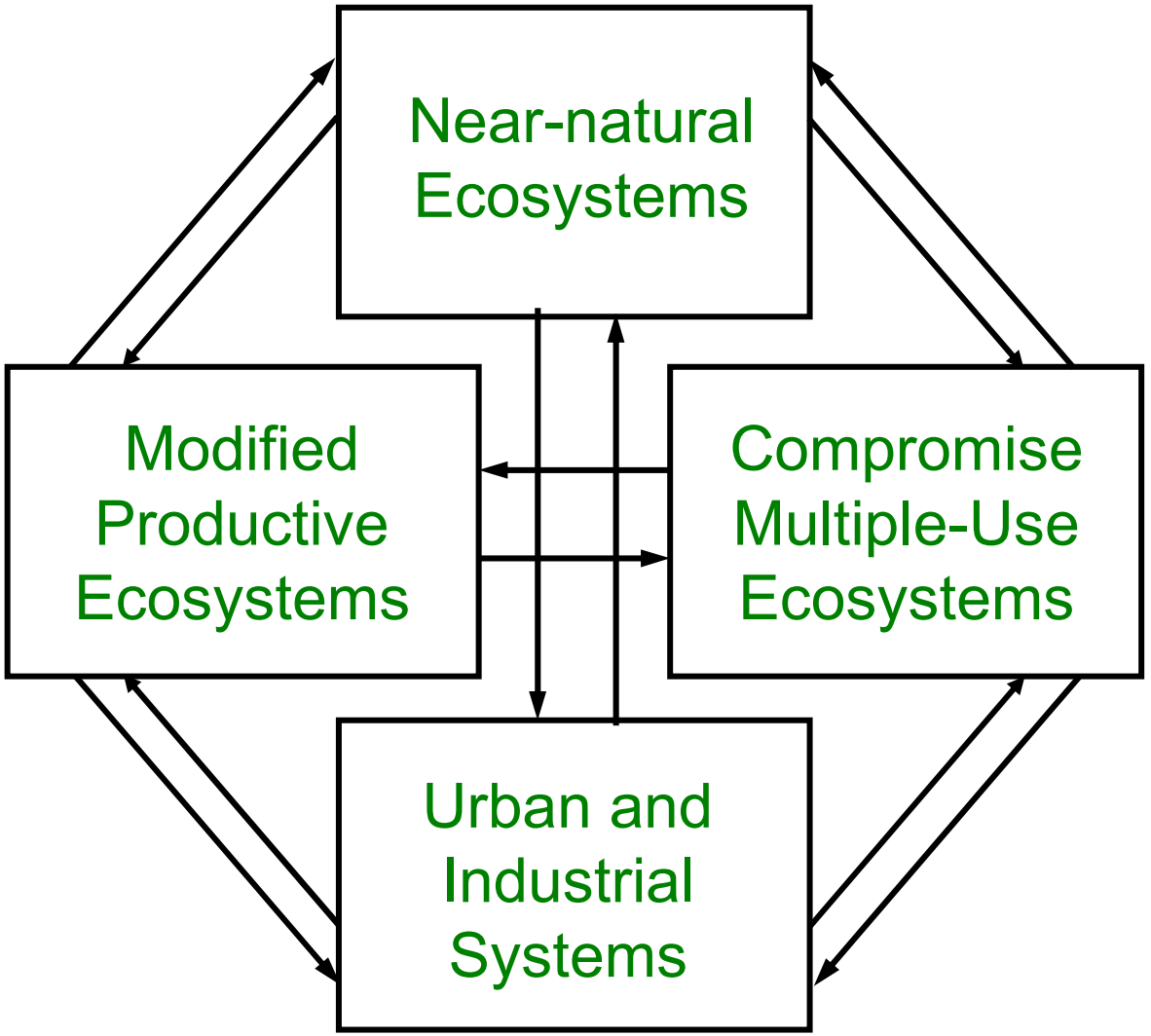
Getting the Most Out of Land Surface Flux Measurements: The Need for Proactive Intiatives to Achieve Regional Resilience and Sustainability

John Tenhunen

Department of Plant Ecology, University of Bayreuth
Bayreuth, Germany

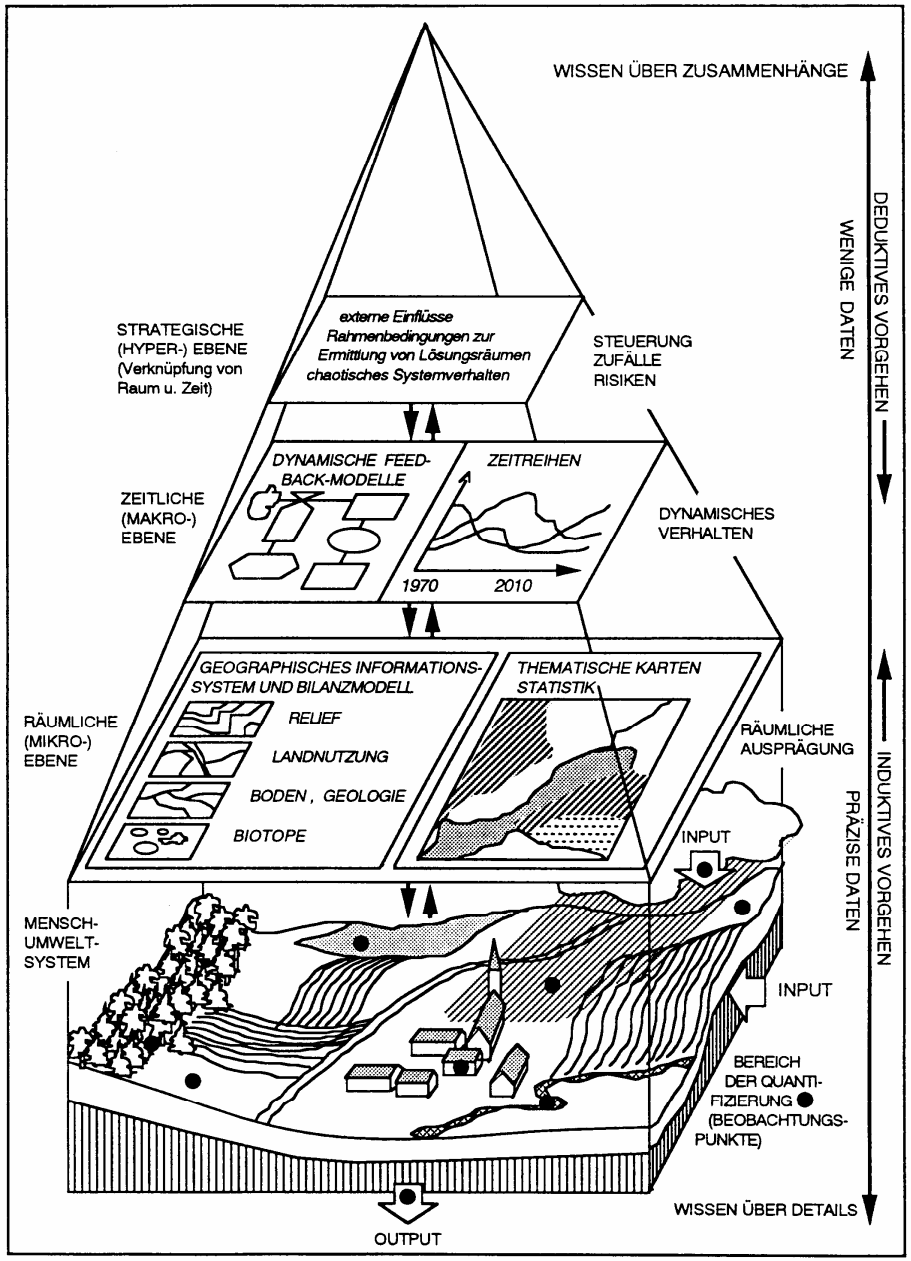
AsiaFlux Workshop 2010, New Challenges to the FLUXNET Community in Resilient Carbon/Water Management, December 1-3, 2010, Guangzhou, China.

IBP (International Biological Program) Perspective:



Odum, E. 1969 The Strategy of Ecosystem Development. Science 164:262-270

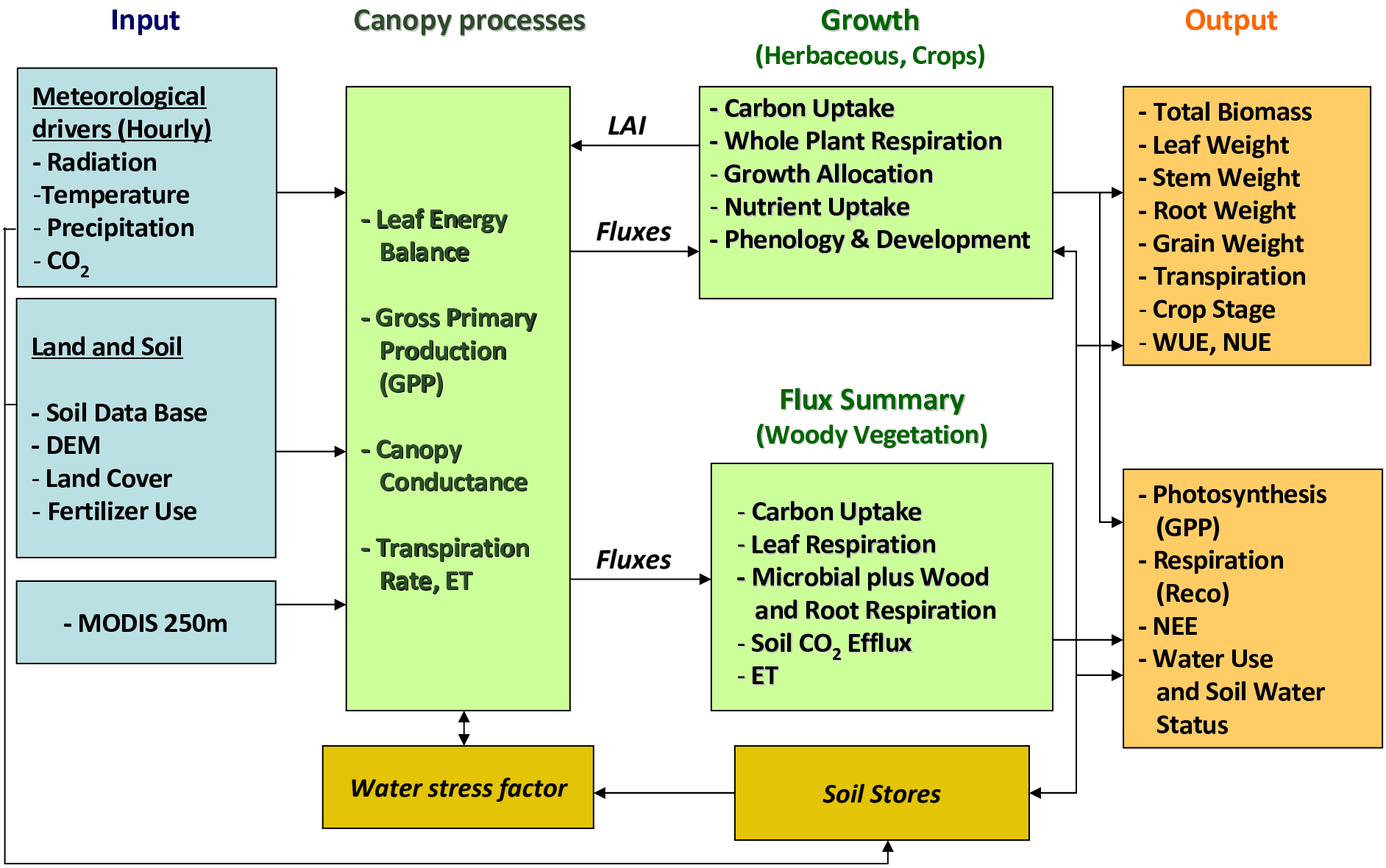
Man and Biosphere Perspective: Studies in Berchtesgaden National Park

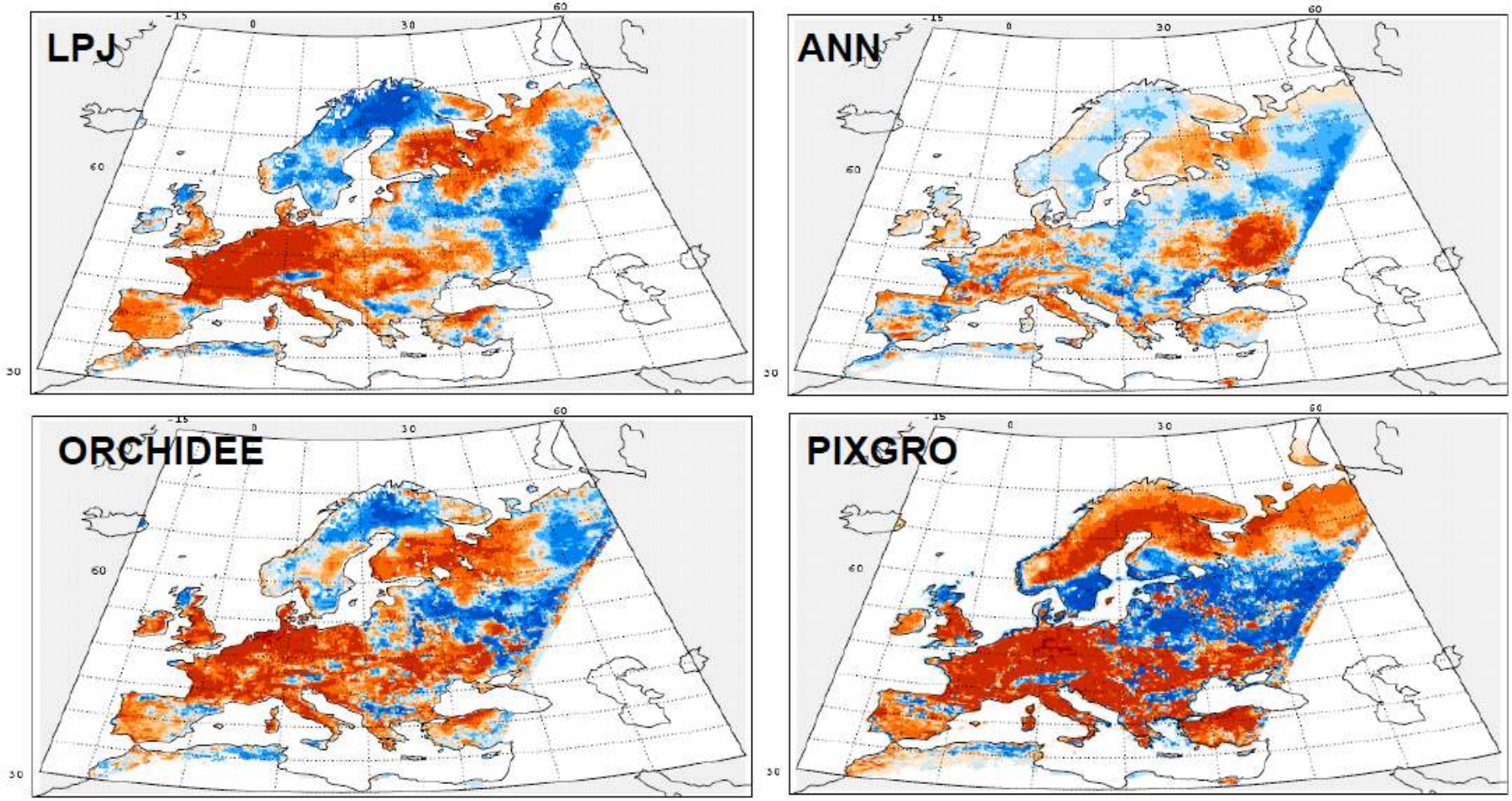


Advances in Flux Network Measurements and Derived Products for Management

AsiaFlux Workshop 2010, New Challenges to the FLUXNET Community in Resilient Carbon/Water Management, December 1-3, 2010, Guangzhou, China.

