



Wind Erosion: The Problem, Mechanisms, Residue, and Crop Rotation

FARM PRODUCTION AND CONSERVATION
FSA | NRCS | RMA | Business Center

with NRCS Agronomist Susan Tallman, CPAg







Wind erosion control requires continued vigilance and maintenance.



Hereford, TX
June 2006



Chadron, NE
March 2013

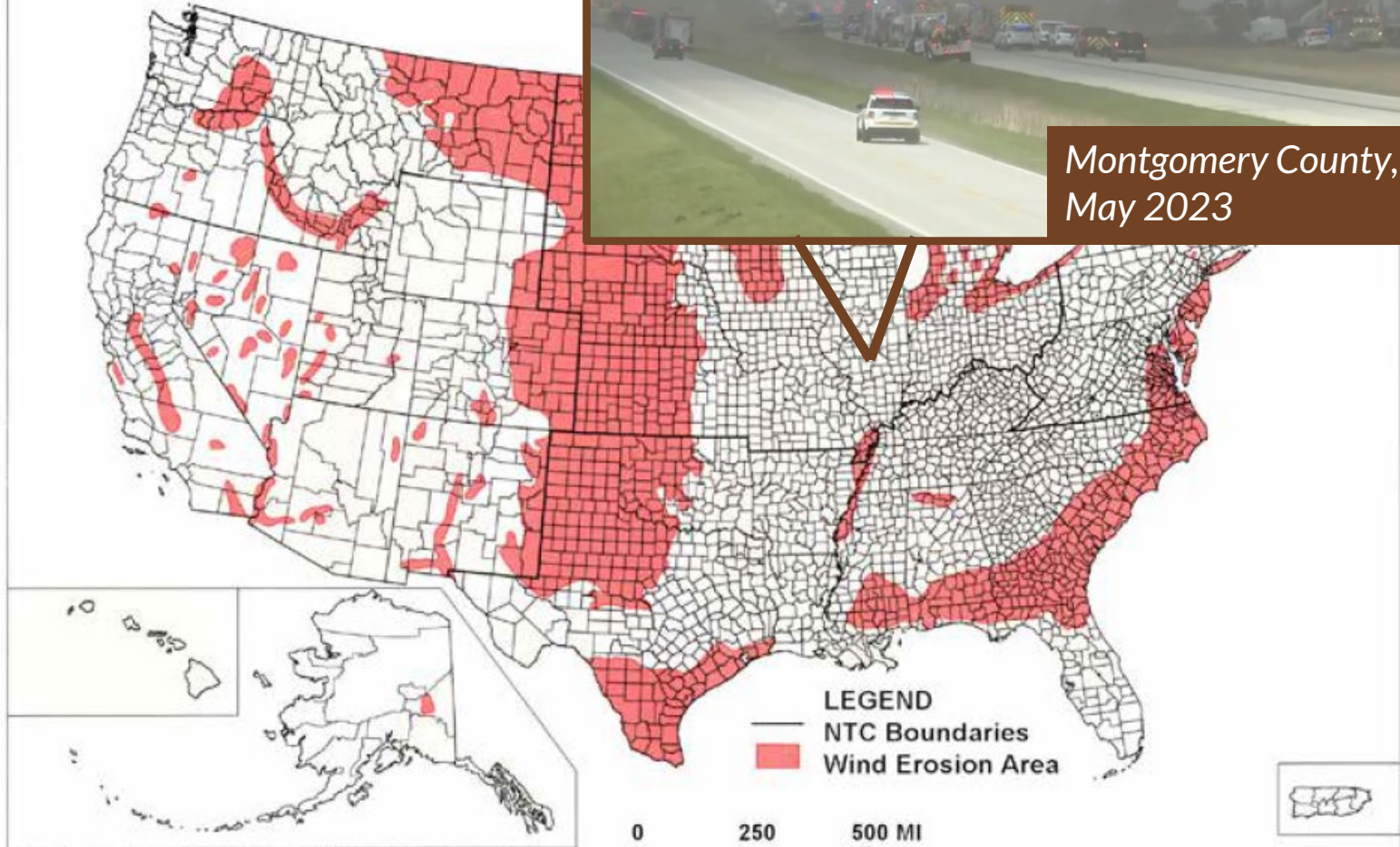


WICS

Newschannel20.com

U.S. Department of Agriculture

AREAS WHERE WIND



Montgomery County, Illinois
May 2023

Map prepared using automated map construction with the FOCAS equipment.

