Minimizing water trade-offs in climate change activities

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Water Conference, 9/15/09

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Projected Patterns of Precipitation Changes

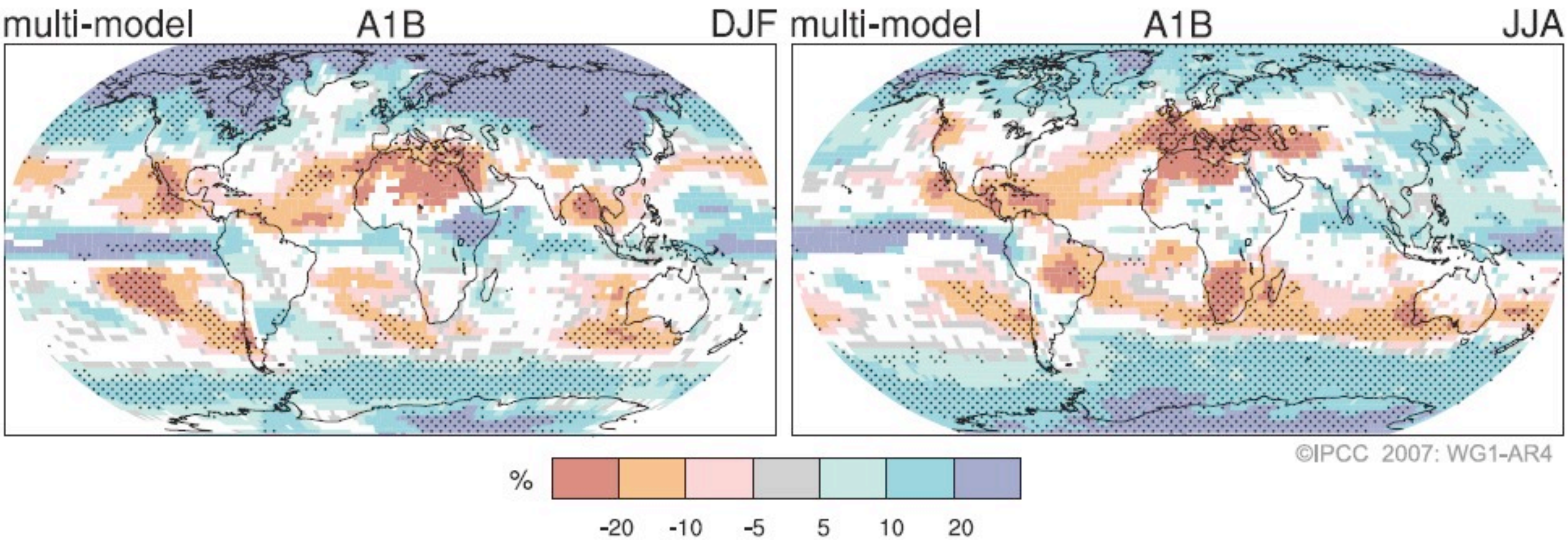


Figure SPM.7. *Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}*

Source: IPCC Fourth Assessment Report (AR4)
Working Group I Report "The Physical Science Basis"

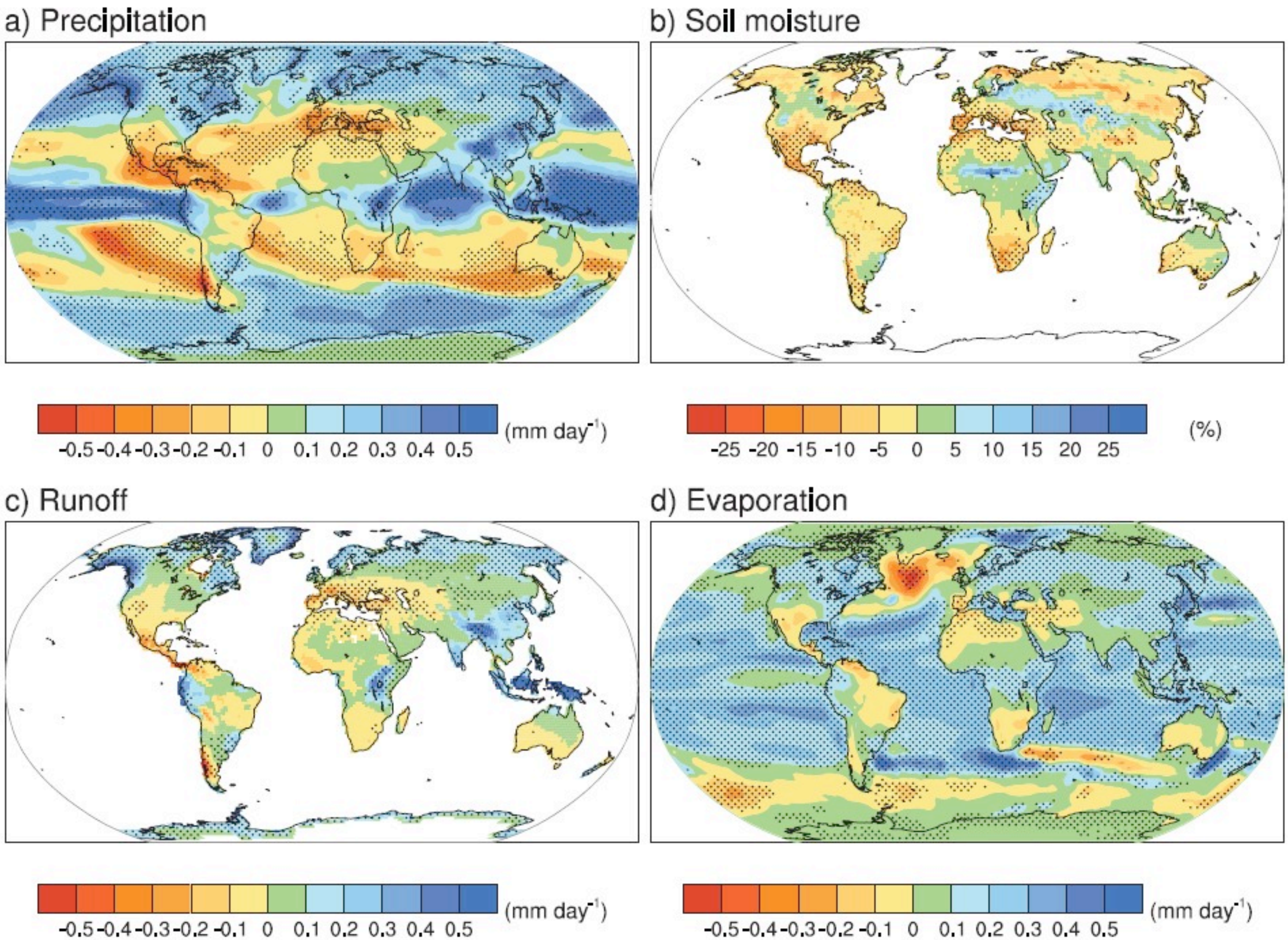


Figure 10.12. *Multi-model mean changes in (a) precipitation (mm day^{-1}), (b) soil moisture content (%), (c) runoff (mm day^{-1}) and (d) evaporation (mm day^{-1}). To indicate consistency in the sign of change, regions are stippled where at least 80% of models agree on the sign of the mean change. Changes are annual means for the SRES A1B scenario for the period 2080 to 2099 relative to 1980 to 1999. Soil moisture and runoff changes are shown at land points with valid data from at least 10 models. Details of the method and results for individual models can be found in the Supplementary Material for this chapter.*

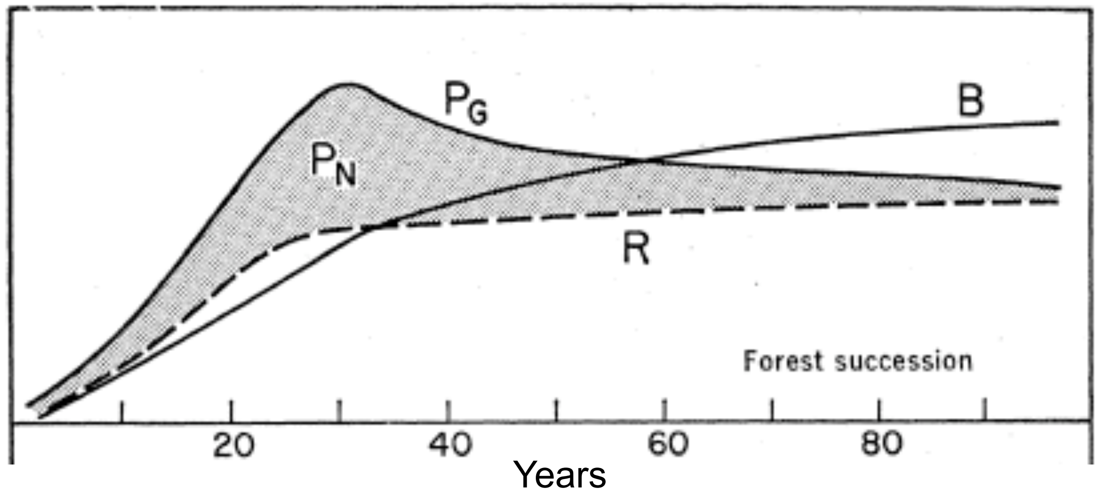
Murray-Darling Basin

Published: April 2009

NATIONAL GEOGRAPHIC

Australia's Dry Run

What will happen when the climate starts to change and the rivers dry up and a whole way of life comes to an end? The people of the Murray-Darling Basin are finding out right now.



The Strategy of Ecosystem Development

An understanding of ecological succession provides a basis for resolving man's conflict with nature.

