

# Crop Residue as a Bioenergy Feedstock: Effects on Soils



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# Fossil Fuel Alternatives Needed!

- National security
- Environmental concerns
- Renewable energy sources desired



# Residue harvest:

- Improved conversion technology
- Inexpensive for energy plants
- Added farmer income
- Abundant in some systems

US Grain and Residue Production for Four Crops, 2000-2002 average

	<b>Corn</b>	<b>Winter Wheat</b>	<b>Spring Wheat</b>	<b>Grain Sorghum</b>
Grain (mill. bu)	9,477	1,357	488	452
<b>Residue (mill. tons)</b>	<b>265.3</b>	<b>69.2</b>	<b>19.0</b>	<b>13.5</b>
Energy (quads)	4.0	1.0	0.3	0.2

- Nelson, 2003

# Residue Ecosystem Services

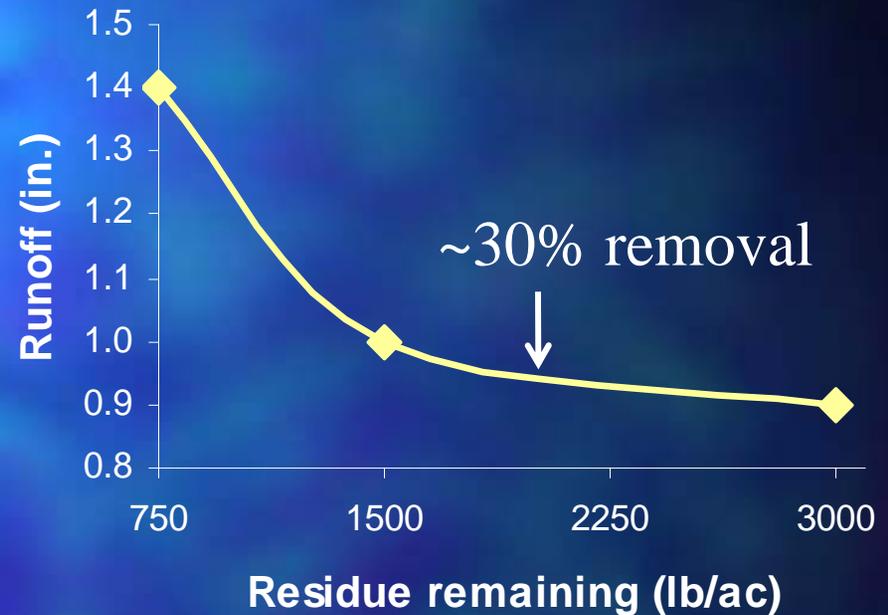
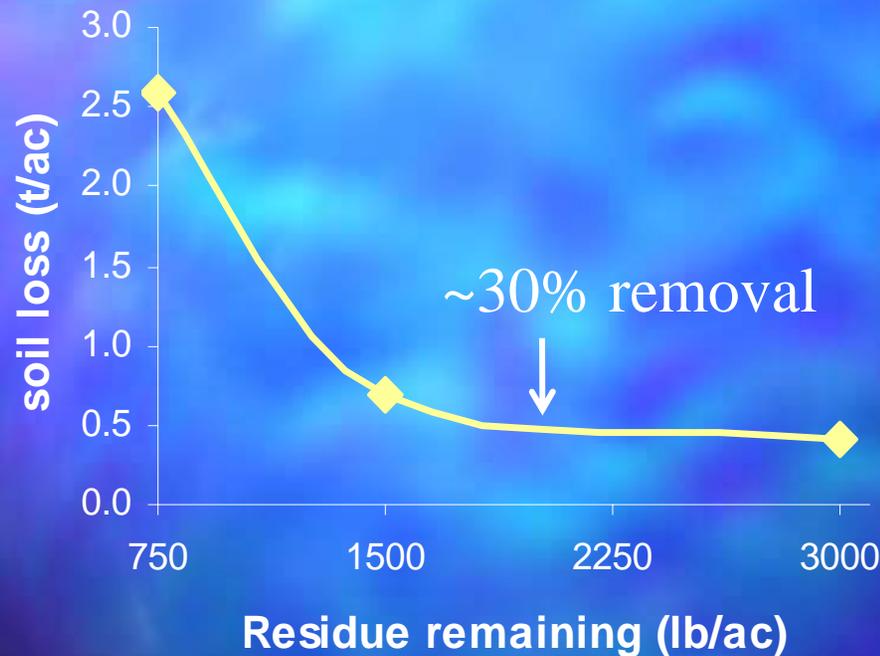
- Protection from soil erosion
- Increased soil organic matter (SOM) and plant-available nutrients
- Increased biological activity
- Increased yields

