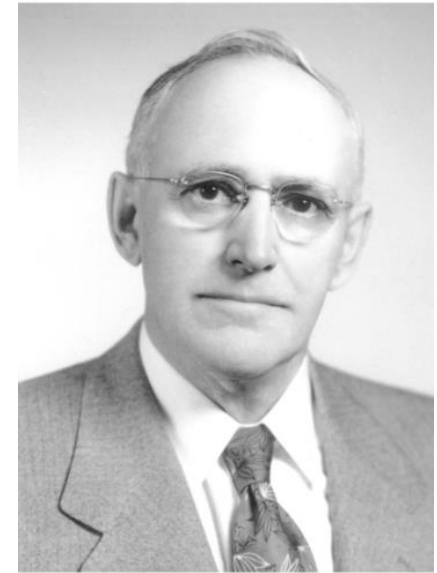


The Legacy of Nine-Mile Prairie

- I. Brief History
- II. Ecological Changes
- III. Environmental Changes
- IV. Changing Perspectives on Tallgrass Prairie Conservation
- V. The Future of Nine-Mile Prairie



**John E. Weaver
(1884-1966)**





State Historic Marker honoring
J.E. Weaver, post-storm 2017

1857: GLO Survey of 9MP – *“The surface is of high rolling prairie”*, no trees were noted. Bison and fire soon disappeared.

1885: Charles Bessey arrives at UNL

1898: Frederic Clements receives PhD UNL

Early 1900’s: 9MP owned by the Flader family (west half), and the McManaman family (east half). Most of the area hayed annually.

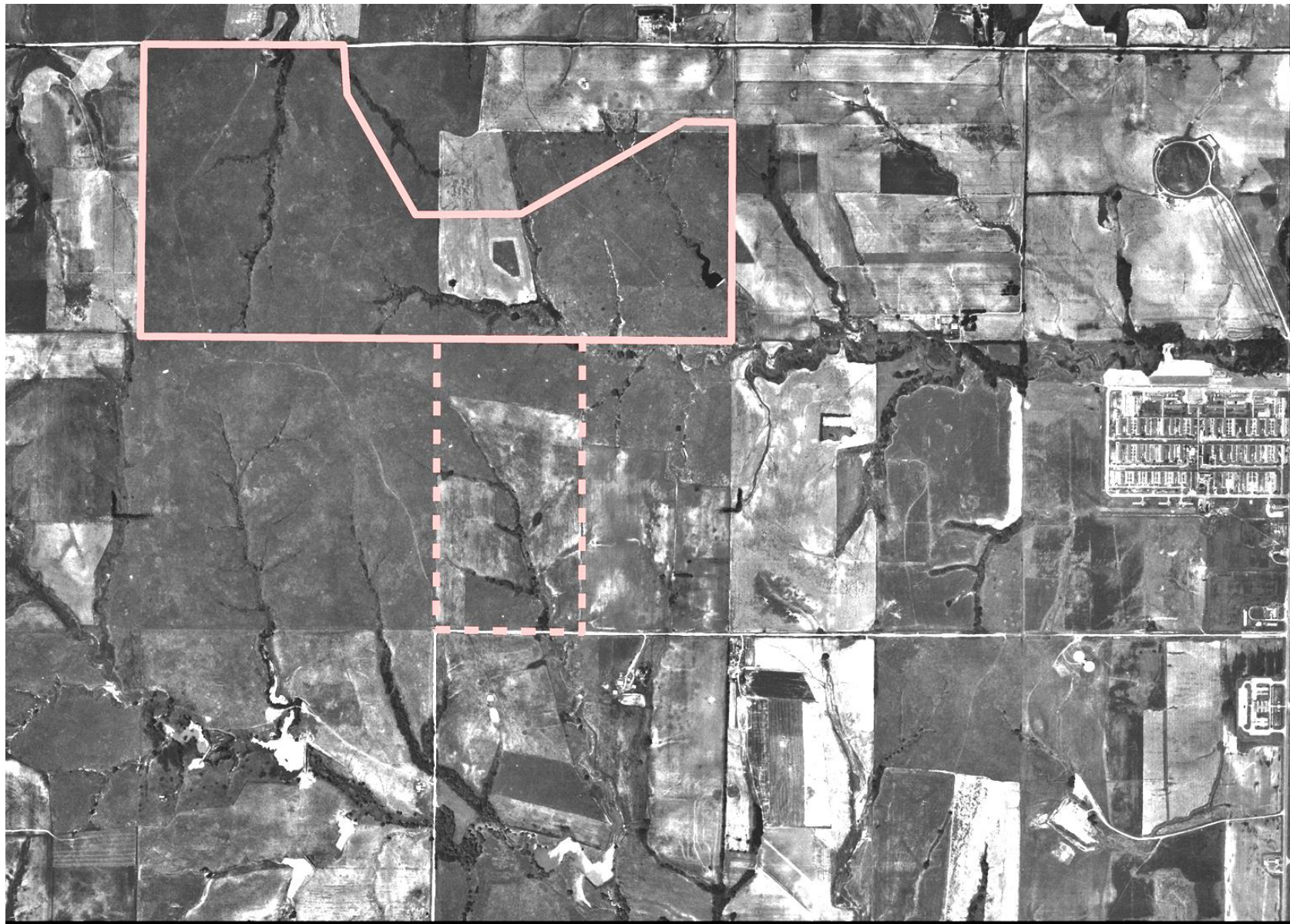
1909: John E. Weaver receives BS UNL

1915: J.E. Weaver new Professor at UNL

1927-1928: First ecological descriptions for *“800 acres of treeless, unbroken prairie”* by T.L. Steiger, a PhD student of Weaver (published 1930)

1934: J.E. Weaver publishes *“The Prairie”* in Ecological Monographs (one of >100 publications)

1930’s: Drought and Dust Bowl



1949

1941: Professor Frank purchases eastern half of 9MP

1944: F.W. Albertson & J.E. Weaver publish "*Nature & degree of recovery of grassland from the Great Drought 1933-1940*"

1952: Weaver retires

1966: Weaver dies

1950: US Air Force takes over 9MP & surrounding area to support a Strategic Air Command Base (1952-1966).

1970's: Lincoln Airport Authority acquires 9MP & Air Park. 9MP is rented by Ernie Rousek on behalf of Wachiska Audubon.

1981: Legislative Act (Bill 58) encourages LAA to protect 9MP (R.B. Crosby, E. Rousek, A.T. Harrison)

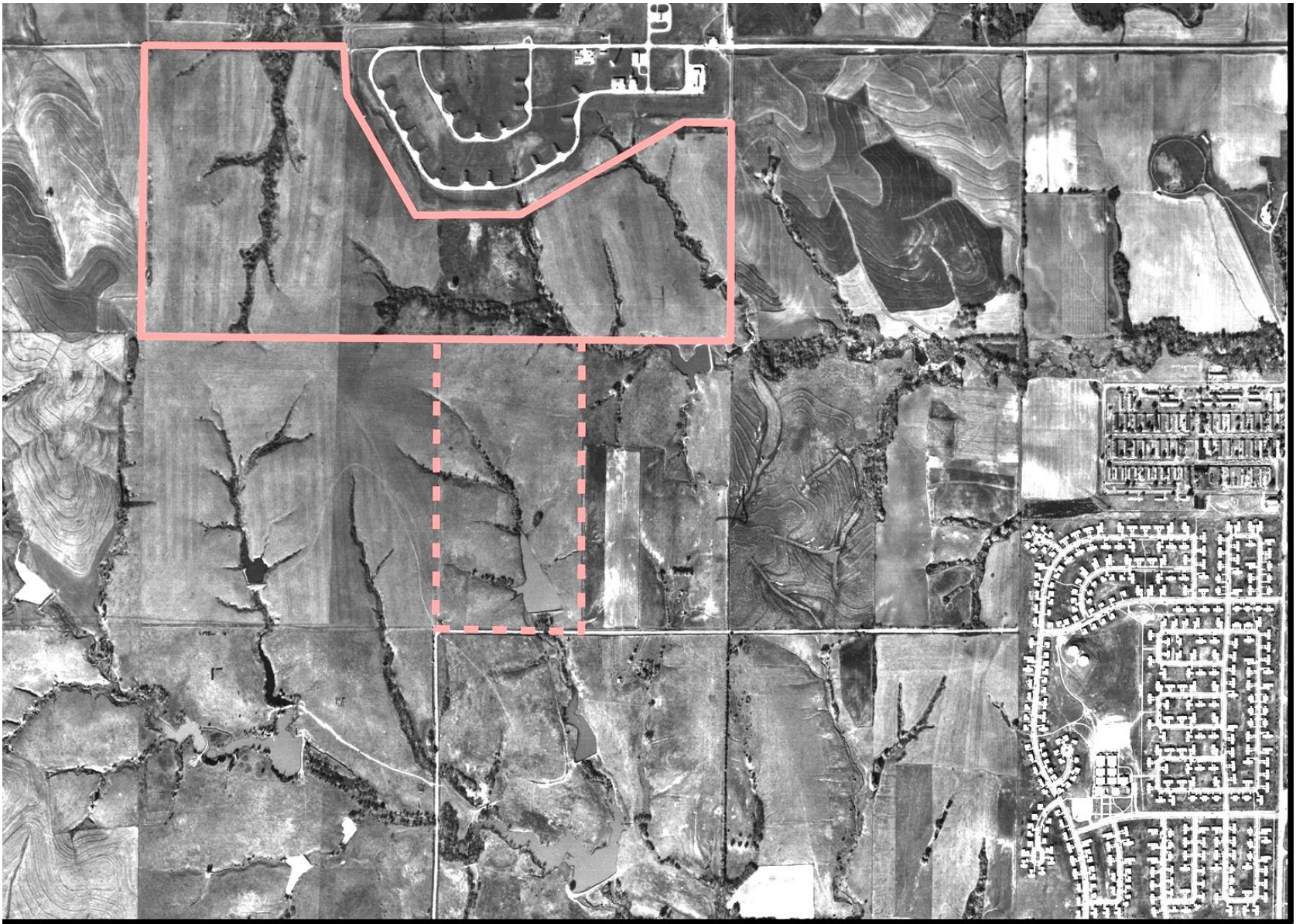
1984: NU Foundation purchases Nine-Mile Prairie (donation by Marguerite Hall)

2001: Michael Forsberg's 9MP photo released as US postage stamp.





