Feb 6 Primary Productivity: Controls, Patterns, Consequences

Yucatan, Mexico, Dry Subtropical

History

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- **habitat heterogeneity**
- **habitat area**
- **trophic structure**
- **evolutionary processes**
- **available energy.**

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- **trophic structure**
- **evolutionary processes**
- **available energy (heat and the organic energy fixed by primary and secondary productivity)**

History

Available energy

- **Little considered by conservation biologists.**

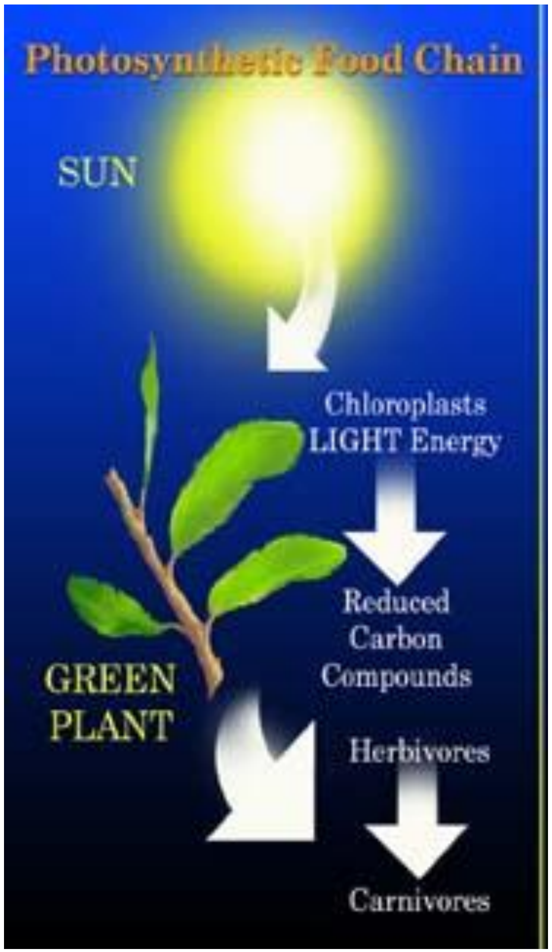
- **Brown (1981) - Due to division of ecology in the 1970s into ecosystem ecology and community ecology.**

- **But biogeographers made considerable progress in "species energy theory".**

- **Current consensus - continental-scale patterns of species richness are driven primarily by:**
    - **kinetic energy (heat)**
    - **potential energy (foods resulting from primary productivity)**
    - **habitat heterogeneity**
    - **availability of water**

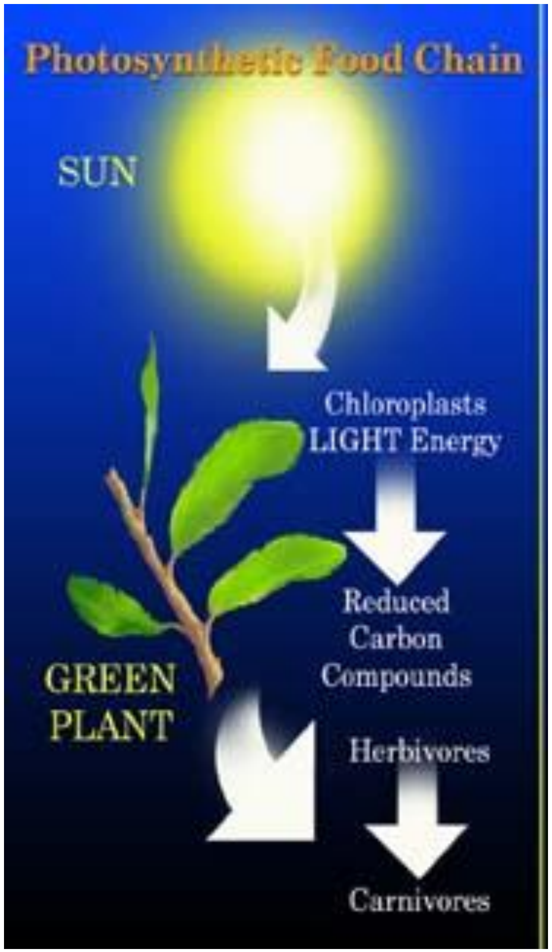
- **Ecologists are just coming around to better integrate energy flow into thinking on population and community ecology**

Topics

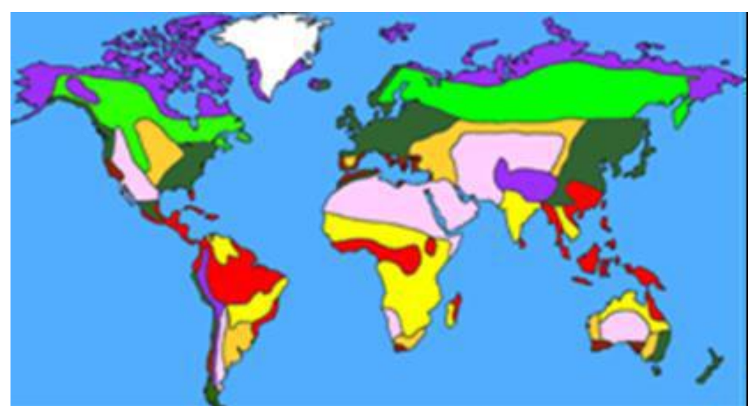


Photosynthetic Food Chain
SUN
Chloroplasts
LIGHT Energy
Reduced
Carbon
Compounds
GREEN
PLANT
Herbivores
Carnivores

