Patterns and Controls of Net Primary Productivity

Alan Knapp\textsuperscript{1}, John Briggs\textsuperscript{2}, John Blair\textsuperscript{3}, Phil Fay\textsuperscript{4}, Dave Hartnett\textsuperscript{3}, Loretta Johnson\textsuperscript{3}, Jim Koelliker\textsuperscript{5}, Jesse Nippert\textsuperscript{3} and Melinda Smith\textsuperscript{6}

\textsuperscript{1}Department of Biology, – Colorado State University
\textsuperscript{2}School of Life Sciences – Arizona State University
\textsuperscript{3}Division of Biology – KSU
\textsuperscript{4}ARS-USDA – Temple, Texas
\textsuperscript{5}Department of Biological and Agricultural Engineering - KSU
\textsuperscript{6}Department of Ecology & Evolutionary Biology – Yale University

> 10,000 plots and counting…
Overview:

- Highlight major accomplishments during the last 5 years
- Present potential new research activities that may be incorporated into the LTER VI proposal.
Dynamics of ANPP in the context of Konza LTER and contemporary global change issues...

- **Land Use Practices**: Fire, Grazing, Land use history
- **Climate Change**: Rainfall timing and amount, Temperature
- **Nutrient Enrichment**: Elevated N deposition, Fertilization
- **Biological Invasions**: Exotic species introductions

Tallgrass Prairie Ecosystems
- Structure
- Function
- Biotic Interactions

- Altered Hydrology
- Land Cover Change/Woody Plant Expansion
- Altered Biogeochemical Cycles
Fire

355.2 g/m²

~30% increase

369.1 g/m²

Abrams et al. 1986
Briggs & Knapp 1995
Knapp et al. 1998
Briggs & Knapp 2001
Nippert et al. 2006

ANPP (g m⁻² yr⁻¹)

<table>
<thead>
<tr>
<th></th>
<th>Annually Burned</th>
<th>Unburned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>417.1 g/m²</td>
<td>~30%</td>
</tr>
<tr>
<td>Grass</td>
<td>432.1 g/m²</td>
<td>~30%</td>
</tr>
<tr>
<td>Forbs</td>
<td>58.0 g/m²</td>
<td>~30%</td>
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</tbody>
</table>
Change in controls on ANPP related to land-use change

An annually burned area:

A fire exclusion area:

Woody plant encroachment
<table>
<thead>
<tr>
<th>Site</th>
<th>Biome type</th>
<th>MAP/ MAT (mm/°C)</th>
<th>PET (mm)</th>
<th>Growing season length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic, AK (ARC)</td>
<td>Tussock Tundra</td>
<td>291/-12.5</td>
<td>114</td>
<td>55 days</td>
</tr>
<tr>
<td>Jornada, NM (JRN)</td>
<td>Chihuahuan Desert</td>
<td>264/14.4</td>
<td>794</td>
<td>255 days</td>
</tr>
<tr>
<td>Konza, KS (KNZ)</td>
<td>Tallgrass Prairie</td>
<td>859/12.9</td>
<td>793</td>
<td>180 days</td>
</tr>
<tr>
<td>La Copita, TX (LAC)</td>
<td>Subtropical Thorn Woodland</td>
<td>680/22.0</td>
<td>1448</td>
<td>289 days</td>
</tr>
<tr>
<td>Sevilleta, NM (SEV)</td>
<td>Chihuahuan Desert</td>
<td>242/13.3</td>
<td>747</td>
<td>210 days</td>
</tr>
<tr>
<td>Vernon, TX (VER)</td>
<td>Temperate Savanna</td>
<td>655/17.0</td>
<td>1487</td>
<td>220 days</td>
</tr>
<tr>
<td>Virginia Coast Reserve, VA (VCR)</td>
<td>Temperate Barrier Island</td>
<td>1065/14.2</td>
<td>786</td>
<td>245 days</td>
</tr>
<tr>
<td>Sierra Madre, WY (WYO)</td>
<td>Sagebrush Steppe</td>
<td>259/6.2</td>
<td>483</td>
<td>100 days</td>
</tr>
</tbody>
</table>
3-fold increase!
Long-term Irrigation Study – resource (H₂O) addition