USDA, SCS National Cartography & GIS Center, Fort Worth, TX. 1993

Revised December 1988 1004069



*MT Hwy 87, Chouteau County, Montana
March 2019*



*TX Hwy 87, Lynn County, Texas
Jan 2021*

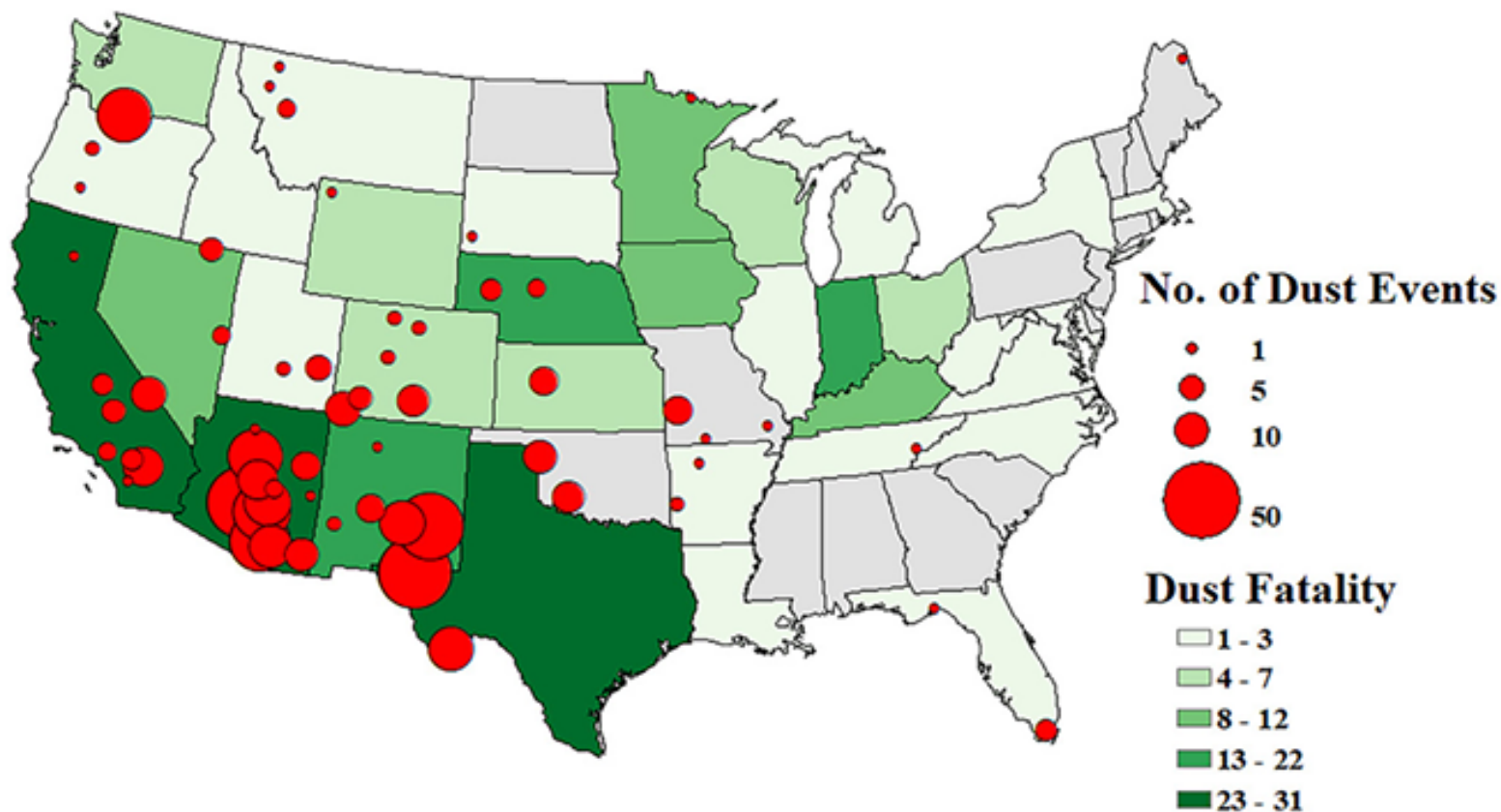


Fig. 4. Spatial distribution of dust storms (red circles) and dust fatalities (background shading) from 2007 to 2017 in the United States. The dust storm data are obtained from the IMPROVE network following Tong et al. (2017) and fatality data are the state totals from the fused FARS and *Storm Data*.

