

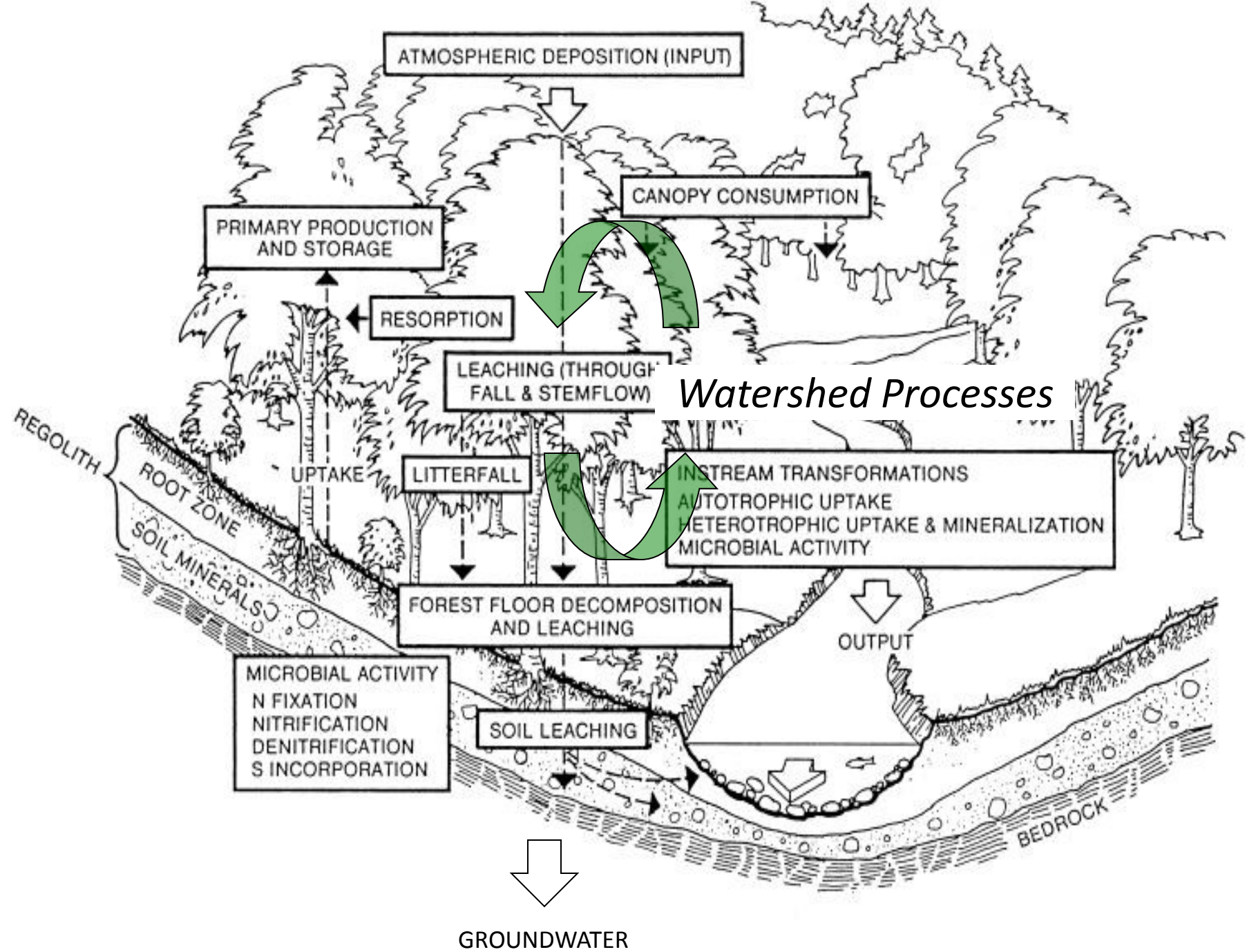
Drivers of Ecosystems: Watershed Science

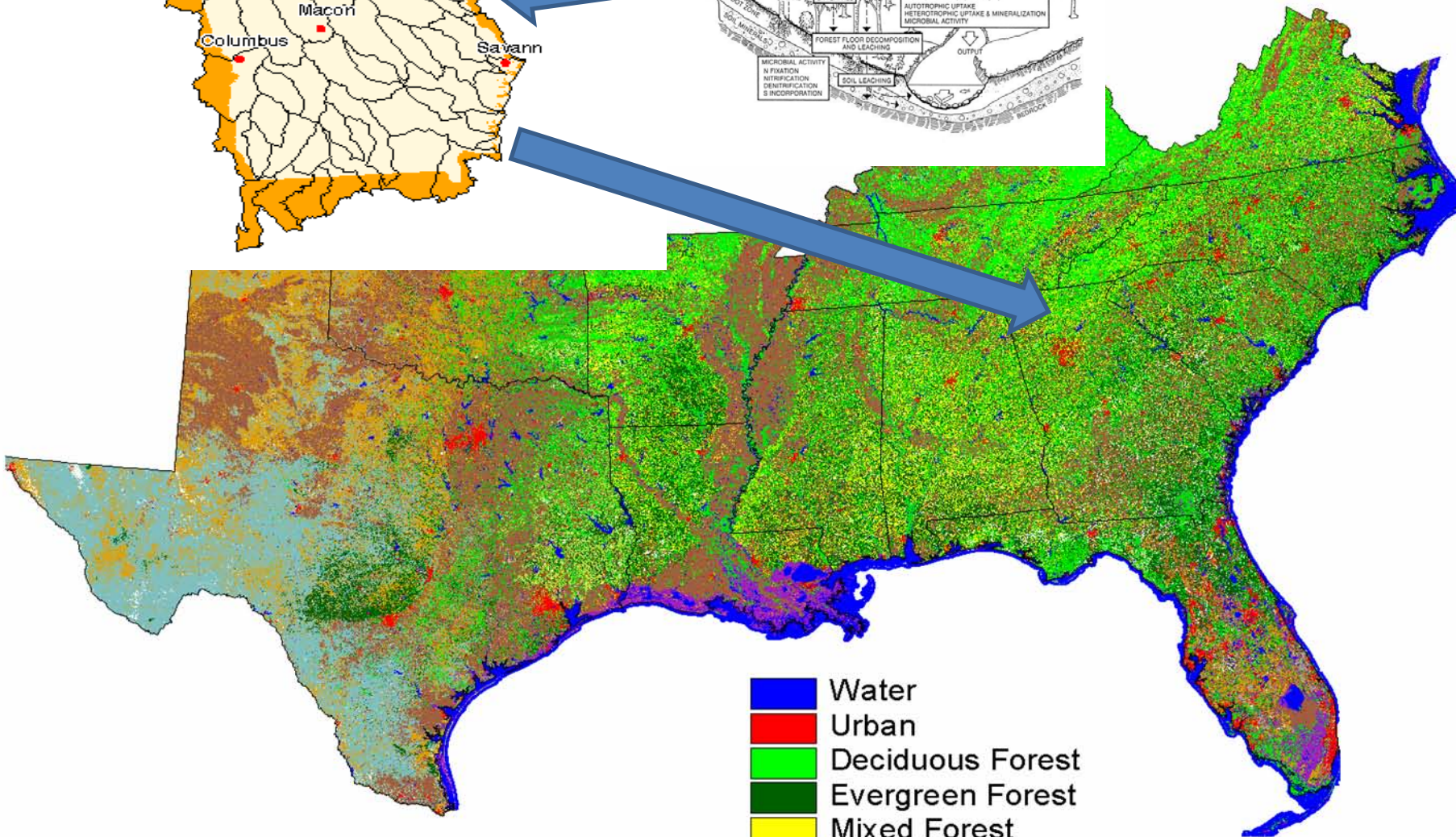
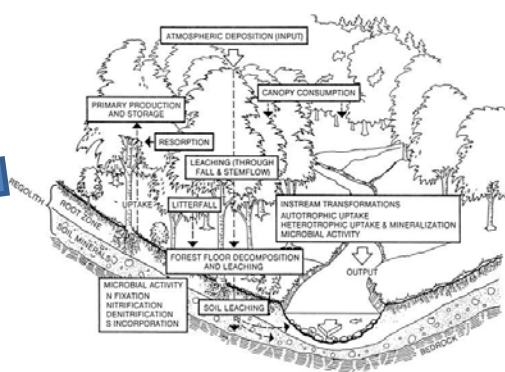
James M. Vose