- Treatments initiated in 1991
- Supplemental water added during the growing season to replicate 140 m transects (paired with control transects)
- Designed to meet plant water demand and minimize intra-annual variability in soil water deficits
Why would the response double from the first 8 years to the next? More on this later…
Climate change

The Rainfall Manipulation Plot (RaMP) Experiment

Address the impact of changes in size and timing of growing season rainfall

- 12 rainfall manipulation plots (RaMPs) + non-sheltered controls
- Collect, store, and reapply natural rainfall on intact prairie plots
- Treatments include ambient and altered rainfall patterns
Altered rainfall patterns and soil moisture

Ambient ppt timing:
• “typical” seasonal pattern

Altered ppt timing:
• repeated deficits
• more extreme wetting and drying cycles

Average soil water content in top 30 cm:
- reduced by 12%

Variability in soil moisture:
- increased by 27%
ANPP responses to altered rainfall timing ~ 10%

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</thead>
<tbody>
<tr>
<td>ANPP (g m⁻²)</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td>700</td>
<td>800</td>
<td>900</td>
<td>1000</td>
<td>1100</td>
<td>1200</td>
</tr>
<tr>
<td>Ambient timing</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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</tr>
<tr>
<td>Altered timing</td>
<td>*</td>
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* P < 0.001

Inset: Pre-treatment ANPP (g m⁻²)

- Ambient (Amb)
- Altered (Alt)
Climate change

Warming treatments (~2 C) implemented in 2003 using IR lamps
Warming reduced ANPP by ~12% in 2 of 4 years

<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
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<tbody>
<tr>
<td>ANPP (g m⁻²)</td>
<td>600</td>
<td>800</td>
<td>500</td>
<td>400</td>
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* indicates significant difference.
**Nutrient (N) addition**

**60-125% increase**

Mean Aboveground Net Primary Productivity

### Significant Effects
- **Burn**: $P < 0.005$
- **Nutrient**: $P < 0.0001$
- **Nutrient x Burn**: $P < 0.005$
- **Mow X Burn**: $P < 0.05$

**Nutrient Treatment**
- **Control**
- **+P**
- **+N**
- **+N+P**

**ANPP (g m$^{-2}$)**
- **Control**
- **+P**
- **+N**
- **+N+P**

- **Unmowed**
- **Mowed**

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**Unburned**

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**Burned**

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Invasive species

40-140% increase

Ecosystem consequences of invasive exotic species in grasslands

P. K. Baker et al. in prep.

Ecosystem consequences of C₄ grass invasion of a C₄ grassland

Reed et al. 2005
Grazing – Our one gap...

Permanent exclosures (long-term) – Movable exclosures (2007)
Planned or new studies

- N pulse press experiment – Smith/Knapp/Blair
- NutNet experiment - Smith
- RaMPs grazing experiment – Knapp/Collins/Smith/Blair
- Role of spring soil moisture experiment– Knapp
Where do we go from here with the core LTER ANPP measurements?

How do we continue our long-term records and still address compelling new science questions?

And with no real “new” funding?!?!

Probably don’t want to clip many more plots....
But we can clip smarter and our data can be used in novel ways.
May require some re-examination of how we collect our data…
Global change and chronic resource alterations

The Konza LTER Program has much to offer....
May be related to species changes (increased cover of *Panicum virgatum*) – Community response

What would change the relationship between ANPP and precipitation in the irrigation transect study?
Currently – we have adjacent measures of community change and ecosystem response

- Consider harvesting biomass by species in a targeted set of treatments to directly link community change to ANPP responses