Development of Research Proposals

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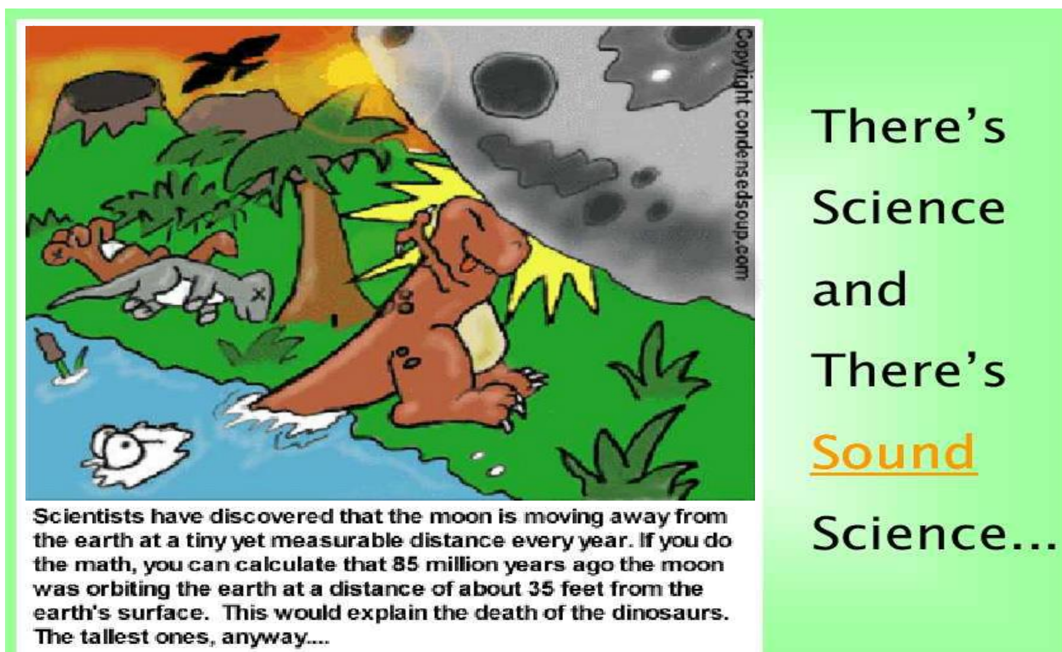
LEES Lab Meeting

Oct. 19, 2016



Structure

Title, Author(s), Affiliations
Summary
Introduction & Objectives
Conceptual Framework
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Experimental Design & Tasks
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Links to online information

Cohesiveness

Definitions for Science and Hypothesis
Class of 2011; DES Grads Seminar

Science

- Science (from Latin: scientia meaning "knowledge") is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe.

- Science is a systematic enterprise of human to understand or better understand the universe. In this enterprise, organized boy of knowledge is acquired through observation of natural phenomena, and/or through experimentation that tries to simulate natural processes under controlled conditions;

- The intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world, through observation and experiment (New Oxford American Dictionary, 2009);

- The study of things which are unknown, through the use of systematic and unbiased observation, in order to bolster knowledge through experimentation, thus allowing one, or many, to share meaningful quantitative results with the greater community.

Definitions for Science and Hypothesis

A hypothesis is a proposition, or set of propositions, set forth as an explanation for the occurrence of some specified group of phenomena, either asserted merely as a provisional conjecture to guide investigation (known as a working hypothesis) or accepted as highly probable in the light of established facts;

- A hypothesis is an educated guess based on observation, i.e., based on your observed phenomenon and established facts, what you think may be the possible answers of your questions. A hypothesis can be proved or disproved;

- A supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation experiment (New Oxford American Dictionary, 2009).

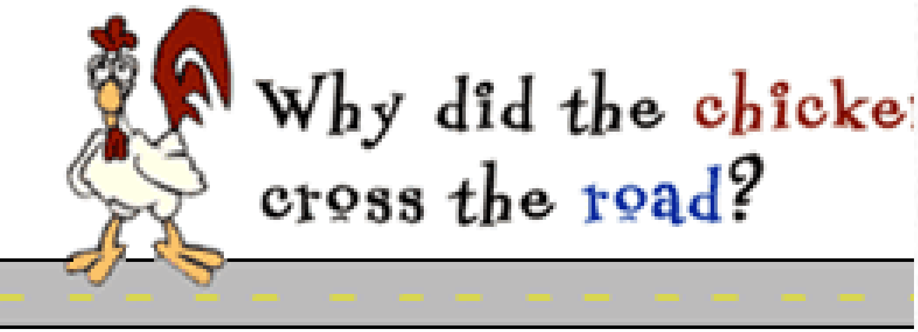
Questions, Hypotheses & Conceptual Framework

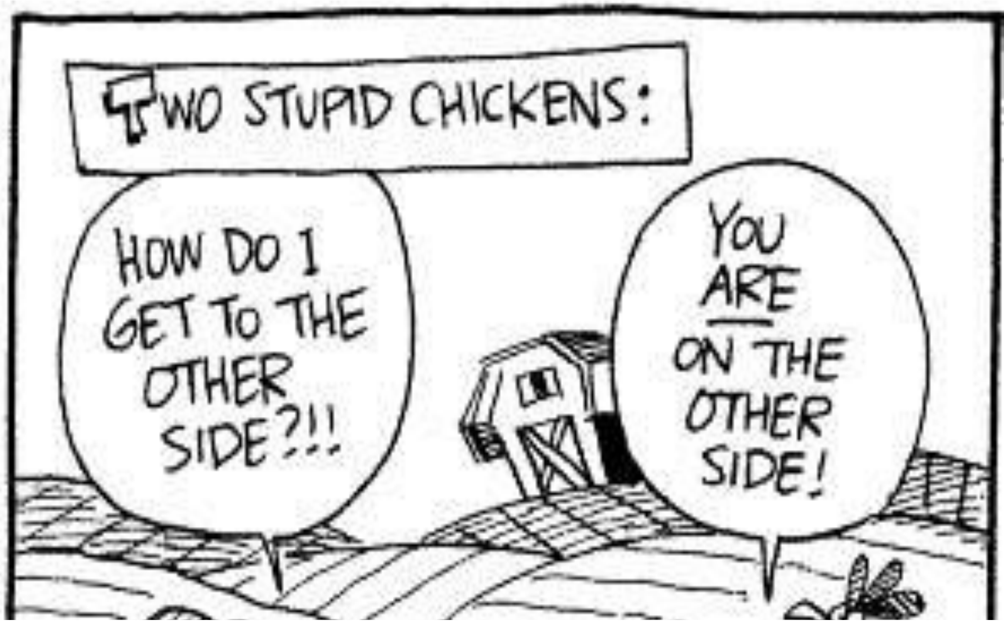
- Modern science is advanced primarily by developing and testing hypotheses!

- A hypothesis isn't an educated guess. It is a tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

- Hypothesis is often too general, not testable, not sound, not interesting, or a statement of truth!

- Developing testable hypotheses and manipulative experiments in landscape research is perhaps the most challenging task in the discipline.





- ✓ To cross or not to cross, that is the question (Shakespeare)
- ✓ Why would he be one a road, I thought chickens lived in the ocean? (Jessica Simpson)
- ✓ This is not about whether inspectors made sure the chicken crossed the road, it's about the willingness of the chicken to cross the road voluntarily (Colin Powell)
- ✓ It was the logical next step after coming down from the trees (Darwin)
- ✓ The news of its crossing has been greatly exaggerated (Mark Twin)

Example I:

Bridgham, S. J. Pastor, and J. Chen. 1997. National Science Foundation

Global Warming and Ecosystem Responses in Peatlands

- Feedback between biotic processes and climate
- Alteration of energy flows through an ecosystem
- Relationship between energy flows & biotic processes

Develop hypotheses

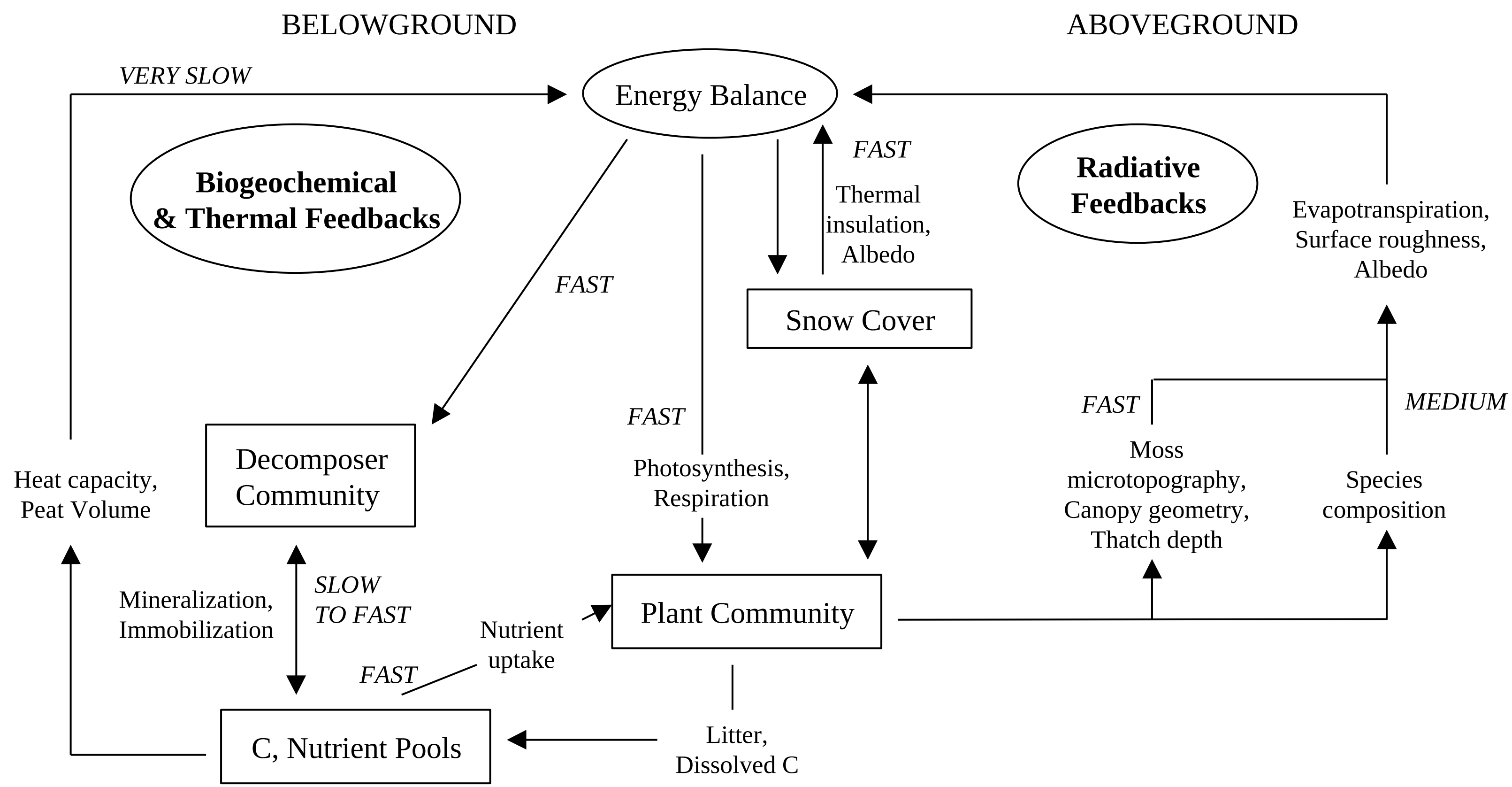
Example 1 (Pastor, Bridgham & Chen, NSF's Biocomplexity)