PIXGRO – Atmospheric Exchange, Plant Growth and Yields





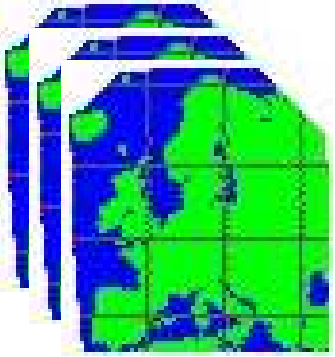
Anomaly in net ecosystem production in 2003 relative to baseline

Analyzing the causes and spatial pattern of the European 2003 carbon flux anomaly using seven models

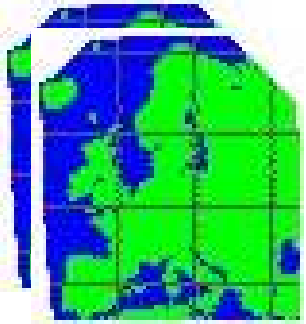
M. Vetter[1], G. Churkina[1], M. Jung[1], M. Reichstein[1], S. Zaehle[2,3], A. Bondeau[2], Y. Chen[1], P. Ciais[3], F. Feser[8], A. Freibauer[1], R. Geyer[5], C. Jones[6], D. Papale[4], J. Tenhunen[5], E. Tomelleri[1,7], K. Trusilova[1], N. Viovy[3], and M. Heimann[1]

Biogeosciences, 5, 561–583, 2008

8 Types for Closed Forest



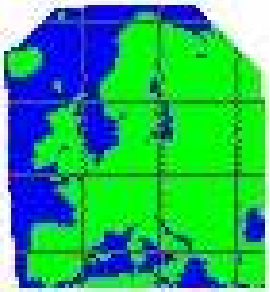
3 Types for Open Woody Vegetation



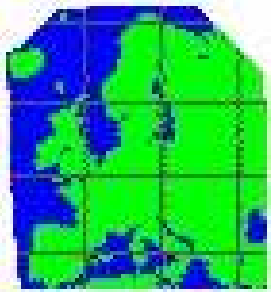
2 Types for Short-statured Vegetation

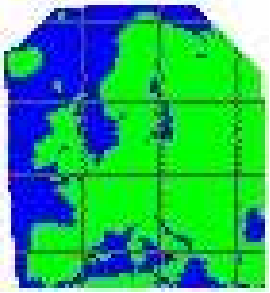
Near-Natural Ecosystems

Summer Crop

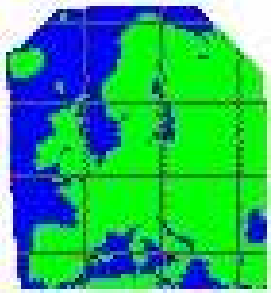


Winter Crop



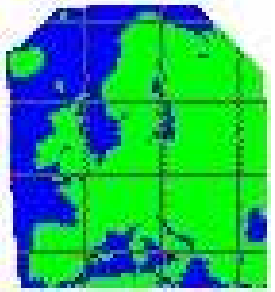


Root Crop



Maize C_4

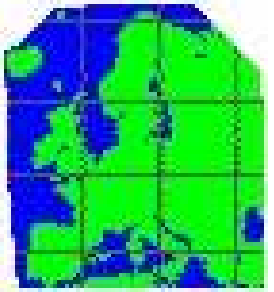
Combined Crops



Final Europe Level Exchange

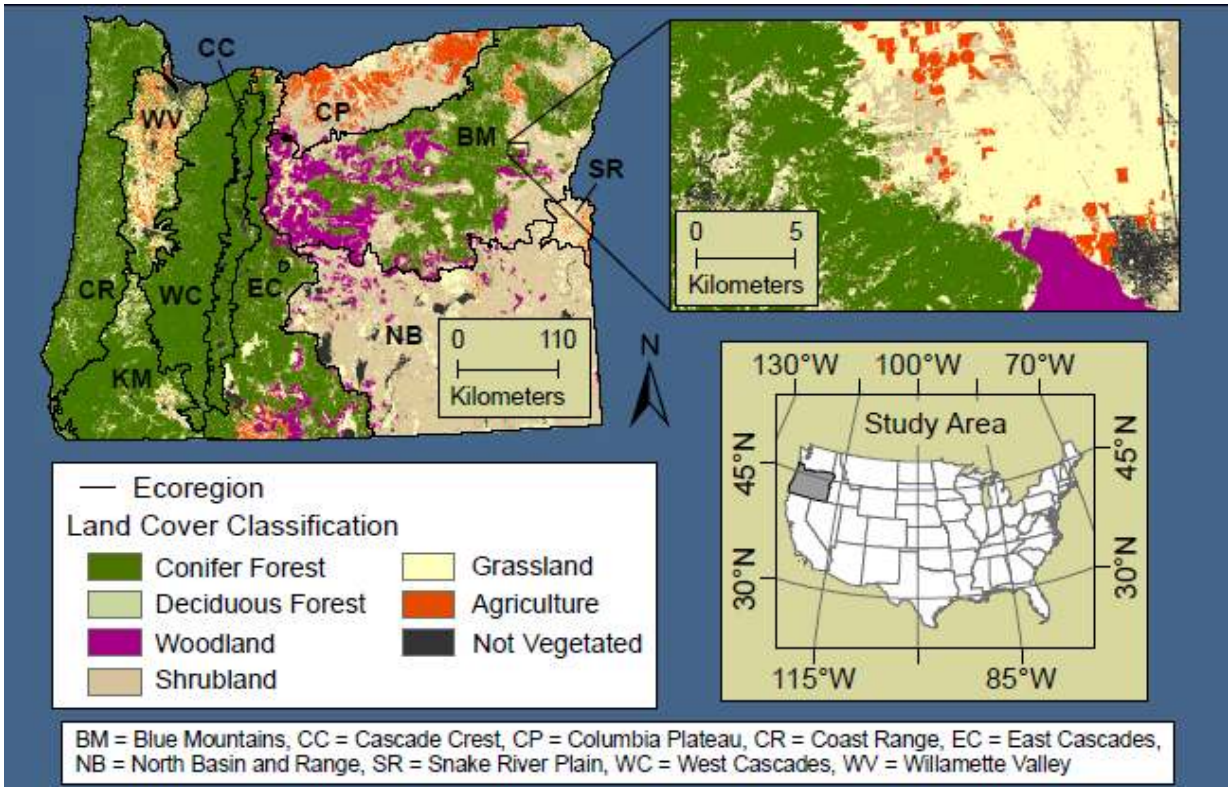
Managed Ecosystems

Mowed Grassland



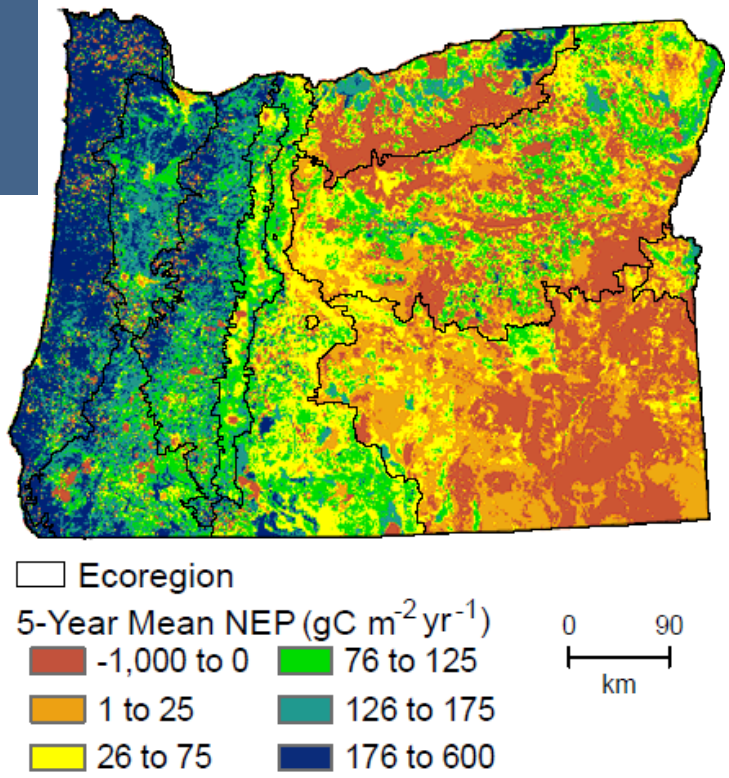
$PIXGRO_{fine}$ Landuse Categories

Biome-BGC Applied at Regional Scale



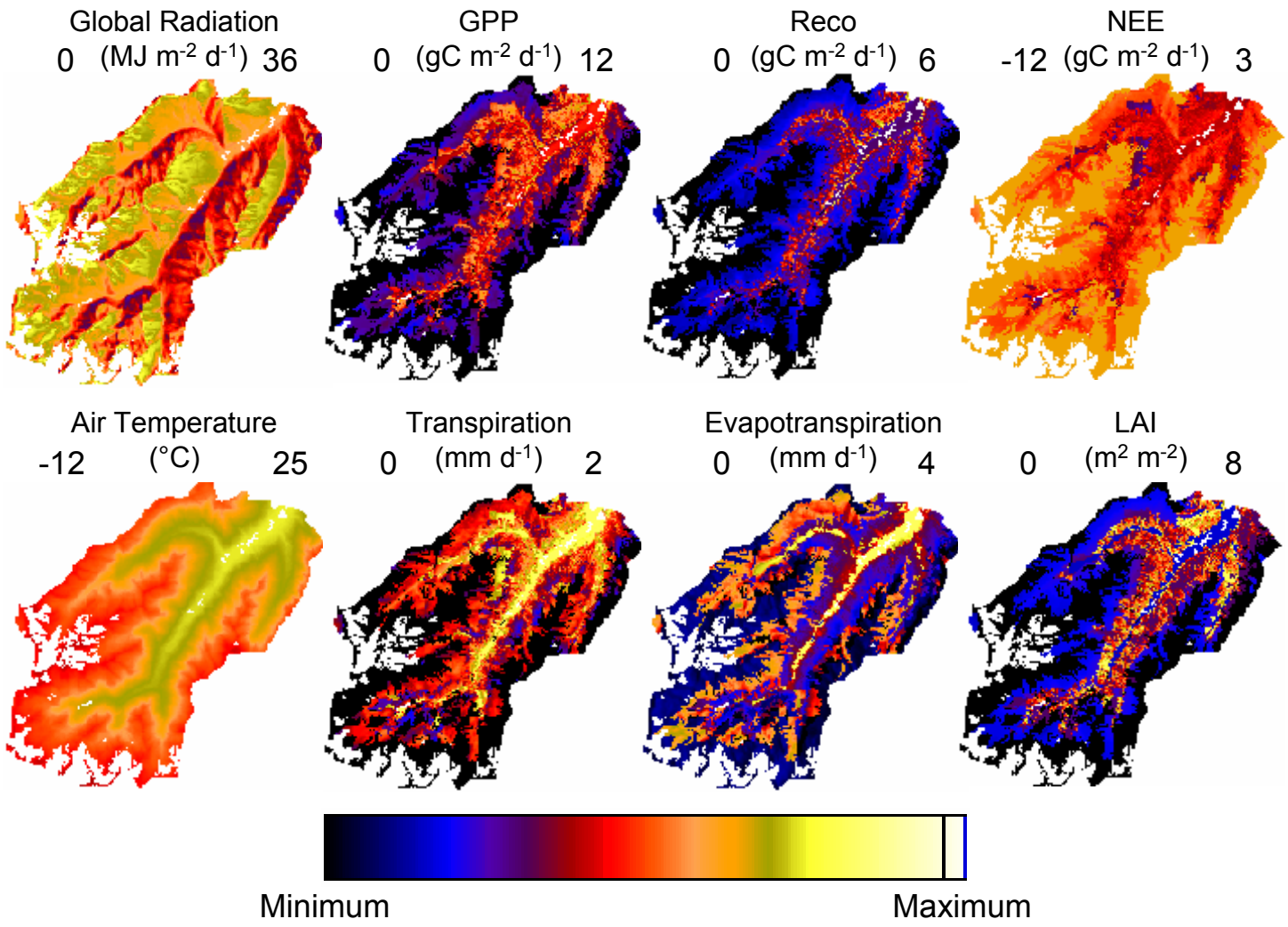
Export due to fires, timber and crop harvests = 63% of NEP.

Climate variation and management sensitivities.



DP Turner, WD Ritts, BE Law et al. 2007. Scaling net ecosystem production and net biome production over a heterogeneous region in the western United States. Biogeosciences 4:597-612

