Impact of LULCC on Water Resources and Policy Implications

- Water: A crosscutting theme of LULCC
- Quality
- Resource Allocation
- Policy Implications

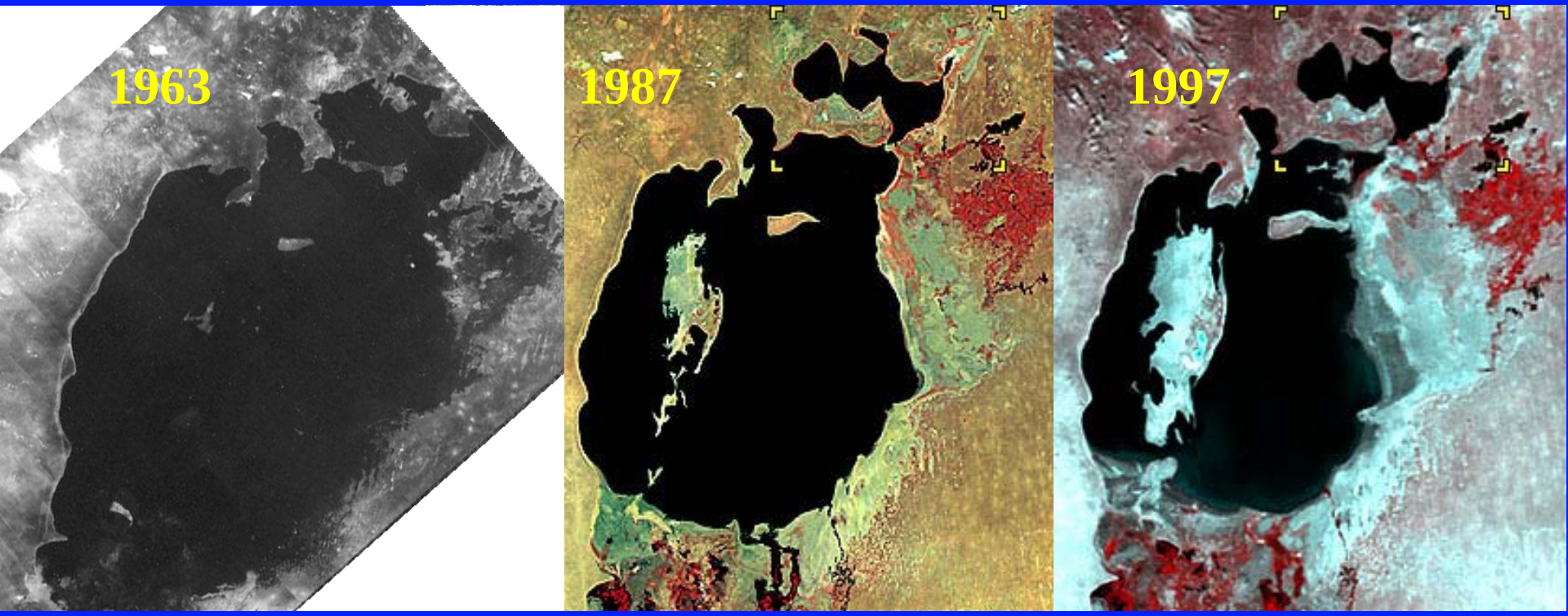
Water: A Crosscutting Theme of LULCC

- Water is a dynamic component of natural and human systems
- Analogous to the atmosphere, carbon
- Amount, quality, history, has a direct impact on individuals, populations, and ecology (terrestrial and aquatic)
- Management, allocation, disposal,

LULCC and the Terrestrial Water Cycle

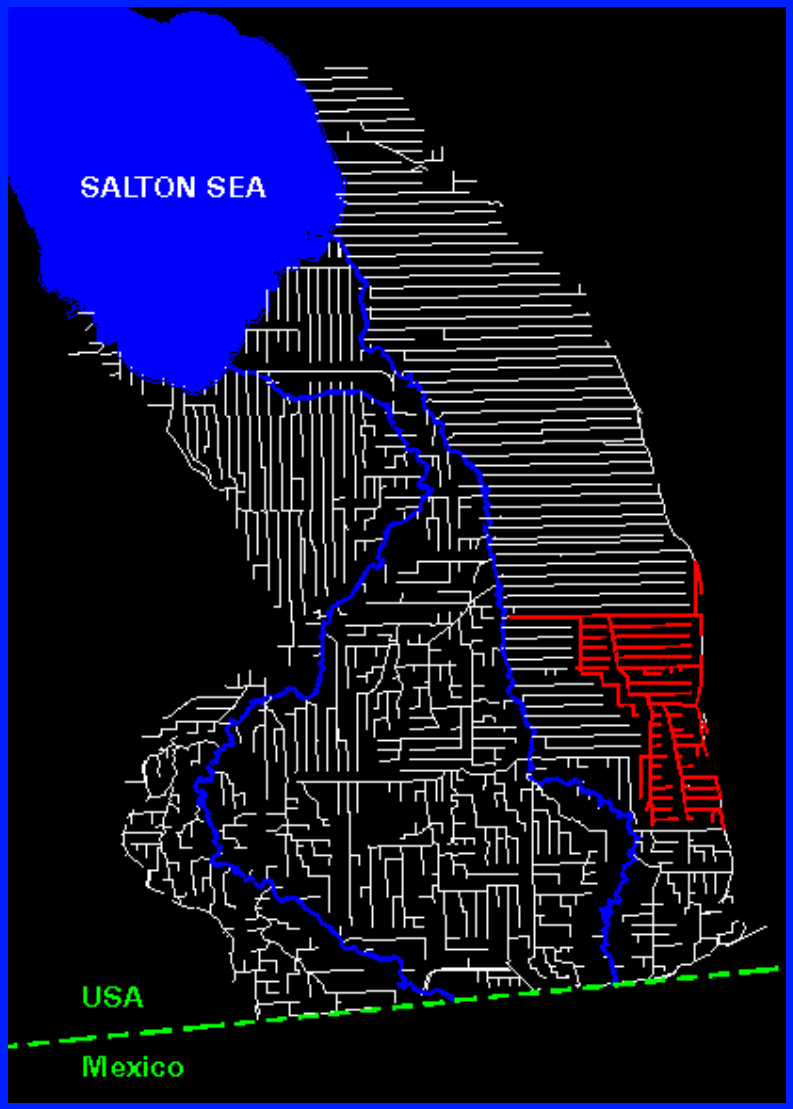
- Impacts on local budgets (e.g. increases in long-term runoff, stormflow)
- Local weather and fragmented landscapes
- Drainage basin scale: LULCC creates complex patterns of water balance
- Changes in water cycle at large scales, climate response, distortion of teleconnections

Resource Allocation: Downstream Effects



- Aral Sea, 1963-2002
- Drop in water a function of upstream irrigation
- Environmental impacts: aquatic ecosystem loss, health effects from dust, modification of climate