Topics



Trinidad, Wet Subtropical



Topics

Definitions of ecosystem productivity

Plant-level mechanisms and controlling factors

Central Surinam Reserve, Wet Tropical

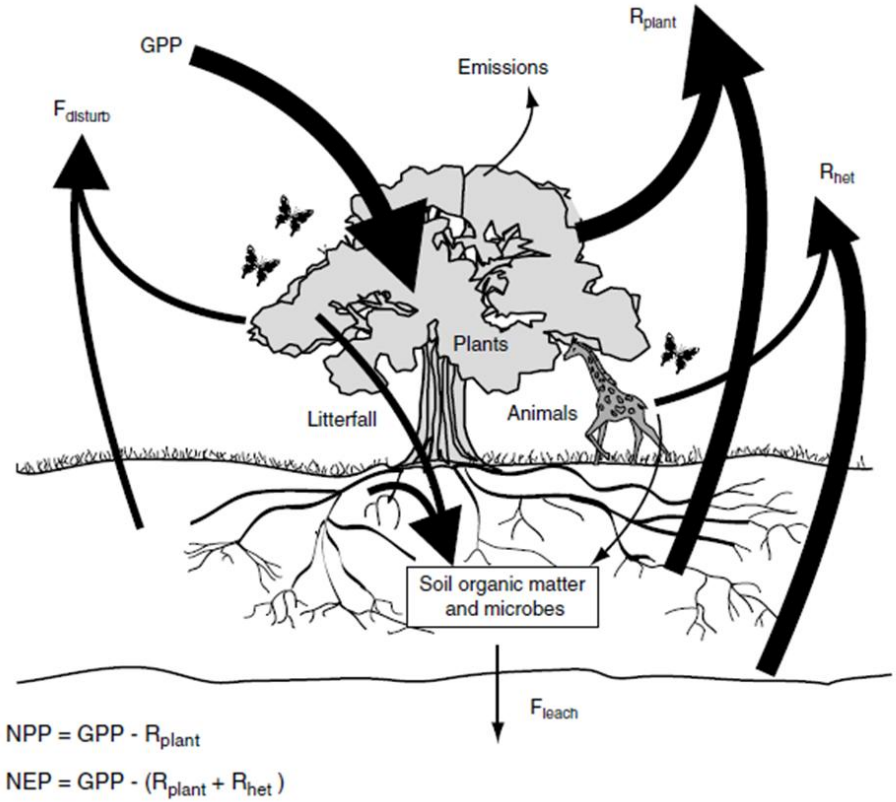
Controlling ecosystem factors

Spatial and temporal patterns within biomes

Consequences

Grand Teton NP, Wyoming, Temperate Coniferous

Primary Productivity



Chapin et al. Fig 6.1

Primary production - the production of organic compounds from atmospheric or aquatic carbon dioxide.

Gross primary production (GPP)- the rate at which an ecosystem's producers convert radiant energy to organic molecules.

Net primary production (NPP)- the rate at which all the plants in an ecosystem produce net useful chemical energy.

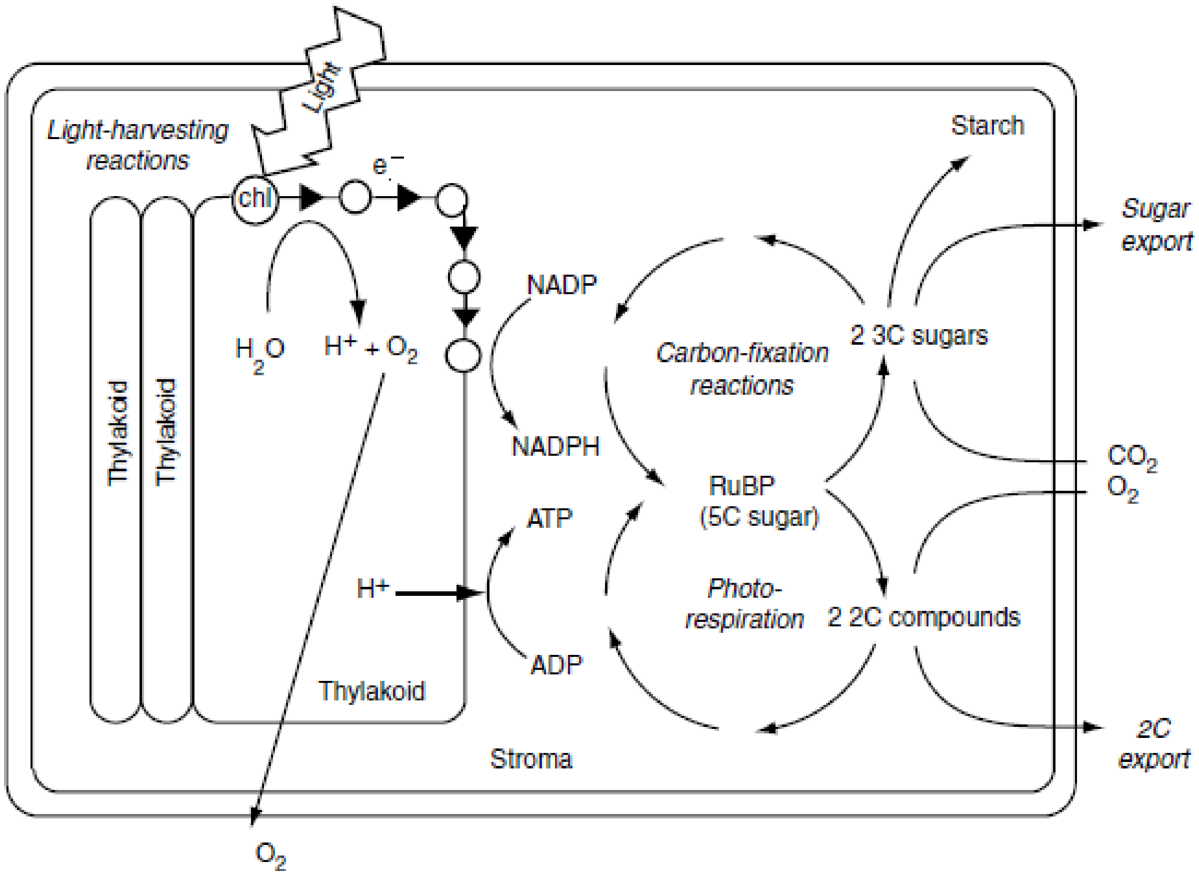
NPP = GPP - respiration

Cellular respiration – "burning of organic molecules to produce ATP to fuel growth and maintenance.

Net ecosystem production (NEP) - the balance between GPP and plant-plus-heterotrophic respiration.

Photosynthesis

A chloroplast, showing the location of the major photosynthetic reactions.