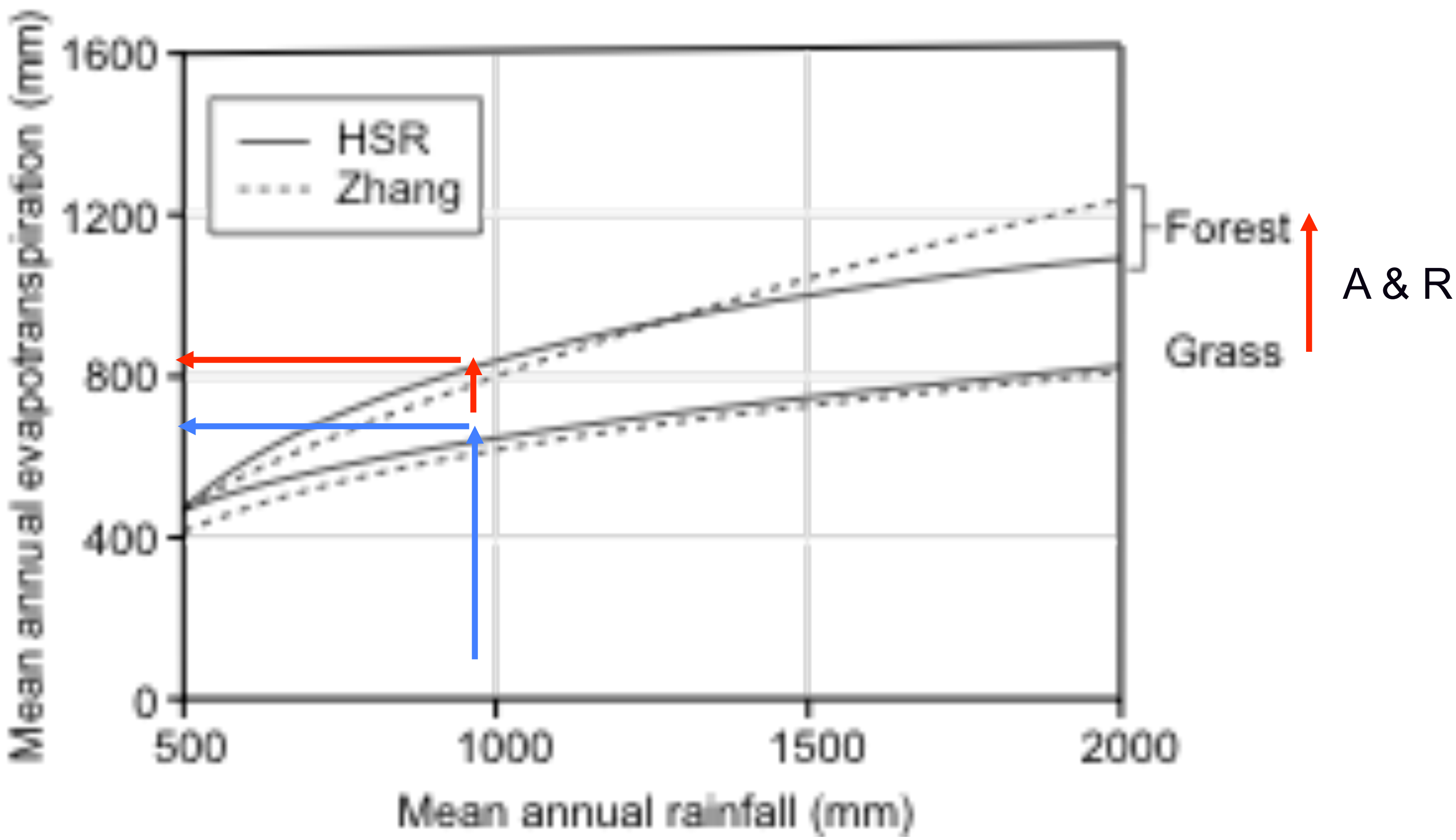
Eugene P. Odum

Odum 1969 Science

Man has generally been preoccupied with obtaining as much “production” from the landscape as possible, by developing and maintaining early successional types of ecosystems, usually monocultures. But, of course, man does not live by food and fiber alone; he also needs a balanced CO_2-O_2 atmosphere, the climatic buffer provided by oceans and masses of vegetation, and clean (that is, unproductive) water for cultural and industrial uses.”

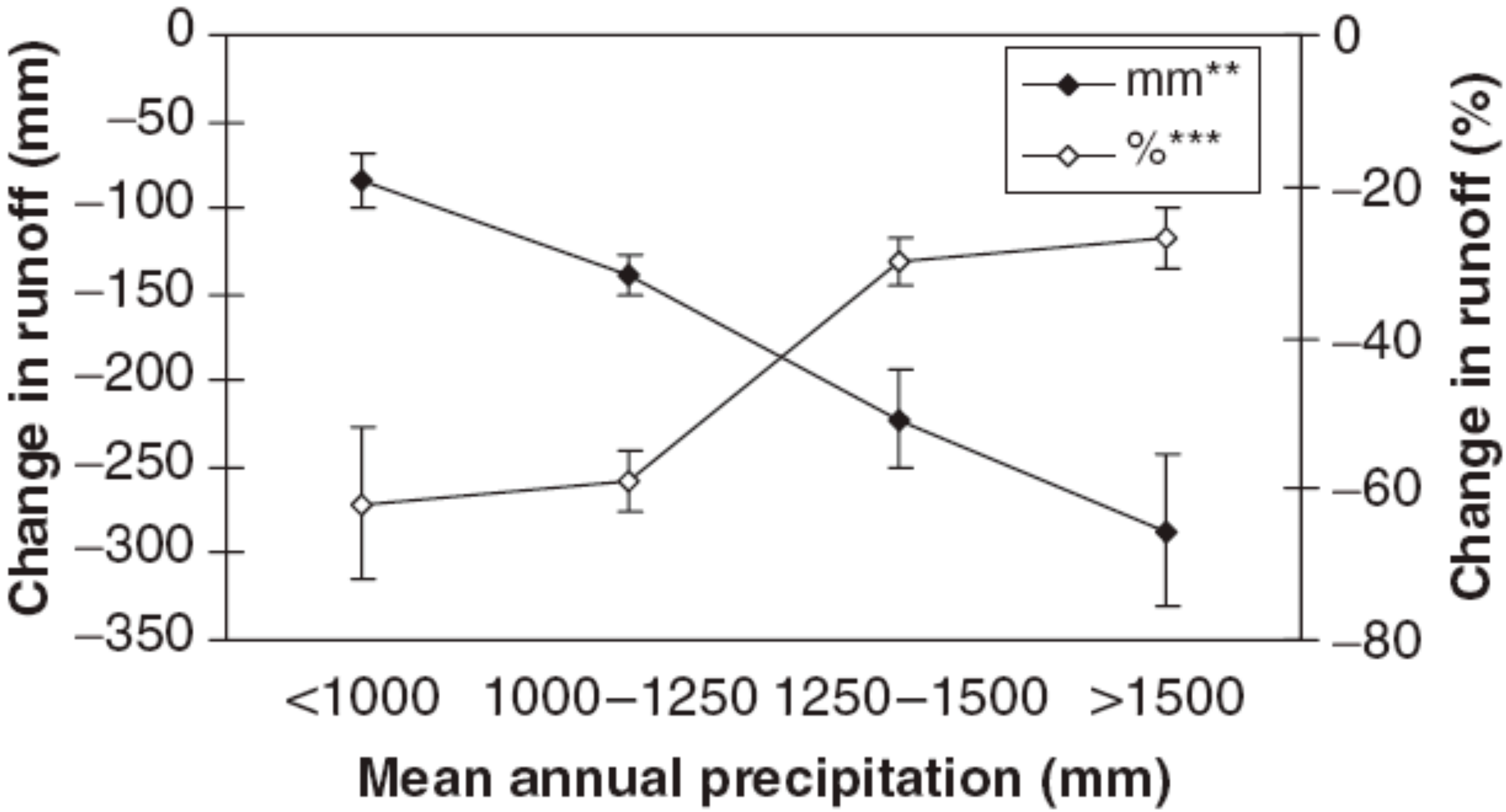
Forest/grassland ET as a function of annual rainfall

Holmes and Sinclair (1986) 19 catchments Victoria
Zhang *et al* (1999) process model output.



100% afforestation increases annual ET

Source: Vertessy, Zhang and Dawes (2003) *Australian Forestry*



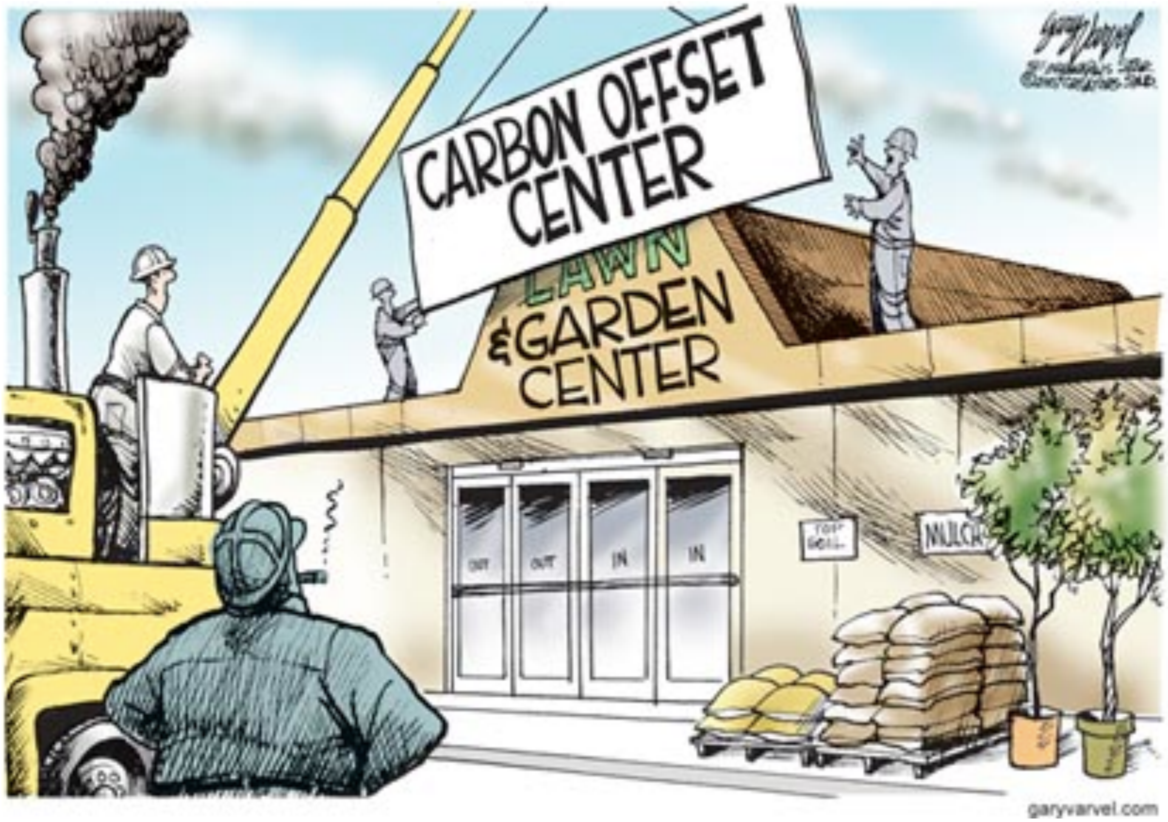
Farley et al. 2005 Global Change Biology

United States Department of Agriculture

Agriculture Secretary Tom Vilsack, August 14th, 2009

"Our shared vision begins with restoration. Restoration means managing forest lands first and foremost to protect our water resources, while making our forests more resilient to climate change. Forest restoration led by the dedicated people at the Forest Service opens non-traditional markets for climate mitigation and biomass energy while appropriately recognizing the need for more traditional uses of forest resources.

"Emerging markets for carbon and sustainable bioenergy will provide landowners with expanded economic incentives to maintain and restore forests. The Forest Service must play a significant role in the development of new markets and ensuring their integrity. Carbon and bioenergy aren't the only new opportunity for landowners. Markets for water can also provide landowners with incentives to restore watersheds and manage forests for clean and abundant water supplies.



