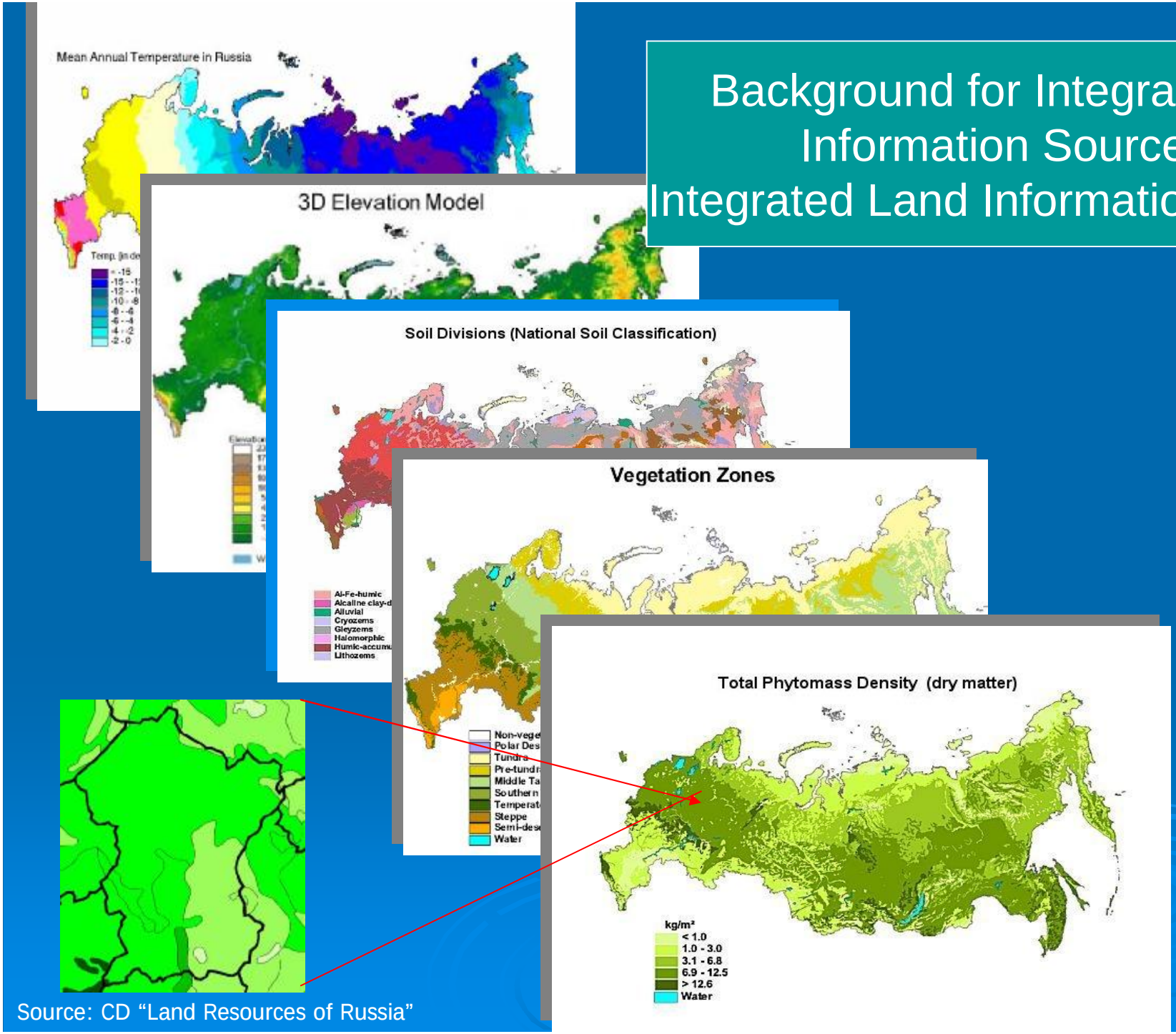
Integration of information, methods and models



Canadell et al. 2000

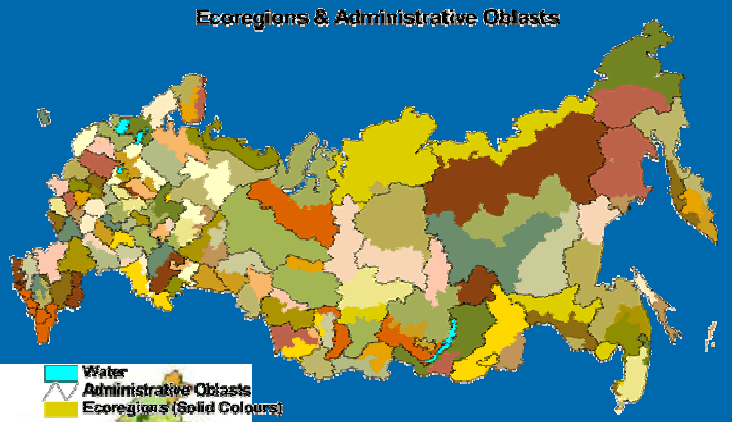
- Integrated Land Information System
- Different inventories and surveys
- Remote sensing (land cover, environmental indicators, NDVI, phenology, live biomass, disturbances, etc.)
- Measurements *in situ* (flux measurements etc.)
- Atmospheric gas composition and isotopes (CO_2, CH_4, O_2/N, ^{13}C, ^{14}C)
- Combining methods (e.g., pool-based *vs* flux-based)
- Relevant combination of models (empirical and process-based)

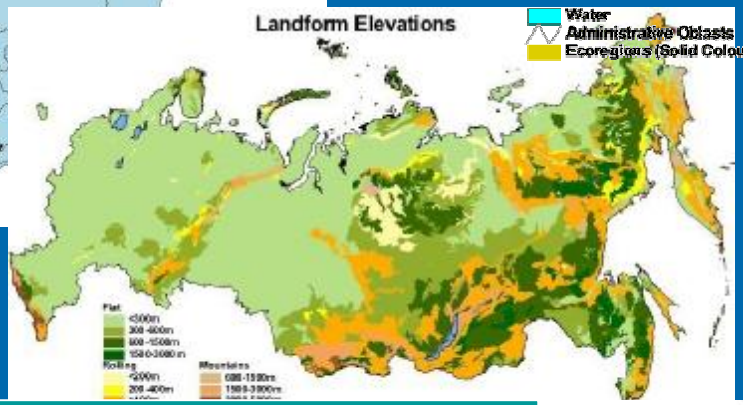
Background for Integration of Information Sources: Integrated Land Information System



Source: CD “Land Resources of Russia”

Ecological Regions (Ecoregions)





