

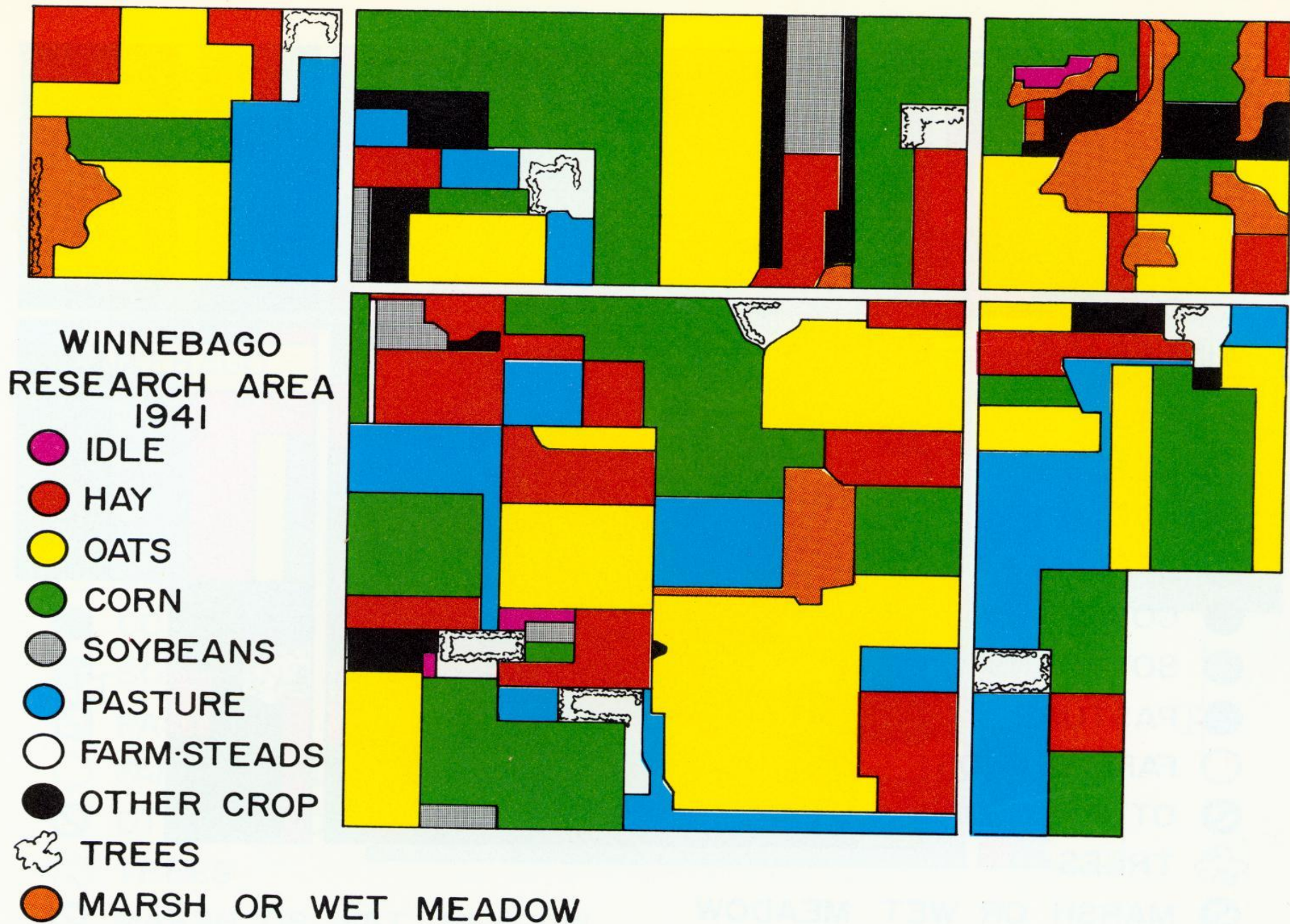
# Developing High-efficiency Agricultural Systems: A Forever Green Agriculture Initiative

Donald Wyse, University of Minnesota

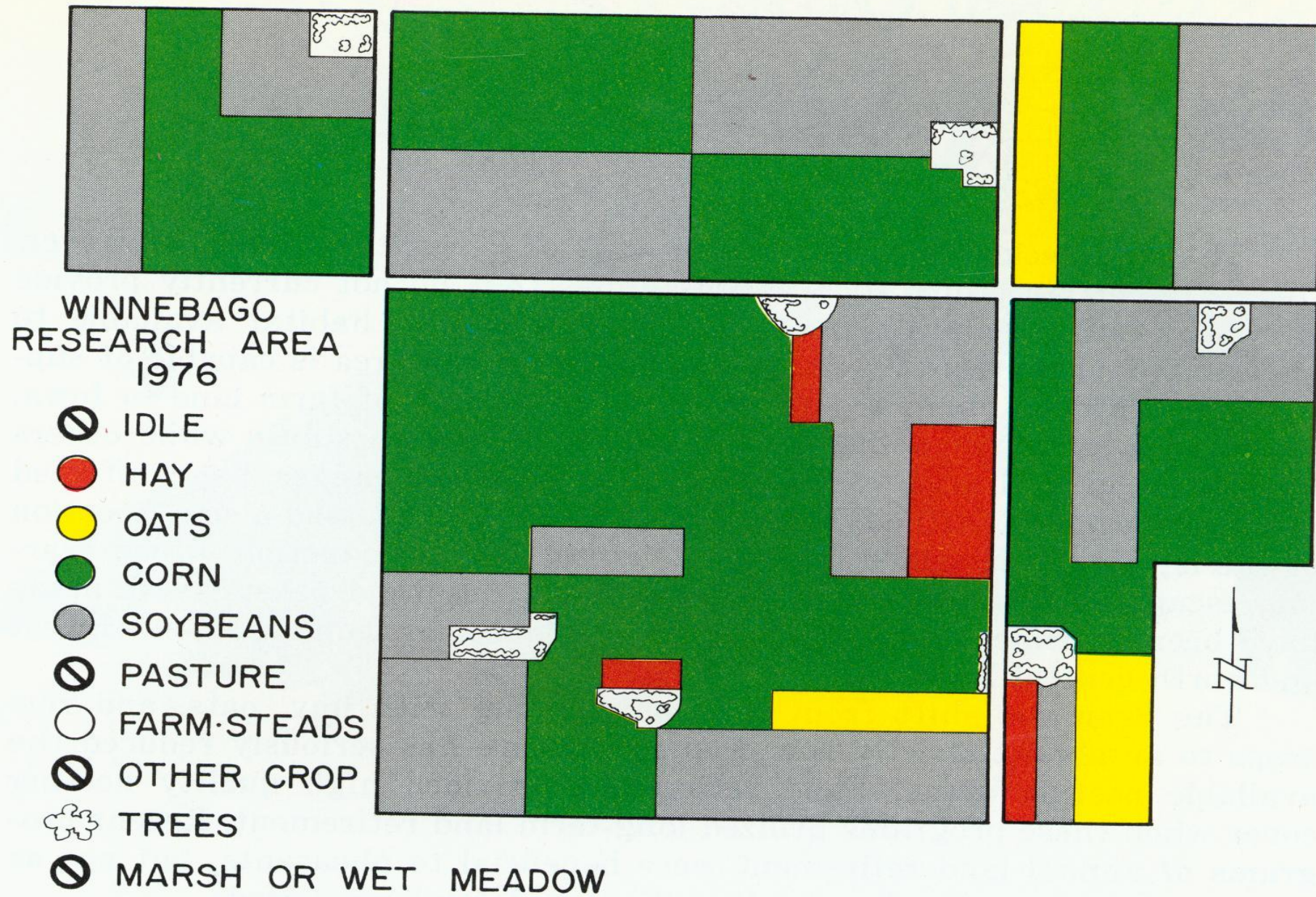


How did agricultural landscapes lose their diversity?

How did agricultural landscapes lose their diversity?