Tong, D., et al. "How many people were killed by windblown dust events in the United States?." *Bulletin of the American Meteorological Society* 104.5 (2023): E1067-E1084.

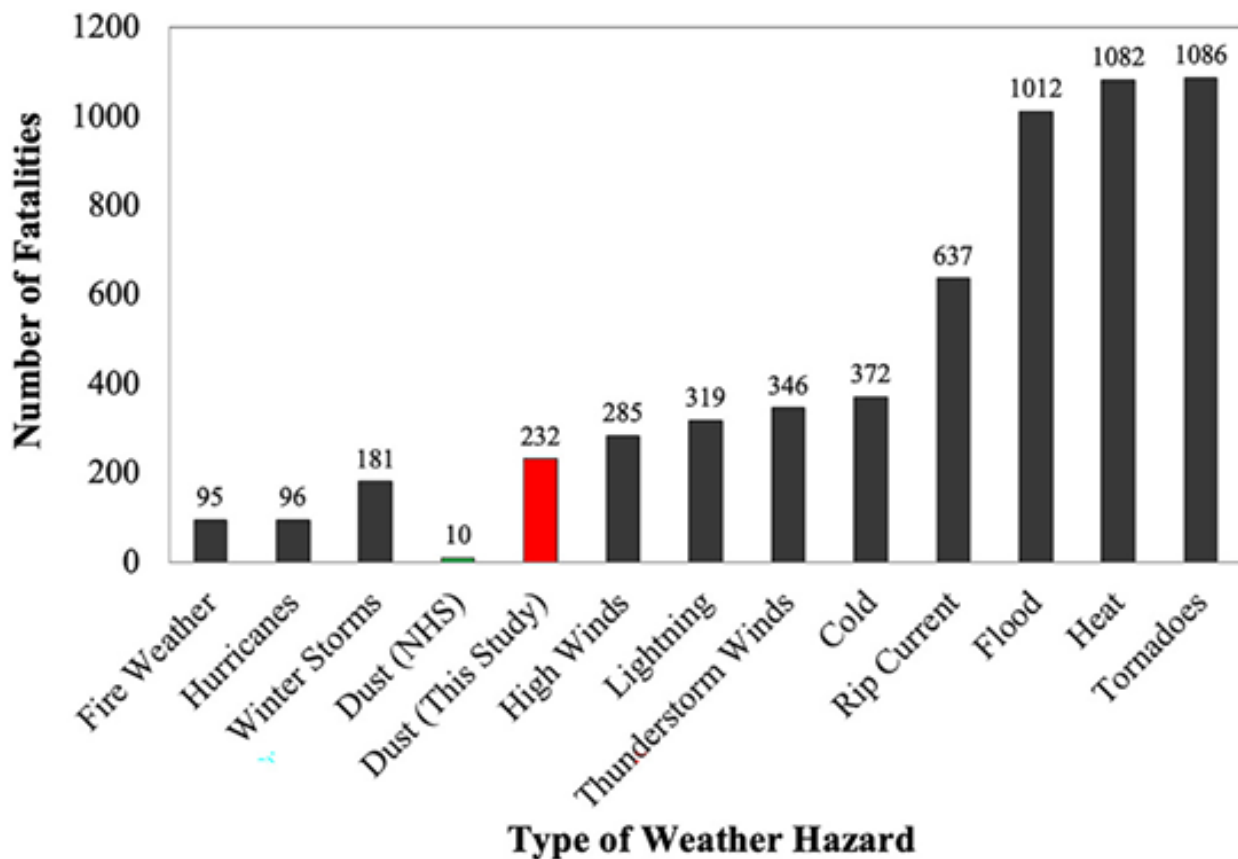


Fig. 7. Comparisons of total fatalities of major weather hazards from 2007 to 2017 in the United States. Dust fatality data are taken from this study while those from other disasters are from the Natural Hazard Statistics.

