



# PROGRESS TOWARDS EARTH SYSTEM MODELING OF THE PACIFIC NORTHWEST REGION

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National Center for Atmospheric Research

**Regional Earth System Modeling and Analysis Symposium**  
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May 20, 2011

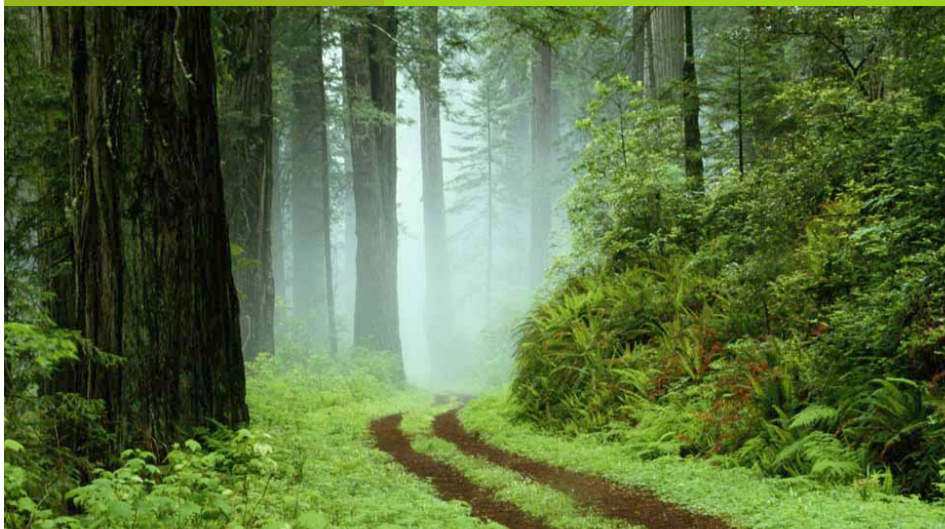


# A NEW EARTH SYSTEM MODEL

**BioEarth**



*Biosphere relevant earth system model*







# GOAL AND OBJECTIVES

***Overarching Goal:*** To improve the understanding of regional and decadal-scale C:N:H<sub>2</sub>O interactions in context of global change to better inform decision makers involved in natural and agricultural resource management.

***Specific Objectives:***

1. ***Air to Land Linkage:*** To investigate the role that atmospheric processes play in land surface C:N:H<sub>2</sub>O cycles.
2. ***Coupled Air/Land:*** To explore how ecosystem changes in the PNW affect land/atmosphere interactions.
3. ***Coupled Air/Land/Human:*** To examine how potential policy changes might affect the interactions between C:N:H<sub>2</sub>O cycles and regional-scale climate.
4. ***Communication:*** To explore how to best communicate the model results to resource managers and policy makers.



# OUTREACH AND COMMUNICATIONS RESEARCH

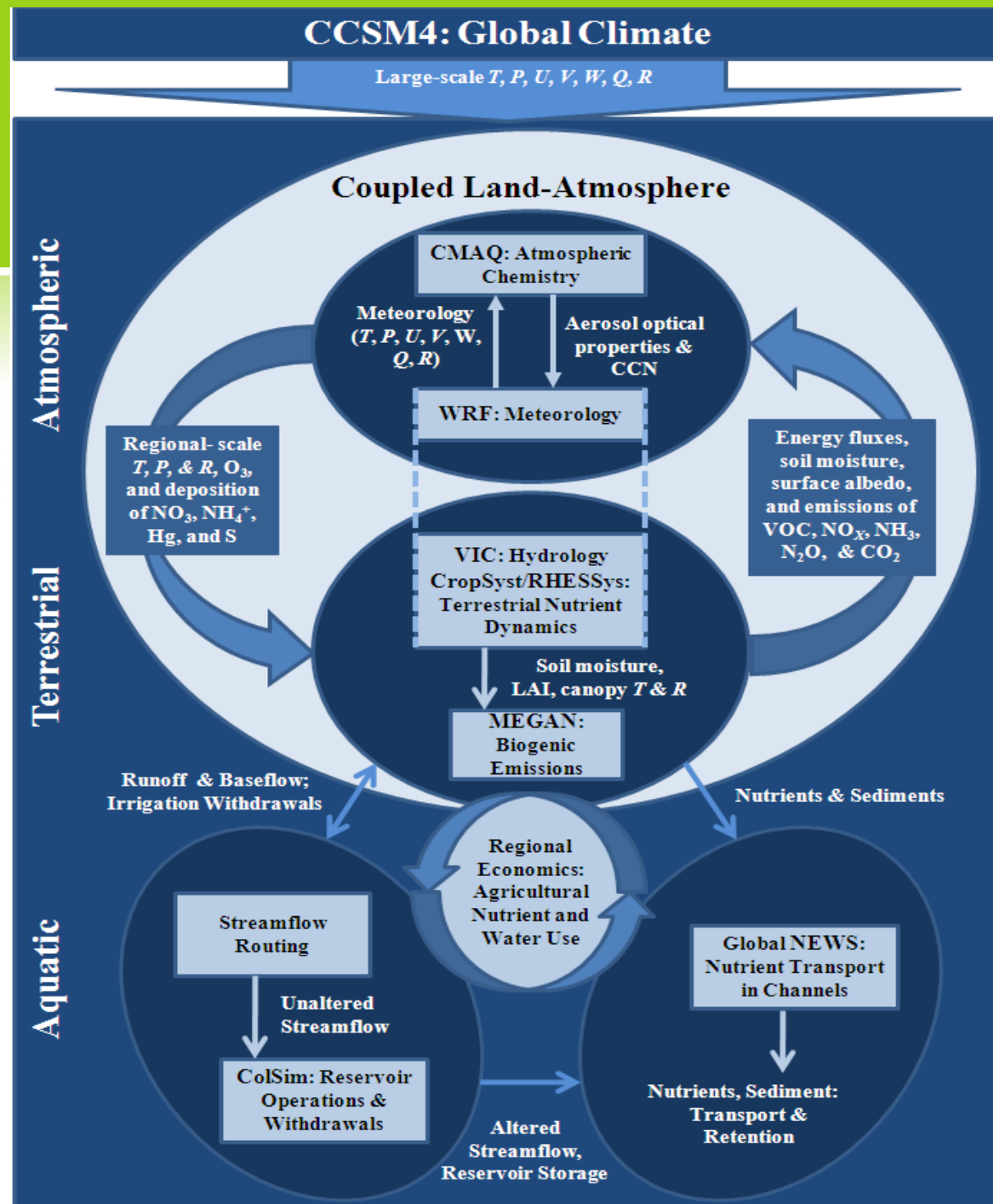
- ◎ WSU Extension will hold two meetings per year (for four years) with stakeholders in
  - ◎ Agriculture
  - ◎ Forestry
  - ◎ Tribes
- ◎ Communications research question: How does regular interaction between BioEarth developers and land-use stakeholders influence the perceived relevance and perceived utility of a model to decision-making?