*Figure 19. Cover map of the Winnebago pheasant study area, 1941.*



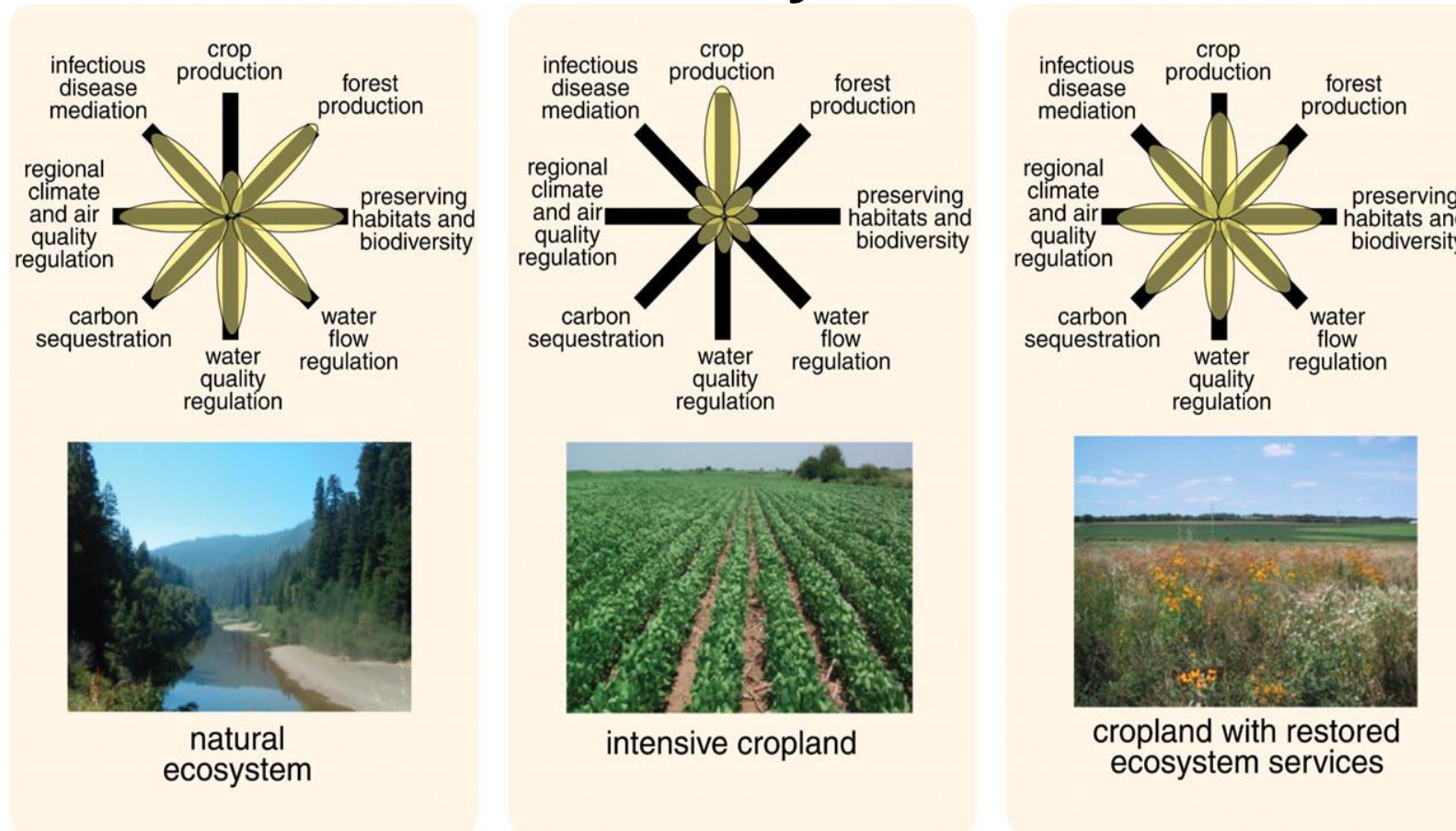
*Figure 23. Cover map of the Winnebago pheasant study area, 1976.*







# Conceptual framework for comparing land use and trade-offs of ecosystem services

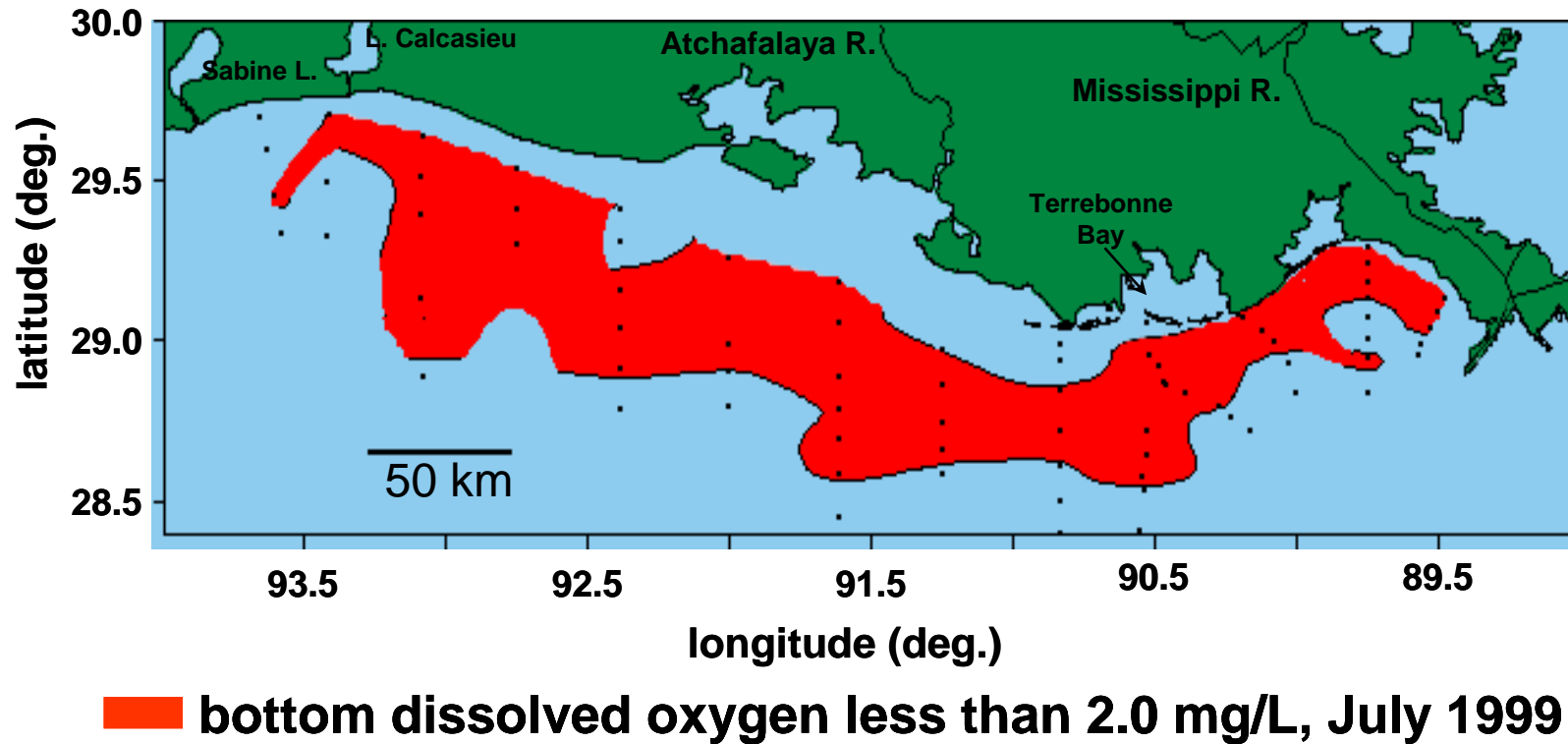


J. A. Foley et al., Science 309, 570 -574 (2005)

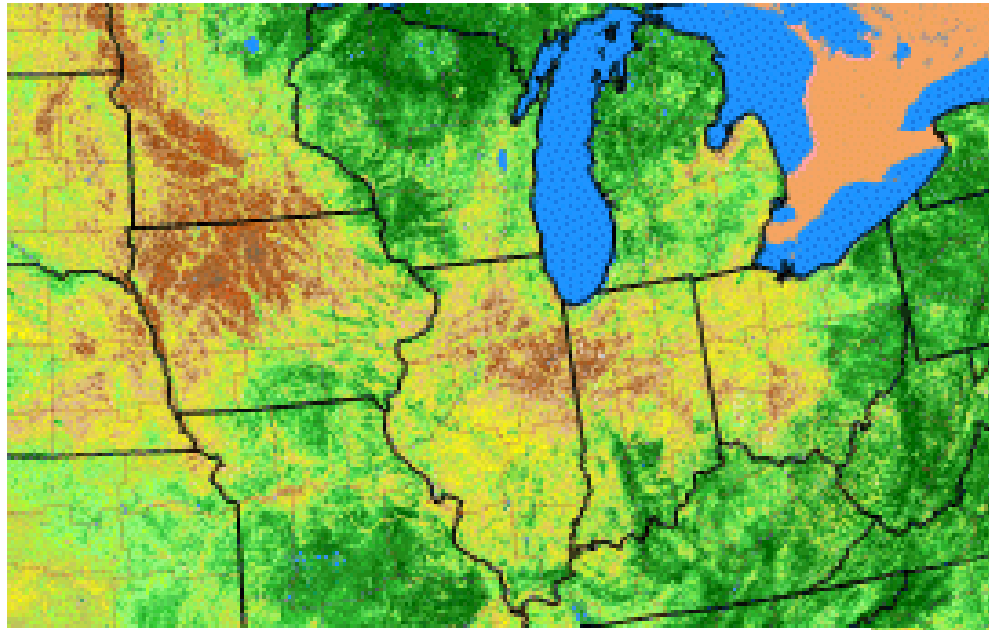
What are some of the  
consequences resulting from  
the loss of landscape diversity and  
continuous living soil covers?



