Bioe 515 Lec 4:
Environmental gradients, landscape pattern, ecological function

Physical Factors that Pattern Landscapes: climate, landform, soils, water, nutrients.

Conceptual Framework

The framework that we will explore today is that:

- **abiotic factors vary across landscapes,**
- **influence spatial patterning of disturbance and plant recovery and growth,**
- **may limit the distribution and performance of wildlife populations and communities,**
- **and influences human land use.**

History

Merriam (1894) – broad vegetation bands with latitude and altitude termed "life zones"

Clements (1936) and Holdridge (1967) - Defined biomes based on climate.

Whittaker (1956) and Daubenmire (1956) – distribution of plant species across environmental gradients.

Hutchinson (1959) - "what factors limit the number of species in a place"? : habitat heterogeneity, habitat area, trophic structure, evolutionary processes, and available energy.

History

Brown (1981) - Ecologists diverged in the 1970s, either to study ecosystems or to seek a better understanding of interactions among species, but ignoring abiotic controls.

Wright's 1983 paper reopened interest in energy/diversity relationships, but largely among biogeographers and those ecologists concerned with developing models to predict geographic variation in species richness.

Caughley (1987) – animal distributions across climate and soils.

Currie (1991) – continental community richness based on energy.

History

Today –

Stand to landscape scale: continued focus on disturbance and succession as drivers of vegetation and biodiversity, but case studies of abiotic controls

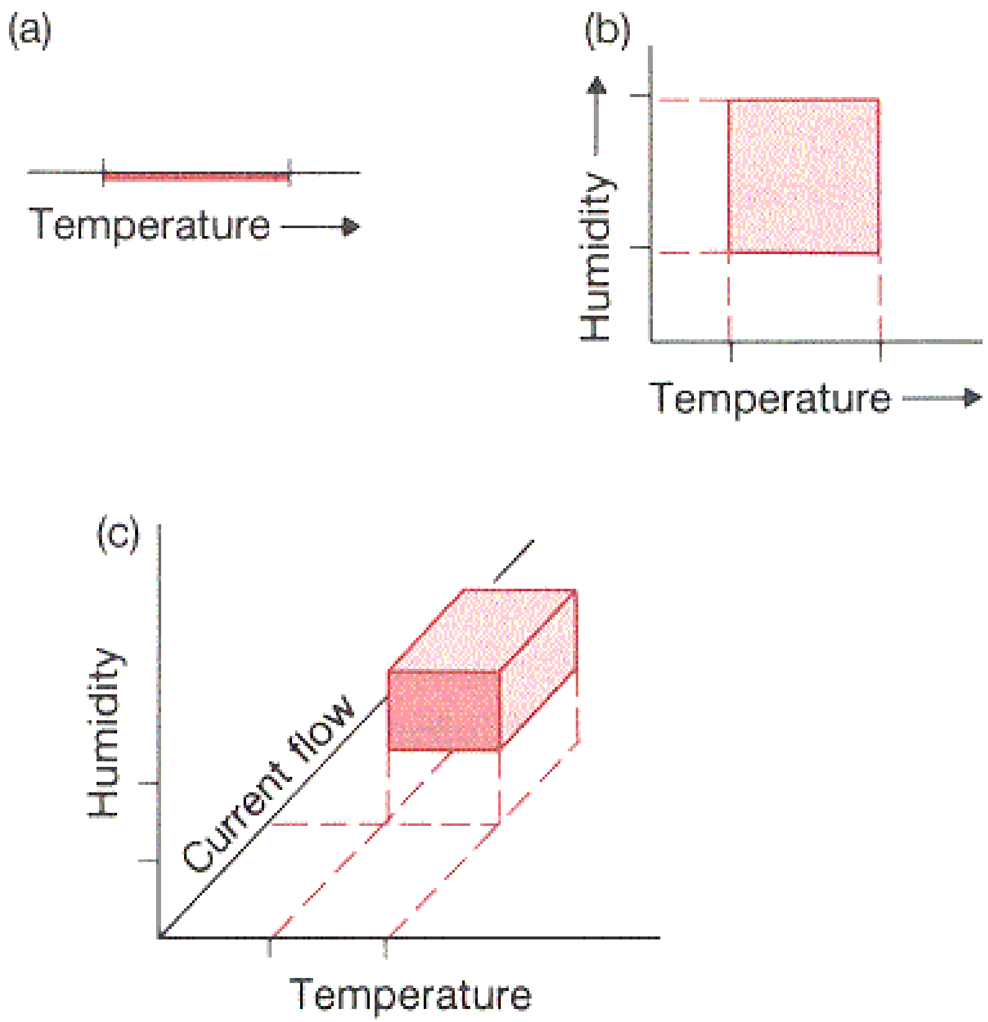
Regional to global scales: climate and ecosystem energy as major drivers of land use and biodiversity

Beginnings of integration of the two perspectives for local to continental scale conservation

Abiotic Factors as Niche Axes

Climate, topography, soils may be resources or conditions that affect the fitness of an organism.

Niche (Hutchinson 1957) – range of abiotic and biotic conditions and resources required by an organism for survival, growth, and reproduction.



(a)
Temperature
(b)
Humidity
Temperature
(c)
Humidity
Current flow
Temperature

Abiotic Factors as Niche Axes

Niche (Hutchenson 1957) – range of abiotic and biotic conditions and resources required by an organism for survival, growth, and reproduction.

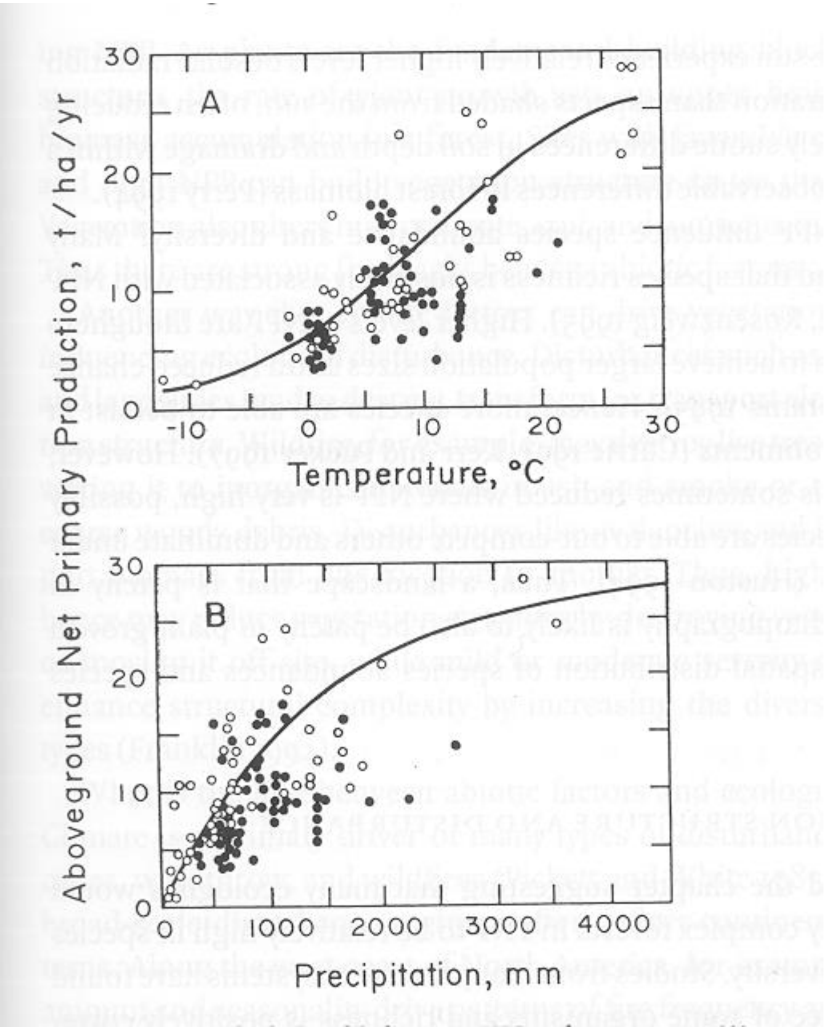
Key point: To the extent that abiotic and biotic limiting factors vary across a landscape, we expect survival, reproduction, and abundance of a species to vary accordingly.