USDA Forest Service

Southern Research Station

Coweeta Hydrologic Laboratory

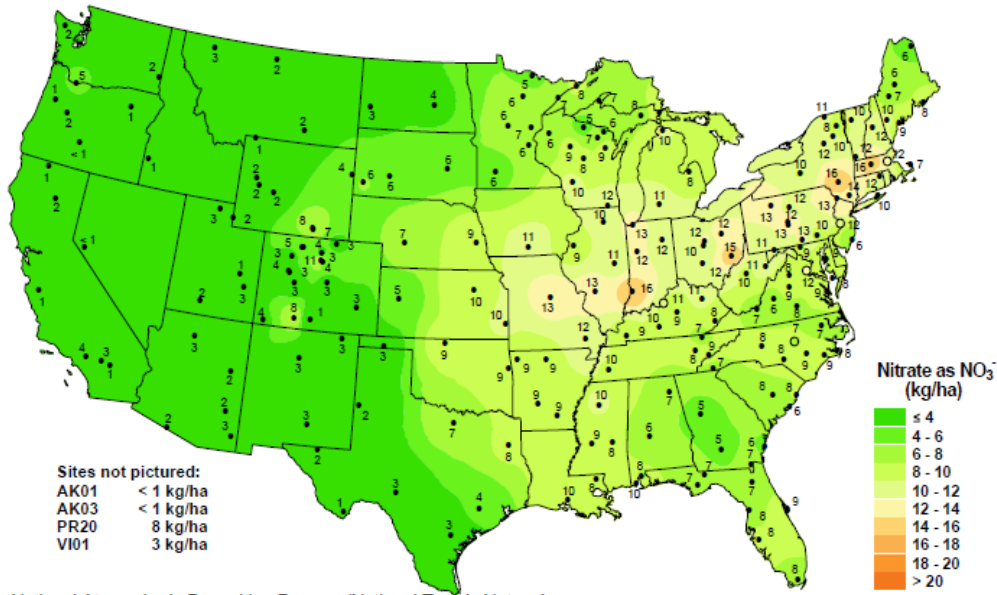




- Water
- Urban
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Agriculture
- Shrubland
- Herbaceous Wetland

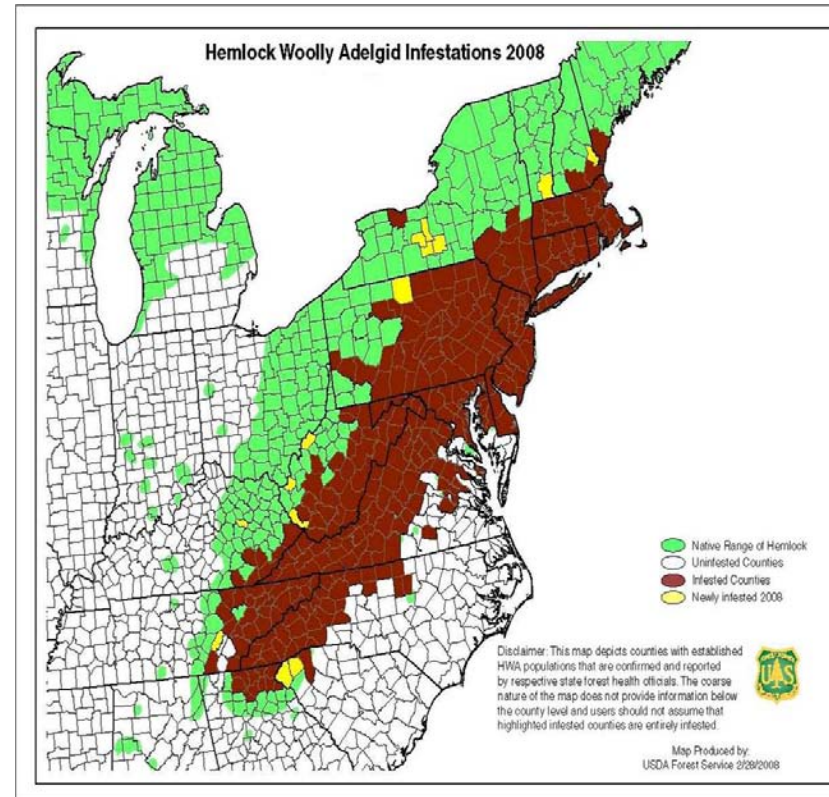
Watersheds are connected by the transfer of materials, species, disturbances...

Nitrate ion wet deposition, 2008

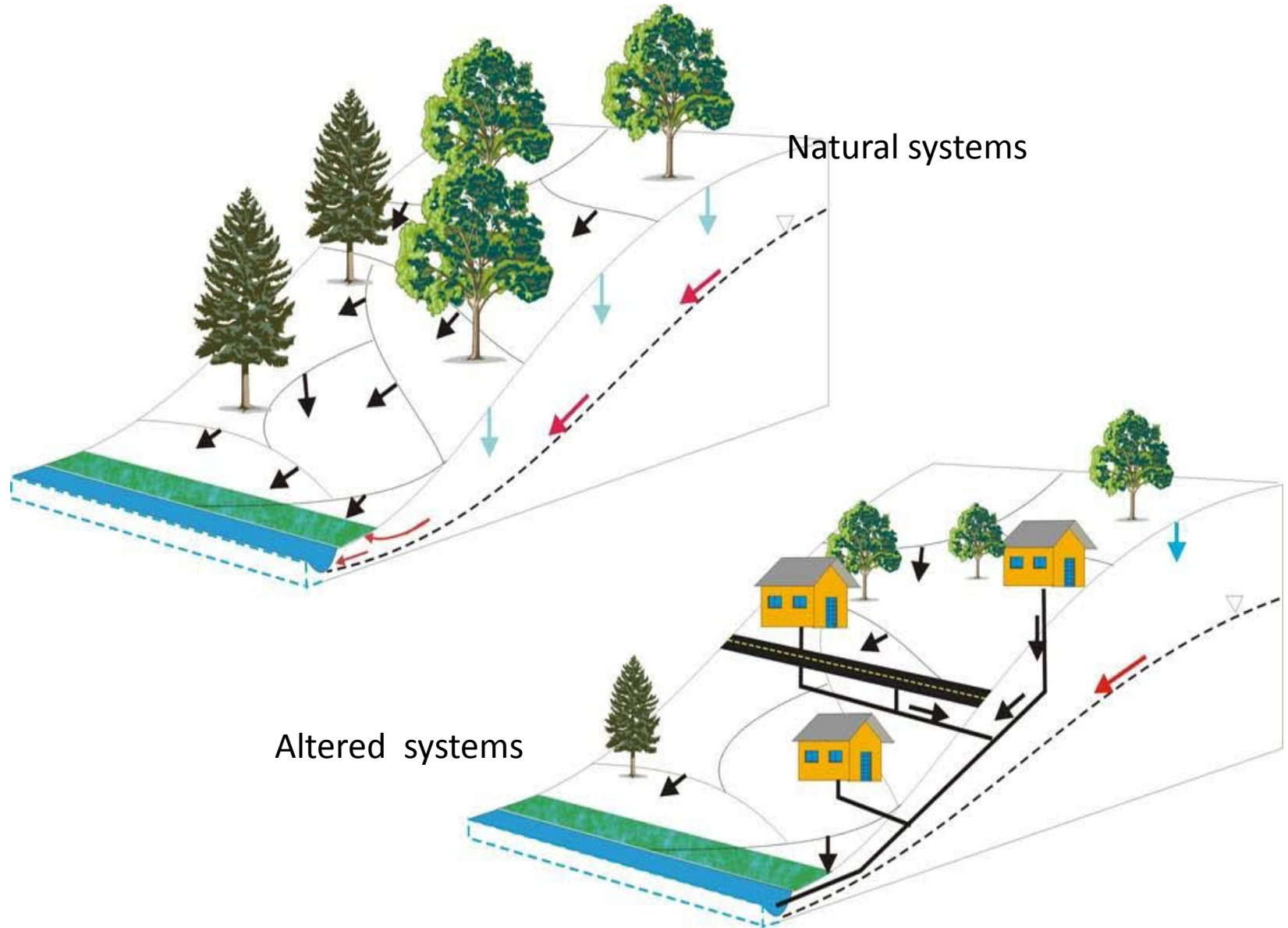


National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>

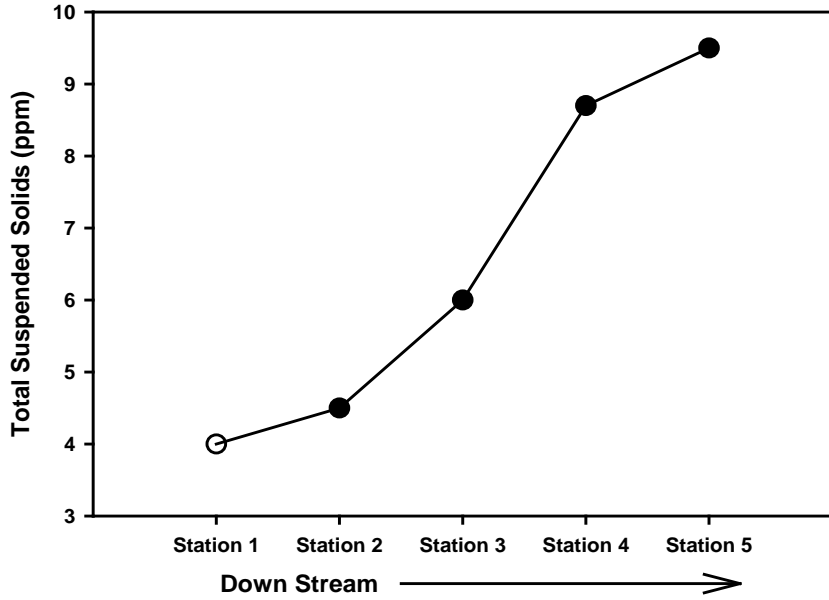
Hemlock Woolly Adelgid Infestations 2008