February 1950 – construction of weapons storage facility



1965



Nine-Mile Prairie Area

2016-2018 image

Legend

LPD training facility

Nine-Mile Prairie

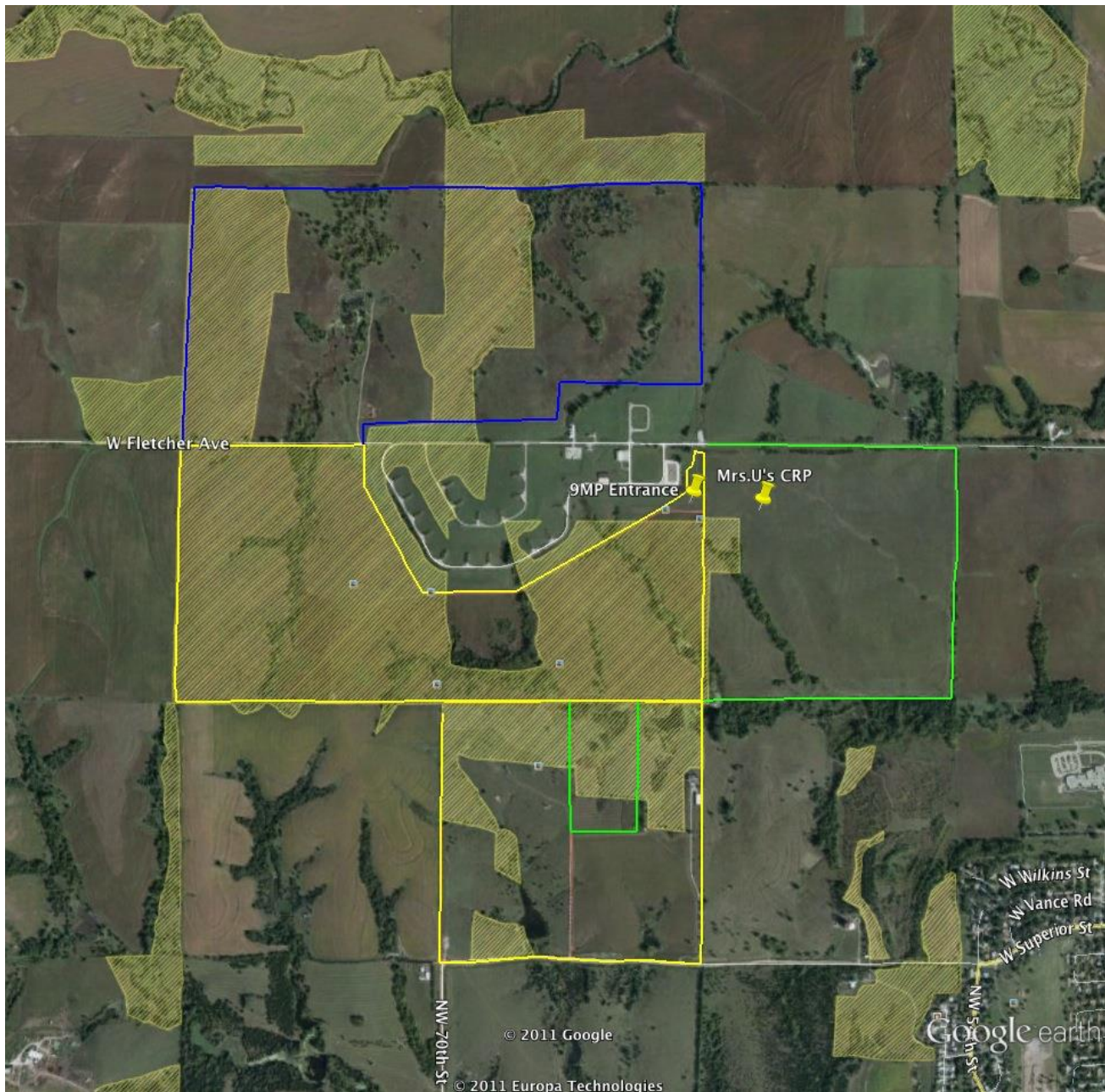
Campus Rec Towers

Arnold Elem. School

Google Earth

4000 ft

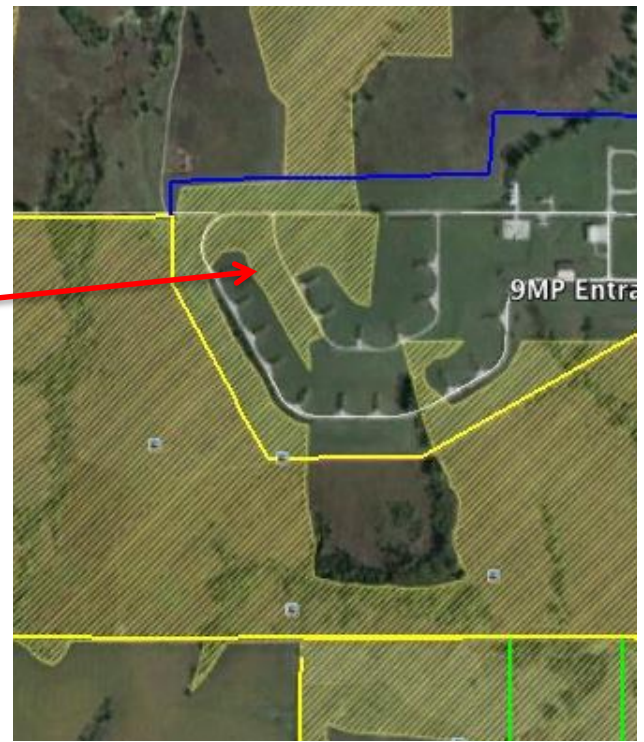
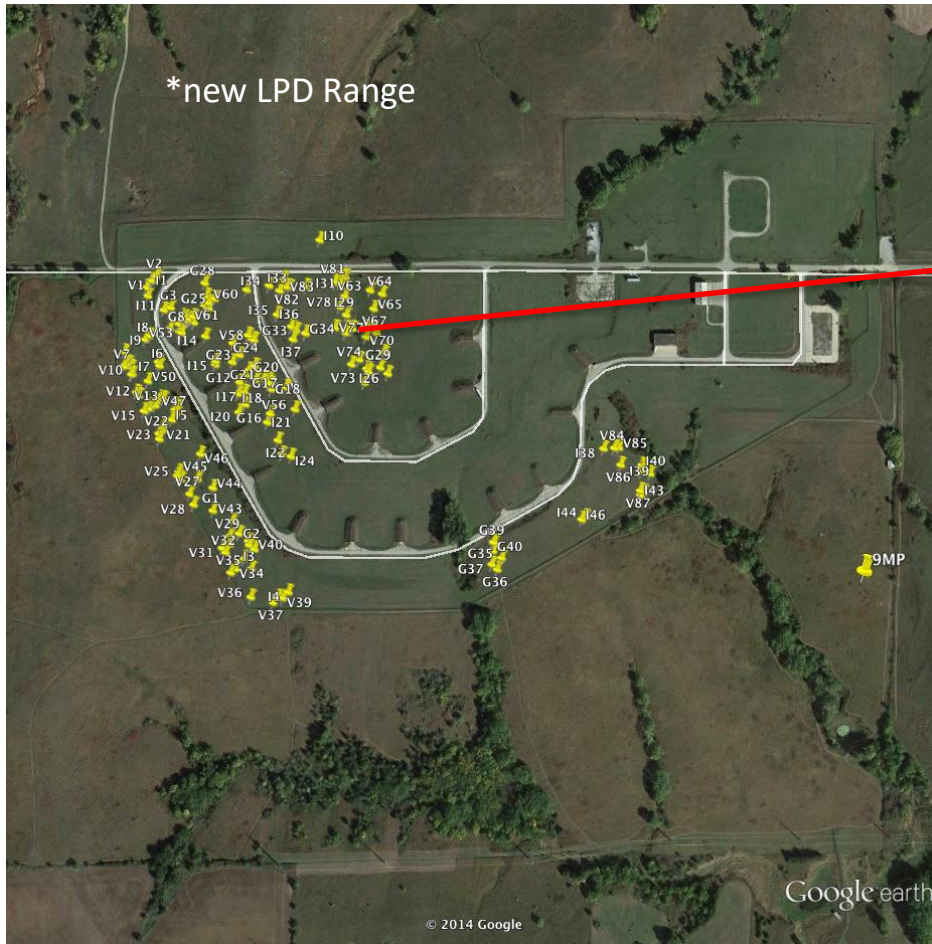




Remaining unplowed land around Nine-Mile Prairie.

Map based on a time-series of aerial photos, but not validated with soil surveys.





Unplowed land (yellow hatching) at and around Nine-Mile Prairie based on historic aerial photos



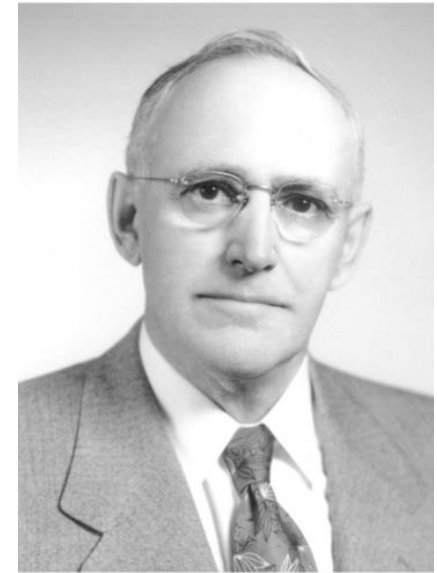
Locations of prairie violet (v), ground plum (g) and indigo (i) plants in LAA Bunker area (June 2014). Note that the distribution of these flowers matches the remnant unplowed prairie distribution.



Prairie violet, host for endangered regal fritillary butterflies found at Nine-Mile Prairie.

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**John E. Weaver
(1884-1966)**



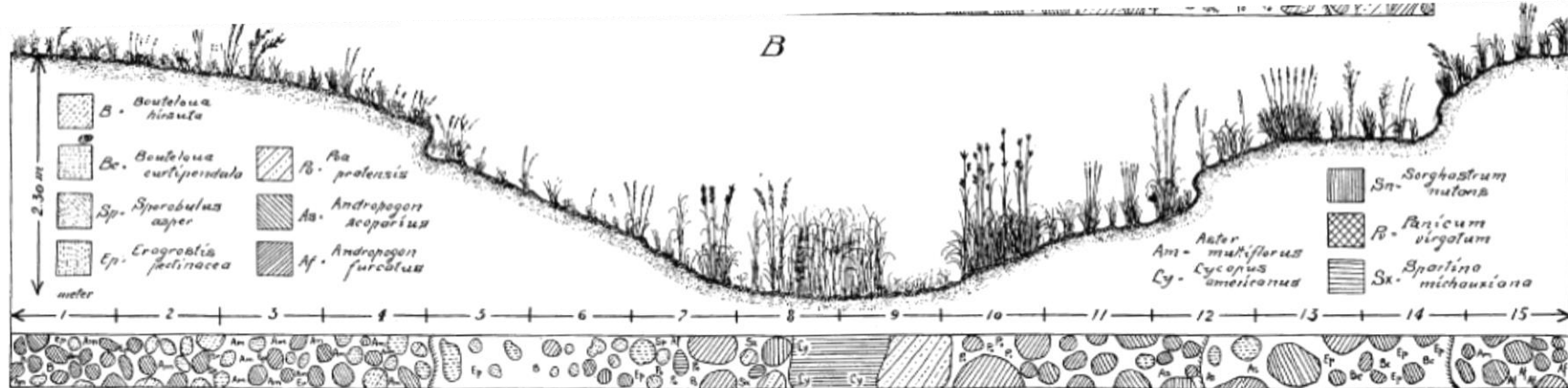


FIG. 14. Transects one half meter wide: *A*, near the head of a small ravine; *B*, 20 meters farther down the same ravine.

T.L. Steiger. 1930.
Structure of Prairie
Vegetation.
Ecology 11:170-217

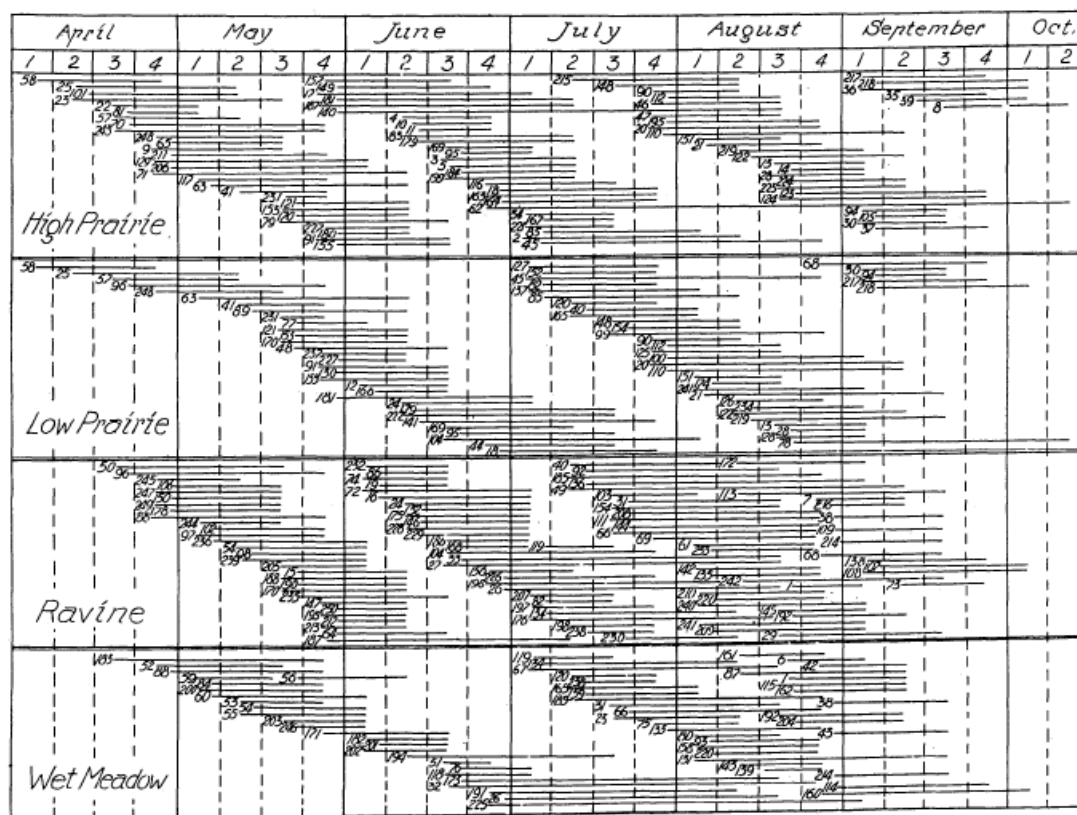
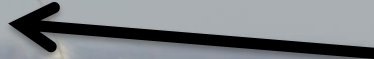


FIG. 15. Aspect chart showing the period of anthesis for each species of the several prairie habitats.