Water Engineering



Urban/Suburban Development

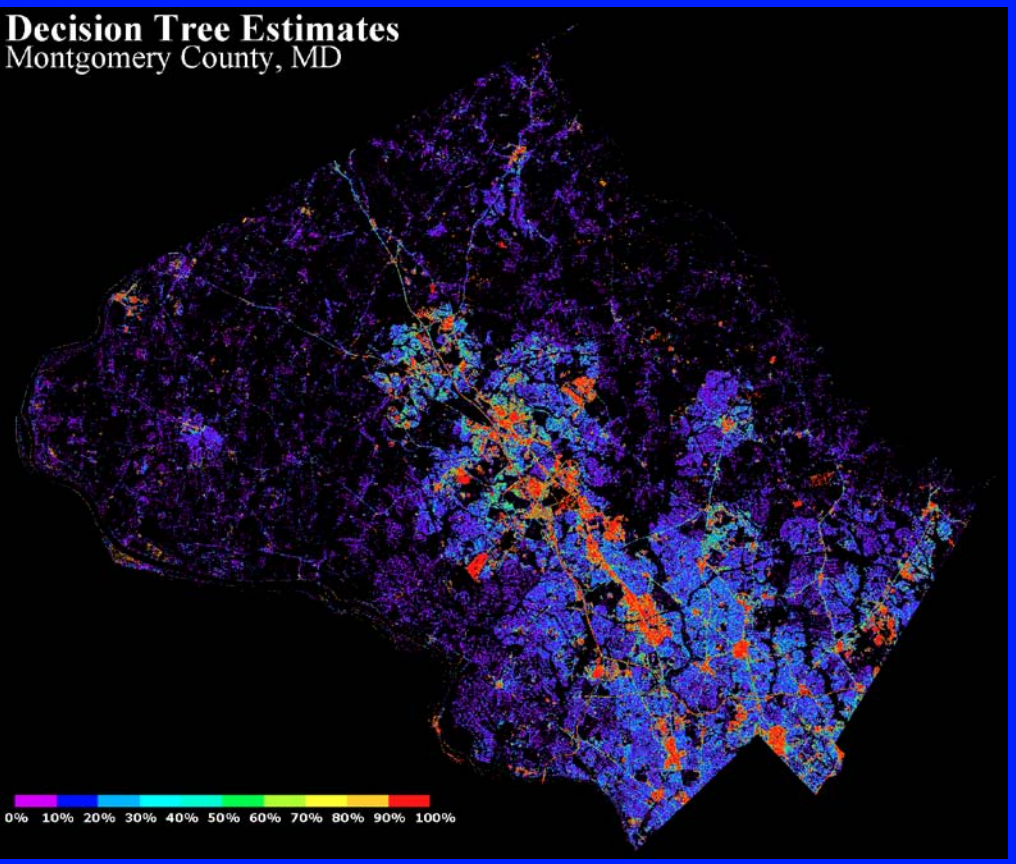
QuickTime™ and a GIF decompressor are needed to see this picture.

- Relative to agriculture, consumer use is a small fraction
- Secure, potable supplies are nevertheless a critical current and future issue

Water Quality

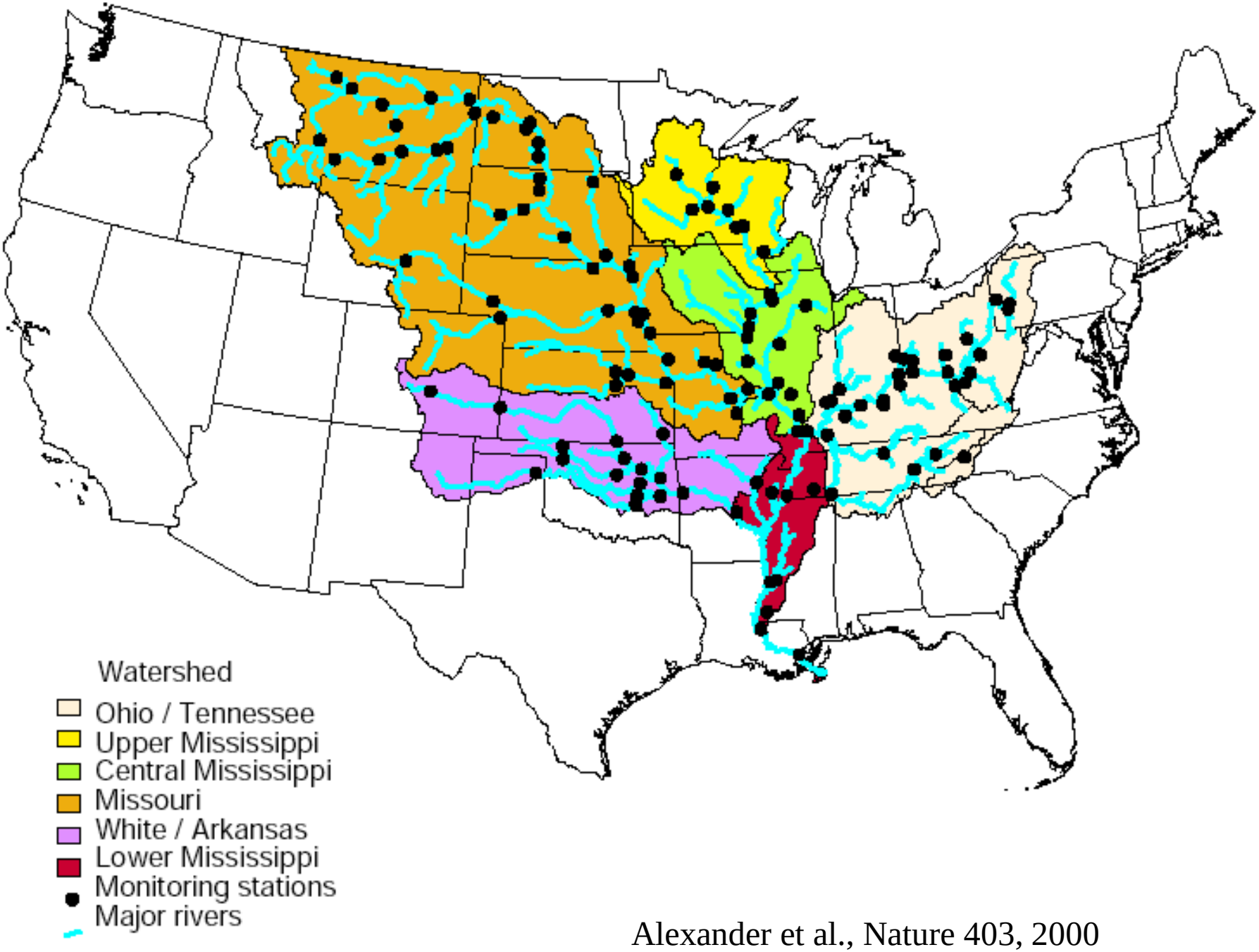
- Agriculture:
  - Animal waste, amendments (fertilizer), diversion
- Industrial:
  - Point source, regulation more easily identified
- Urban/Suburban
  - Non-point source, effluent
- Impacts
  - Rivers, stream, groundwater, lakes, coastal zone..
  - Hydrologic system captures and transports