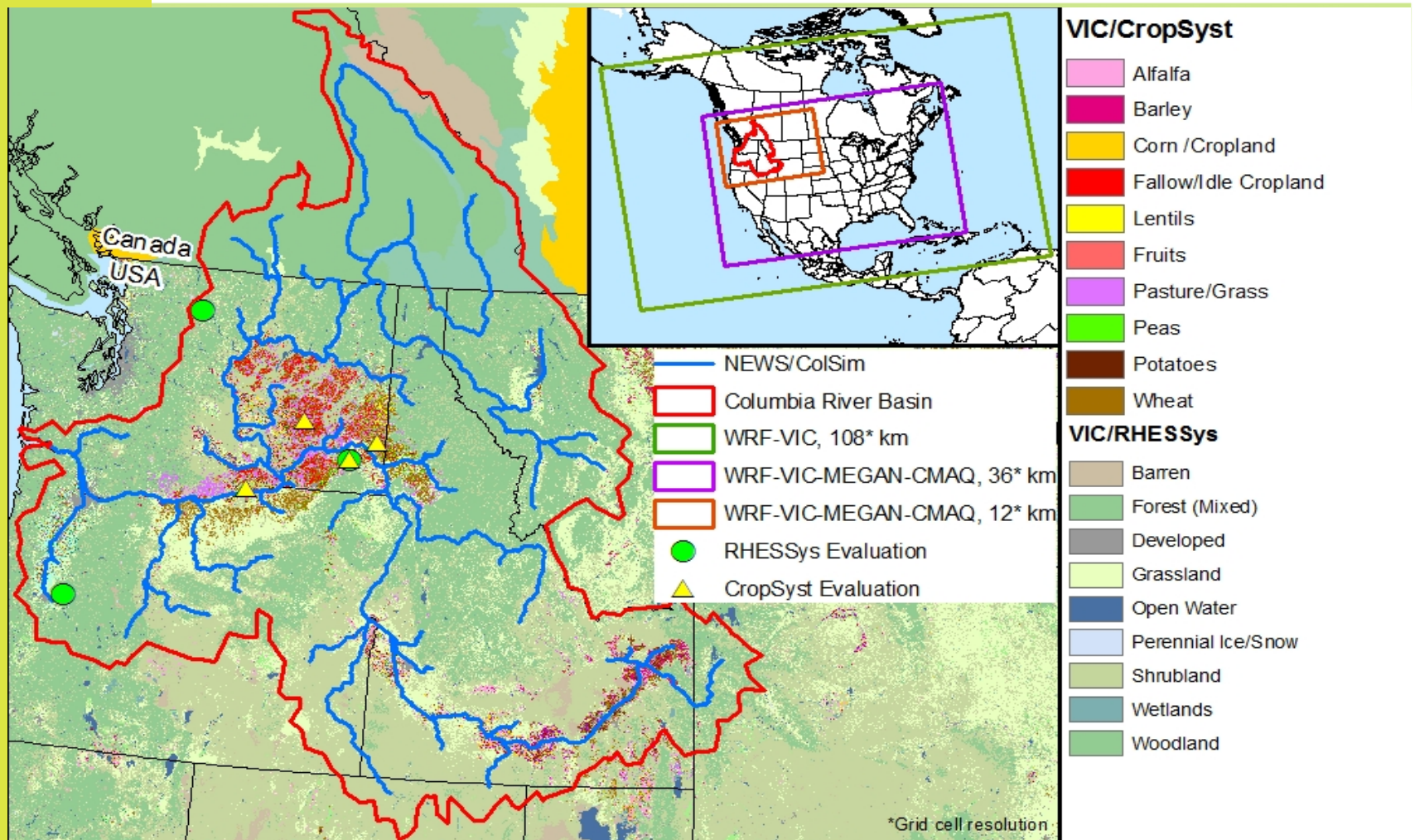
# BIOEARTH VERSUS CESM

BioEarth	CESM
Regional scale: Pacific Northwest (uses a GCM for boundary conditions)	Global Scale (no boundary problems)
Finer Spatial Resolution	Coarser Spatial Resolution
No Ocean, sea ice, or glaciers	Has ocean, sea ice, glaciers
Some components more sophisticated	Some components necessarily less sophisticated
*More explicit handling of human activities: cropping systems (irrigation, tillage, fertilization), forest management, reservoir operations *Integrated economic modeling; can be used for policy scenario investigation *Model outputs more directly relevant for local scale planning/decision making/informing policy	Less explicit handling of human activities

# BIOEARTH



# MODELING DOMAIN: THE PACIFIC NORTHWEST







# CONTRIBUTING FACULTY

Modeling Team	Earth System Component
Jennifer Adam, WSU	Terrestrial/Aquatic
Serena Chung, WSU	Atmospheric
Alex Guenther, NCAR	Atmospheric/Terrestrial
John Harrison, WSU	Terrestrial/Aquatic
Brian Lamb, WSU	Atmospheric
Ruby Leung, PNNL	Atmospheric/Terrestrial
Claudio Stockle, WSU	Terrestrial
Christina Tague, UCSB	Terrestrial/Aquatic
Joe Vaughan, WSU	Atmospheric



# CONTRIBUTING FACULTY

## Economics Team

Michael Brady, WSU

Yong Chen, OSU

Jon Yoder, WSU

## Ecology Team

Dave Evans, WSU

John Harrison, WSU

Christina Tague, UCSB

## Outreach/Education Team

Chad Kruger, WSU

Fok Leung, WSU

Andy Perleberg, WSU

Jennie Stephens, Clark U.