Chapin et al. Fig 5.4

Photosynthesis: $CO_2 + H_2O + \textit{light} \rightarrow CH_2O + O_2$

Cellular respiration: $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

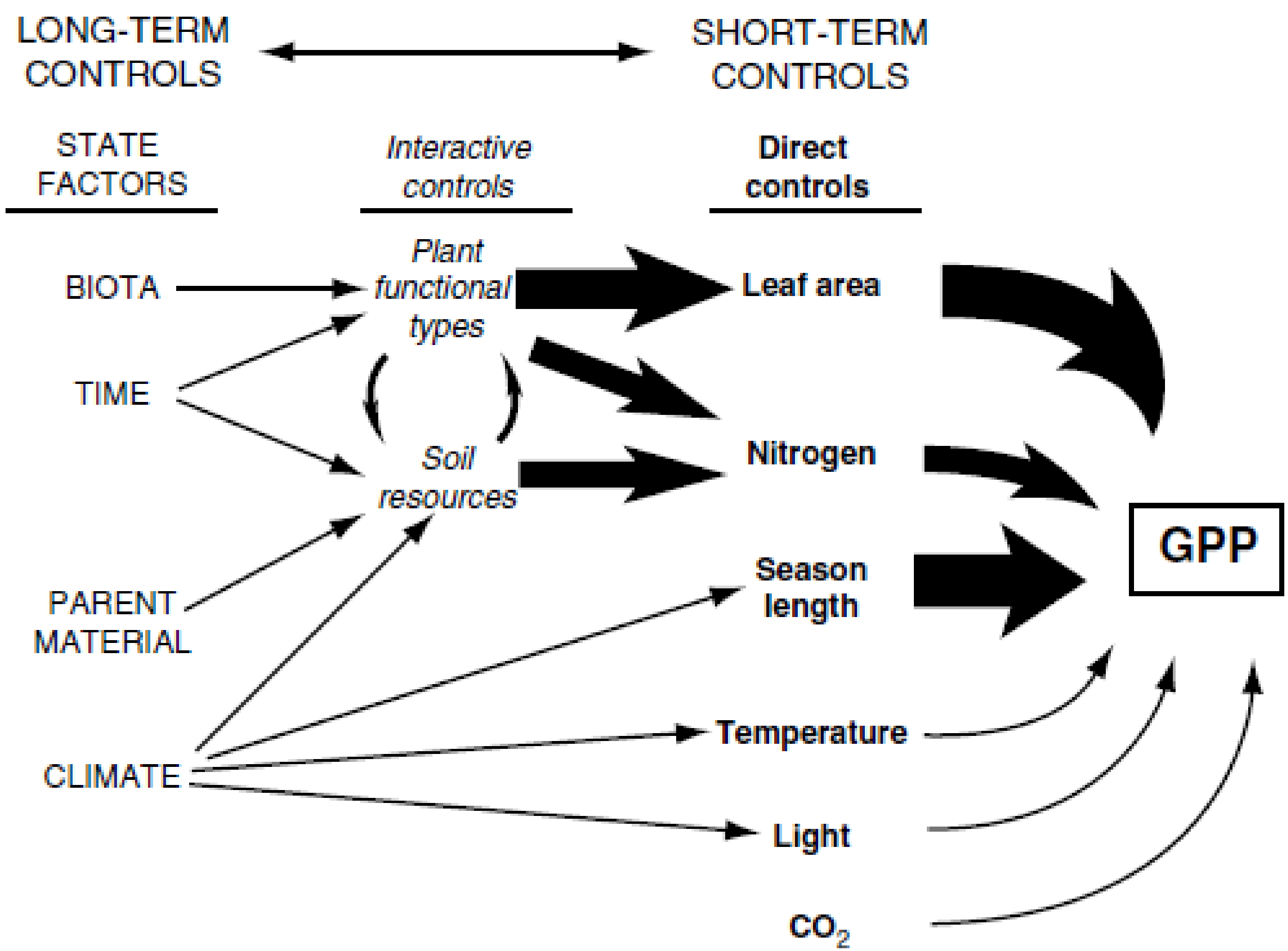
↓

ATP

GPP – production of organic molecules

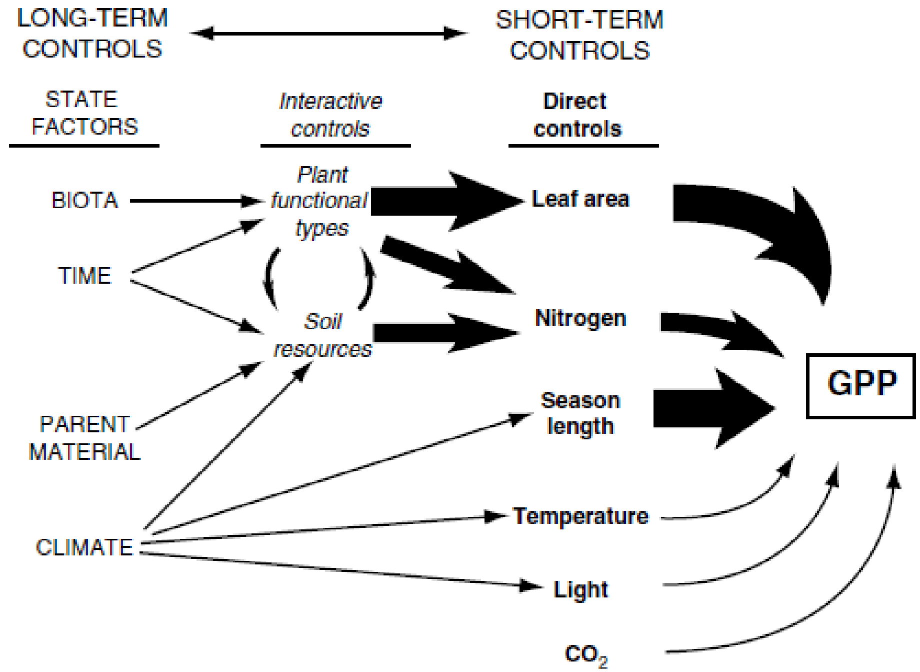
NPP = GPP - respiration

The major factors governing temporal and spatial variation in GPP



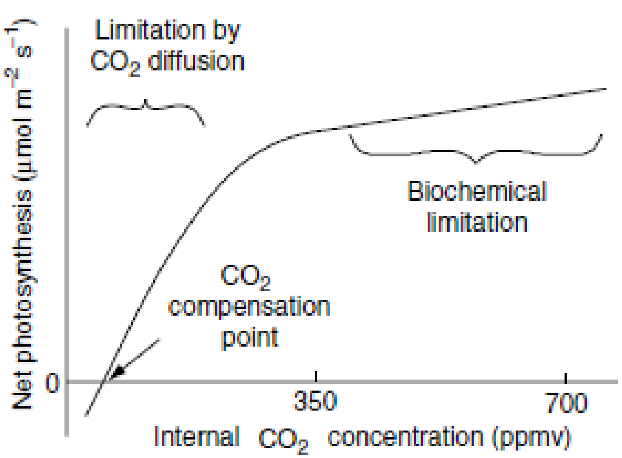