Major requirements to ecoregions

Homogeneity of growth conditions at the level of bio-climatic subzones

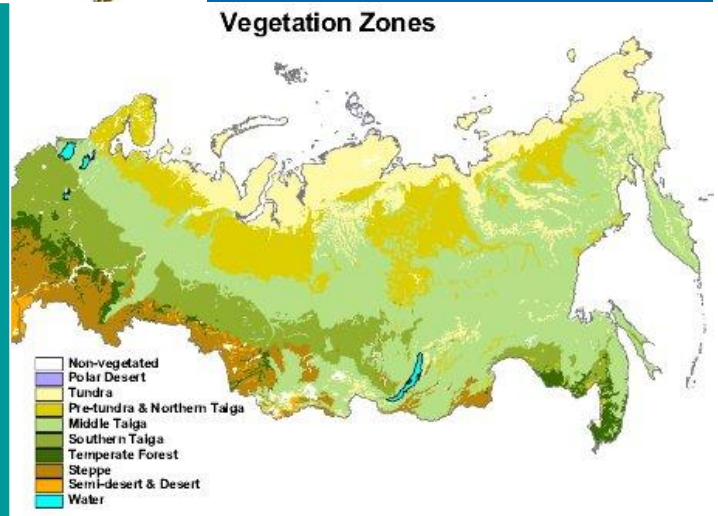
Land forms (mountain and plain territories)

Specifics of hydrology (permafrost etc.)

Level and peculiarities of transformation of indigenous vegetation

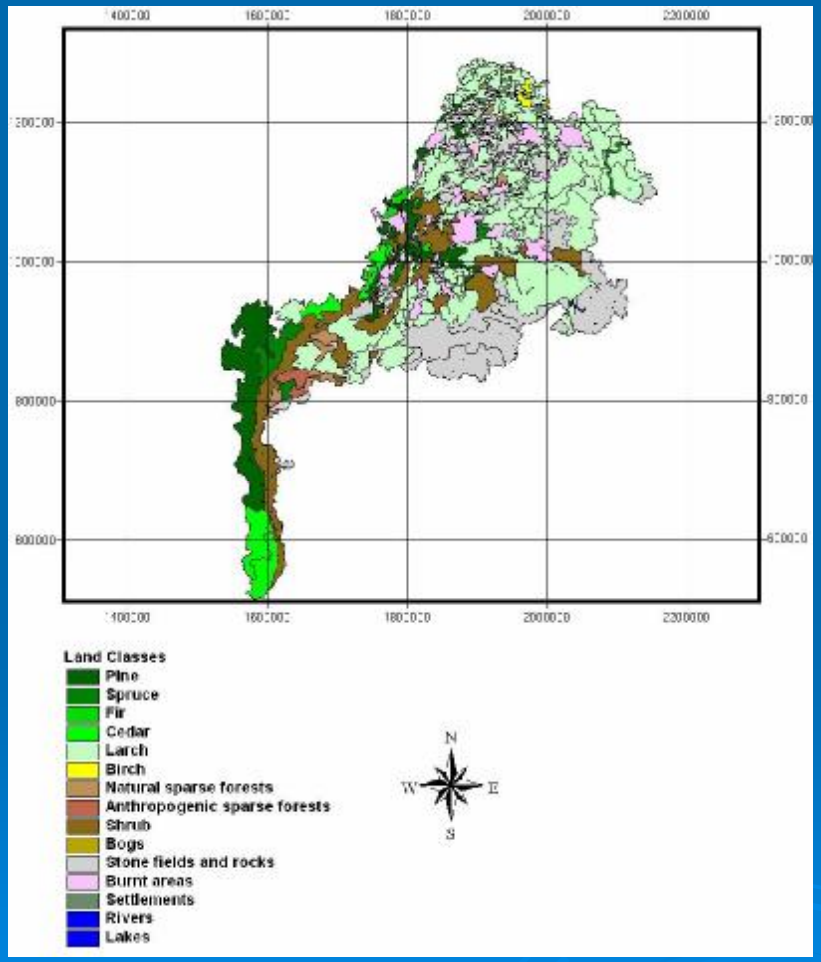
Comparability of contribution of each ecoregion to major Terrestrial Biota Global Biogeochemical Cycles

ER boundaries cannot cross boundaries of subjects of the RF

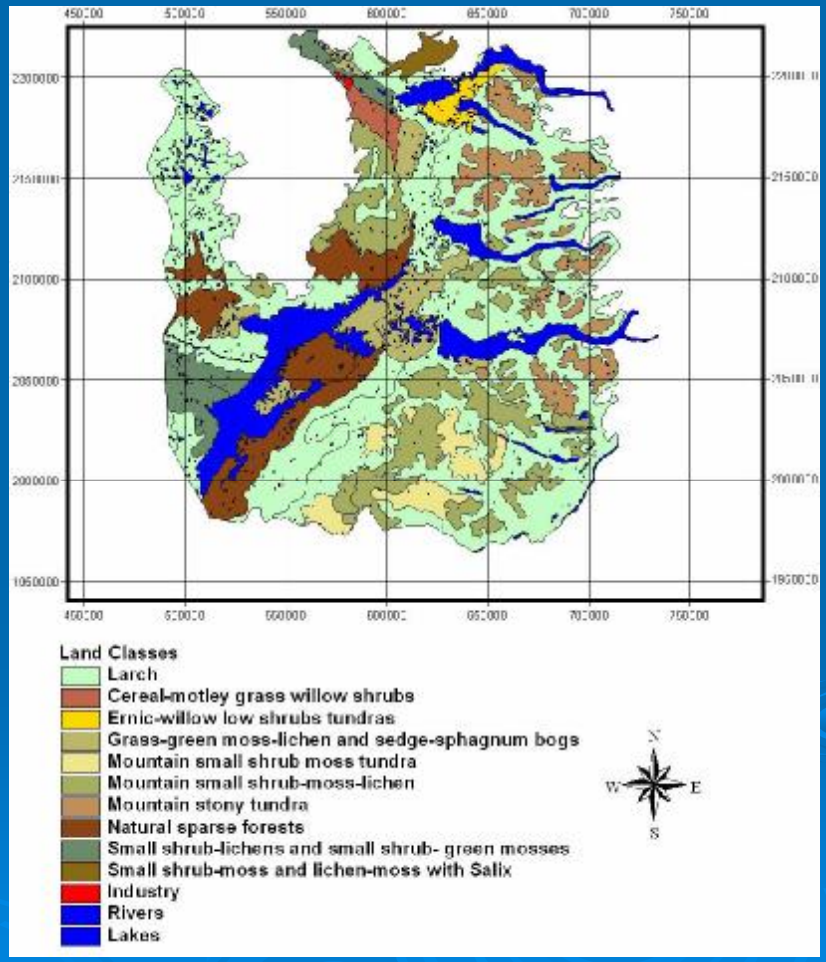


SIBERIA-II Land Cover “relevant for the FABC”