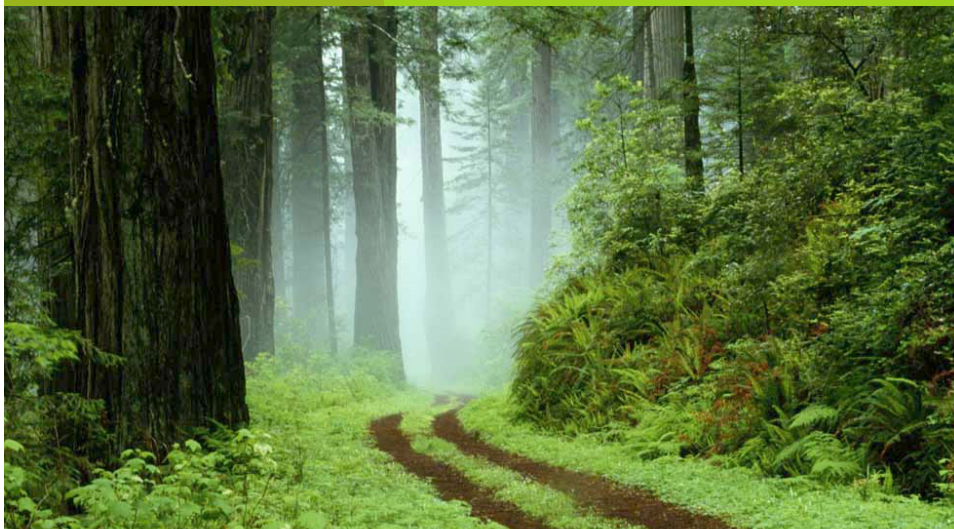
## Cyberinfrastructure Team

Ananth Kalyanaraman, WSU

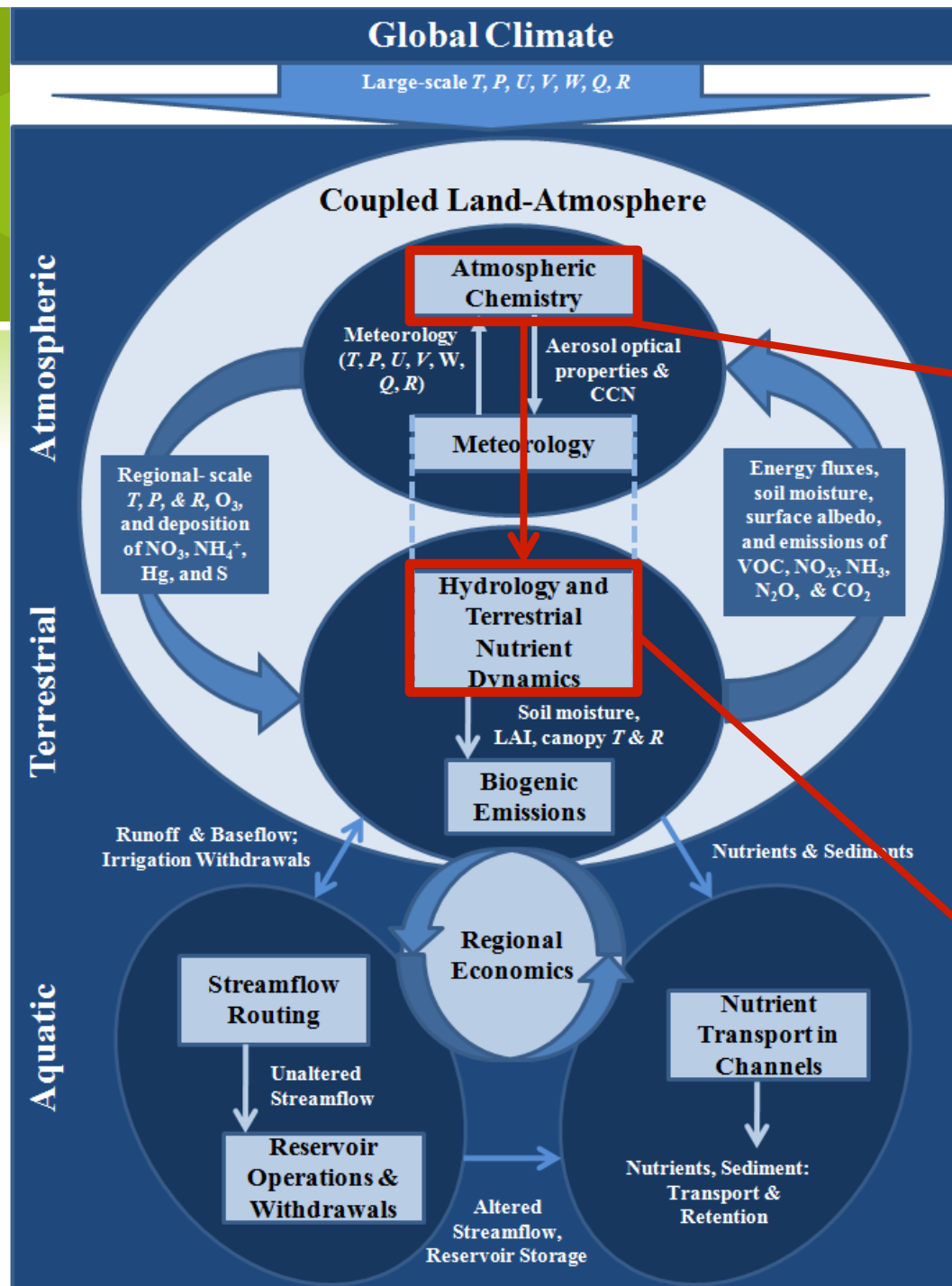
Joe Vaughan, WSU



FOUNDATIONAL PROJECT: LINKAGES  
BETWEEN ATMOSPHERIC CHEMISTRY AND  
TERRESTRIAL BIOGEOCHEMICAL CYCLING







# BIOEARTH

**CMAQ**: for atmospheric chemistry

**RHESys**: for vegetation processes and biogeochemical cycling in forests/grasslands

# REACTIVE NITROGEN (N) AND GLOBAL CHANGE

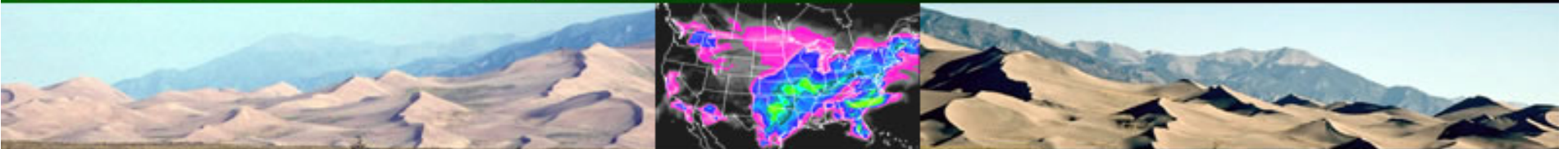
- ⊙ Reactive N rates have doubled from those of the pre-industrial era due to fossil fuel combustion and use of N fertilizers.
- ⊙ The N cycle interacts with the carbon cycle and is thus connected to climate.
- ⊙ Linking these biogeochemical processes with hydrology and the atmosphere helps to understand potential impacts of the atmosphere on the terrestrial biosphere.
- ⊙ Research Question: How does atmospheric deposition of N affect terrestrial ecosystem processes and how does this linkage feed back to the atmosphere?

Courtesy Julian Reyes

# REGIONAL ATMOSPHERIC CHEMISTRY: CMAQ

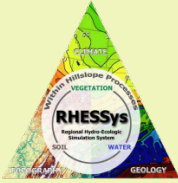
- ◎ CMAQ: Community Multi-Scale Air Quality Model
- ◎ Project of the U.S EPA
- ◎ Solution to the pollutant conservation equation
- ◎ 50-100 chemical species, 100's of reactions
- ◎ Cloud chemistry
- ◎ Detailed wet/dry deposition scheme