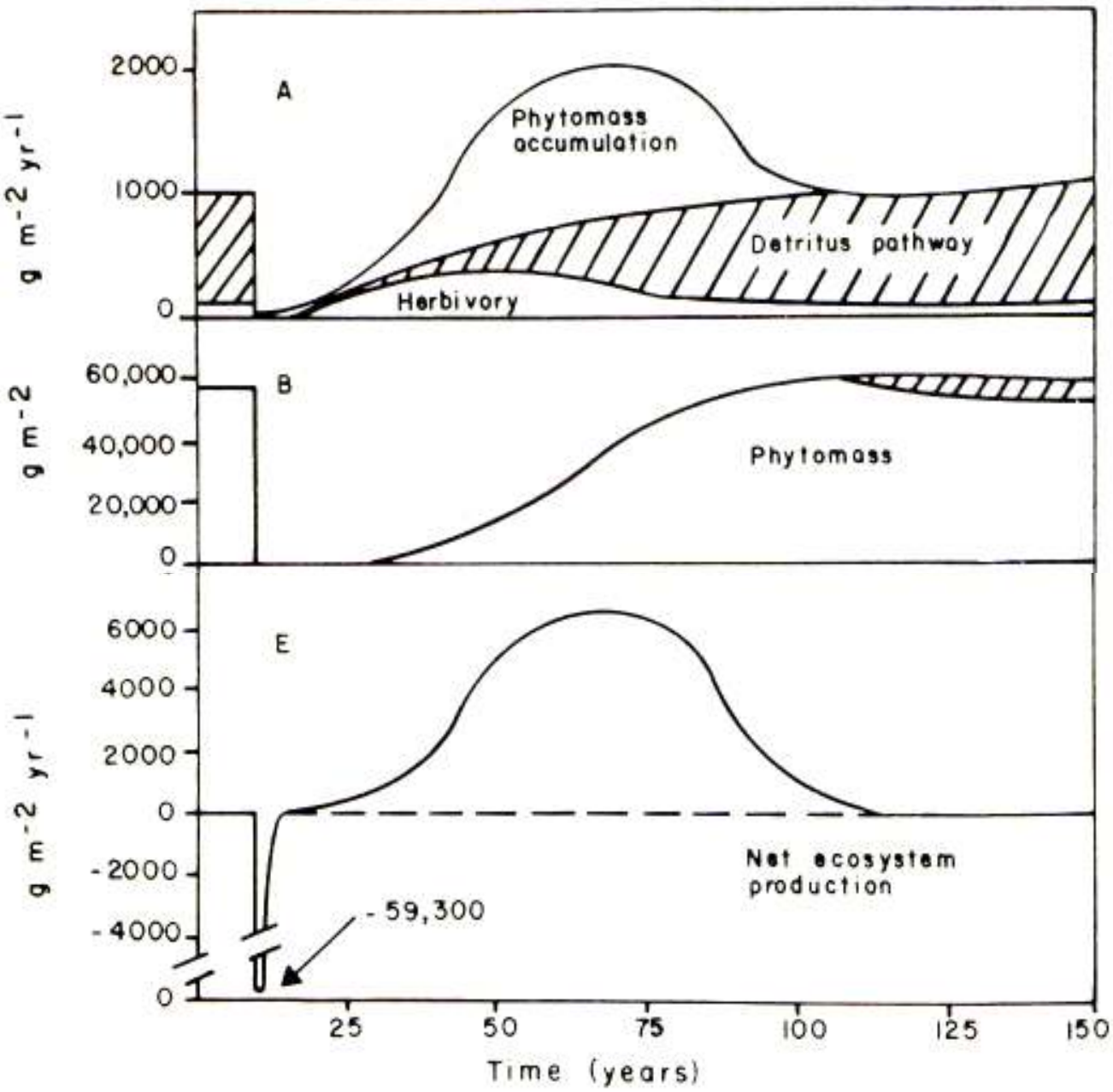
PIXGRO Stubai Valley Landscape Study



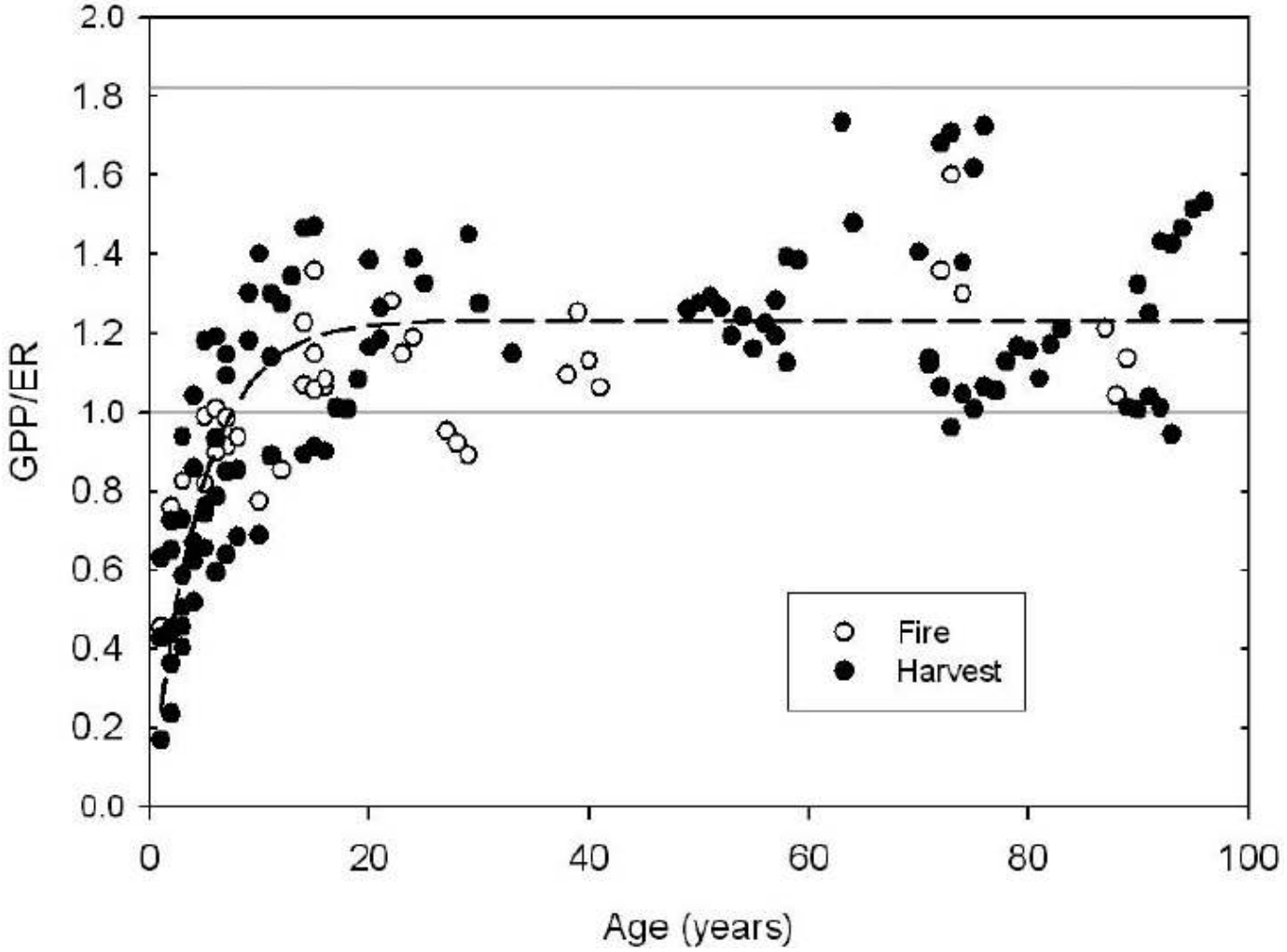
Influences of changing land use and CO_2 concentration on ecosystem and landscape level carbon and water balances in mountainous terrain of the Stubai Valley, Austria

J. Tenhunen [a,*], R. Geyer [a], S. Adiku [a,b], M. Reichstein [a,c], U. Tappeiner [d], M. Bahn [d], A. Cernusca [d], N.Q. Dinh [a], O. Kolcun [a], A. Lohila [e], D. Otieno [a], M. Schmidt [a], M. Schmitt [d], Q. Wang [a,f], M. Wartinger [a], G. Wohlfahrt [d]

Global and Planetary Change 67 (2009) 29–43



Reiners, W.A. 1983. Disturbance and Basic Properties of Ecosystem Energetics. In Mooney, H.A. and Godron M., Disturbance and Ecosystems, Ecological Studies 44, Springer Verlag, pp 83-98.

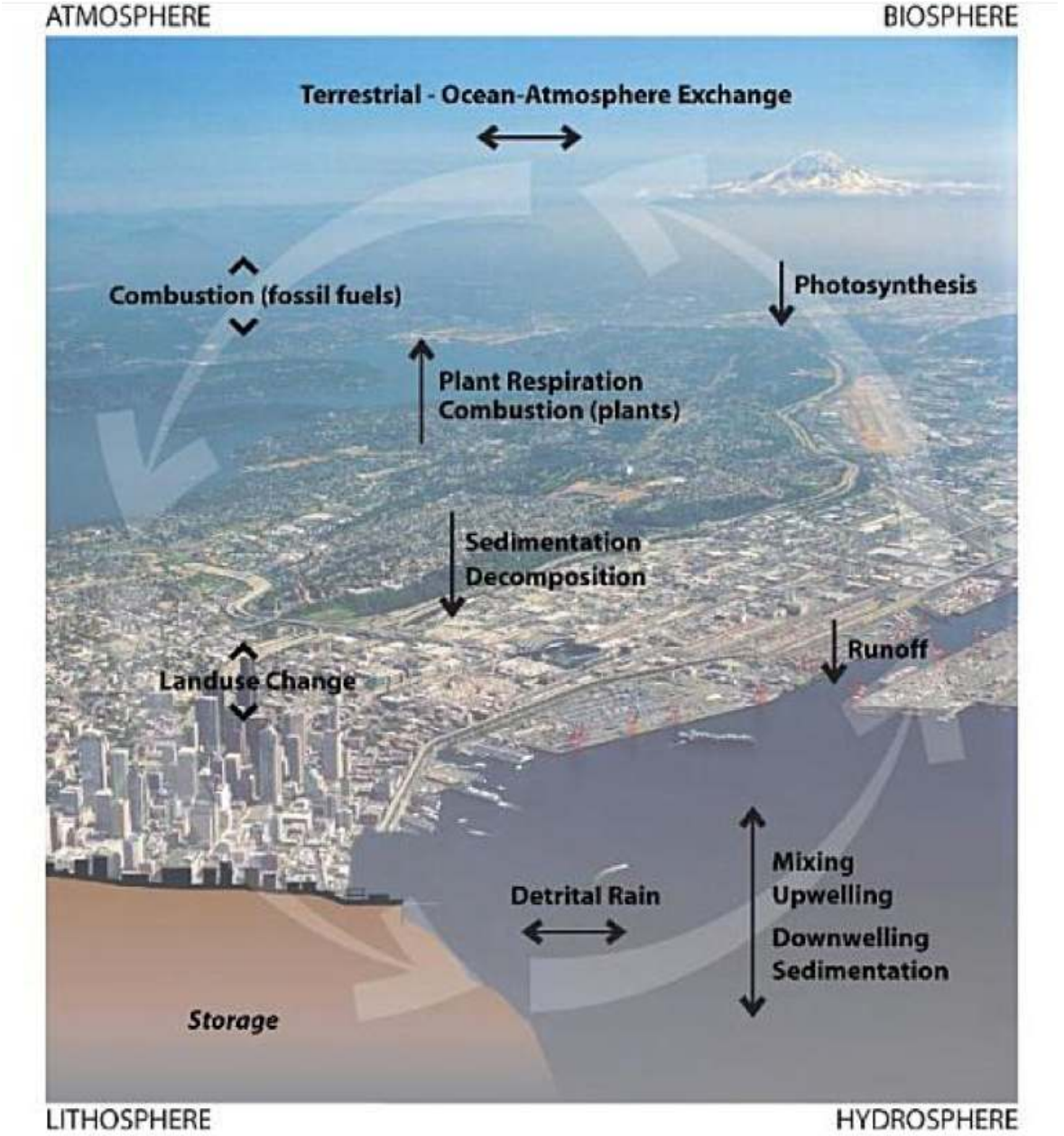


The ratio of annual GPP/ER with stand age for fire and harvest sites.

Amiro, B.D., Barr, A.G., Barr, J.G., and 24 others,

Ecosystem Carbon Dioxide Fluxes After Disturbance in Forests of North America

JGR-Biogeosciences, Special NACP Disturbance Issue, Revisions to Initial Review
June 8, 2010



From Alberti, M. 2009. Advances in Urban Ecology; Integrating Human and Ecological Processes in Urban Ecosystems, Springer Verlag, pp 366.