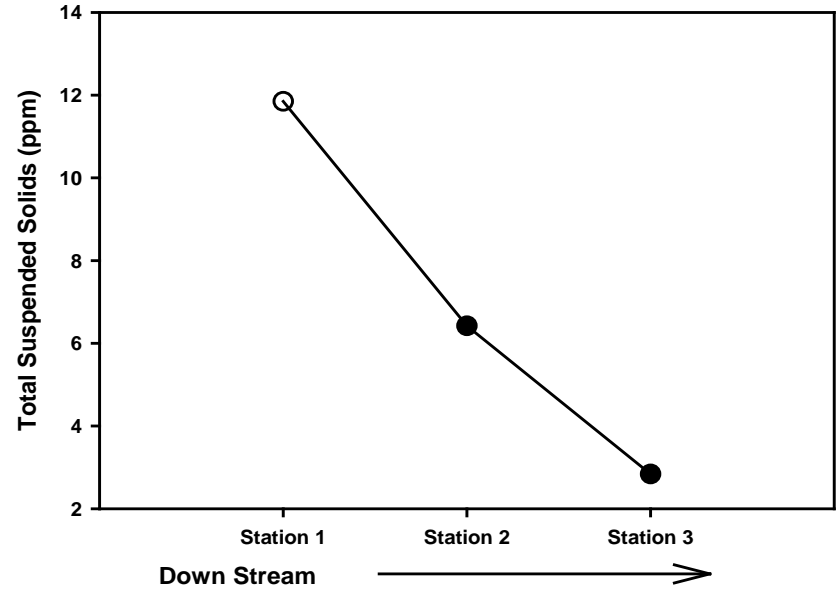
Watersheds are **connected** at all scales **by hydrologic flowpaths**....*water is an integrated measure of watershed health*...



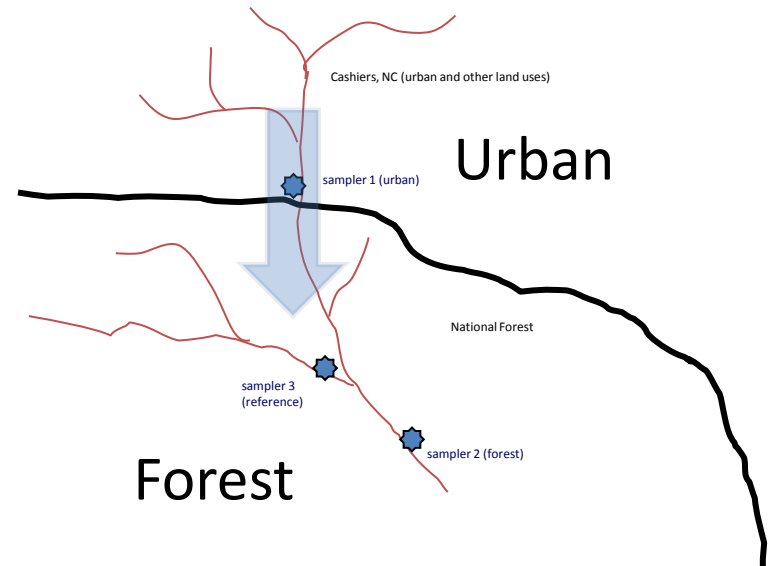
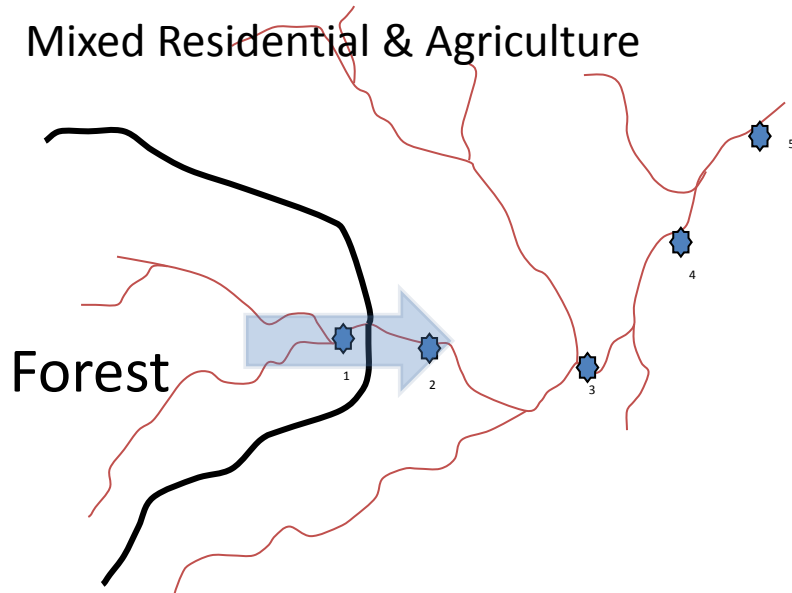
Forested Headwaters