This complex behavior suggests two hypotheses to be tested by our current mesocosms:

- As the water table rises or falls, peat either accumulates or decays, respectively, until it's thickness *H* reaches a new equilibrium with the water table;

- There will be alternative stable states of peat thickness (*H*) and water-table depth (*W*).

A conceptual model of feedbacks among ecosystem energy balance, plant community structure, snow cover and carbon and nutrient pools in peatlands.



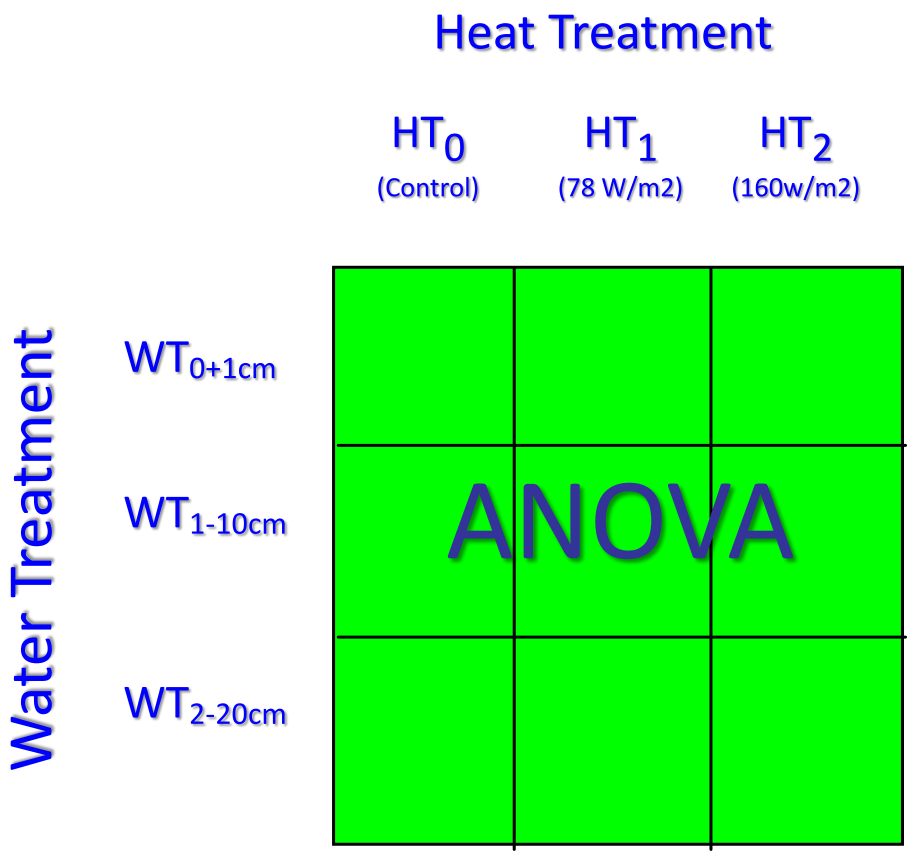
HYPOTHESIS

Climate forcing of heat loading and water-table depth determine plant community and ecosystem structure in northern peatlands, which in turn have a feedback effect on the thermal and radiative energy budgets of the system.

Experimental Design

The Mesocosm Facility

54 minimally disturbed soil monoliths of 2.1 m^2 (85 cm in diameter) surface area, 60-cm depth placed in insulated plastic tanks in a large field.

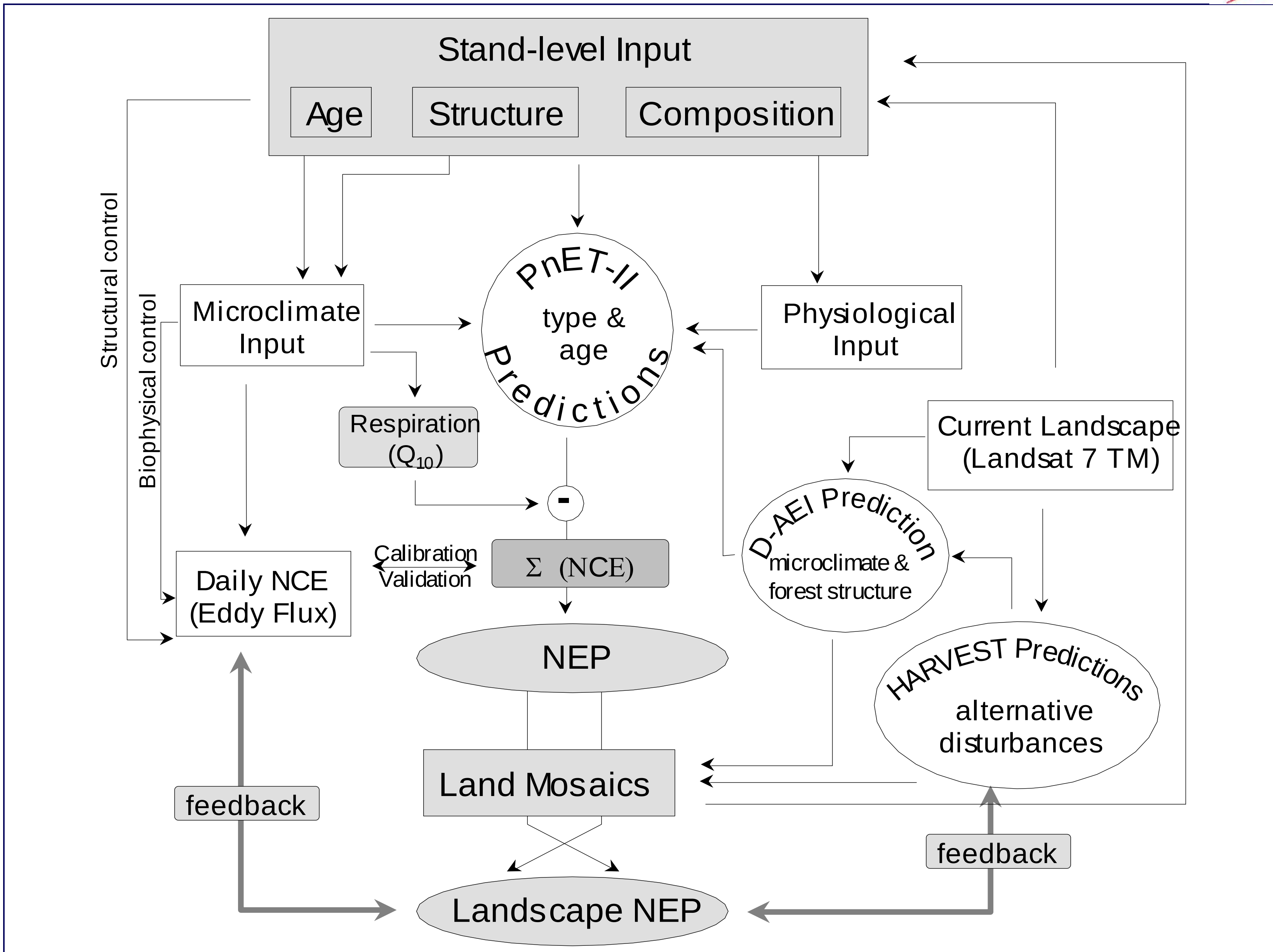


Peatland Types: bog & fen

Example II: Objective

To enhance understanding of landscape-level carbon exchange in disturbed land mosaics, taking into specific consideration of age structure and the area-of-edge-influences (AEI), which can be considerable in many fragmented landscapes. We use a combination of **flux towers, biometric estimation, chamber measurements (P_s & R), RS products and ecosystem modeling.**

Conceptual Framework



Hypothesis

Our central hypothesis is that the cumulative NEP of a landscape is determined by the land mosaic; that is, the various ages and types of ecosystems present, as well as their arrangement.

RESEARCH COMPONENTS

- **Flux Towers:** 2 permanent, 3 mobile (10 ecosystems so far, excluding the JP in UP)
- **Microclimate**: 11 stations
- **Biometric estimation:** overstory, litter, soil, CWD, etc.
- **Landsat TM**: empirical models
- **Modeling (**PnET): soil, vegetation, climate, foliar N, SLW, NDVI/LAI, etc.