LULCC and Water Quality

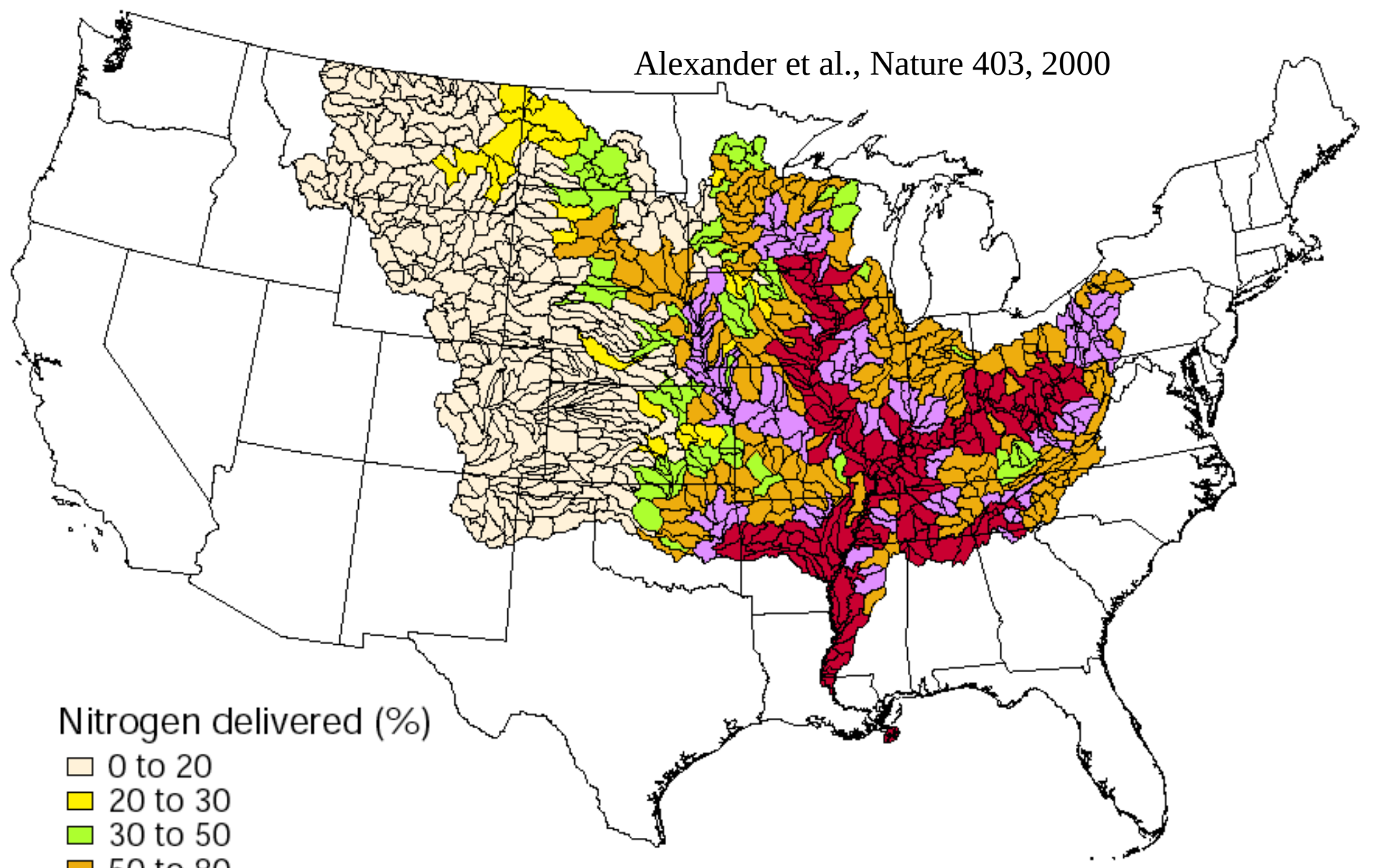


- Surface runoff in urban/suburban areas a function of impervious surface area
- When impervious surface >10% area, then water quality begins to be affected

S. Goetz, UMD RESAC



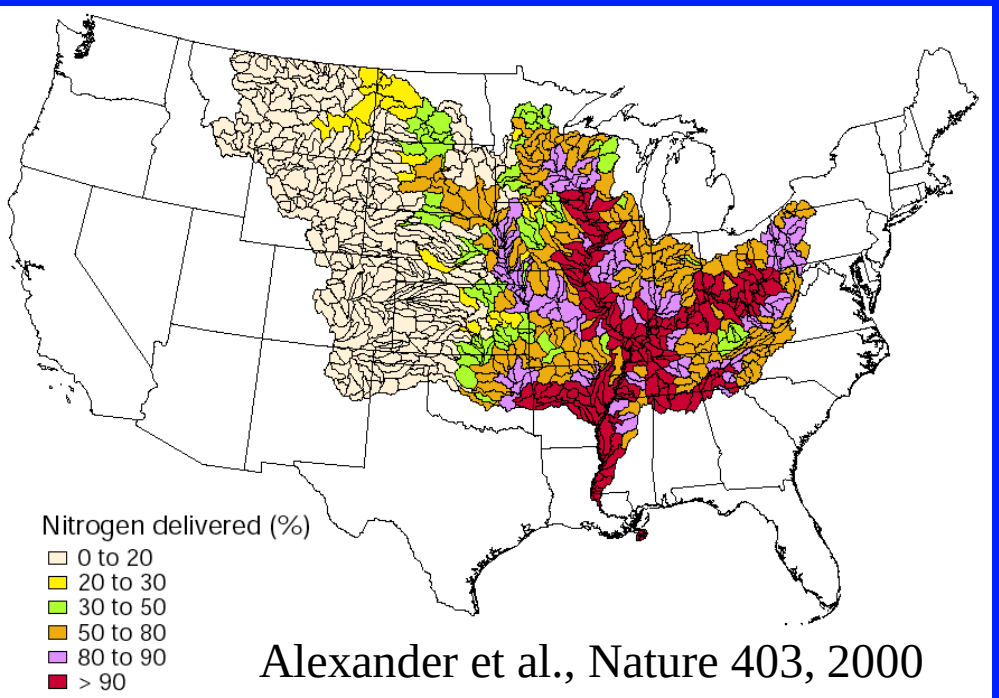
Alexander et al., Nature 403, 2000



Fraction of nitrogen exported from a basin that remains after instream transport to the gulf

Implications for LULCC

- Nitrogen input to the Gulf is a function of upstream inputs, modulated by stream channel size and time in transit
- Watersheds located close to large rivers deliver large fractions of their inputs