Chapin et al. Fig 5.2

The major factors governing temporal and spatial variation in GPP

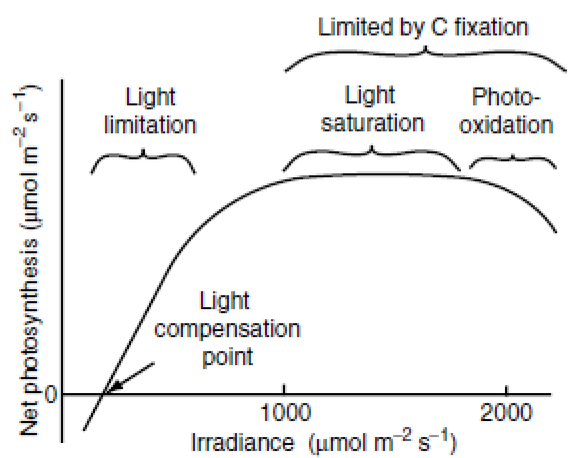


Chapin et al. Figs 5.10 and 5.5

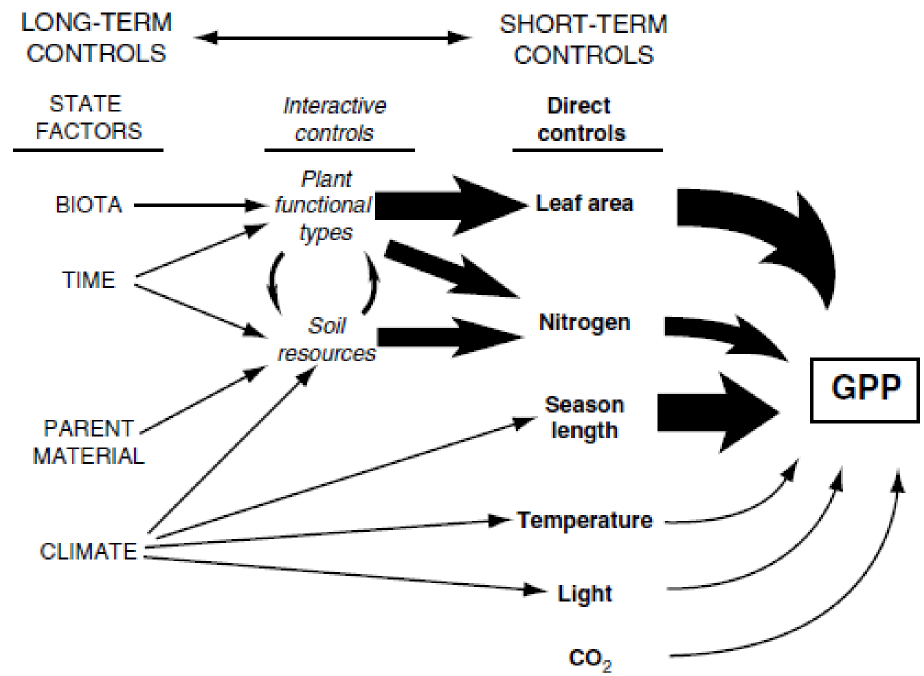
CO2



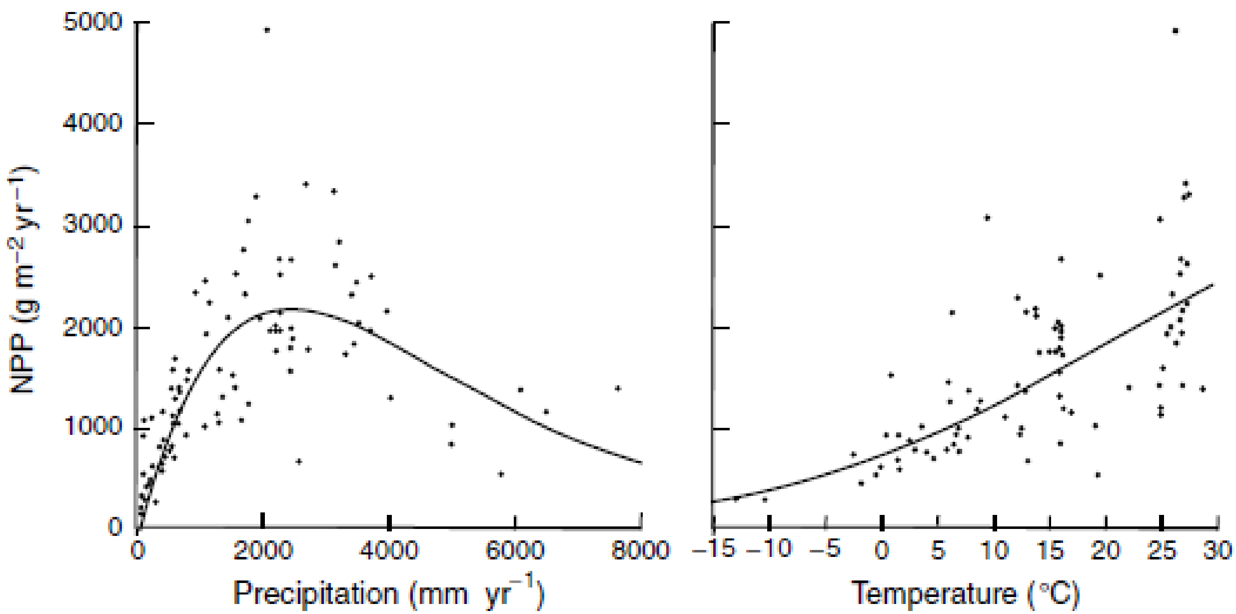
Light



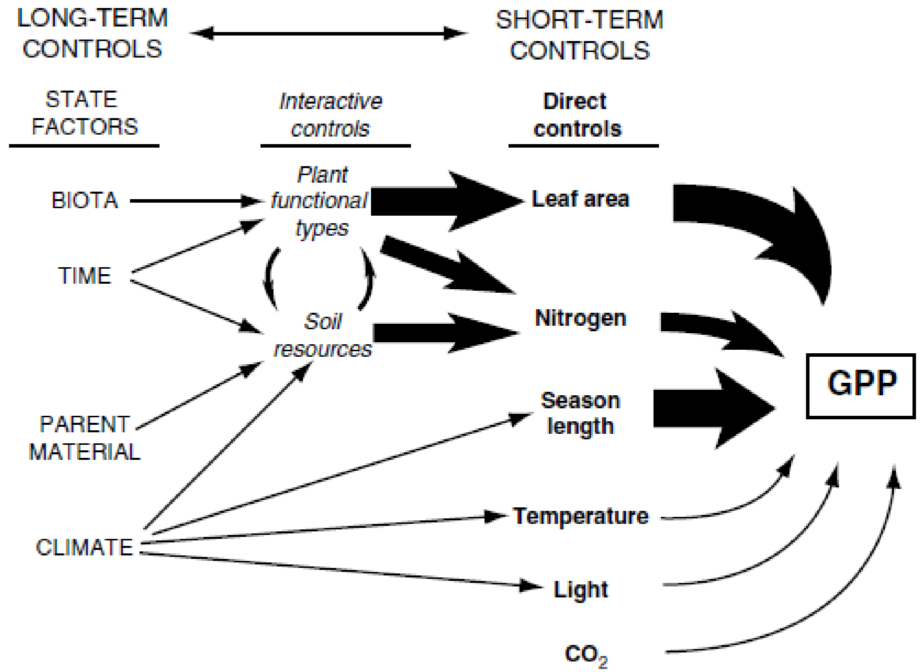
The major factors governing temporal and spatial variation in GPP



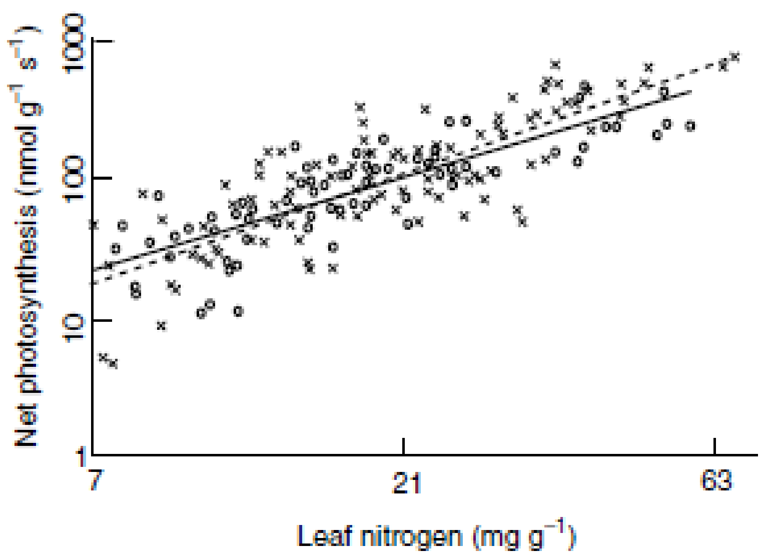