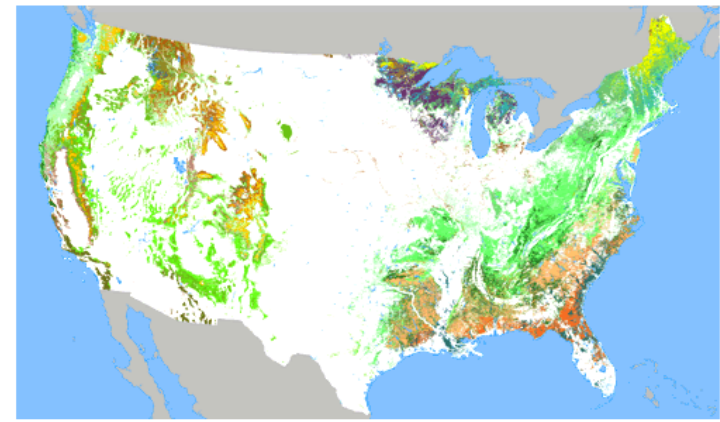
Urbanized Headwaters



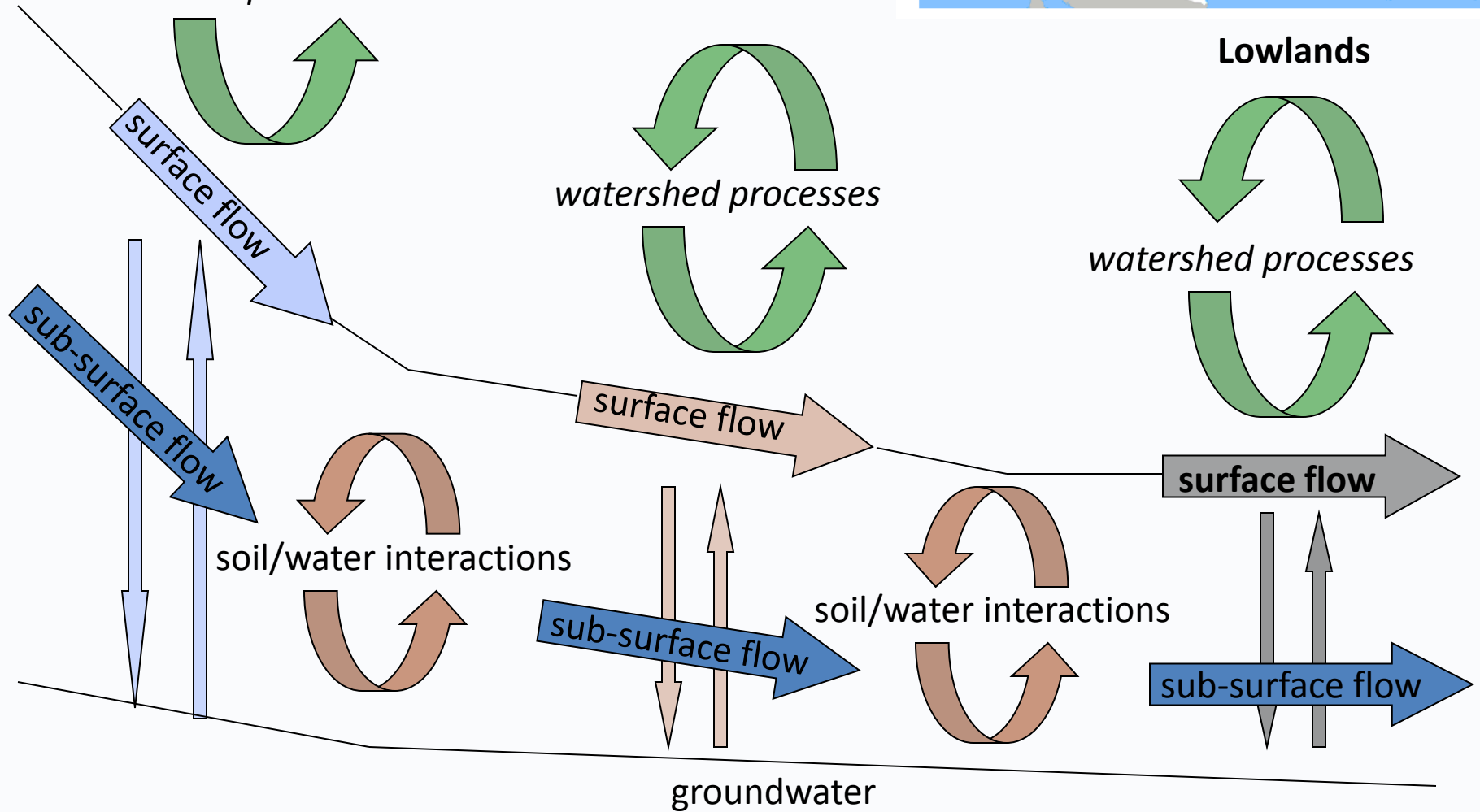
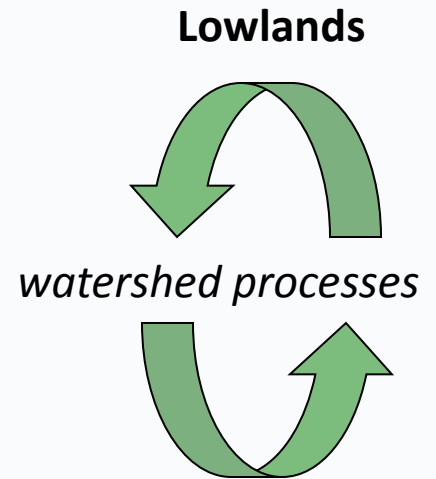
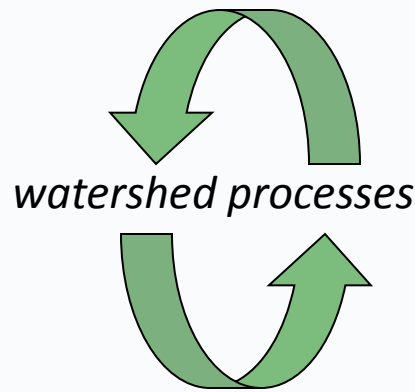
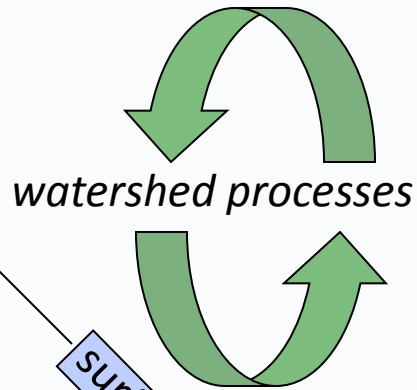
Mixed Residential & Agriculture



Landscape Scale



Uplands



Land management, land use change, and other disturbance activities alter watershed processes that effect resiliency at small and large scales

Physical

roads

dams/inter-basin transfer

erosion/infiltration

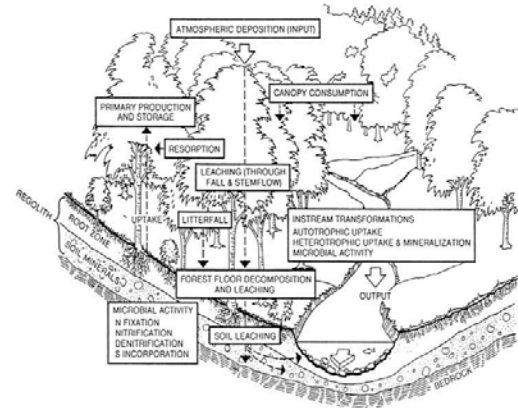
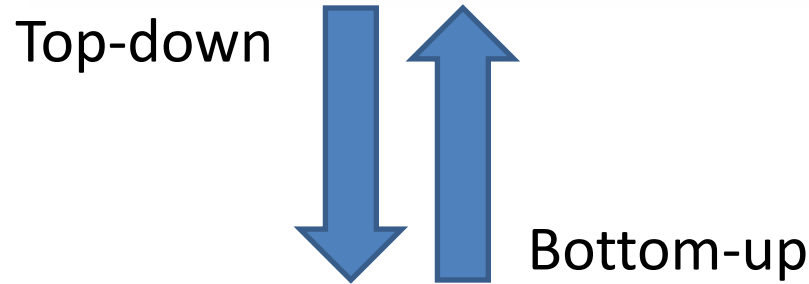
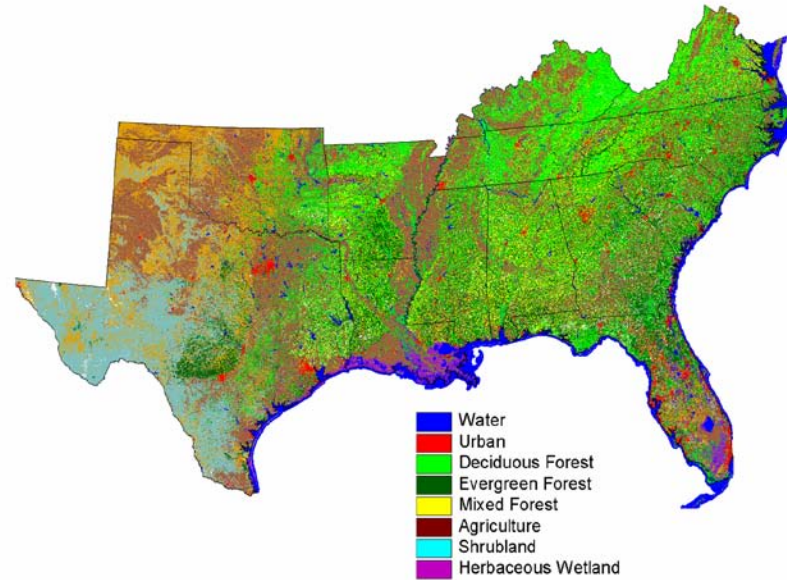
Biological

species composition

age class distribution

spatial arrangement

How do we work across these different scales to quantify the impacts of disturbance and identify management options?