Abiotic Factors and Ecological Processes

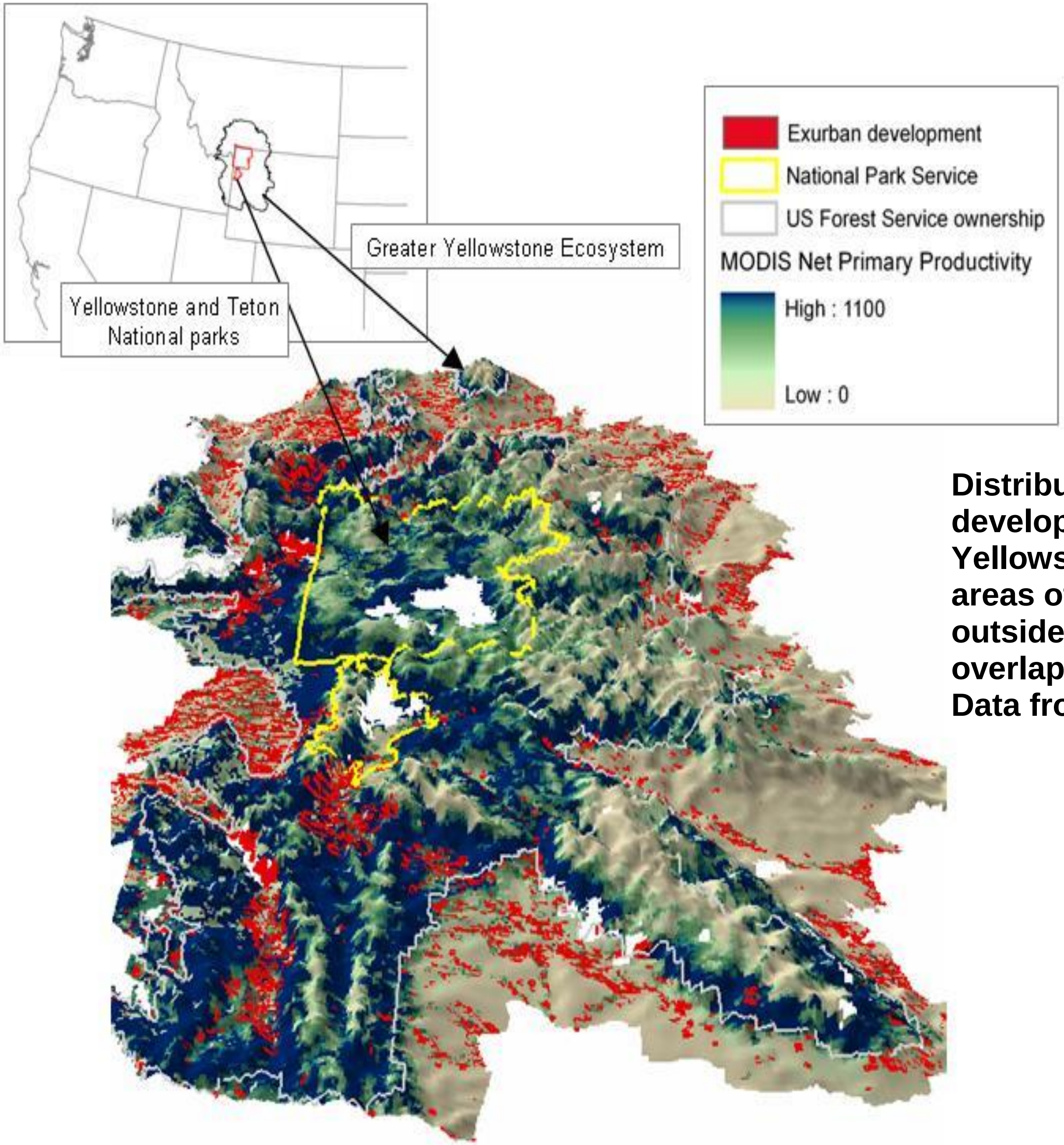
Primary Productivity:

Abiotic Factors and Ecological Processes

Primary Productivity:

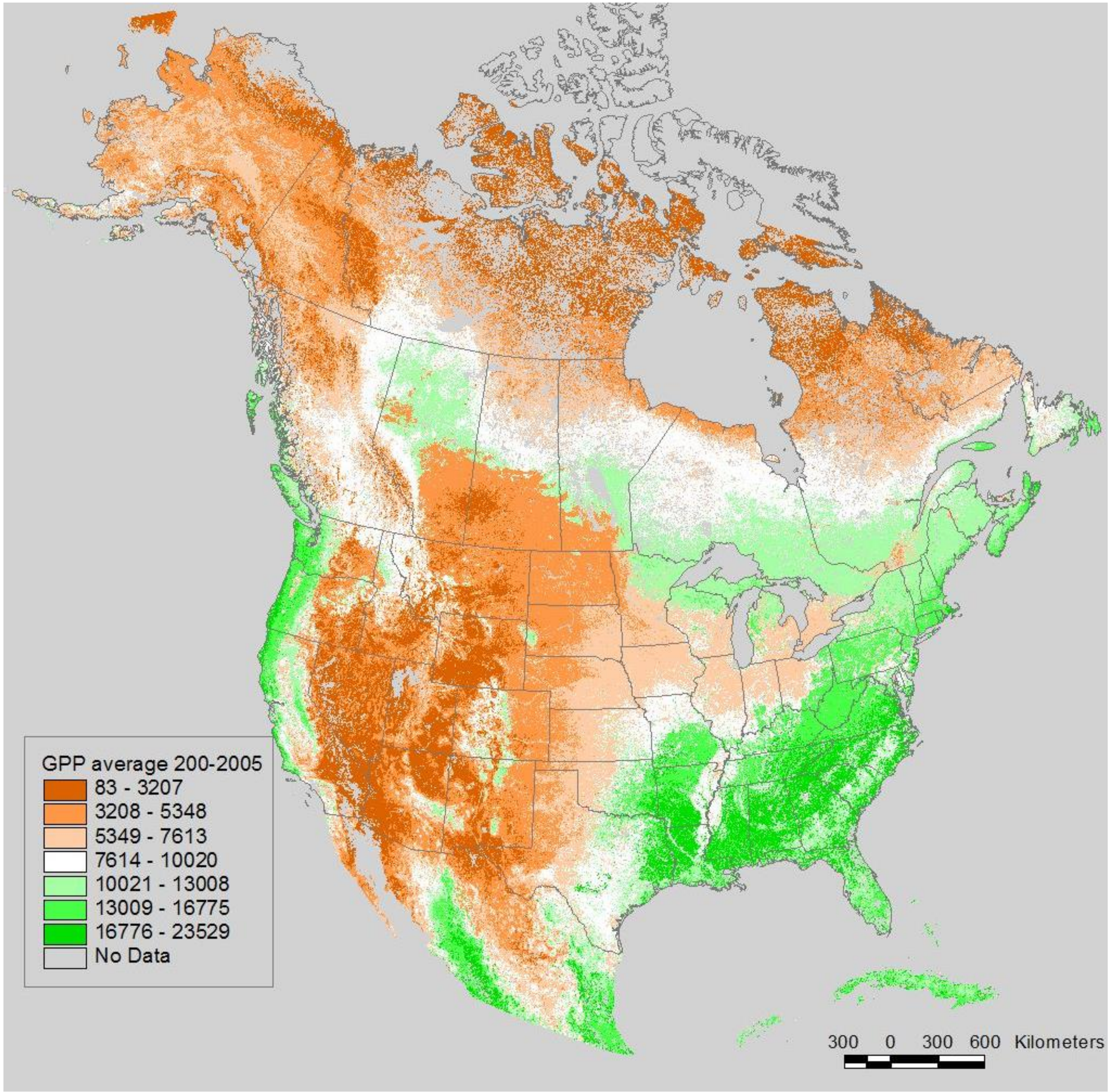


Abiotic Factors and Ecological Processes

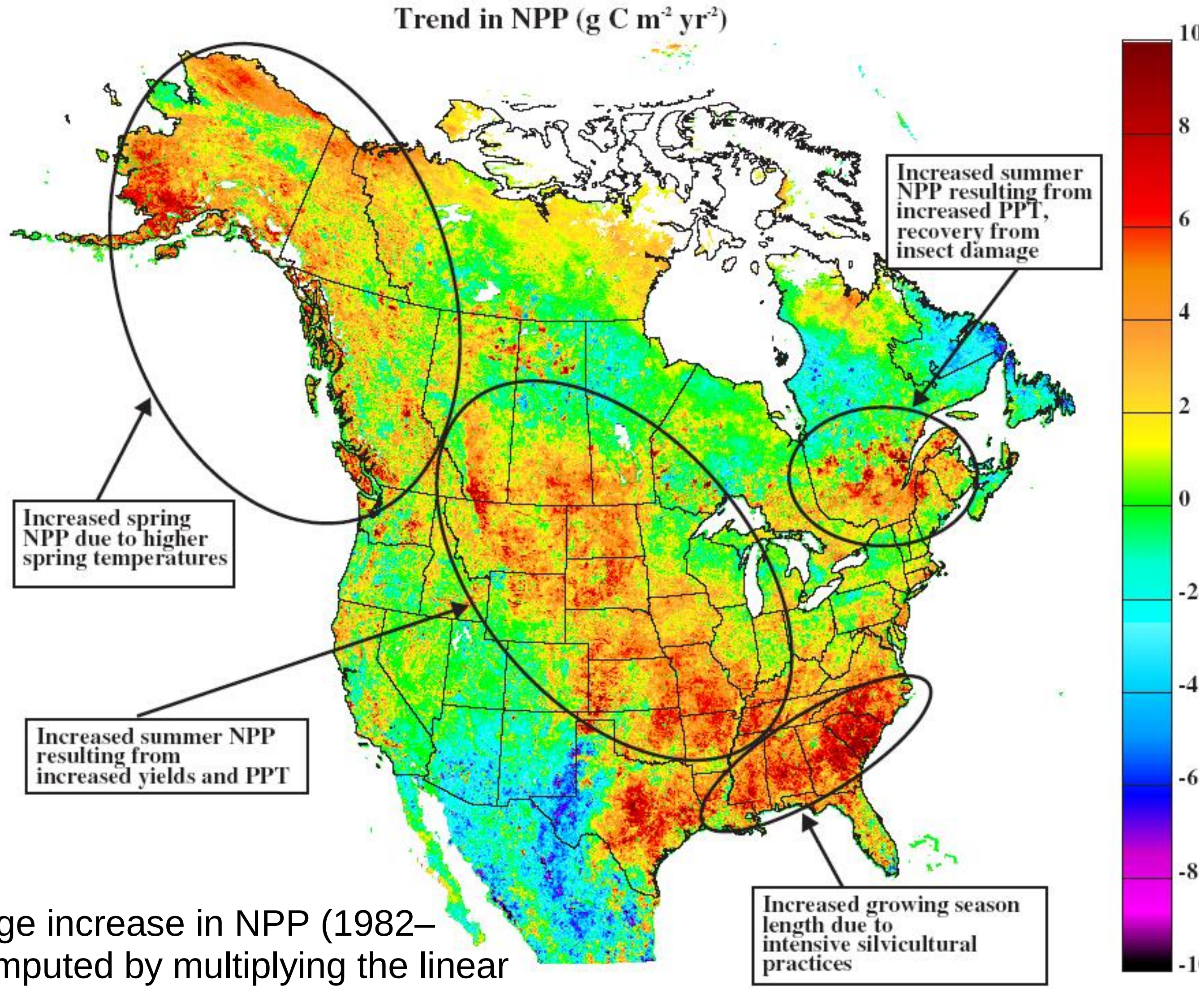


Distribution of NPP and exurban development across the Greater Yellowstone Ecosystem. Notice that areas of highest NPP are largely outside of the national parks and overlap with exurban development. Data from Gude et al. in press.

MODIS Gross Primary Productivity



Abiotic Factors and Ecological Processes



Percentage increase in NPP (1982–1998), computed by multiplying the linear trend at each location by the number of years in the time period (17), then dividing by the 1982 NPP. Modified from Hicke et al. 2002.

Abiotic Factors and Ecological Processes

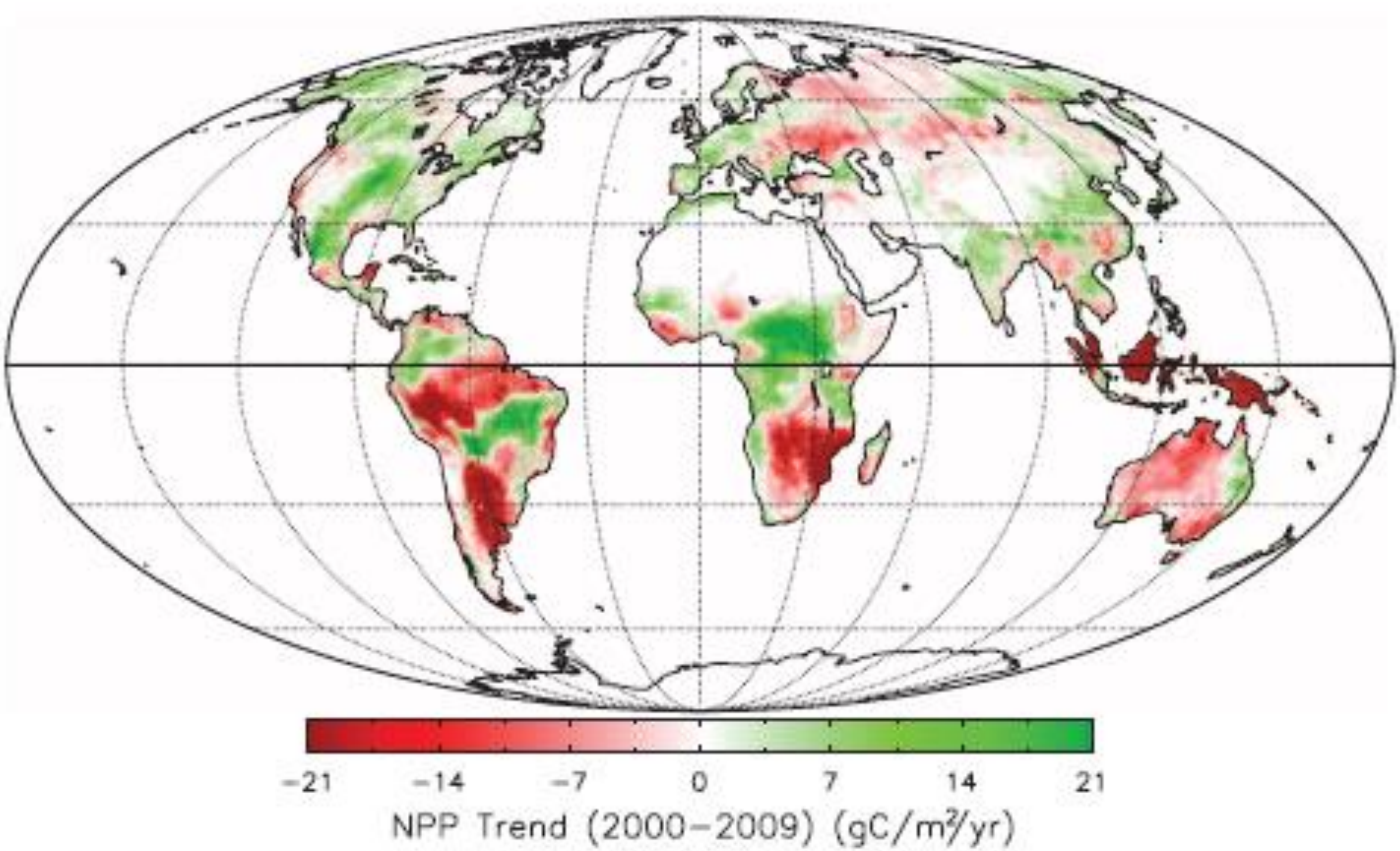


Fig. 2. Spatial pattern of terrestrial NPP linear trends from 2000 through 2009 (SOM text S1) (*8*, *10*).