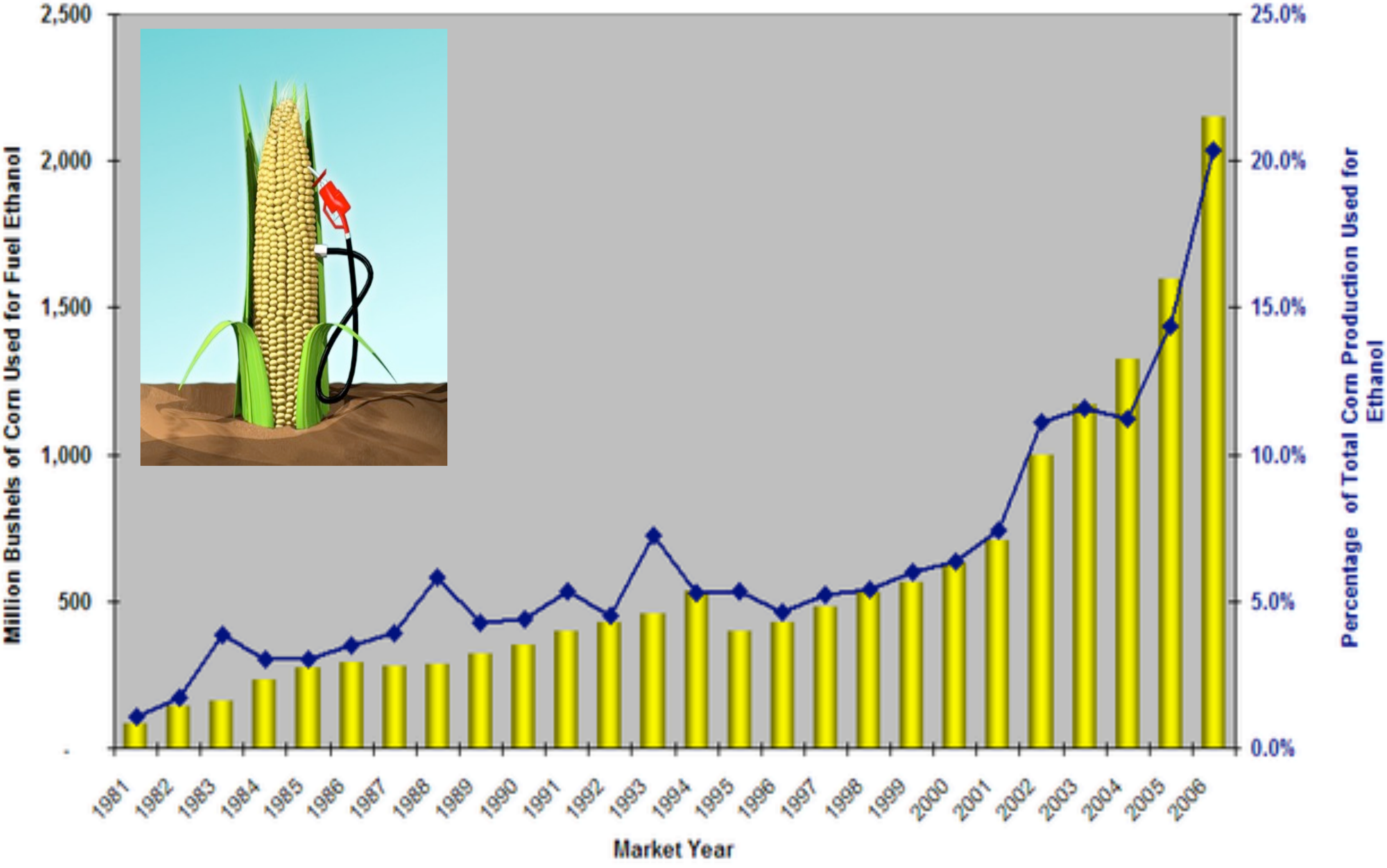
Three Examples:

1) Biofuels
2) Mitigation and radiative forcing
3) Afforestation and other land uses

Biofuels: Is there a Revolution Going On?

What Does it Mean for Water Resources?

US Corn Production Used for Fuel Ethanol



Source: USDA

Water Requirements of Growing Corn

~4,000 gallons of water are evaporated by one acre of corn each day

This water yields:
150 bushels of corn on a quality acre, and
3 gallons of ethanol for each corn bushel
So ~500 gallons of ethanol can be "grown" on one acre

A 100-million gallon EtOH production facility therefore needs 200,000 acres of corn transpiring ~800 million gallons of water a day

Water Requirements of Biofuel Processing

Corn-grain ethanol - 4 gallons H_20/gallon ethanol (Pate et al. 2007)
Cellulosic ethanol - 9 g H_20/g ethanol
Biodiesel - 3 g H_20/g ethanol

A 100 million gallon production plant requires ~400 million gallons of water or 1.1 million gallons a day. This is about as much water as a town of 5,000 people uses (NAS 2007)

October 2007

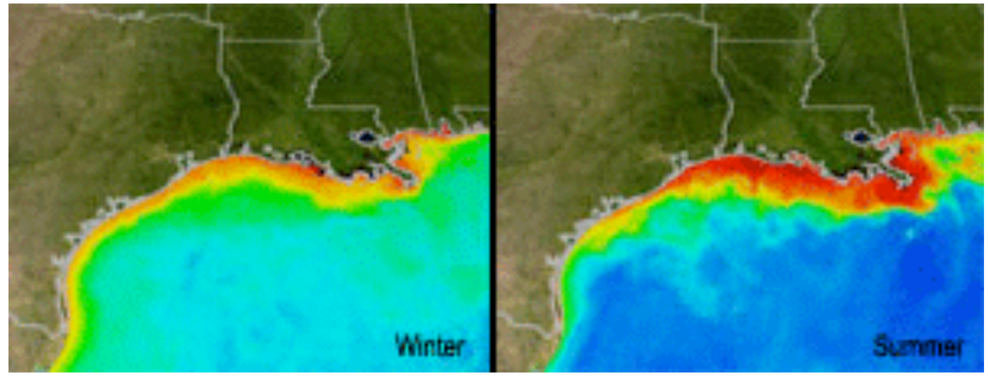
Water Implications of Biofuels Production in the United States

National interests in greater energy independence, concurrent with favorable market forces, have driven increased production of corn-based ethanol in the United States and research into the next generation of biofuels. The trend is changing the national agricultural landscape and has raised concerns about potential impacts on the nation's water resources. This report examines some of the key issues and identifies opportunities for shaping policies that help to protect water resources.

Biofuels—fuels derived from biological materials—are likely to play a key role in America's energy future. In 2007, President Bush called for U.S. production of ethanol to reach 35 billion gallons per year by 2017, which would displace 15 percent of the nation's projected annual gasoline use. By 2030, the administration aims to increase that production to 60 billion gallons per year. Recent increases in oil prices in conjunction with subsidy policies have led to a dramatic expansion in corn ethanol production and high interest in further expansion over the next decade.

production based on discussions at the colloquium, written submissions of participants, the peer-reviewed literature, and the best professional judgments of the committee.

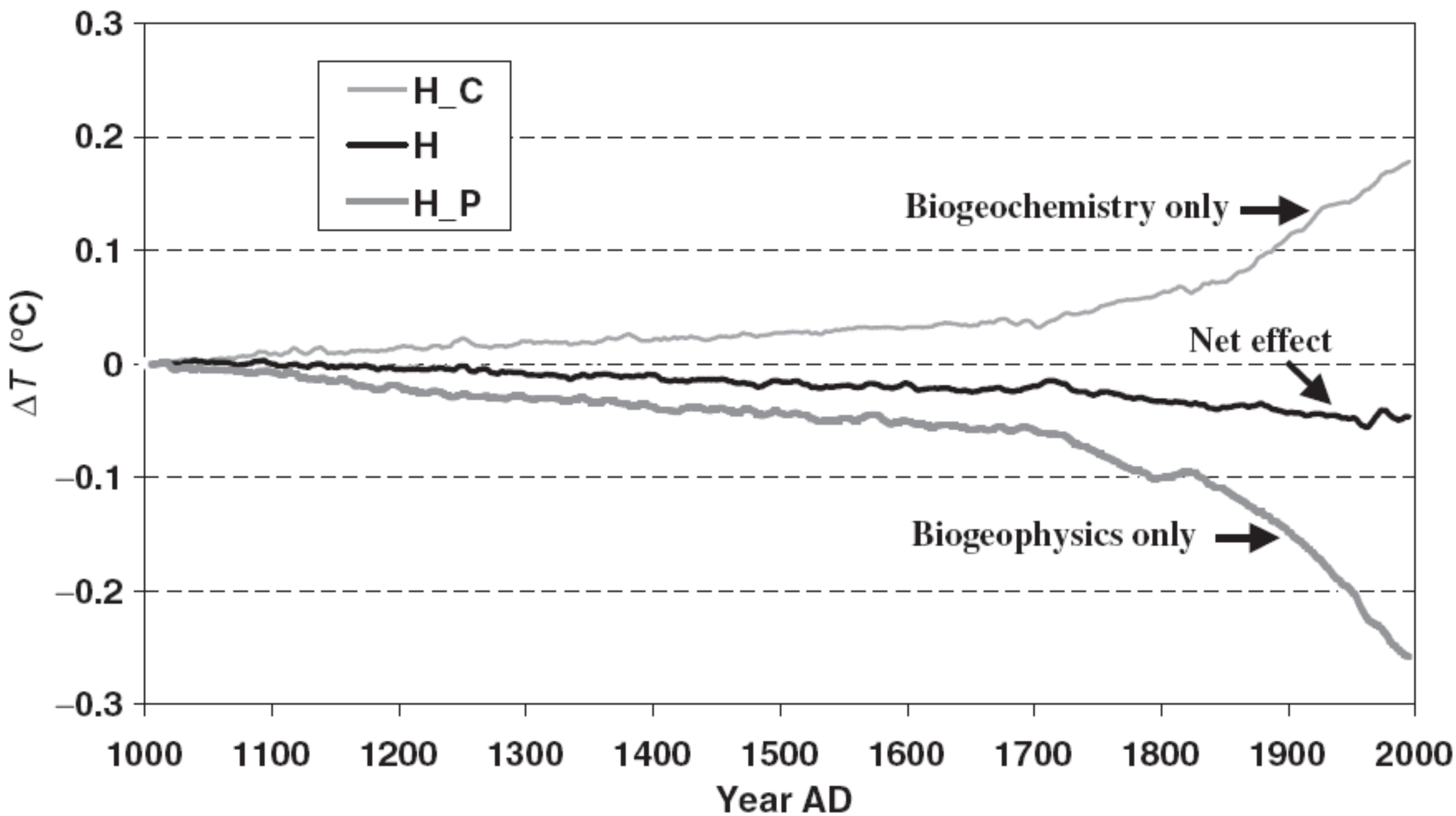
Water Quality Effects



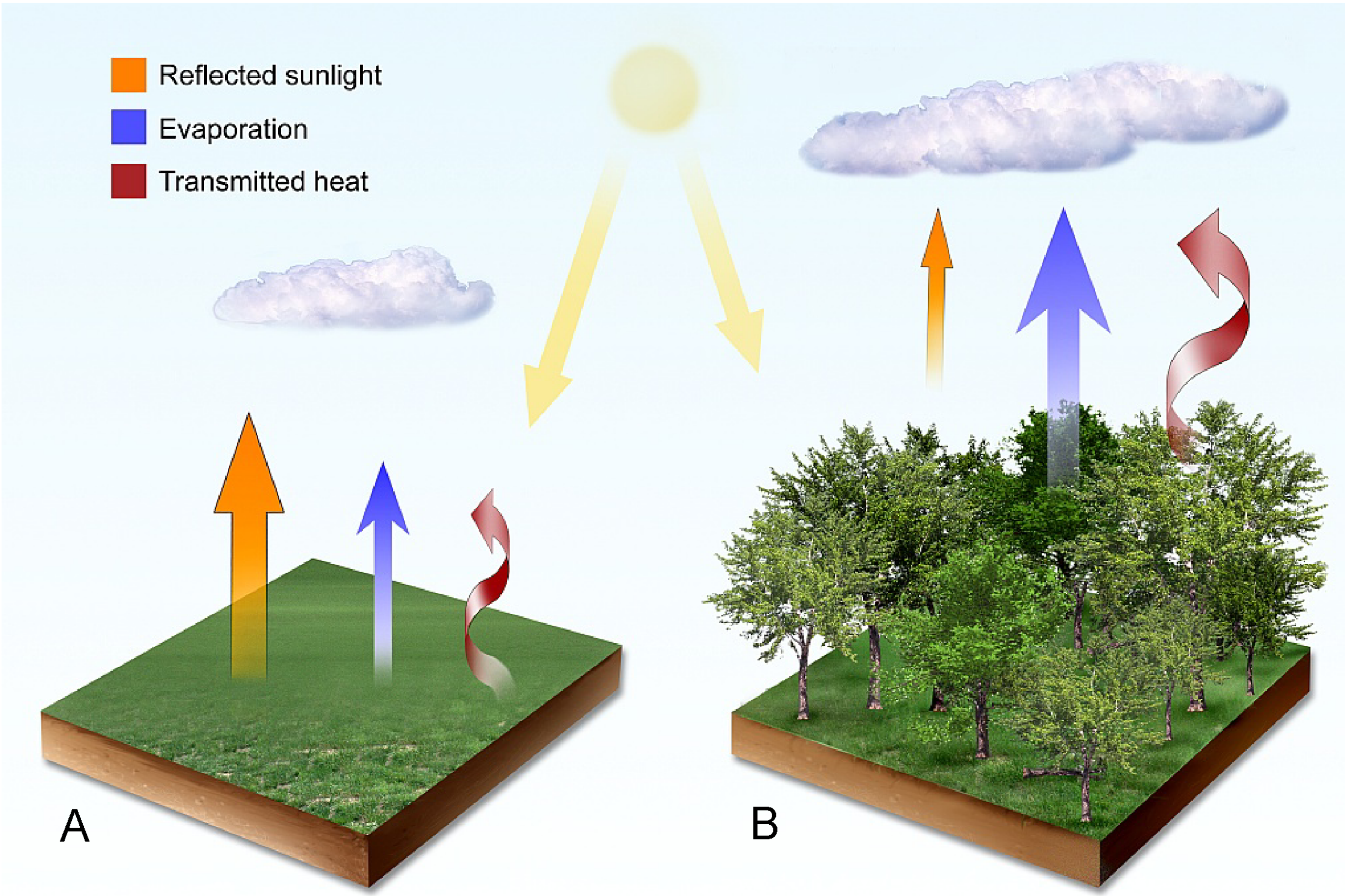
Global Change Biology (2004) 10, 1253–1266, doi: 10.1111/j.1365-2486.2004.00812.x