Tong, D., et al. "How many people were killed by windblown dust events in the United States?." *Bulletin of the American Meteorological Society* 104.5 (2023): E1067-E1084.

300-acre field 1/4 inch of topsoil

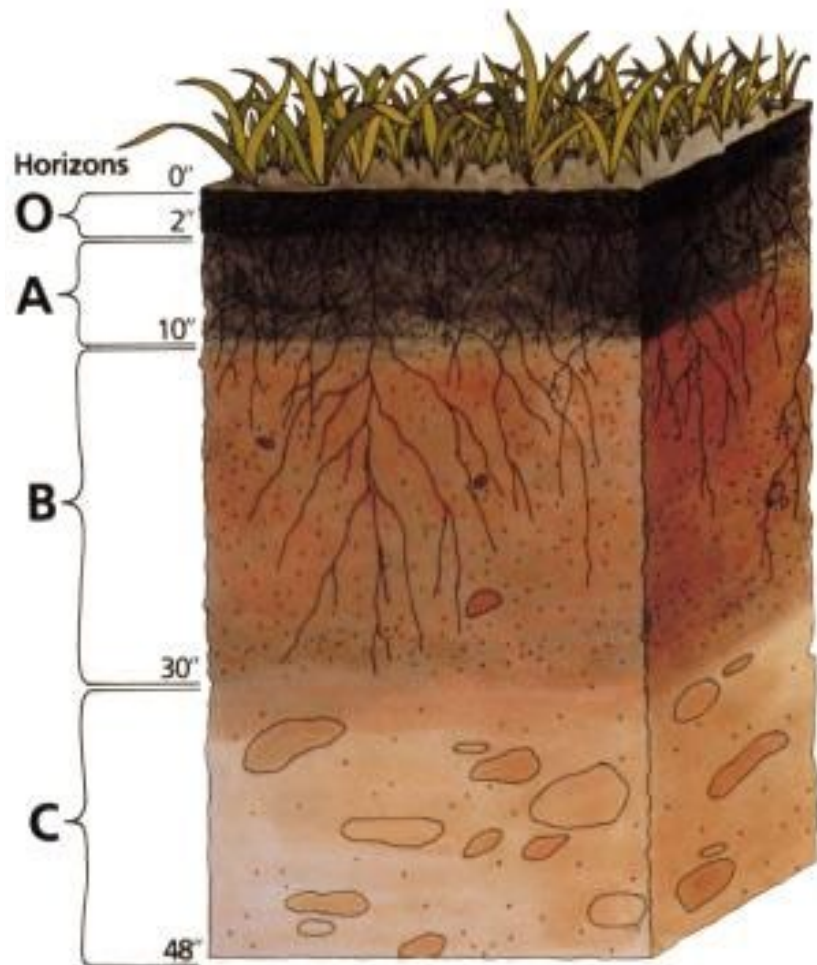
\$7,875 available fertility lost

Liberty County, Montana
April 2022

Nutrient	Available Soil Test, lb/ac (0 – 6 inch)	Fertilizer Cost (Jan 2023)	Cost per 6-inch depth
N	34	\$0.70/ unit N	\$24
P	26	\$0.80/unit P ₂ O ₅	\$48
K	700	\$0.65/unit K ₂ O	\$551
S	7	\$1.04/unit	\$7
Total			\$630

Jones, Clain, and Kathrin Olson-Rutz. Montana State University Extension, 2017, *Fire and Drought Effects on Soil Nutrients*.

Function of Topsoil and Organic Matter



- Regulating water
- Filtering and buffering potential pollutants
- Cycling nutrients
- Providing soil structure and support
- Sustaining plant and animal life
- Providing a food source for soil biota