Zhao and Running 2010

Abiotic Factors and Ecological Processes

Natural Disturbance:

- **Fire**
- **Windthrow**
- **Landslides**
- **Avalanches**
- **Hurricanes**

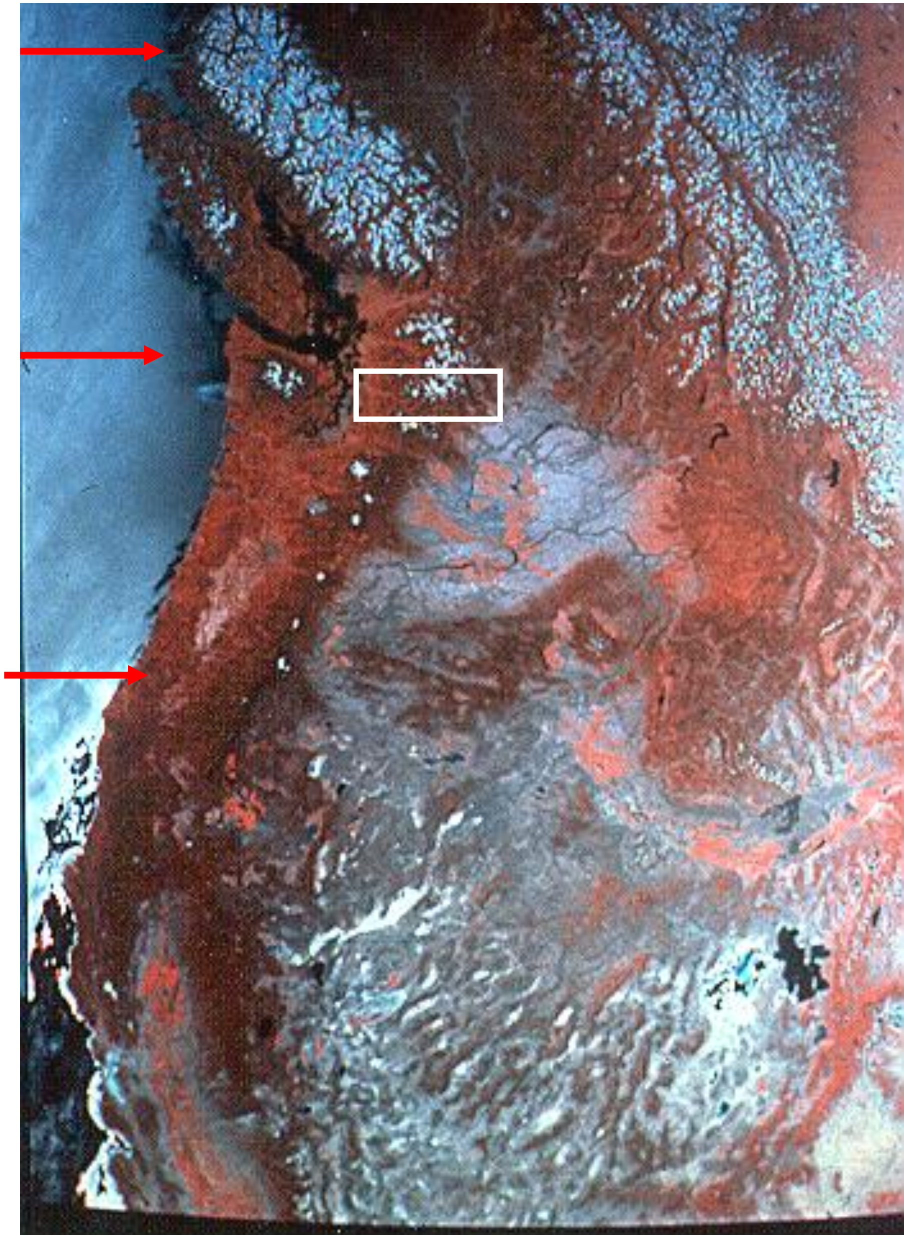
No fires

High severity

250-450 yr intervals

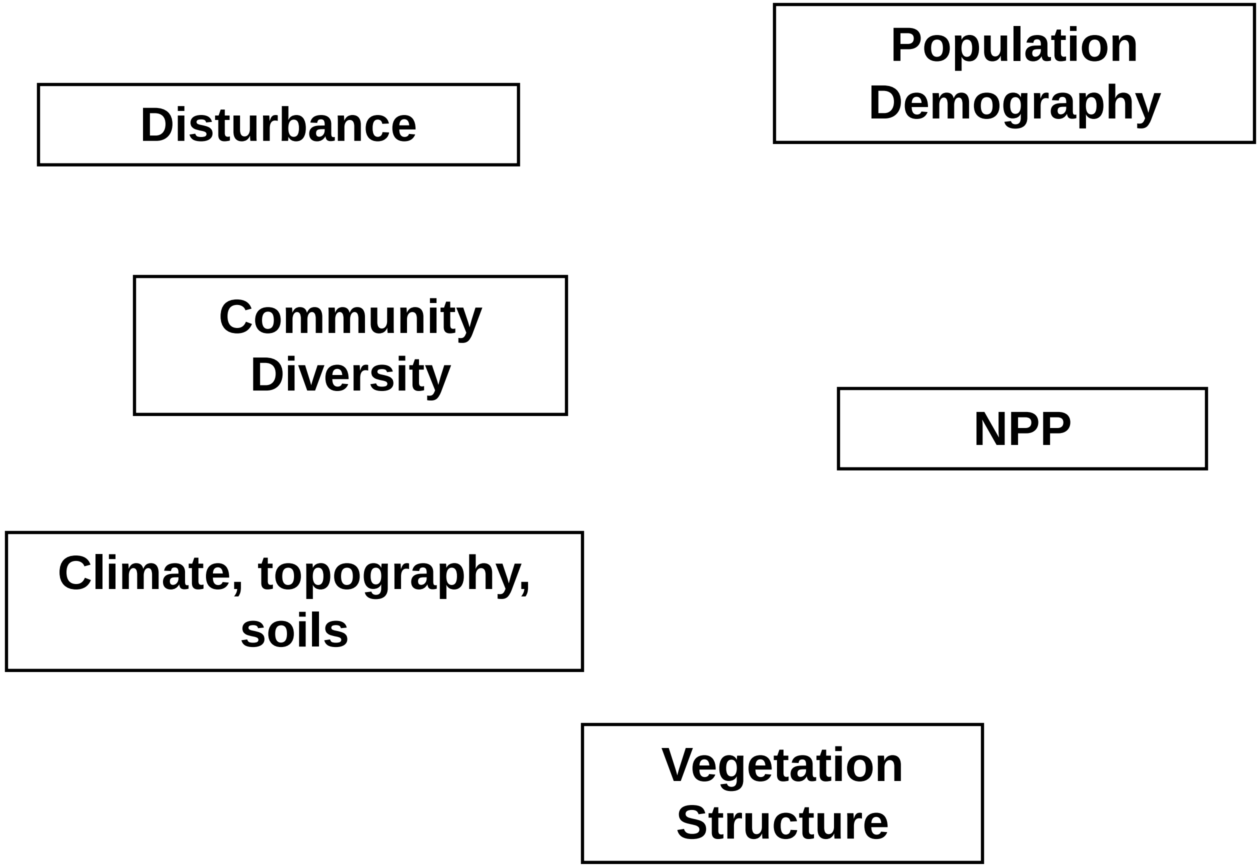
Light to moderate severity

50-90 yr intervals



Ppt

lightning


Population Demography
Disturbance
Community Diversity
NPP
Climate, topography, soils
Vegetation Structure