Chapin et al. Fig 6.8



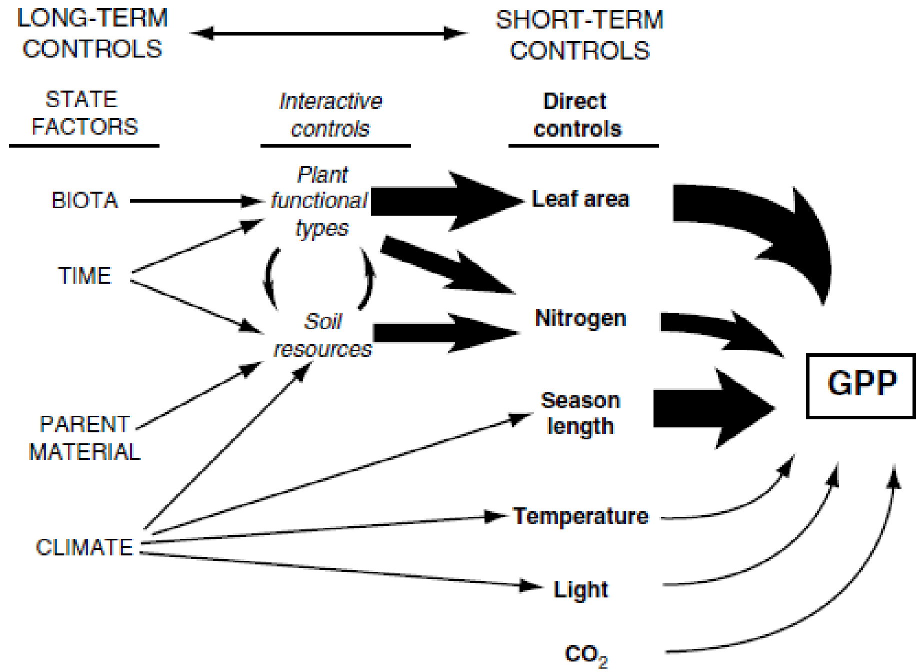
The major factors governing temporal and spatial variation in GPP



Chapin et al. Fig 5.13



The major factors governing temporal and spatial variation in GPP

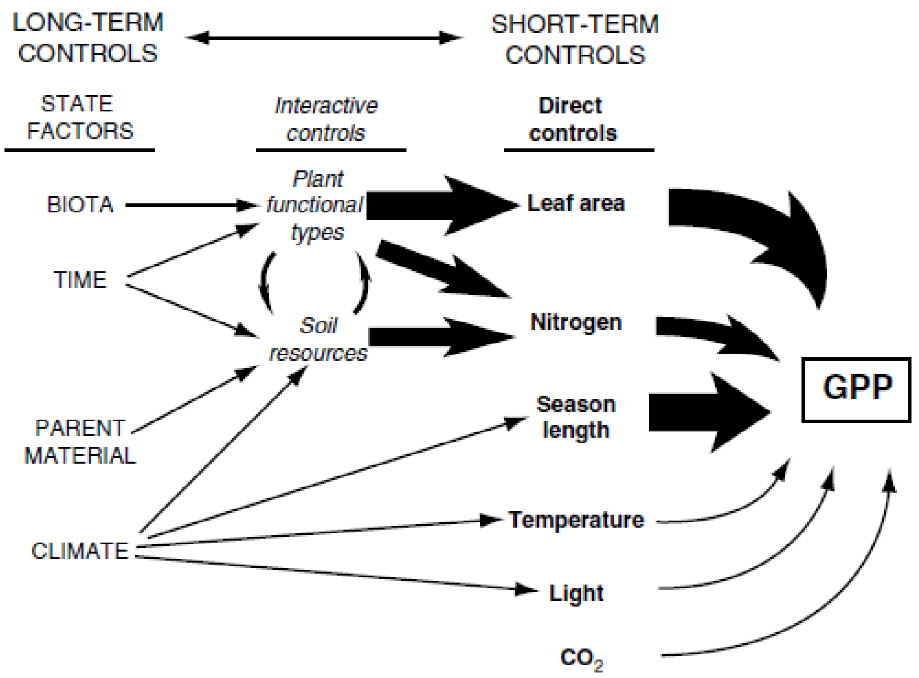


Leaf area index (LAI) - equivalent to the total upper surface area of all leaves per area of ground. Ranges from 0 to 8 m^2 leaf/ m^2 ground.