Example III: Hypotheses

AEI and AMEI support different functional groups. Their contributions to the cumulative species pool at the landscape level exceeds their proportional area in the landscape. This can be stated as:

$$\frac{Area_i}{\sum_{i=1}^{n} Area_i} \neq \frac{\sum_{Area_i}(species)}{\sum_{i=1}^{n}\left[\sum_{Area_i}(species)\right]}$$

Chen et al. 2001

Example IV: Coupled Natural and Human Systems (CHN) NH on Mongolia Plateau

Objective: to examine and model the interactive changes of the *NS* and *HS* at different temporal and spatial scales for use in recommending plans to increase the success of ecosystem and human adaptation to the changing climate and land use on the Mongolian plateau (Fig. 1). Specifically, we aim to understand how global climate and land-use change regulate both biophysical and socioeconomic functions by exploring the major underlying processes and conducting a vulnerability analysis pertaining to IM, MG, and the plateau.

Chen et al. 2008

Example IV: Coupled Natural & Human Systems (CHN) on Mongolia Plateau

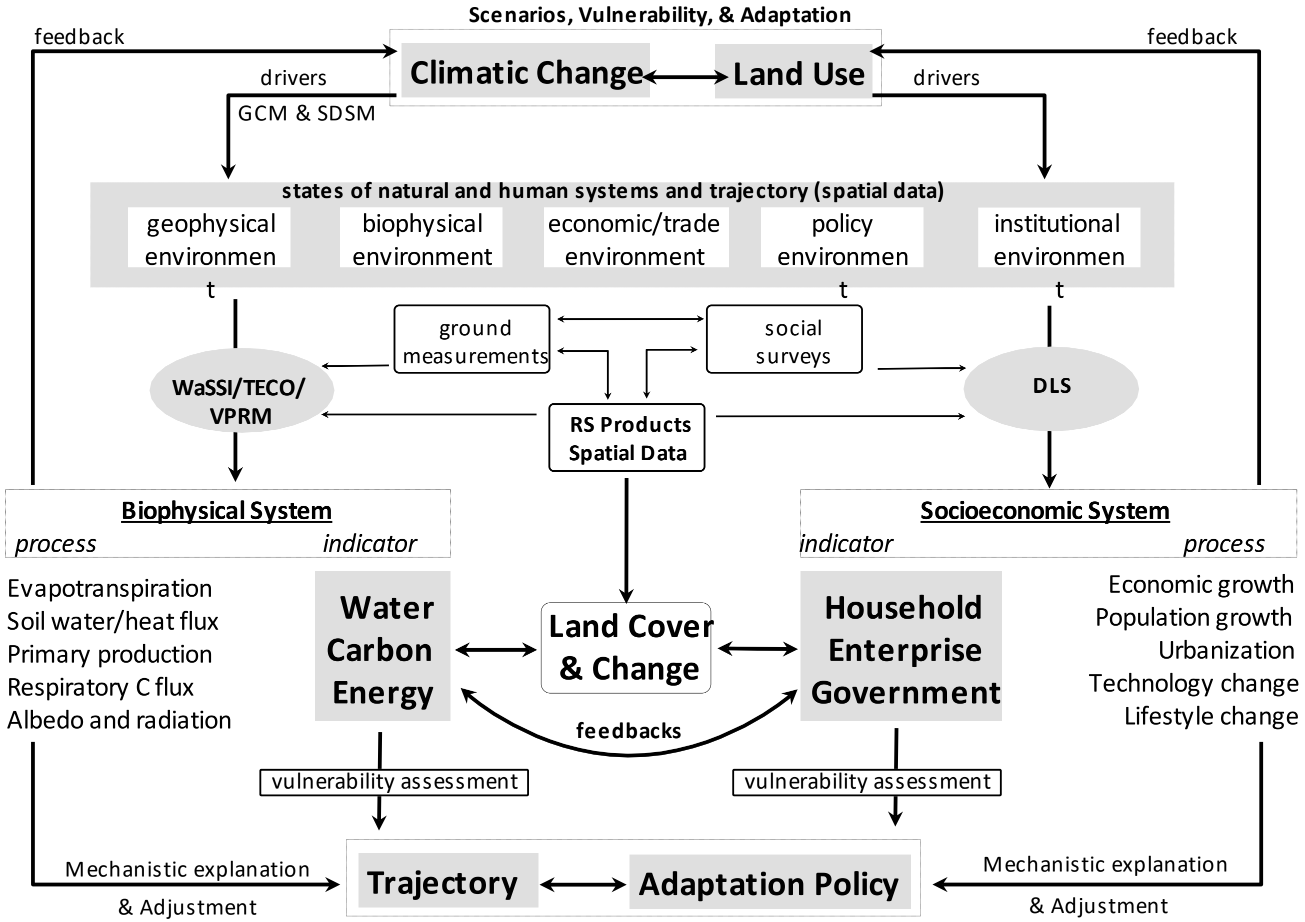


Figure 2. Proposed research components and their linkages for process-based predictions of the ***HS*** and ***NS*** on the Mongolian Plateau using "Land Cover & Change" as the intermediate variable. Five environmental variables through ground/field measurements and/or satellites will be used as the primary input for biophysical (WaSSI/TECO/VPRM) and a socioeconomic (DLS) models to predict system functions. The statistical downscaling modeling (SDSM) will be used to predict future local climate (county level) from GCM predictions. Vulnerability analysis will be performed using Bayesian models for trajectory and developing adaptation plans.

Chen et al. 2008

Example IV: CNH on Mongolia Plateau

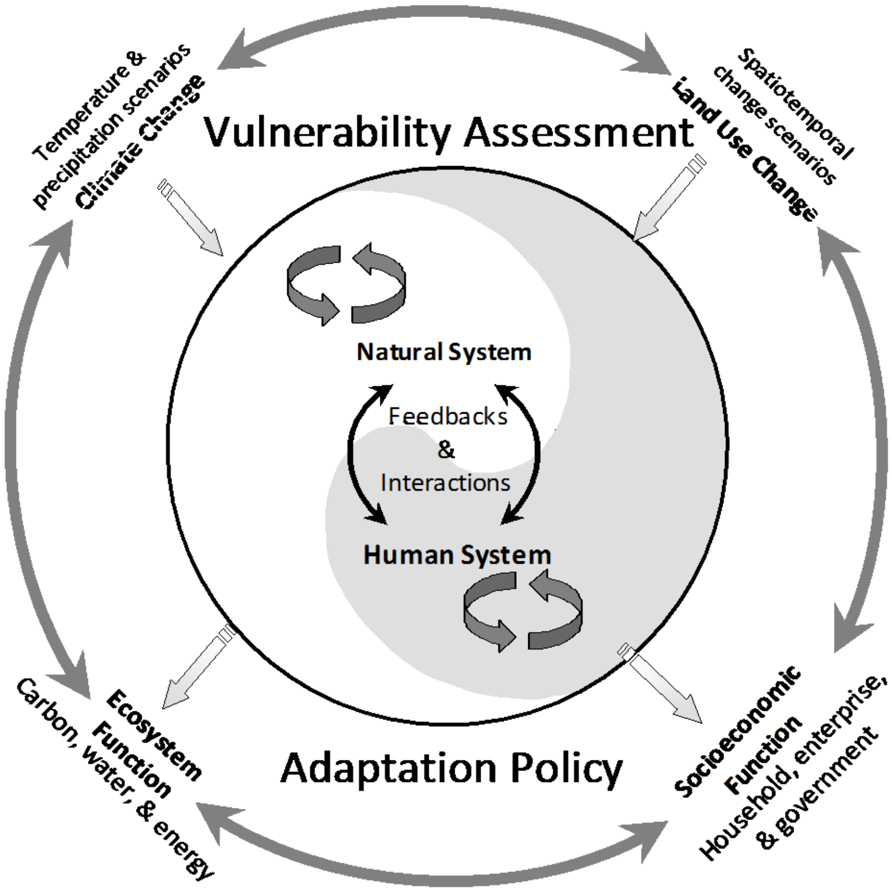


Figure 1. Conceptual framework to examine the coupled effects of climatic change (variability) and socioeconomic shifts on the interactions and feedbacks within and between the ***HS*** and ***NS***.

Chen et al. 2008

Example V: CHEMS (USA vs China)

- Conceptual framework for IMPACT-CHEMS. (a) Environmental sustainability is a function of interactions between coupled human (H) and environmental (E) systems, which co-evolve as balanced networks driven by external drivers. (b) CHEMS in the USA and China will be contrasted along H-E gradients and at multiple spatial and temporal scales. (c) Sustainability is achievable only if a balance between H-E systems is maintained; if H-E thresholds are exceeded, the system becomes dysfunctional.

- Environmental sustainability and the function, structure and resilience to global change of CHEMS will vary along gradients of changing biophysical and socioeconomic characteristics, from regional to national scales (Fig.1b).

Chen et al. 2011

Example V: CHEMS/PIRE proposal

Impact of drivers: How will changes in drivers (e.g., climate change, technological advancements, institutional shifts, land use policies, education, human demography, market access) impact the environmental sustainability of CHEMS (urban, agricultural, natural) in the USA and China?

