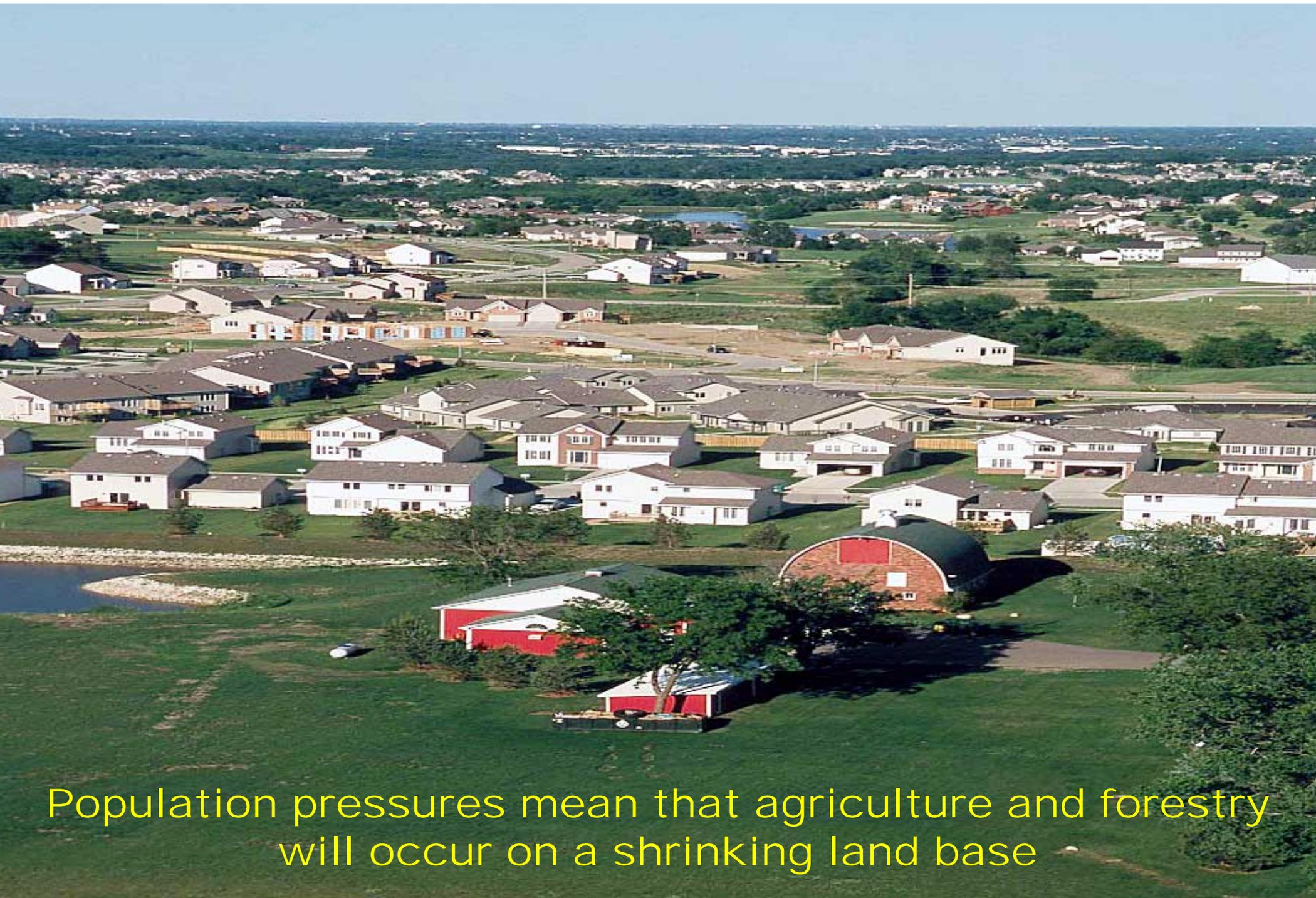


Perennial Crops for Bio-fuels and Conservation

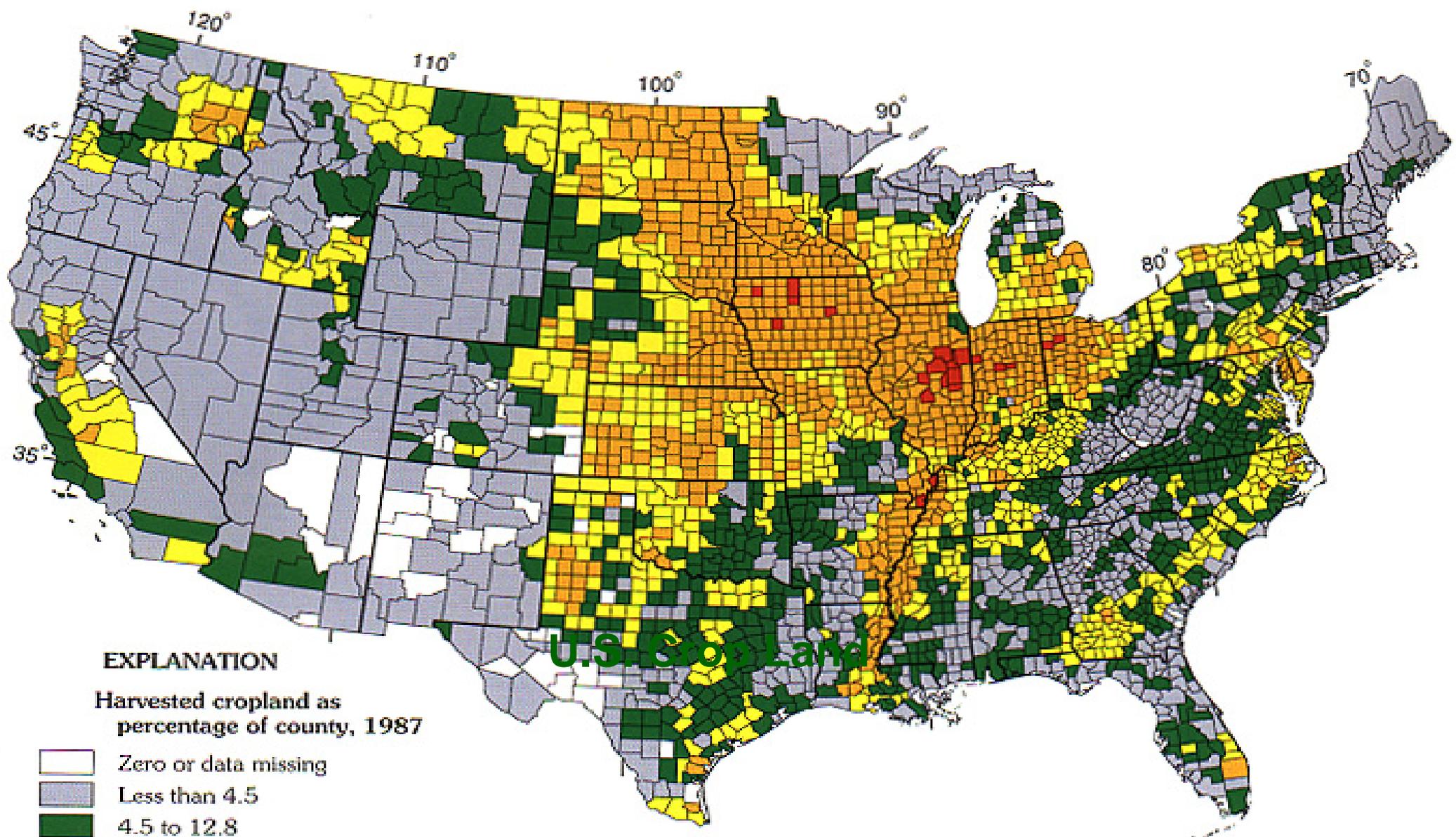


by
Dr. Greg Ruark
Director
USDA National Agroforestry Center

www.unl.edu/nac



Population pressures mean that agriculture and forestry will occur on a shrinking land base



EXPLANATION

Harvested cropland as percentage of county, 1987

- Zero or data missing
- Less than 4.5
- 4.5 to 12.8
- 12.9 to 32.9
- 33.0 to 73.0
- More than 73.0



U.S. Cropland

Between Harvest and Planting

--- bare soil for 6-7 months ---



Down on the farm!