-after Hargrove, 1991

# Presentation Overview

- Review research on soil effects
- Discuss recommendations
- Outline research needs

# Residue Effects: Erosion

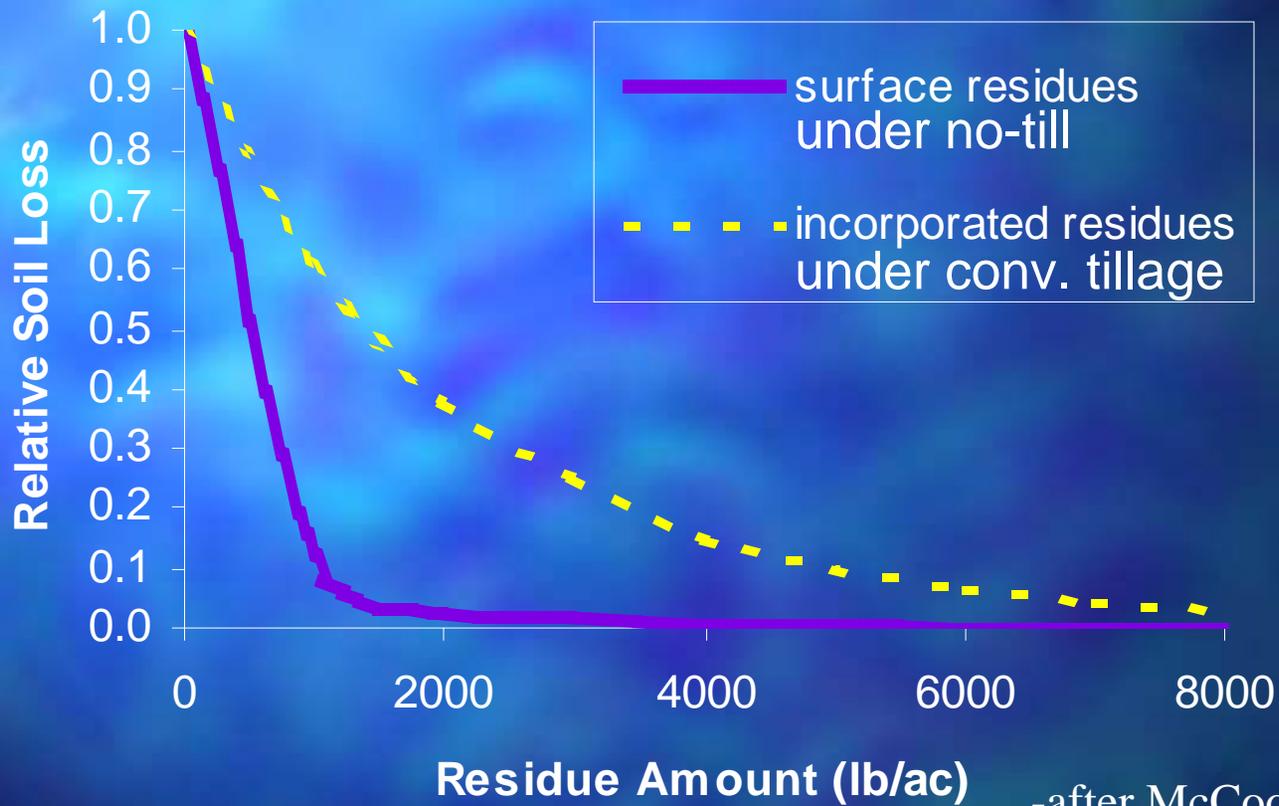


-after Lindstrom, 1986

This exact relationship varies with tillage & soil type

- Benoit and Lindstrom, 1987

# Residue Effects: Erosion



Residue removal requires conservation tillage!