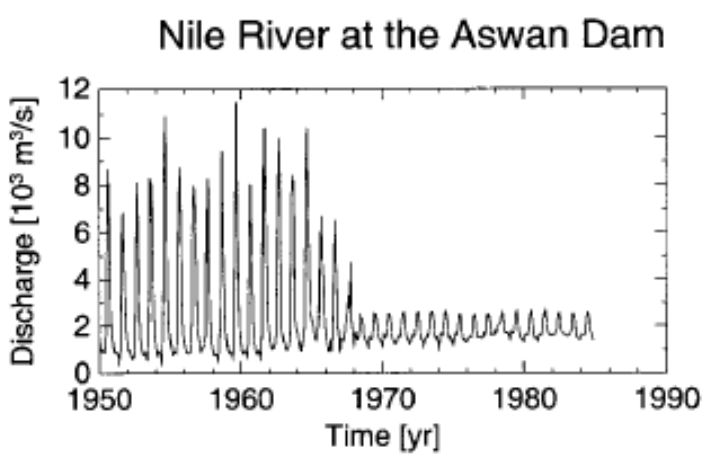


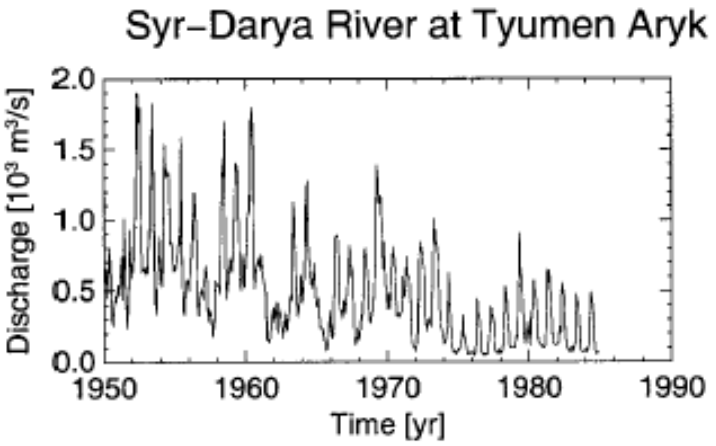
Alexander et al., Nature 403, 2000

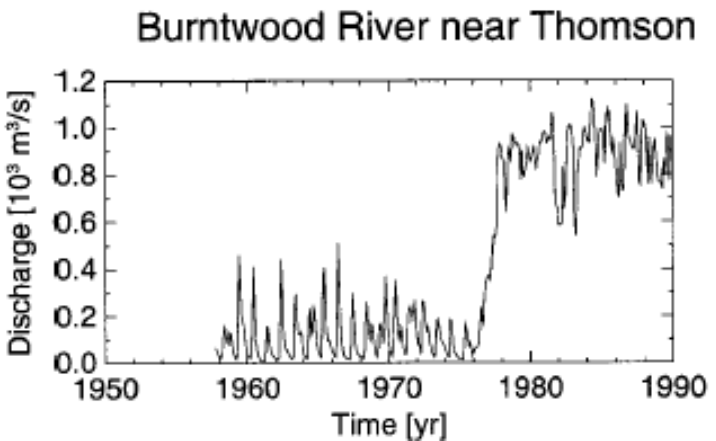
- Implications for understanding impacts of land use on water quality
- Implications for policy

Water Engineering

- Aquifer mining
- Surface water diversion
- Desertification
- Wetland drainage
- Soil erosion
- Deforestation
- Dam building
- Urbanization
- Agriculture