Role of land cover changes for atmospheric CO_2 increase and climate change during the last 150 years

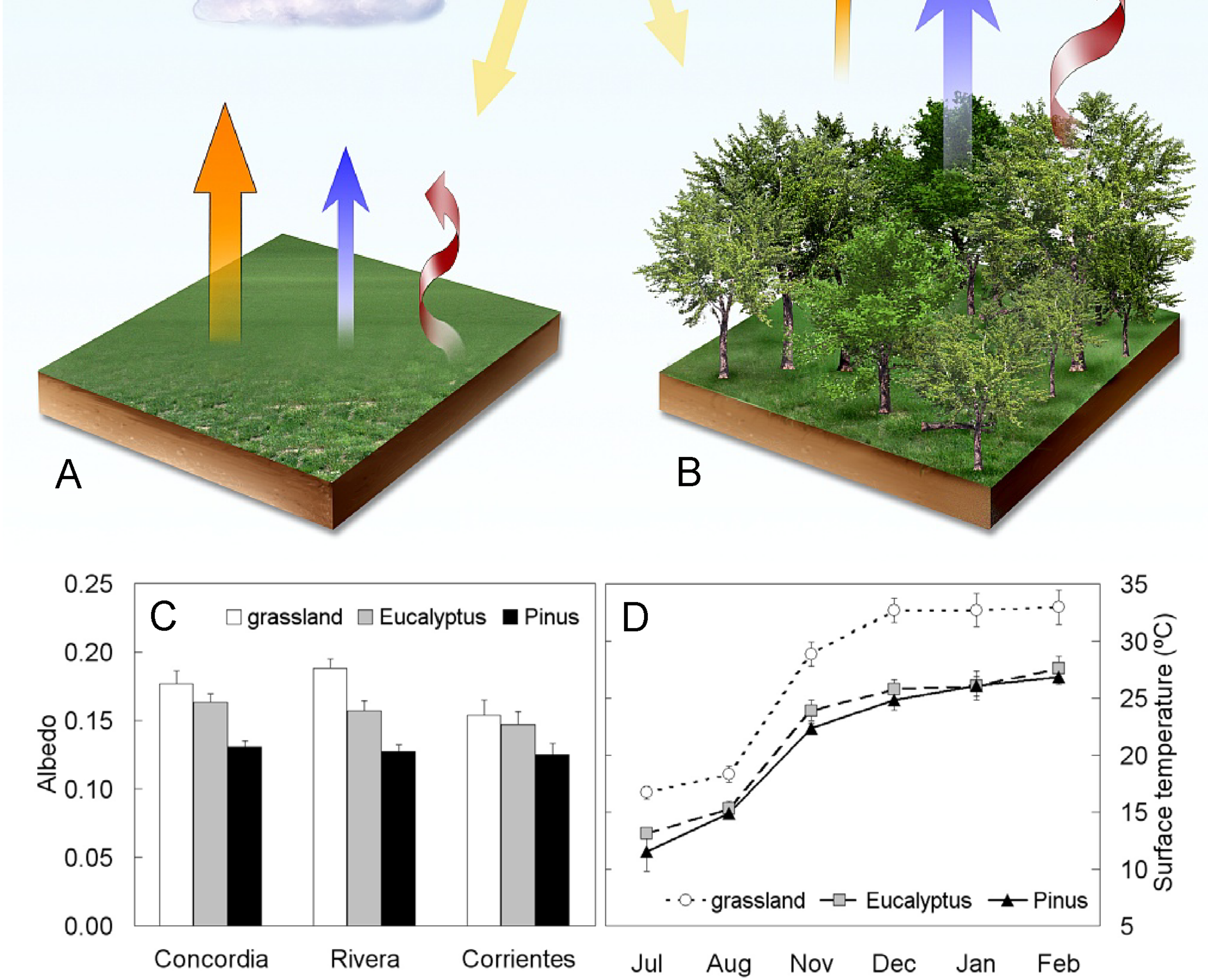
VICTOR BROVKIN, STEPHEN SITCH, WERNER VON BLOH, MARTIN CLAUSSEN, EVA BAUER and WOLFGANG CRAMER
Potsdam Institute for Climate Impact Research, PO Box 601203, D-14412 Potsdam, Germany



Where might biophysical factors offset C storage?

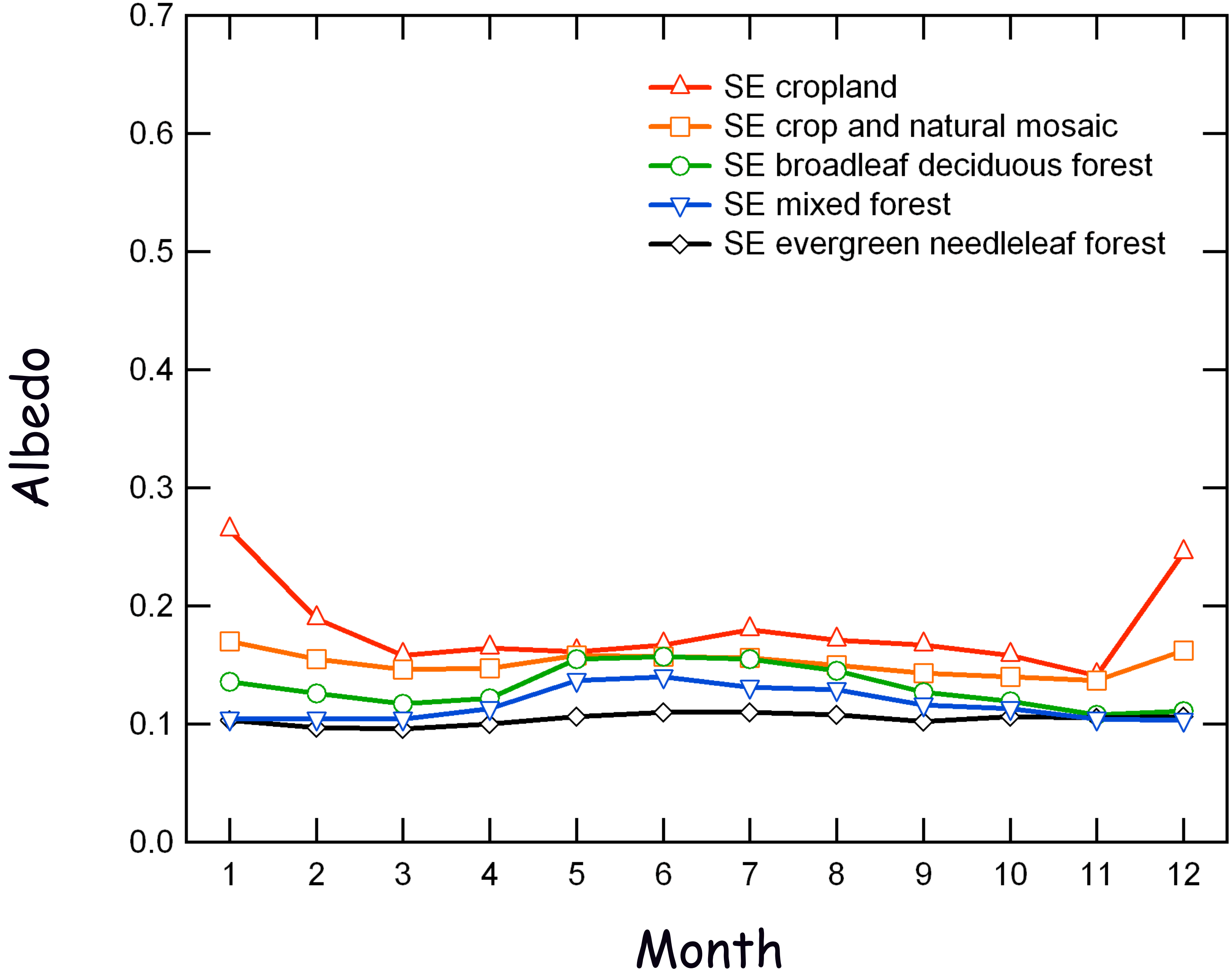


Jackson et al. 2005 Science; 2008 Env Res Letters

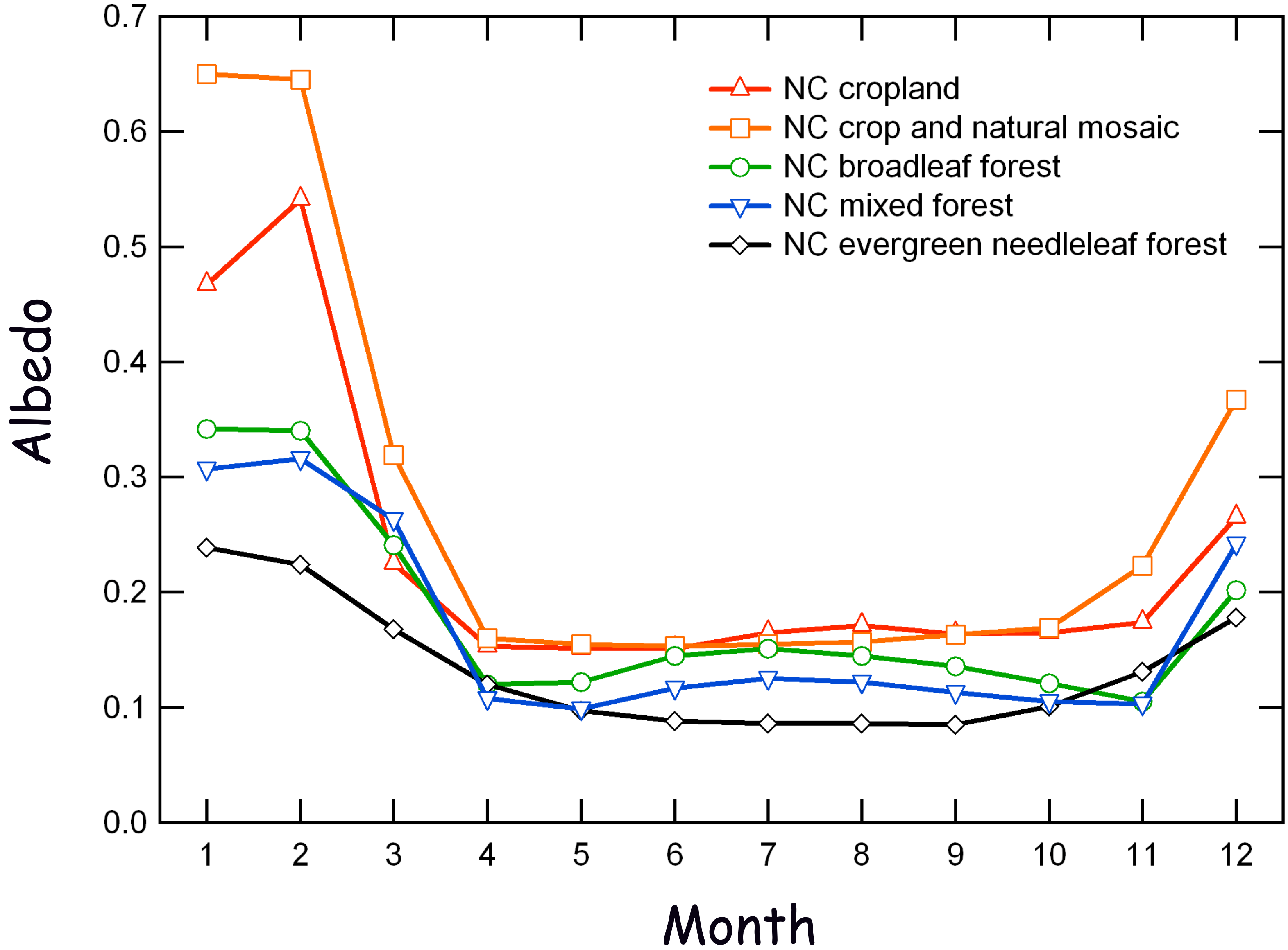


Despite lower forest albedo, forests cool at >200 sites in Argentina analyzed using Landsat. At least they cool locally…