C M A Q - M O D E L . O R G

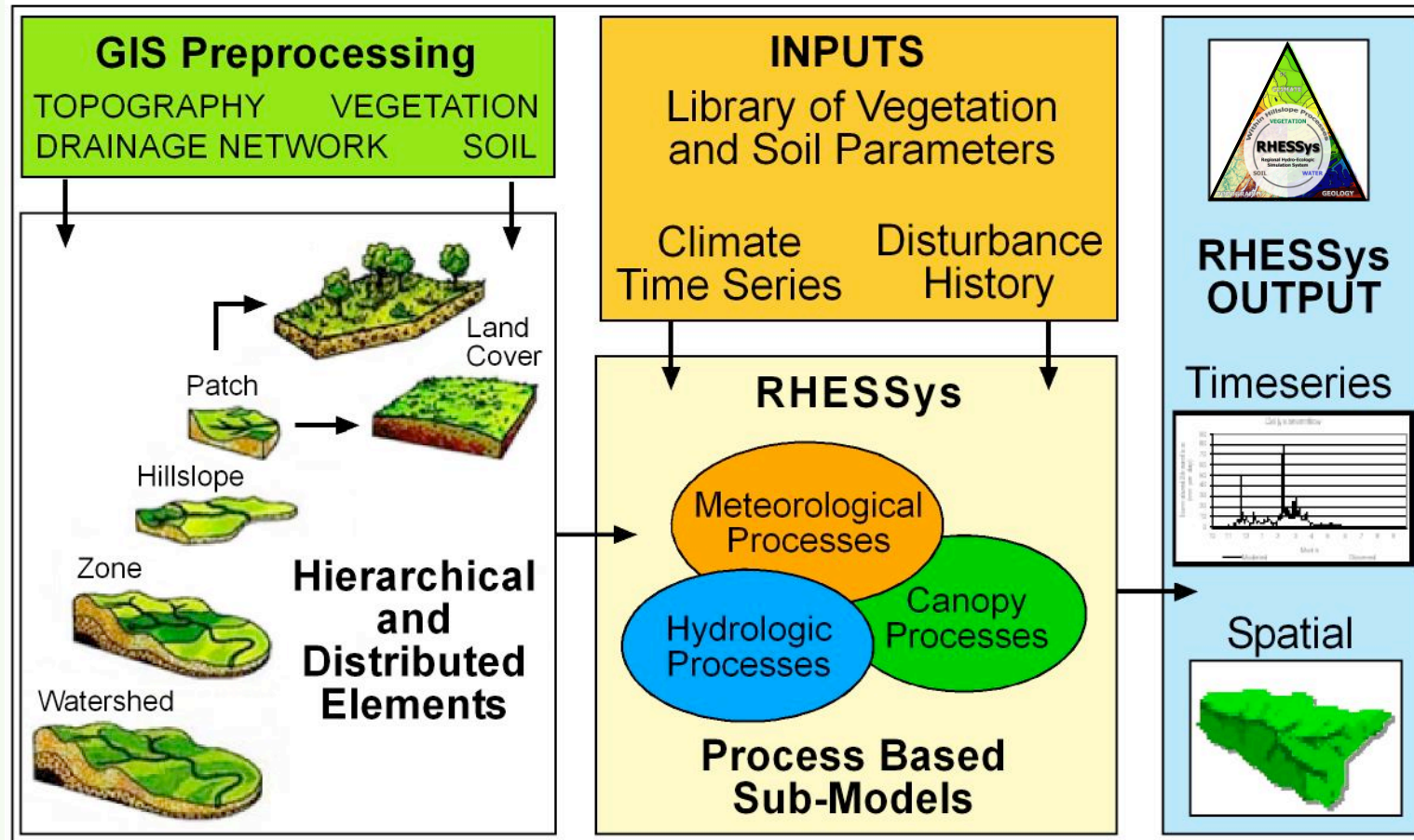


C o m m u n i t y M u l t i s c a l e A i r Q u a l i t y





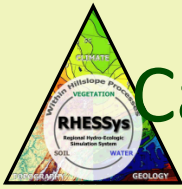
# REGIONAL HYDRO-ECOLOGIC SIMULATION SYSTEM (RHESSys)



<http://fiesta.bren.ucsb.edu/~rhesys>

**Christina Tague**

Bren School of environmental science and management  
University of California, Santa Barbara