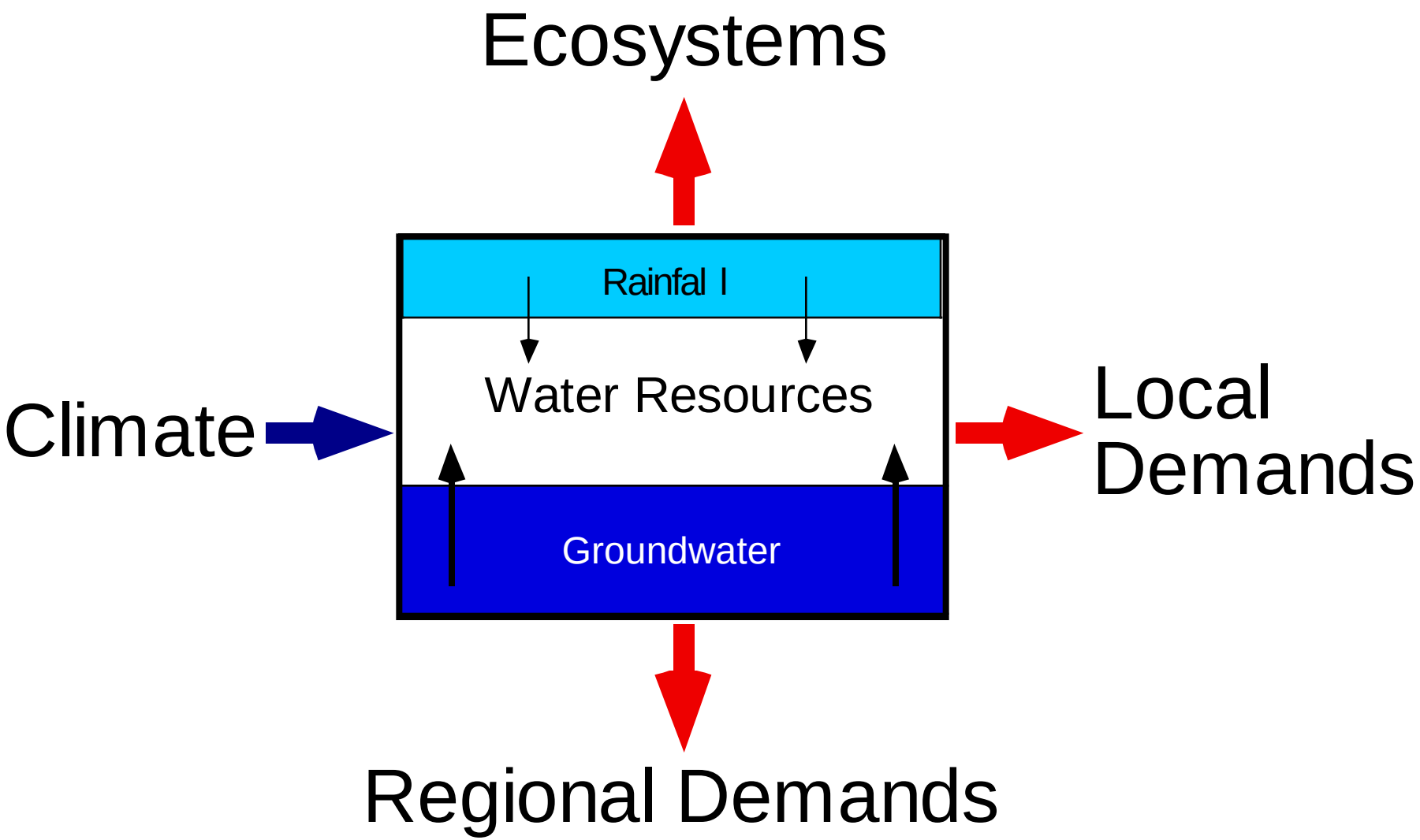






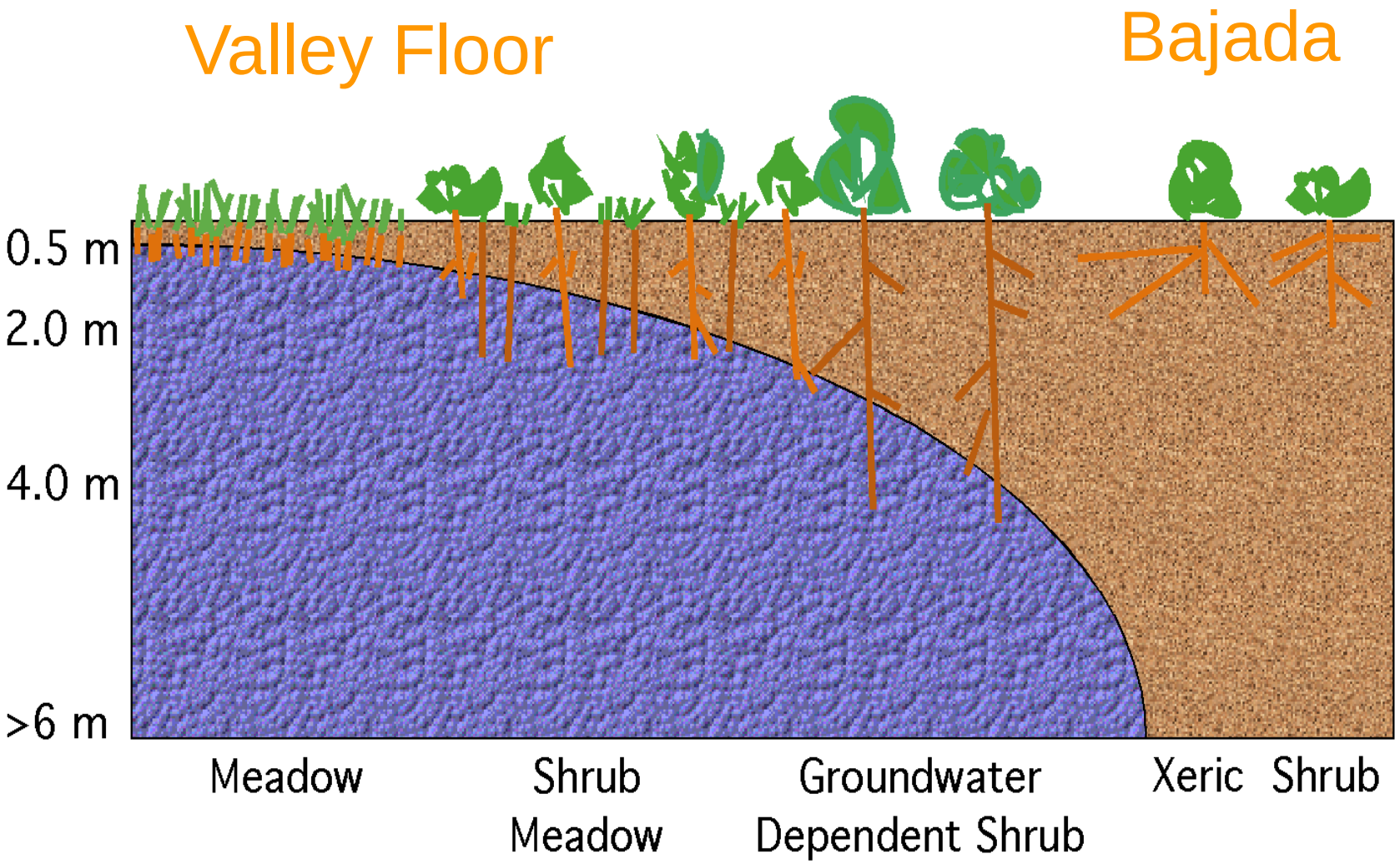
Resource Allocation

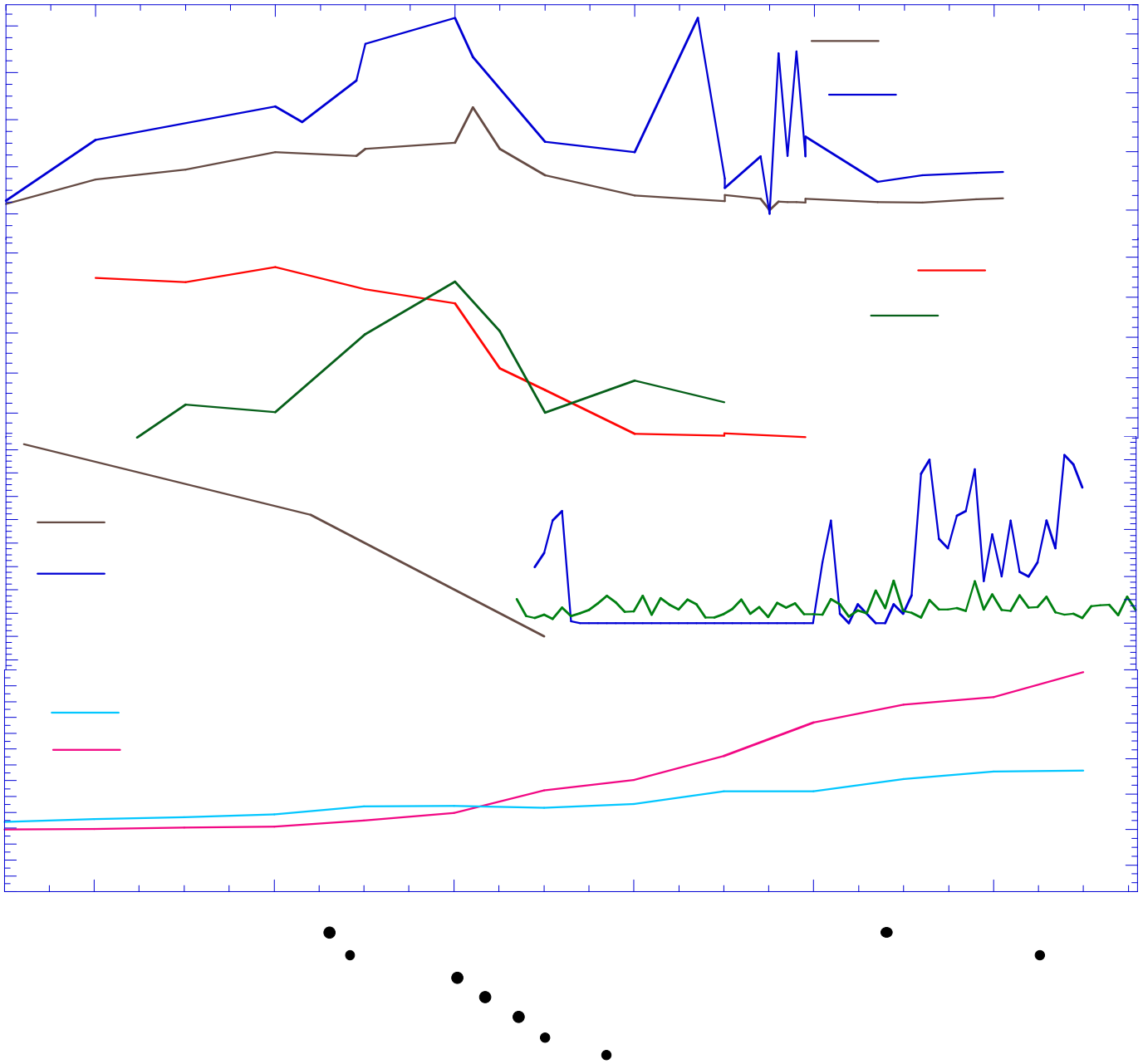
- Fundamental issue in arid-semi arid regions of the world
- Water rights place demands often in excess of the flow (e.g. Colorado River)
- Tension between ecological, domestic, and agricultural needs
- Interbasin transfer and international issues