**Current
Nebraska
Capital**



**Former
Nuclear
Bomb
Bunkers**

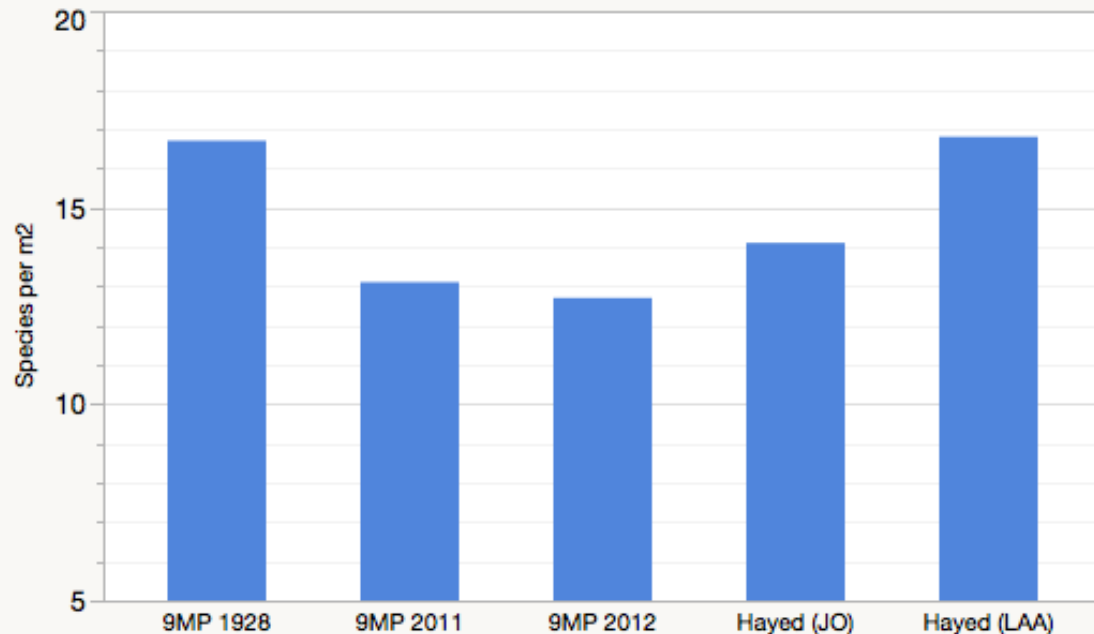
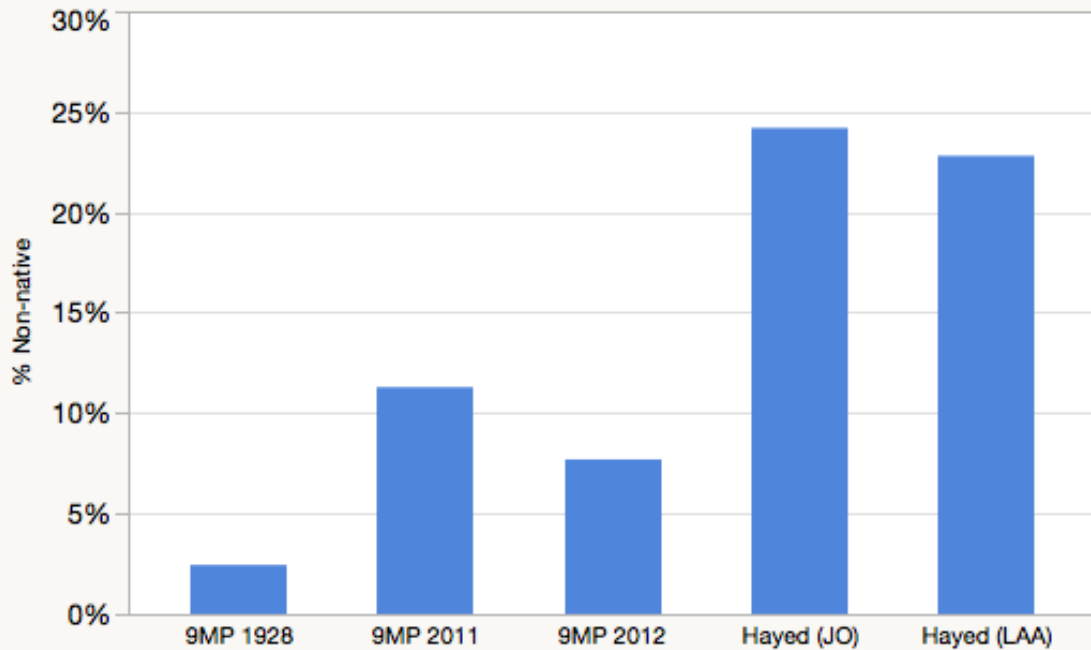


Long-term burned and hayed prairies

Plant Diversity at 9-Mile Prairie in 1928 and 2011-2012

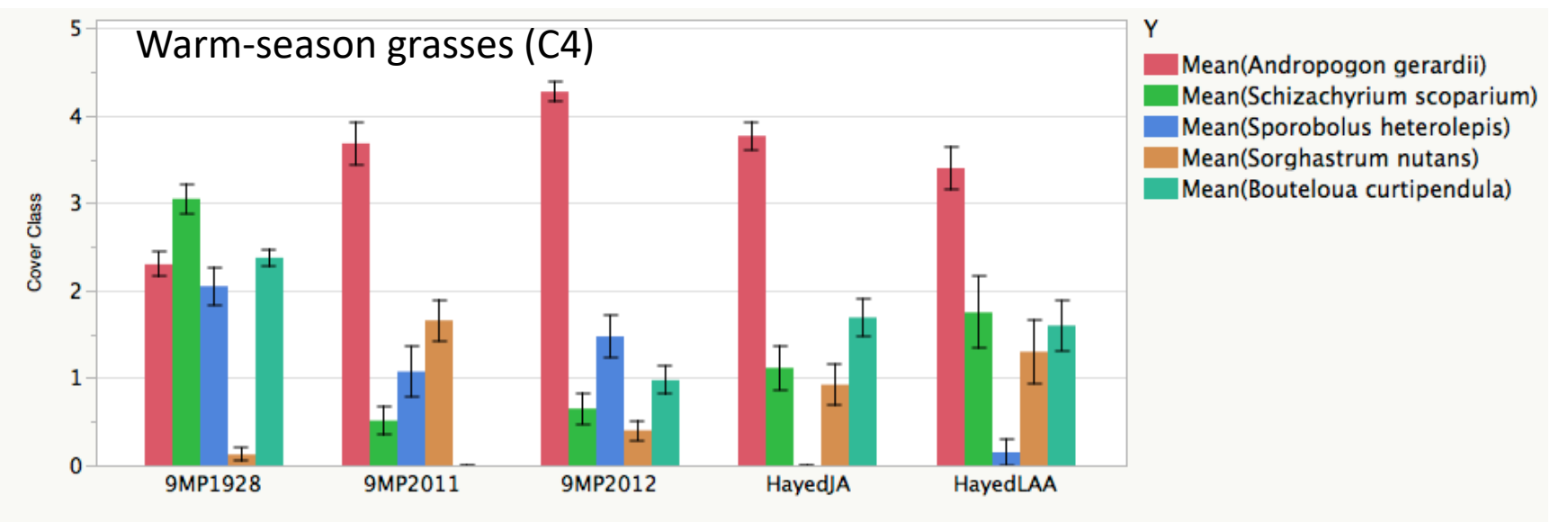
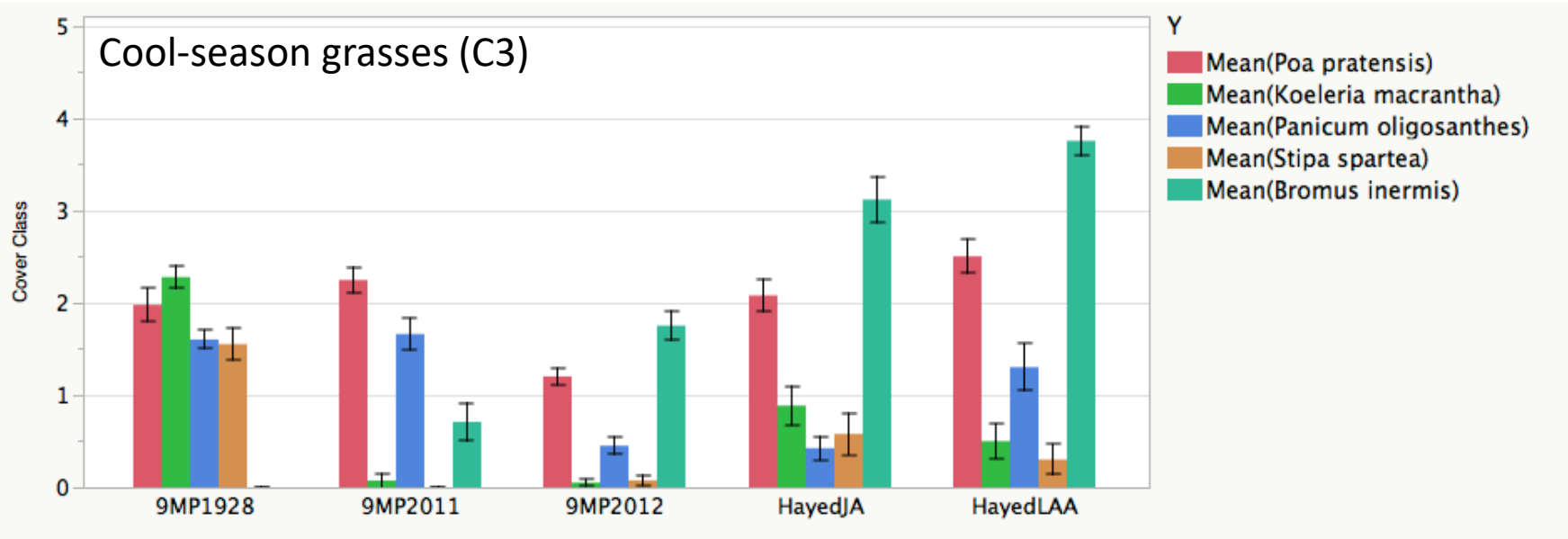
% non-native species

Steiger observed only one non-native species in his upland prairie quadrats: *Poa pratensis*.



of plant species per square meter

Grass cover at Nine-Mile Prairie in 1928 and 2011-2012



Issues with old and new species



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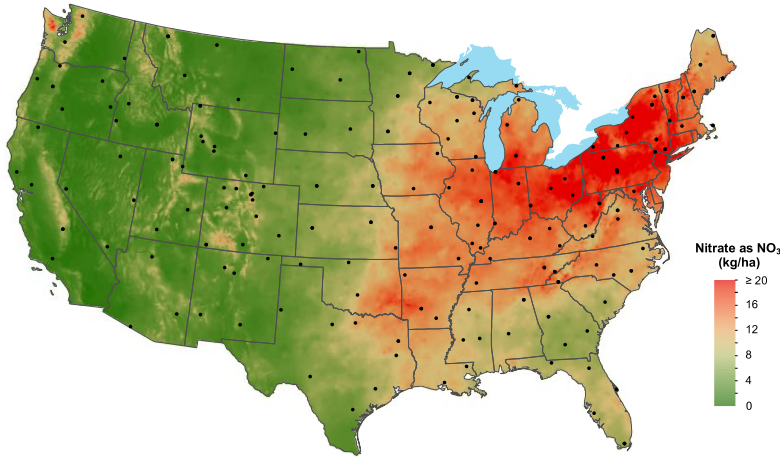


**John E. Weaver
(1884-1966)**



Nitrate (wet fall only)