Forest Ecoregion

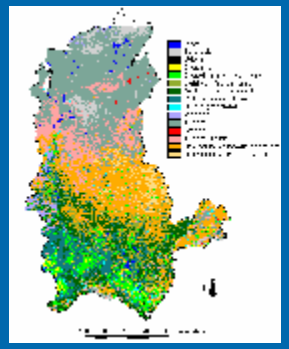


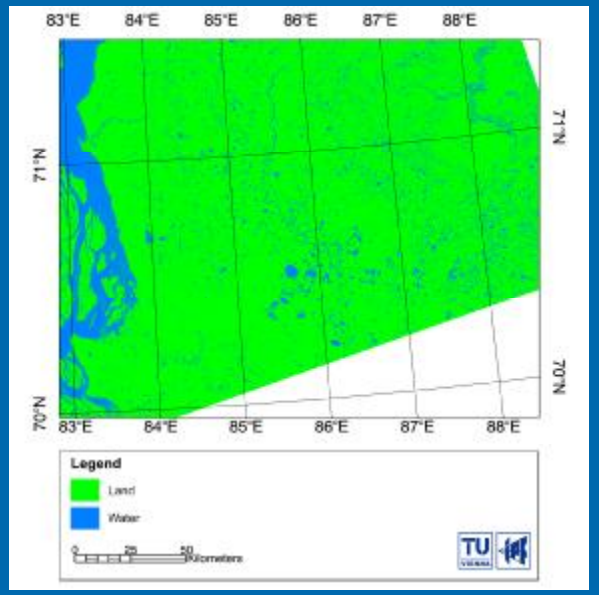
Tundra Ecoregion

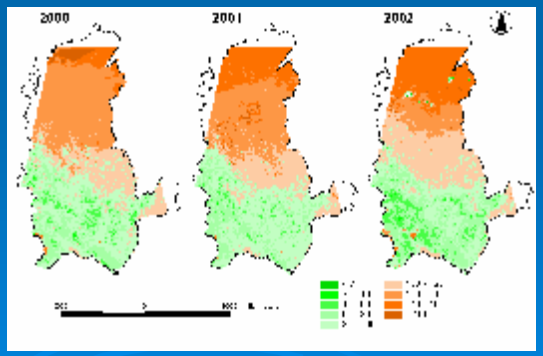


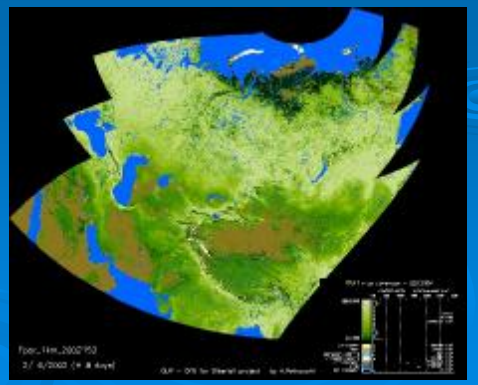
Remote sensing data – a vitally important component of FABC

- Land cover
- Wetlands/hydrology
- Disturbances
- Freeze/thaw
- LAI/FPAR
- Snowmelt
- Phenology