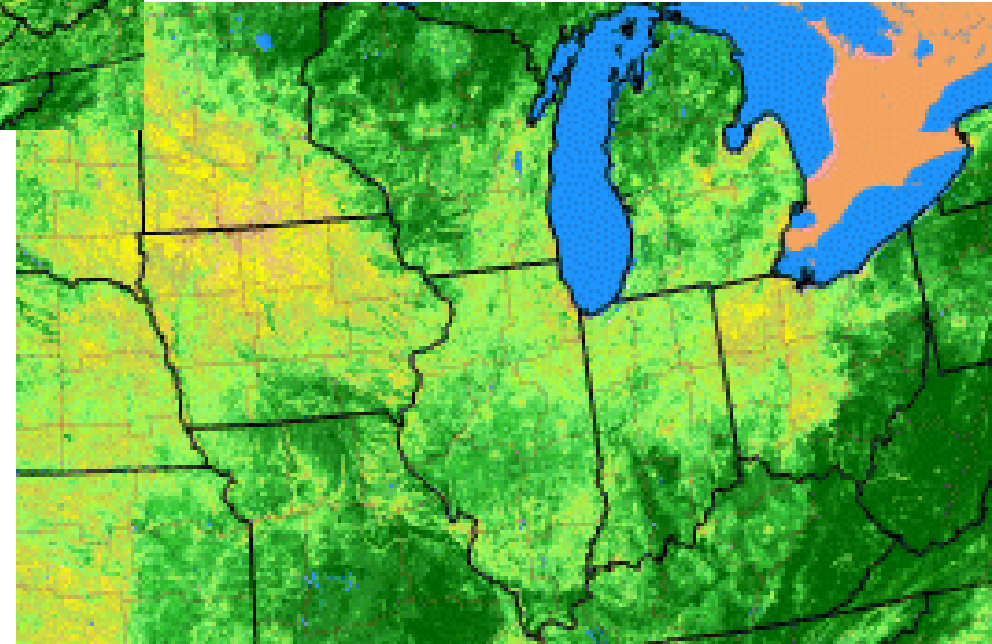
# Hypoxia in the Gulf of Mexico



Satellite images of vegetative activity.



May 18 - 31

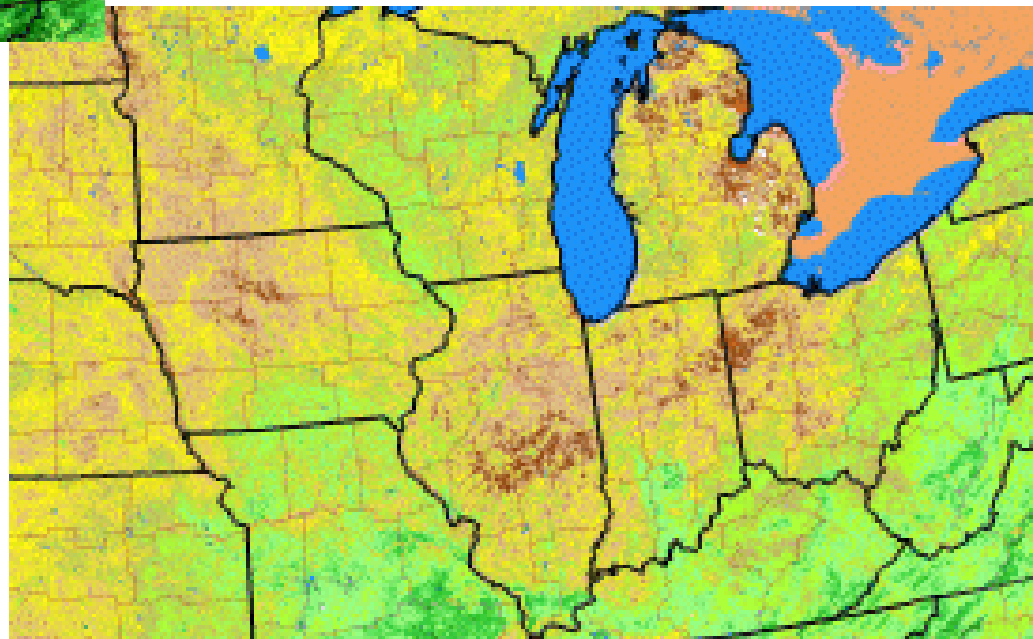


June 15 - 28

Satellite images of vegetative activity.