Nitrate ion wet deposition, 1990

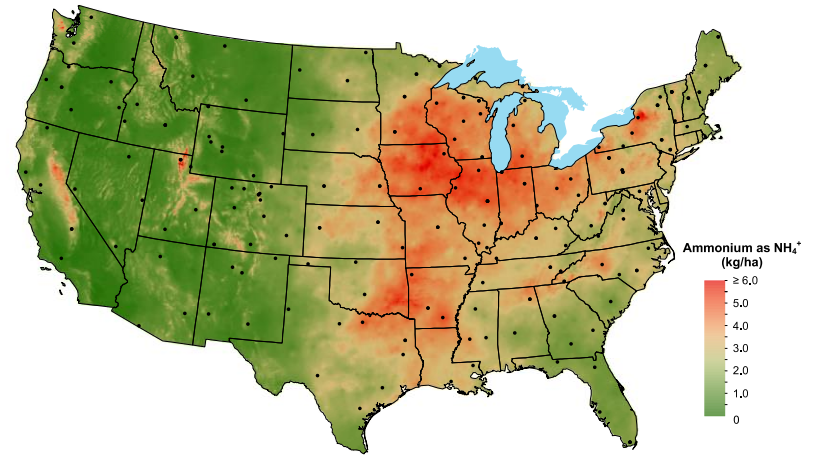


1980

National Atmospheric Deposition Program/National Trends Network
<http://nadp.isws.illinois.edu>

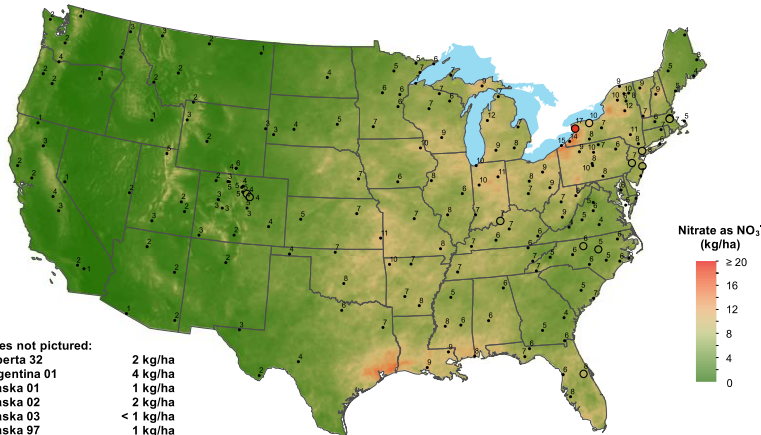
Ammonium (wet fall only)

Ammonium ion wet deposition, 1990



National Atmospheric Deposition Program/National Trends Network
<http://nadp.isws.illinois.edu>

Nitrate ion wet deposition, 2017



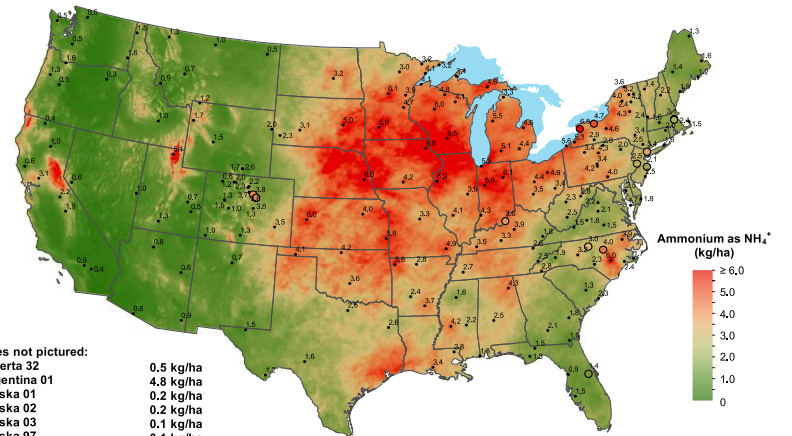
2017

Sites not pictured:

Alberta 32	2 kg/ha
Argentina 01	4 kg/ha
Alaska 01	1 kg/ha
Alaska 02	2 kg/ha
Alaska 03	< 1 kg/ha
Alaska 97	1 kg/ha
British Columbia 22	2 kg/ha
British Columbia 23	1 kg/ha
British Columbia 24	3 kg/ha
Saskatchewan 21	3 kg/ha
Saskatchewan 31	2 kg/ha

National Atmospheric Deposition Program/National Trends Network
<http://nadp.sln.wisc.edu>

Ammonium ion wet deposition, 2017



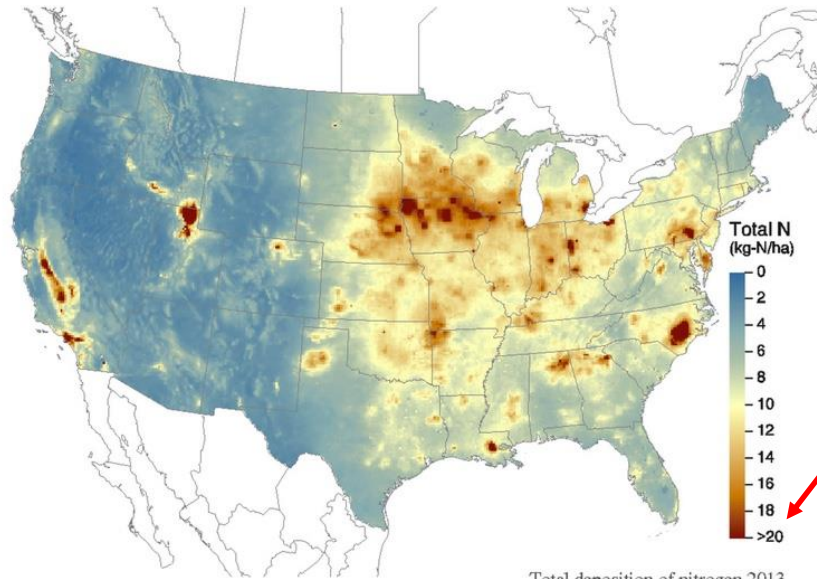
Sites not pictured:

Alberta 32	0.5 kg/ha
Argentina 01	4.8 kg/ha
Alaska 01	0.2 kg/ha
Alaska 02	0.2 kg/ha
Alaska 03	0.1 kg/ha
Alaska 97	0.1 kg/ha
British Columbia 22	0.5 kg/ha
British Columbia 23	0.2 kg/ha
British Columbia 24	0.5 kg/ha
Saskatchewan 21	1.8 kg/ha
Saskatchewan 31	1.5 kg/ha

National Atmospheric Deposition Program/National Trends Network
<http://nadp.sln.wisc.edu>

How much nitrogen do we get from air pollution? To get the total we have to estimate the dry deposition component.

Figure 1. Map of Total Nitrogen Deposition 2013

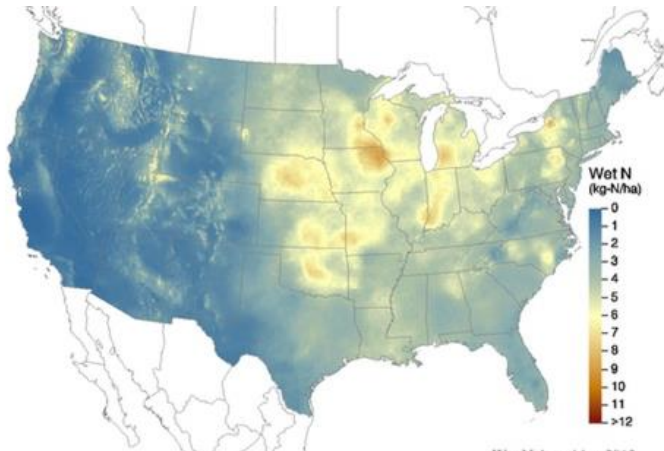


20 kg/ha
= 2.0 g/m²
= 19.6 lb/acre

Source: CASTNET/CMAQ/NTN/AMON/SEARCH

Total deposition of nitrogen 2013
USEPA 10/15/14

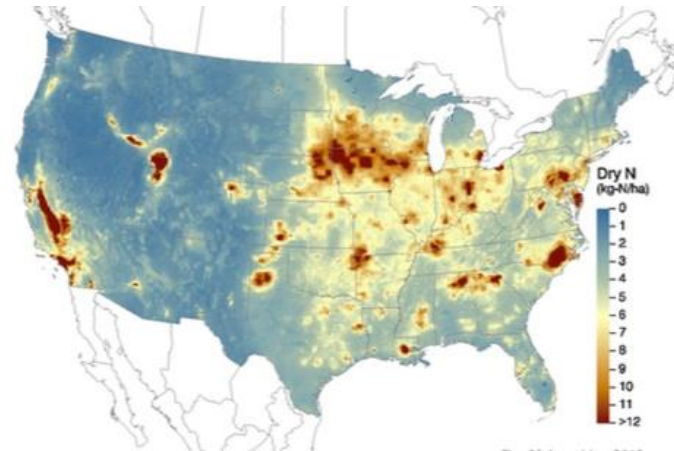
Wet



Source: CASTNET/CMAQ/NTN/AMON/SEARCH

Wet N deposition 2013
USEPA 10/15/14

Dry



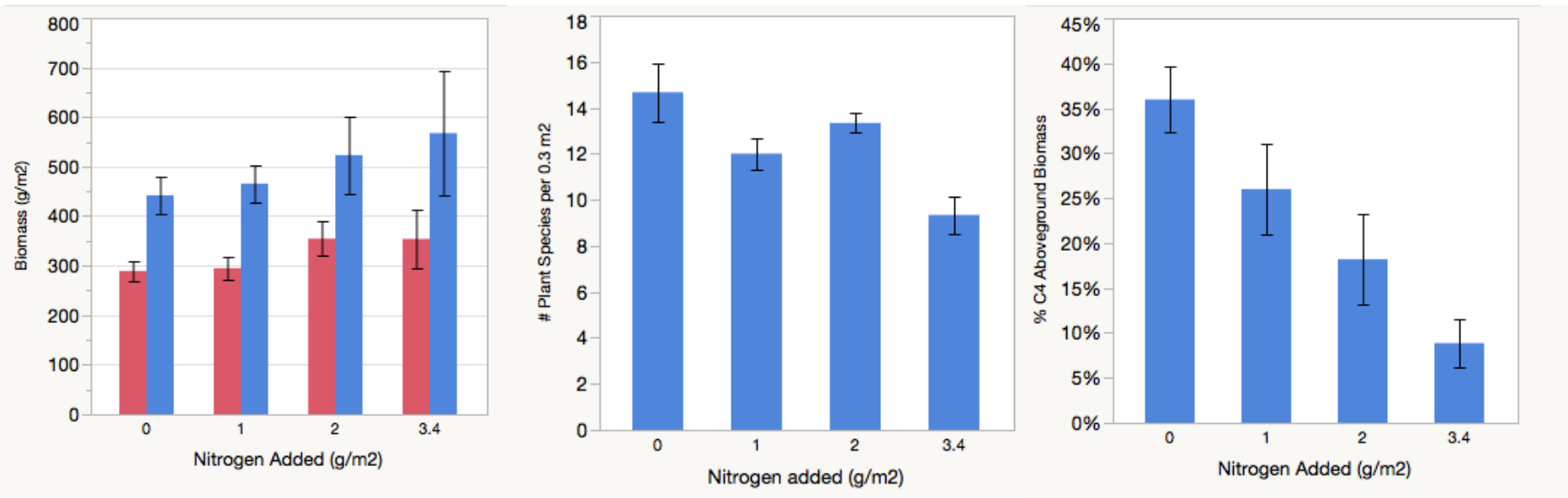
Source: CASTNET/CMAQ/NTN/AMON/SEARCH

Dry N deposition 2013
USEPA 10/15/14

Influence of Nitrogen Loading and Species Composition on the Carbon Balance of Grasslands

David A. Wedin* and David Tilman

In a 12-year experimental study of nitrogen (N) deposition on Minnesota grasslands, plots dominated by native warm-season grasses shifted to low-diversity mixtures dominated by cool-season grasses at all but the lowest N addition rates. This shift was associated with decreased biomass carbon (C):N ratios, increased N mineralization, increased soil nitrate, high N losses, and low C storage. In addition, plots originally dominated by nonnative cool-season grasses retained little added N and stored little C, even at low N input rates. Thus, grasslands with high N retention and C storage rates were the most vulnerable to species losses and major shifts in C and N cycling.