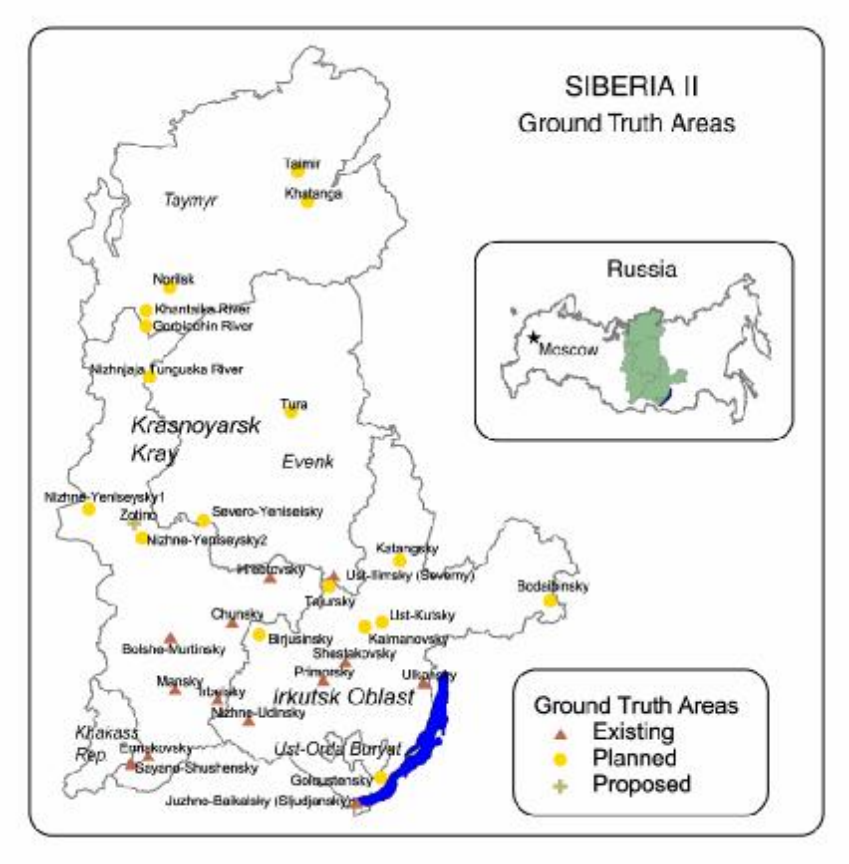


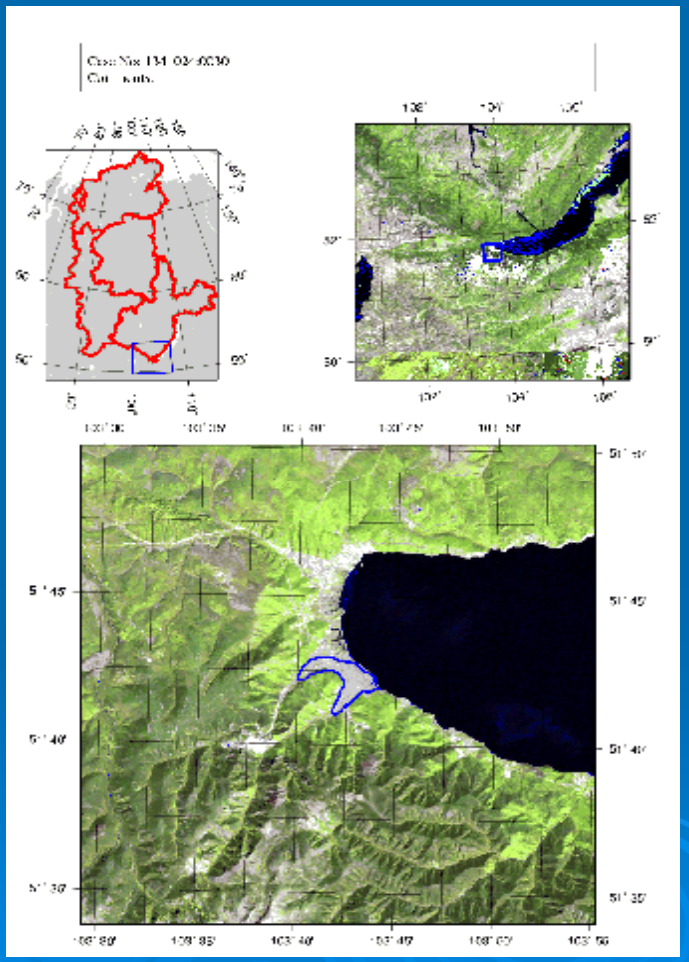






In-situ Data/High Resolution Images

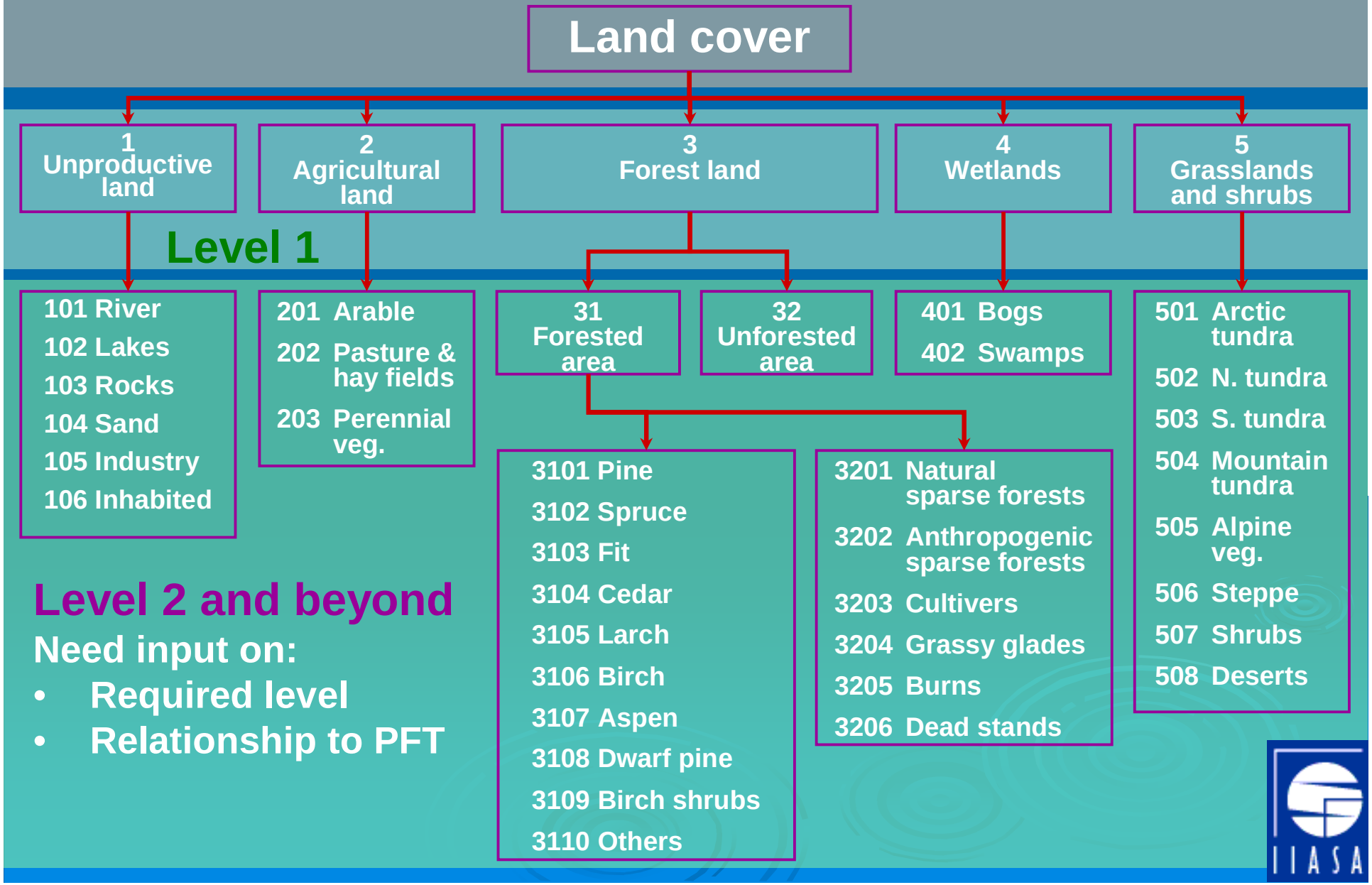




RS Applications to the FABC-questions to be solved

- Continuity of RS sensors
- Needs of special sensors aiming at FABC specifics (e.g., biomass, severity of disturbances)
- Coarse resolution – a need of auxiliary information in order to provide synergetic use of information
- Insufficient accuracy of some process indicators
- Lack of proper regional validation of some global products

GIS classification

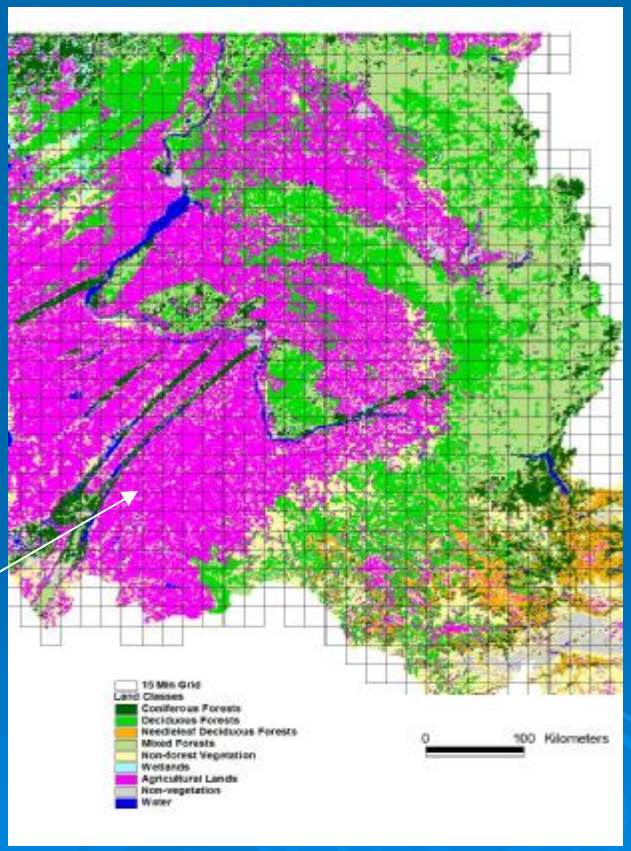


Level 2 and beyond

Need input on:

- Required level
- Relationship to PFT

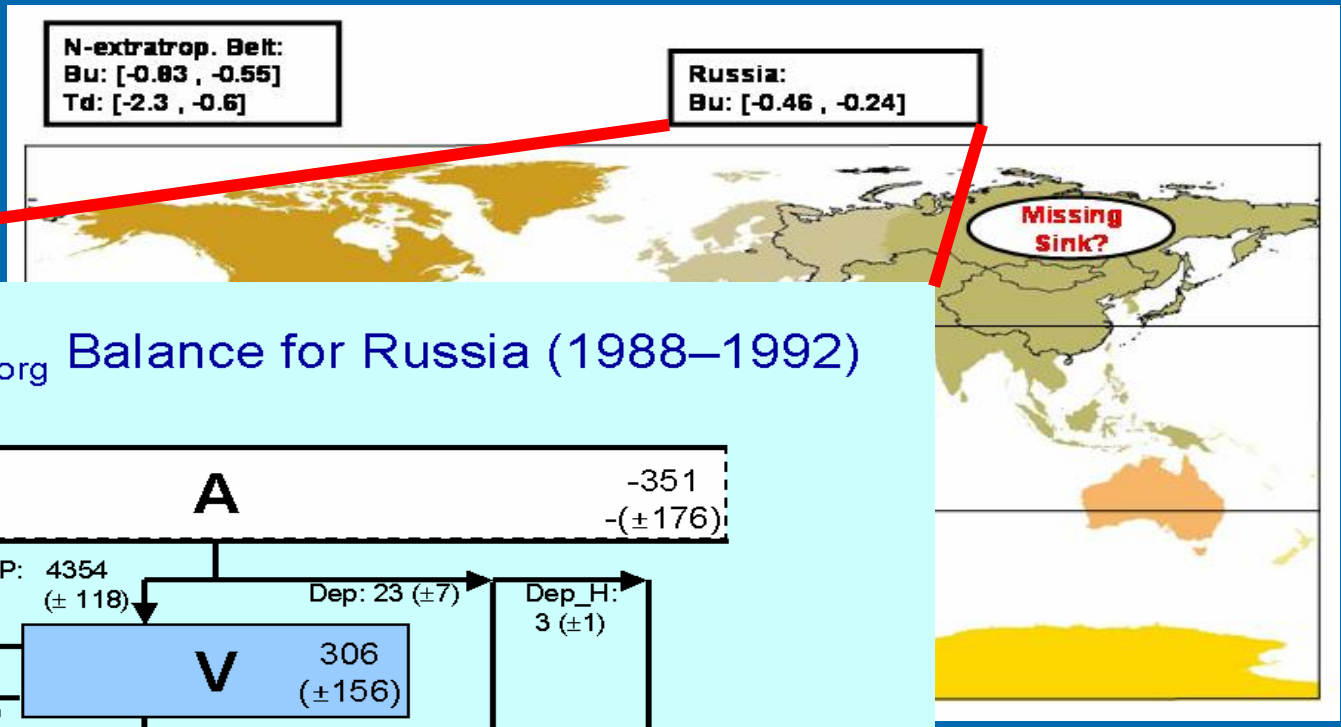
Synergetic use of forest inventory and RS land cover data for West Siberia



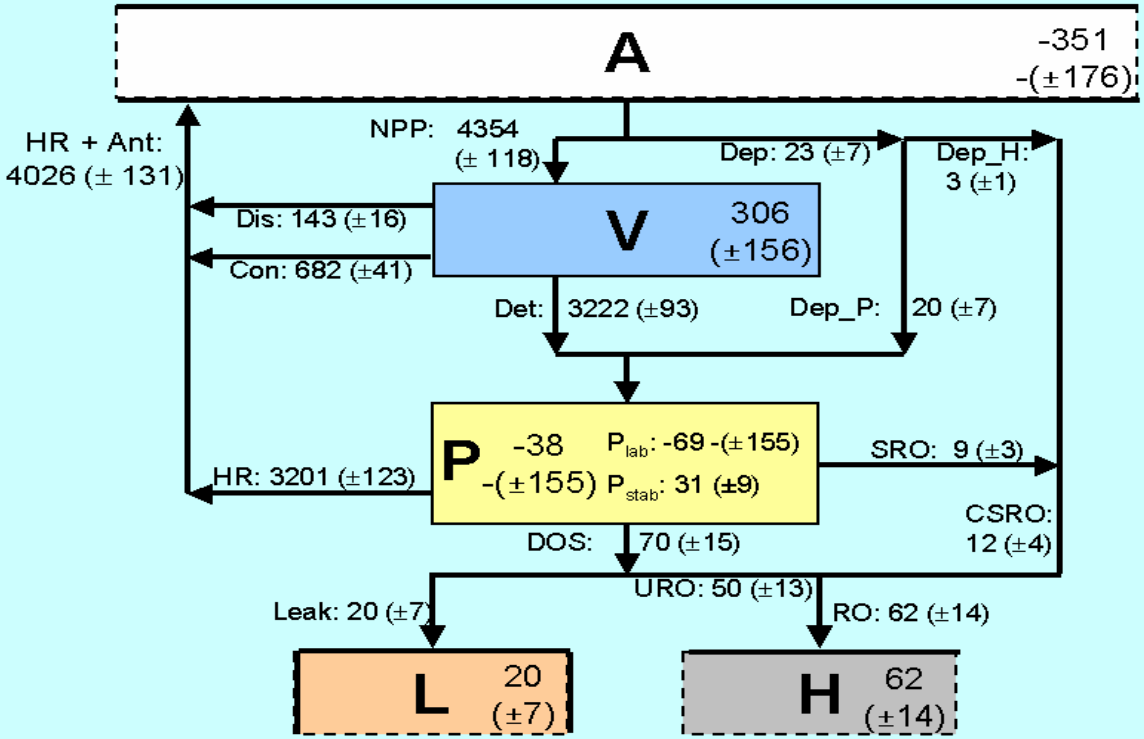
Integration: Combination of Models of Different Types

- Selection of **a set of models** (a relevant combination of terrestrial biogeochemical models + inventory based and semi-empirical models +inverse models).
- **Harmonization of data** and **information** requested by the models
- Search strategy for finding **the optimum structure** of modelling (cost function)
- **Synthesis**:
  - Model properties to be adjusted
  - Assessment of uncertainties
  - Multi-dimensional harmonization of the results

Terrestrial FCA for Russia (1988-1992): Fluxes and Pool Changes, including Uncertainties in TgC yr^{-1}