Bank Channel Erosion



Soil Erosion



Fertilizer / Pesticide



Livestock Waste

Conservation Benefits of Trees in Agriculture



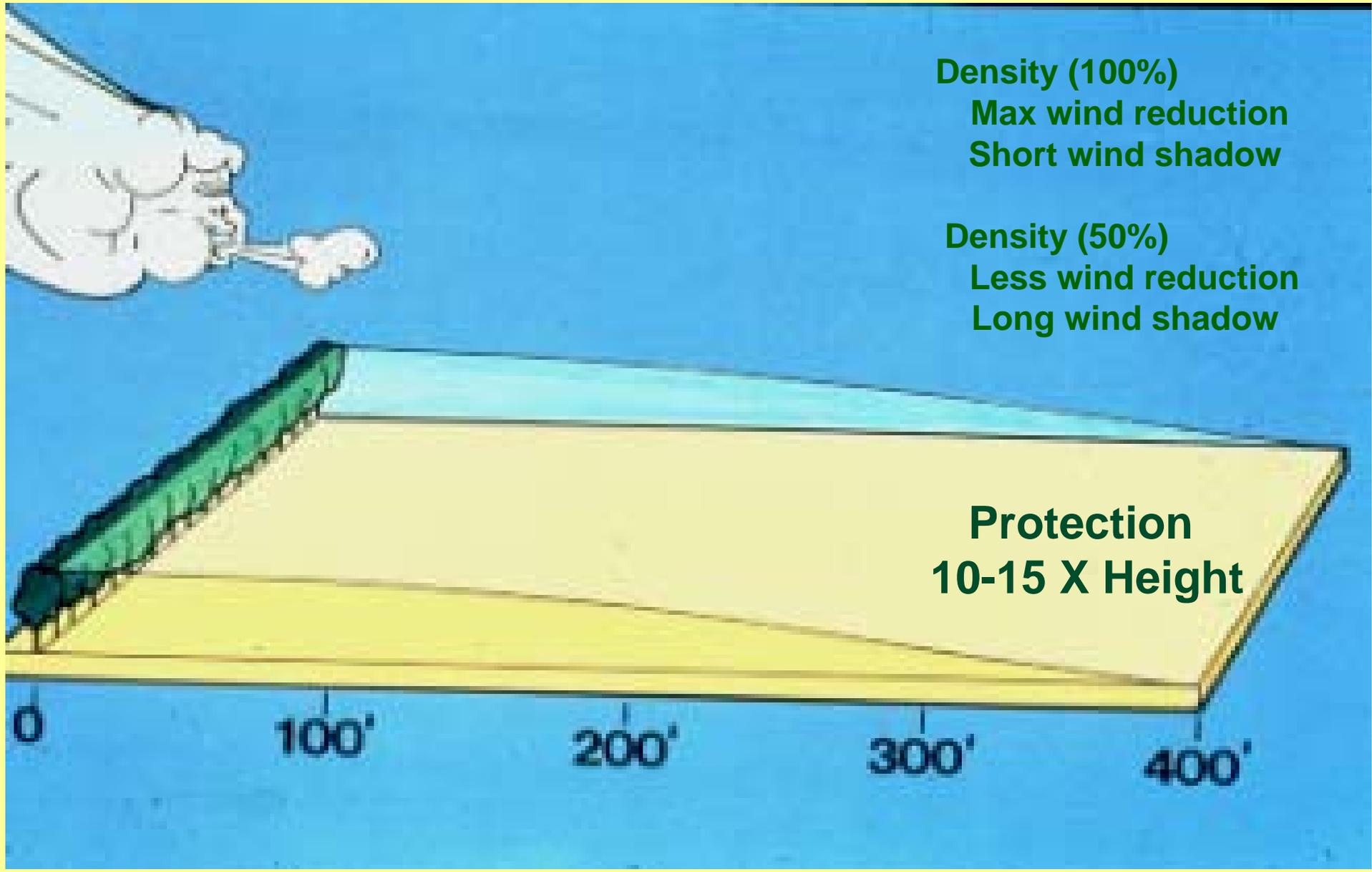
Montana 1938

Historically, windbreaks are associated with the “dust bowl” of the 1930’s.