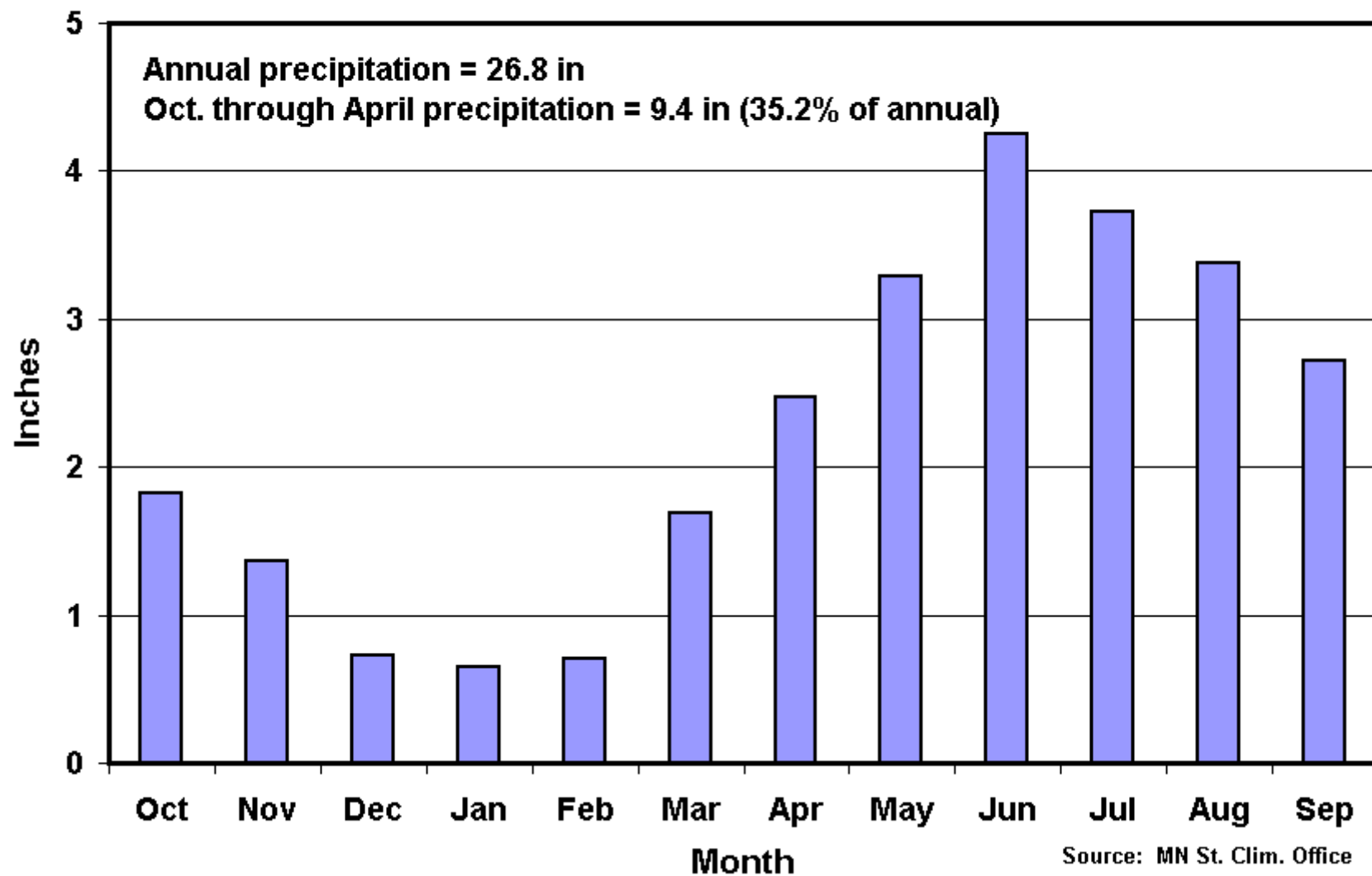
July 13 - 26



October 5 - 18

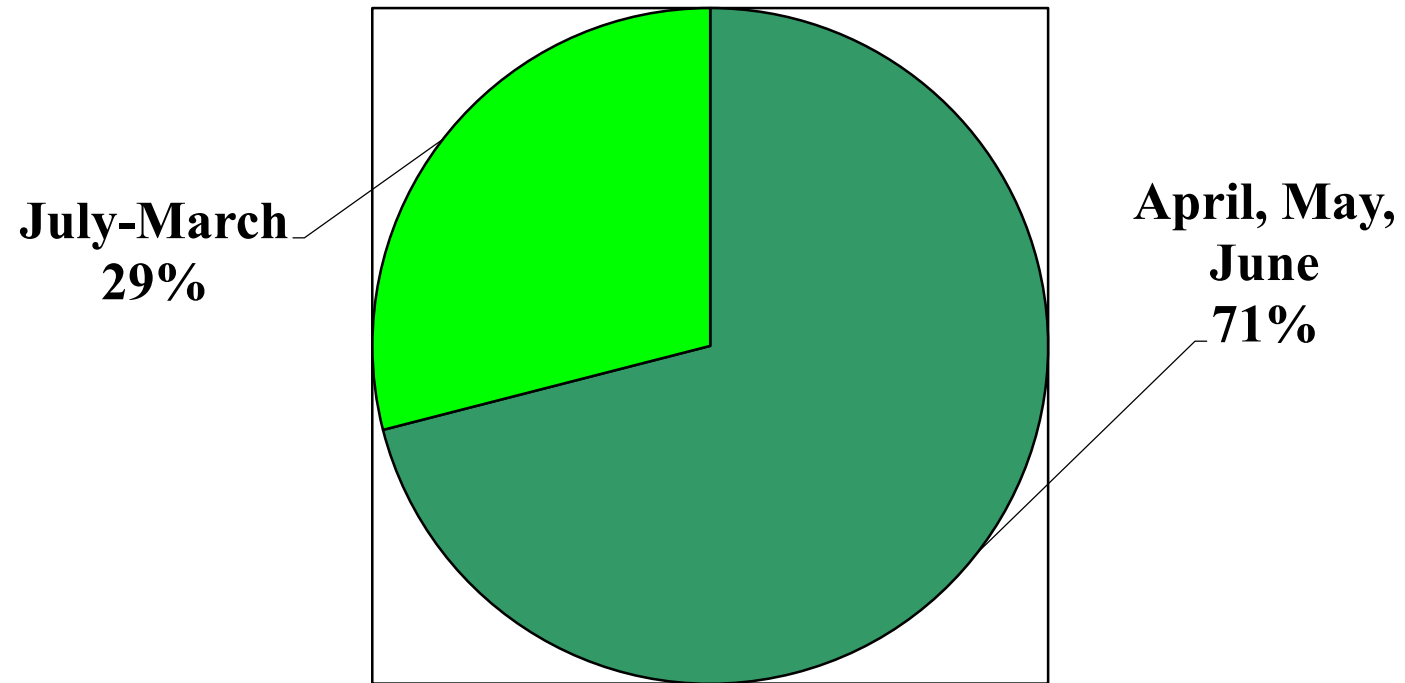
## Monthly Precipitation in the Cottonwood River Watershed