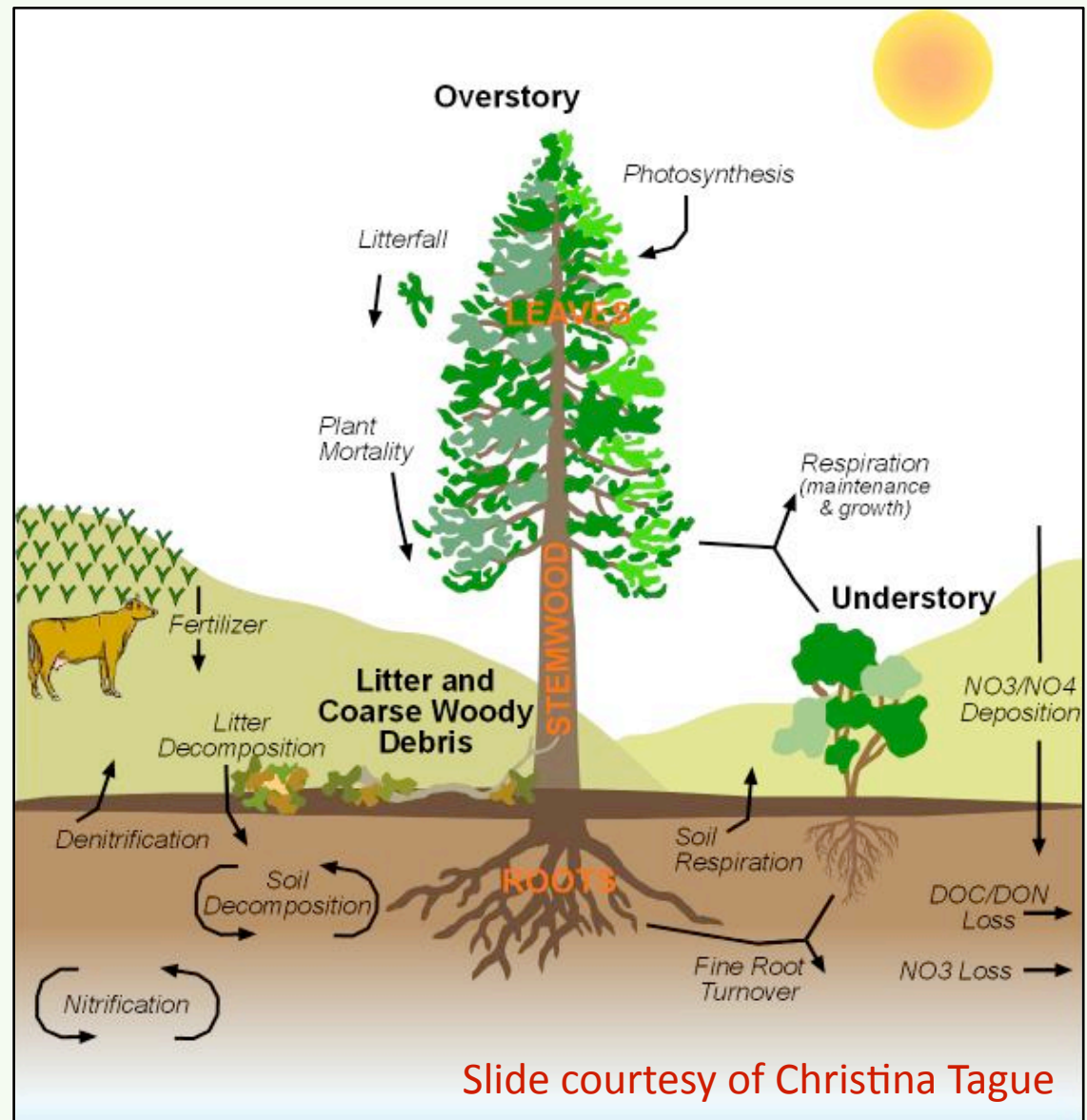


# Carbon and Nitrogen cycling in the RHESSys model

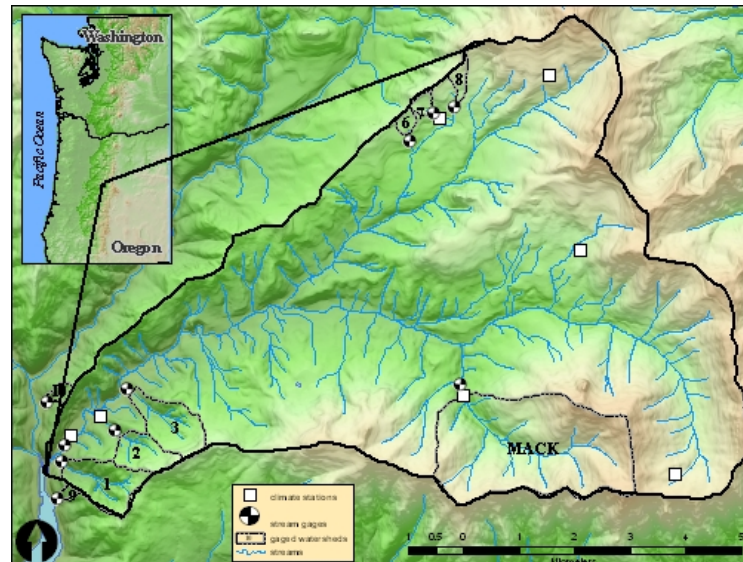
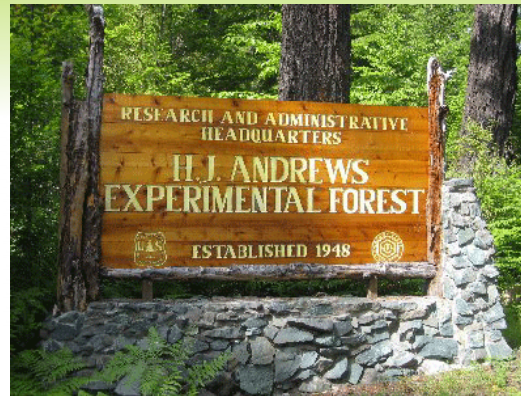
Energy (radiation), carbon,  
nitrogen and water  
balance

Stand competition for  
water, light, nutrients

Feedback between  
NPP, growth,  
phenology, and soil  
biogeochemical cycling



# STUDY WATERSHED



- ◎ H.J. Andrews Experimental Forest, Oregon
- ◎ NSF Long Term Ecological Research (LTER) for analysis of forest and stream ecosystem dynamics
- ◎ Long-term observations focused on climate dynamics, streamflow, water quality, and vegetation succession