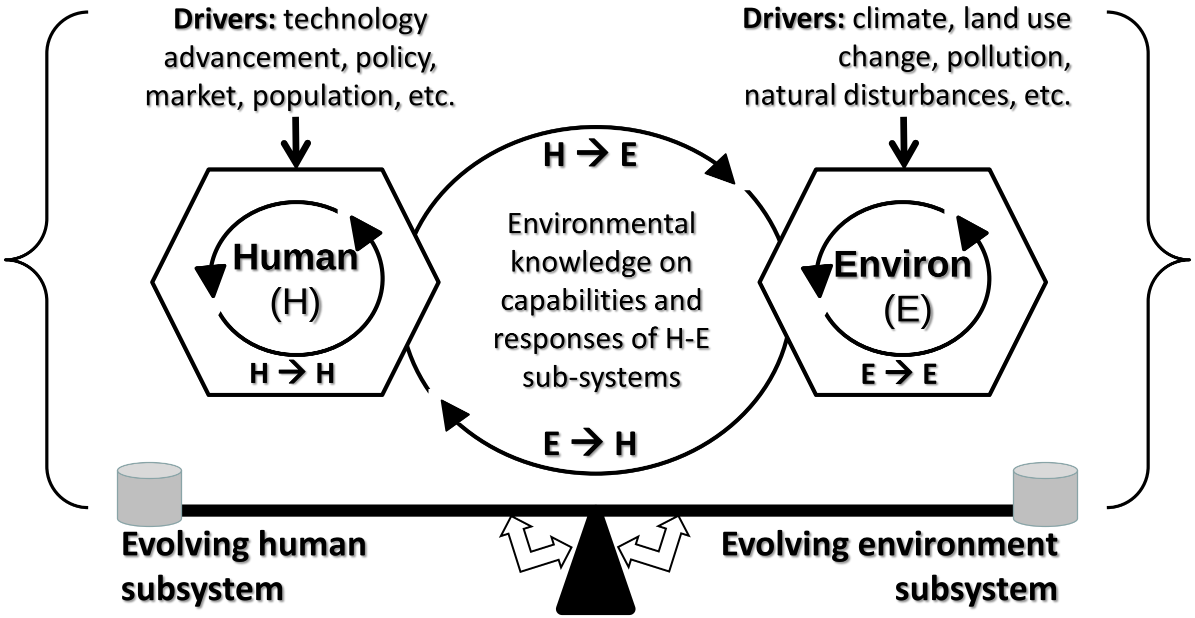
Impact of 'slow' versus 'fast' variables: Inherent to the structure and functioning of CHEMS are slow variables and their thresholds. For example, crop yield is a fast variable because it changes year to year; in contrast, slow variables like soil fertility and technological knowledge are better indicators as to whether a CHEMS region is susceptible to future drought shocks. A slow variable at one scale (e.g. debt to equity ratio or forest cover) may be a fast variable when considered at a regional scale where they are nested within other related 'slower' variables such as interest rates or land use patterns.

Integrated assessment: What will likely be the most serious threats of global environmental change to the sustainability of CHEMS in the next 20 years? What will constitute sound adaptation strategies for achieving environmental sustainability in the two countries under rapid global changes? To answer such questions requires that we integrate scientific knowledge of all types (H-E) to accurately represent and analyze data in a holistic, comparative manner. We will use integrated assessment (IA) methodologies. IA involves trans-disciplinary knowledge so that all relevant components of an H-S system are considered for the benefit of stakeholders and decision-makers. We will develop a family of models to understand the mechanisms of the CHEMS functions (within and between H-E subsystems) based on the socioeconomic and ecological trajectories of the past and future in USA and China.

Chen et al. 2011

Example V: CHEMS (USA vs China)

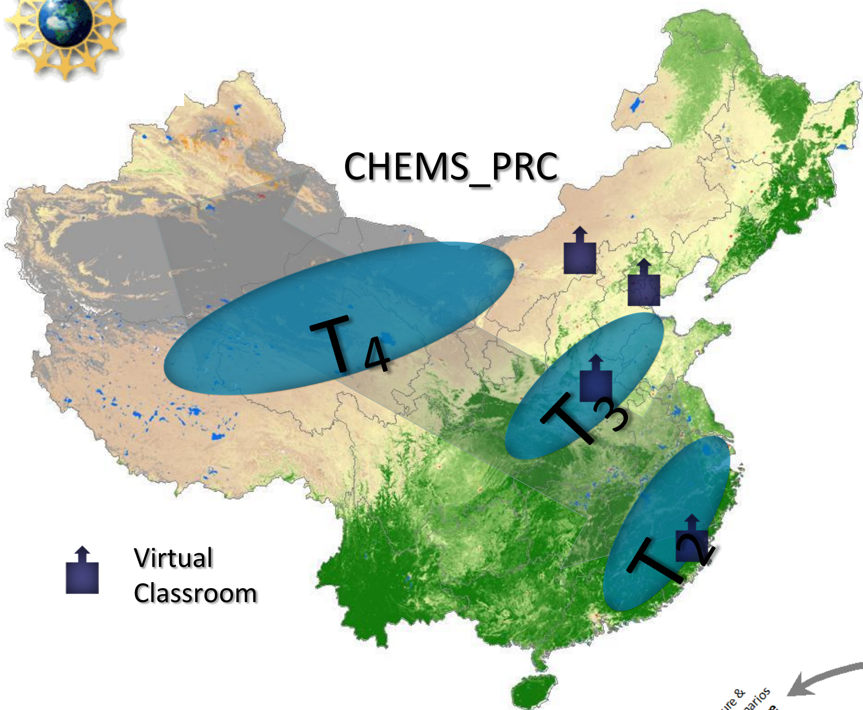
Education
Income
Household
Institutions
Networking
House Size
Life Expectancy
Gini Coefficient
Communication
...

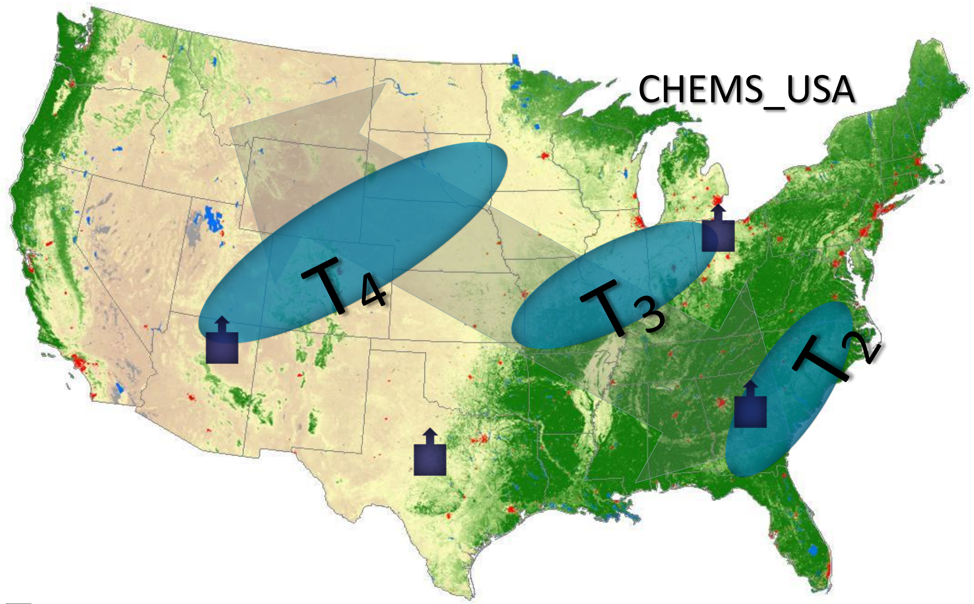


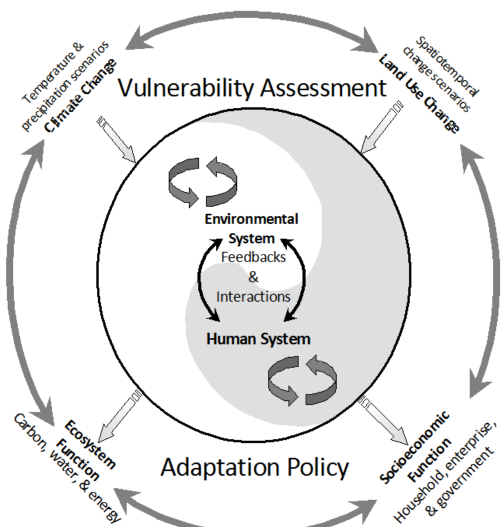
Vulnerability
Ecosystem Production,
Water Supply
Air Quality
Food Production
Bioenergy
GHG Reduction
Forest/grassland cover
Green space per capita
...

Our working ***hypothesis*** is that environmental sustainability and the function, structure and resilience to global change of CHEMS will vary along gradients of changing biophysical and socioeconomic characteristics, from regional to national scales