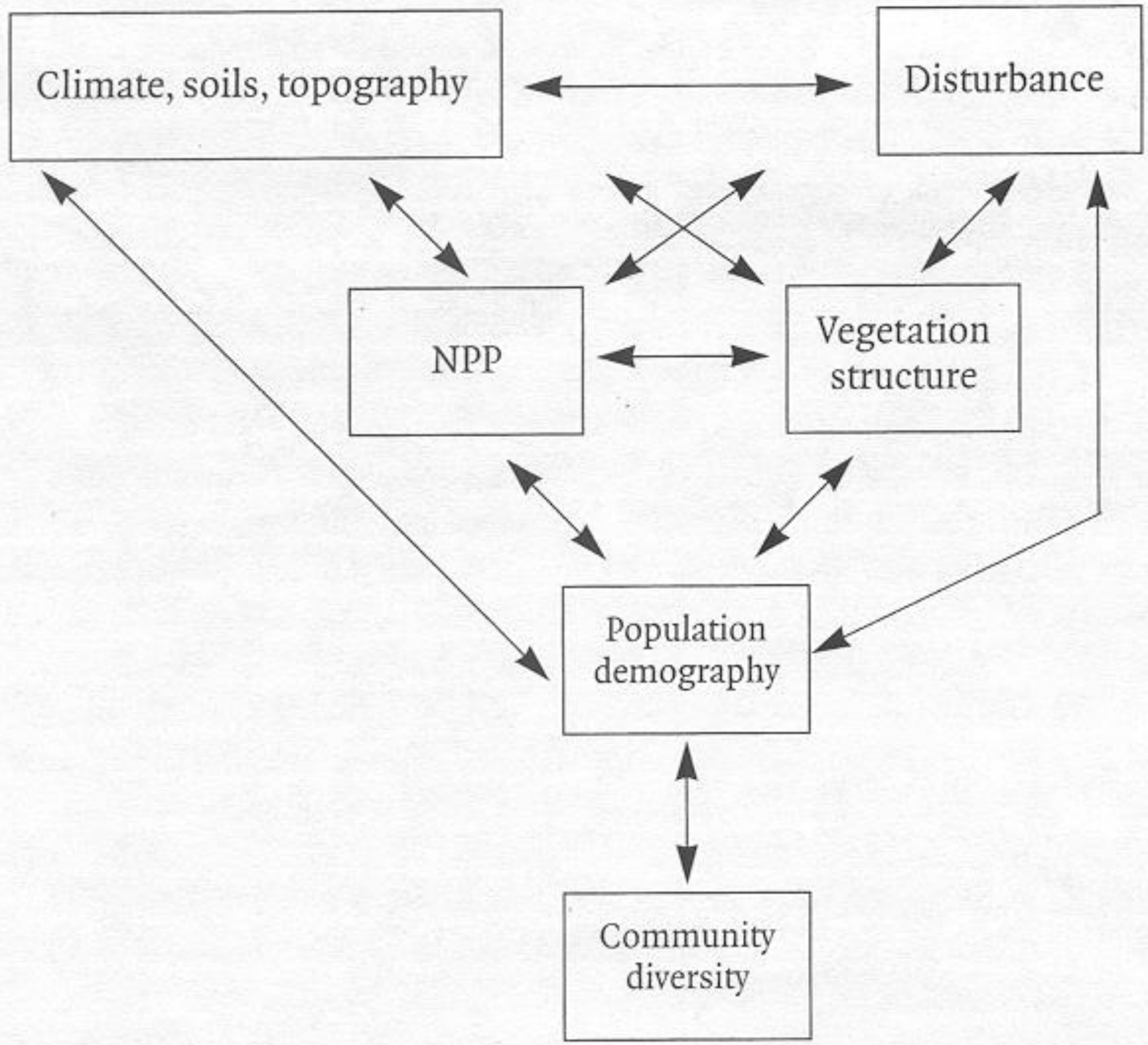
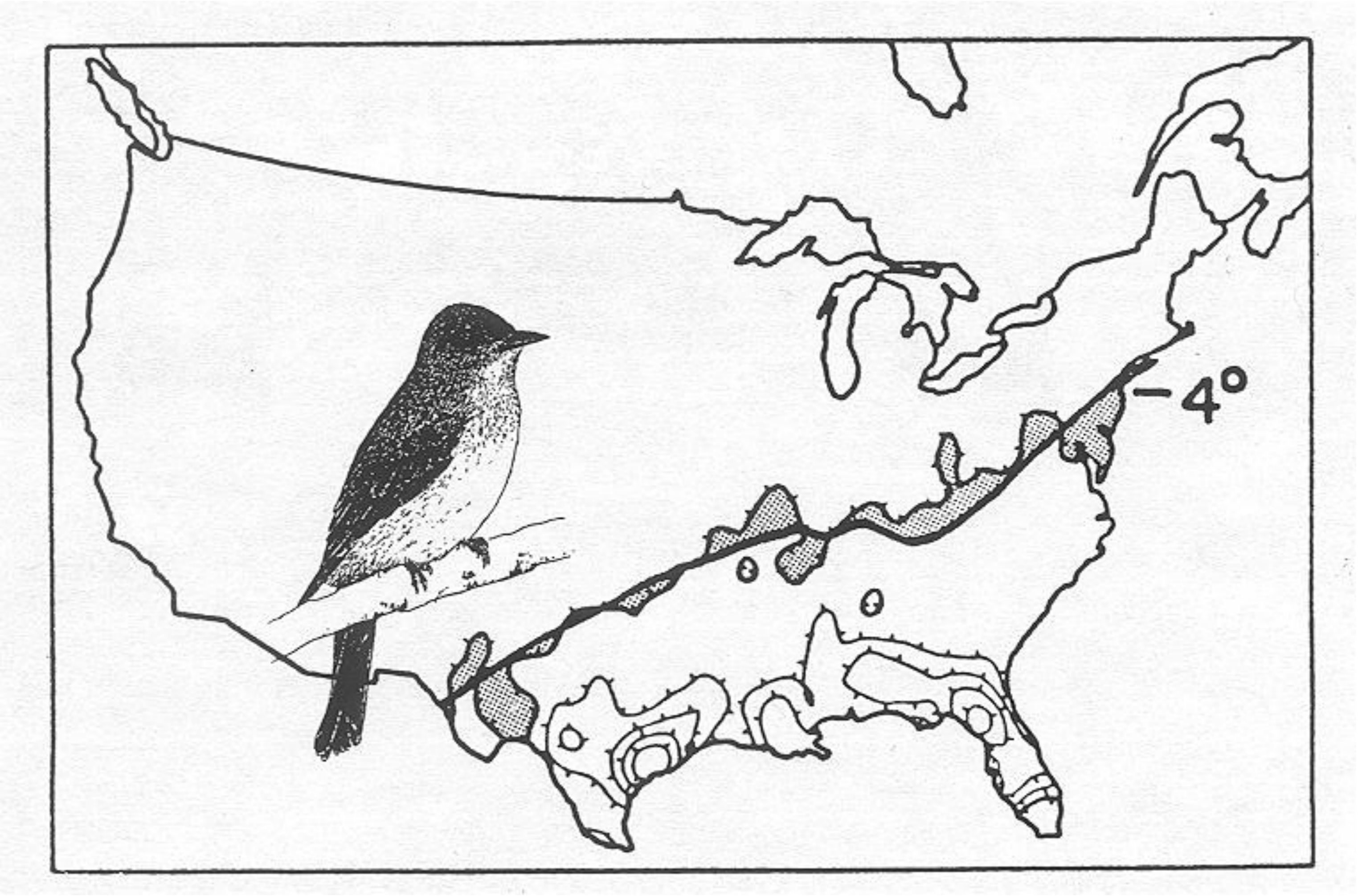
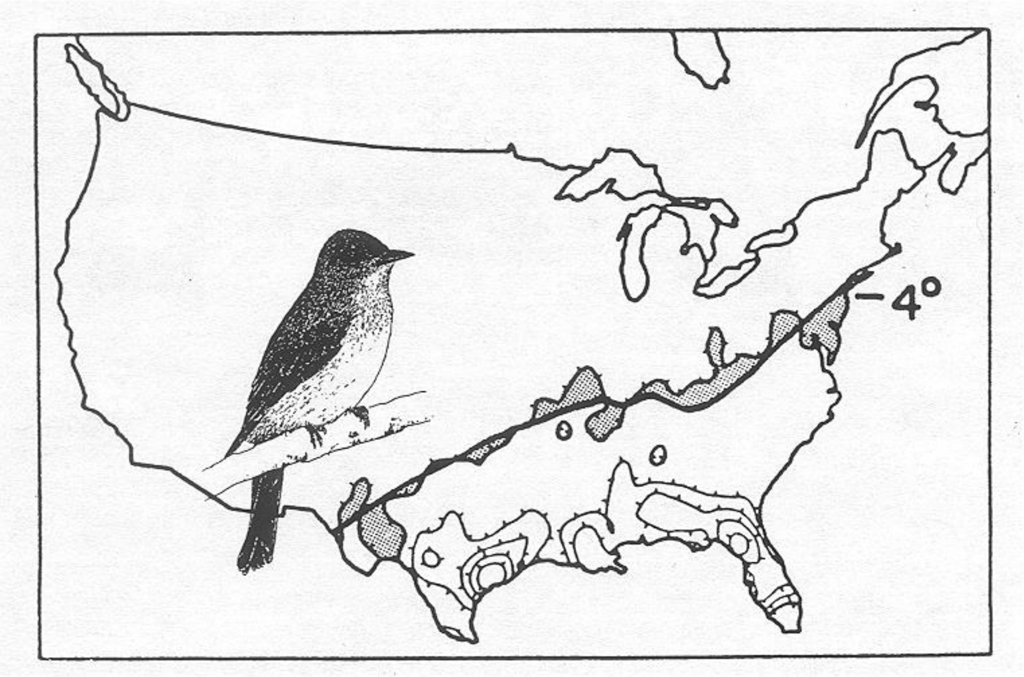


Fig. 5.2. Conceptual model of the interactions between abiotic factors, ecological processes, and biodiversity. See text for explanation.