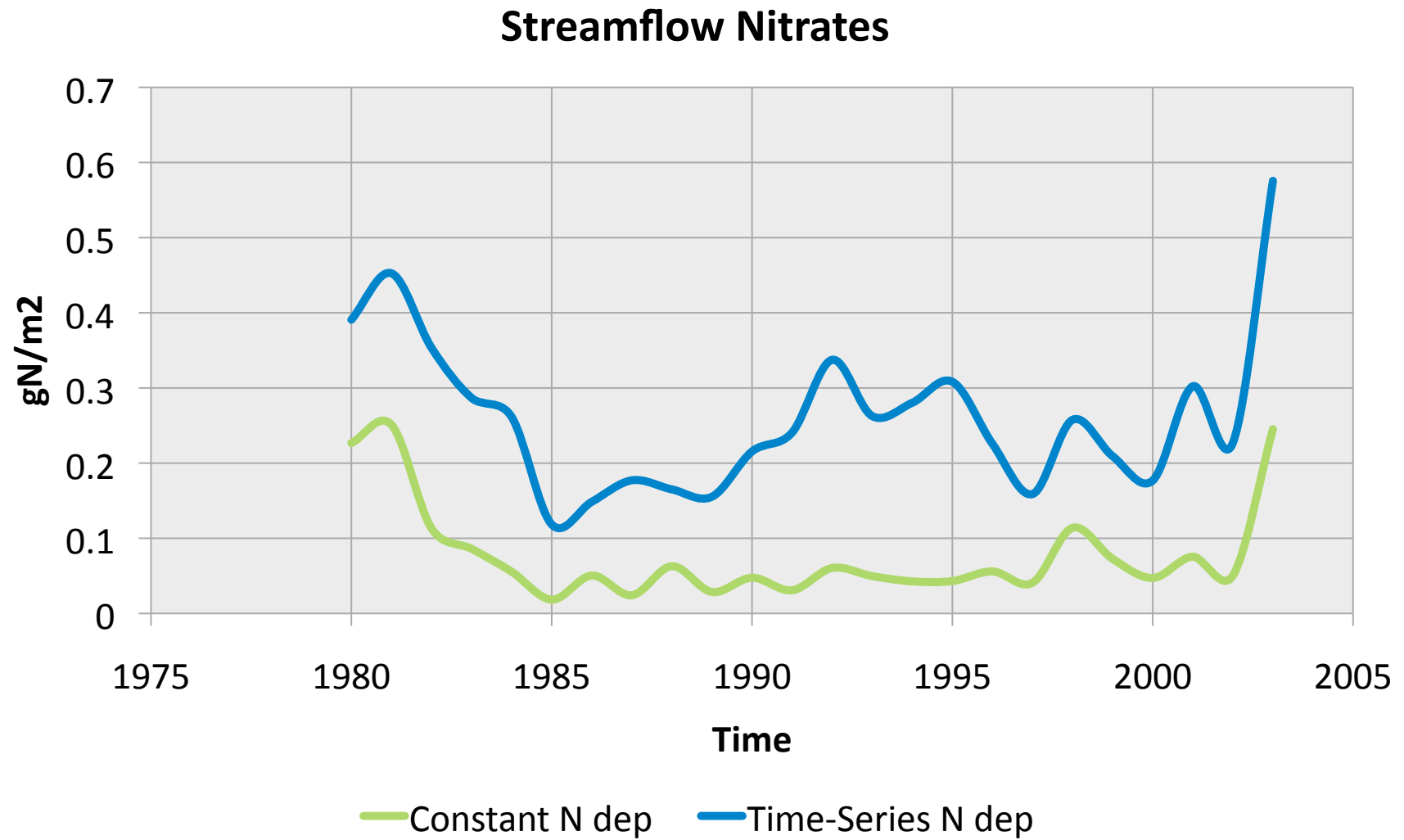
Graphics courtesy <http://andrewsforest.oregonstate.edu/>



# STUDY APPROACH

- ◎ Compare sensitivity of RHESSys-simulated (short- and long-term soil and plant) biogeochemical processes to atmospheric deposition of N (ADN) as determined by
  - ◎ Observed wet/dry ADN depositions
  - ◎ CMAQ-simulated wet/dry ADN (historical and future projected under climate change)
  - ◎ Hypothetical perturbations of ADN:
    - Chronic low level, chronic high level
    - Spikes
    - Long-term increase or decrease

# EXAMPLE OF RESULTS



# NEED FURTHER INFORMATION?

- ◎ Please contact:
  - ◎ Jennifer Adam: [jcadam@wsu.edu](mailto:jcadam@wsu.edu)
  - ◎ Or visit our webpage:  
<http://www.cereo.wsu.edu/bioearth/>  
(currently in development)



QUESTIONS?