Coupled Human and Environment MacroSystem (CHEMS): USA vs China



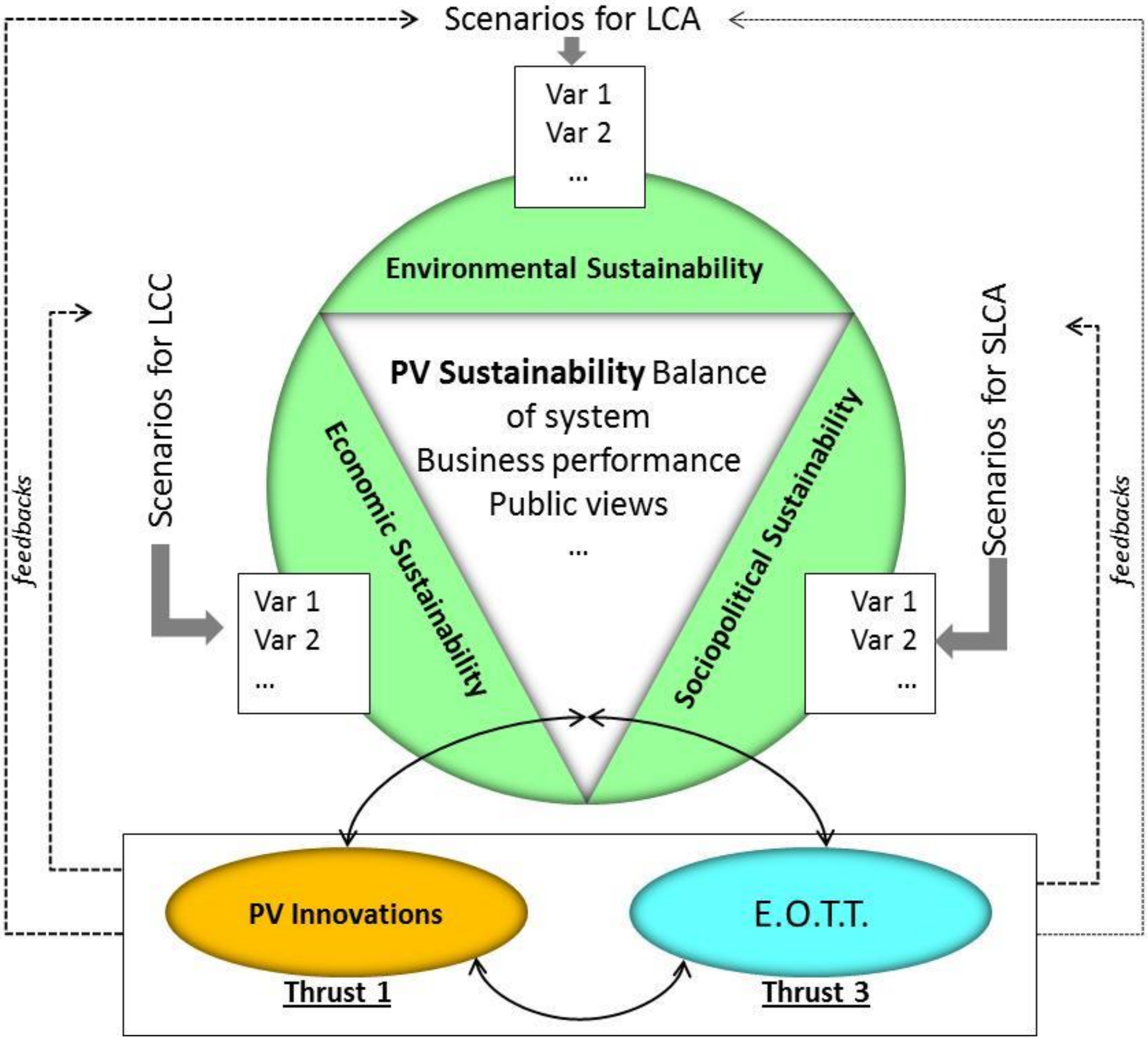




RESEARCH PARTNERSHIP
Urban Development (T_2)
Agricultural & Food (T_3)
Natural Res. & water (T_4)

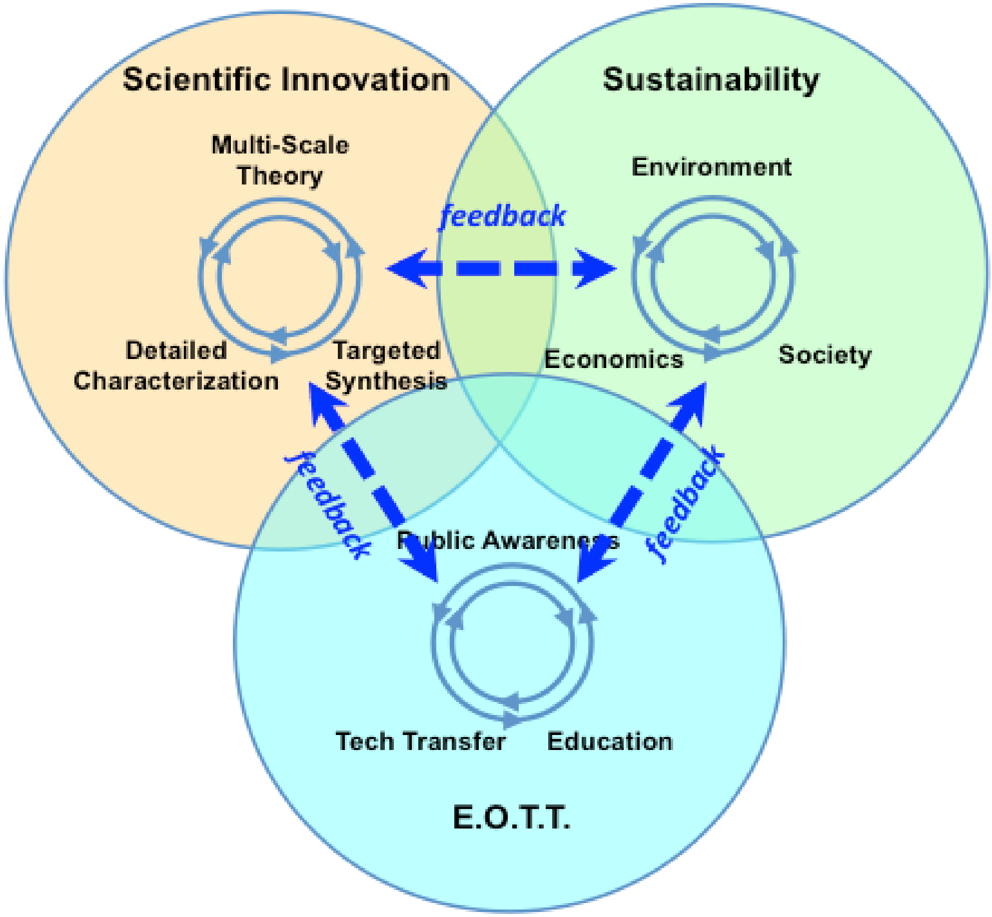
EDUCATION PARTNERSHIP
Global Change Biology
Sustainable Science
Landscape Ecology
...

Example VI: The Conceptual Framework for Sustainable PV System



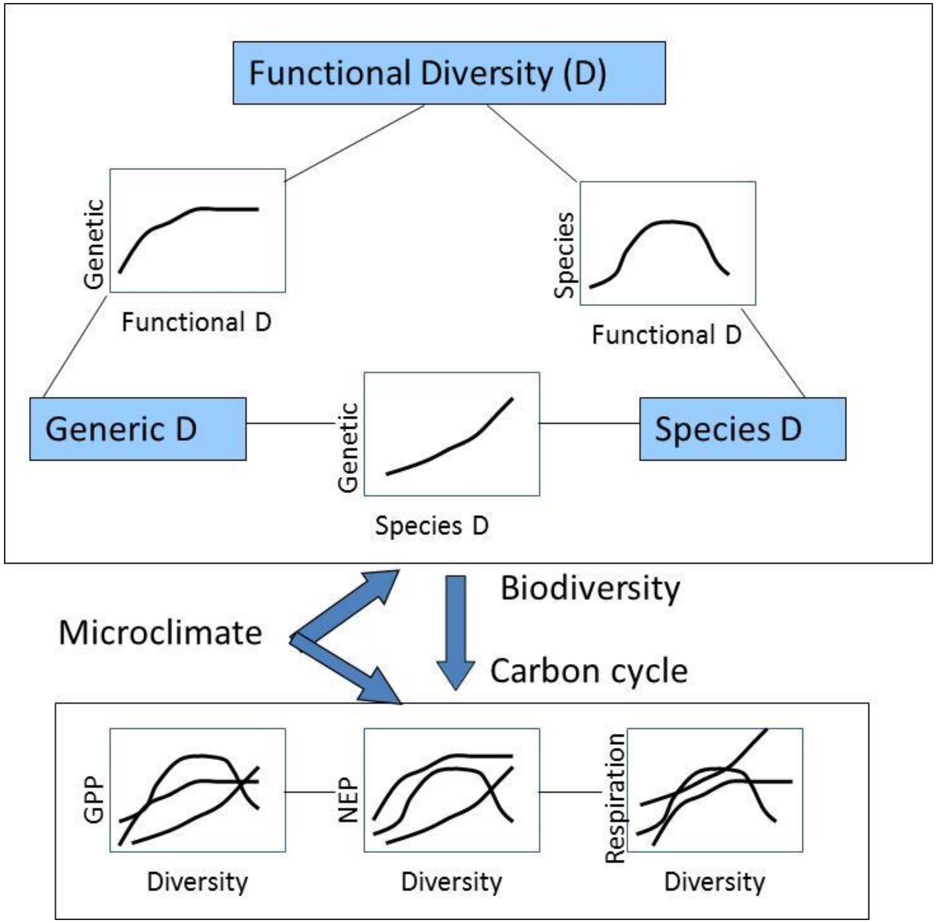
Example VI: The Conceptual Framework for Sustainable PV System

We hypothesize that the trade-offs among the options of sustainable aspects may be off-balance or might appear to compete over short timelines but could positively correlate over long time scales. This transformative research will assure the development of a truly sustainable PV technolo



Example VII: Biodiversity and ecosystem functions

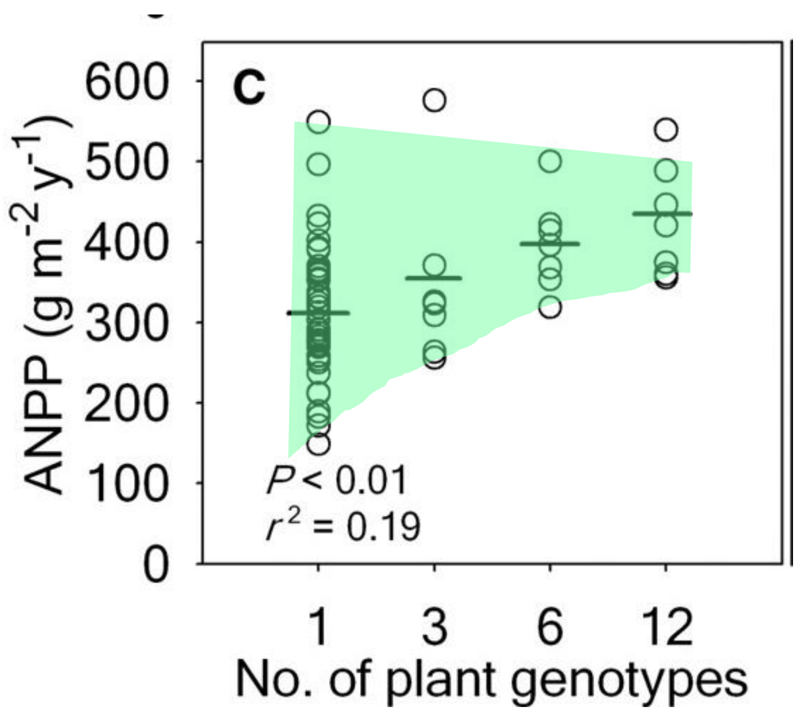
Conceptual framework and hypotheses. ***Gd***, ***Sd***, and ***Fd*** interact each other. The metrics of biodiversity affect metrics of the carbon cycle, resulting in complex matrices of causes and consequences between biodiversity, the carbon cycle and climatic/soil drivers.