LAI is a key parameter governing ecosystem processes because it determines both the area that is potentially available to absorb light and the degree to which light is attenuated through the canopy.

GPP correlates closely with leaf area below an LAI of about 4, suggesting that leaf area is a critical determinant of GPP on most of Earth's terrestrial surface.

The major factors governing temporal and spatial variation in GPP



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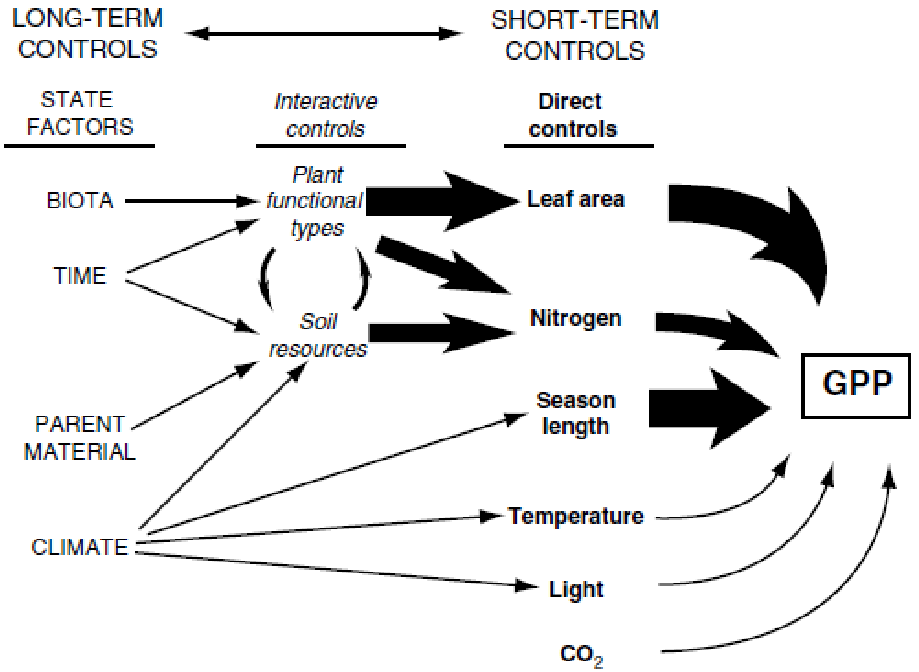
What factors influence LAI?