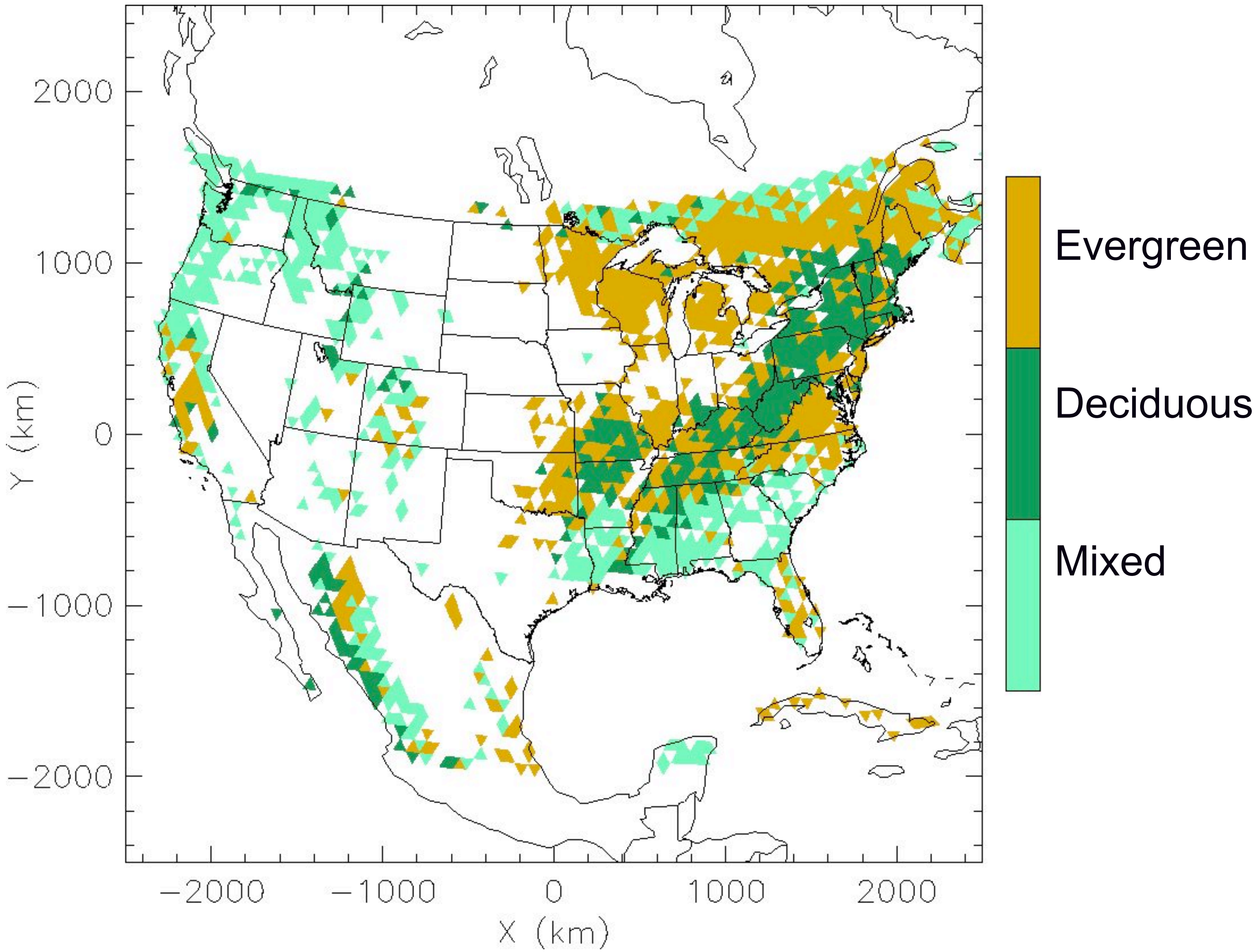
Southeastern U.S.



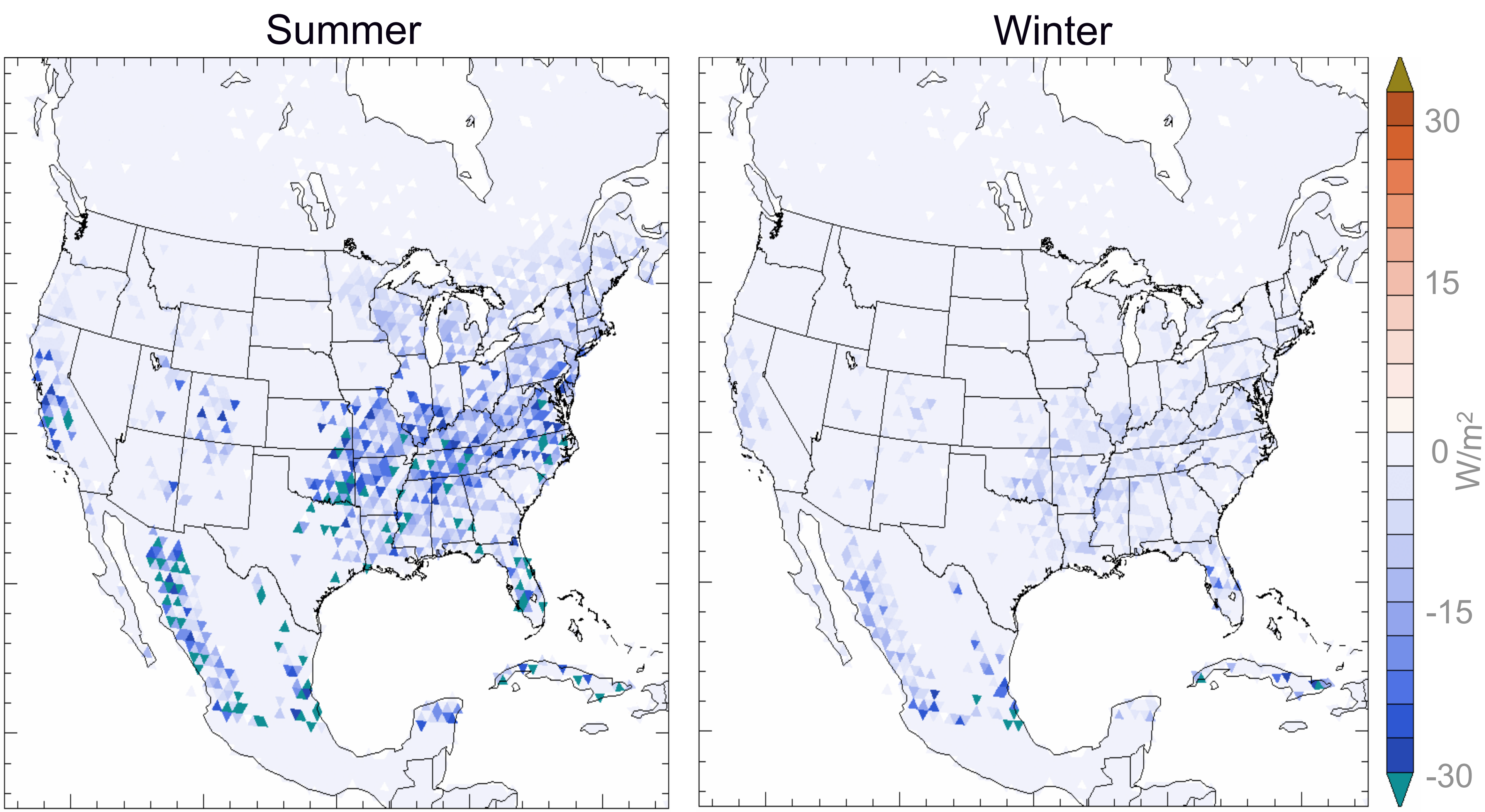
Northcentral U.S.



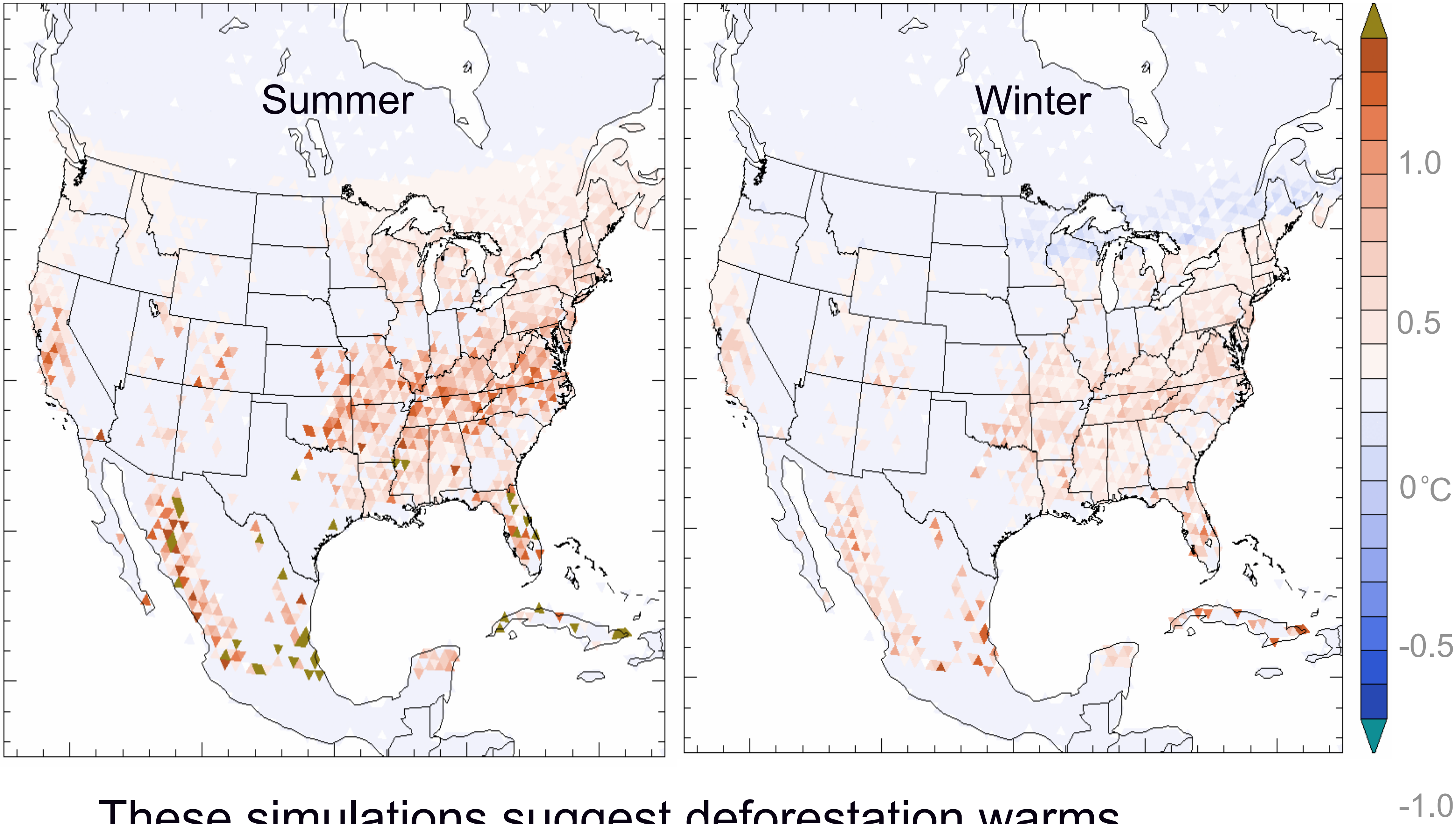
Climate simulations of forests converted to grassland in a belt from 20 to 50 degrees latitude