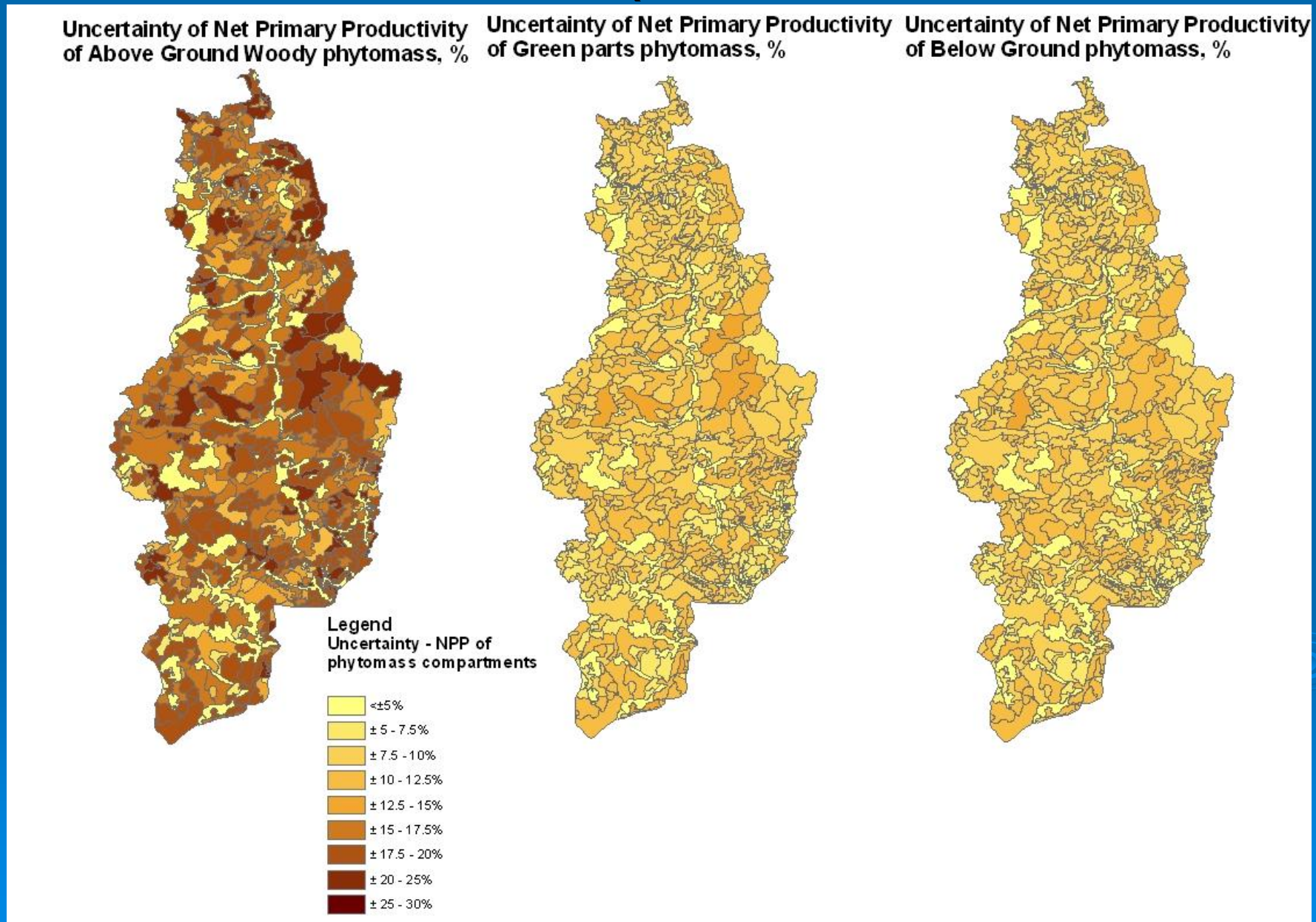


Terrestrial Full C_{org} Balance for Russia (1988–1992)



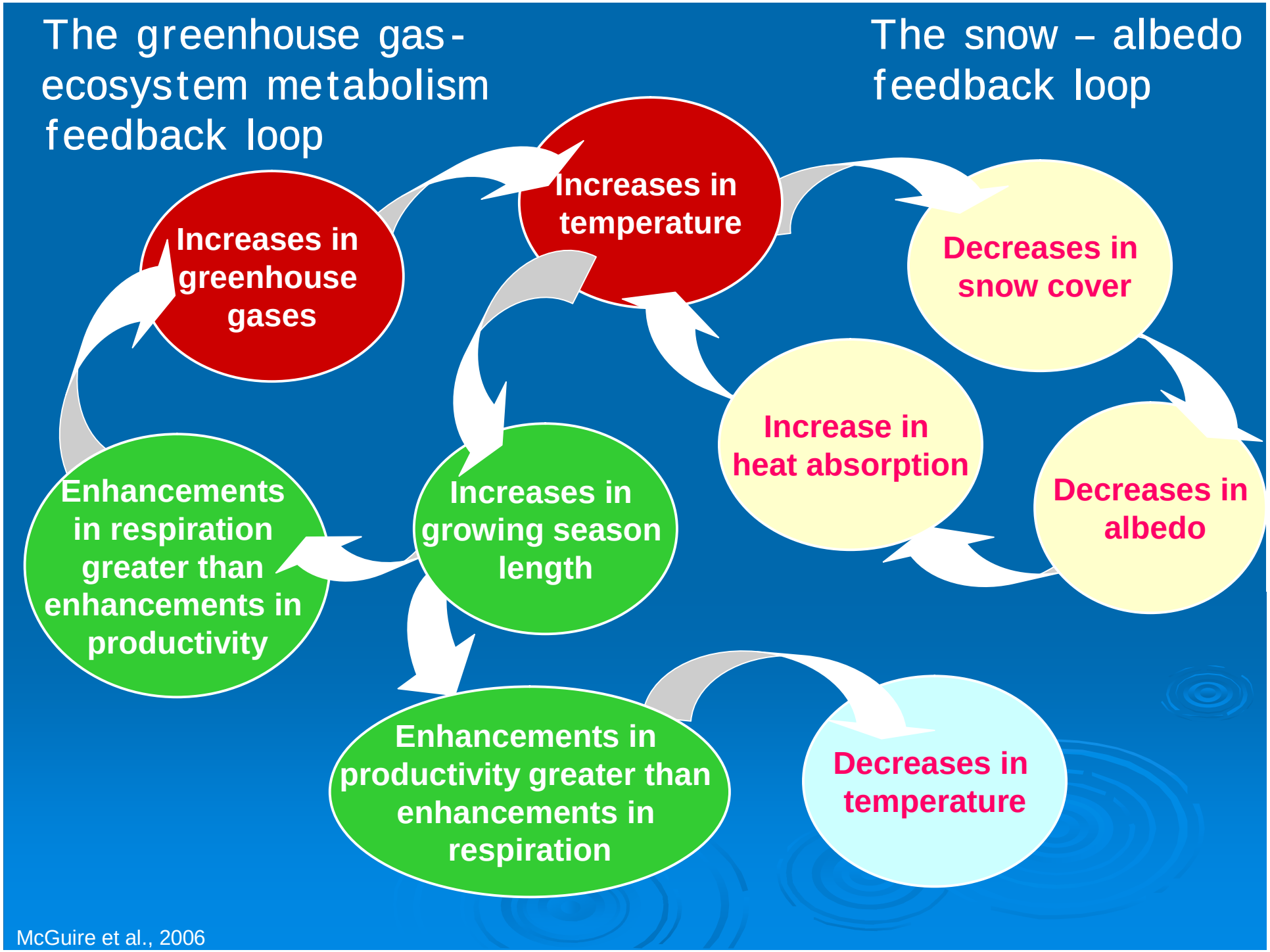
IIASA Forestry Project

Uncertainties of NPP (Monte Carlo simulations)