Productivity up
(red live, blue dead biomass)

Plant diversity down

Shift from warm-season to cool-season grasses

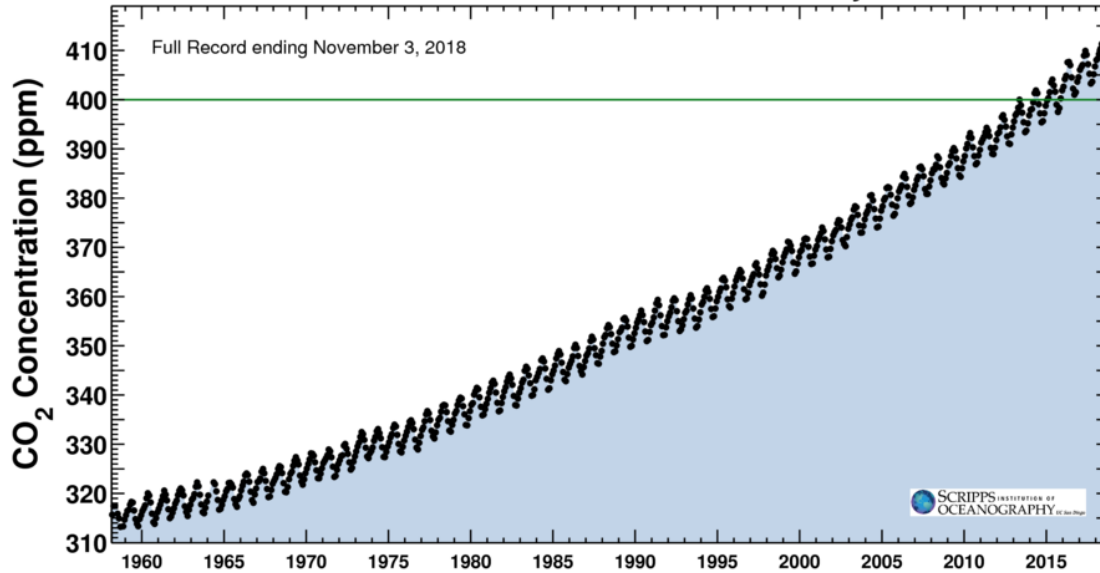


Carbon Dioxide

Latest CO₂ reading
November 03, 2018

407.14 ppm

Carbon dioxide concentration at Mauna Loa Observatory



The most famous, but certainly not the only, record of our changing atmosphere.



Charles David Keeling
(1928-2005)

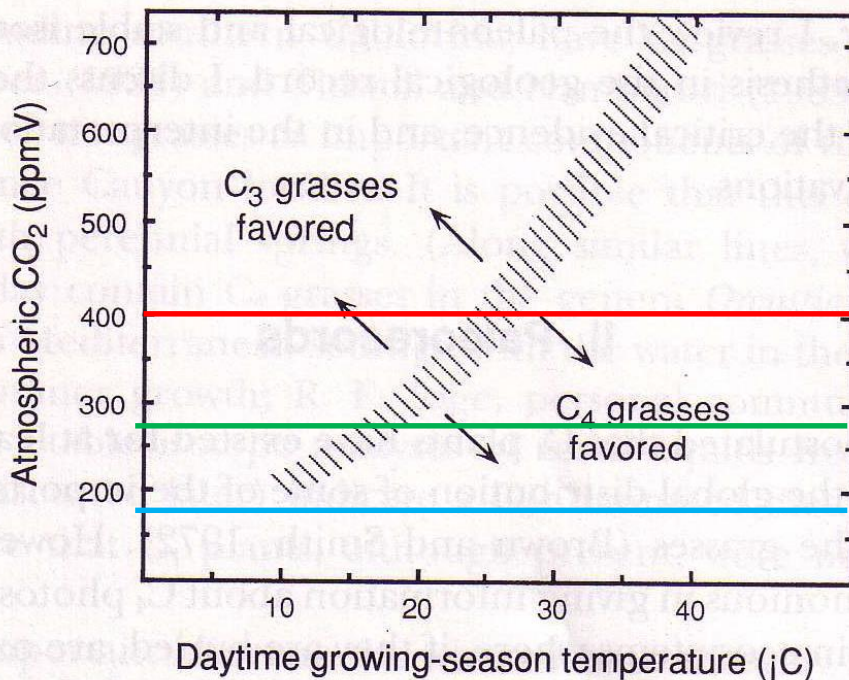
<http://keelingcurve.ucsd.edu/>

What favors warm-season (C4) grasses?

Dry and hot conditions, but it's not that simple.

“C₄ photosynthesis is an evolutionary solution to high rates of photorespiration and low photosynthetic efficiency caused by high temperature and low atmospheric CO₂. The C₄ pathway evolved independently over 45 times in 19 families of angiosperms, and thus represents one of the most convergent of evolutionary phenomena.” Rowan Sage, U of Toronto

13. Paleorecords of C₄ Plants and Ecosystems



Atmospheric Carbon Dioxide Concentrations

Ice Age (14,000 ybp) = 180ppm

Pre-industrial (1840) = 280ppm

2018 = 405ppm and going up

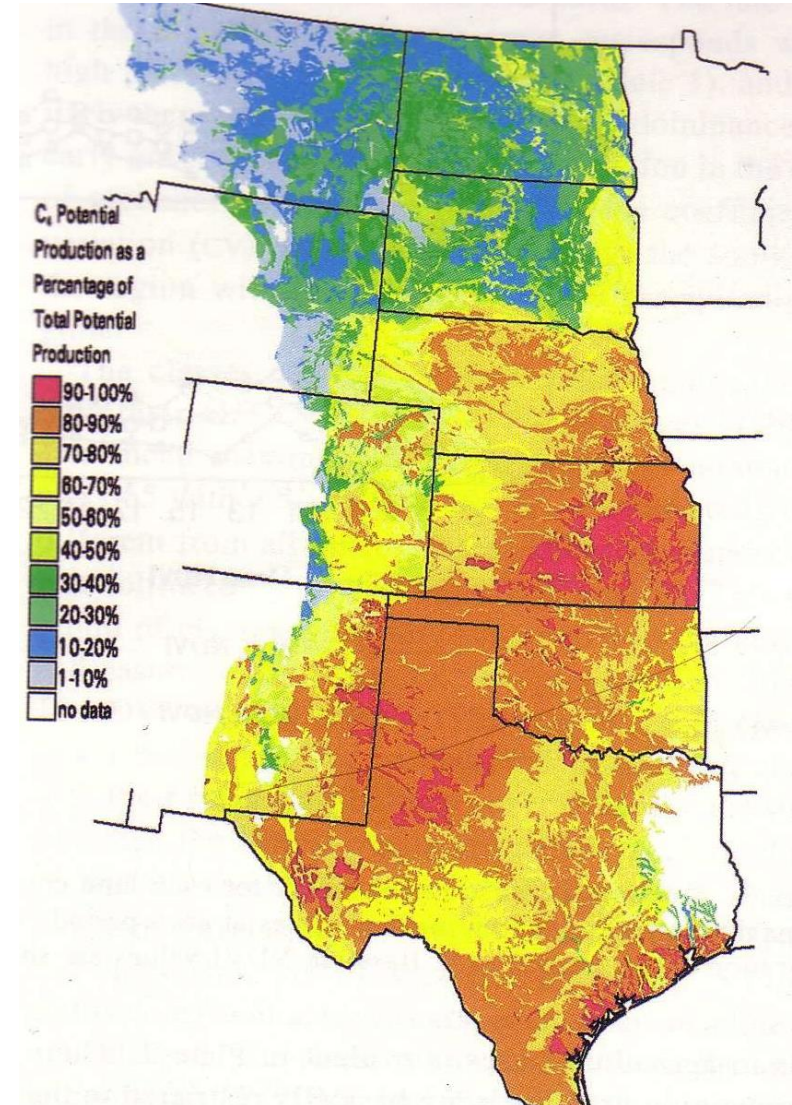
The 6-Million Year Battle between Trees (C_3) & Prairie Grasses (C_4)

I can't imagine a better place to study this battle than Nebraska.

- We are a C_4 -dominated landscape
- The importance of this battle has been clear for a century at UNL
- We have an incredible fossil record spanning the Tertiary when grasses became players in global vegetation
- We have excellent fossils from the period when C_4 -dominated grasslands expanded.
- We have the worlds greatest company for equipment to measure leaf level physiology and atmospheric CO_2 dynamics



1900 - "We have to preach the crusade of filling Nebraska with trees, and to do that we must plant trees, and plant trees, and plant trees." Charles E. Bessey



Tiezen et al. 1997

“Climax” prairie and trees in the prairie?

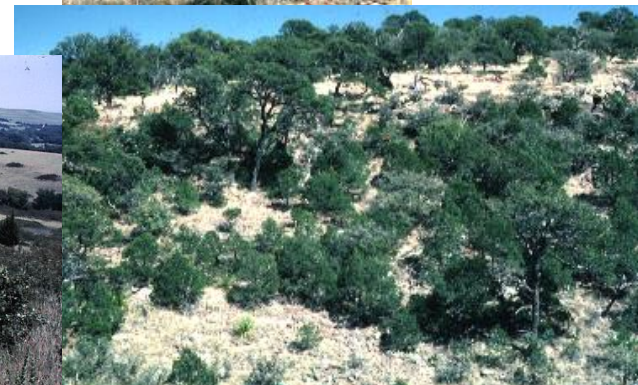
J.Weaver, 1965 (Native Vegetation of Nebraska)- “It has been conclusively shown that trees cannot successfully invade undisturbed true prairie (climax). This is not the opinion of a layman, but the conclusion after long-term experimentation and observation.”

P.V. Wells, 1965 (Science 148:246-249)- “It is misleading to describe the climate in the Great Plains as a grassland climate, with the implication that precipitation limits trees...Apparently, there is no range of climate in the vast grassland province of North America that is too arid for trees...the distribution of woodlands in the plains may be accounted for by the simple fact that topographic breaks have acted as fire breaks”.



Woody Encroachment in the Great Plains

- Woody species encroachment is changing the face of the Great Plains
- Expansion of mesquite (*Prosopis*) in Texas and the Southwest
- Expansion of pinyon- juniper woodlands in the southwest and Great Basin
- Red Cedar (*Juniperus virginiana*) invasion in the tall grass prairie region
- Shifts in functioning within grasslands (balance of C₄ and C₃ grasses and forbs)



From UNL's 2014 Climate Change Report (Bathke et al.)