6 location average, 1939-1998

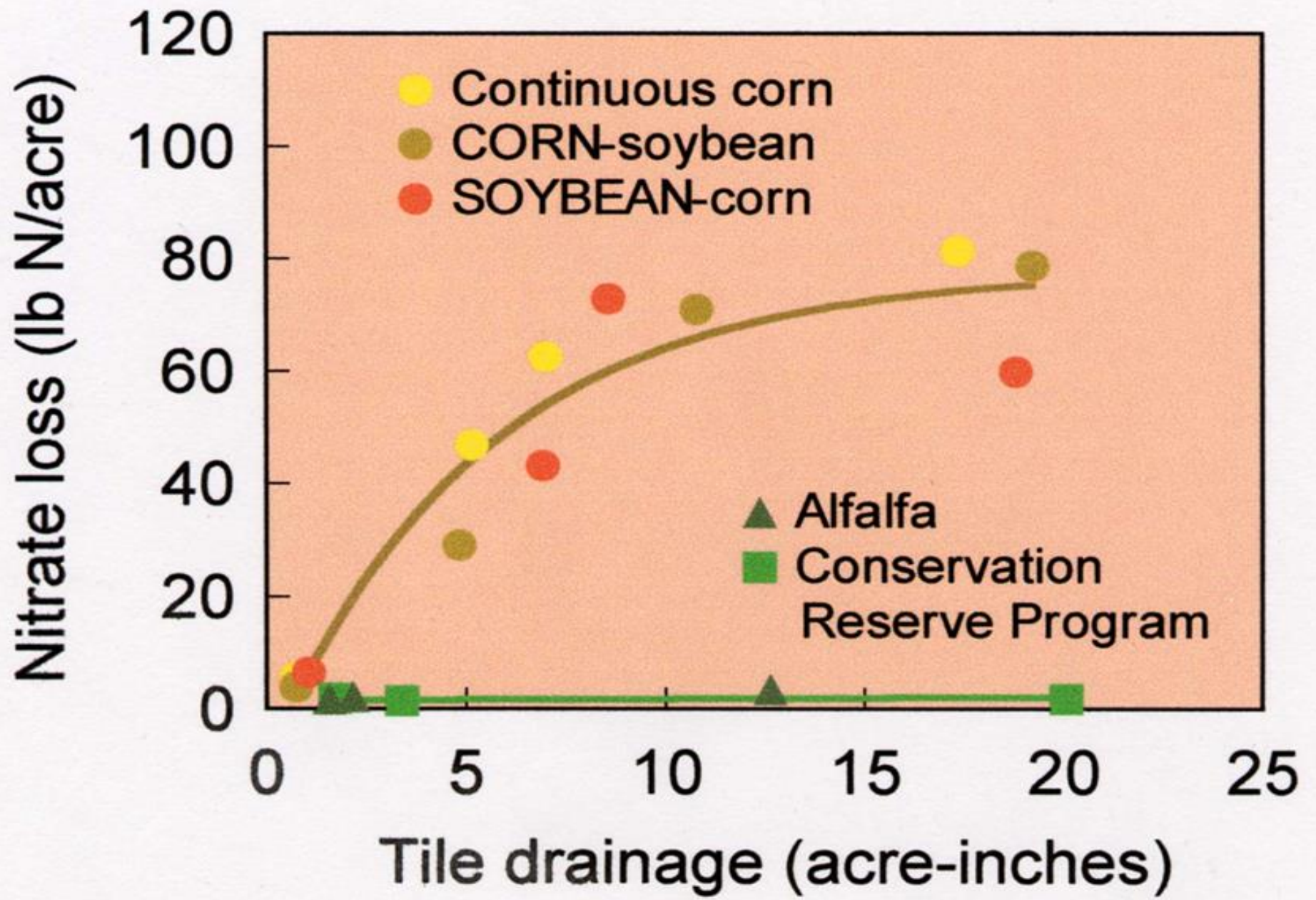


# Annual Tile Drainage Loss in Corn-Soybean Rotation

Waseca, 1987-2001

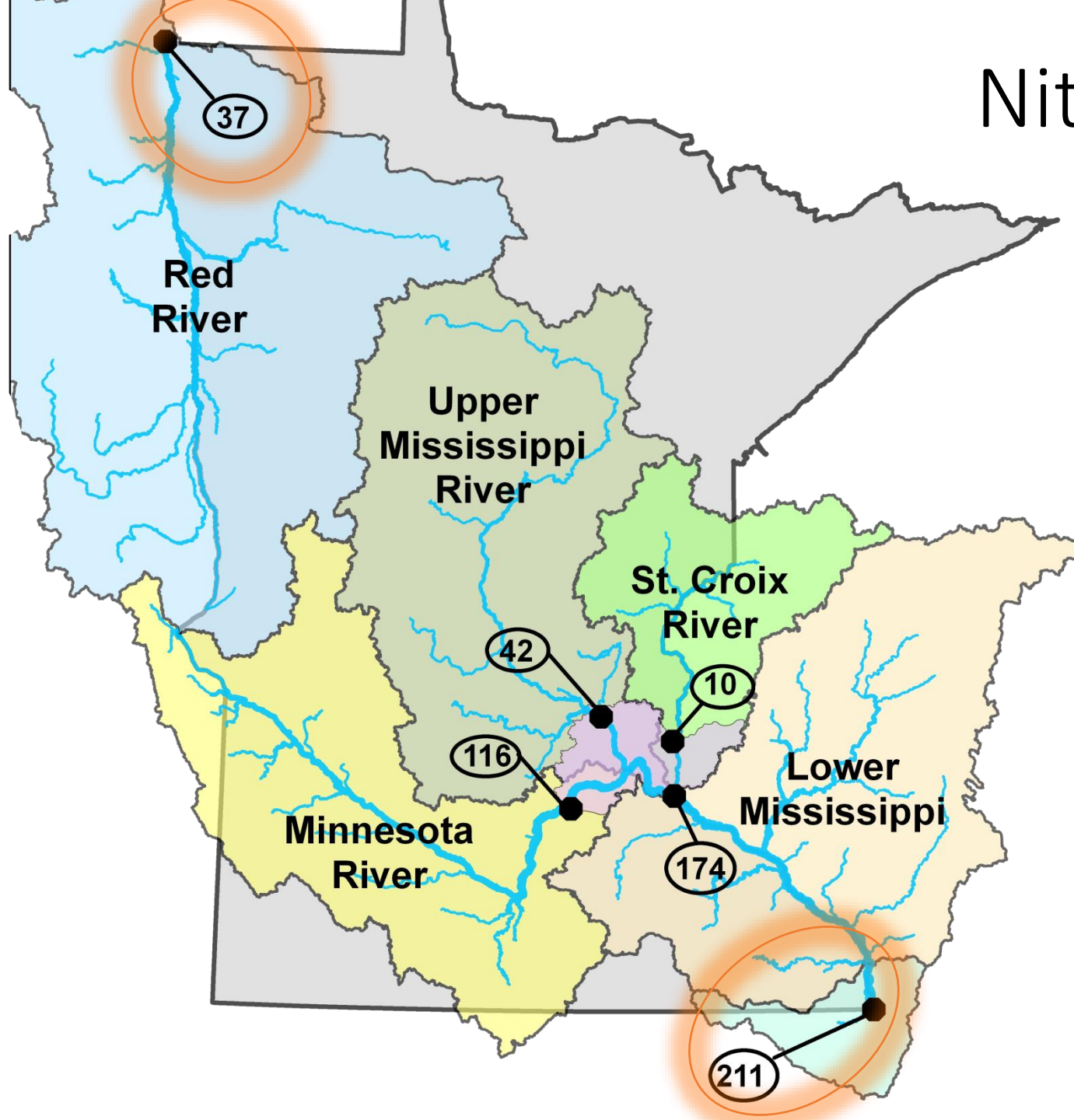




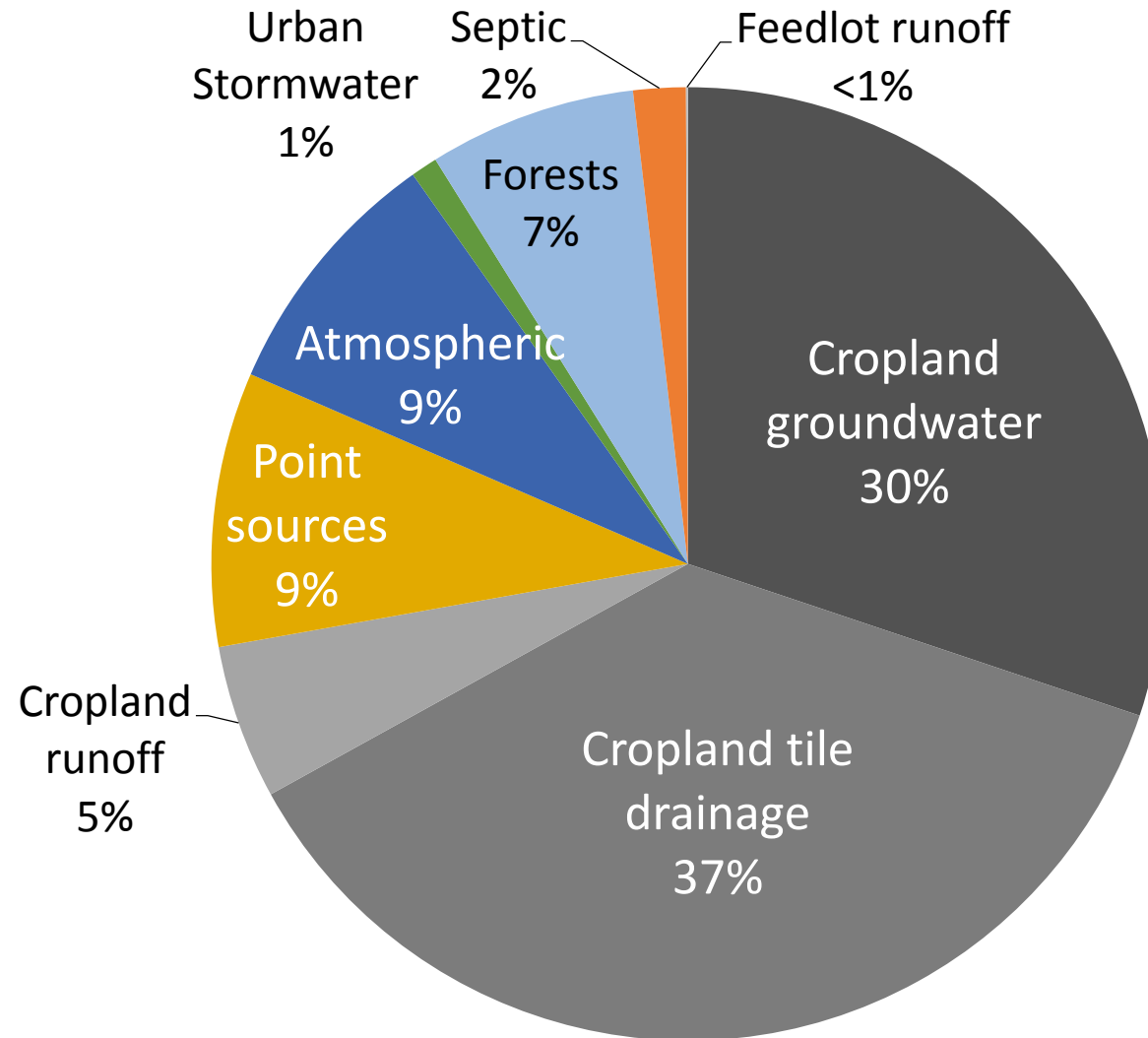


# Nitrogen Loads

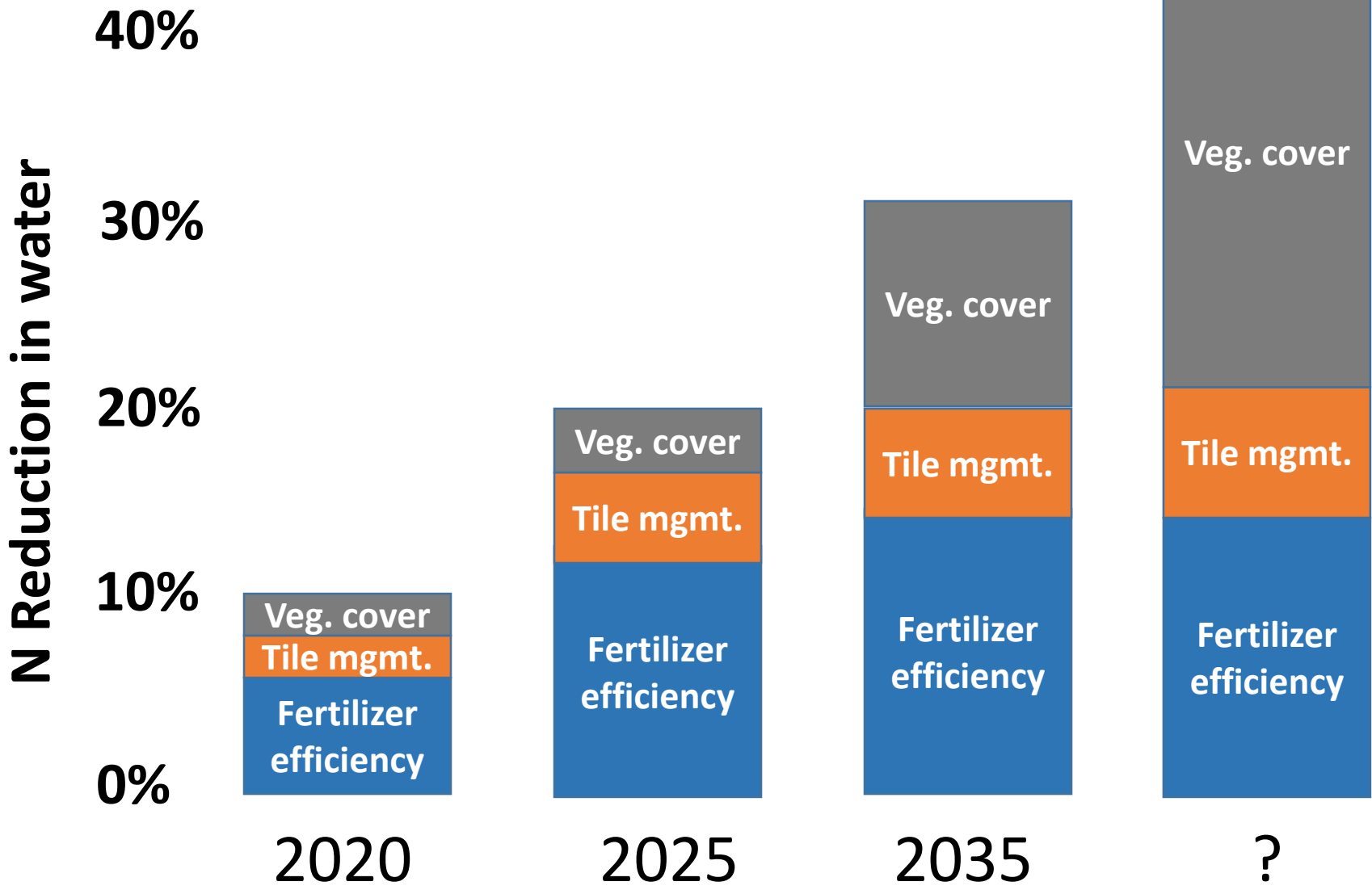
long-term average  
million lbs per year



# Statewide nitrogen sources to surface waters



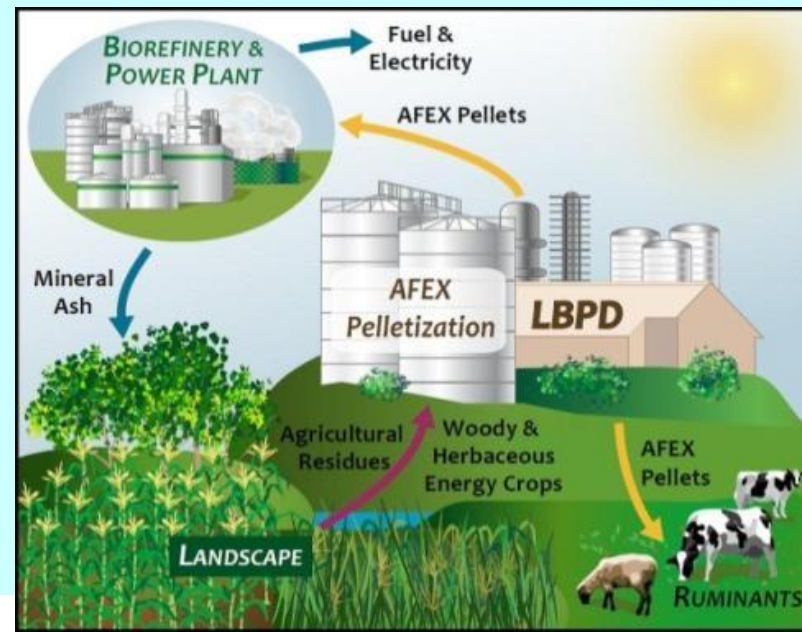
# Long Term Nitrogen Reductions



# Getting There from Here: Forever Green

**Getting perennials & winter annuals on the landscape by germplasm development, new agronomic practices, commercialization & supply-chain development**

- New genetic technologies allow rapid germplasm development
- Develop new agronomic practices (e.g. seeding tech.)
- Commercialization: new market opportunities
- Supply chains: from production to end use





## Developing New Perennial and Winter Annual Crops to Enhance Minnesota’s Soil and Water Resources

### PERENNIAL CROPS

- Intermediate wheatgrass “Kernza” – wheat-like grain, forage, biomass
- Perennial sunflower – edible seeds, oil
- Native polyculture grassland mixtures – biomass, forage, natural products
- Perennial flax – edible oil
- Kura clover – N-fixing cover crop
- Silphium – edible oil



### WINTER ANNUAL CROPS

- Pennycress – oil, biofuel, cover crop
- Camelina – edible oil, biofuel, cover crop
- Winter barley – food, malting barley
- Hairy vetch – cover crop, N-fixation

### NATIVE WOODY CROPS

- Hazelnuts – nuts, edible oil
- Shrub willow – biomass
- Elderberry – antioxidant-rich fruit
- Agroforestry – woody and herbaceous crop mixtures for feed, food and fuel



# 1. Field Pennycress

*Thlaspi arvense*

Enterprises:

Oil—biodiesel/food

Protein—food and feed

Double or relay crop with soybean

**Funding source: DOE/USDA, U of MN, MDA, Forever Green Initiative**



# ***Thlaspi arvense***

## **Pennycress**

**Brassicaceae  
(mustard family)**

**Extremely cold tolerant  
winter annual**

**Rapid seed maturity**

**High oil content**

**Double or relay cropping  
potential with soybean**

**Diploid/good breeding  
potential**





**Fall soybean with  
pennycress regrowth**



**Corn/PC/Soybean  
Rotation**



**Pennycress seeded  
into corn**



**Soybean planted  
no till into  
pennycress stubble  
1<sup>st</sup> week of June**



**Pennycress mid-  
May**



**Pennycress late fall**



5 Harvest cover over soybean



6 Summer crop grows



1 Plant cover crop in corn



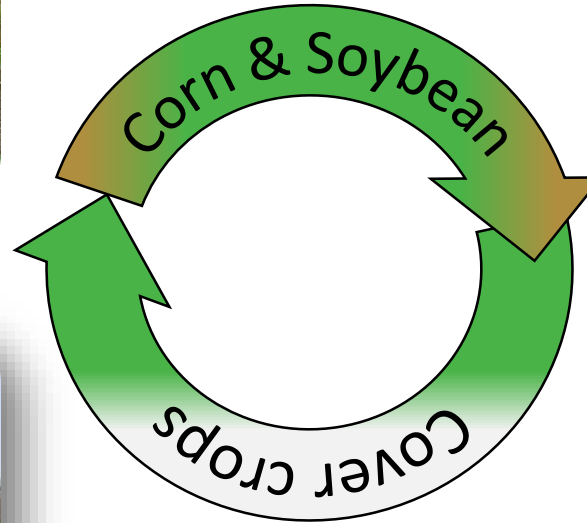
4 Plant soybean into cover crop



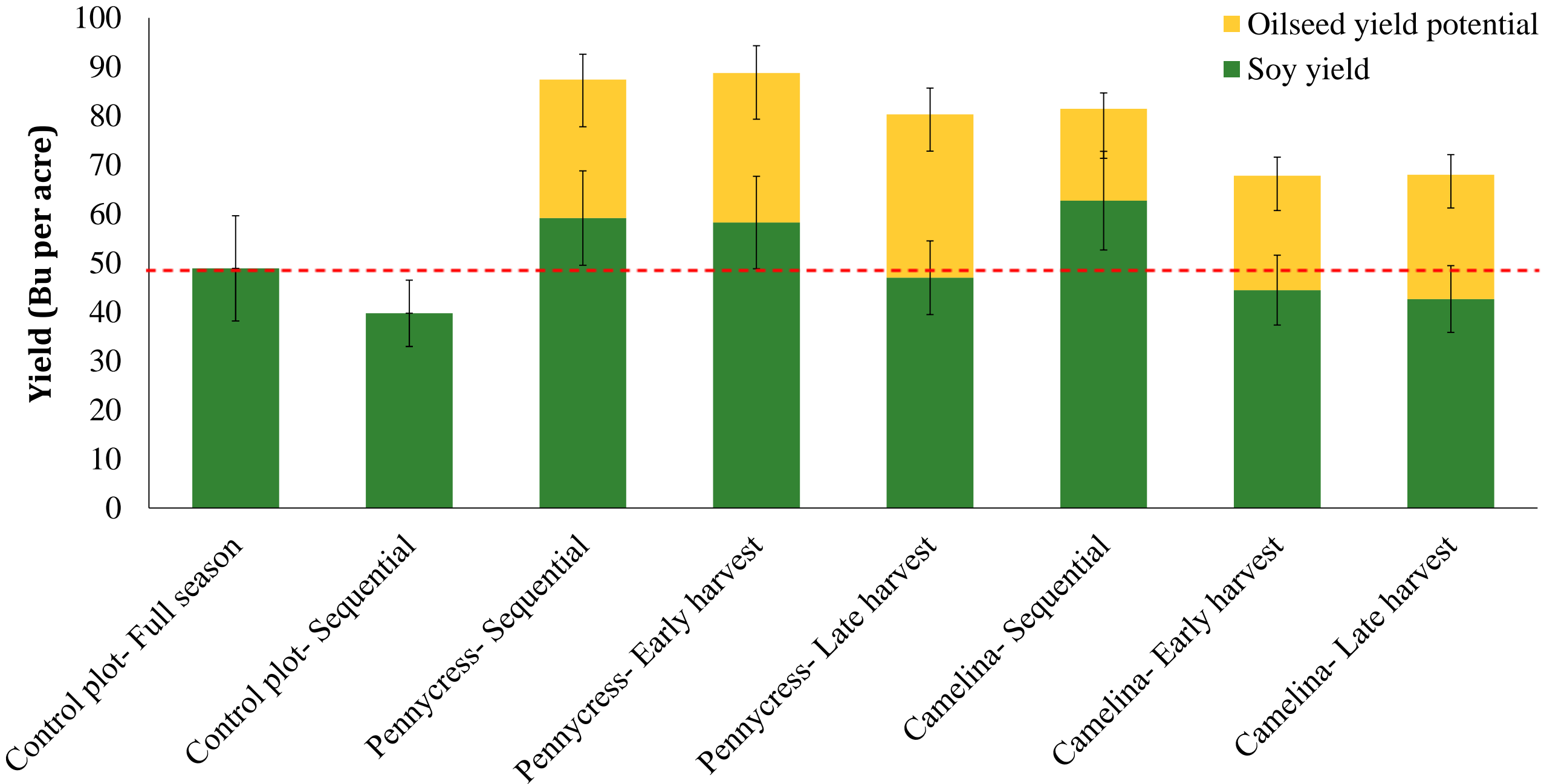
3 Cover crop lies dormant



2 Harvest corn over cover crop



# 2014 Soybean and Oilseed yield St. Paul



# 7. Intermediate Wheatgrass

Kernza™

*Thinopyrum intermedium*

Enterprises:

Beer/Whiskey

Food

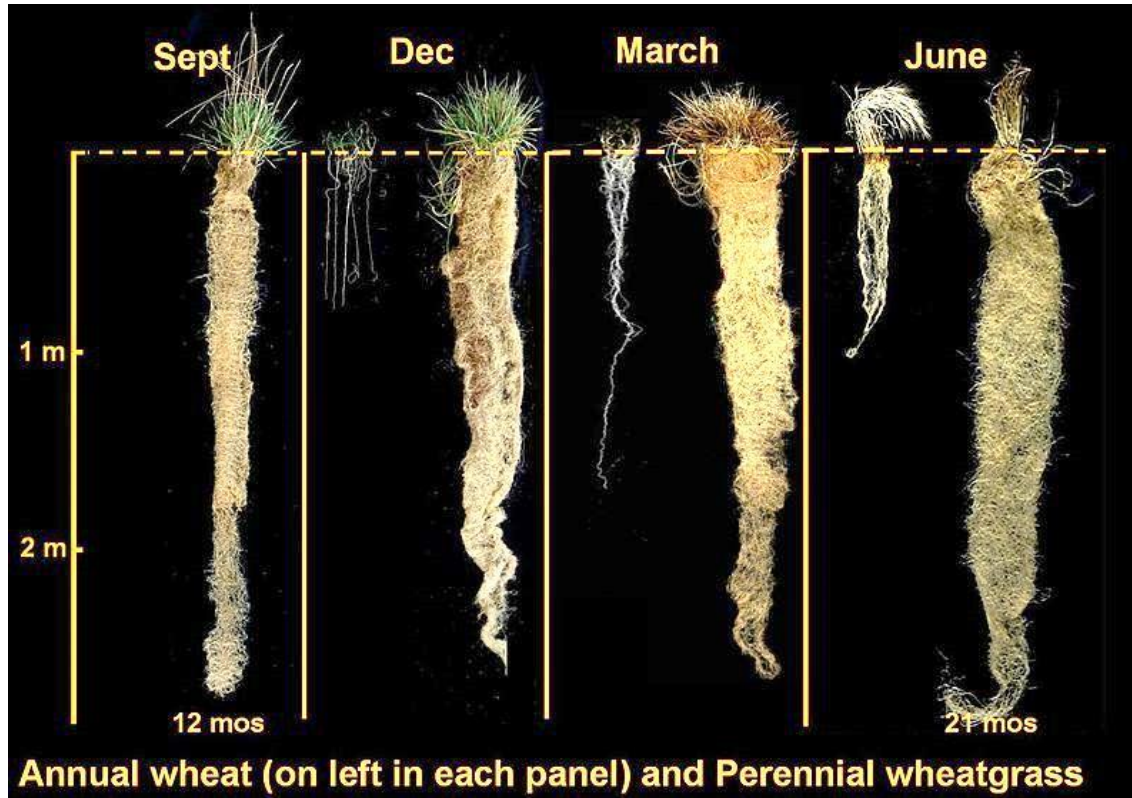
Biomass

Grazing

Funding: IREE, MDA, Forever Green  
Initiative, The Land Institute

# Intermediate wheatgrass

---- Environment services



- ◆ Reduce erosion and soil nitrate leaching
- ◆ Reduce inputs of energy and pesticide
- ◆ Increase carbon sequestration



# Intermediate wheatgrass in Minnesota



St. Paul Campus

# Intermediate wheatgrass

## ---- Agronomic traits



### Large seeds

---- 10-15g/1000 seeds



### Large biomass

---- comparably to big bluestem and switchgrass)



### Disease resistance

---- Lr38, Sr43, Sr44, Pm40, Pm43...

### Favorable end-use food

---- wheat-wheatgrass blends



# Evaluation of intermediate wheatgrass grain for **food use**

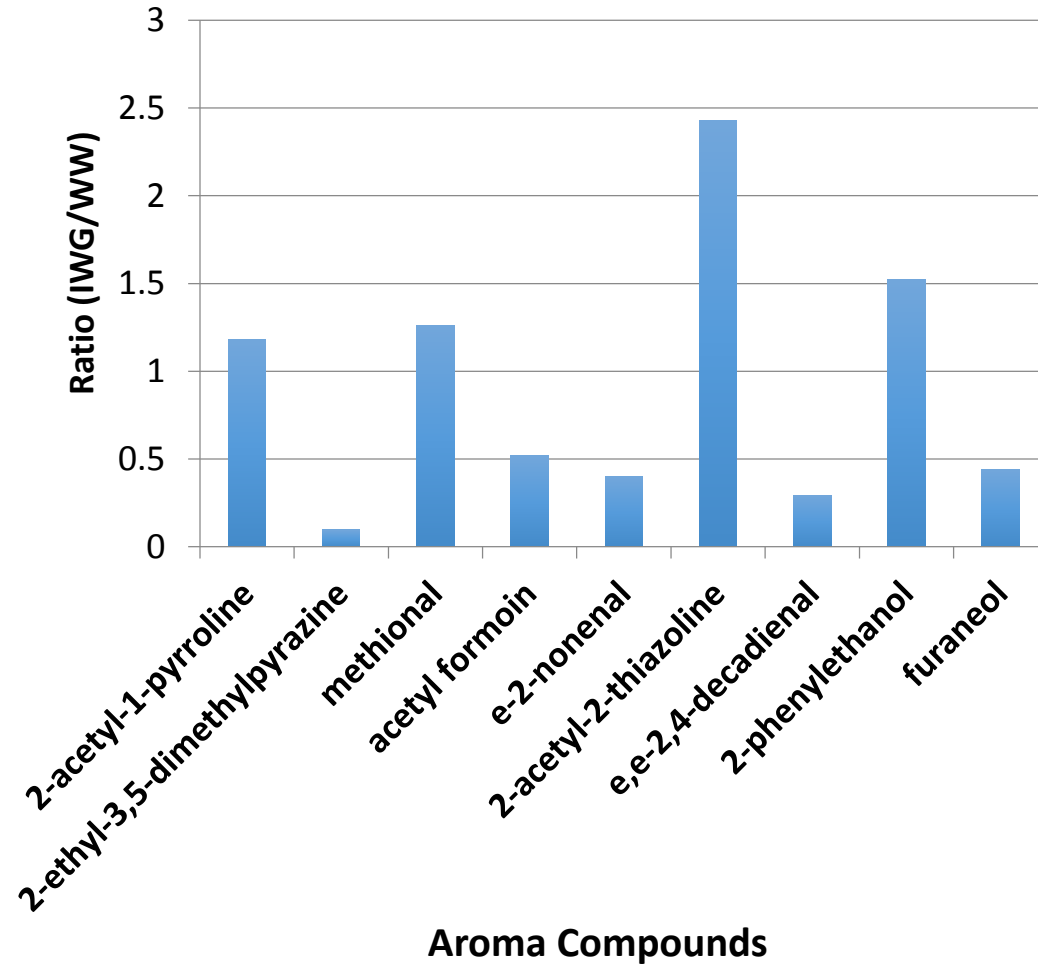


Testing





# Flavor Development in IWG



Aroma Compound	IWG Concentration (ug/kg)
2-acetyl-1-pyrroline	5.4
2-ethyl-3,5-dimethylpyrazine	0.17
methional	547
acetyl formoin	1241
e-2-nonenal	0.82
2-acetyl-2-thiazoline	37
e,e-2,4-decadienal	0.69
2-phenylethanol	32.
furaneol	2296