Technology

RF Telemetry
Macro-organisms



Sap Flow
Sensor Array



Minirhizotron
Array



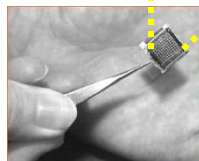
'Smart Dust' tagged Insects



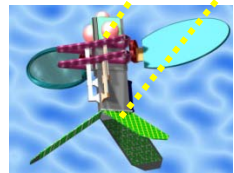
E-nose



Automated E-tongue



Multiparameter
Soil Probes



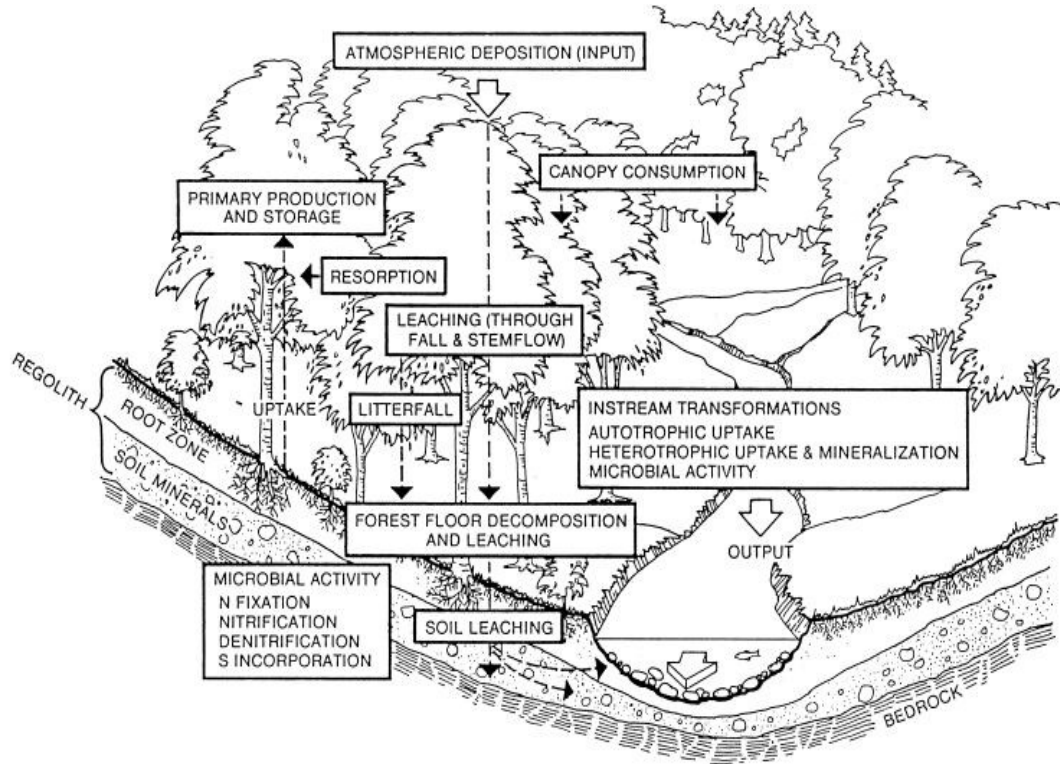
Sensor Clustered
MEMS Insects



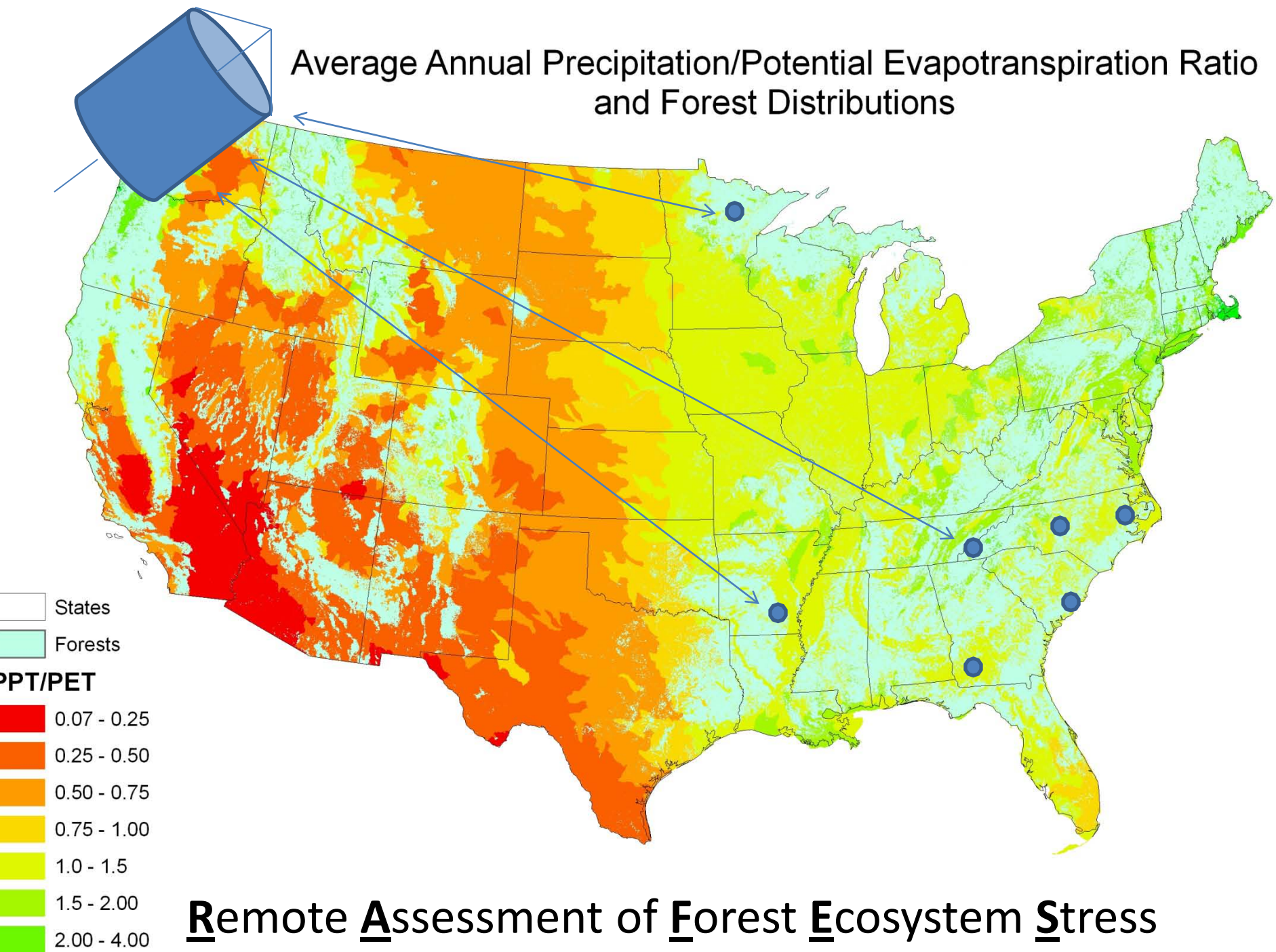
Micro-weather
Stations



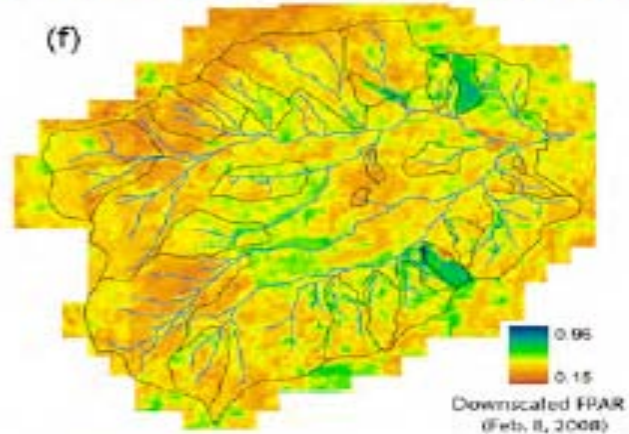
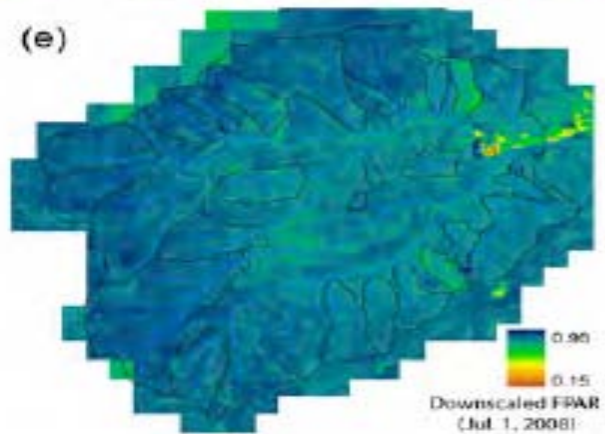
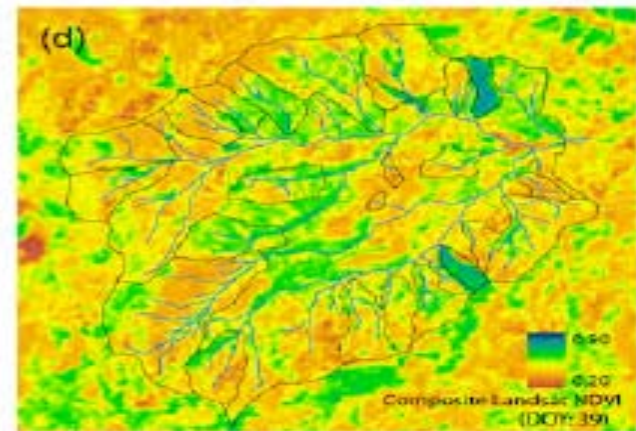
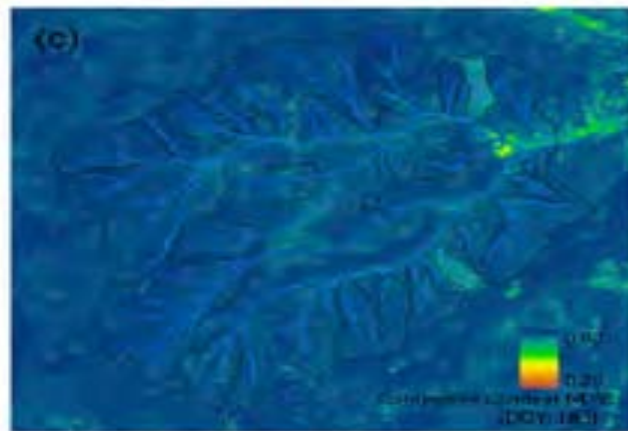
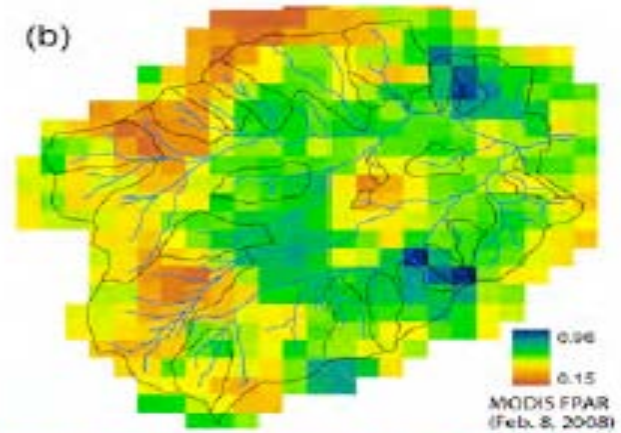
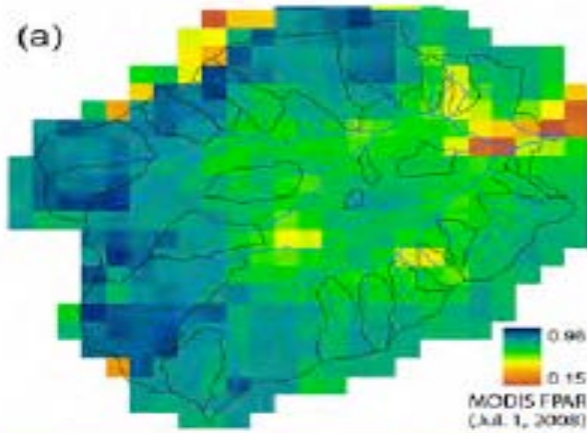
Smart Sensor Web