Δ LE (grass-forest)



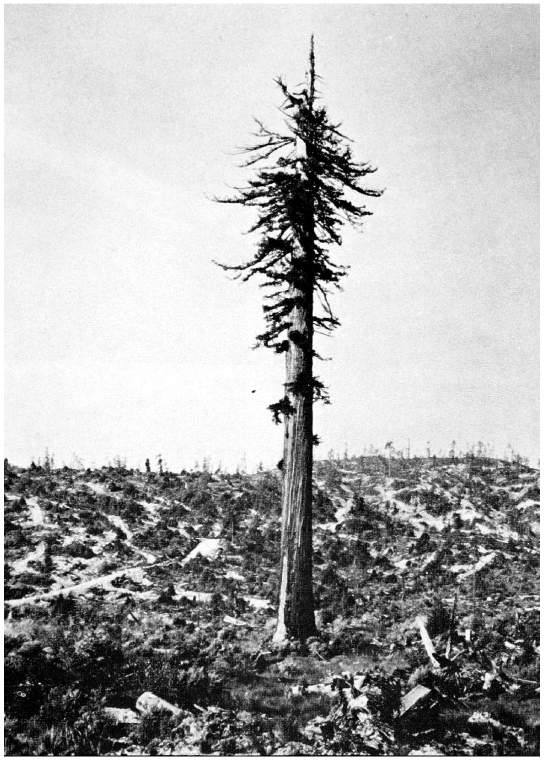
ΔT_s (grass-forest)



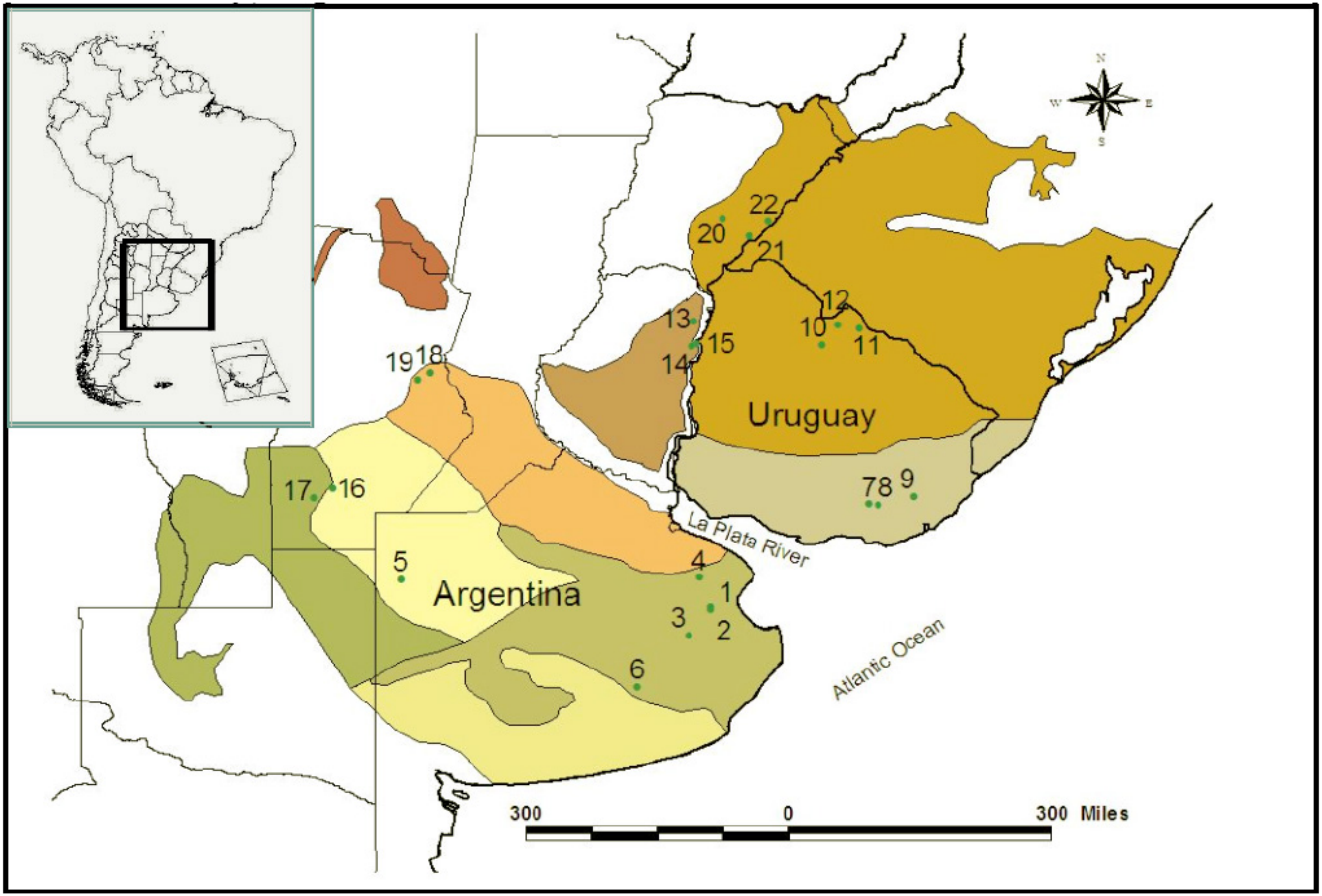
These simulations suggest deforestation warms except where snow cover is prevalent (upper right in winter)