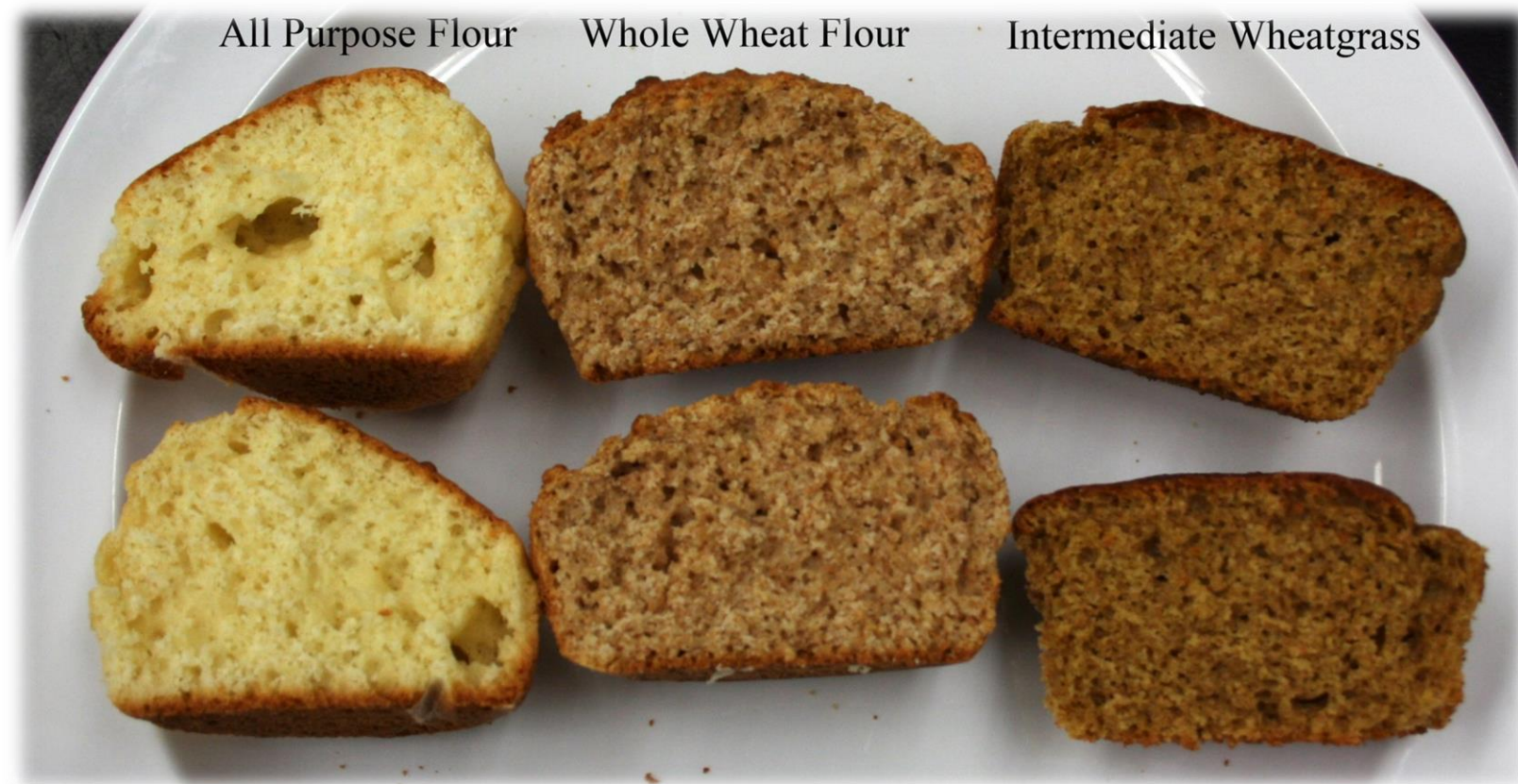
# Food products

Cookies are good



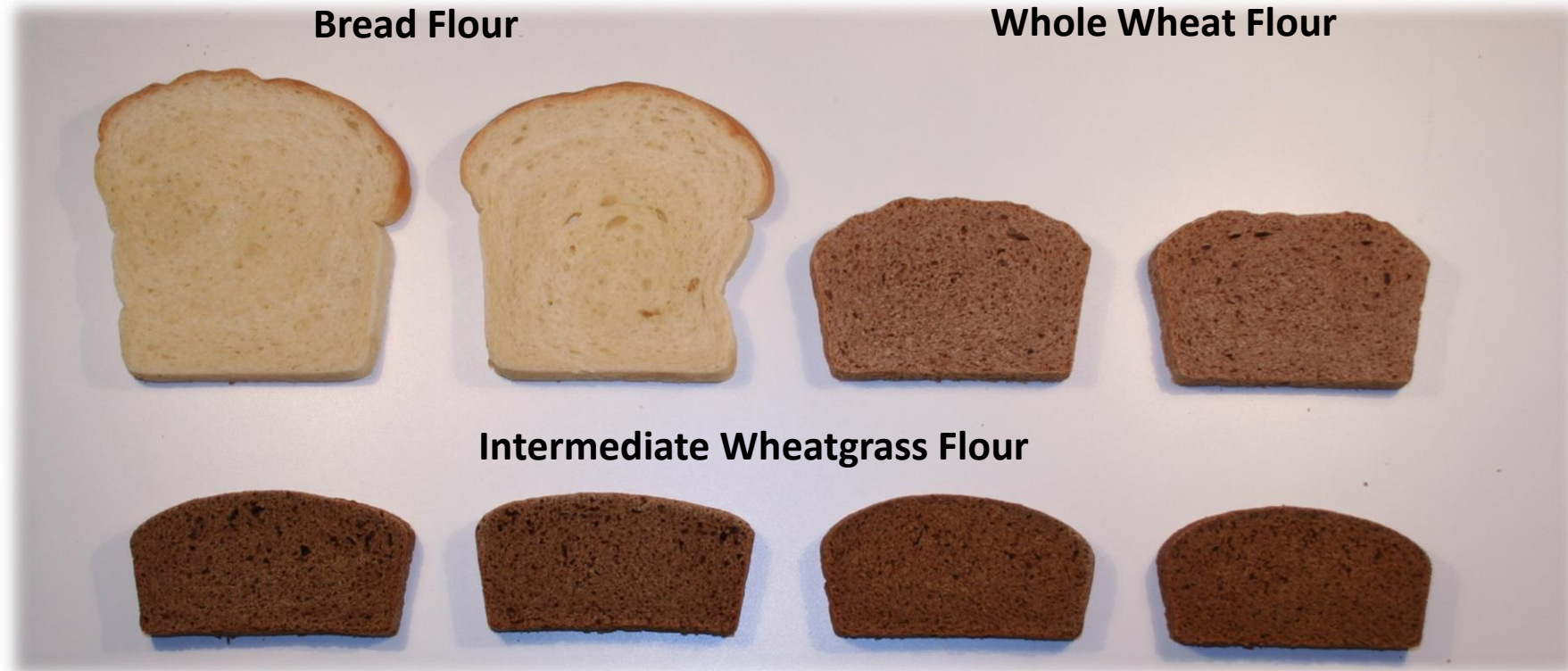
# Food products

Muffins are OK



# Food products

Yeast bread is not good alone





**However,**

**20 to 50% IWG  
produces a good  
bread product**