Wind Erosion Mechanisms





*Video: Ryan Cassillas, near Great Falls,
MT, Jan 2021*

More dust

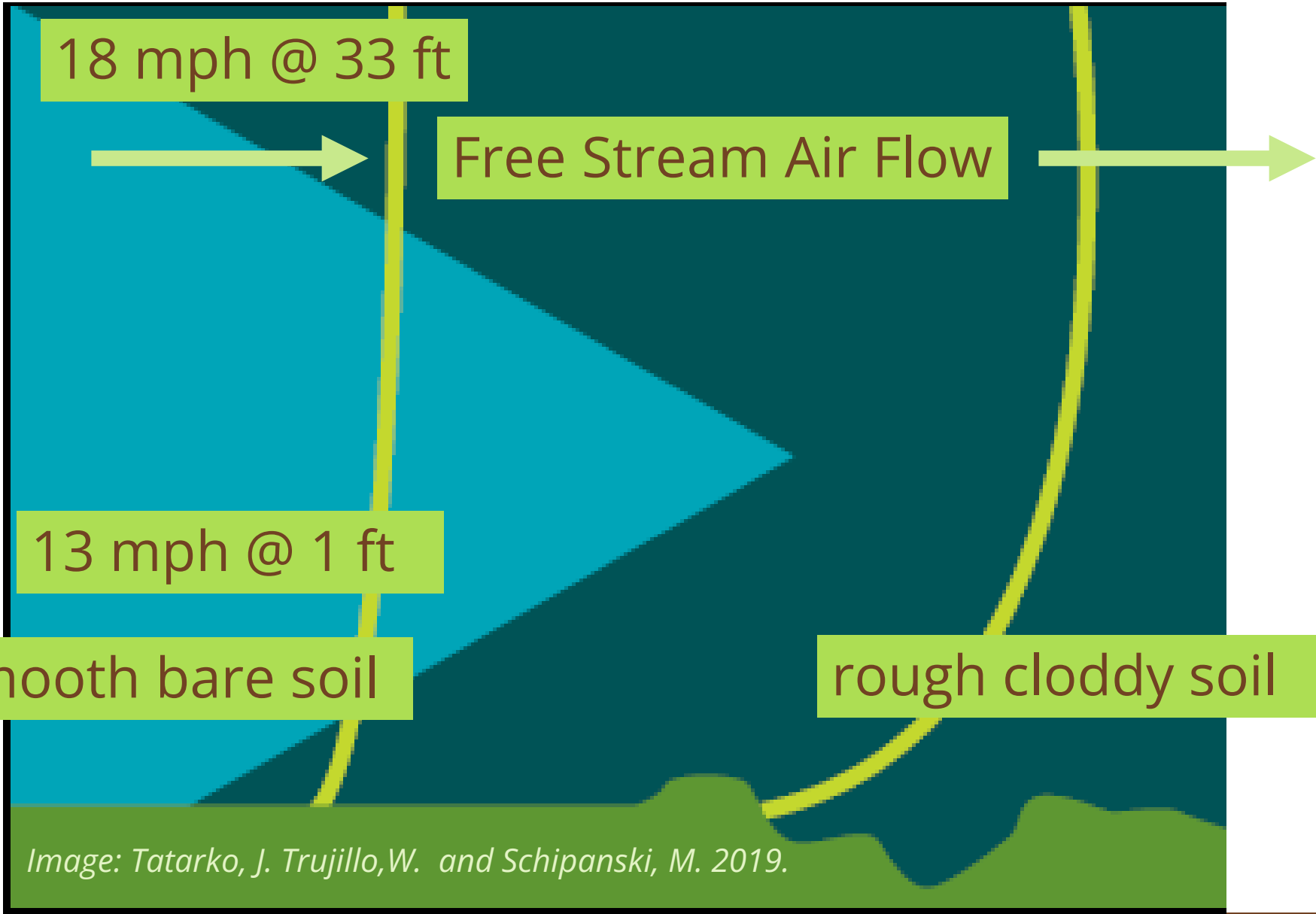


Less dust

Wind Energy vs Wind Speed

$$\text{wind energy} = 0.5 (\text{air density}) (\text{area}) (\text{wind speed})^3$$

Texhoma, TX, April 2016



Greatest
Wind
Energy



Least
Vegetation
and
Residue



Prevailing
Wind
Direction

Critical
Wind
Erosion
Period

November through April

Critical Wind Erosion Period

Lubbock, TX

Wind Station Data

Station:
 Threshold: m/s
 Elevation: 984 Avg Energy: 2,209

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winds > Threshold	16.5	20.9	27.9	29.2	26.4	21.8	10.1	5.2	7.5	11.5	15.0	15.5
Energy kJ/m²/day	2,271	3,252	5,337	4,724								2,024
Monthly Percent	8.6	12.3	20.1	17.8	11.6	7.0	2.1	0.9	1.6	3.4	7.0	7.6
Preponderance	1.3	1.3	1.2	1.3	1.4	1.9	2.5	2.2	2.3	1.9	1.4	1.3
PWED	SW-225	NNE-22	SW-225	SSW-202								SW-225