Effects on Species Distributions



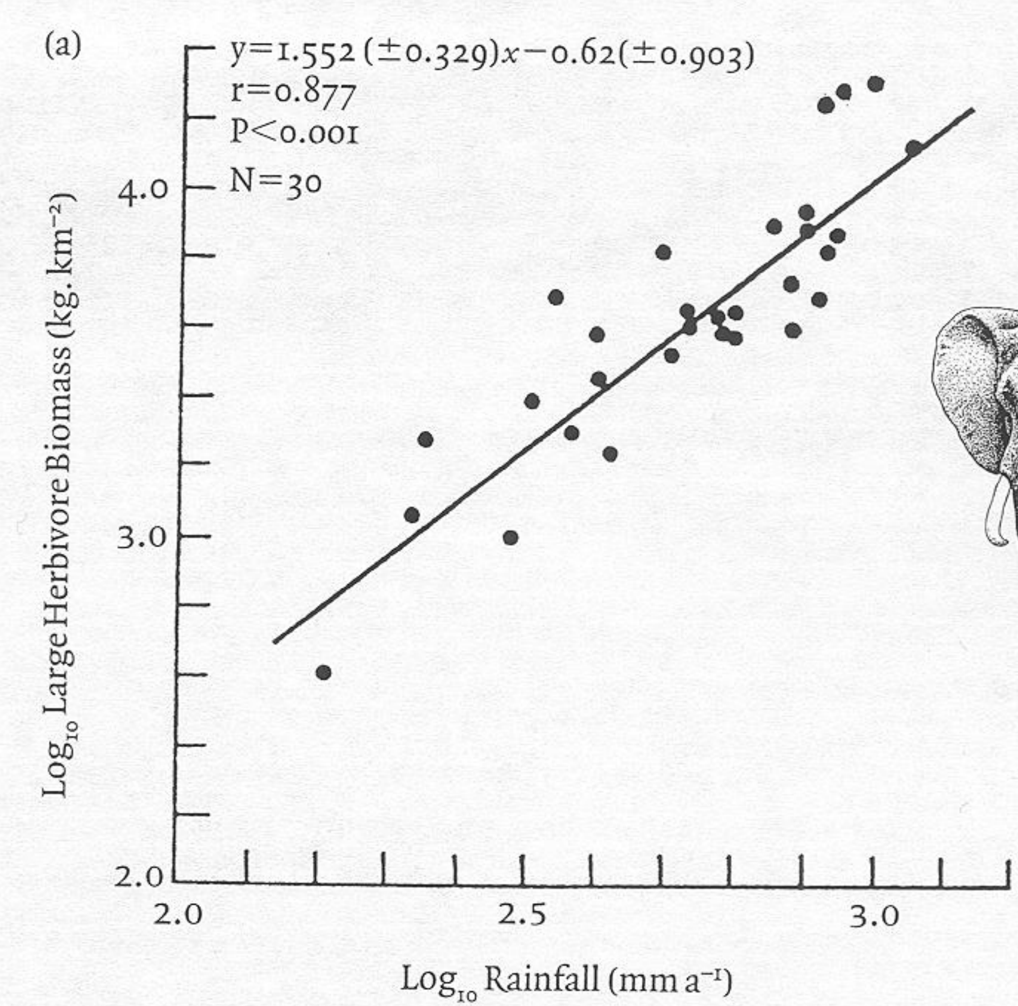
Effects on Species Distributions

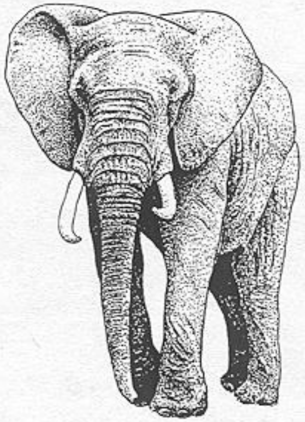


Basic metabolic rate – Metabolic rate of a night-resting individual at an ambient temperature above that at which an individual must increase its metabolic rate to maintain heat balance.

Resting metabolic rate at the northern range limit was 2.49 times greater than BMR for each of 14 species studied.

Effects on Species Abundances





Effects on Species Movements

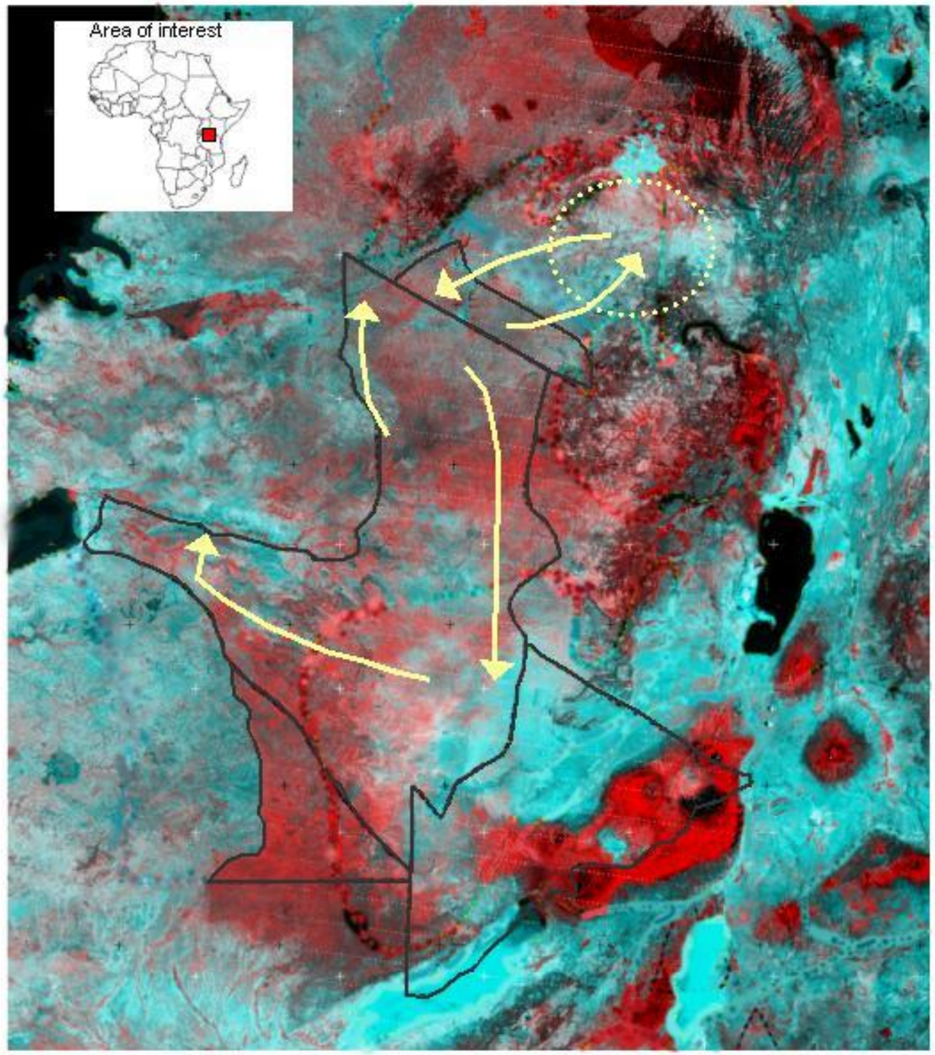
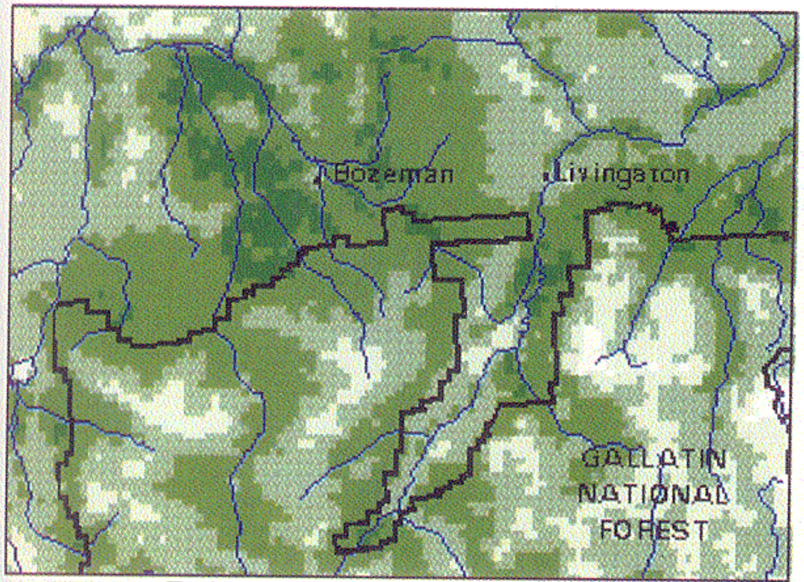