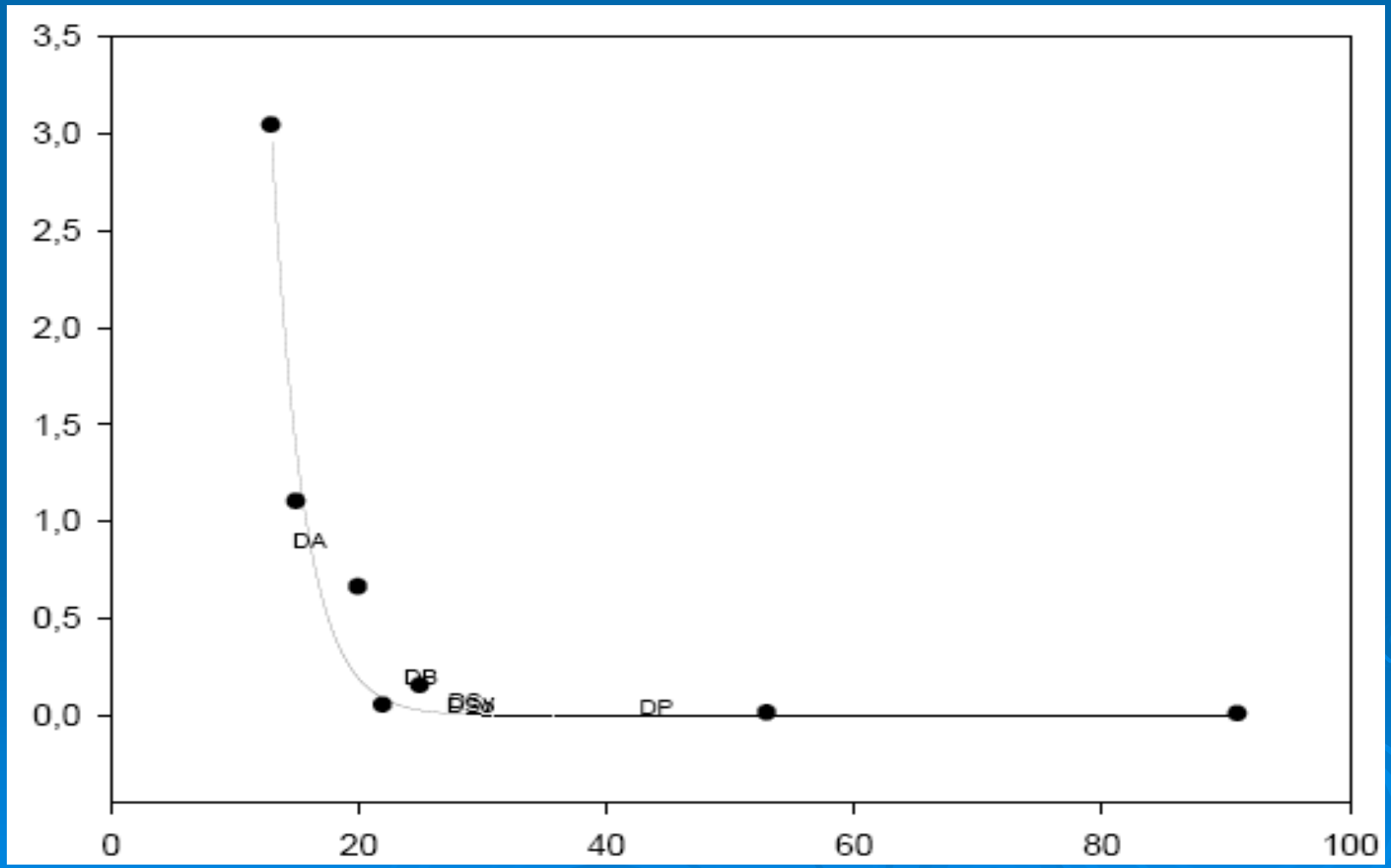


Managing Uncertainty

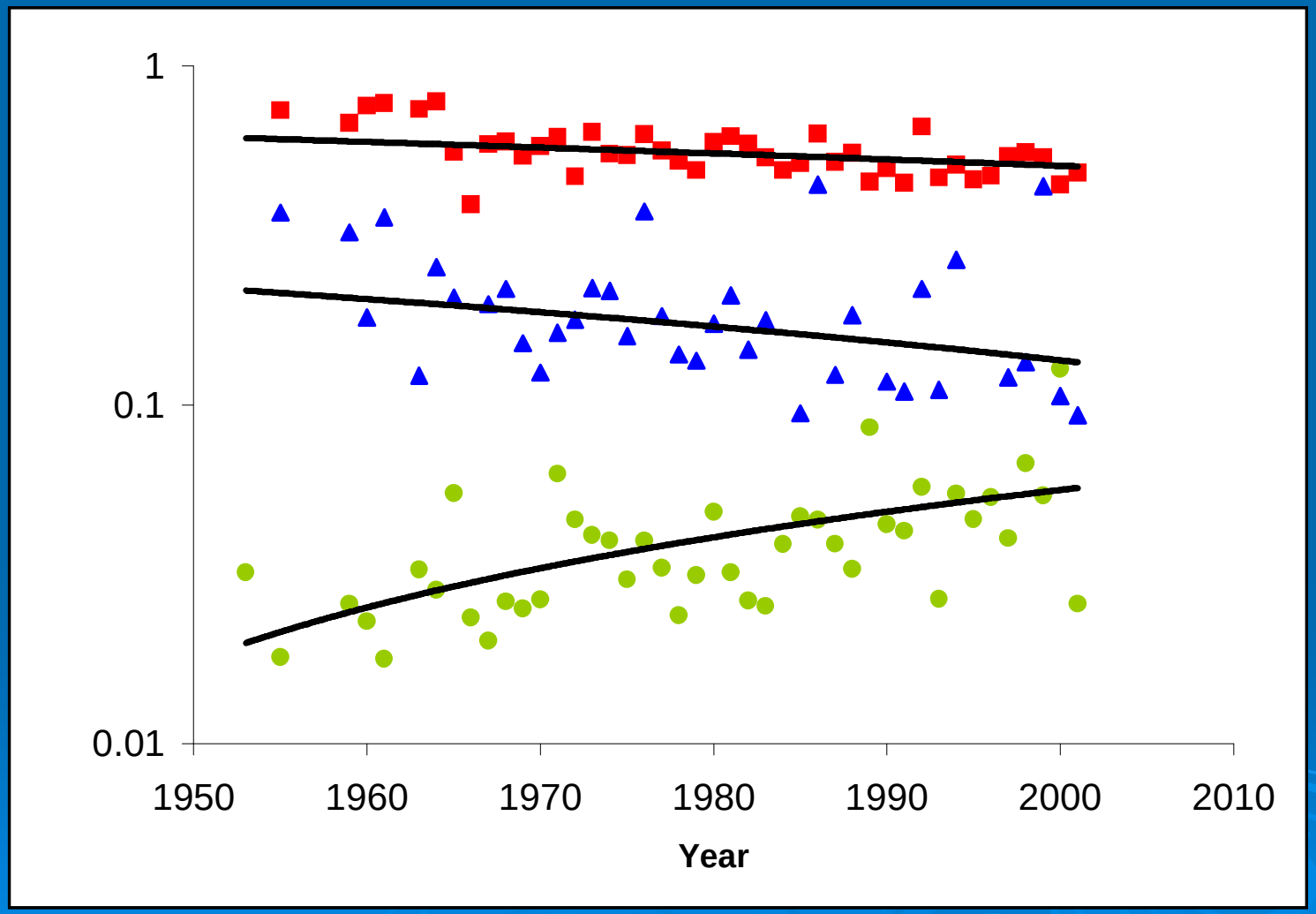
- Spatial and temporal incompleteness of measurements
- Insufficient knowledge of spatial gradients
- Lack of knowledge of some important processes, particularly, in below ground part of ecosystems
- Weak experience in a systems consideration of major GBGCs
- Unrecognized changes in responses and feedbacks


The greenhouse gas-ecosystem metabolism feedback loop
The snow – albedo feedback loop
Increases in temperature
Increases in greenhouse gases
Decreases in snow cover
Increase in heat absorption
Decreases in albedo