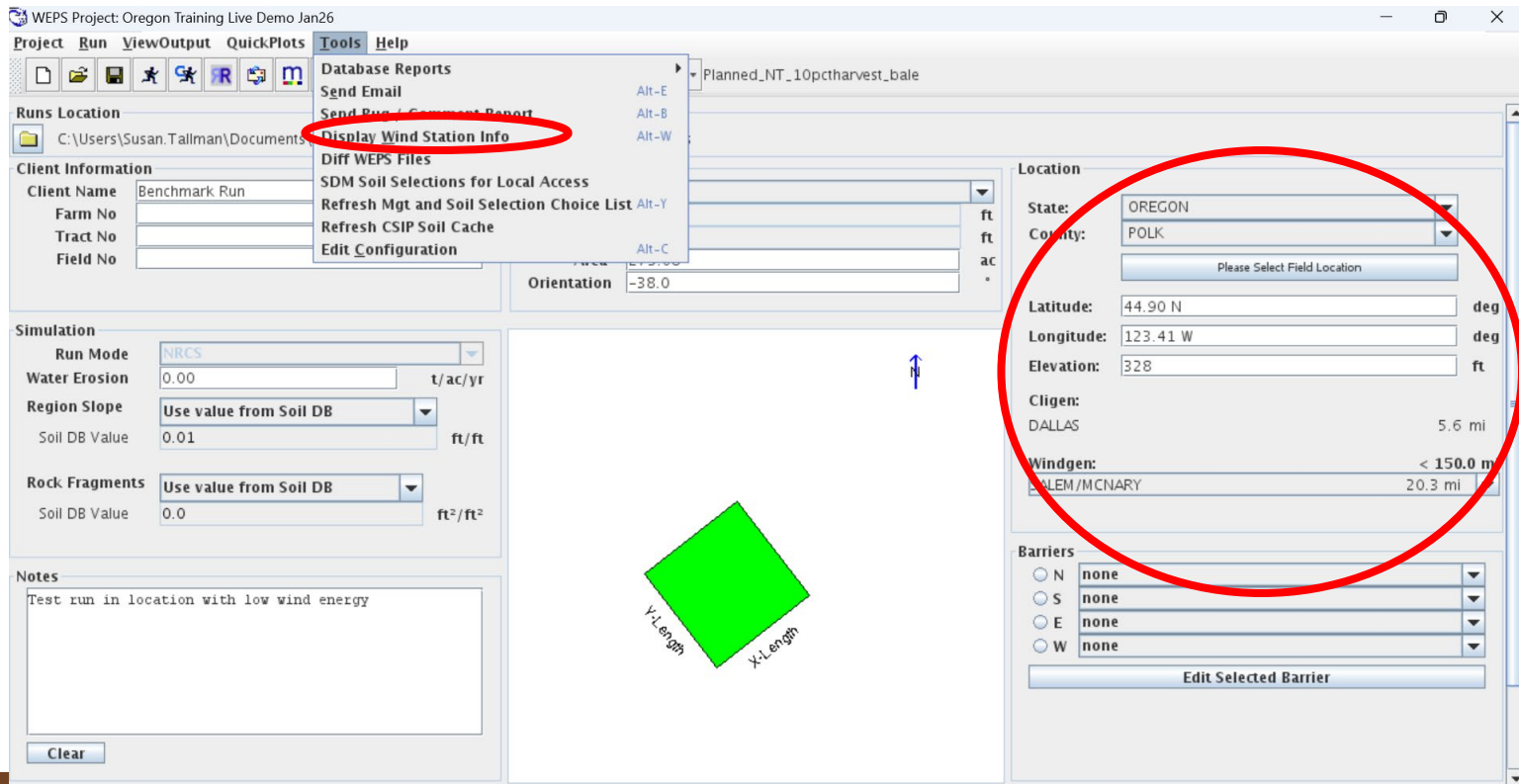
Critical Erosion Period = December through April