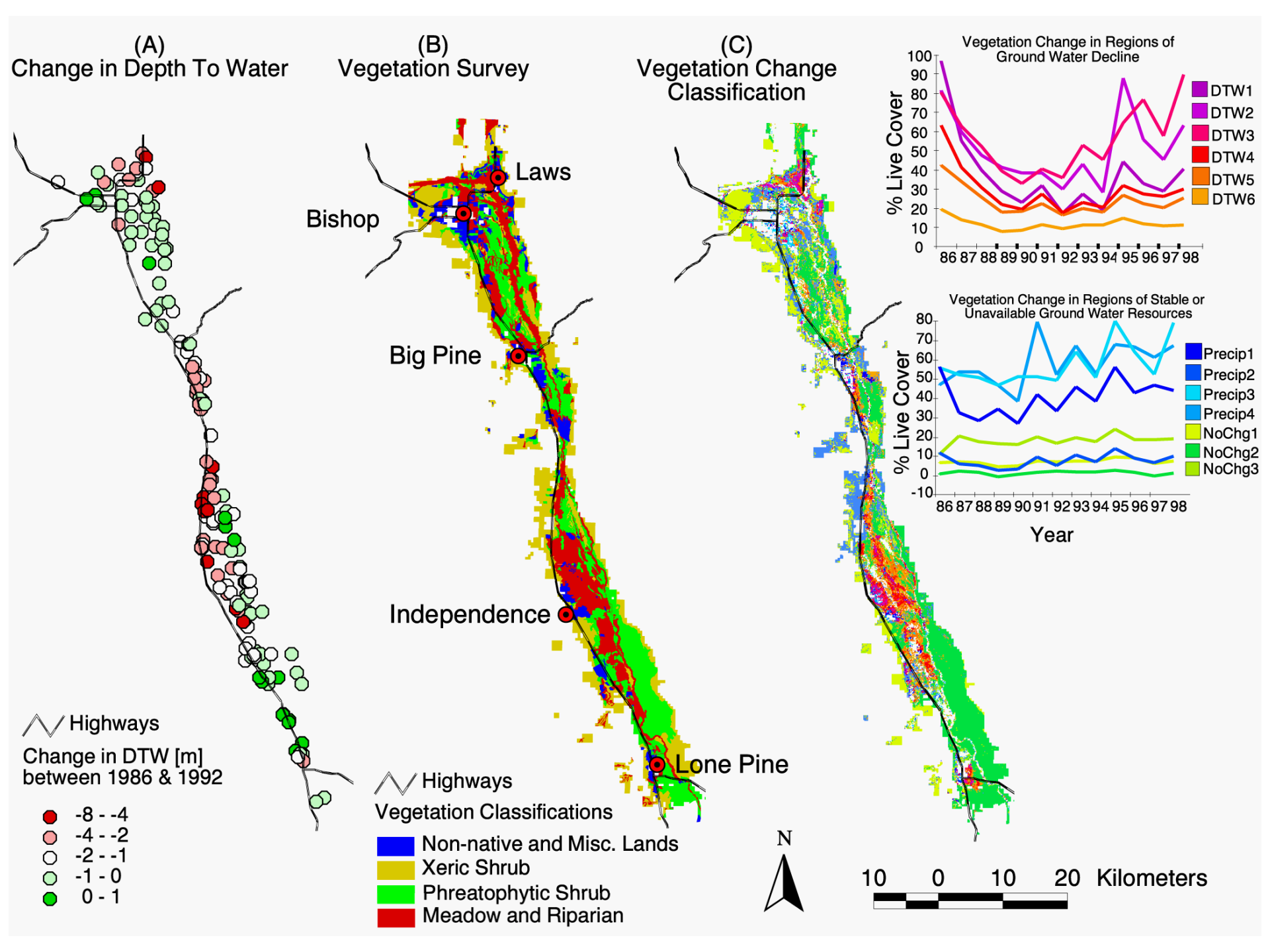

Ecosystems
Rainfal l
Water Resources
Climate
Local
Demands
Groundwater
Regional Demands


Reno
Owens Valley
San Francisco
Las Vegas
Los Angeles
San Diego
N
W
E
S
0 70 140 Kilometers

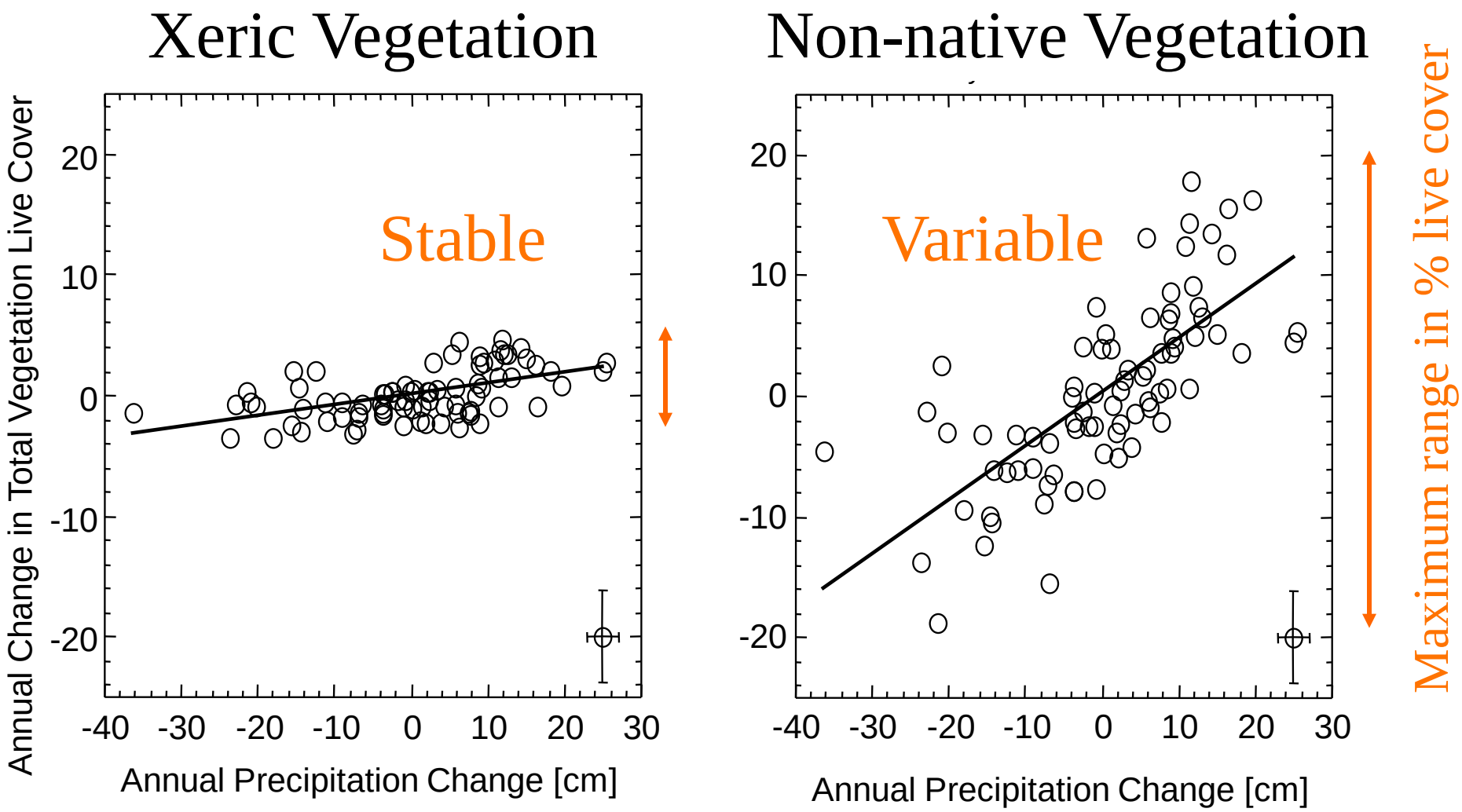
Community-Groundwater Relationships






(A)
Change in Depth To Water
(B)
Vegetation Survey
(C)
Vegetation Change
Classification
Laws
Bishop
Big Pine
Independence
Lone Pine
Highways
Change in DTW [m]
between 1986 & 1992
-8 - -4
-4 - -2
-2 - -1
-1 - 0
0 - 1
Highways
Vegetation Classifications
Non-native and Misc. Lands
Xeric Shrub
Phreatophytic Shrub
Meadow and Riparian
Vegetation Change in Regions of
Ground Water Decline
% Live Cover
100
90
80
70
60
50
40
30
20
10
0
86 87 88 89 90 91 92 93 94 95 96 97 98
DTW1
DTW2
DTW3
DTW4
DTW5
DTW6
Vegetation Change in Regions of Stable or
Unavailable Ground Water Resources
% Live Cover
80
70
60
50
40
30
20
10
0
-10
86 87 88 89 90 91 92 93 94 95 96 97 98
Year
Precip1
Precip2
Precip3
Precip4
NoChg1
NoChg2
NoChg3
N
10 0 10 20 Kilometers