Tang et al. declined

Example VII: Biodiversity and ecosystem functions

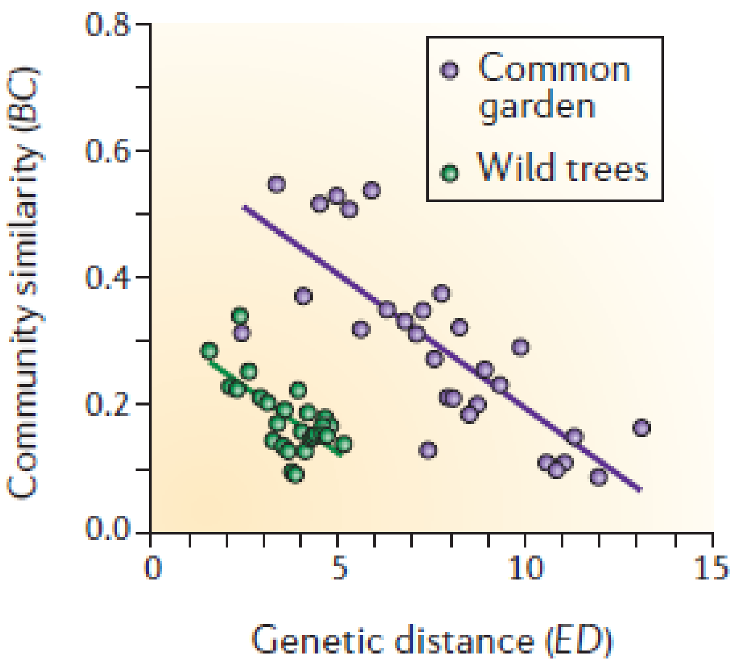
Relationship between population-level plant genotypic diversity and ecosystem production

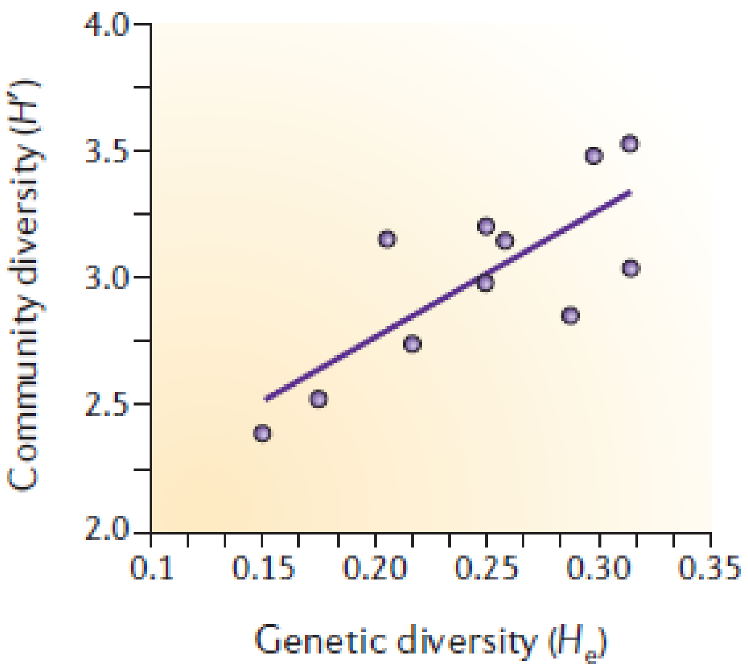


Published by AAAS

Example VII: Biodiversity and ecosystem functions

Relationship between community complexity and genetic diversity (Whitham *et al*. 2006). The intra-relationships among the diversity dimensions as well as their roles in regulating carbon cycles will be the focus of this study.





Objective

To understand how forest biodiversity, defined here as genetic diversity, species diversity, and functional diversity, co-exists and changes across temperate deciduous forests and regulates key elements of carbon cycles.

The overarching hypothesis is that ecosystem production and biomass, as results of various carbon cycling processes, will approach the maximum levels through optimizing the multiple dimensions of genetic (***Gd***), species (***Sd***), and functional (***Fd***) diversity. Specifically, we hypothesize that:

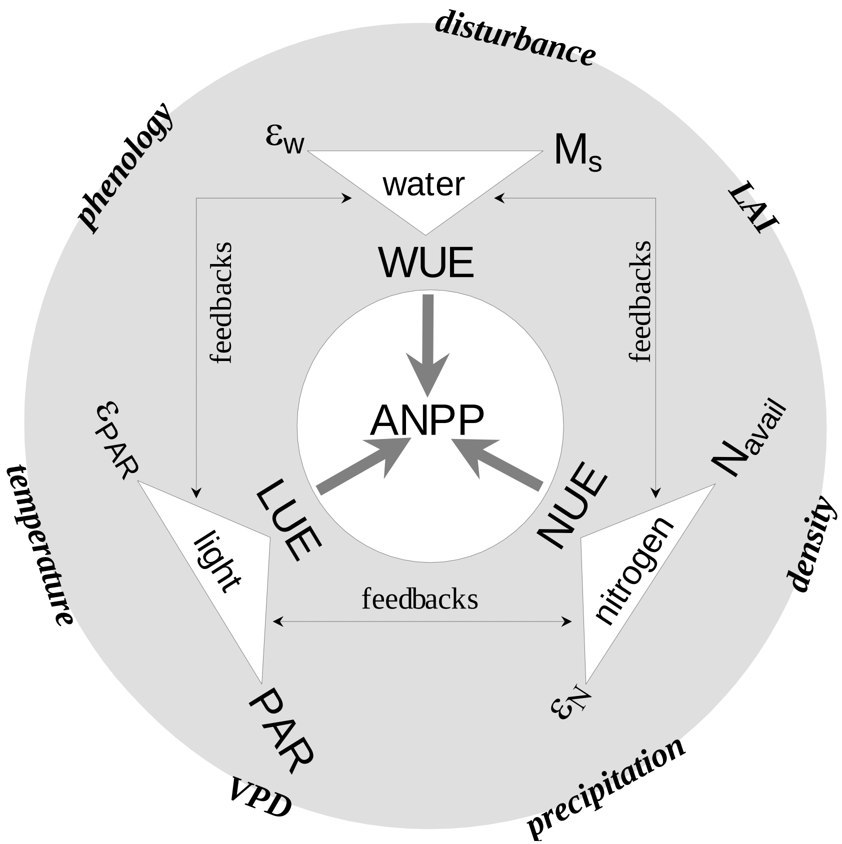
H1: There exist positive, non-linear relationships among the elements of the three diversity matrices. These relationships are not the same at species, community, or cross-community scales;

H2: There exist positive relationships between each dimension of biodiversity and ecosystem productivity, but each dimension plays a different role in regulating productivity at the community scale;

H3: There exist two thresholds of biodiversity when the positive relationship between biodiversity and productivity is strongest between the thresholds; and

H4: The above relationships are coupled with much higher variation when diversity is low. For example, a positive relationship between aboveground productivity (ANPP) and genetic diversity has been found, but it is not clear why the variation of ANPP at low diversity is much higher (Fig. 2).

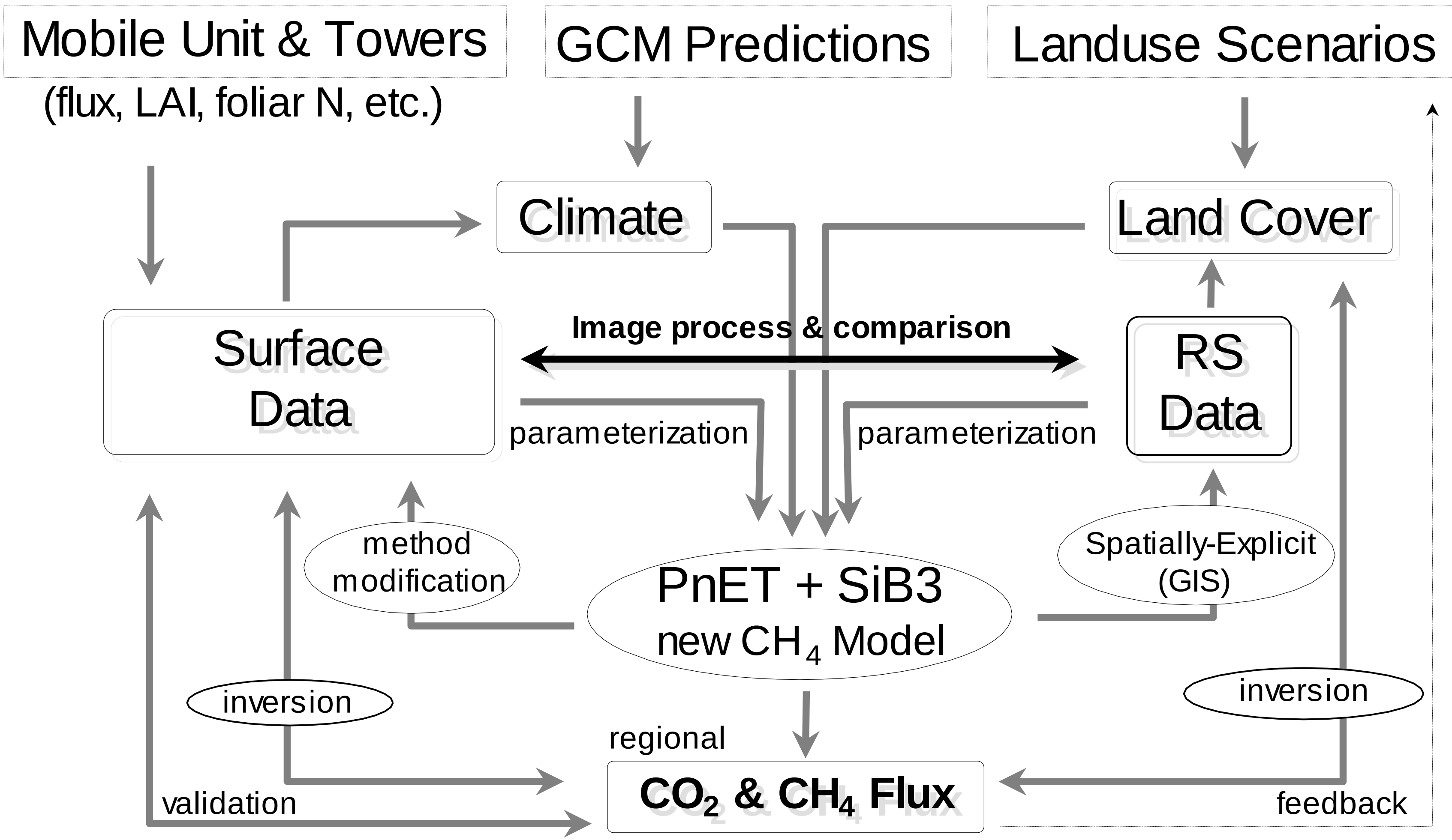
State your study objectives and develop a conceptual framework