Observed U.S. Temperature Change

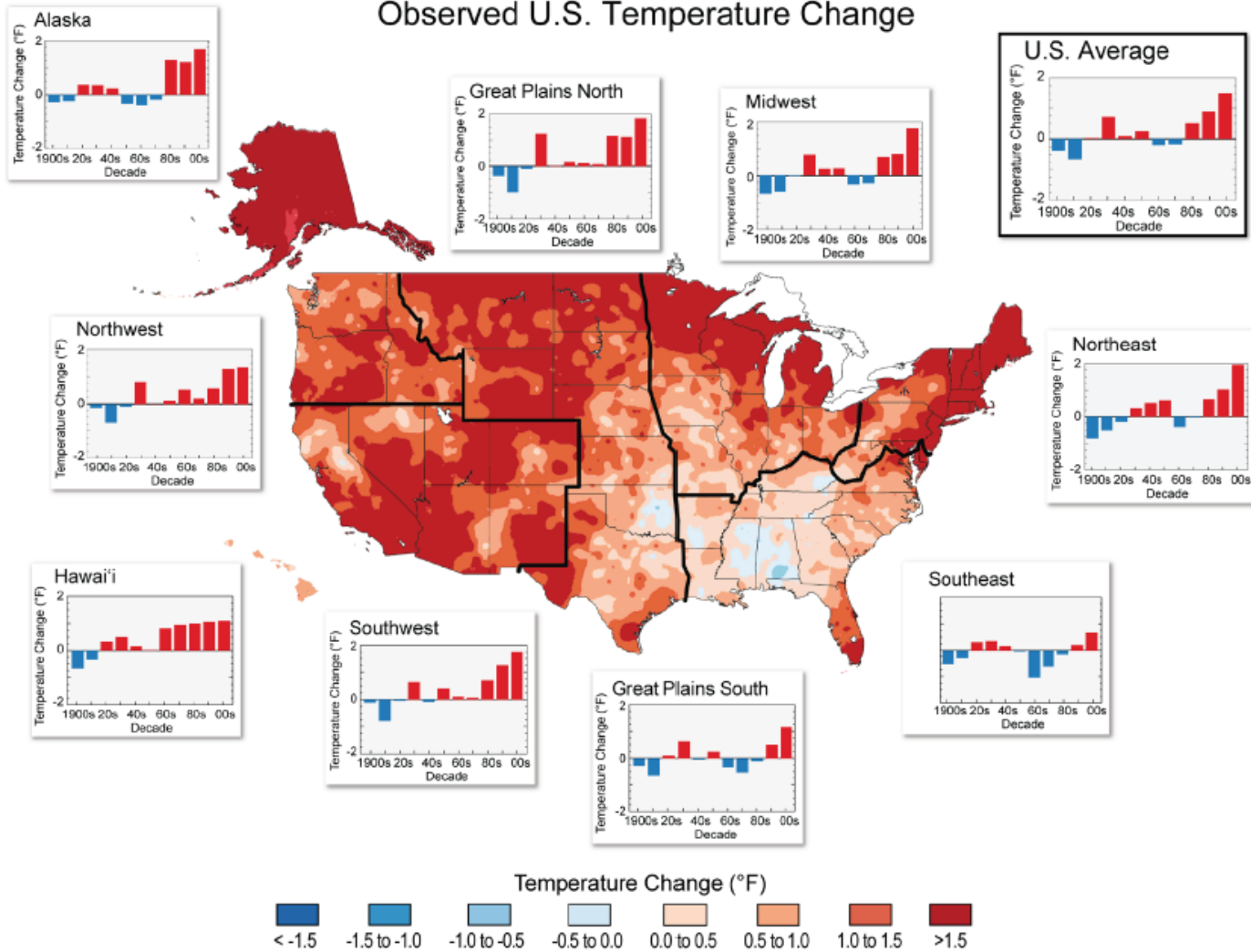


Figure 3.3. The colors on the map show temperature changes over the past 22 years (1991-2012) compared to the 1901-1960 average for Alaska and Hawaii. The bars on the graphs show the average temperature changes by decade for 1901-2012 (relative to the 1901-1960 average) for each region. The far right bar in each graph (2000s decade) includes 2011 and 2012. The period from 2001 to 2012 was warmer than any previous decade in every region. (Source: Walsh et al., 2014)

Observed U.S. Precipitation Change

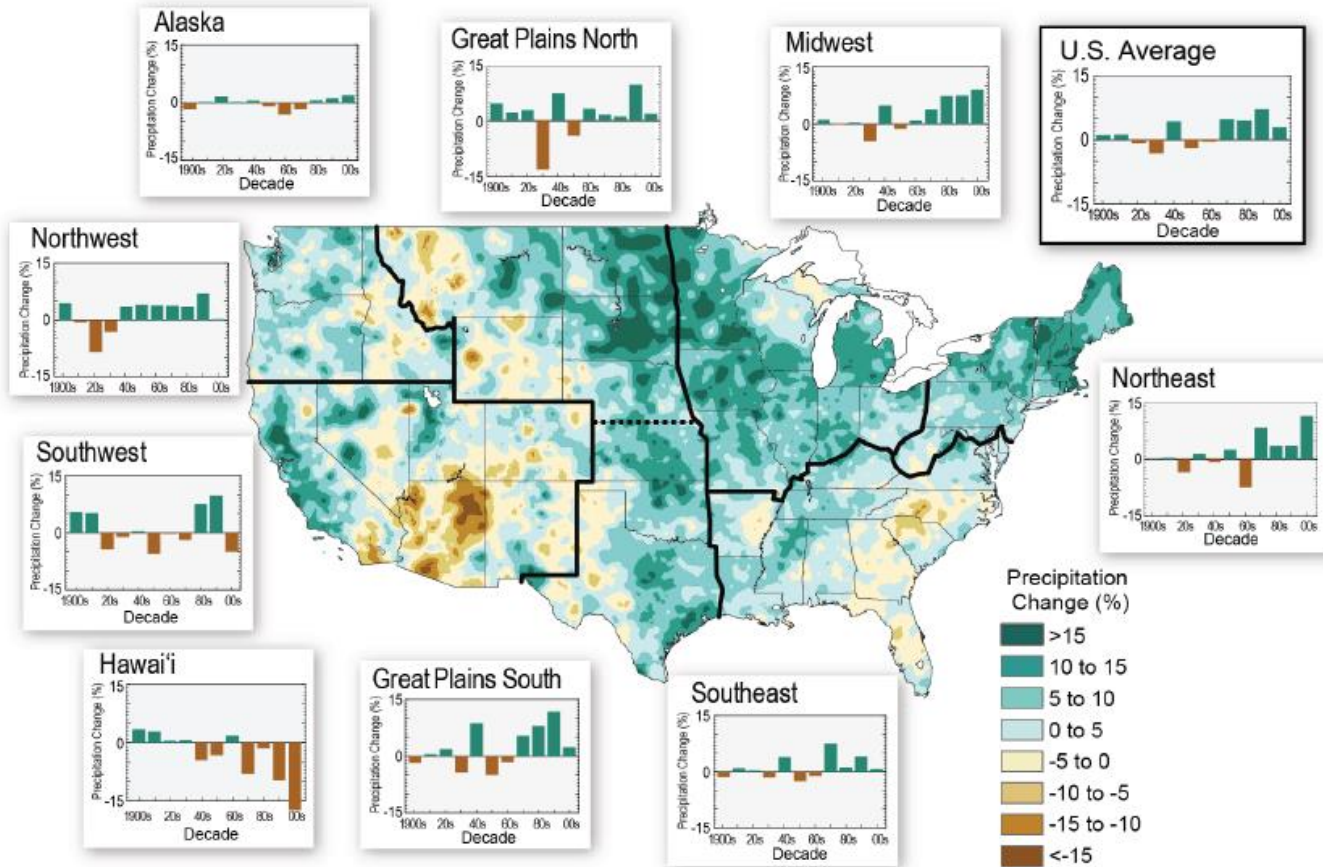
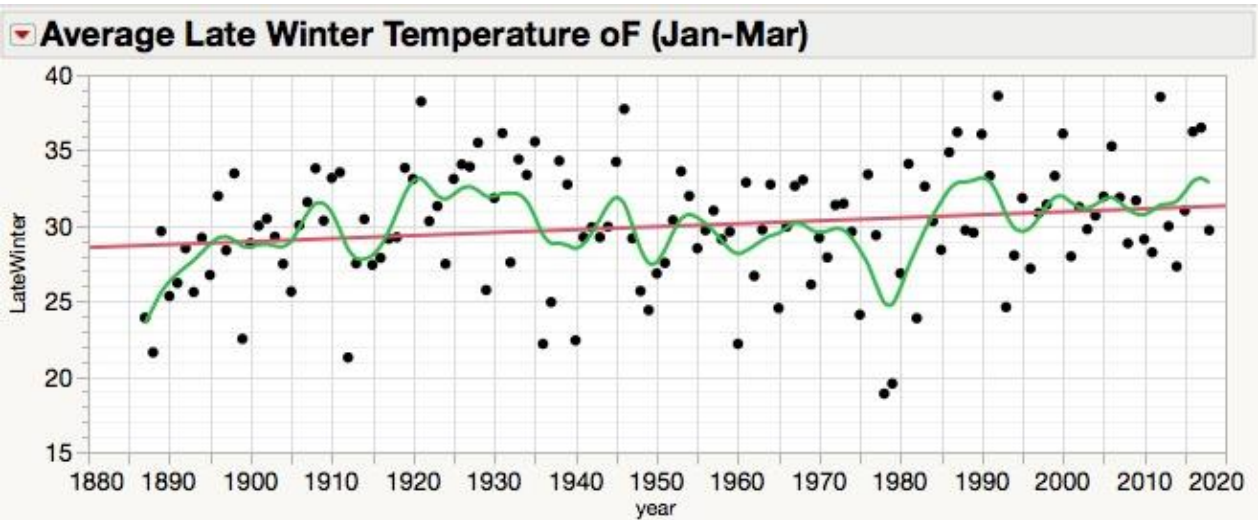
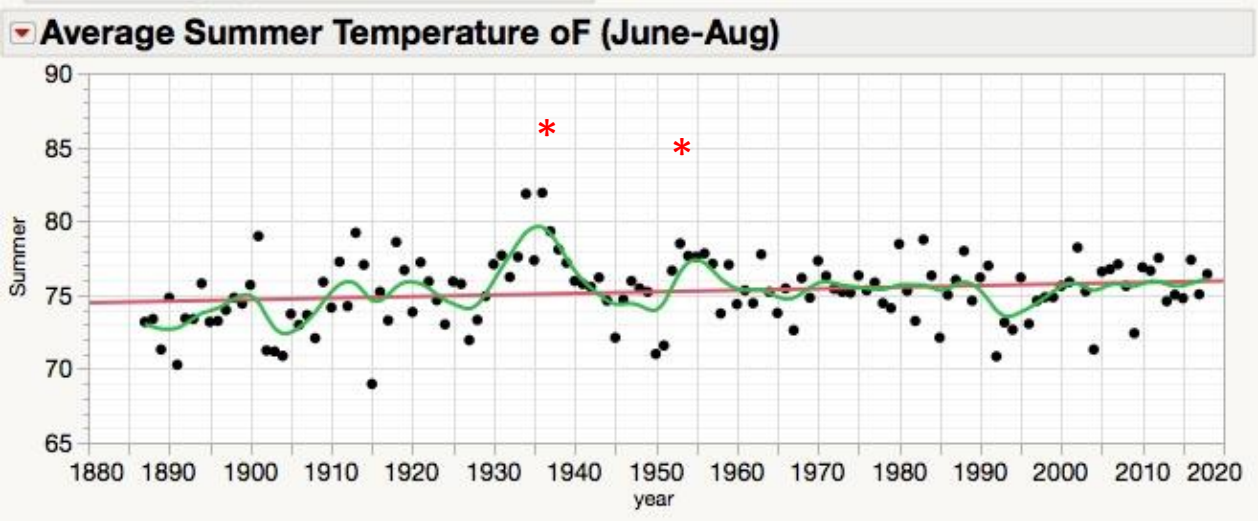


Figure 3.4. The colors on the map show annual total precipitation changes for 1991-2012 compared to the 1901-1960 average, and show wetter conditions in most areas. The bars on the graphs show average precipitation differences by decade for 1901-2012 (relative to the 1901-1960 average) for each region. The far right bar in each graph is for 2001-2012. (Source: Walsh et al., 2014)



- ▼ Linear Fit
- ▼ Smoothing Spline Fit, lambda=10
- ▼ **Linear Fit**
- ▼ **Smoothing Spline Fit, lambda=10**



Lincoln Historical Data:

Winter - up > 2oF

Summer - up 1oF

It's getting warmer, but not that much hotter.

Warming is falling more in the winter, and spring is coming earlier.

Which plants will that favor?

The Legacy of Nine-Mile Prairie

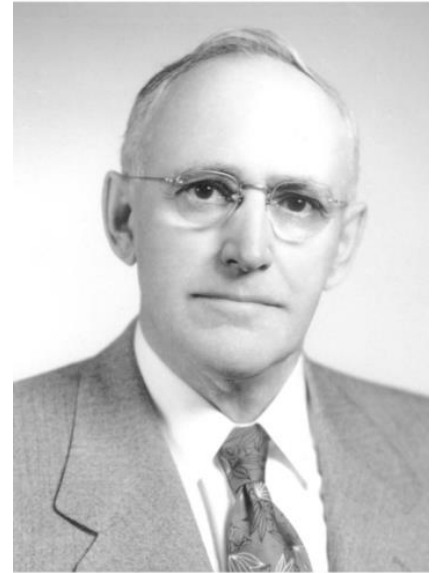
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1940's

Grassland soils through untold centuries have been thoroughly protected by the unbroken mantle of prairie vegetation. The vegetation and soil are closely related, intimately mixed, and highly interdependent upon each other and upon the climate. Hence prairie is much more than land covered with grass. It is a slowly evolved, highly complex organic entity, centuries old. It approaches the eternal. Once destroyed, it can never be replaced by man.

University of Nebraska, January, 1944



John E. Weaver
(1884-1966)



Aldo Leopold
(1887-1948*)

What a thousand acres of Silphiums looked like when they tickled the bellies of the buffalo is a question never again to be answered, and perhaps not even asked. 1948

I grew up in Iowa in the 1960 —1970s.

Prairie conservation took off in the 1970's. The challenge was finding and protecting the few remnants of tallgrass prairie left in our agricultural landscape. Most pieces protected by schools, universities, DNR and TNC were less than 80 acres. The emphasis was on preserving prairie species, with limited effort put toward management (other than a fence and a sign). The North American Prairie Conferences, held every 2 years, began.