Characteristic plant community response



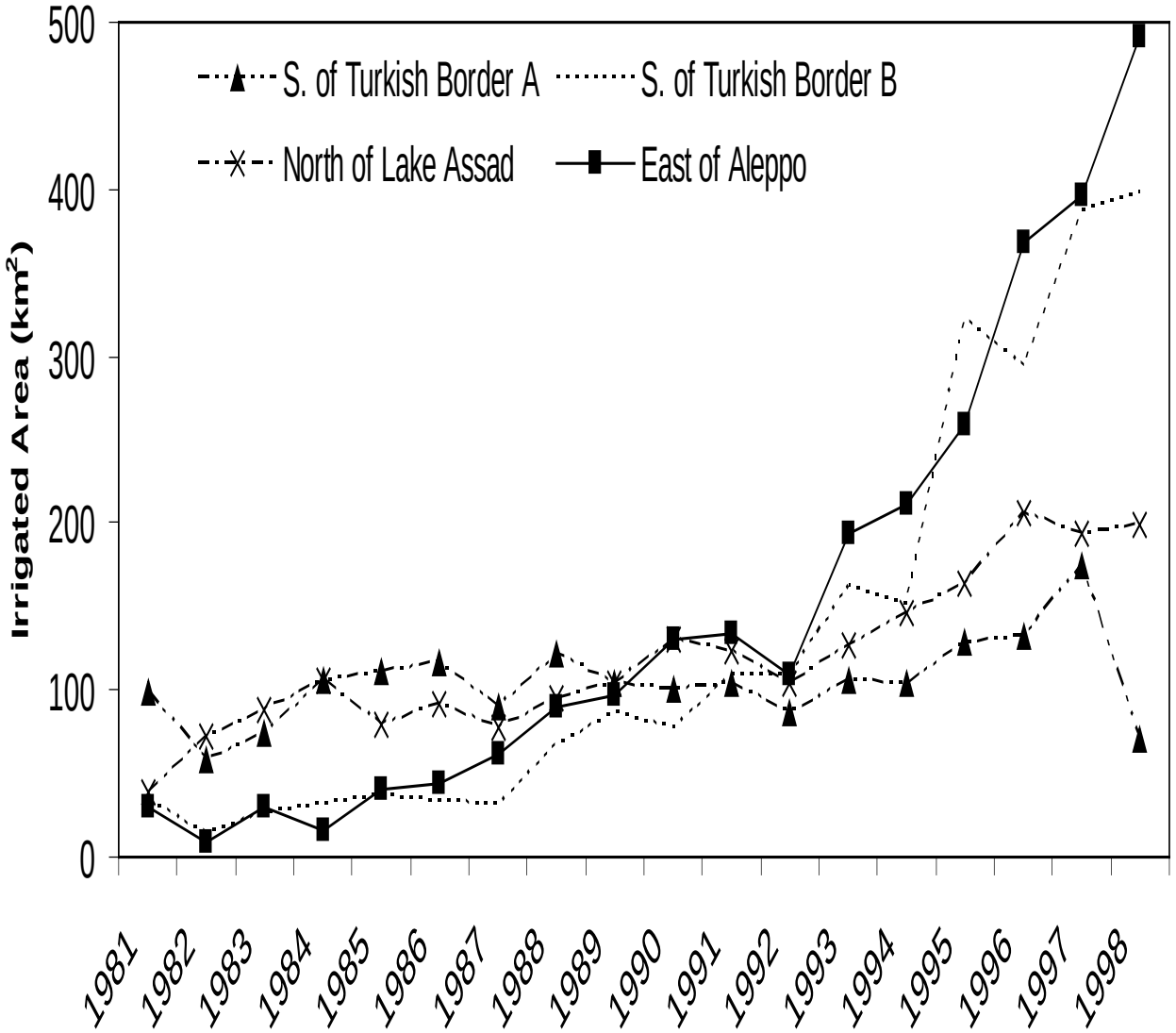
Plots reproduced from Elmore et al. (~2002) *Ecological App*. In press.

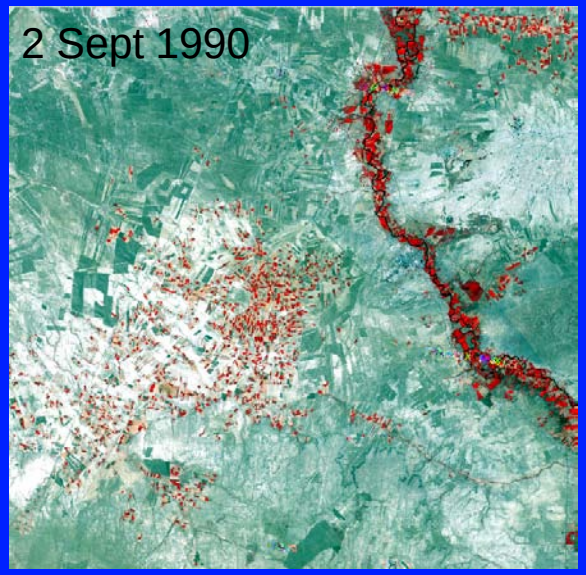
Owens Valley Case Study
(Elmore et al., 2000, 2002, 2003)

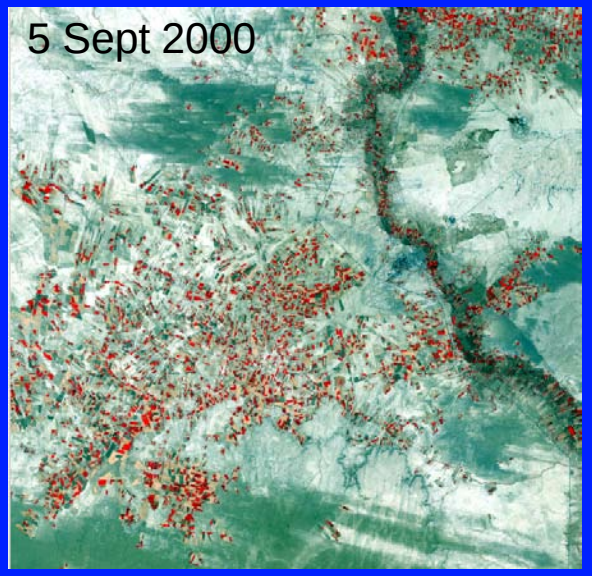
- Ecological response to drought
  - Drought adaptive species and systems
- Anthropogenic response to drought
  - Maintain supply by tapping into ecological reserves
- Landscape response and long term effects
  - Threshold response in groundwater communities, transition to non-native annuals
- Management implications
  - Use of thresholds in groundwater management

