Notes from Breakout Group "Process Studies and Biogeochemical Modeling (land)"

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The group addressed the following 3 questions:

1. How will the information be incorporated into the integrated analysis?
2. What needs to be measured (long term, short term, manipulations)?
3. What are the criteria for prioritizing and selecting the process studies to be included in the NACP?

Question 1 – What is our integrating strategy?

INTEGRATION STRATEGY FOR LAND PROCESSES

Linking across space and time domains (bottom-up; top-down; fast-slow-long)
Coupling atmospheric, environmental, and human dynamics on ecosystem function and structure

Model Analysis is a fundamental component of integration

Dynamic coupling of human modified ecosystem dynamics with atmospheric dynamics

Development of data analytical strategy for synthesis

SCALING ACROSS SPACE OR SITES (NESTED DESIGN)

NA meso-k sites to bridge the gap between intensive (eg towers) and extensive (eg FIA/NRI) observations

NPP, estimate C exchange, C stocks, climate data, ancillary data (vegetation structure, soil moisture, temperature, ppt, N-dep, land use, soil properties, development, topography)

SCALING ACROSS PROCESSES (TIME)

Develop process studies for scaling processes for integration

* linking across scale of fast and slow processes
  * provide characteristic biophysical with Ps and Ra+Rh and disturbance events
  * provide observations that are consistent across the scale of observations

Scaling using multiple-tracers and isotopes

Incorporate social dimension related to urban/development patterns/demographics/industry that influence ecosystem structure and processes (eg, woody encroachment, fire, etc)

DISTINGUISH NEE AND NBP (NET C EXCHANGE) ALONG GRADIENTS

climate
inter-annual and seasonal
disturbance: land use, fire, pests, etc

WHAT ARE THE PARAMETERS THAT ARE NEEDED FOR INTEGRATED MODELING

Linking the data to models and models to data (use of extensive characteristics for process and spatial scaling, e.g., soil texture, vegetation type, topography, etc)

Use of remote sensing and other extensive observations for integration of temporal and spatial dynamics of net C exchanges

Identify points for integration across process

Priority short-term needs:

Common data sets to initialize models for net C exchange that provide information on state conditions of C pools, land use histories, soil properties, and climate.

Develop a terrestrial carbon modeling consortium for continental scale computation of the NEE to facilitate a common data, computational and analytical framework and to facilitate model experiments to test sensitivity of net C exchange to environmental factors including climate, N deposition, land use change, urban environmental conditions etc

Develop appropriate diagnostics for evaluating seasonal and interannual NEE/NBP relative to flux time-series

Model experiments to test sensitivity of net C exchange to environmental factors including climate, N deposition, land use change, urban environmental conditions etc

Common data interface with atmospheric analysis and biospheric modeling

Wetland modeling and CH4 production and consumption modeling

thoughts on development of insitu measurements for carbon stocks that are needed for initializing models

Question 2. What needs to be measured?

Process Studies and BGC Modelling
What needs to be measured & Missing Pieces

Philosophical Points

- Objective is to get at NEP and NBP. Hence, accurate estimates of absolute *changes* in C pools is probably of greater importance than estimation of the pools themselves.
- Model credibility is an issue when providing results to policymakers. Hence it must be possible to show that diagnostic results are based on real data at some level!
- Past and future changes in the C budget of the continental US are probably dominated by effects of land-use change.
- Data requirements for modeling vary with scale:

- There is great value in being able to model ecosystem processes for a flux-tower site very accurately, but scaling up to larger domains will generally require model simplification.
- Data availability likely to vary with region—particularly when extending the program from the North American domain to the globe.

International Collaboration

Likely to find interest and willingness to cooperate in Mexico and Canada. Some relevant data sets and other initiatives are already under development in both countries.