But Fluxes Are Much More … Assessment Requires Quantifying Many Dimensions

Levels of GPP to Reco

Need for auxiliary energy inputs

Export of primary production

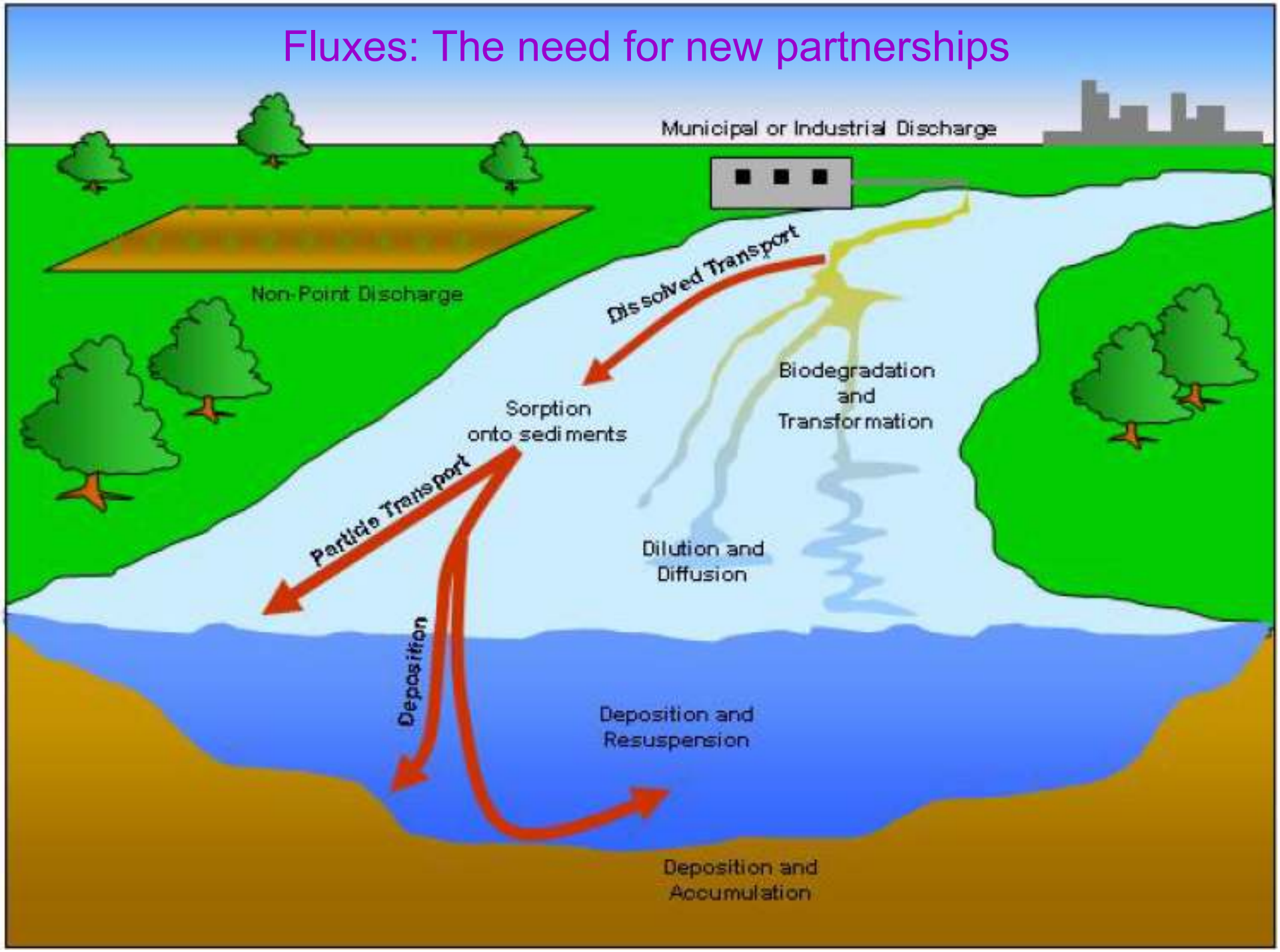
Rates of nutrient turnover and loss

Radiation, nutrient, water use efficiencies

Degree of throughflow

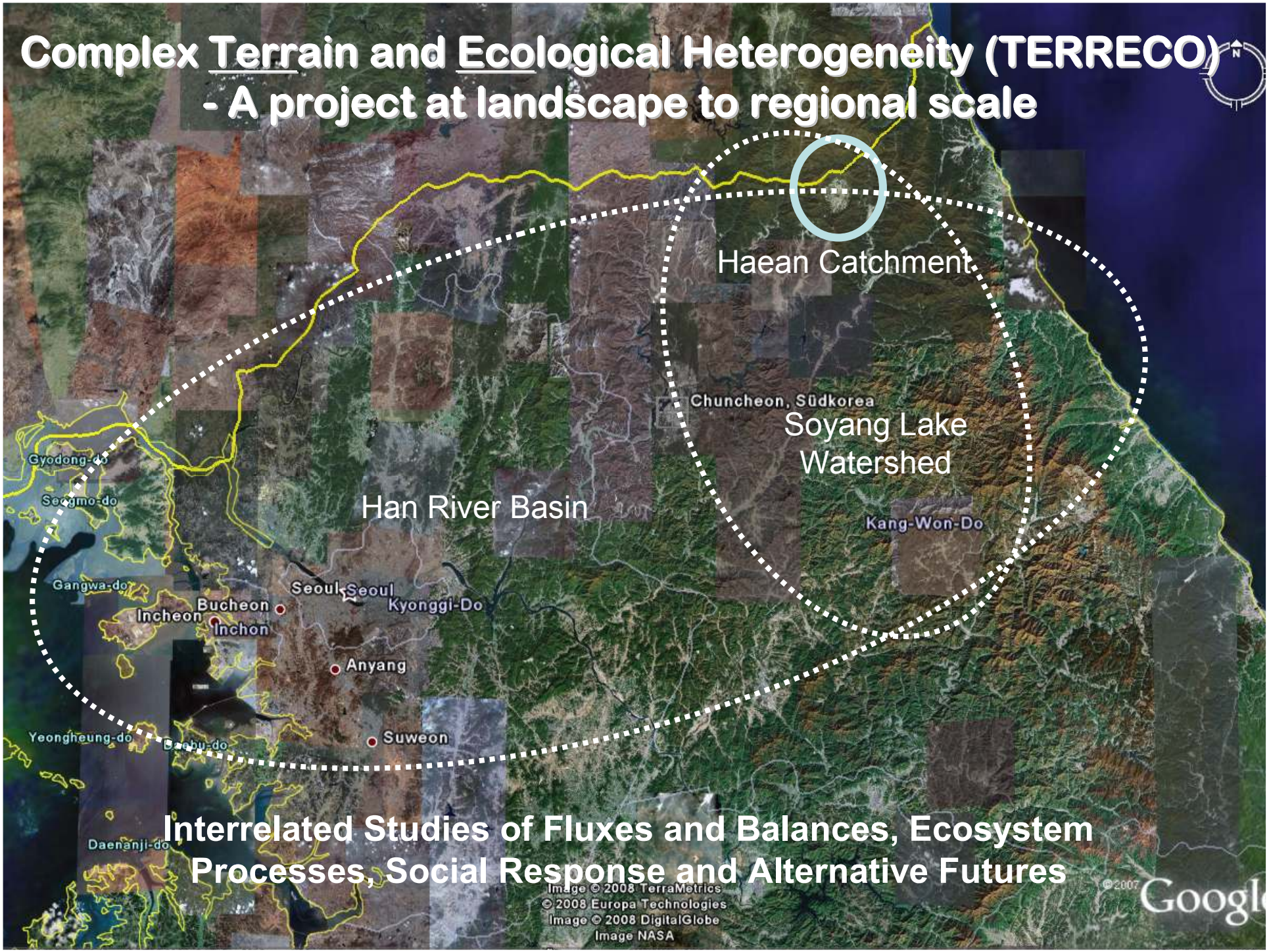
Odum, E. 1969 The Strategy of Ecosystem Development. Science 164:262-270

Fluxes: The need for new partnerships

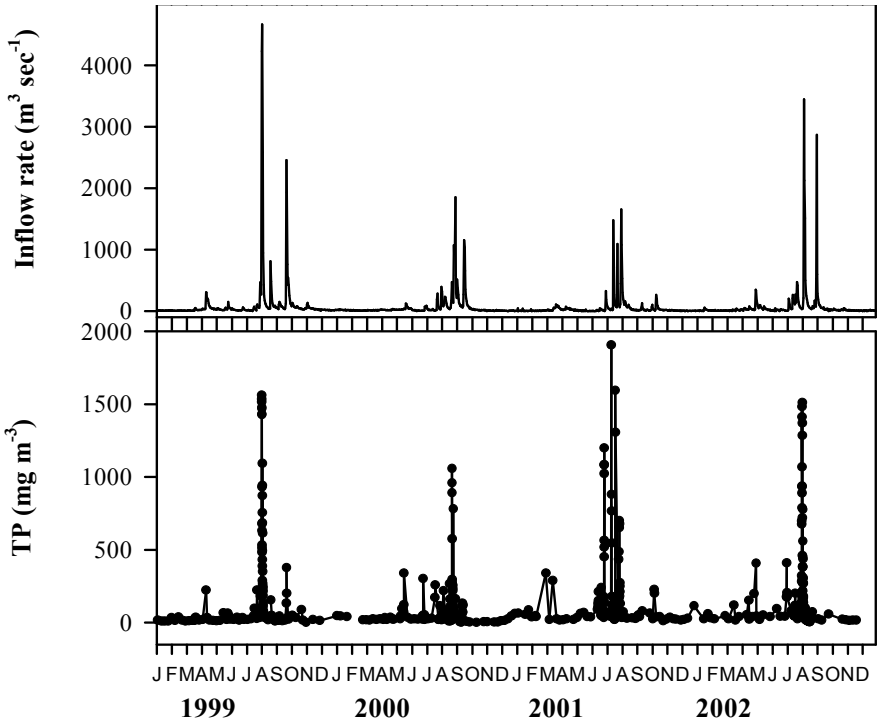


Case Study: Landscape/Regional Flux Analysis Focusing on Agricultural Production versus Impacts on Water Quality

AsiaFlux Workshop 2010, New Challenges to the FLUXNET Community in Resilient Carbon/Water Management, December 1-3, 2010, Guangzhou, China.


Complex Terrain and Ecological Heterogeneity (TERRECO)
- A project at landscape to regional scale
Haean Catchment
Chuncheon, Südkorea
Soyang Lake
Watershed
Han River Basin
Kang-Won-Do
Gyodong-do
Seongmo-do
Gangwa-do
Seoul
Seoul
Kyonggi-Do
Bucheon
Incheon
Inchon
Anyang
Suweon
Yeongheung-do
Baeby-do
Daenanji-do
Interrelated Studies of Fluxes and Balances, Ecosystem
Processes, Social Response and Alternative Futures
Image © 2008 TerraMetrics
© 2008 Europa Technologies
Image © 2008 DigitalGlobe
Image NASA
©2007
Google

Complex Terrain and Ecological Heterogeneity (TERRECO)
- A question requiring social-ecological analysis

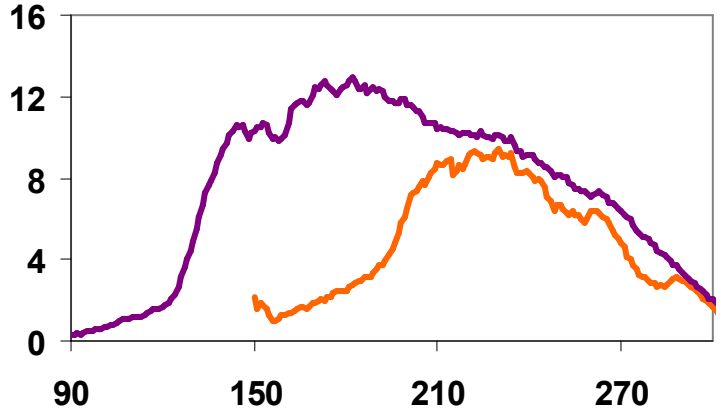


A Strategy for Quantifying Landscape Services: Land Surface Phenomena

AsiaFlux Workshop 2010, New Challenges to the FLUXNET Community in Resilient Carbon/Water Management, December 1-3, 2010, Guangzhou, China.


Seolmacheon


Haean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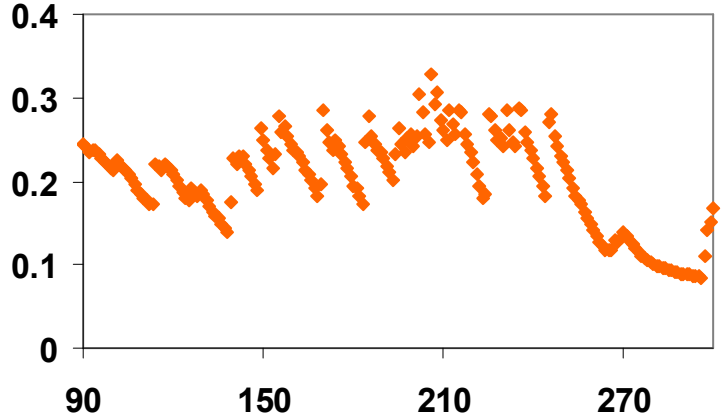
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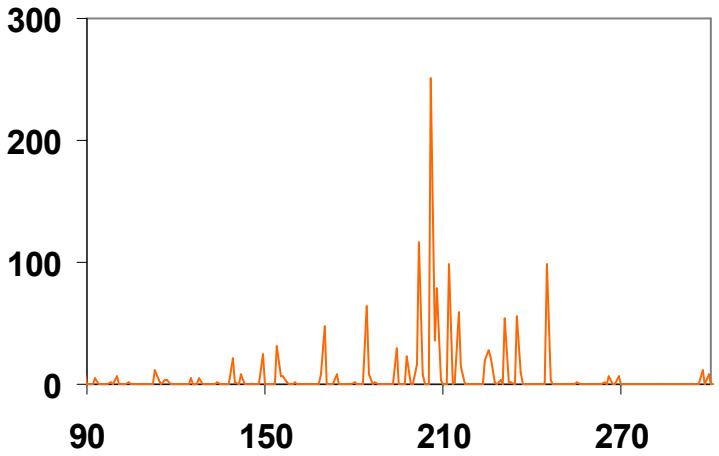
300
200
100
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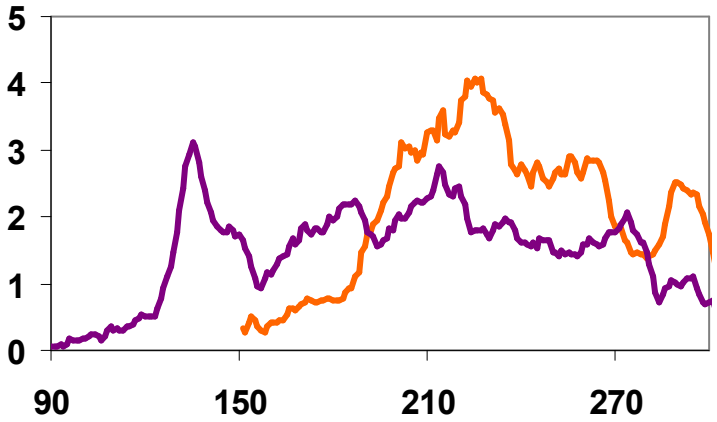
5
4
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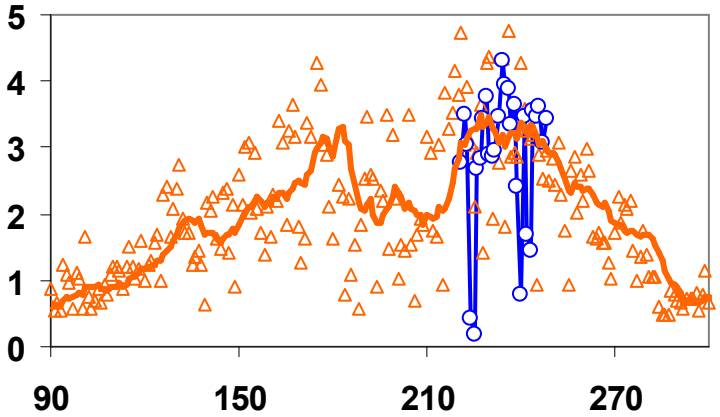
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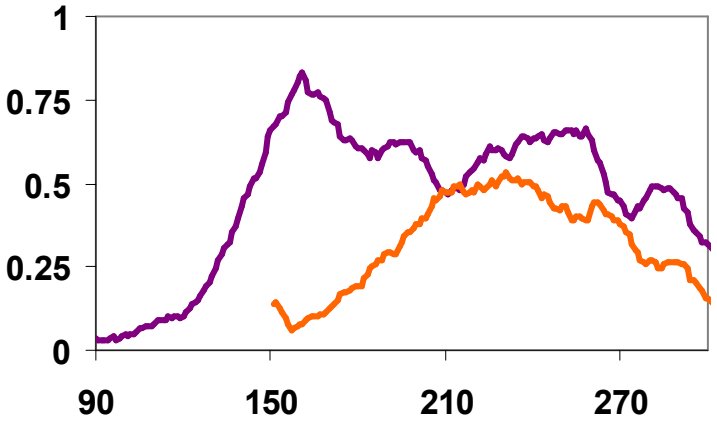
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0.5
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0
90
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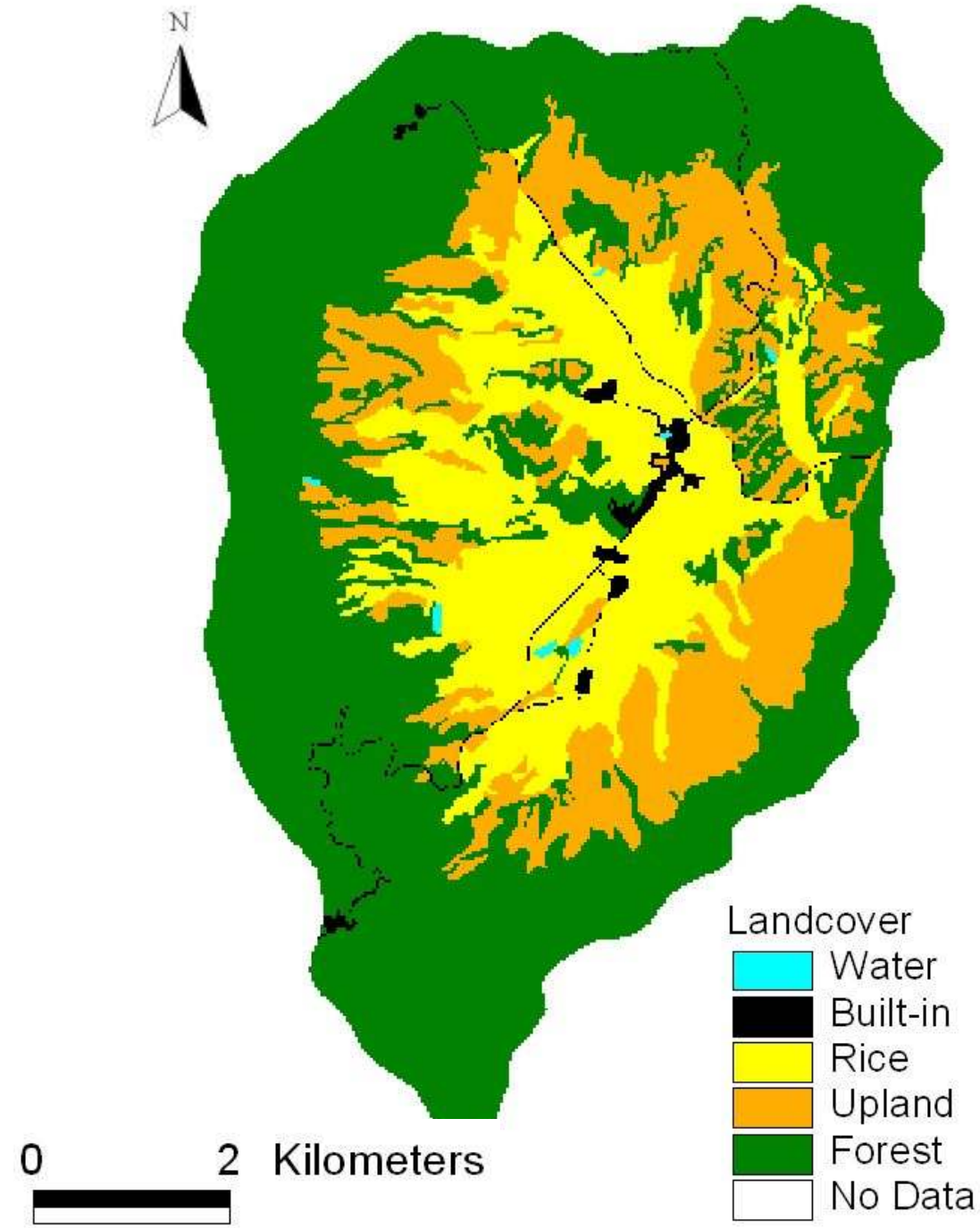
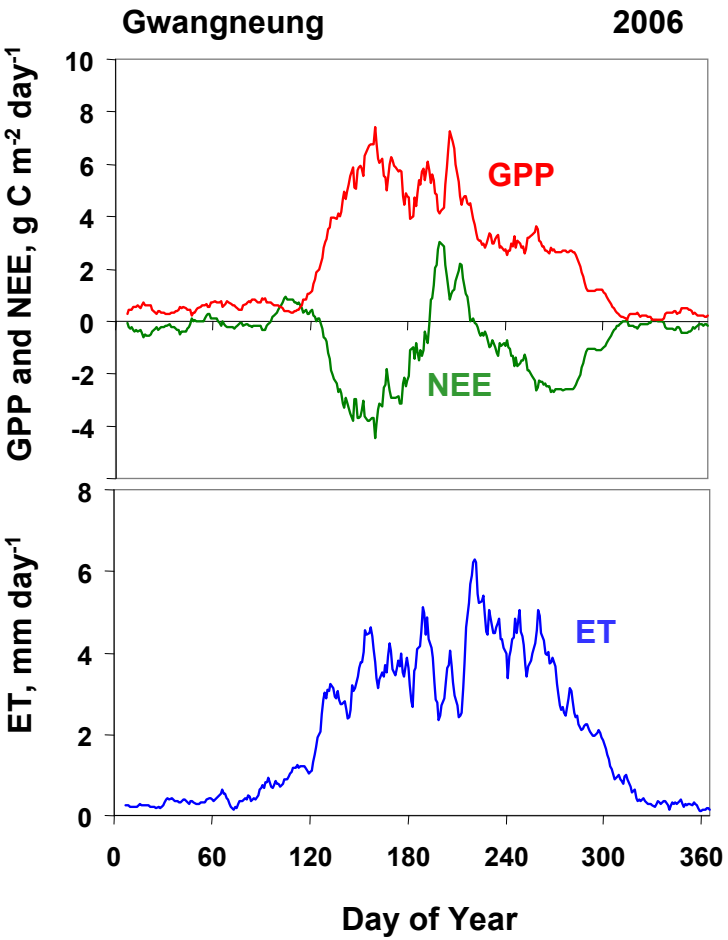
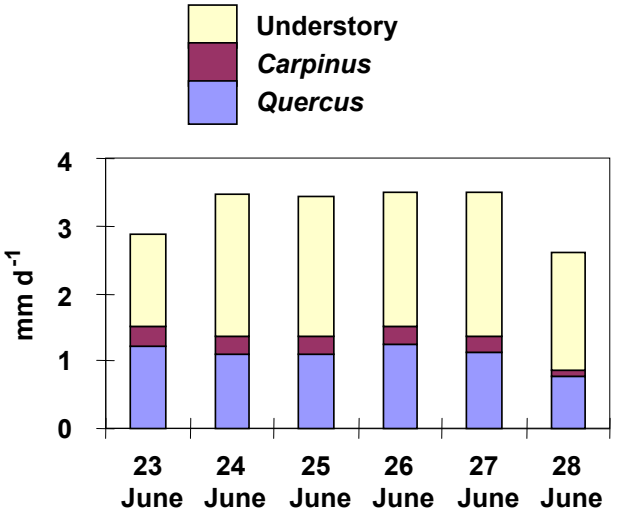
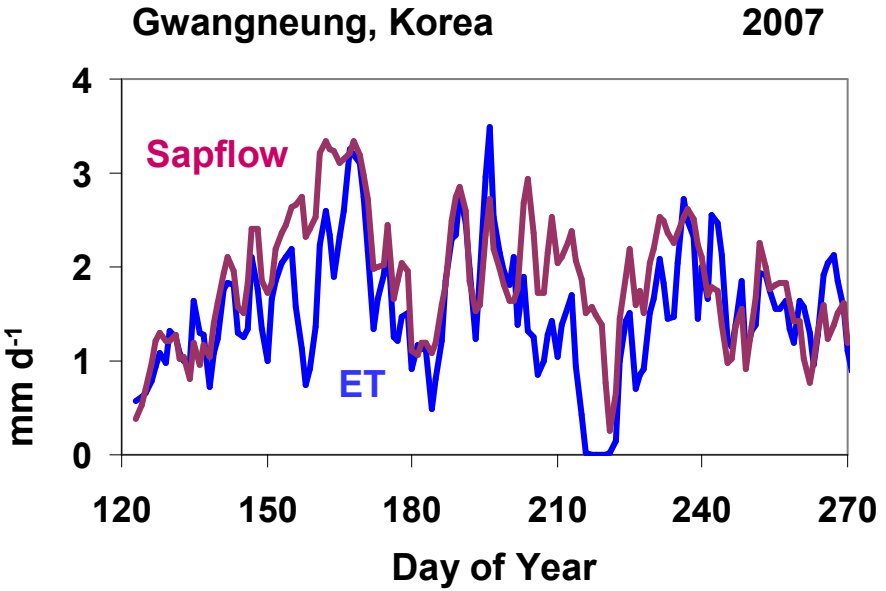
210
270