# Residue Effects: SOM & Nutrients

- Net losses of soil nutrients when residue is removed  
–Holt, 1979; Lindstrom, 1986
- SOM higher with residue
  - under no-till  
–Reicosky et al., 2002
  - added N fertilizers  
–Dick et al., 1998
  - Clapp et al., 2000
- Cooler, drier climates allow more C accrual than warmer wetter ones  
–Potter et al. 1998

# Residue Effects: Biological and Physical Effects

- Soil organisms

- Reduced earthworms, microbes

-Karlen et. al., 1984

- Wildlife food & habitat

-NRCS, 2004

- Effects on soil pathogens vary

- Physical properties

- higher bulk density

-Clapp et al., 2000

- lower aggregate stability

-Karlen et al., 1994

# Residue Effects: Yield

## ■ Available Water

- Residue increased water conservation, soil moisture  
-Power et al., 1986; Sauer et al, 1996
- Higher yield in dry years with residue -Linden et al., 2000

## ■ Soil Temperature

- Lower soil temperatures decreased germination  
-Swan et al., 1987, Dam et al., 2005
- Issue in poorly drained, fine textured soils  
-Benoit & Lindstrom, 1987

# Other Effects: Economic Trade-offs

- Potential long-term yield loss
- More field passes & fuel use
- Opportunity Costs:
  - C trading
  - Conservation Programs
  - Other uses



# Recommendations

- Guidelines for residue removal rates
- Additional Conservation Practices
- Alternative Crops
- Periodic monitoring and assessment

# Removal Guidelines

Sustainable harvest amounts will vary by:

- Management practice →
- Crop & yield →
- Climate →
- Topography →
- Soil type →

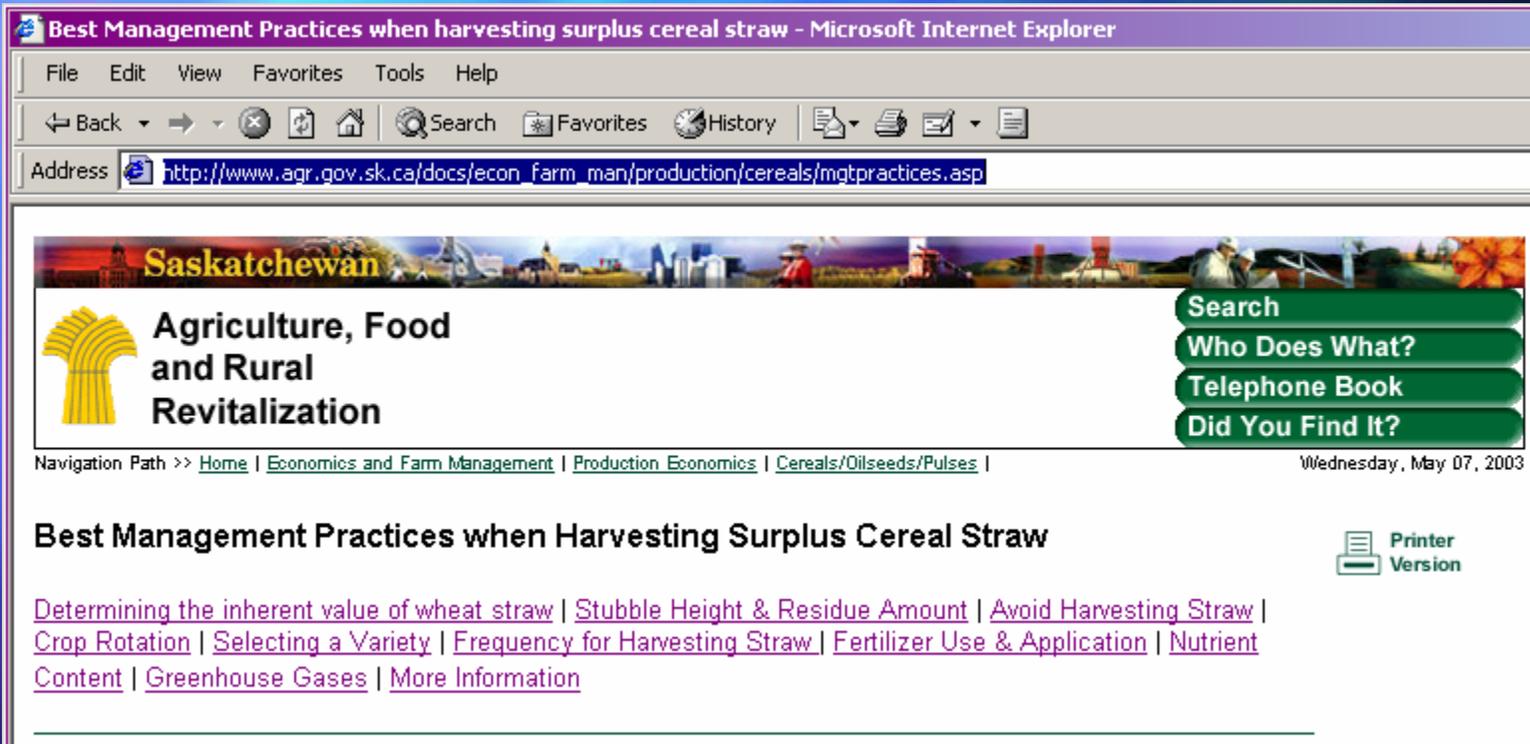
Harvest rates need to decrease with:

- Increased soil disturbance
- Lower yield or lower C:N
- Warmer, wetter climate
- Greater slope
- Coarser soil texture

# Potential Guideline Tools:

- Informational Tools
- USDA-NRCS Practice Standards
- Erosion Models (RUSLE2, WEQ, WEPP)
- Carbon models  
(Soil Conditioning Index - SCI)

# Guidelines: Informational Tools



The screenshot shows a Microsoft Internet Explorer browser window. The title bar reads "Best Management Practices when harvesting surplus cereal straw - Microsoft Internet Explorer". The address bar contains the URL: [http://www.agr.gov.sk.ca/docs/econ\\_farm\\_man/production/cereals/mgtpractices.asp](http://www.agr.gov.sk.ca/docs/econ_farm_man/production/cereals/mgtpractices.asp). The main content area features a banner for "Saskatchewan Agriculture, Food and Rural Revitalization" with a search bar and navigation buttons: "Search", "Who Does What?", "Telephone Book", and "Did You Find It?". Below the banner is a navigation path: "Home >> [Home](#) | [Economics and Farm Management](#) | [Production Economics](#) | [Cereals/Oilseeds/Pulses](#)". The date "Wednesday, May 07, 2003" is displayed in the top right. The main heading is "Best Management Practices when Harvesting Surplus Cereal Straw" with a "Printer Version" link. A list of links follows: [Determining the inherent value of wheat straw](#) | [Stubble Height & Residue Amount](#) | [Avoid Harvesting Straw](#) | [Crop Rotation](#) | [Selecting a Variety](#) | [Frequency for Harvesting Straw](#) | [Fertilizer Use & Application](#) | [Nutrient Content](#) | [Greenhouse Gases](#) | [More Information](#).

[http://www.agr.gov.sk.ca/docs/econ\\_farm\\_man/production/cereals/mgtpractices.asp](http://www.agr.gov.sk.ca/docs/econ_farm_man/production/cereals/mgtpractices.asp)

# Guidelines: USDA-NRCS Residue Management Practice Standards (329 a,b,c)

- Vary by tillage
- Use RUSLE2 & SCI
- Could include harvest maximums

# Guidelines: Erosion Model Use

Nelson (2002):

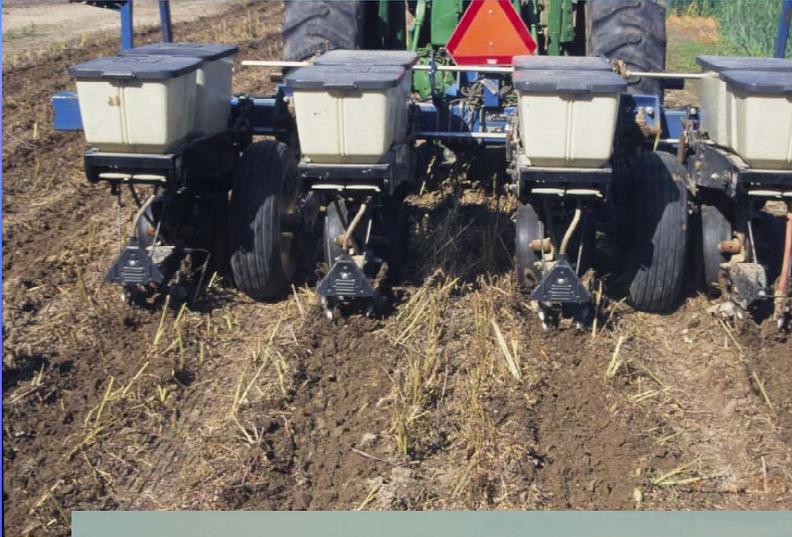
- Criteria included meeting T
- Used RUSLE & WEQ
- Determined residue availability to be:
  - 43 million tonnes of corn stover
  - 8 million tonnes wheat straw
- Identified critical areas