EXTRA SLIDES

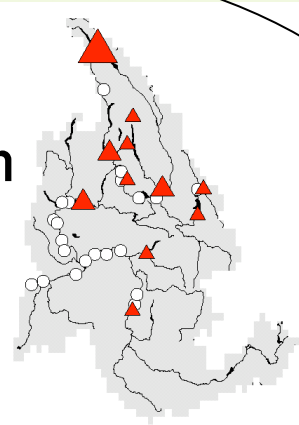


# APPROACH AND RATIONALE

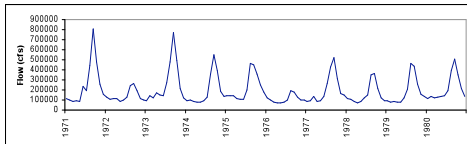
- ⊙ Integrate or link existing sophisticated “stand alone” models that are in continuous development
  - ⊙ Atmosphere: meteorology, atmospheric chemistry
  - ⊙ Terrestrial: hydrology, soil/plant biogeochemistry in cropped and natural systems, biogenic emissions
  - ⊙ Aquatic: river routing, reservoir modeling, nutrient export
  - ⊙ Economics
- ⊙ As the “stand alone” components continue to improve by their developers, the BioEarth will also continue to develop

# THE RESERVOIR MODEL (COLSIM)

Physical System  
of Dams  
and Reservoirs



VIC Streamflow Time Series

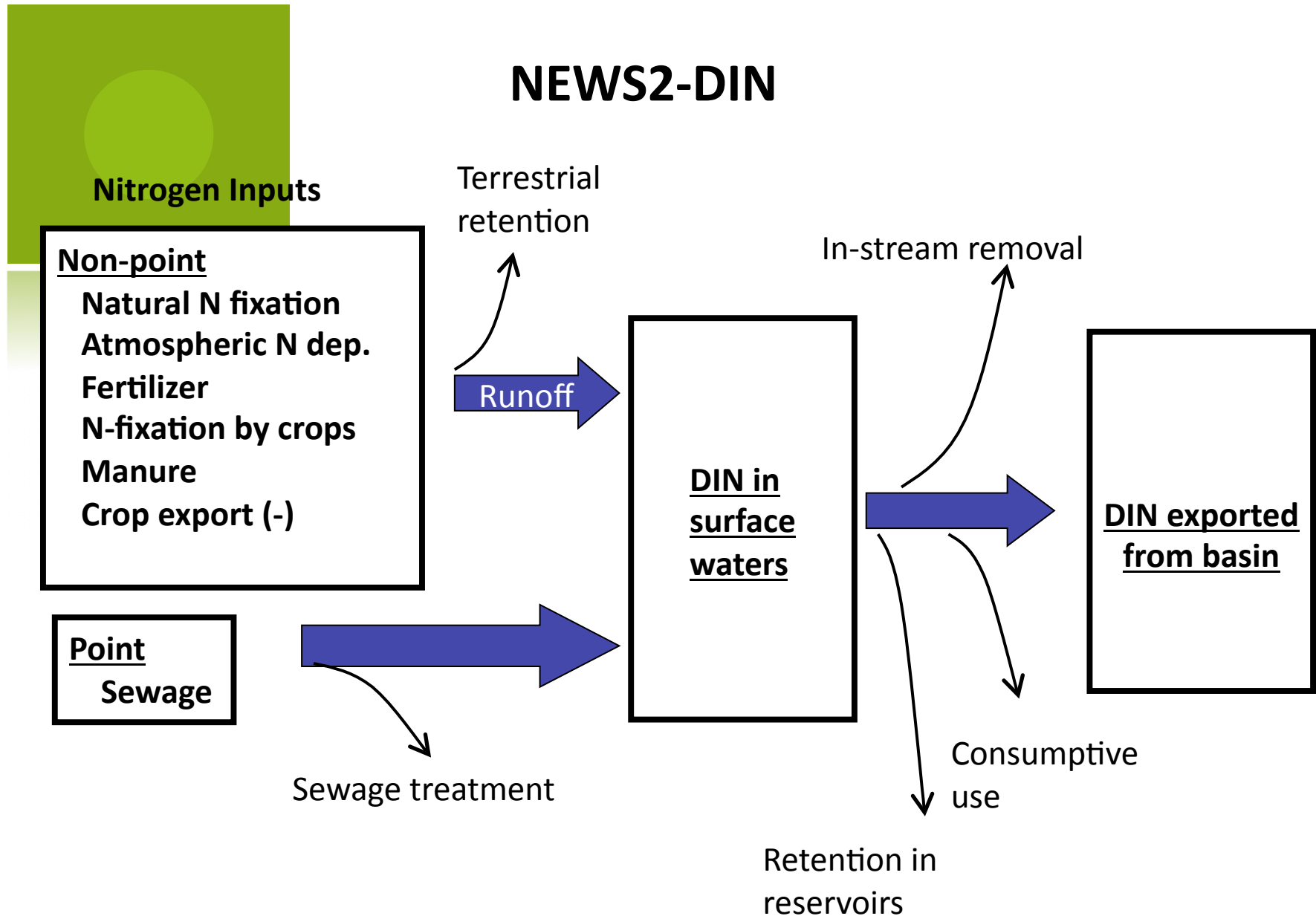


Reservoir Operating Policies

Reservoir Storage  
Regulated Streamflow  
Flood Control  
Energy Production  
Irrigation Consumption  
Streamflow Augmentation

Slide courtesy of Alan Hamlet

# NEWS2-DIN



Slide borrowed from Kara Goodwin



# WSDA / USDA crop distribution data

WSDA DETAILED CROP  
INFORMATION FOR  
WASHINGTON STATE

USDA CROPLAND DATA LAYER  
(CDL) FOR OTHER STATES



Courtesy Kiran Chinnayakanahalli

## Global Climate

Large-scale  $T, P, U, V, W, Q, R$

# BIOEARTH