A new concept of resource use and limitation by Chen will be applied. Within the matrix of the biophysical environment (soil, vegetation and microclimate), the resource use matrix of [ε, RUE, R_{avail}] and their complex interactions determine the magnitude and dynamics of production. For each type of resource, there exist complex interactions among [ε, RUE, R_{avail}] at various temporal scales. Alteration of any element of the resource use matrix will trigger changes in other elements. We will examine the feedback among the elements with a focus on water, light and nitrogen (N).

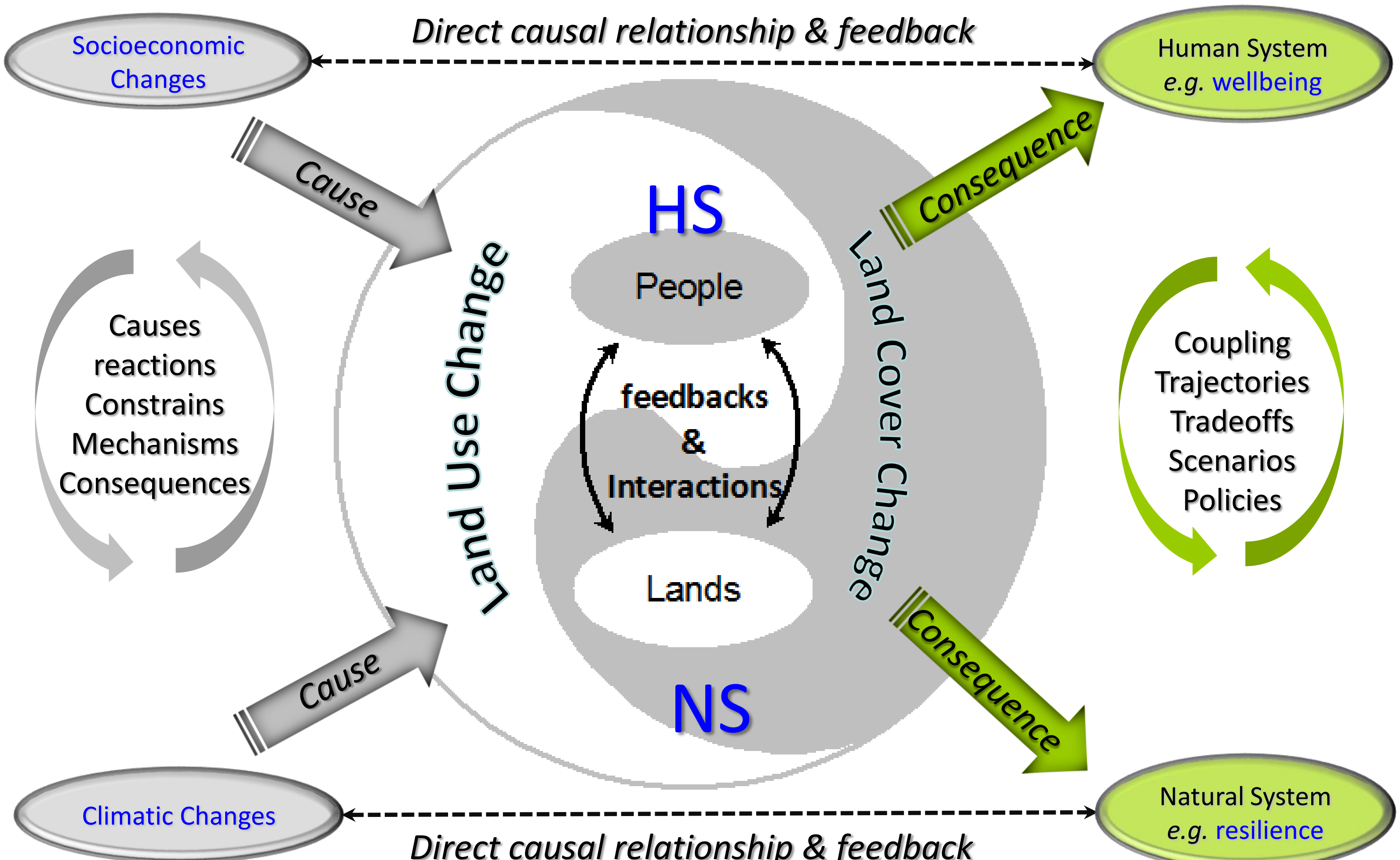
Chen 2008

Another example of conceptual framework

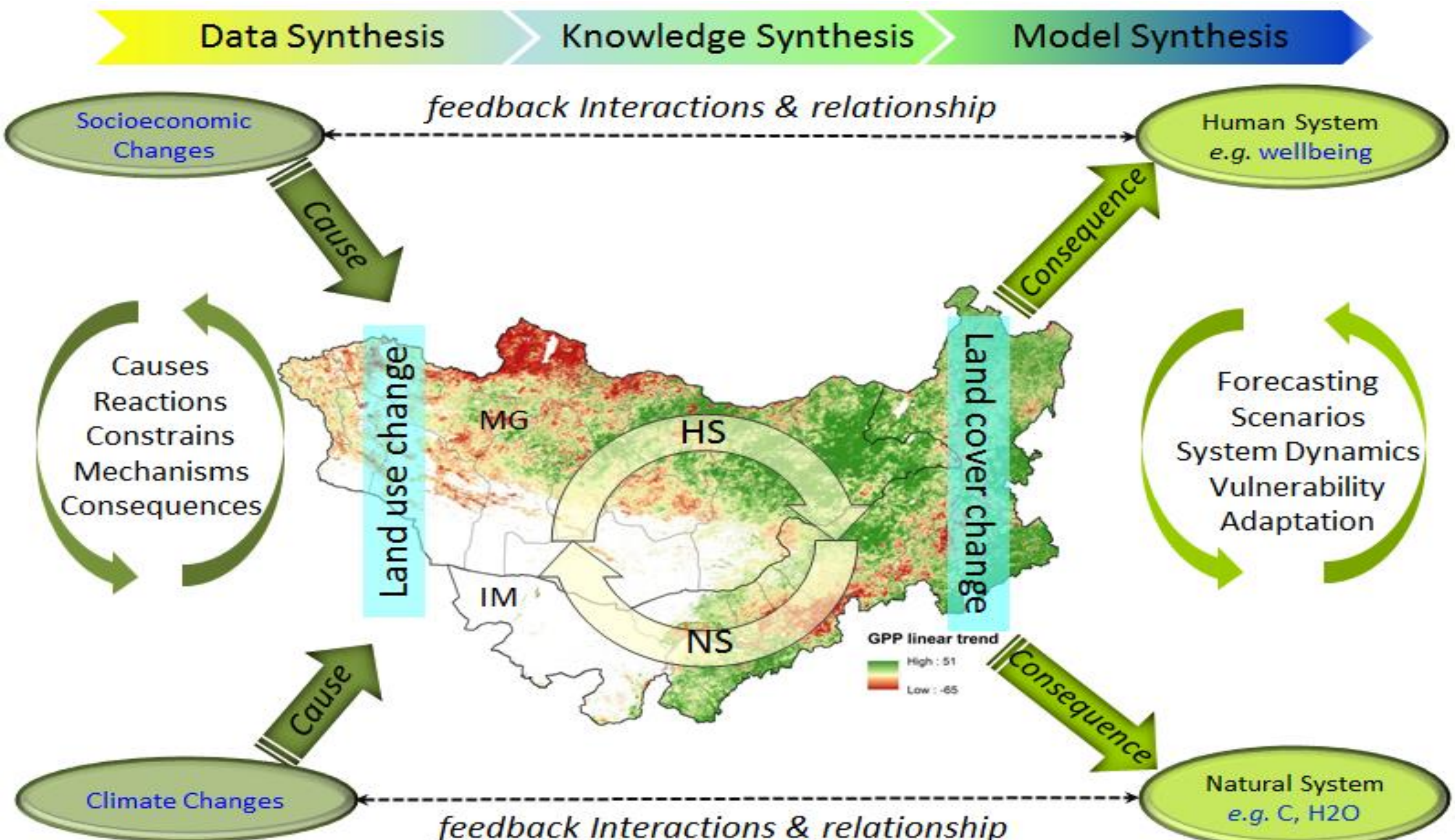


Chen et al. 2003

Drivers and Functions as Moving Targets (i.e. focus on the changes)