1960's & 1970's



Bill Whitney



Dave Stock

1980's

TNC Burn Crew, 1983, Minnesota

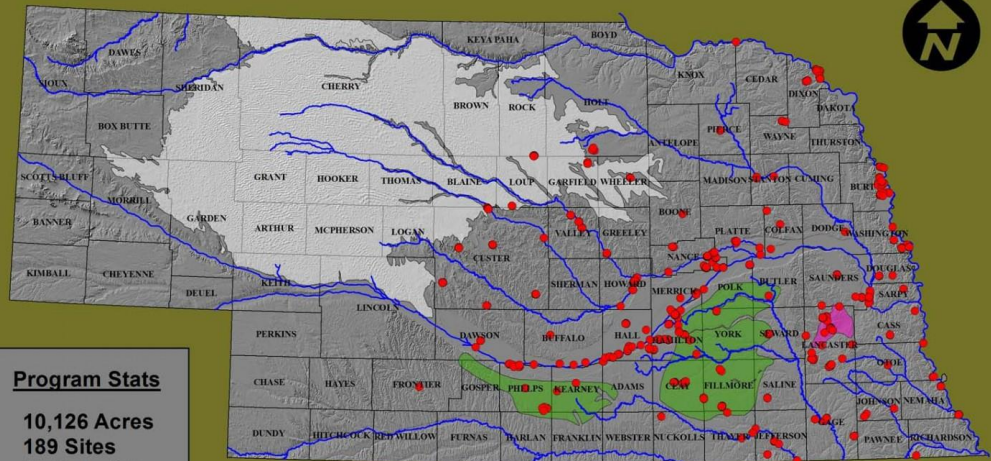
Prairie conservationists began emphasizing prescribed fire as a management tool for healthy grassland natural areas, particularly in the tallgrass prairie region. Interest and expertise in prairie restoration rapidly grew. Elsewhere on the landscape, the Farm Crisis led to the start of the Conservation Reserve Program.



Hand collected diverse seed mix



PPRI High-Diversity Prairie Restoration Sites 1979 - 2014

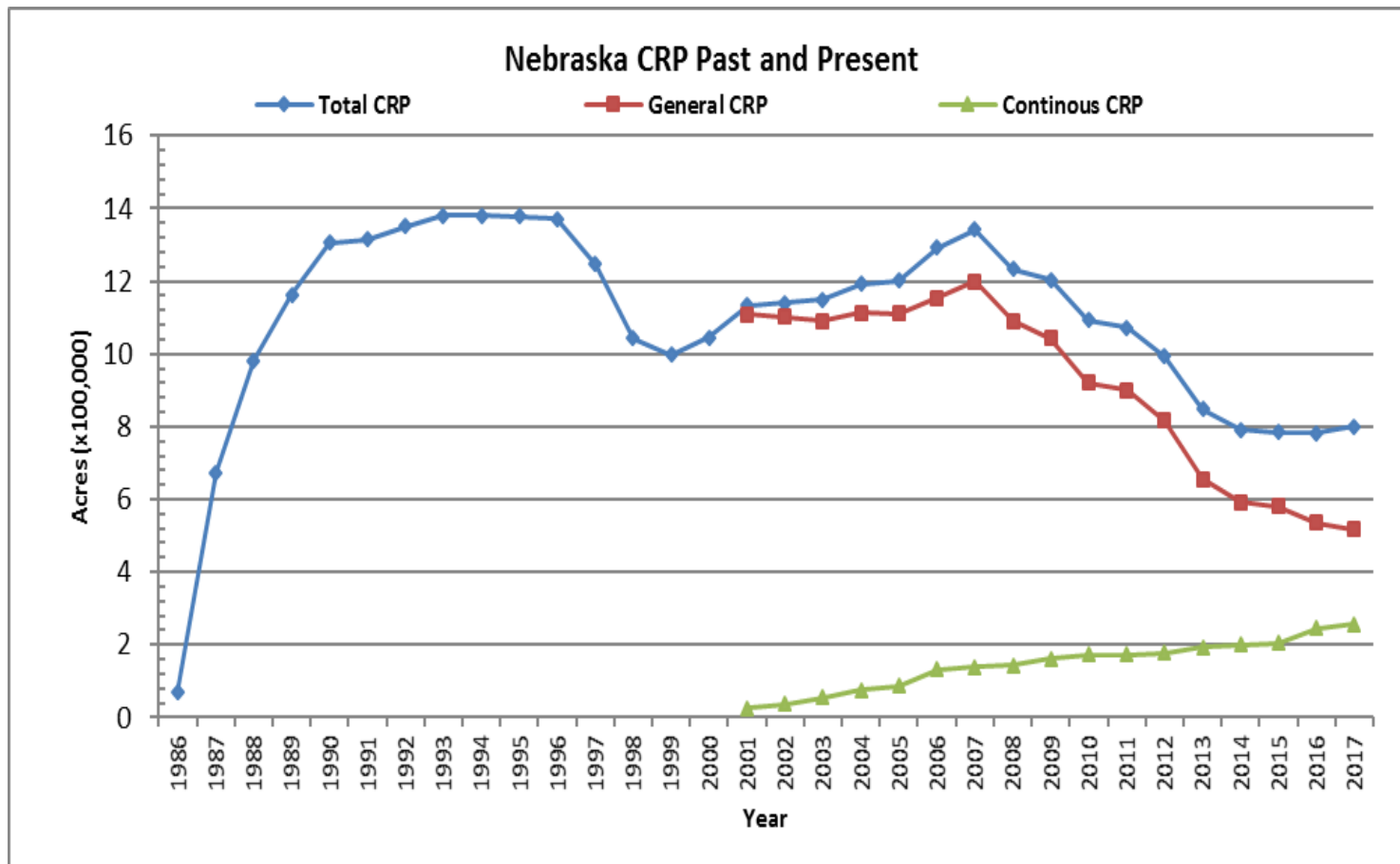


Program Stats

10,126 Acres
189 Sites
50 Counties



Nebraska Conservation Reserve Program in Nebraska



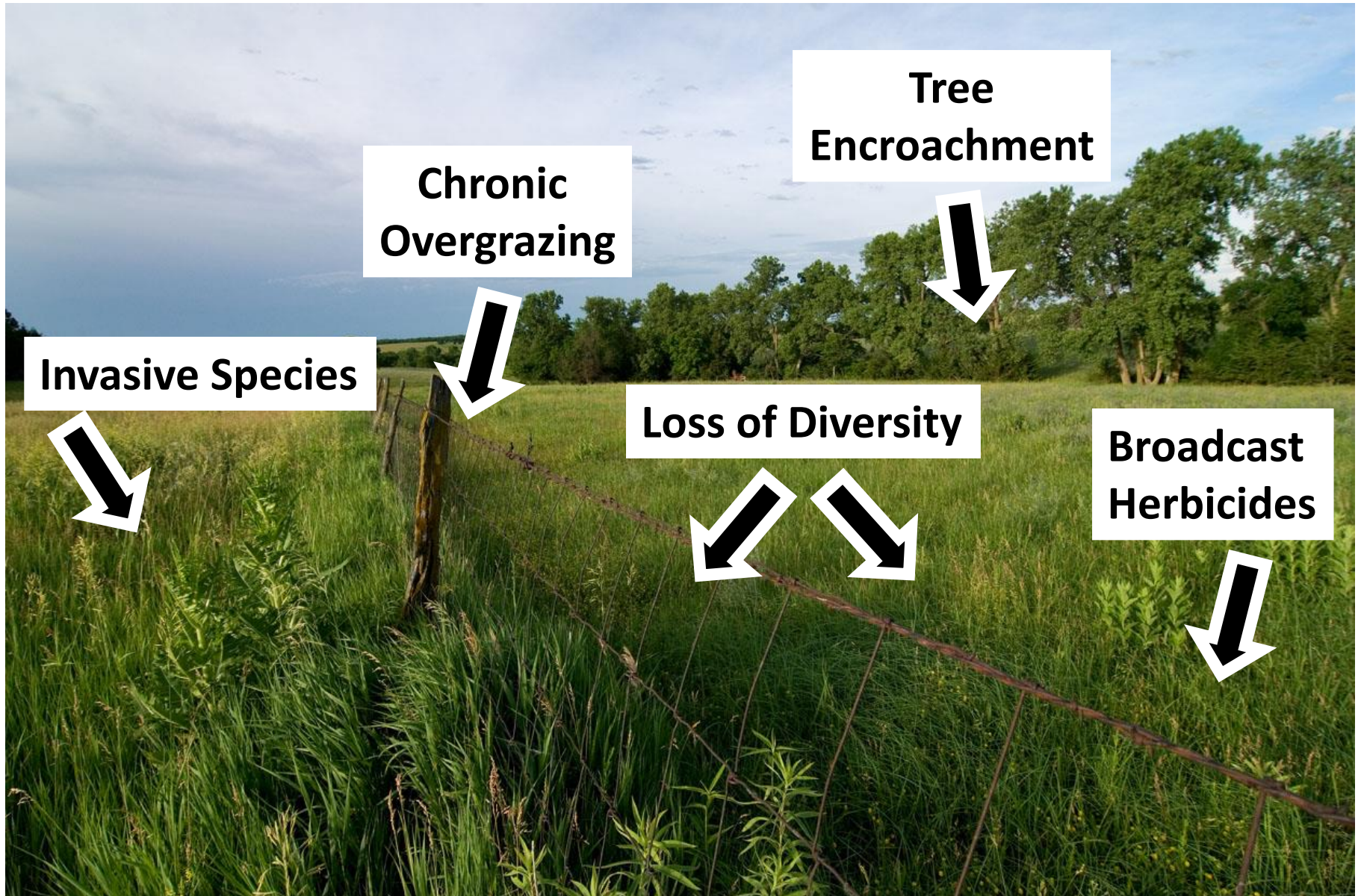
1990's and 2000's

New Problems and Questions:

- * Are small isolated prairie preserves viable in the long term?
- * Why are we losing native plant and insect species in protected prairies, even with prescribed fire management?
- * Why does the encroachment of shrubs and trees seem to be accelerating?
- * Why does the invasion of non-native cool season grasses seem to be accelerating?



Threats to Prairies (Chris Helzer slide)



Annual grants are funded through the proceeds of the Nebraska Lottery, meaning that people who enjoy the fun and excitement of the Lottery also know they are helping keep the state's land, air and water clean for future generations. The Nebraska Environmental Trust receives 44.5% of the profits of the Nebraska Lottery.



**The Nebraska
Environmental Trust**

preserving NATURAL NEBRASKA™ for future generations



Photo taken at Spring Creek Prairie, one of the many prairie restoration sites funded by the Trust: a living laboratory for ecology lessons.

“In 2016, NET will fund \$18,780,000 in grants. By my count, 19% (\$3,500,000) directly involve grassland conservation. Many of the other grants also impact grassland conservation.”