Average Annual Precipitation/Potential Evapotranspiration Ratio and Forest Distributions



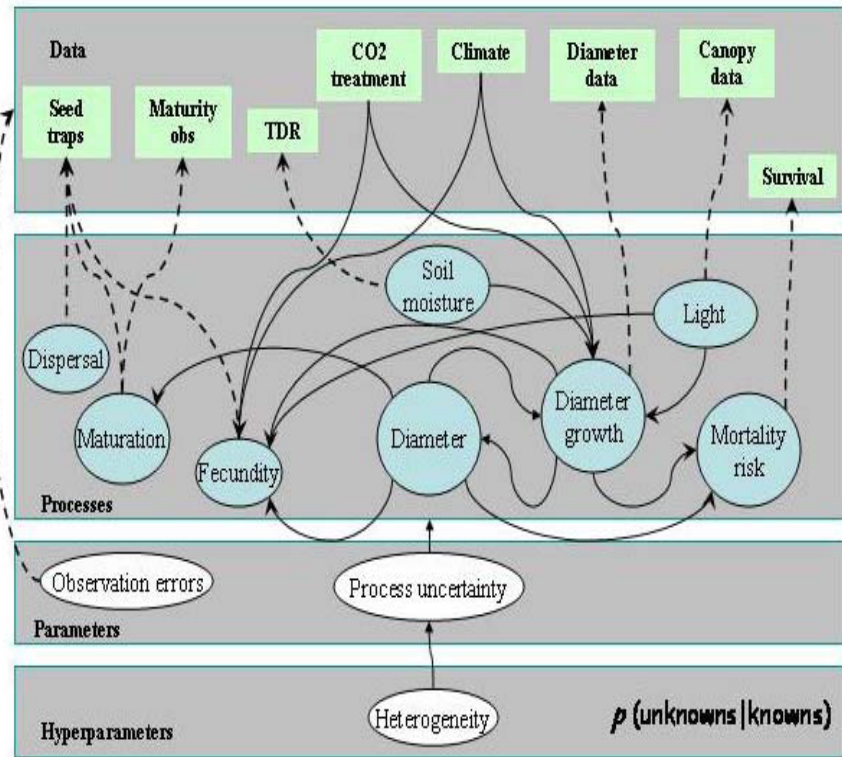
Remote Assessment of Forest Ecosystem Stress



Meso-Scale Monitoring Networks and Modeling

Top 10 species by number of trees [1" dbh and larger] in 2002

Common name	Genus	Species	Number of trees	Percent of all trees
Red Maple	<i>Acer</i>	<i>rubrum</i>	21,834,748,401	7.6%
Loblolly Pine	<i>Pinus</i>	<i>taeda</i>	19,133,975,069	6.6%
Sweetgum	<i>Liquidambar</i>	<i>styraciflua</i>	13,153,930,093	4.6%
Douglas-Fir	<i>Pseudotsuga</i>	<i>menziesii</i>	9,962,056,987	3.5%
Quaking Aspen	<i>Populus</i>	<i>tremuloides</i>	9,065,591,863	3.2%
Sugar Maple	<i>Acer</i>	<i>saccharum</i>	8,993,035,576	3.1%
Balsam Fir	<i>Abies</i>	<i>balsamea</i>	8,918,466,178	3.1%
Flowering Dogwood	<i>Cornus</i>	<i>florida</i>	8,608,168,855	3.0%
Lodgepole Pine	<i>Pinus</i>	<i>contorta</i>	7,078,252,791	2.5%
White Oak	<i>Quercus</i>	<i>alba</i>	5,412,297,254	1.9%

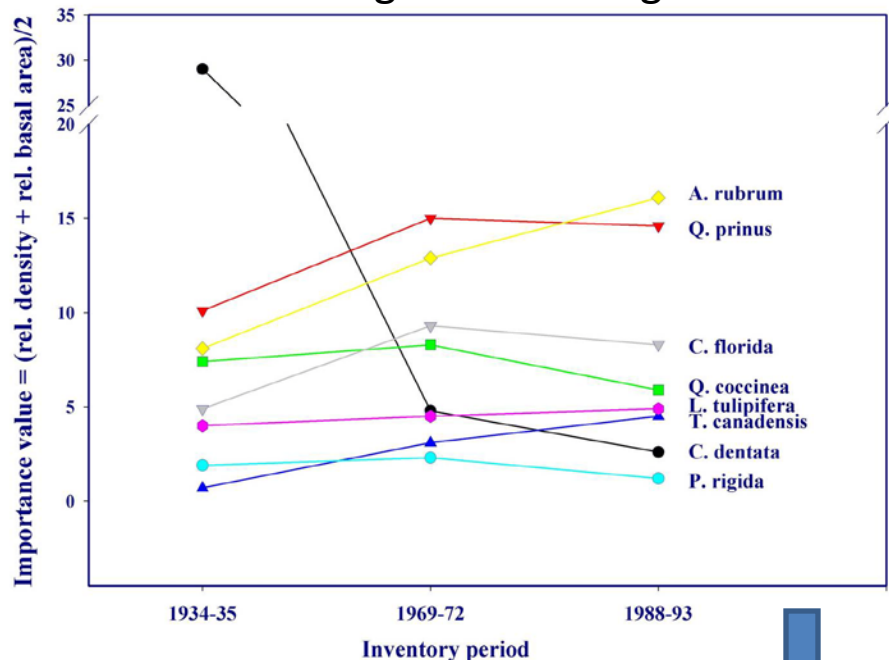


Using watershed science to manage for resiliency and adaptation

...climate change is hydrologic change...

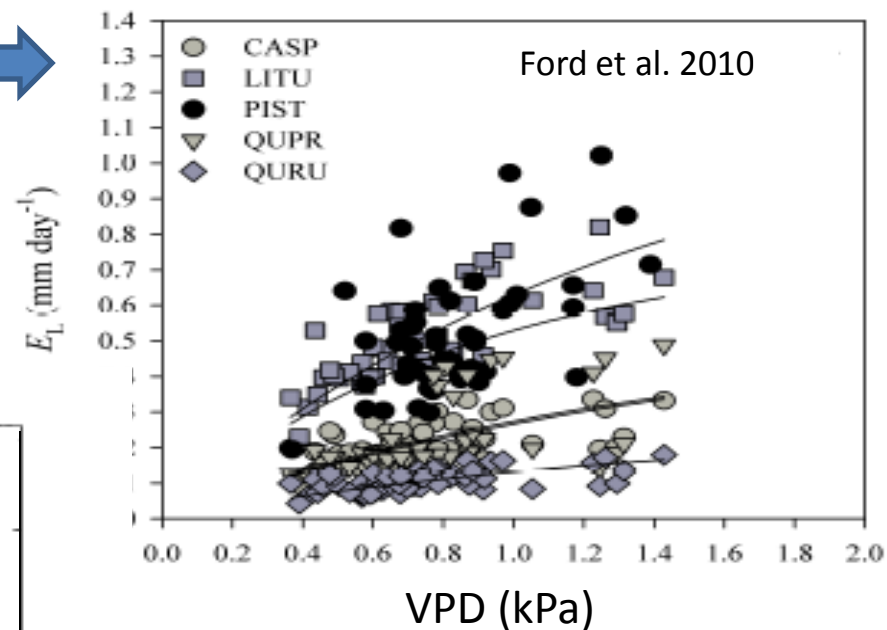
- increased temperature
 - VPD
 - phenology
- increased frequency of extreme events
- changes in **species composition**
- changes in **forest structure**