N
0
2 Kilometers
Landcover
Water
Built-in
Rice
Upland
Forest
No Data


Gwangneung
2006
GPP and NEE, g C m-2 day-1
GPP
NEE
ET, mm day-1
ET
Day of Year


Understory
Carpinus
Quercus
mm d-1
23 June
24 June
25 June
26 June
27 June
28 June


Gwangneung, Korea
2007
Sapflow
ET
mm d-1
Day of Year

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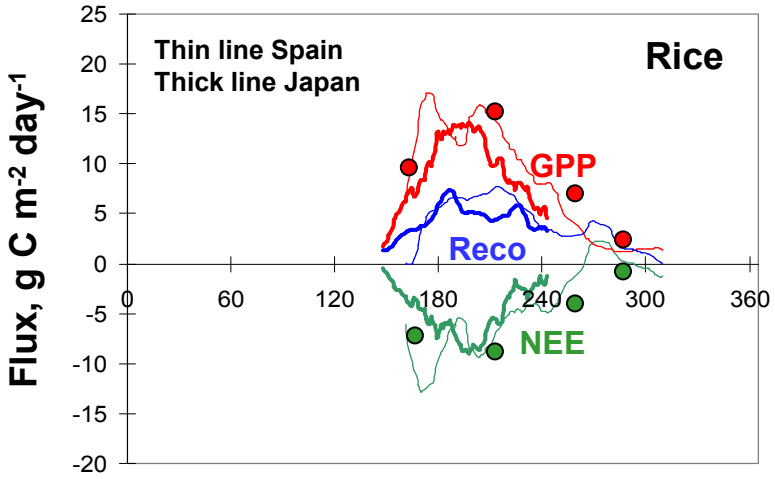