Irrigation Trends Middle East

R. Smith, Yale







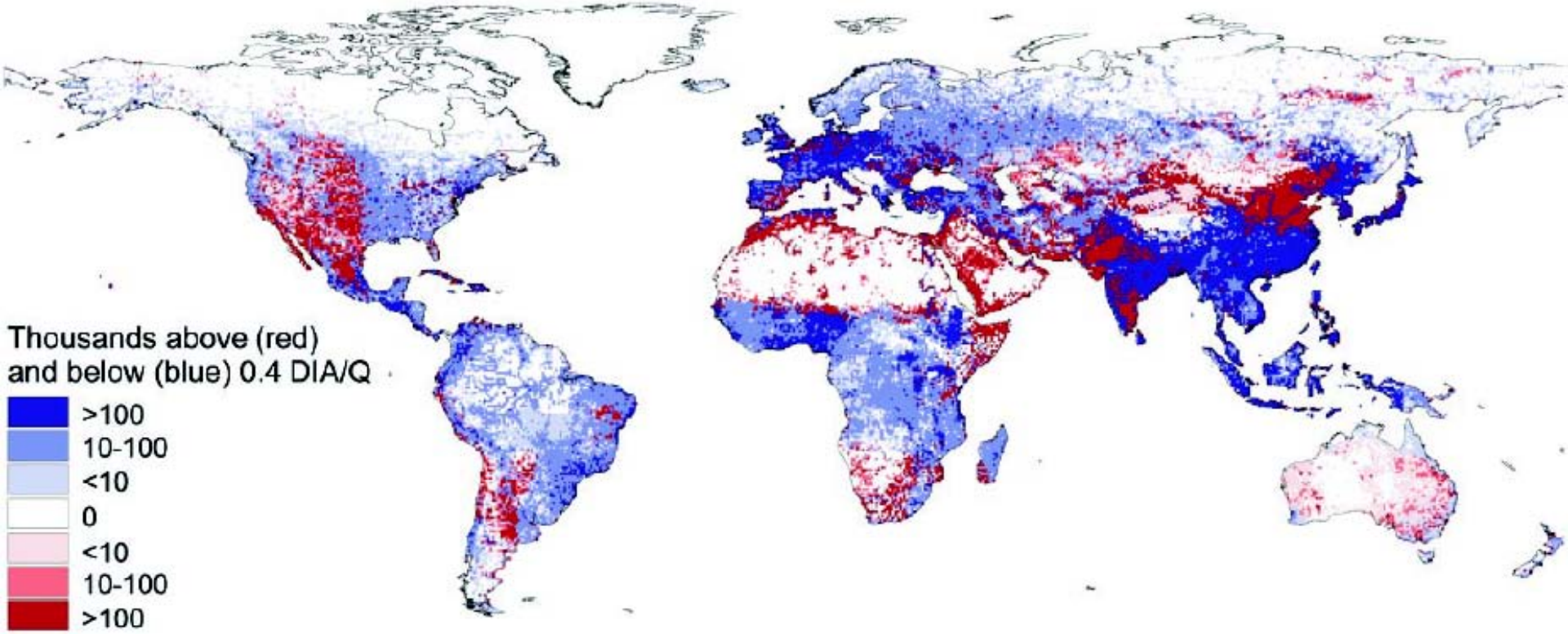
Water Supply
(Vörösmarty et al, Science 289, 2000)

- What is the state of global water supply and water use, and where are the biggest concerns?
- What is likely to be the largest stressor on future water supply (population or climate change)?

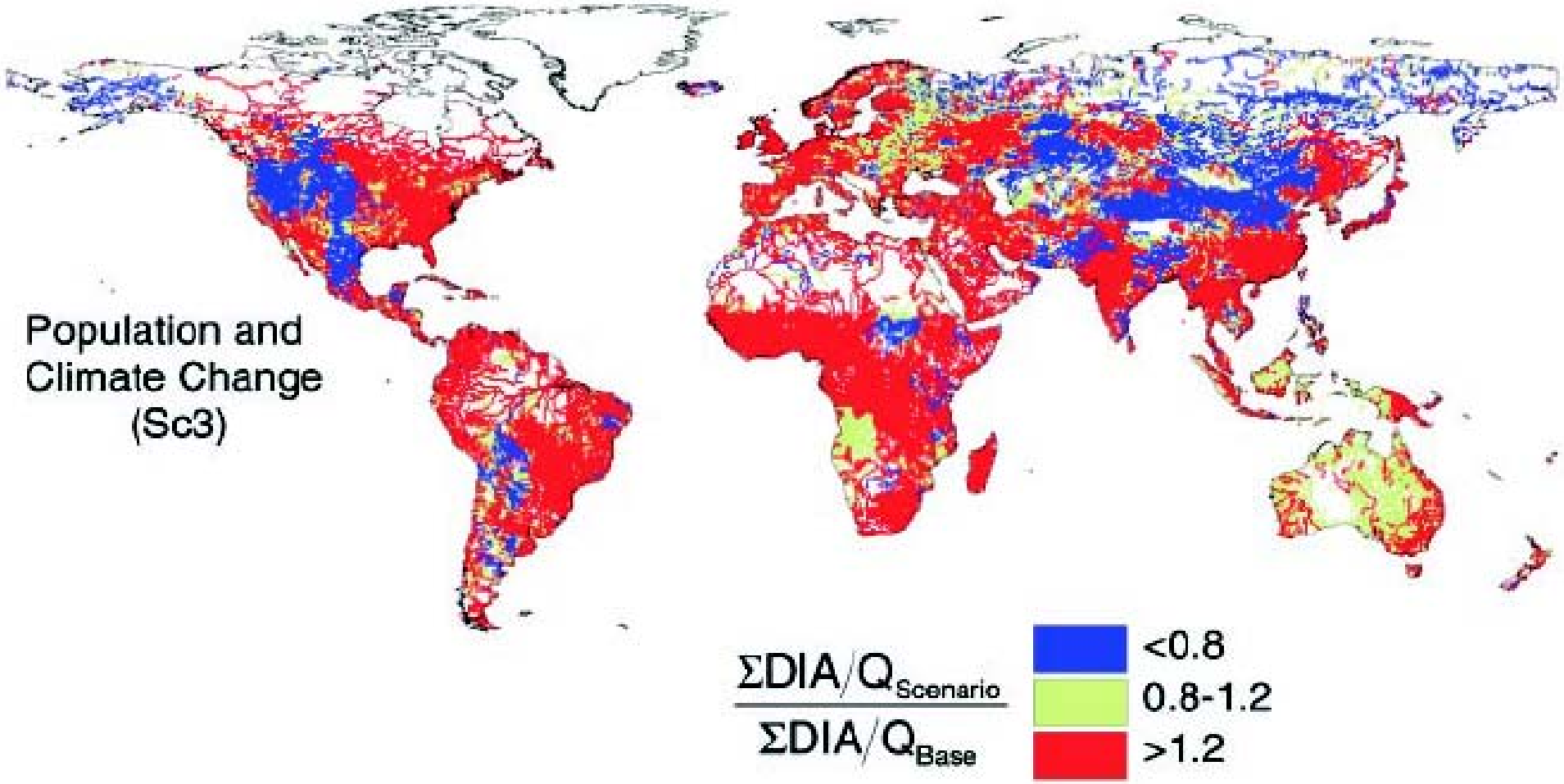
Water Supply
(Vörösmarty et al, Science 289, 2000)

- Q = river discharge, including mean annual surface and subsurface flow
- Relative water demand:
  ratio of water withdrawn/Q
- Include domestic (D), industrial (I), and agricultural (A) withdraws on the supply
- DIA/Q < 0.2 adequate supply
  0.2-0.4 moderate to high stress
  >0.4 severe water stress
- Factor in the population served by water supplies

Contemporary Population Relative to Demand per Discharge
Stress Threshold (DIA/Q = 0.4)



Population and Climate Change: 2025



Research Issues

- Water is intimately associated with many LULCC priorities: population will likely be the largest driver of change in the state of water resources in the next 50 years
- Water could be more integrated into LULCC studies (in contrast with carbon)
- Research does need to address policy relevant questions as well as basic research

Policy Implications: Resource Allocation

- Water scarcity, declines in aquatic biodiversity indicate current water policies are inadequate
- Water is undervalued:
  - Price of irrigation water << infrastructure costs
  - Water shed management not accounted
- Change the price structures
- Include ecosystem/land use in the cost structures of watershed management