The major factors governing temporal and spatial variation in GPP

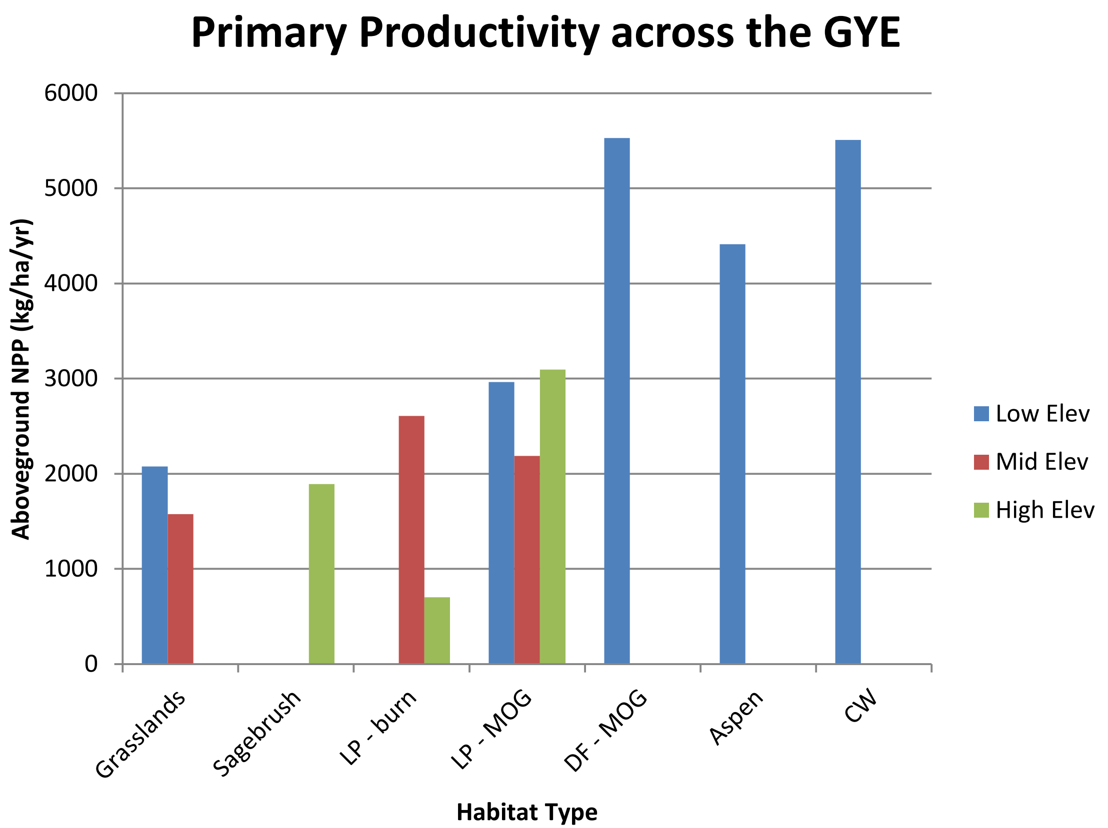


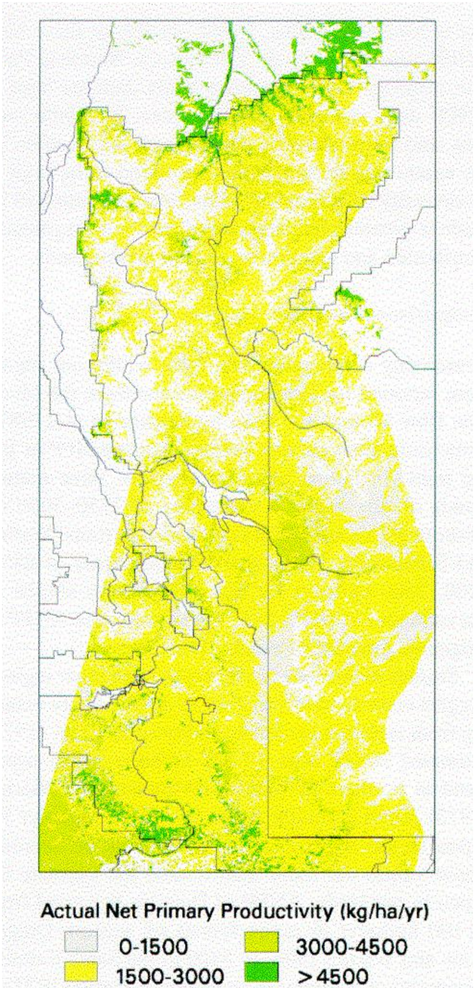
Summary - The major environmental factors that explain differences among ecosystems in carbon gain are the length of time during which conditions are suitable for photosynthesis and the soil resources (water and nutrients) available to support the production and maintenance of leaf area.

Variation within Biomes

Paradise Valley, MT

Variation within Biomes: Spatial



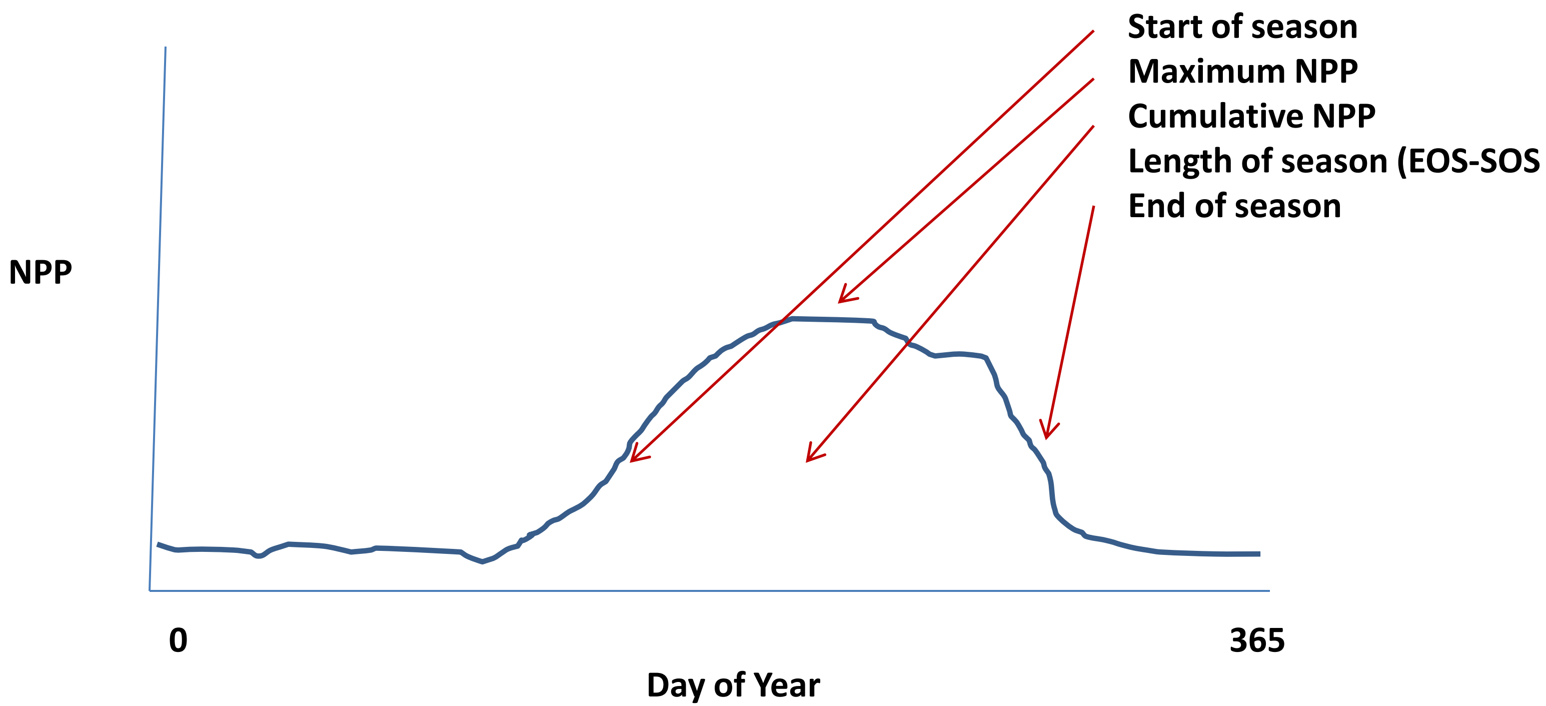


gure 5. Predicted distribution of ANPP over the study area bas

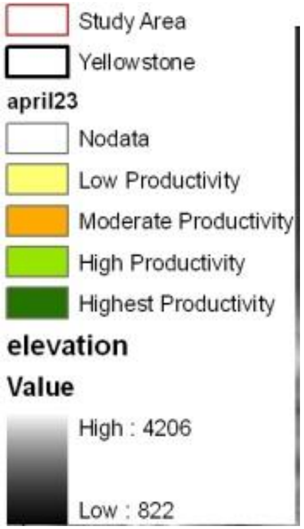
Best Predictive model: Cover type, elevation*cover type, parent material