Vegetation change

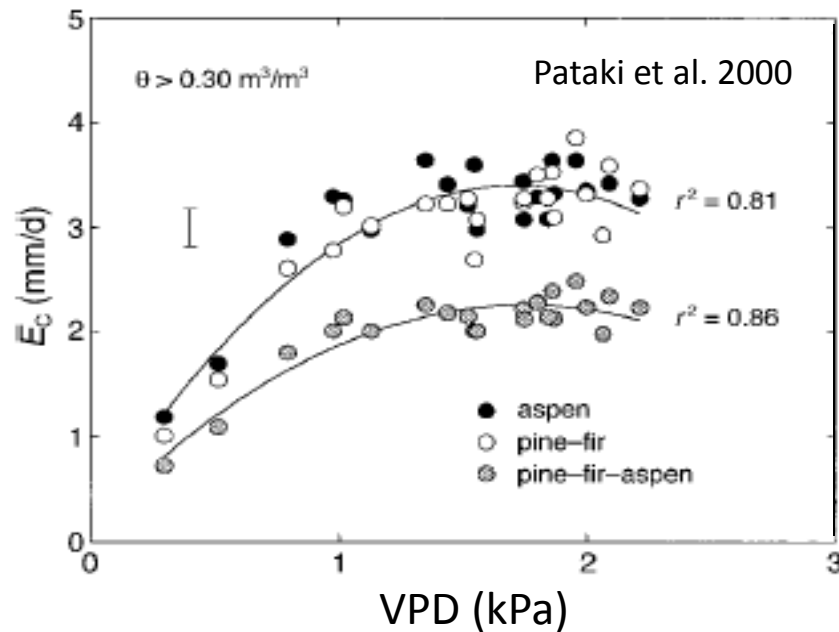


We can predict how changes in species composition and climate will affect hydrologic processes

Eastern U.S.



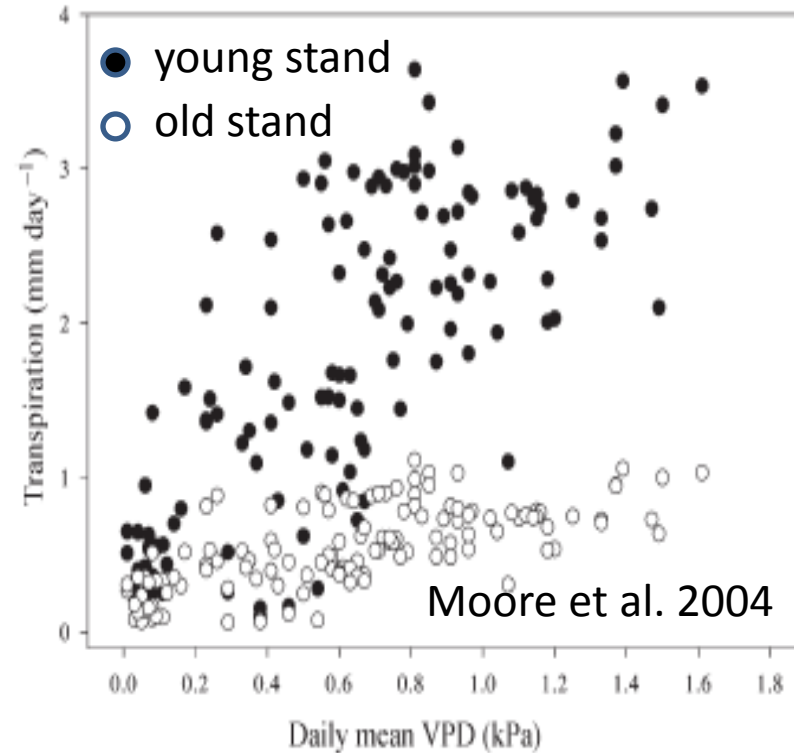
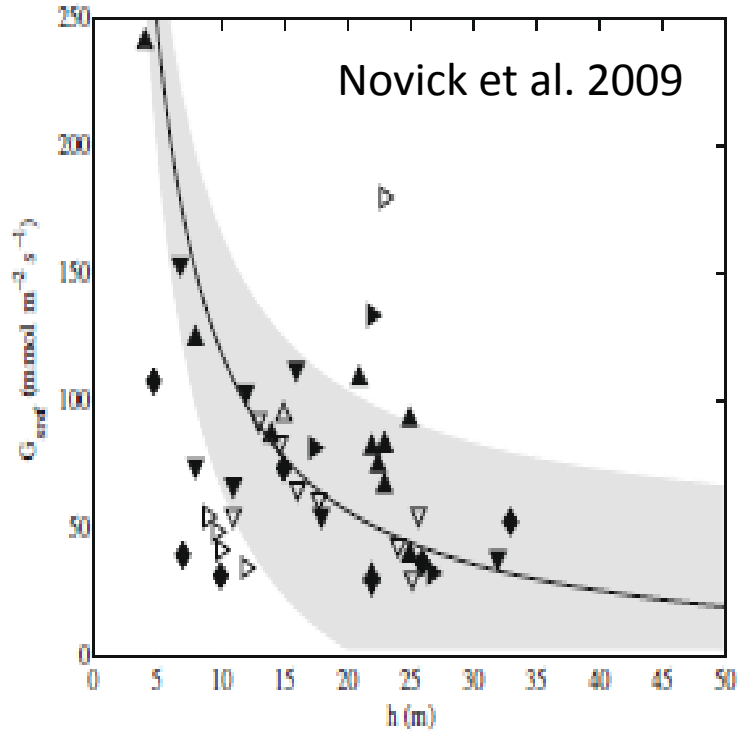
Western U.S.



Focus on transpiration because

Streamflow = precipitation - evapotranspiration

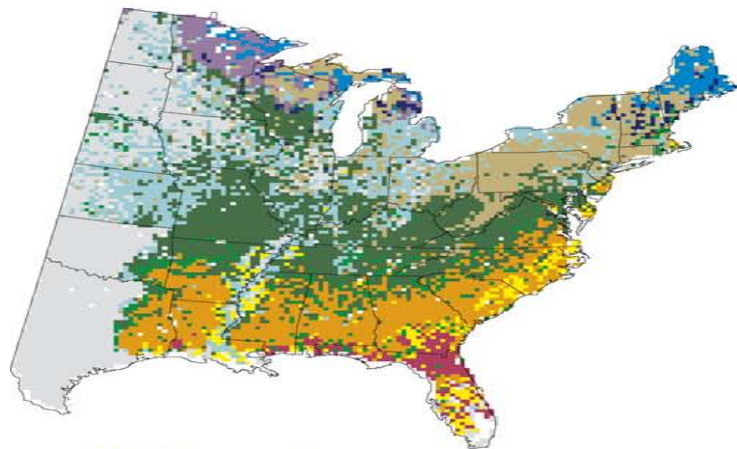
As trees get taller (structure), transpiration rates decline.....



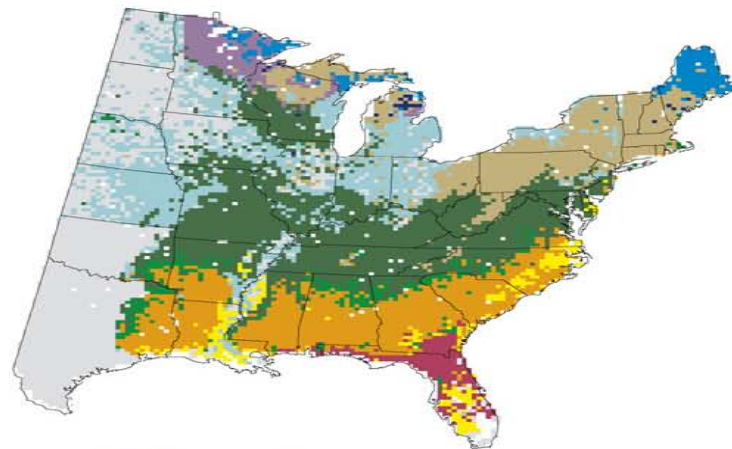
We can predict how forests of different ages influence hydrologic processes

Vegetation Type	Transpiration (mm yr ⁻¹)
Longleaf pine savannah	244
Old field pine	250
Upland oak	313
Mixed pine hardwood	450
Loblolly pine plantation	490
Slash pine flatwoods	563
Eucalyptus plantation	882
Oak-pine-hickory	278