Mark Brohman

**Mark Brohman, Executive
Director, Nebraska
Environmental Trust.**

Grassland Conservation in Nebraska - 2018

1. Set realistic, forward-looking conservation goals. Chris Helzer (TNC) - *“Building and maintaining ecological resilience in prairies”*.
2. Plan, fund and manage grasslands at the **landscape scale**
3. Build conservation **partnerships**
4. Encourage grassland conservation on **private lands** in rural, agricultural landscapes
5. Use all of the tools in your grassland management toolbox:
 - * **prescribed burning**
 - * **herbicide control** of woody vegetation and non-native plant
 - * **grazing**
 - * **haying** (different from mowing!)
 - * **managing species**: overseeding/reseeding/restoration
6. Adjust/adapt to unprecedented **global change** in our grasslands (*warmer winters, more big rain events, elevated CO₂, atmospheric N deposition, new invasive species, etc*)
7. **Pollinators!!**

The two faces of Grassland Conservation

Goal of the Neal Smith National Wildlife Refuge (central Iowa)

“Neal Smith National Wildlife Refuge was established in 1990 with ambitious goals and a multifaceted mission. The mission of the Refuge is to actively protect, restore, reconstruct and manage the diverse native ecosystems of tallgrass prairie, oak savanna, and sedge meadow. These were the native habitats existing on the Refuge’s 5600 acres prior to Euro-American settlement. “



Goal of the USDA Conservation Reserve Program

“The Conservation Reserve Program (CRP) is a land conservation program administered by the [Farm Service Agency \(FSA\)](#). In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. “



Natural Protected

Sohn Mon
Wildness
Preservation
Doesn't close
Jala

Landscape Focused
Prairie Restoration
Perpetuity
No Taxes

Dept Int

Neal Smith
NWR
(Prairie Center)

Bison
Tourism
Educational
Goat

Parks
Habitat



Preserving and restoring an iconic landscape



Resilient, diverse working landscapes

USDA
Shorter time frame

CRP

\$ Contracts
Farmers
Privately owned land
Habitat
Fragmented

Field
Negate Env. Impact
Ecosystem Services
Plant Native grassland
Property Taxes

Manages
Working lands
Gifted Pindot
Multiple Use
Close agday

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Nine-Mile Prairie Partnerships



Wachiska Audubon



Lincoln Police Department



Neighbors (noxious weeds)

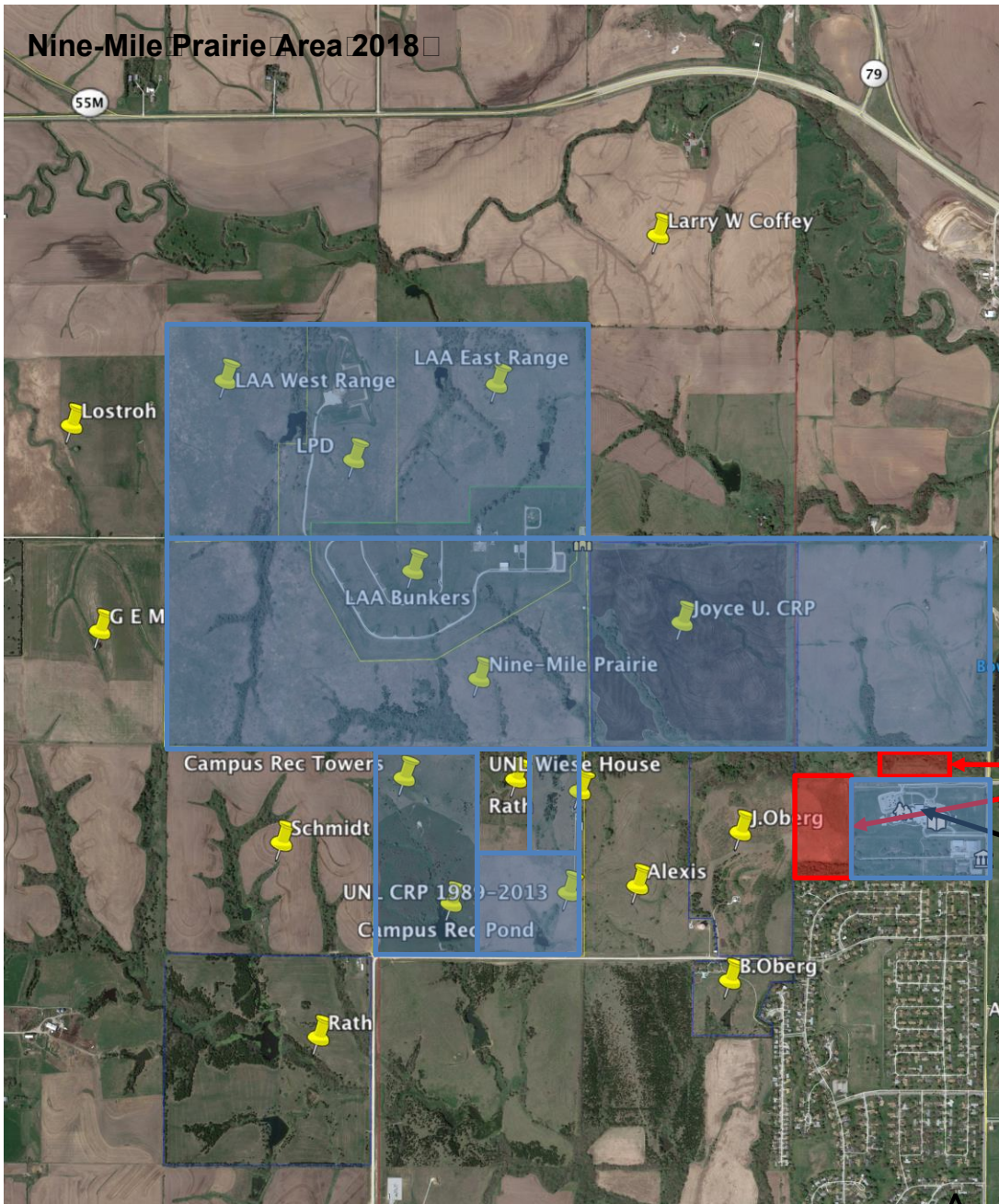


NRCS



Nebraska Forest Service

Nine-Mile Prairie Area 2018



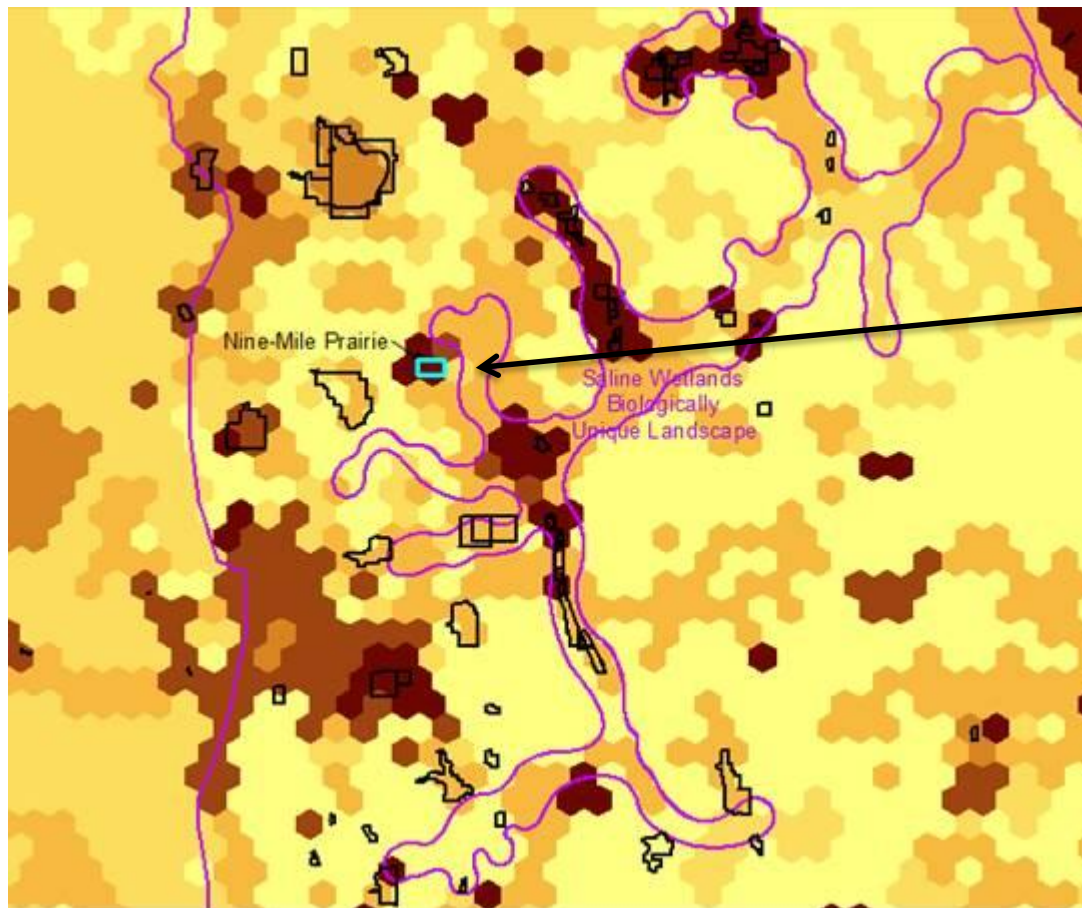
Areas in blue are either publicly owned (multiple agencies) or under long-term contract (USDA/NRCS) in a conservation program.

** Two Lincoln Airport Authority parcels being discussed (October 2018) by the Lincoln-Lancaster County Commission and the Lincoln City Council as properties to be sold for development.

**
Arnold Elementary School

Nine-Mile Prairie in Nebraska Natural Heritage Database of rare species occurrences (Rachel Simpson, NGPC, 1/9/2014)

*“To summarize, the database shows four Tier 1 species (**Married Underwing**, **Whitney’s Underwing**, **Iowa Skipper**, and **WPFO**) and five Tier 2 species (**Sedge Wren**, **Yellow-grey Underwing**, **Zabulon Skipper**, **Senna**, and **Spring Ladies’ Tresses**) documented at Nine-Mile since 1985. As I mentioned we do not track **Regal Fritillary**, but it is a Tier 1 species that occurs at the site. ”* (pollinator species in bold)



“Because of the highly ranked species and community, the area came out with the highest rank possible (a rank of 1, on a scale of 1 to 6) in the recently released Western Governors’ Association (WGA) Crucial Habitat Assessment Tool (CHAT).”

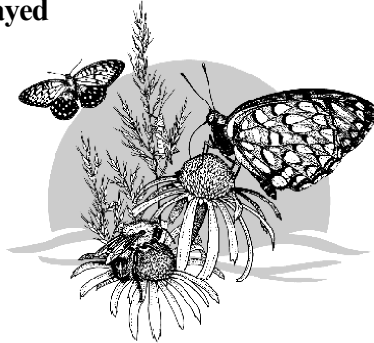
New pollinator habitat demonstration project at Nine-Mile Prairie

N

Nine-Mile Prairie

University of Nebraska – Lincoln

The 0.8-acre grassland of smooth brome grass west of the entrance path was sprayed with an herbicide to suppress the grass and then interseeded with a 46 species seed mixture on April 15, 2014.



The seed mixture, donated by Stock Seed Farms, included 36 native forb and legume species that can support native pollinators and honey bees, including 6 rare moth and butterfly species found at Nine-Mile Prairie.

UNIVERSITY OF
Nebraska
Lincoln

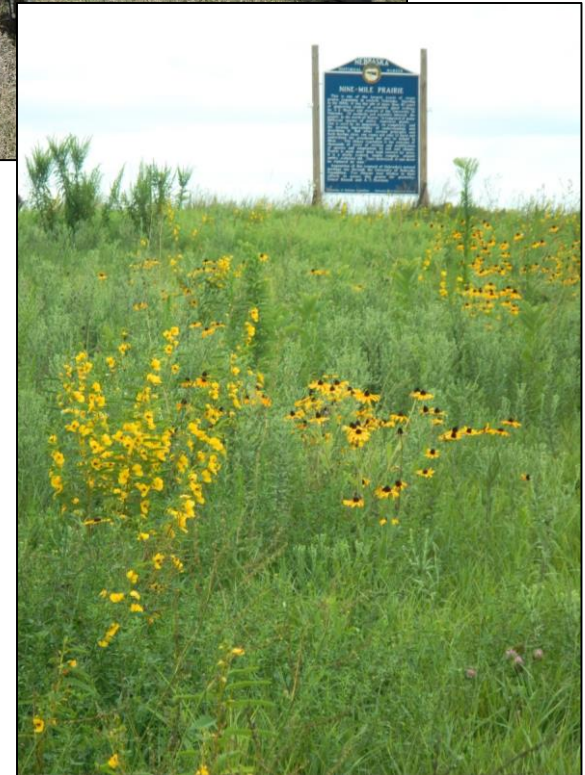
Please report problems to the
Director, Nine-Mile Prairie
402-472-3471

For more information on this project see:
<http://snr.unl.edu/aboutus/where/fieldsites/ninemileprairie.asp>



Dr. Bruce Anderson explaining use of a no-till drill to the capstone Grassland Conservation and Management course at 9MP

New pollinator planting after one growing season.



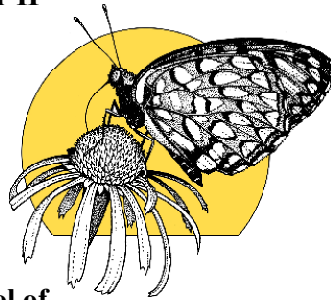


Nine-Mile Prairie

University of Nebraska – Lincoln

This transmission line, built in 2008, is part of Lincoln Electric System's North Tier II network of 345kv lines.

LES and UNL are working together at Nine-Mile Prairie to develop best management practices for maintaining high diversity prairie while meeting federal standards for control of trees and tall shrubs in transmission line right-of-ways. The approach emphasizes a combination of mowing, prescribed fires and targeted herbicide use on encroaching woody vegetation.



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