Omissions from Draft NACP Plan

- Consideration of role of wetland/peatland/tundra/permafrost ecosystems. These ecosystems occupy a significant proportion of land area in Canada and Alaska: even where NEP is small, the total C sink they create is likely to be important. Major source of methane. They are also potentially very sensitive to climate warming. Some specific problems in measurements and modeling.
- Rolling and mountainous terrain covers about 50% of the continental USA (and in North America?), but is seriously under-represented in the FluxNet network. This omission could lead to serious errors in estimates of the spatially integrated C budget. Also presents serious problems in modeling as well as measurement. (But some LTER sites have been established in such terrain and would likely provide some useful information.)
- Importance of changes in land-use, land management practices (e.g., shifts in cultivation practices over the 20^{th} century), and natural disturbance effects. It may be possible to determine areas affected by some of these changes reasonably accurately, but the C losses associated with such changes are largely unknown. Age-class dynamics in forests (and other ecosystems?) are also important, and will require particular attention.
- Adequate treatment of soil respiration—the second largest C flux. Spatial and temporal variability in soil conditions, including C content, and sensitivity to changes in temperature and moisture make this a very difficult variable to measure over large regions.
- Lateral transfers of C across the "boundaries of the box", e.g. aquatic transport of dissolved and particulate C between terrestrial and ocean systems; commercial exports/imports of food and wood products to other geographic regions.
- Woody encroachment in some regions of USA. Can this be detected by Landsat?
- "Human-dominated" systems—e.g., feedlots, urban regions. Should these be treated as ecosystems or as point sources of GHGs?

Measurements/Datasets

Intensively measured sites:
Existing FluxNet network provides appropriate data. Expanding this network into more regions would be desirable. May be possible to enhance some existing LTER sites, e.g., by installing flux towers, but this potential is limited by the stringent site requirements needed to make meaningful eddy covariance (EC) measurements.

Semi-arid ecosystems are missing from the intensive site network, but this deficiency might be corrected to some extent by including some 11 sites run by ARS on rangelands. Fluxes have been measured routinely at these sites for 3-4 years, but some calibration of the measurement systems (Bowen Ratio) against EC measurements of FluxNet standard is required.

Medium intensity sites:
Chris Field suggested there should be about 1000 such sites spread across the study domain. These sites could perhaps be selected from existing FIA and NRI networks. In some cases, past or ongoing studies carried out at these sites may already provide much of the data needed for NACP objectives.

LAI measurements routinely required at these medium intensity sites?

Soil C flux measurements needed at these sites: sampling must account for spatial and temporal variability. Will be labour intensive and expensive. Can this procedure be automated? There is an important need for a cheap accurate and portable soil C flux measurement system.

Emphasize need for unified approach to data management, with appropriate QA/QC. (This also applies to intensively managed sites, but data management issues are already addressed within FluxNet).

Large-scale integration:
Some data sets that will be needed but which are not presently available:

- High resolution (10 x 10 km??) climatological and meteorological (daily/hourly?) fields.
- Remote sensing products: [Clearly crucial but not discussed in detail!] E.g., maps of LAI and phenology?
- Historical time-series maps of land use and disturbances derived from Landsat imagery 1970-present day. (Should be available fairly quickly?)

Question 3. What are criteria for selecting sites?

Minutes and Suggestions on Site Selection for the Land Workshop Group of the NACP (9/06/01) *as recorded by Ronald Follett.*

Site selection is one of the most important considerations in the conduct of the terrestrial component of the NACP. The workshop breakout group devoted considerable time to this topic, including private discussions and phone calls following the meeting. Among the important criteria for site selection are the following considerations:

Criteria for Site Selection:

1. It is important that for more intensive sites that there be a history of collaboration and cooperation as well as the ability to do scaling, including on the temporal scale.
2. It will be important that the site selection process be coordinated with atmospheric scientists. Some sites will be better suited to "small towers" (here defined as bowen ratio or eddy diffusion equipment) and others to "tall towers" (such as in the Ameriflux network).
3. There will need to be a dedicated effort to data collection and interpretation mechanisms for data consolidation.
4. More intensive sites must have more stringent criteria for the types and intensity of data that is collected.
5. Intermediate and low intensity sites will need to adapt more statistical approaches to aid in the interpretation of data.
6. Finally, there was considerable discussion of how landscape units might be defined. Such units need to extend across the borders between Canada, the United States, and Mexico. In fact such landscape units are, or are nearing, completion in the form of "ecological regions" as described by McMahon et al. 2001 along with related efforts described by Ecological Working Group 1995, and Pater et al. 1998). Specifically these efforts tie directly into the Ecological Framework for Canada, with similar types of coordination with Mexico. Within the US, these efforts mesh with the Major Land Resource Areas (MLRA's) and consequently also with the NRI. Because US Forest Service Personnel are active on the team, it is also assumed that the FIA points can also be accommodated within this same ecological region structure.
7. It is recommended that to better coordinate with the Land Management research component of the NACP, that the atmospheric scientists also consider the potential importance of basing the location of towers used in their studies on the ecological region approach described in item 6, above.

Types of Sites:

1 Extensive (low intensity) site network. Such a network may indeed contain perhaps 1000 sites or more and would consist of a network of some type. Two networks that appear to fit this description include the NRI and the FIA site networks. Both currently contain extensive amounts of historical data, are located in a statistical manner on the landscape, and repeated temporal measurements will continue at these sites. Shortcomings of these sites are that, at least the NRI, covers primarily privately owned lands. Thus, the vast areas of non-forested publicly-owned lands is not well covered, unless the US Bureau of Land Management has some type of inventory network that could also be used. Additionally the measurements taken may not fit well with the NACP data needs. Additionally, the participants in this session are not aware of similar networks in Canada or Mexico, although they may well exist.

2 Intermediate intensity site network. Such a network could consist of a statistical subset of the NRI and/or FIA that could be sampled more frequently

and that perhaps that could have additional types of data collected that would more nearly address the types of data needs of the NACP program. Other intermediate networks that could likely participate are the many USDA/Agricultural Research Service, Agriculture and Agrifood Canada, and possibly INIFAP research locations in Mexico as well as many of the Universities within the three countries where high quality data is already being collected, often including weather and climate information.

3 Intensive sites network. Such a site network could include nested chronosequences, sites where intensive measurements of the behavior of various signals of interest, ground truth measurements, and climate (perhaps decadal) and seasonal disturbances could be obtained. Such sites could, or already may, have small towers or perhaps could be equipped with additional small towers to supplement atmospheric information that is otherwise already planned or being collected.

Intensive sites can be located and participate in research on processes. Concerning the presence of either small or tall towers in cropland areas of the corn belt, there are eddy diffusion towers already located with the USDA/ARS lab in Ames, IA and with the University of NE in Lincoln, NE. In addition there is a desire on the part of a scientist at Michigan State Univ. to add the capability of an eddy diffusion tower to his research program. Atmospheric scientist at this meeting indicated interest in having some input on where to locate a tall tower. In either IA or NE there is good potential for scientific collaboration. Further discussion of the most interested atmospheric scientists with key members of the Land Management workshop planning group is advised before final selection.

There is need to link at least the intermediate and intensive sites to some type of time scale. There may also be some desirability to considering clustering of such sites. Site selection may have the potential to be model driven or geographically driven. The geographically driven concept should be possible to aid based upon the "ecologic region" approach discussed above. The working group did not identify any models that might be used. Criteria for a model driven approach might include, in addition to criteria discussed above, evaluating the most critical land-based (soil, plant, available plant water) parameters needed to assess fluxes and transport in some of the atmospheric transport models. Other model-based factors would be flux intensities (either source or sink) and understanding why. These are suggestions and there must be the scientific capability available to provide such information at the site(s) selected, but perhaps the suggestion will be useful.

Finally, the sense of the working group was that "experiments are important", and that there is opportunity to influence existing programs to help offset experimental costs.

Respectively submitted,

Ronald F. Follett

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