Forest Type Maps

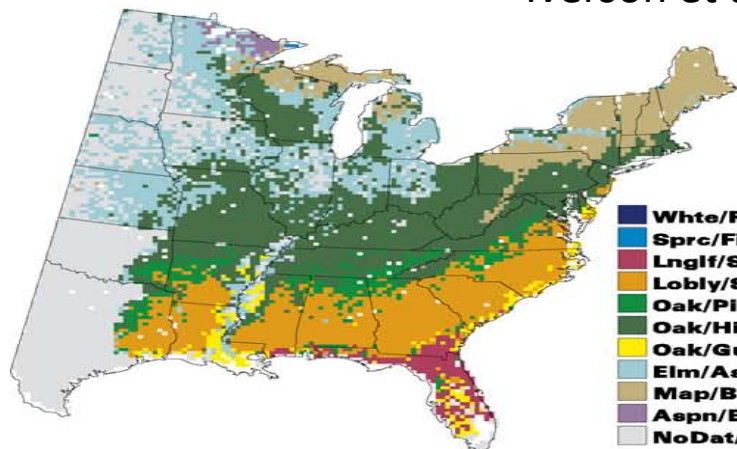


FIA-Current

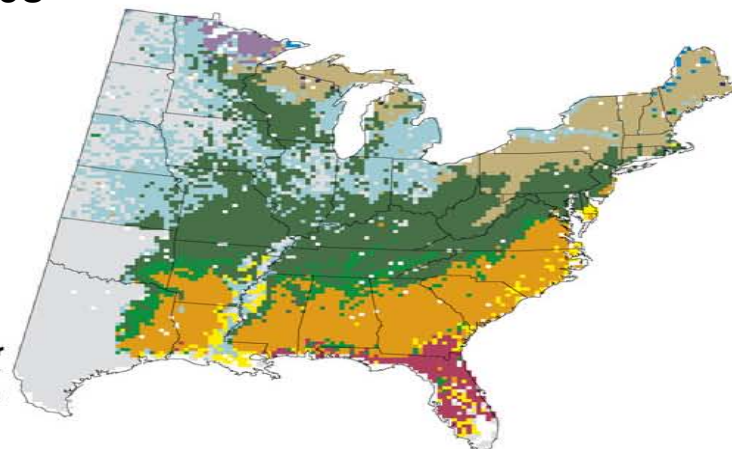


RF-Current

Iverson et al. 2008



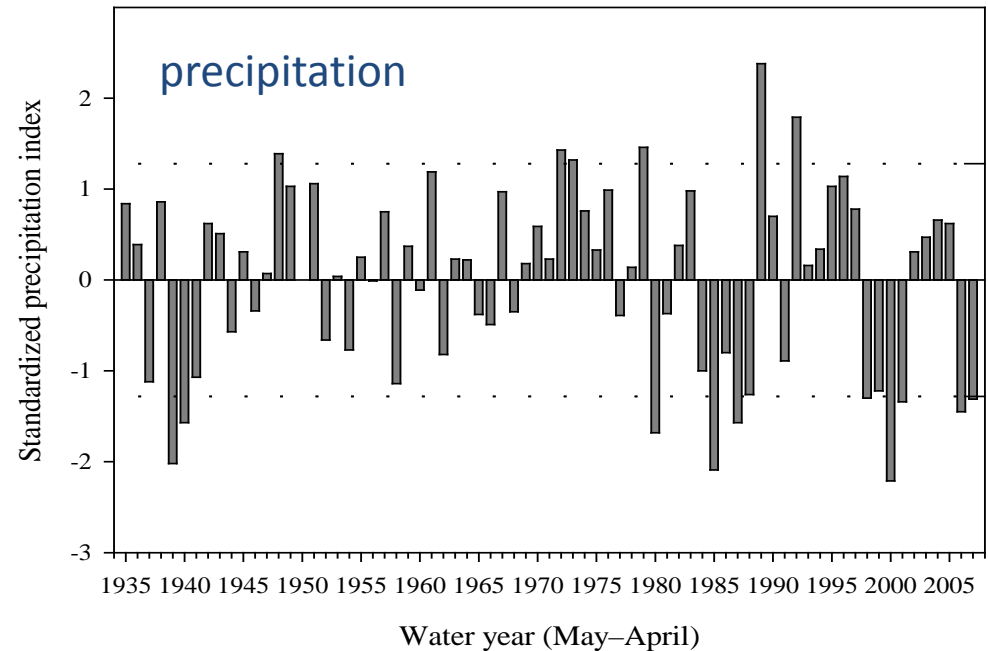
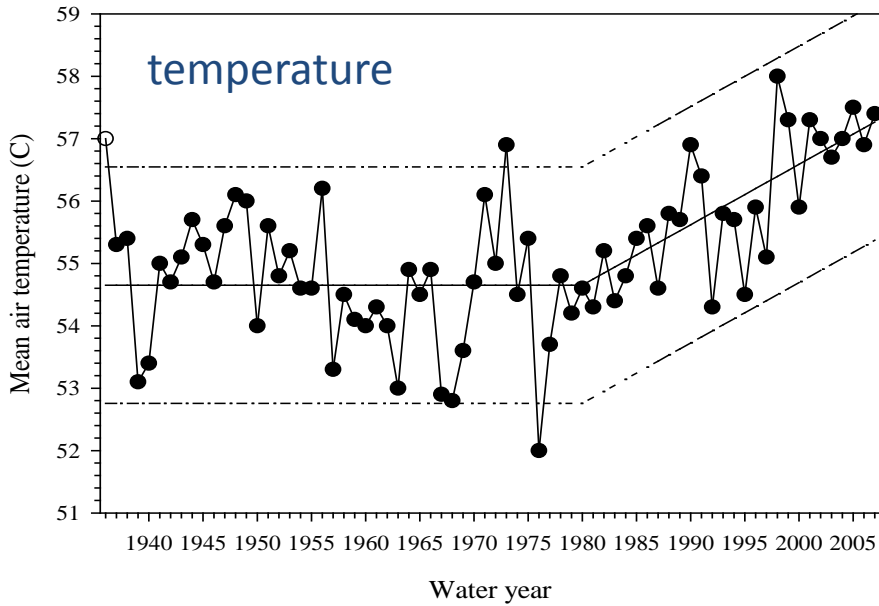
GCM3Avg Lo



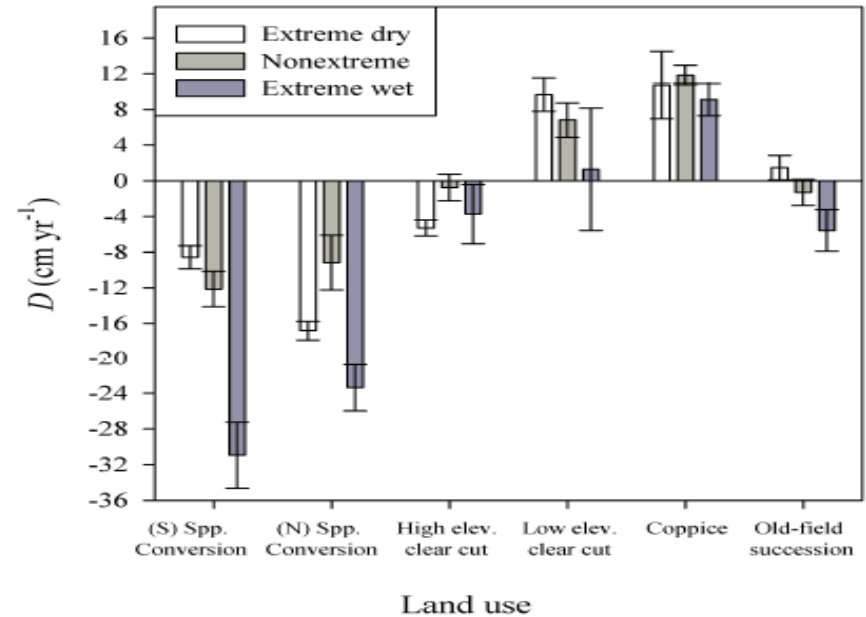
PCM Lo

- White/Red/Jck
- Sprc/Fir
- Lnglf/Sish
- Lobly/Shrtlf
- Oak/Pine
- Oak/Hikry
- Oak/Gum/Cypr
- Elm/Ash/Ctnw
- Map/Bch/Brch
- Aspn/Brch
- NoDat/NoFor

Long-term data from experimental watersheds can be used to examine Interactions between climate change and forest management options...



Can management actions implemented today affect resiliency or adaptation to future climatic conditions?



	Land use			
	Drought		Precipitation Excess	
	Exacerbates	Mitigates	Exacerbates	Mitigates
Spp. conversion	✓			✓
High-elevation clear cut		✓		✓
Low-elevation clear cut	✓		✓	
Coppice		✓	✓	
Old-field succession	✓			✓

Science and Landscape Scale Watershed Management

Where?

How?



What?

Why?

Where identify priority ecosystems/watersheds for restoration, protection, or management actions that increase resilience.

What long history of research on watershed management activities provides strong scientific basis for predicting the outcomes of “traditional” management activities; opportunities for testing & demonstrating novel management.

How

- combinations of disciplines and new technologies,
- new partners and approaches,
- recognition of novel conditions and approaches to understand the connectivity across the landscape, and
- involving multiple ownerships, land uses, and management practices.