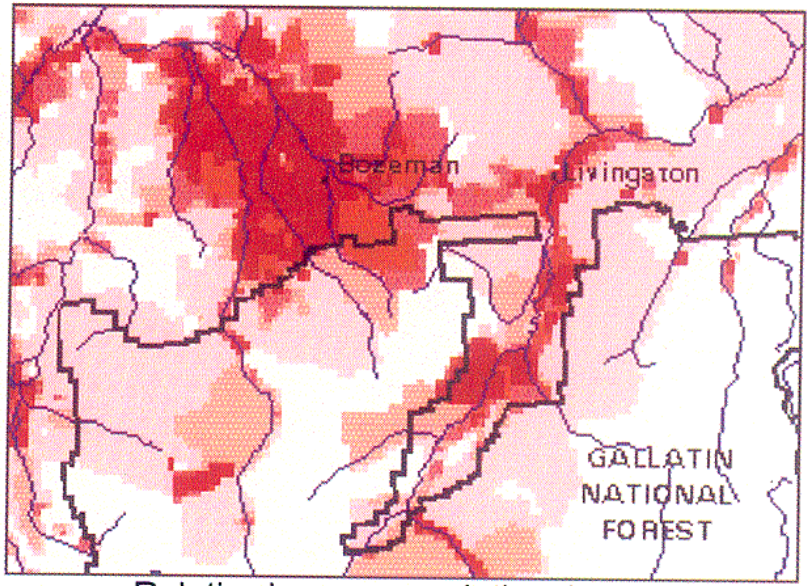
Figure x. Red-near infrared false color composite acquired by MODIS sensor on March 2, 2001 at 250m resolution for the Greater Serengeti Ecosystem. Wildebeest migration route (yellow arrows) span outside reserve boundaries (black lines) during The wet season. The yellow dotted line is ????????????????.

Effects on Birth and Death

Human Land Use



Relative net primary productivity



Relative human population density

Abiotic Factors and Ecological Processes

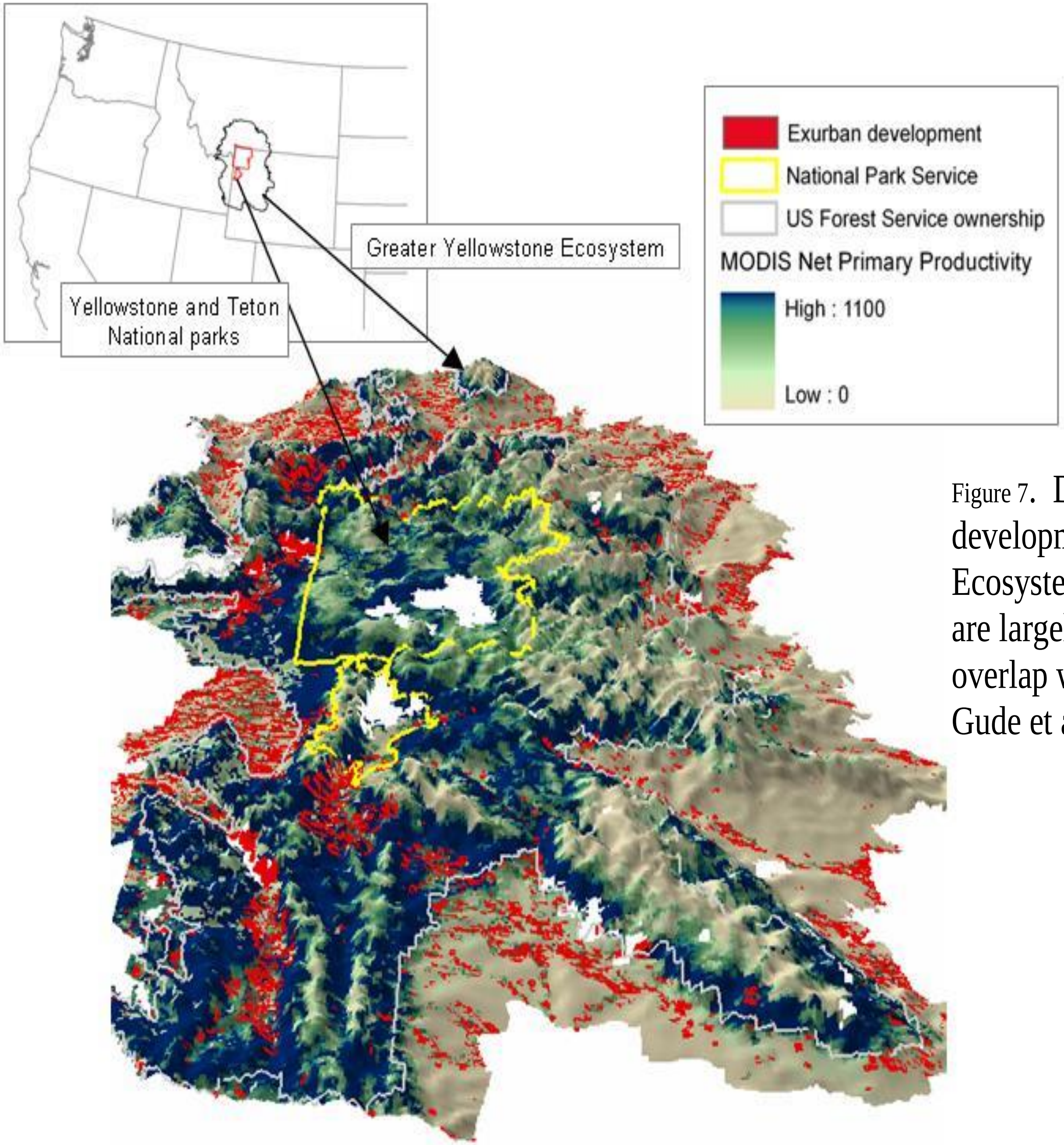
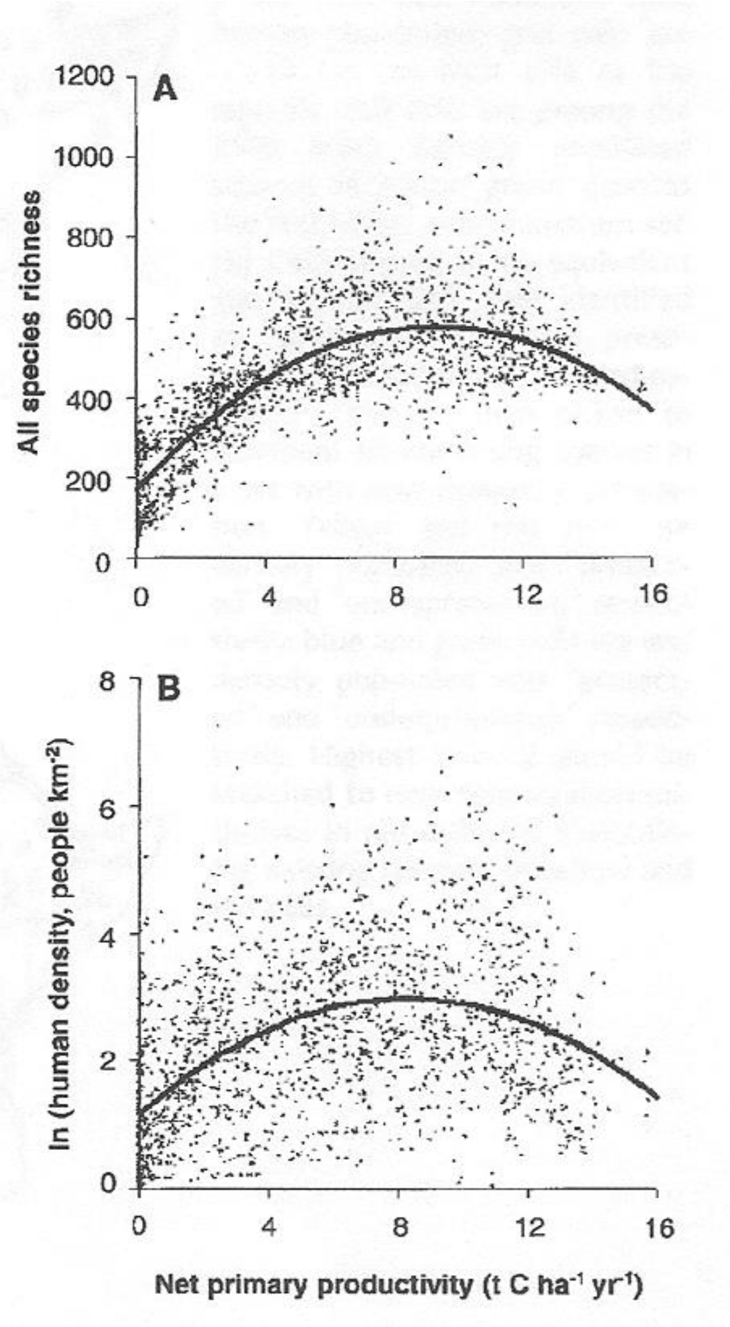
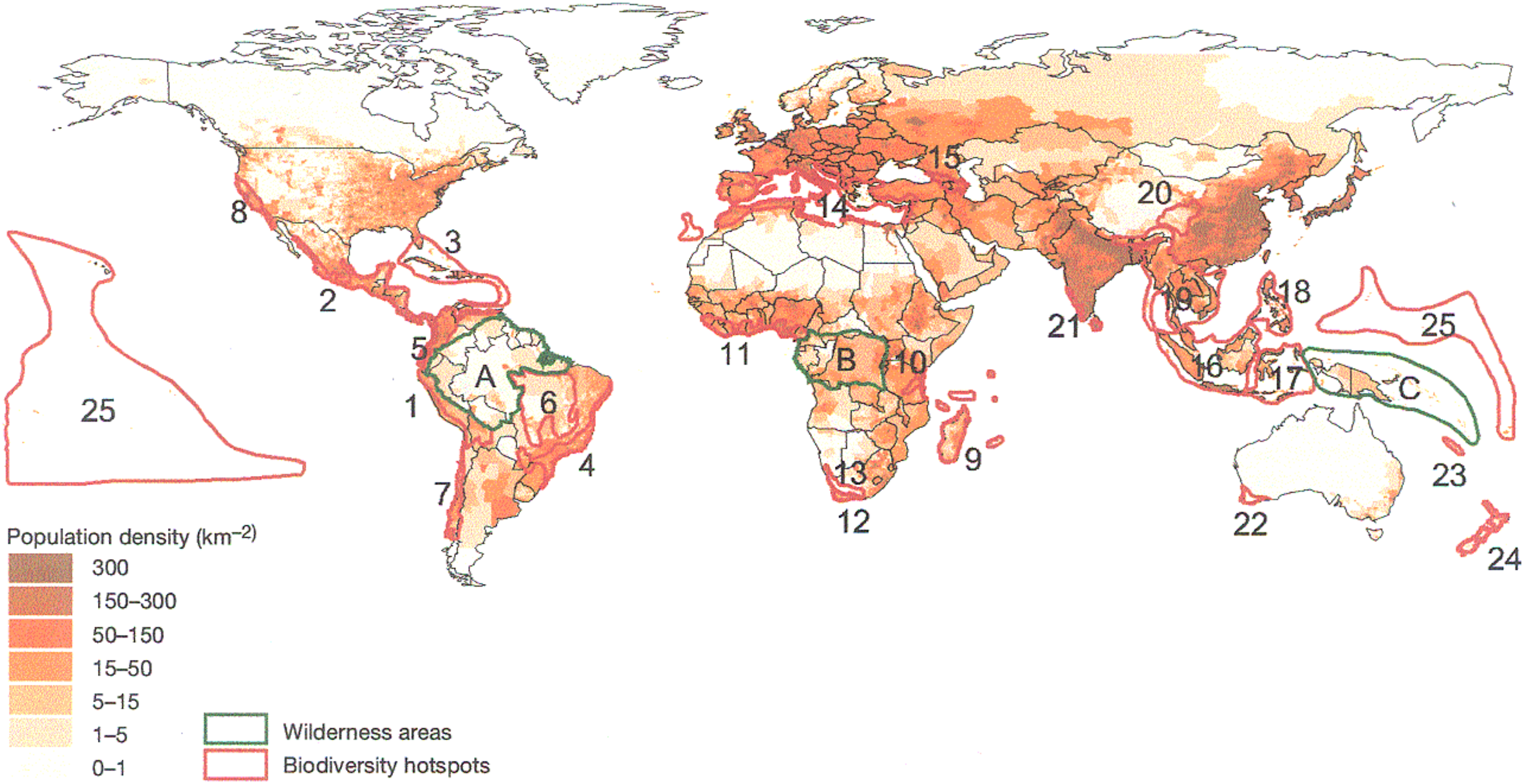