# Guidelines:

## Soil Conditioning Index (SCI)

- Predicts organic matter trends
- Embedded in RUSLE2
- Based on three components
  - Organic material produced (or added)
  - Field Operations
  - Erosion

# Additional Conservation Practices



NRCS



Soil Quality Team

# Alternative Crops

Dedicated energy crops:

- more environmentally benign

-Giampietro et al., 1997

- Use perennials on marginal lands

-Paine et al., 1996



# Periodic monitoring & assessment

- Visual monitoring for increased erosion
- SOC checked as part of fertility tests
- Use adaptive management



# Research Needs

- Variable rate harvesters
- Systems modeling
  - Linking C-dynamics and soil erosion
  - Adding alternative practices
  - Validation!!!
- Monitor long-term removal effects
- Continued research on dedicated, perennial bioenergy crops

–Mann et al., 2002

# Research Needs continued...

## Guidelines for Residue Removal

- Simple decision aid
- Practical to apply
- Educational
- Based on crop, climate, soil and management



I speak for  
the SOILS!



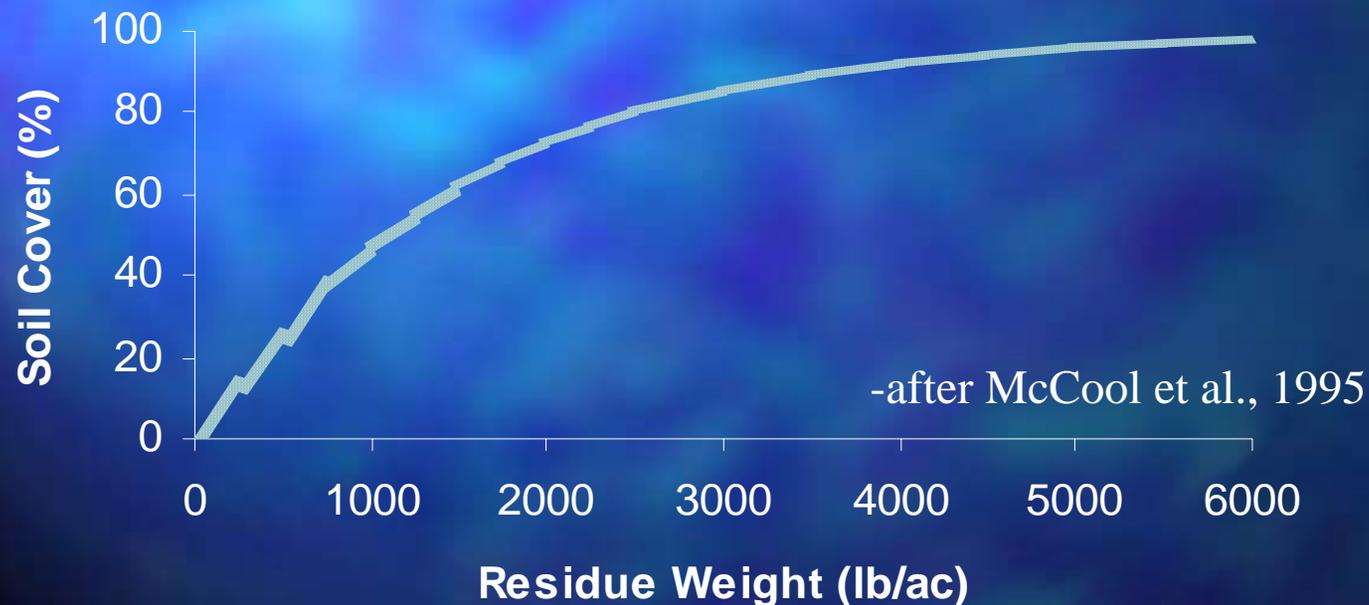
**THE  
END**

**The Lorax**

By Dr. Suess

# Research Needs: Plant Data

% soil cover  $\approx$  100 - % removal rate



# Residue effect factors:

- Management
- Crop
- Climate
- Soil type
- Slope