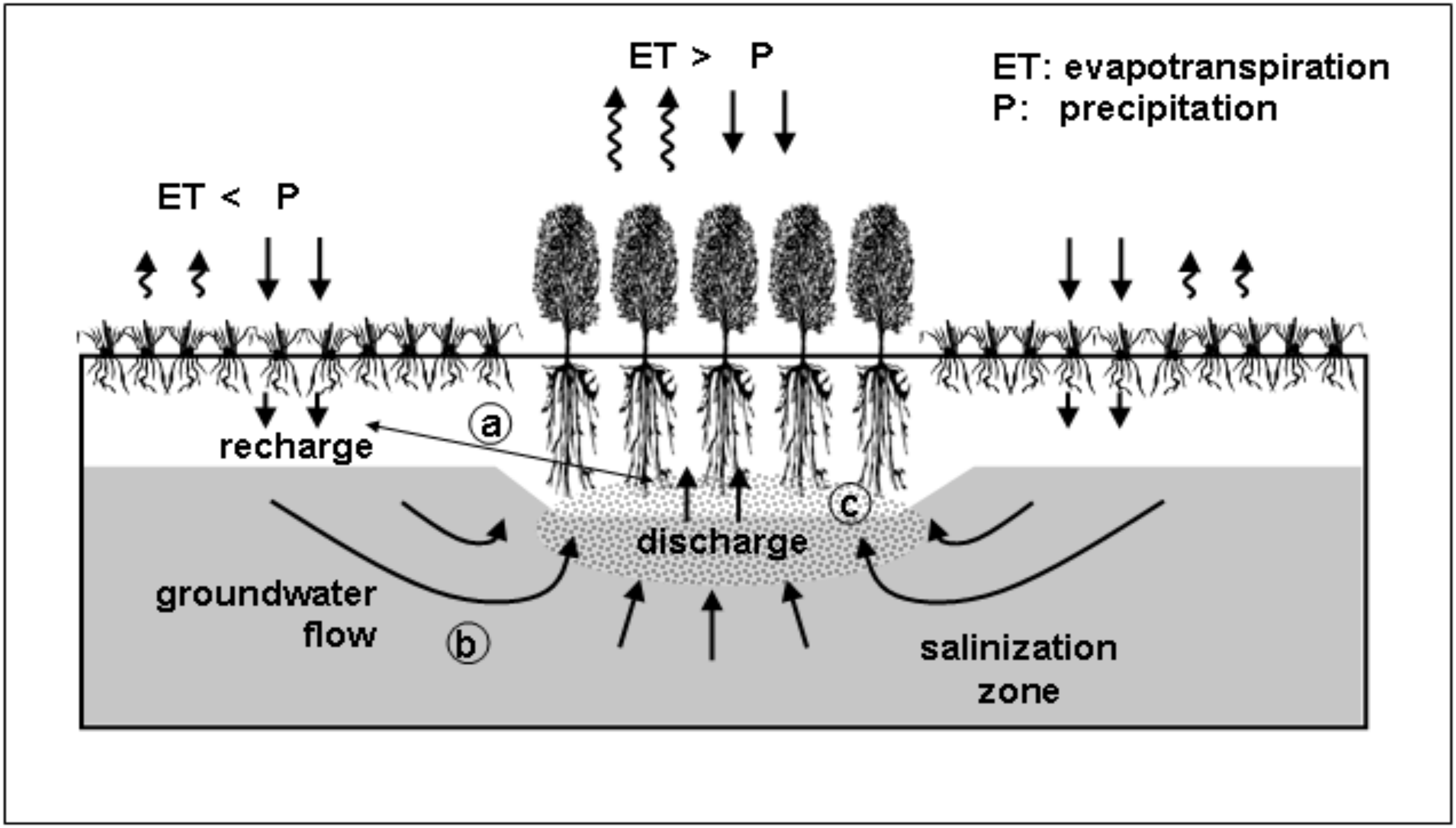
Vegetation Change Studies

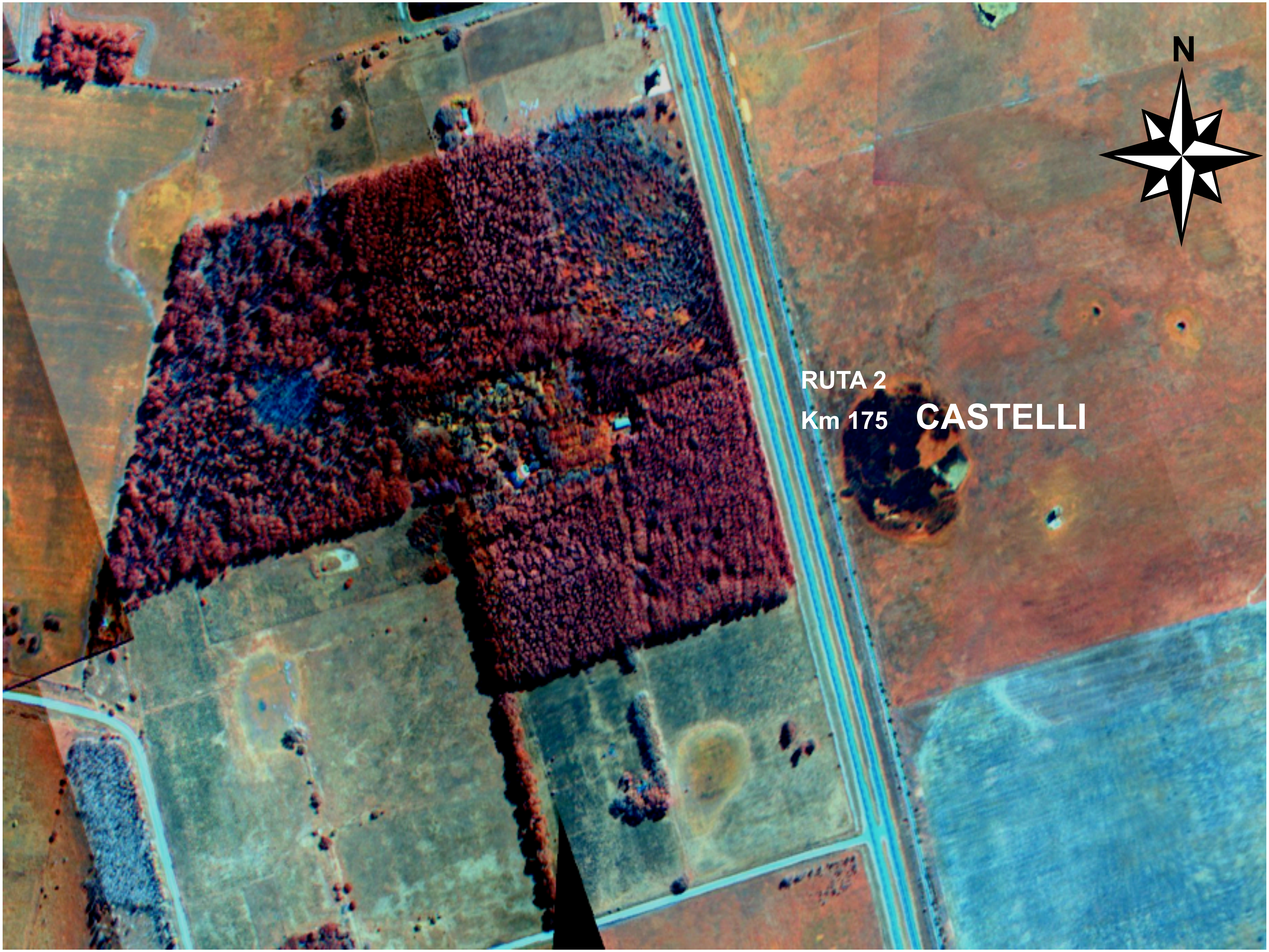
1) Focusing on on U.S. and South America (so far)
2) Basic ecosystem experiments and understanding
3) Early warning of potential problems
4) Seeking solutions - improved management practices and information transfer

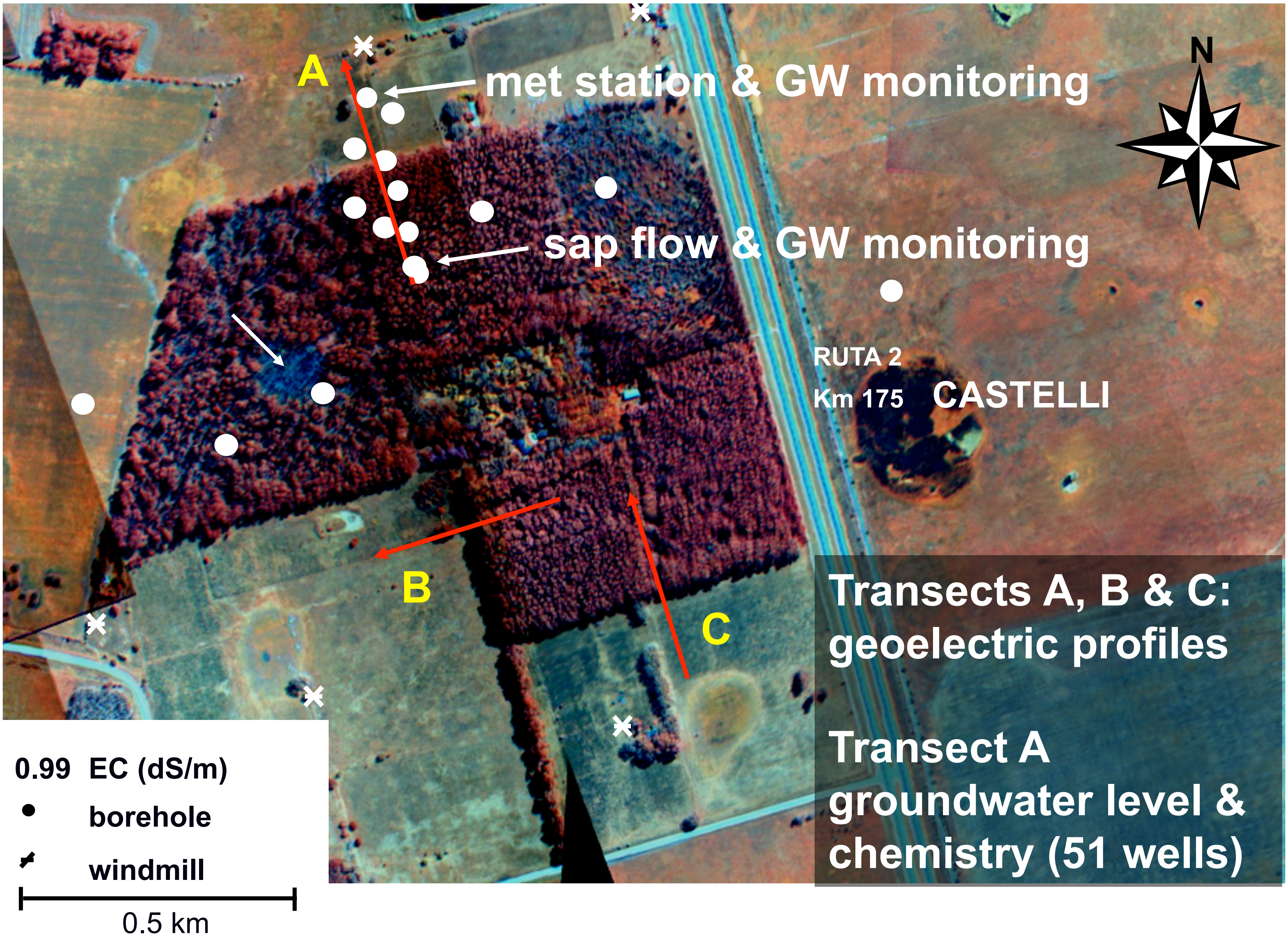


Research Sites

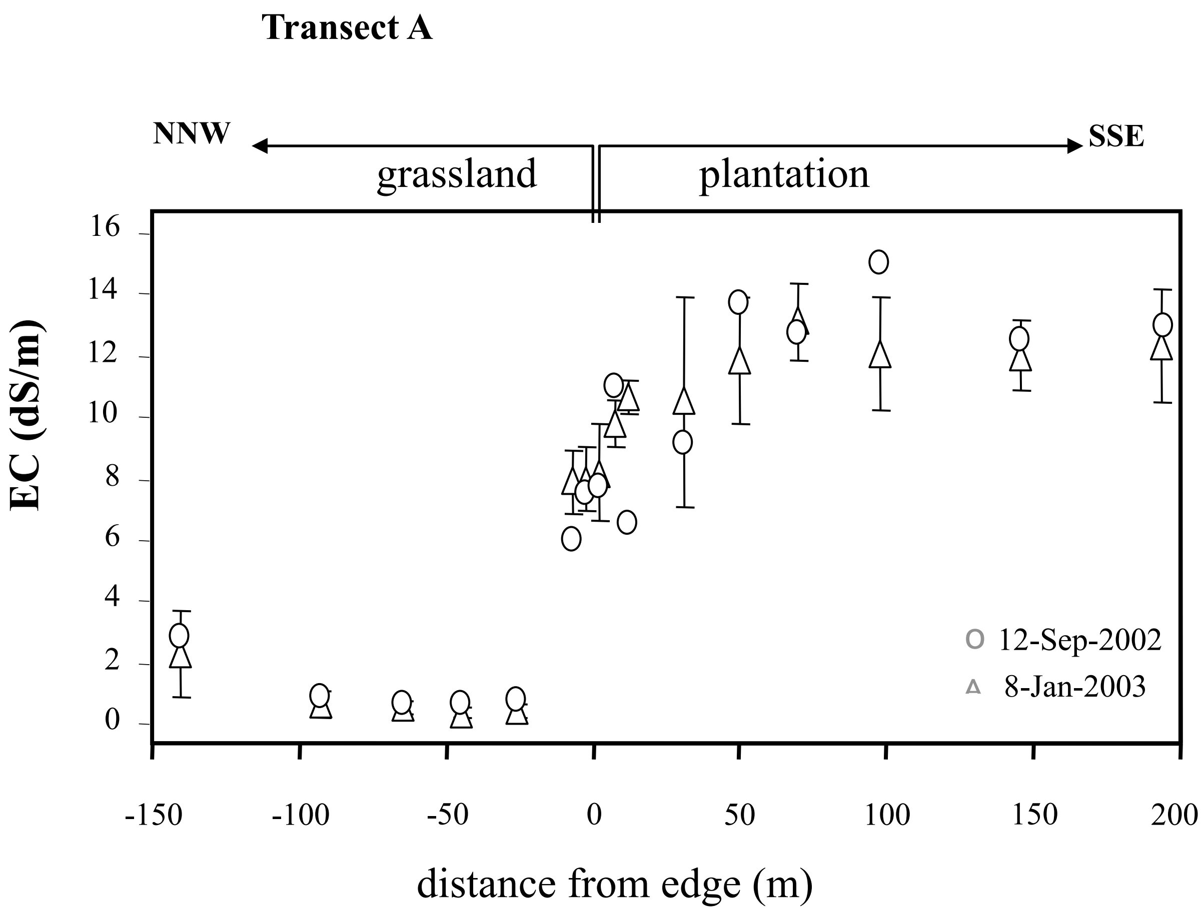



ET > P
ET: evapotranspiration
P: precipitation
ET < P
a
recharge
c
discharge
groundwater
flow
b
salinization
zone