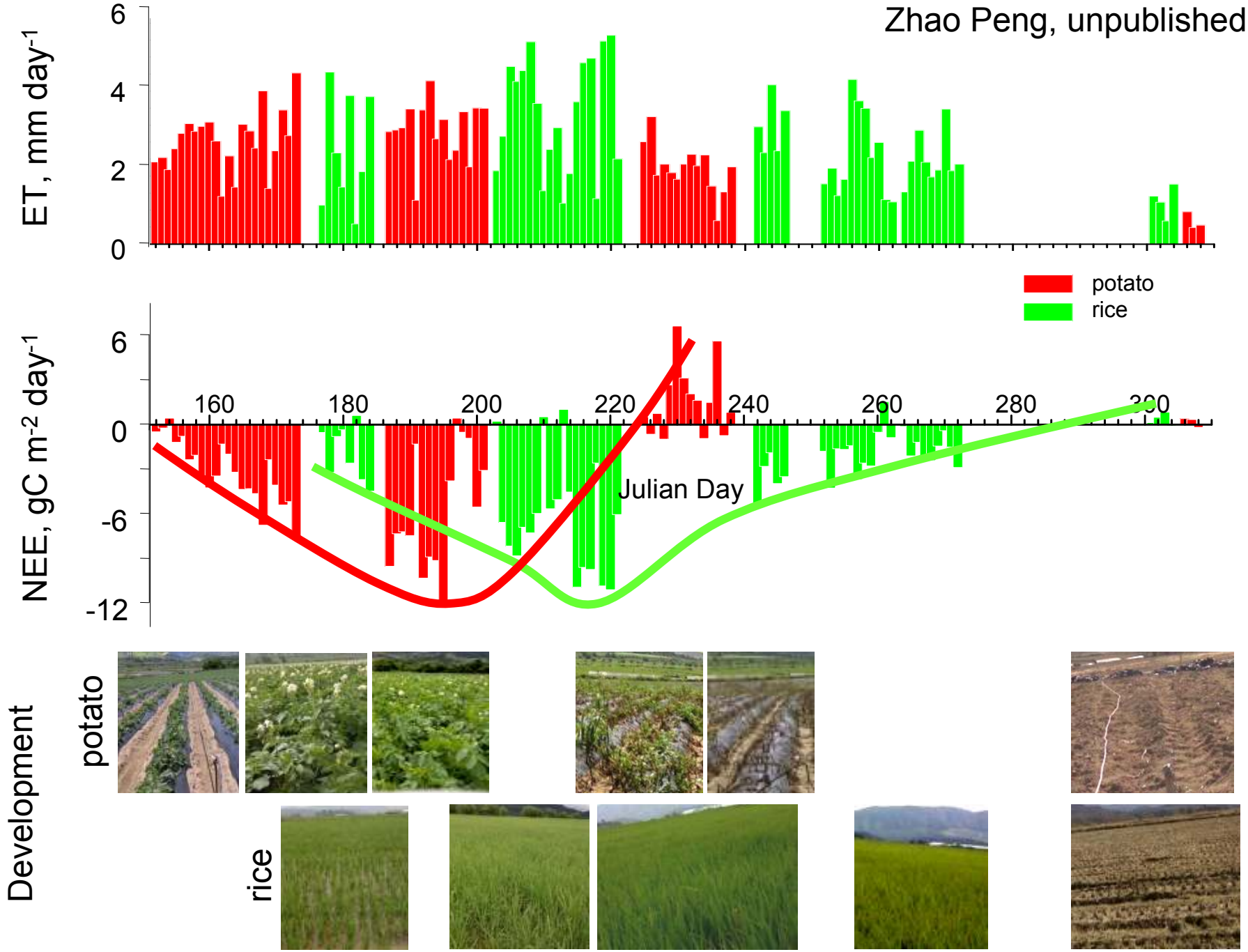
Surface Exchange

⇩

Plant Growth

⇩

Yield


Zhao Peng, unpublished
ET, mm day-1
6
4
2
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potato
rice
NEE, gC m-2 day-1
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-6
-12
160
180
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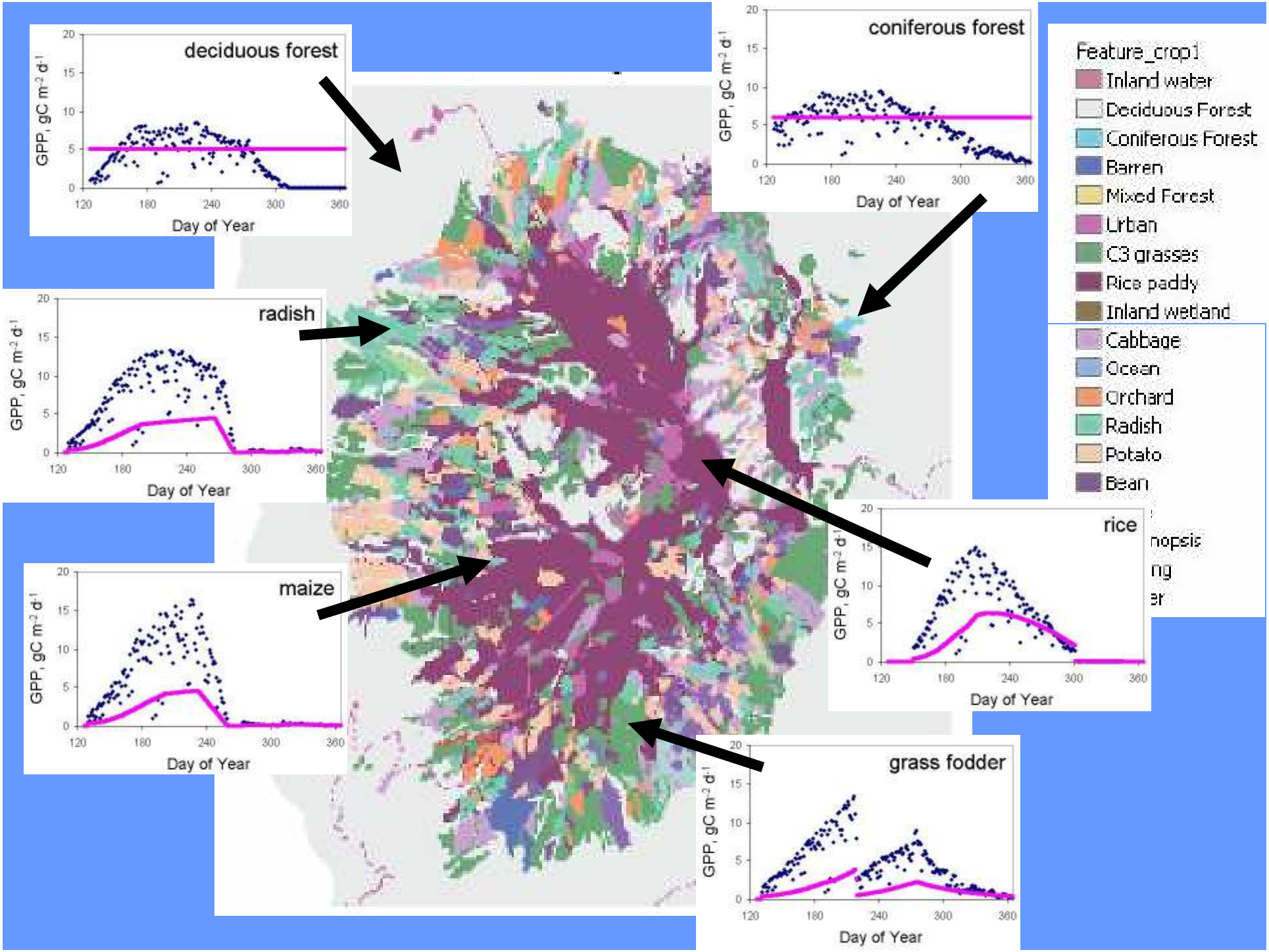
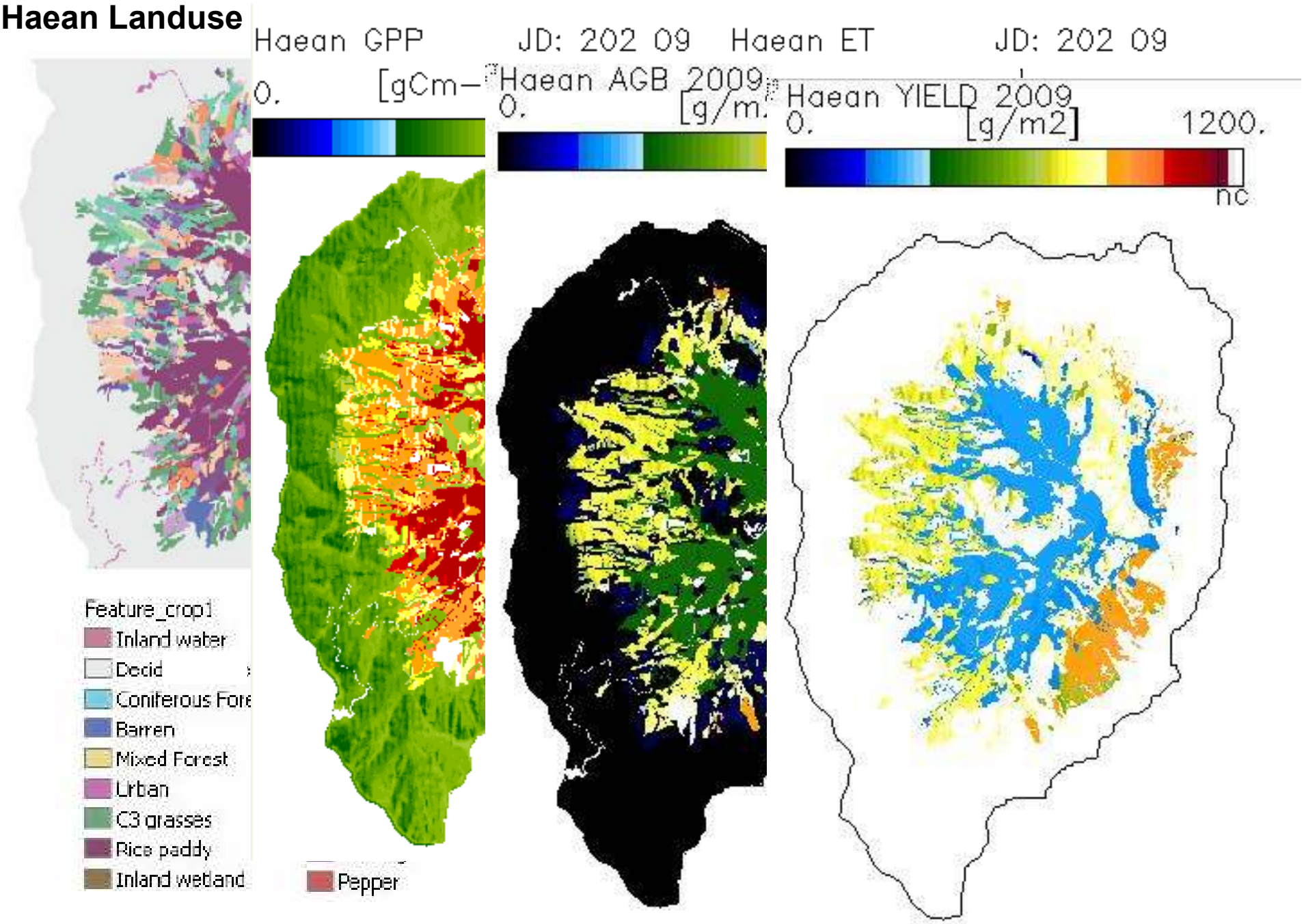
220
240
260
280
300
Julian Day
Development
potato
rice

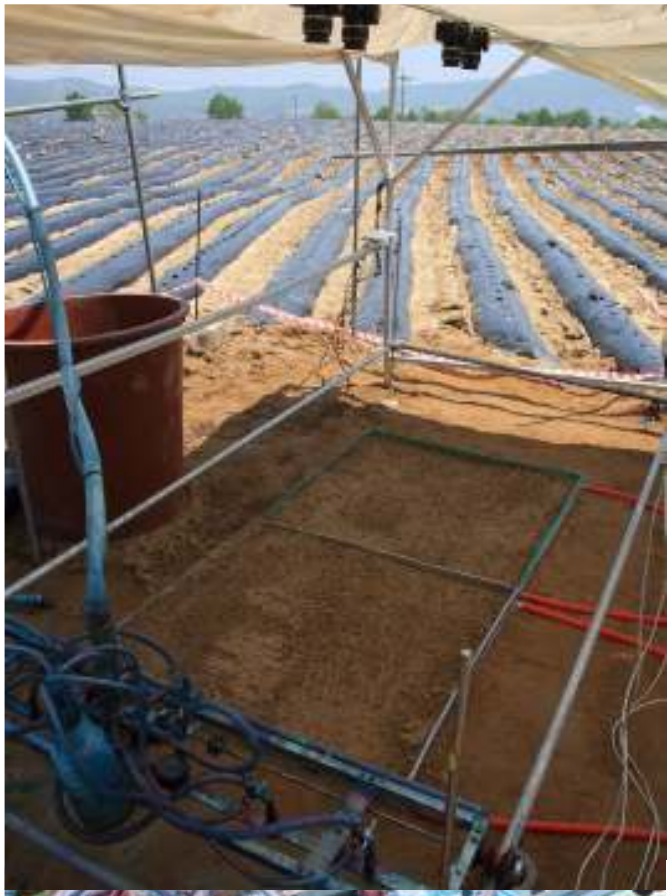

deciduous forest
coniferous forest
radish
maize
rice
grass fodder
GPP, gC m-2 d-1
Day of Year
Feature_crop1
Inland water
Deciduous Forest
Coniferous Forest
Barren
Mixed Forest
Urban
C3 grasses
Rice paddy
Inland wetland
Cabbage
Ocean
Orchard
Radish
Potato
Bean

Haean Landuse



A Strategy for Quantifying Landscape Services: Nutrient and Water Balances

AsiaFlux Workshop 2010, New Challenges to the FLUXNET Community in Resilient Carbon/Water Management, December 1-3, 2010, Guangzhou, China.

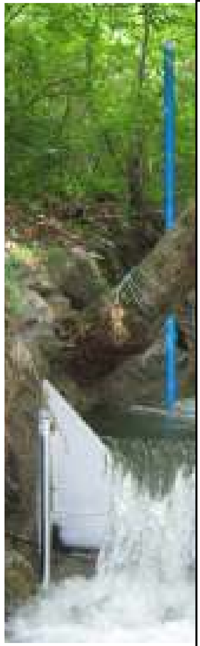


Monsoon Runoff Monitoring

Infiltration and
Preferential Flow Paths

www.bayceer.uni-bayreuth.de/terreco

Flows and biogeochemistry in Haean catchment



Electro-magnetic methods

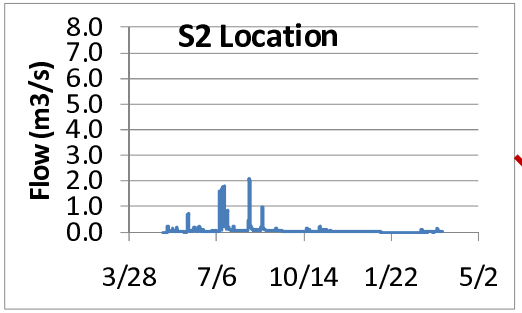
Monsoon event

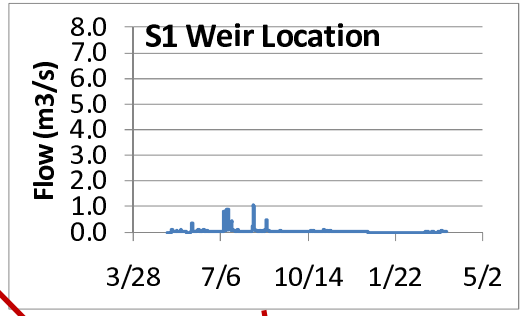
Ultra-sonic methods

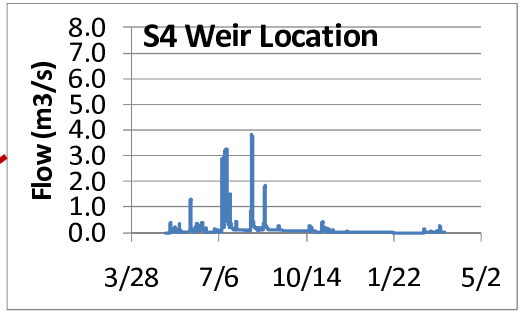
Mandae River during dry conditions

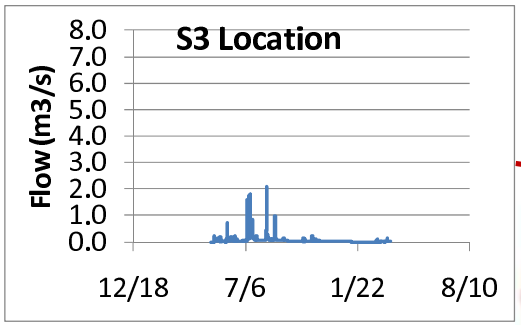
ransects

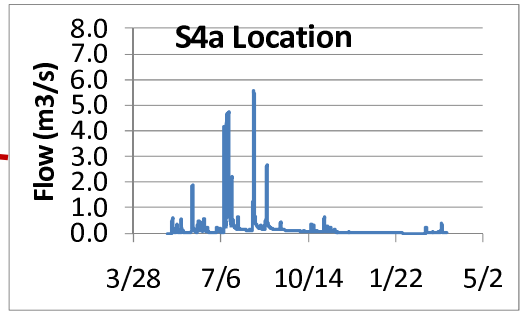
Water Yield 2009 - 2010

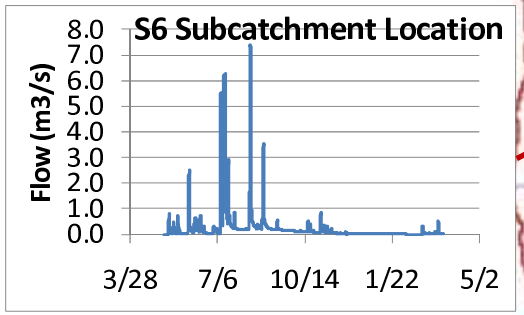


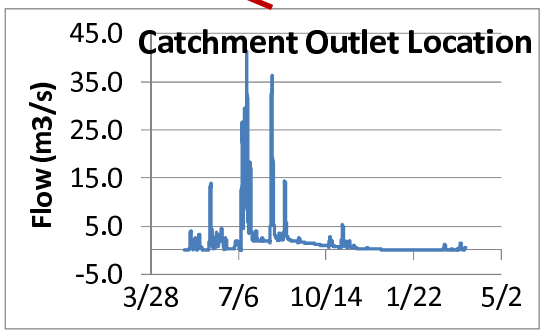


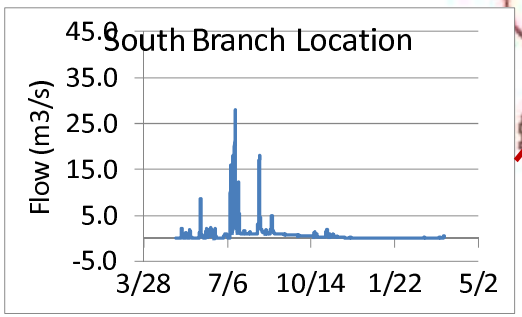












Soil & Water Assessment Tool SWAT

A Strategy for Quantifying Landscape Services: The Economic Perspective

AsiaFlux Workshop 2010, New Challenges to the FLUXNET Community in Resilient Carbon/Water Management, December 1-3, 2010, Guangzhou, China.