Trees control soil erosion

MONT-10122



Density (100%)

**Max wind reduction
Short wind shadow**

Density (50%)

**Less wind reduction
Long wind shadow**

**Protection
10-15 X Height**

0 100' 200' 300' 400'



Weighted Average Yield Increase

Corn	12 %
Soybean	13 %
Winter Wheat	23 %
Spring Wheat	8 %
Hay	20 %

Trees protect crops and reduce crop evapotranspiration

Windbreaks - improve irrigation efficiency of center pivot irrigation



Living Snow Fences – manage drifting snow



Windbreaks – protect livestock



Windbreak Design for Wildlife

Habitat

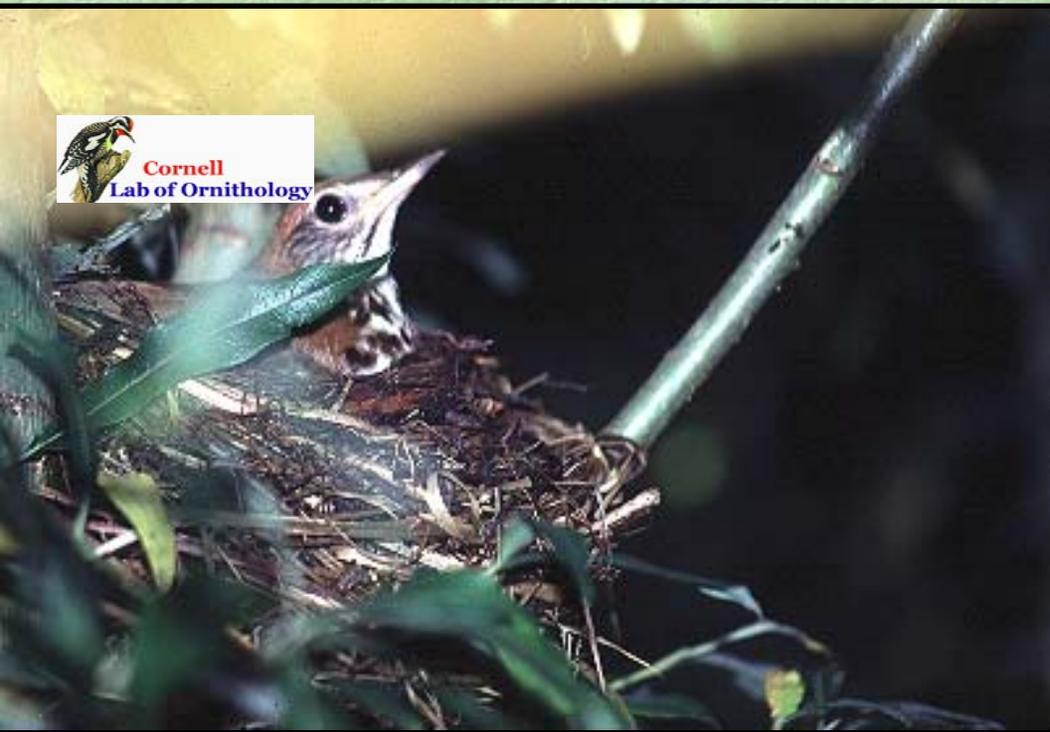
Connections

Food / Nesting

Structure



Bird Diversity in Short Rotation Woody Crops (SRWC)



Wood thrush nesting in SRWC willow

☞ 57 species used

☞ 28 species for breeding

SRWC not significantly different from:

-old fields

-deciduous forest

-suburban natural areas

(Dhondt and Wrege 2003)

Riparian Forest Buffers

Designed with trees, shrubs, and grasses to protect surface water resources from runoff.



3 Years



Conversion Efficiency

Wood has high hemi-cellulose and cellulose content

Willow - Net energy ratio

1:11 co-fired with coal
1:16 gasification

Corn < 1:1.3

Some Perennial Production Systems:

- **Hybrid Poplars**

 - Large Plantations

 - Agroforestry Timberbelts

- **Willows**

 - Large Plantations

Hybrid Poplar



Hybrid Poplar Plantations



**Yields in excess of 5dt/ac/yr
350gals/ac/yr ethanol**

If planted 38 million acres of CRP:

3 quads/yr

(2X annual estimate from using all forest logging residue)