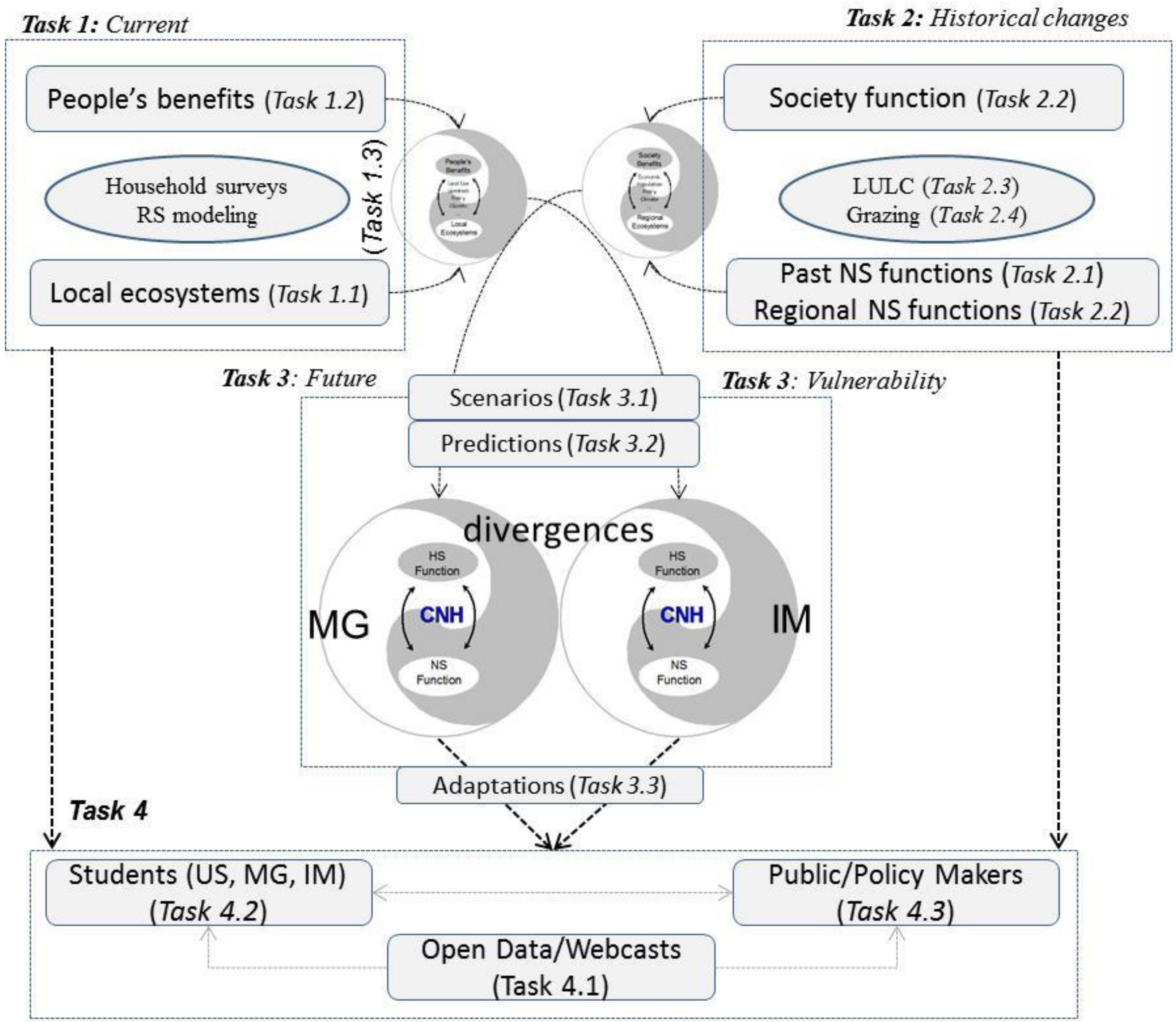
Develop hypotheses: CNH conceptual framework to understand the drivers, mechanisms, and consequences of socioeconomic and physical **changes** on the functional **changes** of the HS and NS on the Plateau. LUC and LCC will be considered as the intermediate variables facilitating the causal.



Develop hypotheses – justifications

Hypotheses: The fundamental household behaviors are reflected in production and consumption. Household is a rational individual. The large biophysical variation in space and time would have significant impacts on people (e.g., household socioeconomic activities) including land and other resource use (e.g., grazing, farming, settlement, consumption, socioeconomic structure, and institutional arrangement of the society). However, people are not simply just adaptive but also actively modify and change the biophysical landscape to meet the needs. Households act rationally, both individually and collectively, to adjust production and consumption in response to the changes and institutional arrangement.

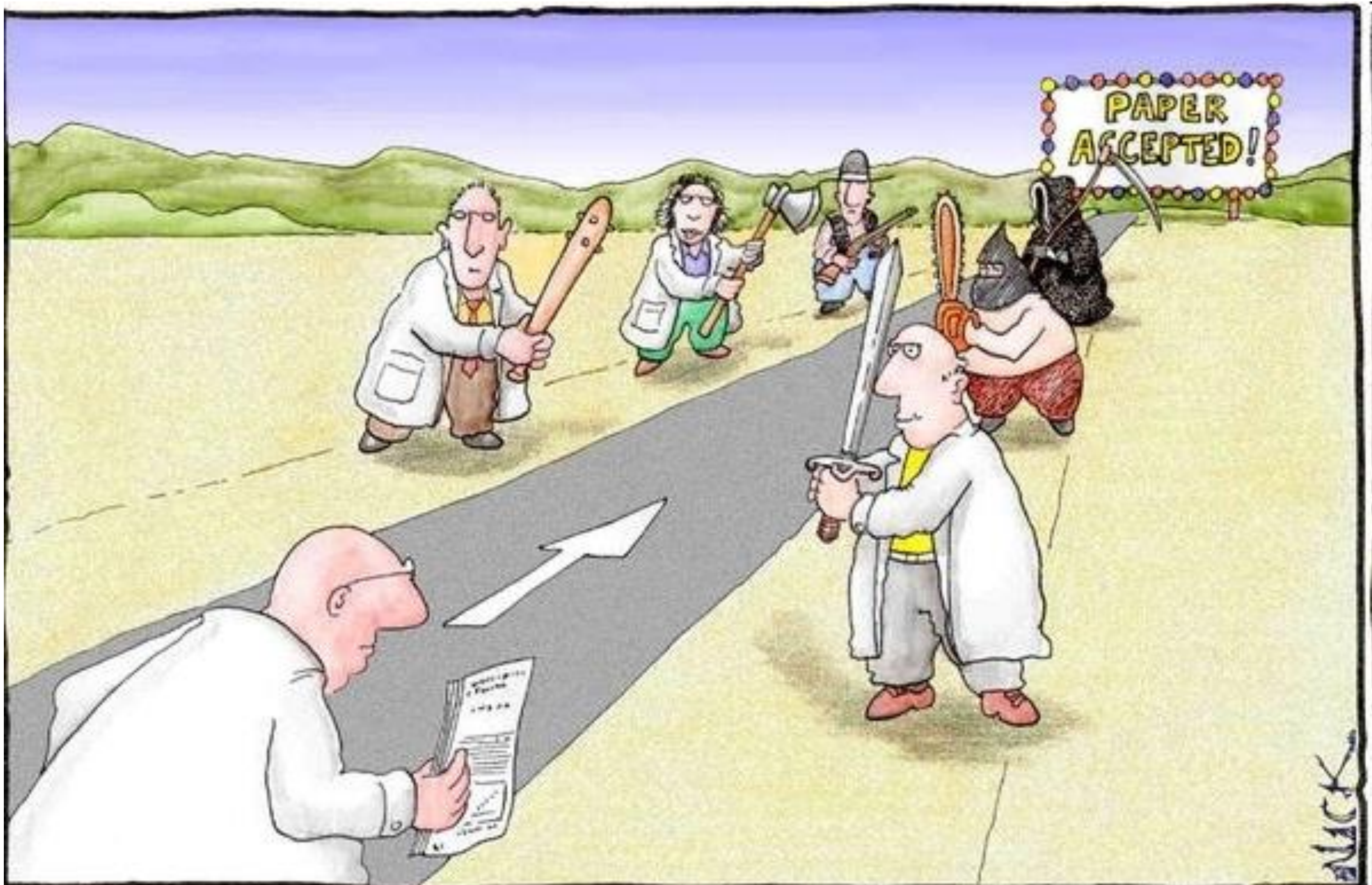
Working flowchart for understanding the status and changes of CNH functions



Review Process

- Review is designed to be as fair as possible to the applicants.
- Reviewers and panel members include diverse expertise, gender, seniority, region, institutions, etc.
- Some of your reviewers or panel members know your research well.
- Supporters in a panel may not be important, but those who are against your proposal critical (i.e., professional image and network).

Because of fierce competitions, one of the assignments is indeed to find a reason to kill your proposal, friendly or not.



Most scientists regarded the new streamlined peer-review process as 'quite an improvement.'

Less Available Funds => Low Success Rate!

Developing hypotheses

- Scientists are used to present null hypotheses. However, alternative hypothesis is more preferred in modern science.
- Justifications are needed for every specific hypothesis.
- New science is developed through hypothesis-testing. Be very CREATIVE! THINK! THINK! and THNK!
- Ask an experienced expert to proof-read and criticize it.
- A hypothesis is not always needed for every proposal. Many mission-oriented programs do not require a hypothesis!
- Take notes while writing!

Persistent!

Positive!

Strong!

After rejection...

Notes from NSF Panel Reviews

- Exciting ideas
- “Transformative” is a key word, but do not overuse it
- Strong track record. It can hurt if any COI is not strong; strong one may not warrant anything.
- Many proposals are resubmitted multiple times (e.g., 5 times). Resubmission seemed have slightly higher rate of success
- Report every previous funding, do not hide
- Training foreign students appears to be favored by the panel, make sure there is a budget backing up any plans
- Incorporating research into classes is widely practiced, but no longer considered as a merit. But its absence can hurt the proposal.
- Develop short courses, field trips, video, youtubes, symposiums, etc. Prototype will be strong evidence showing the feasibility
- Mentoring plan for postdocs is required by the NSF
- International collaborators are good, but should be always backed with budget and actions, not just a collaborative letters. Letter absence can hurt though
- Cross-site comparisons are favored.
- Do not cite too many own works
- No conceptual framework is needed
- Think what new science we will develop
- Get small funds to develop pilot project and preliminary results
- Occasionally, some tasks need to be near completion
- Don’t count on your track record when it is strong

Confidence & Persistence