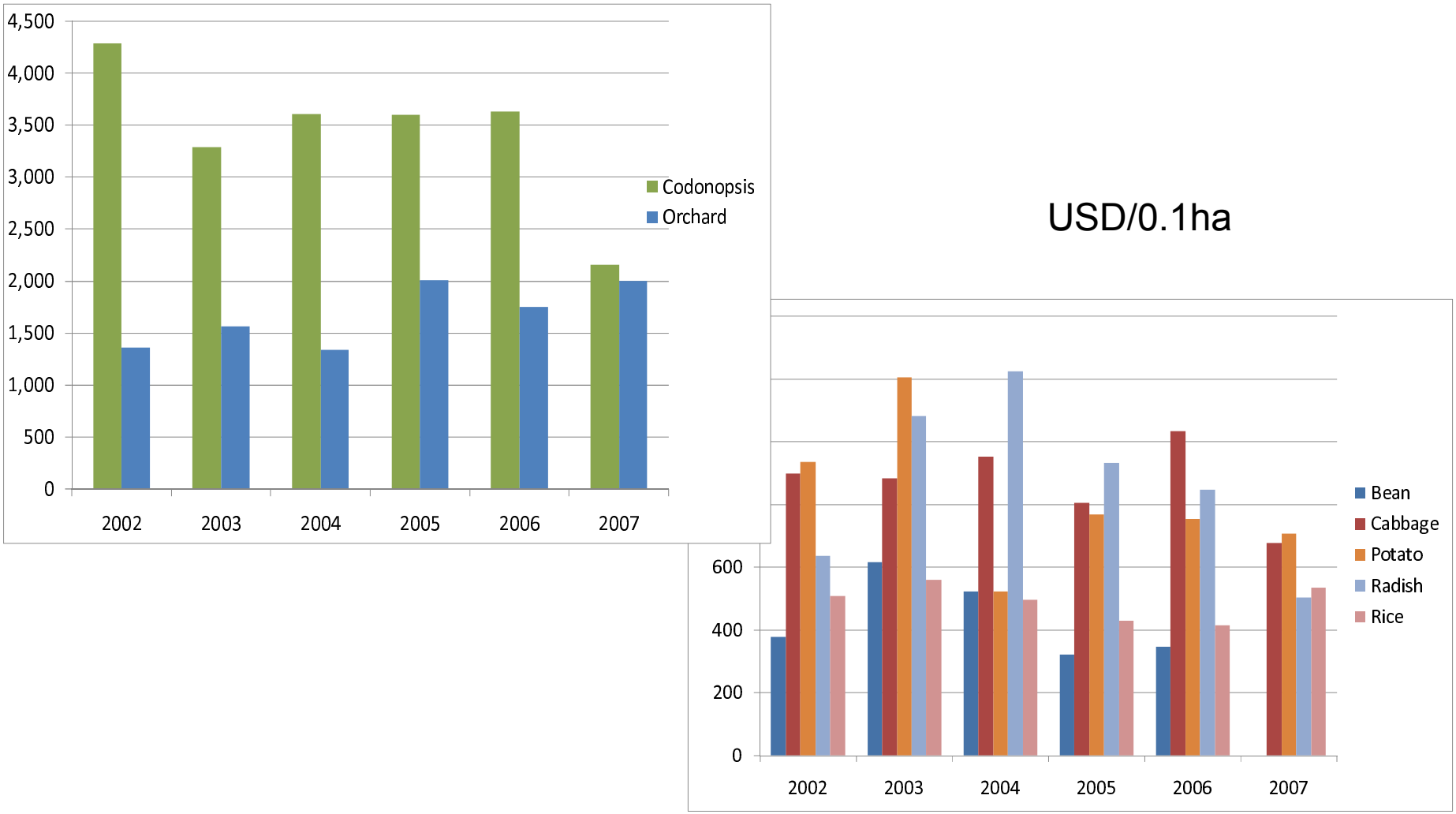
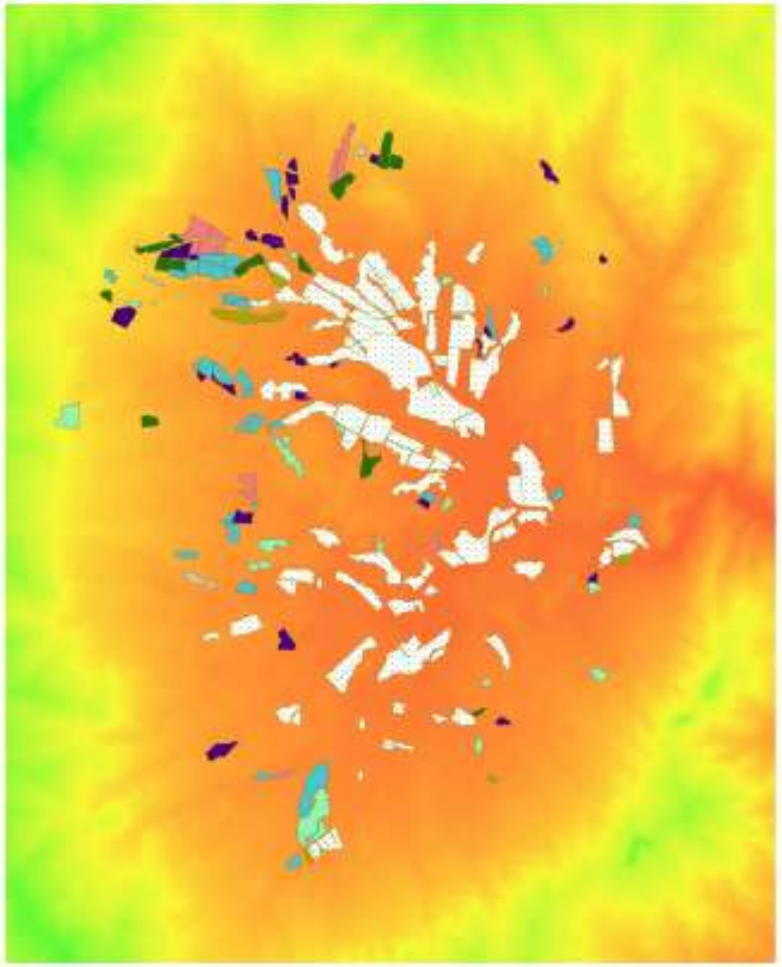
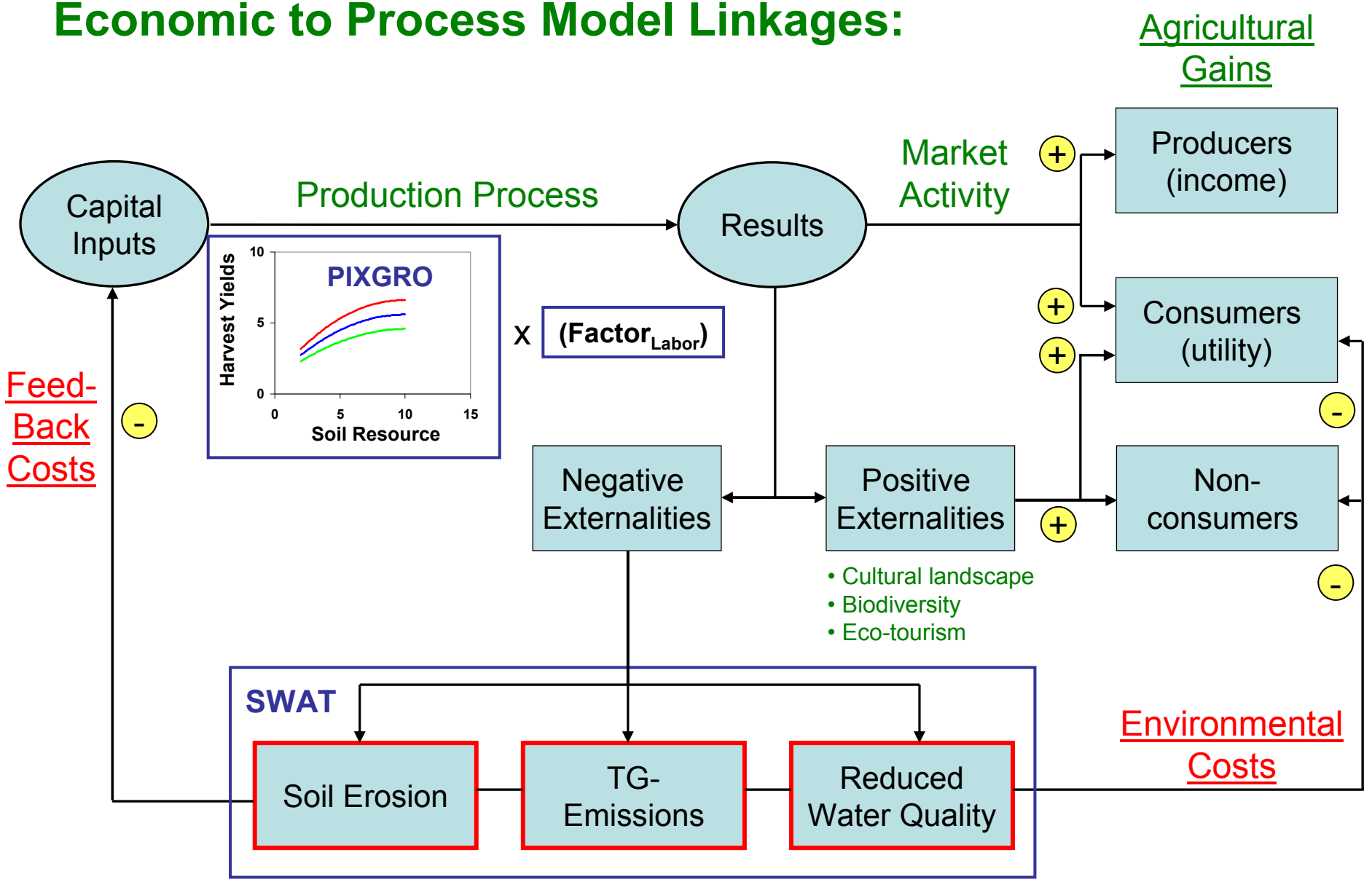


Fig.7. Yearly income for major crops in Haean. The income data obtained from Rural Development Administration in Korea (RDA). a) income of 5 major crops from 2002 to 2007 and b) income for spatial crops including orchard. Haean basin is characterized be low temperatures, therefore orchards were not established before the last 10 years. However, the percentage of orchards is increasing steadily along with climate change. In the case of *Codonopsis* and ginseng, their areas have also increased, but the product supply is currently outstripping demand.


Legend
bean
cabbage
ginseng
maize
orchard
potato
radish
rice paddies



Economic to Process Model Linkages:



A Strategy for Quantifying Landscape Services: Integration and Scenarios

AsiaFlux Workshop 2010, New Challenges to the FLUXNET Community in Resilient Carbon/Water Management, December 1-3, 2010, Guangzhou, China.

TERRECO Focuses on a Transdisciplinary Evaluation of Ecosystem Services

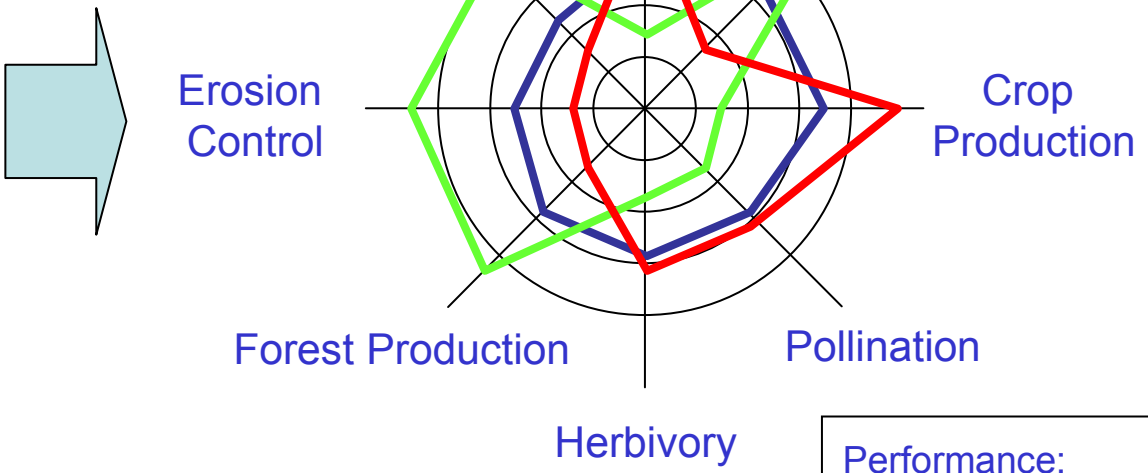
Evaluations via:

Statistical Models

Process-based Models

Phenomenological Models

Physically-Based Models



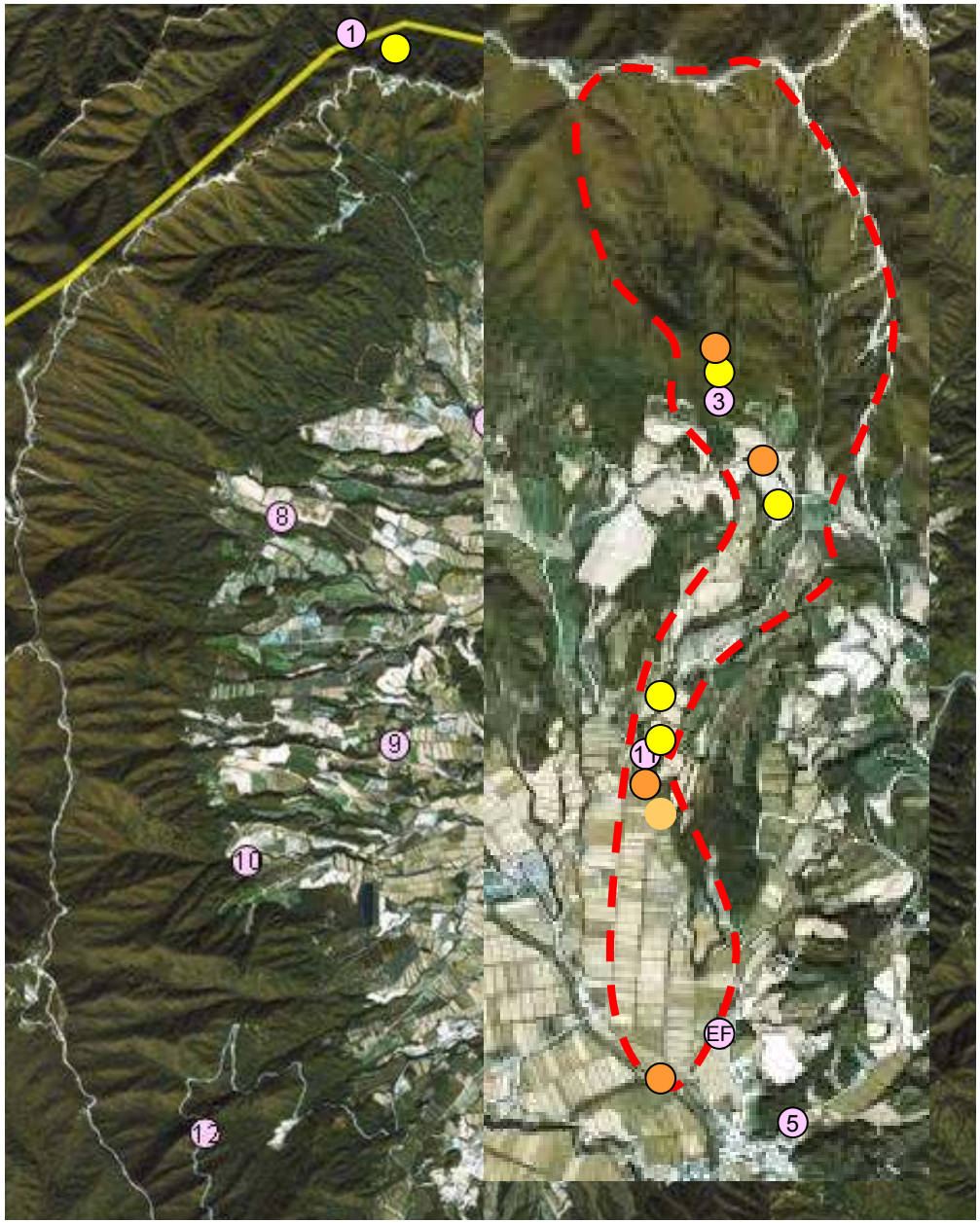
Trade-offs in Production vs. Water Yield and Water Quality

Performance:

Forested Catchment

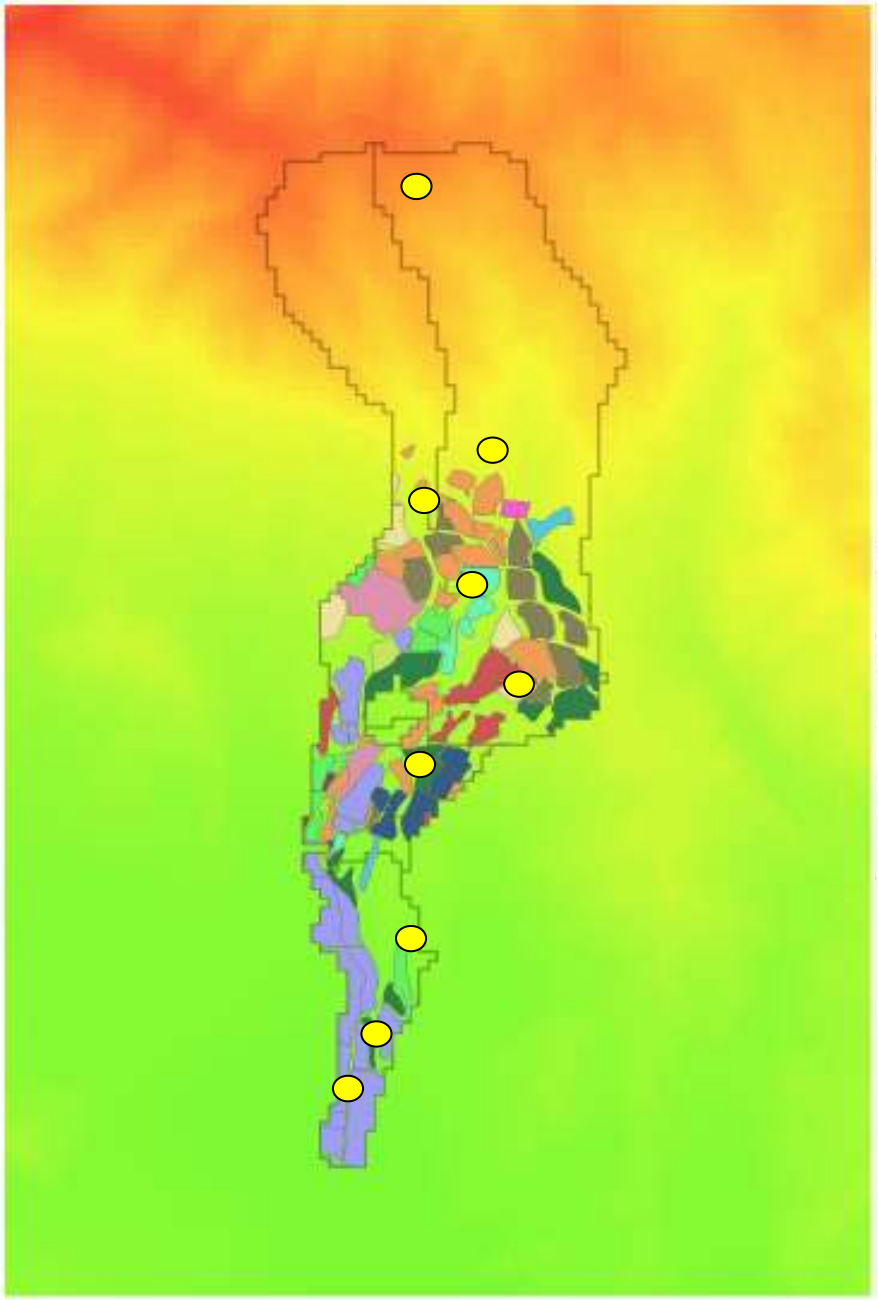
Agricultural Catchment

Regional Mean



Hydrology subcatchment

- Climate documentation
- Ecosystem physiology and production
  - Oak forest
  - Bean
  - Potato
  - Rice
- Stream water chemistry
- Measurements of flow
- Groundwater exchange (piezometers)



Hydrology subcatchment

- 904 m deciduous forest

- 665 m deciduous forest
- 600 m deciduous forest
- 546 m deciduous forest

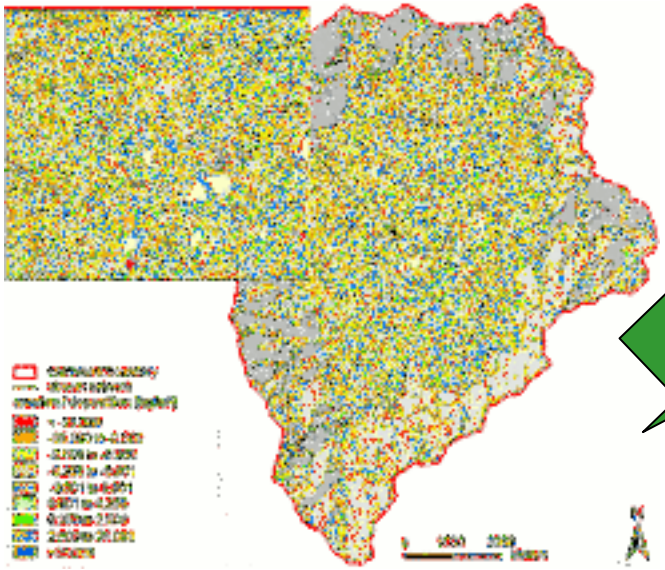
- 538 m cabbage field
- 493 m bean field

- 460 m potato field

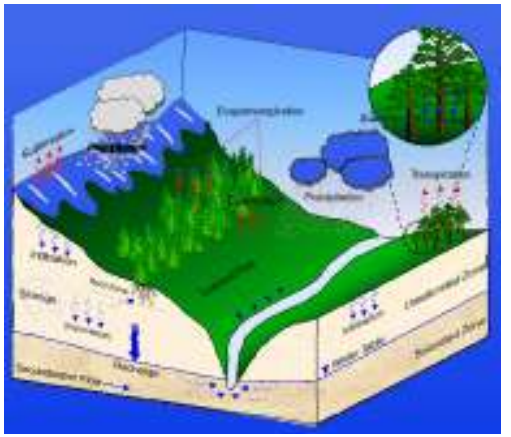
- 438 m radish field
- 426 m rice paddy

Production/Hydrological Framework:

EROSION-3D

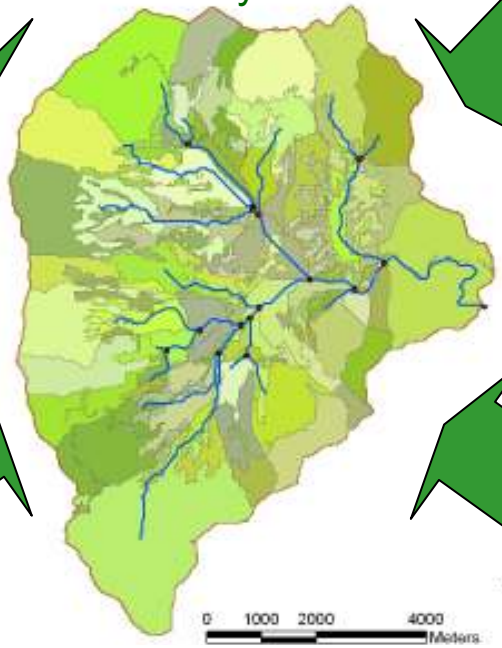


HydroGeoSphere

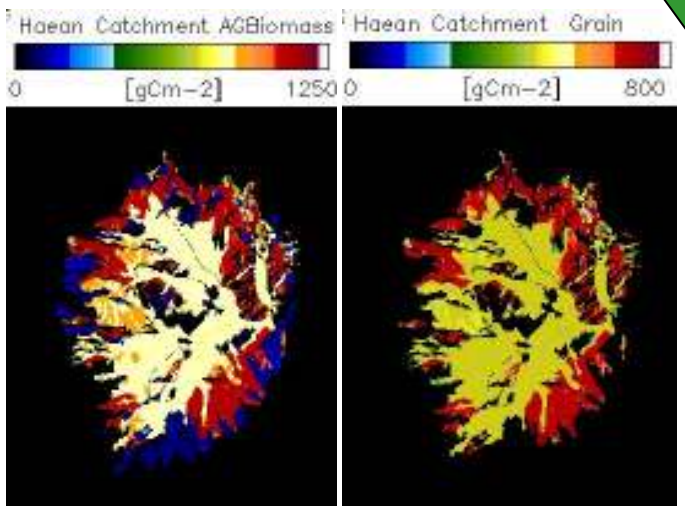


SWAT$_{2005}$

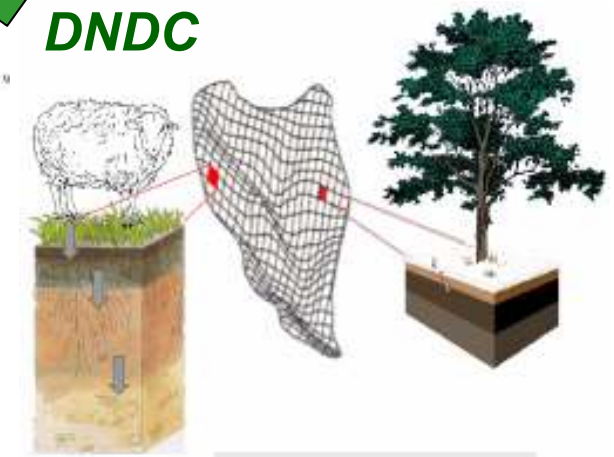
Production, HRU response,
River System



PIXGRO

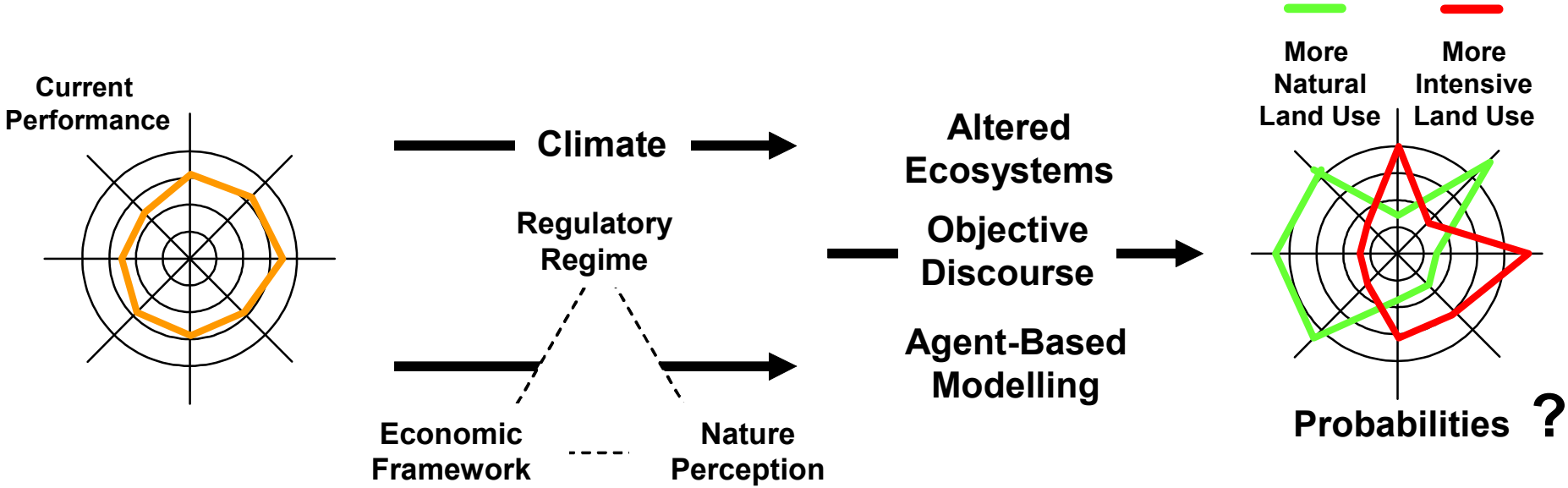


DNDC



www.bayceer.uni-bayreuth.de/terreco

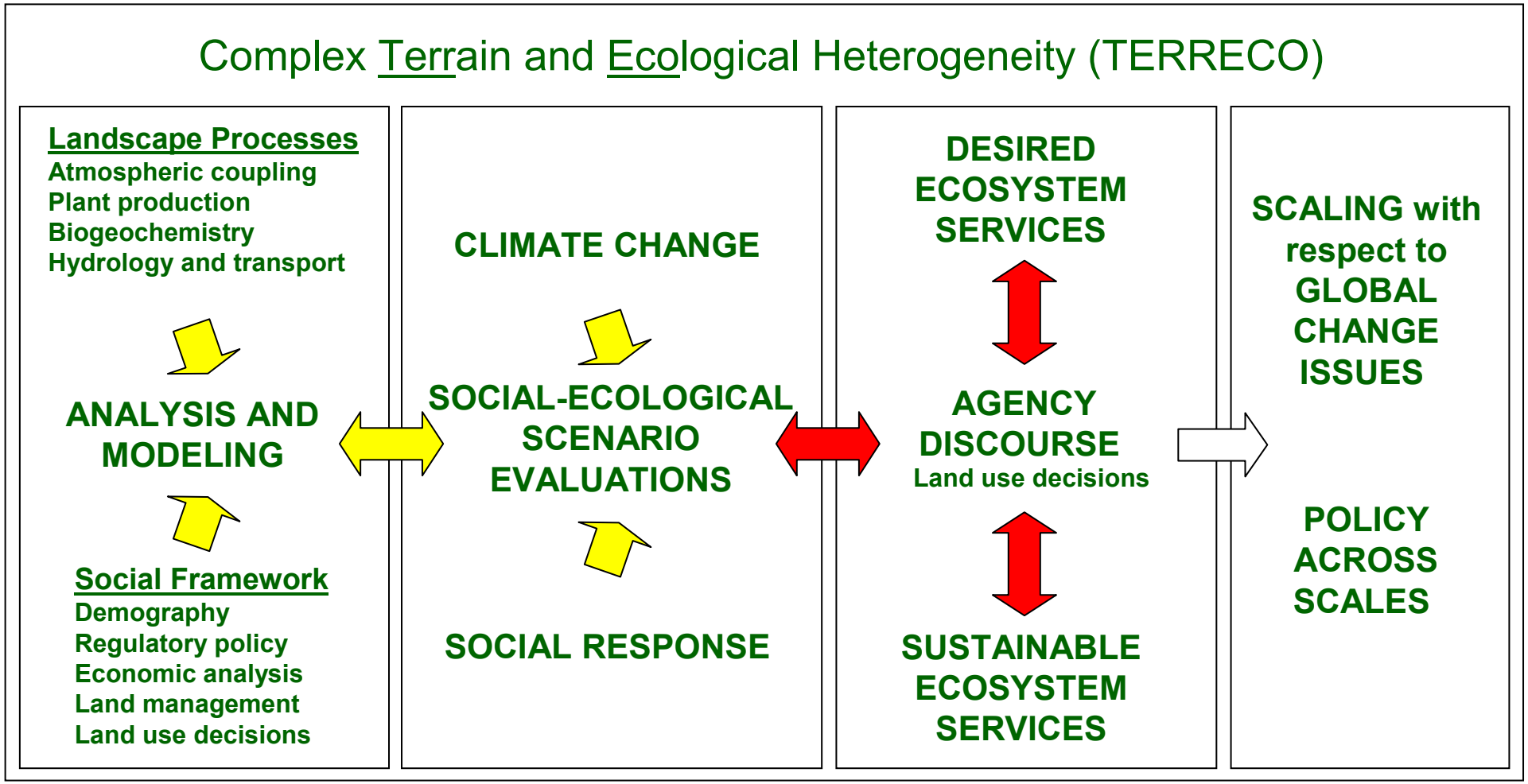
Social – Ecological Analysis
Ultimately, A Focus on Scenario Evaluations



Development of Scenarios: Future Climate and Land Use

Fertilizer and pesticide reduction, subsidies for land use with erosion control, new pricing of clean water supply, modification of water distribution . . . even reunification (?)

Agency Discourse and Scenario Development



“One of the anomalies of modern ecology is the creation of two groups, each of which seems barely aware of the existence of the other. One studies the human community, almost as if it were a separate entity, and calls its findings sociology, economics and history. The other studies the plant and animal community and comfortably relegates the hodge-podge of politics to the liberal arts. The inevitable fusion of these two lines of thought will constitute the outstanding advance of the present century.”

Aldo Leopold, Berlin 1935

Landscale to Regional Scale Concerns About Human Well-Being in the Context of Global Change

www.millenniumassessment.org

Problem Solving Will Require Us to Put It Back Together.

A problem of scale, focus and complexity
A question of flexibility and willingness
A dilemma of dedication

BUT, New Program Design

will contribute to problem solving related to global change

and tight links between education and environmental policy.


Gwangneung


Seolmacheon


Haean