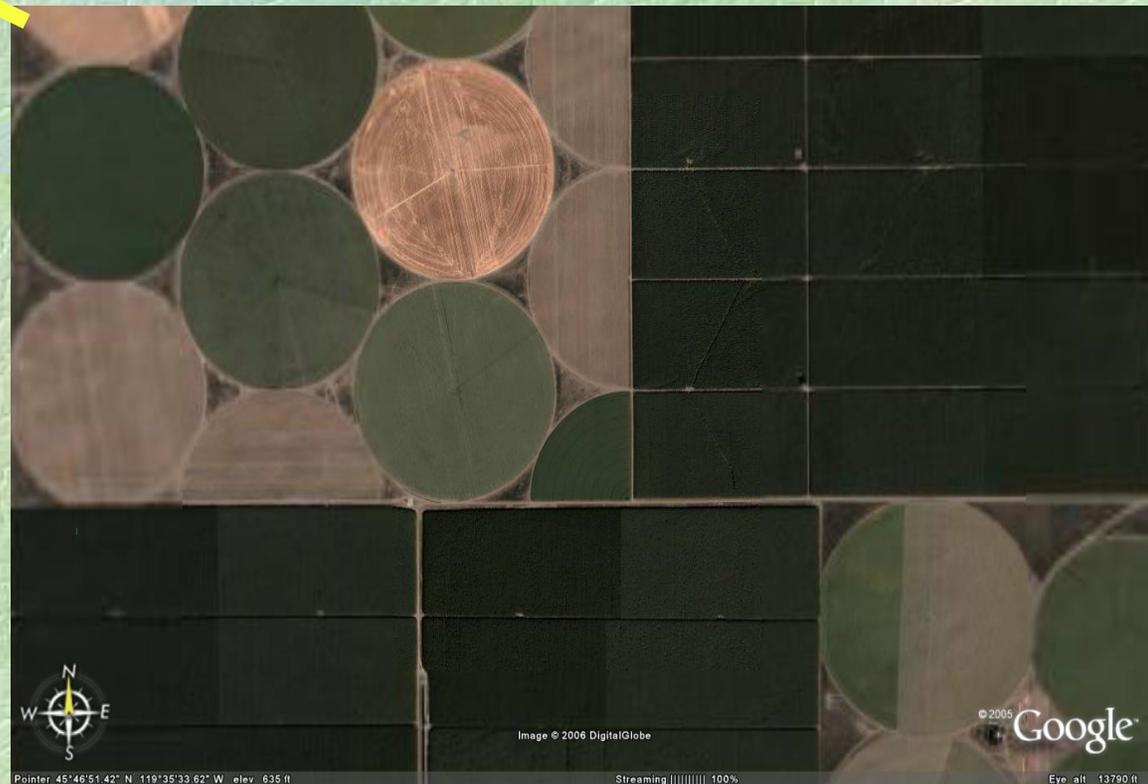
**In 2025, an estimated 24 quads will
be needed for gasoline**

Plantations are Kyoto accountable



Satellite images of eastern Oregon showing:

small grain crops under center pivot irrigation and, 50,000 acres of hybrid poplars under trickle irrigation.



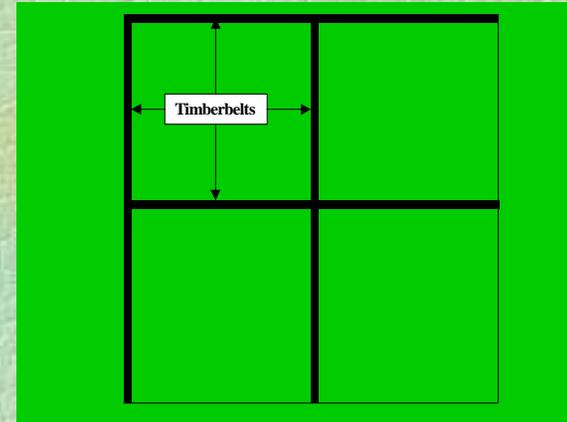
Timberbelts are multiple row, multipurpose windbreaks planted to fast growing trees



Three Timberbelt Scenarios

- **10-Row on field edges**

(52% wind protection)

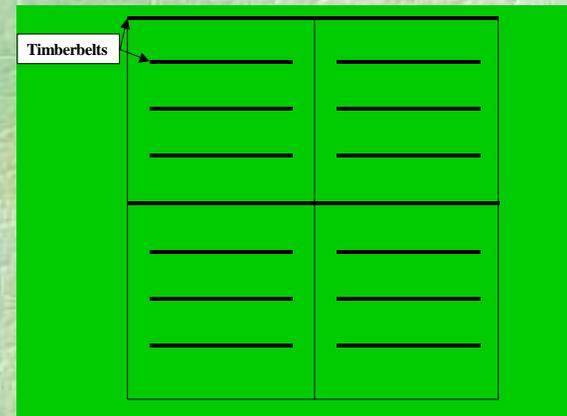


- **5-Row within field**

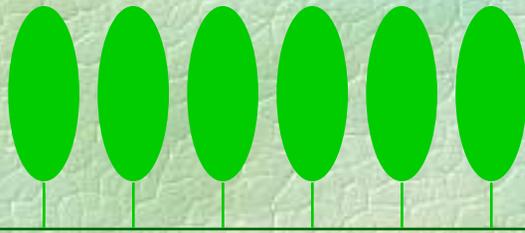
(98% wind protection)