Hansen et al. 1990

Variation within Biomes: Temporal



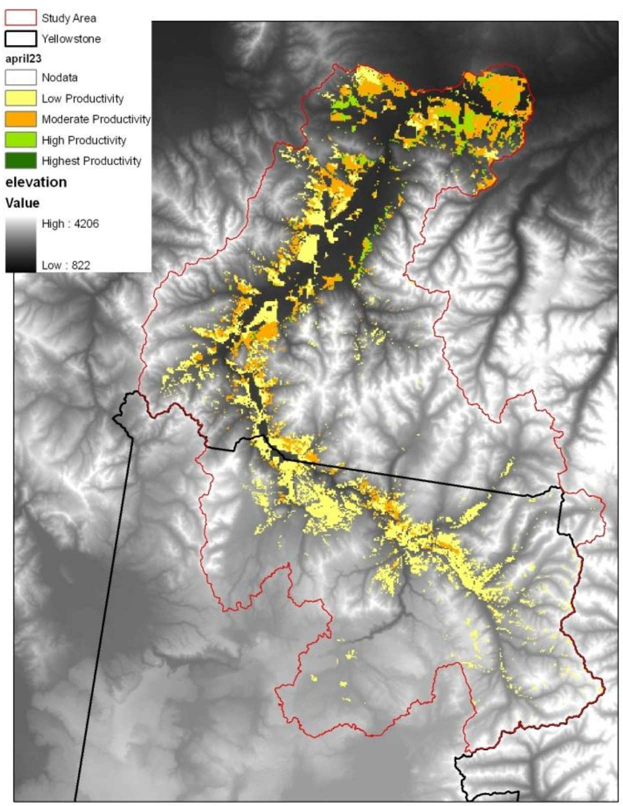
Metrics used to quantify phenology



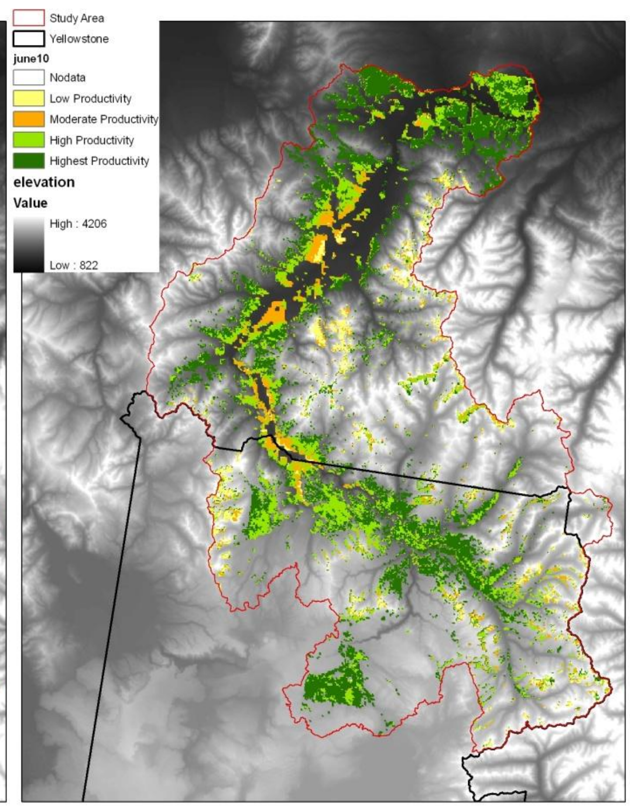
Variation within Biomes: Temporal

Spatial and Temporal Variation "Green Patches" across the Upper Yellowstone Watershed

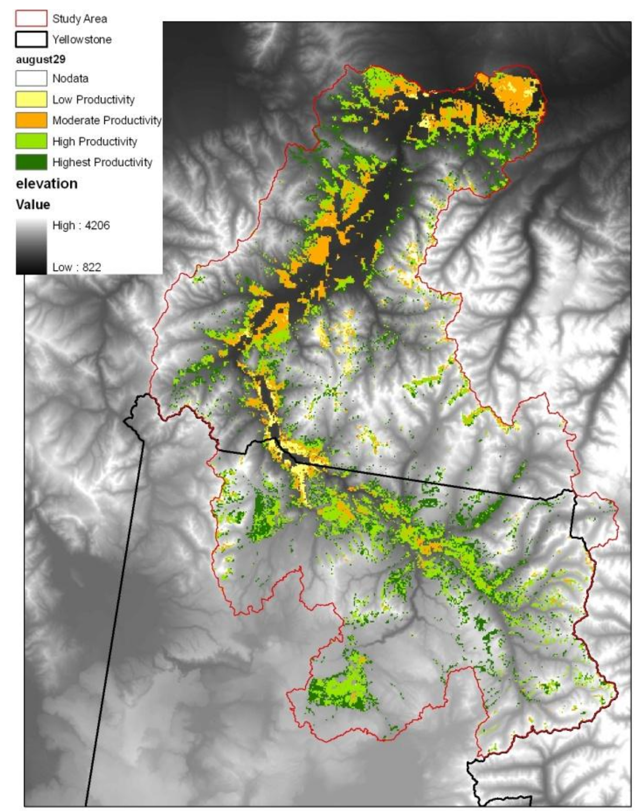
Piekielek in prep.



April 23, 2010



June 10, 2010



August 29, 2010

Variation within Biomes: Temporal

Effects of Land Use?

Variation within Biomes

Central Surinam Reserve, Wet Tropical

Consequences of NPP

Topic	Relationship with Energy	Key Reference	Weight of Evidence
Pop growth rt, abundance, extinction risk	+ or flattening,	Evans et al. 2005a	Strong Strong Partial
Home range size	-	Haresrad and Bunnell 1979	Strong
Large ungulate migrations	+ with patchiness	Oiff et al. 2002	Inadequately tested
Source/sink pop dynamics	+ with patchiness	Naves et al. 2003	Strong
Species richness	+, flattening, or unimodal	Wright 1983	Strong
Disturbance / Succession	Interacts with productivity	Huston 1979, 1994	Strong
Within-patch veg structure	Interacts with productivity	MacArthur et al. 1966	Intermediate
Habitat edge effects	+ with biomass	McWethy et al. 2009	Intermediate
Trophic cascades	"Top-down" in under low energy	Melis et al. 2009	Inadequately tested
Invasive species	+	Huston 2004	Inadequately tested
Land use intensity	+, flattening, or unimodal	Luck et al. 2010	Strong

References

Hansen, A.J., J.J. Rotella, M.L. Kraska and D. Brown. 2000. Spatial patterns of primary productivity in the Greater Yellowstone Ecosystem. Landscape Ecology. 15:505-522.