Enhancements in respiration greater than enhancements in productivity
Increases in growing season length
Enhancements in productivity greater than enhancements in respiration
Decreases in temperature
McGuire et al., 2006

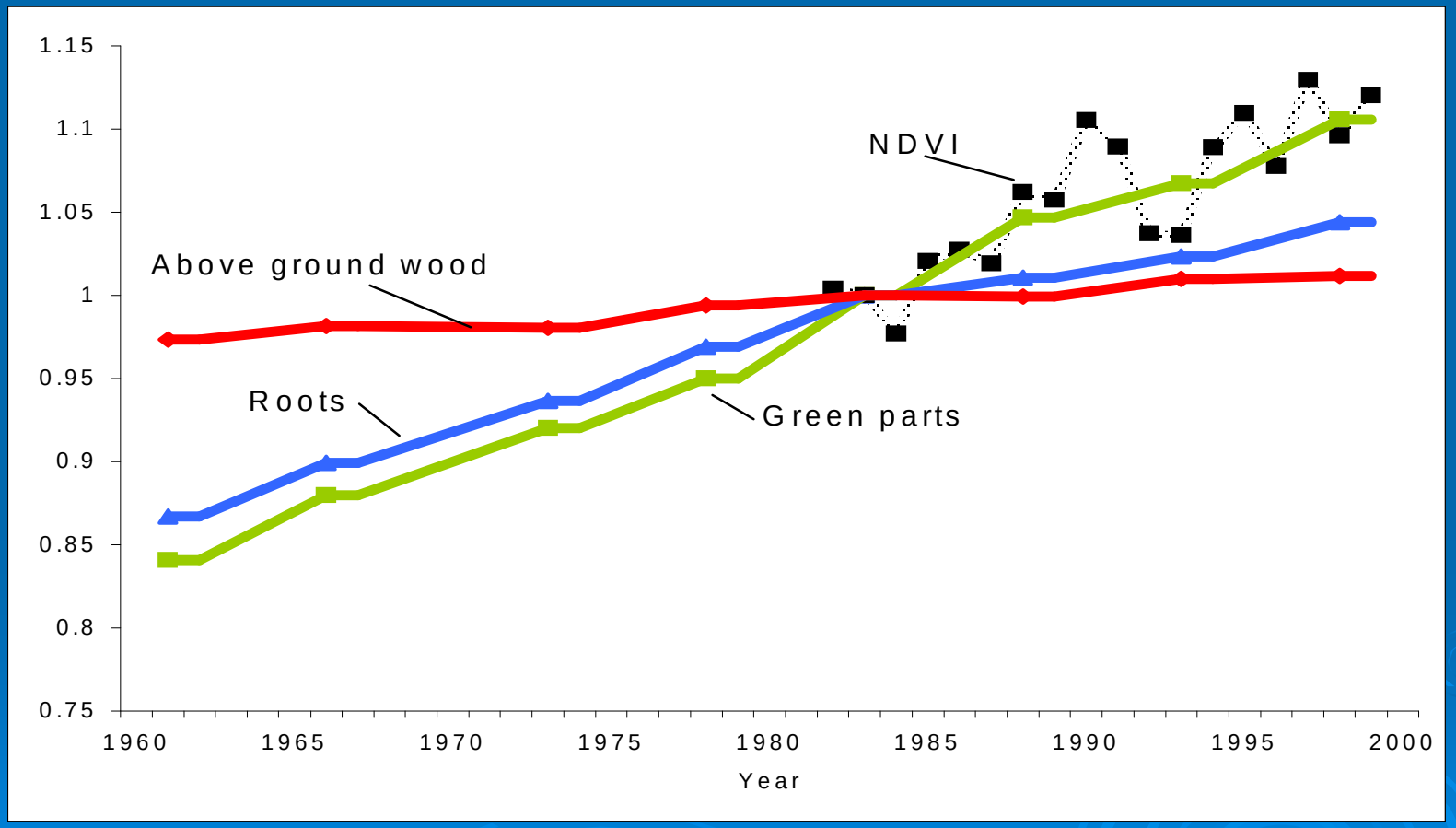
Correlation Between CN Ratio in the Upper Layer of the Soil and Mean Annual Nitrous Oxide Emissions



Acclimation of boreal and temperate forests?



Изменение структуры фитомассы в лесах России в 1961-1998



Средняя плотность фракций фитомассы (отношение массы фракции к запасу древостоя): красный – надземная древестна; голубой – корни; зеленый – хвоя и лисья (значения нормализованы к данным 1983 года)