- **2-Row within field**

(91% wind protection)



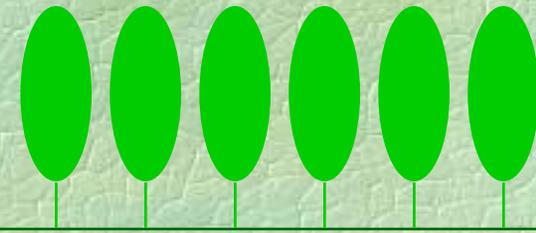
Harvesting Timberbelts for Continuous Wind Protection



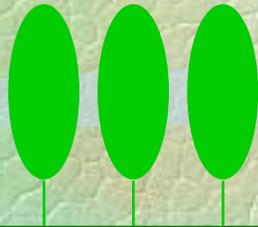
Established Timberbelt

Protected Annual Crops

←10-15 times mature tree height→



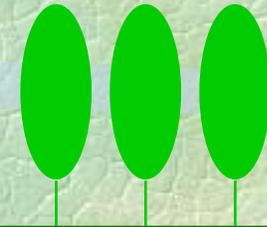
Established Timberbelt



Harvested
Trees

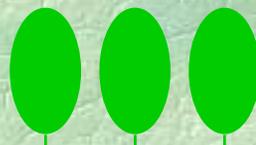
Protected Annual Crops

←10-15 times mature tree height→



Harvested
Trees

Harvested
Trees

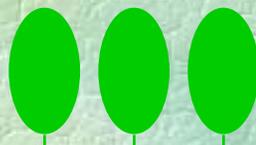


Coppice

Protected Annual Crops

←10-15 times mature tree height→

Harvested
Trees



Coppice

Willows...