Figure 7. Distribution of NPP and exurban development across the Greater Yellowstone Ecosystem. Notice that areas of highest NPP are largely outside of the national parks and overlap with exurban development. Data from Gude et al. in press.

Human Land Use - Africa

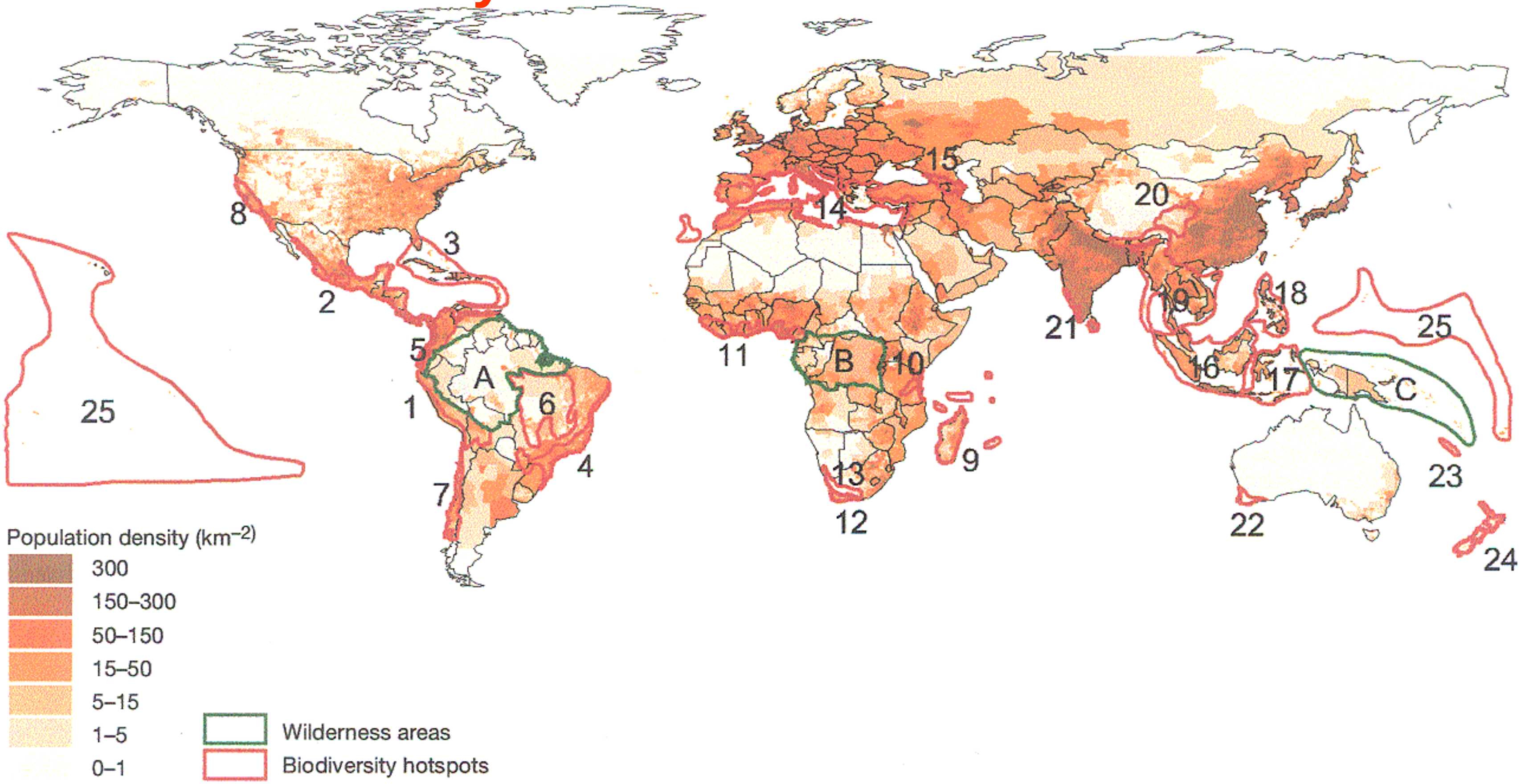


Balmford et. al. 2001



From Cincotta et al. 2000

Key Point: Biophysical factors may result in strong overlap between the locations humans and biodiversity.



From Cincotta et al. 2000

IMPLICATIONS FOR CONSERVATION AND MANAGEMENT

1. **Landscape Classification – Map biophysical factors across the management unit.**
2. **Demography - Understand how population parameters vary across the landscape and manage accordingly.**
3. **Hot Spots – Quantify community patterns over landscape as a basis to identify, maintain, and/or restore hot spots.**
4. **Multiple-use Lands- Tailor commodity extraction to the landscape.**
5. **Land Allocation – Careful distribution of management strategies and intensities within major land allocations and among allocations may be necessary to maintain native species.**