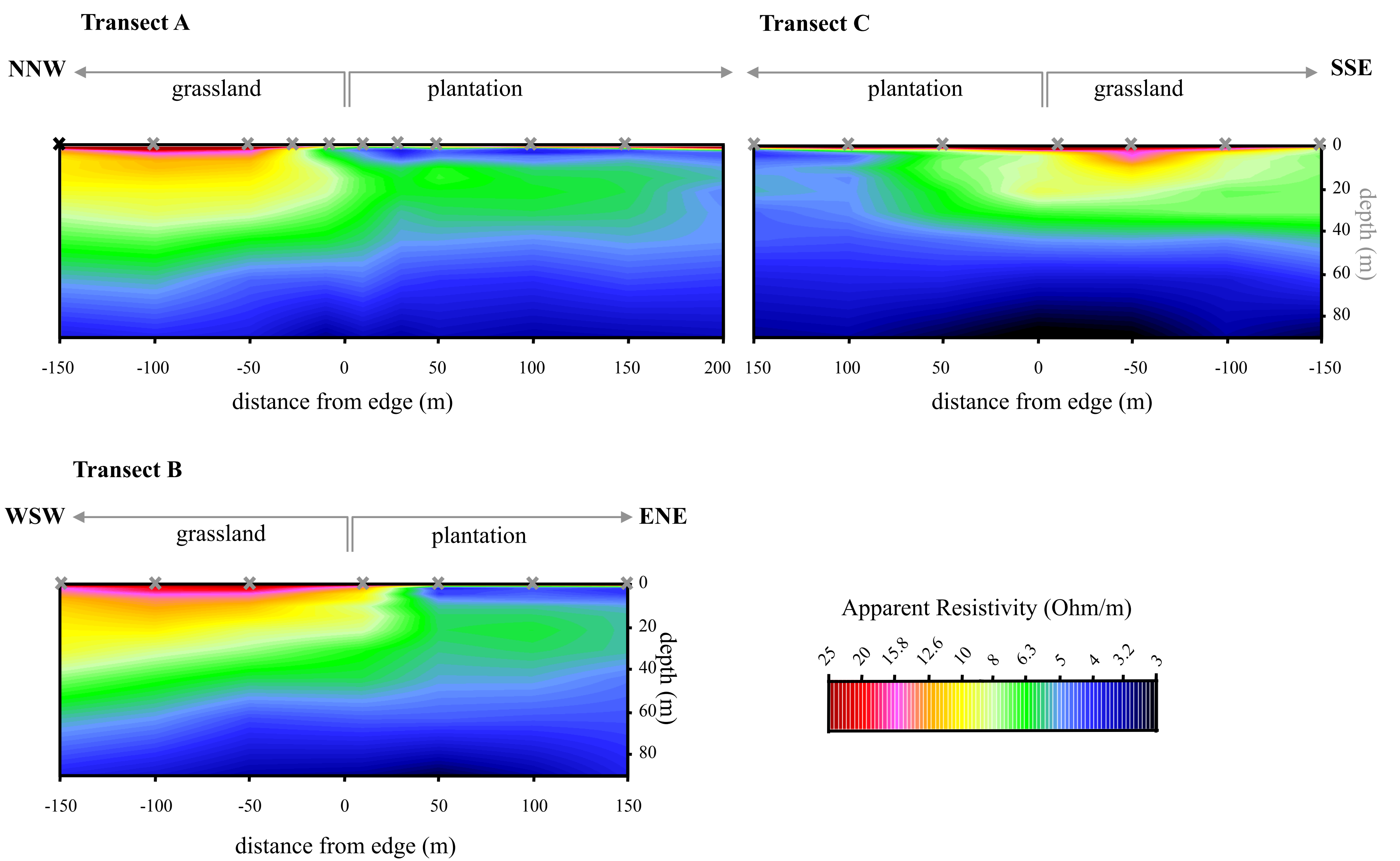

N
RUTA 2
Km 175
CASTELLI



A
B
C
N
met station & GW monitoring
sap flow & GW monitoring
RUTA 2
Km 175
CASTELLI
Transects A, B & C:
geoelectric profiles
Transect A
groundwater level &
chemistry (51 wells)
0.99 EC (dS/m)
borehole
windmill
0.5 km



Jobbagy and Jackson 2007 JGR-Biogeosciences

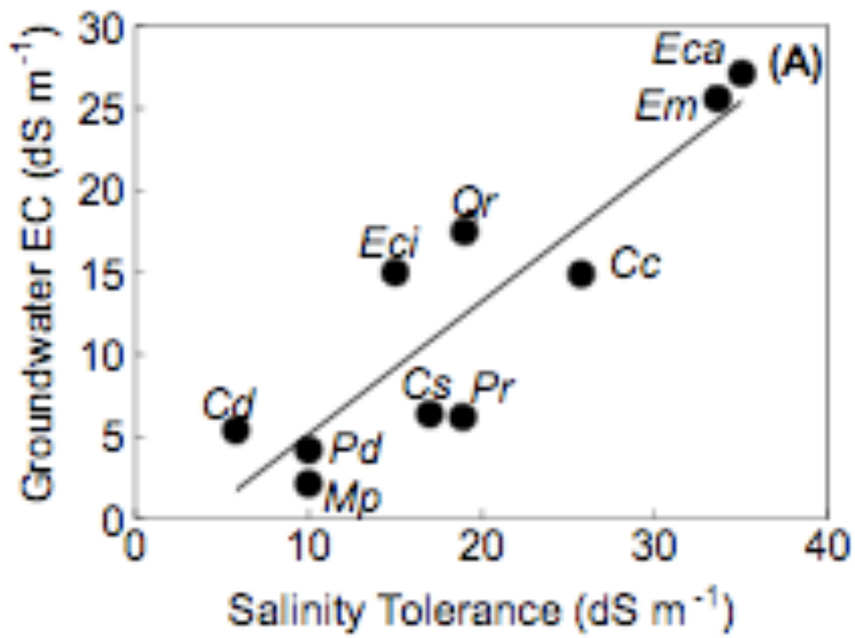


Jackson et al. 2005 Science

Tree species	Maximum salinity value reported (dS m-1)
Eucalyptus camaldulensis	35
Eucalyptus melliodora	33.6
Eucalyptus cinerea	15
Pinus radiata	18.9
Cedrus deodara	5.8
Cupressus sempervirens	17.7
Casuarina cunninghamiana	25.7
Quercus robur	18.9
Populus deltoides	10
Maclura pommifera	10

Salinity tolerances from the literature

Observed groundwater salinity



Nosetto et al. 2008 Glob. Biogeo. Cycles

GM Eucalyptus in the southeastern U.S.

ARBORGEN® MORE WOOD. LESS LAND.™

International Paper Treads Monsanto's Path to 'Frankenforests'

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By Jack Kaskey

Aug. 28 (Bloomberg) -- **International Paper Co.**, the world's largest pulp and paper maker, plans to remake commercial forests in the same way **Monsanto Co.** revolutionized farms with genetically modified crops.

International Paper's ArborGen joint venture with **MeadWestvaco Corp.** and New Zealand's **Rubicon Ltd.** is seeking permission from the U.S. Department of Agriculture to sell the first genetically engineered forest trees outside China. The Australian eucalyptus trees are designed to survive freezes in the U.S. South.

Conclusions

Keith Carter, *Sky and Water*, 1996

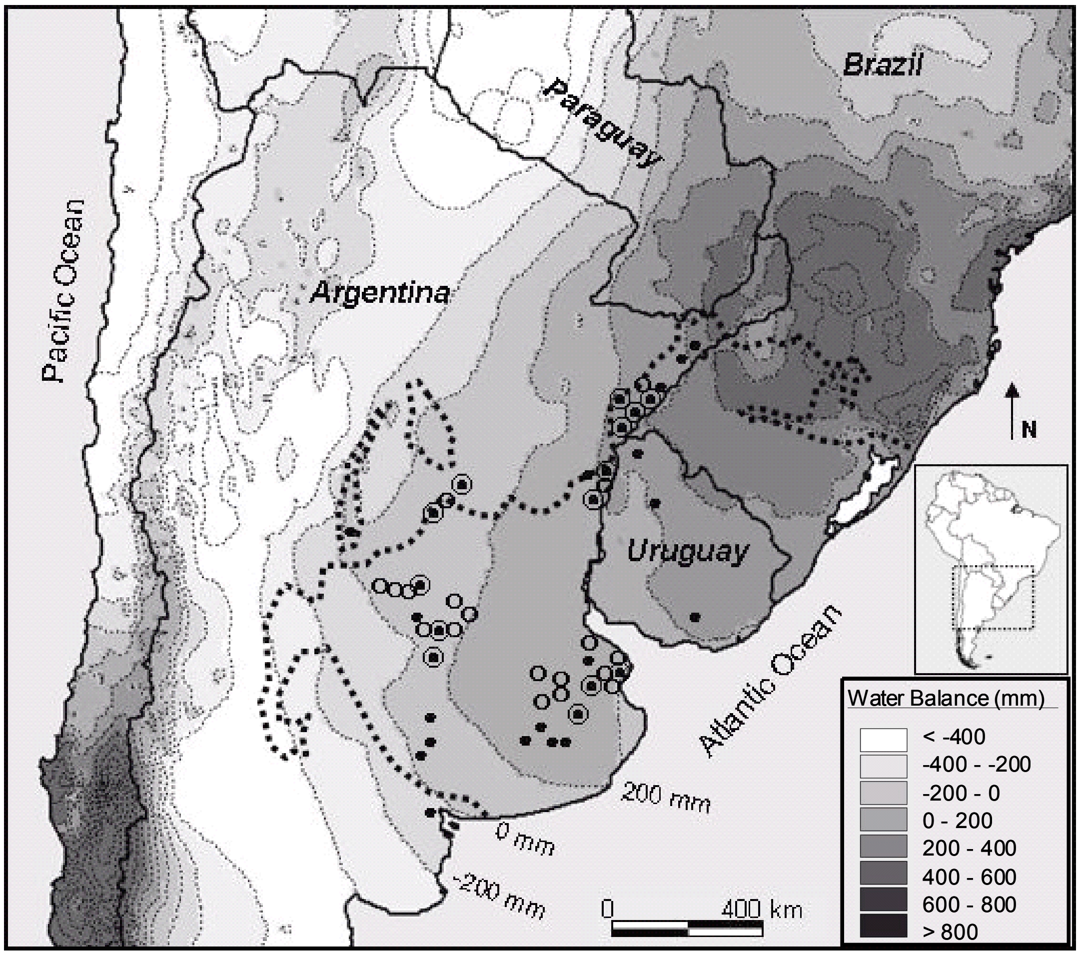
1) Climate change will affect forests and water resources profoundly.

2) In the next 10 to 20 years, climate policy will affect forests and water resources more than climate change will in most locations.

3) Our community should view our research not just as an end point – valuable in its own right – but as an entry point into the broader community.

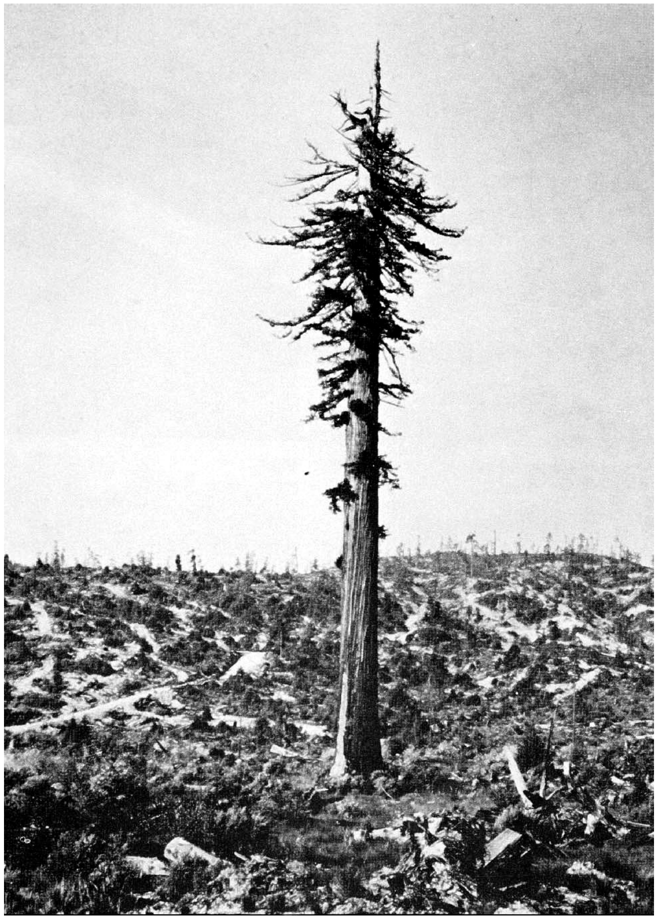
Opportunities for Scaling Up

1) Streams and catchments
2) Remote sensing (e.g., MODIS EVI and the GRACE mission)
3) Regional modeling (economic, RAMS, and GCMs)
4) Cropland water use



Afforestation

Woody Encroachment



Deforestation