Harvested at age 3

15-25 ft. height

7-8 coppice cycle

Non-irrigated

3.4 - 4.6 dt/ac/yr in New York

2nd rotation increased 18-62%

Irrigated

10.8 dt/ac/yr

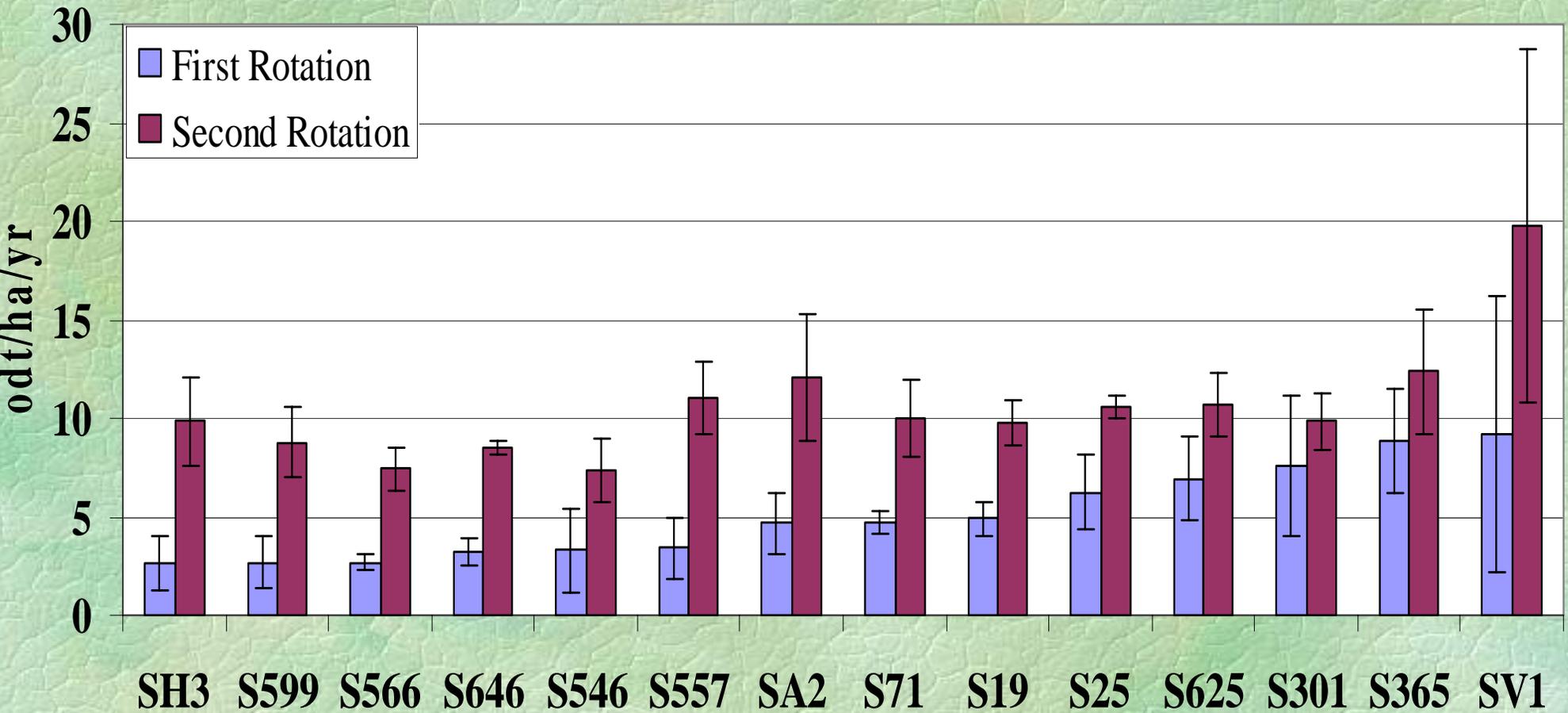
North America

12.0 dt/ac/yr

Europe



First and Second Rotation Yields, Massena NY



(Volk et al. 2001)

Each MW of power from cofiring willow:

- ✓ **Avoids 7,000 tonnes of net CO₂ emissions**
- ✓ **Avoids 60 tonnes of SO₂ emissions**
- ✓ **Avoids 6 tonnes of NO_x emissions**

Dunkirk steam station has been retrofitted to cofire woody biomass and coal.

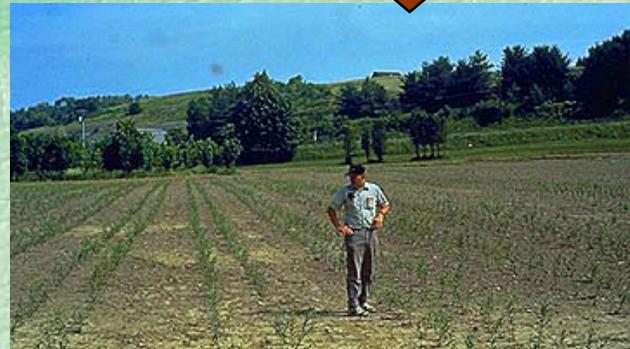


Model SRWC - Willow

Site Preparation

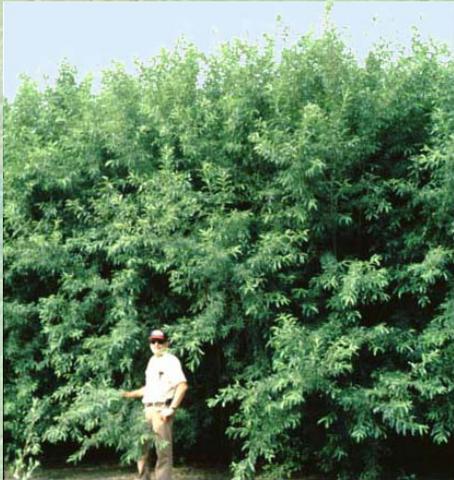


Planting

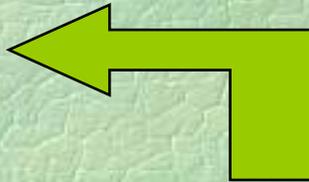


First year growth

Harvest



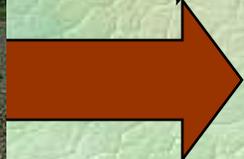
Three years old after coppice



One year old after coppice



Coppice



Early spring after coppicing

SRWC Research Needs...

- **Operational production systems for plantation and agroforestry approaches**
- **Optimizing growth allocation for specific plant constituents (ie cellulose vs. lignin)**
- **Feedstock production, harvesting, and handling**
- **Soil sustainability and other environmental factors, like wildlife and water quality**

Conclusion...

A variety of approaches will be needed to meet our nations future energy demands...

Short rotation woody crops, like poplar and willow trees, when grown on agricultural lands can contribute significantly.