Prevailing Wind Direction = from the southwest, at 225°



WEPS tool

- Download the WEPS WebStart bootloader at <https://www.nrcs.usda.gov/resources/tech-tools/wind-erosion-prediction-system>



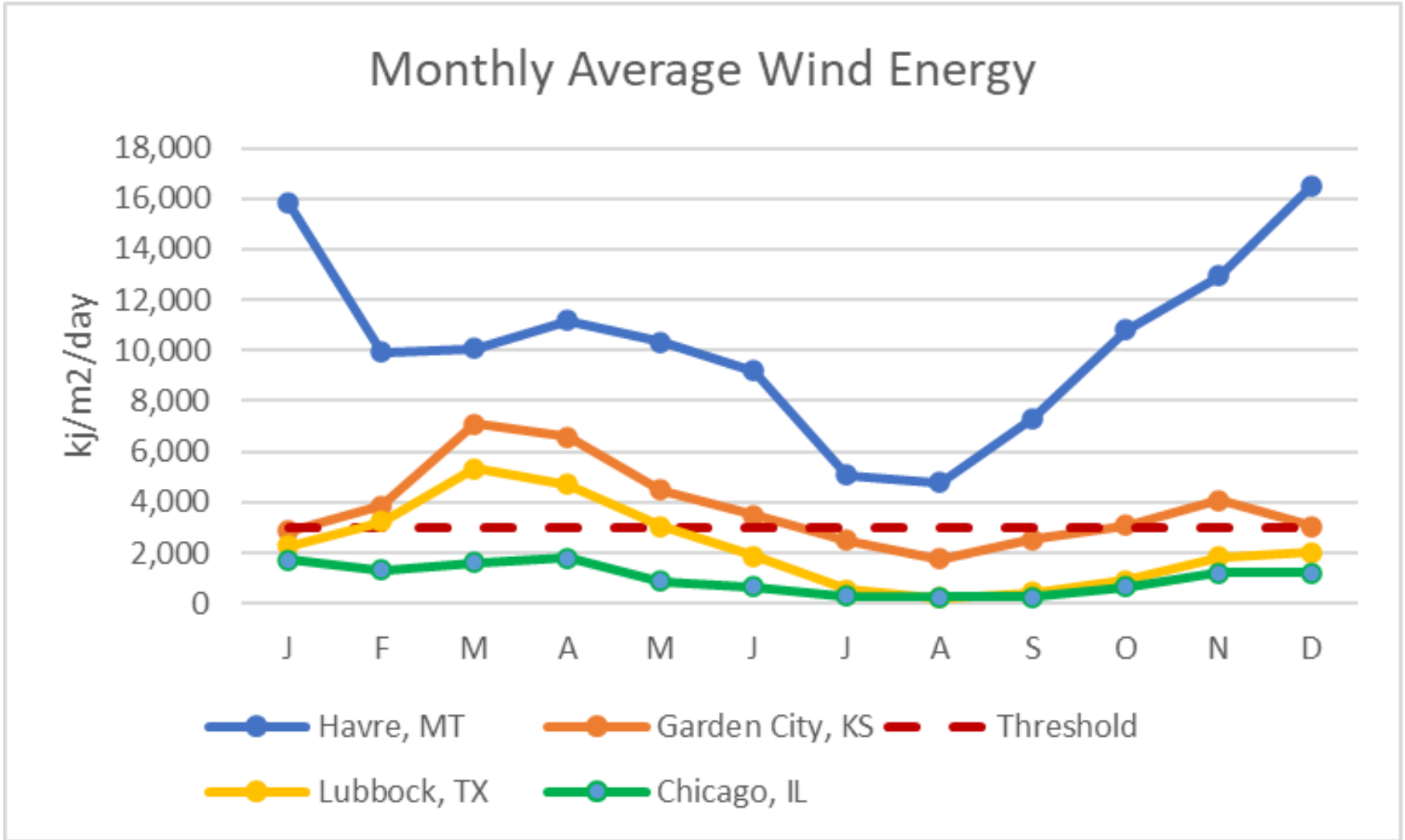
Wind Station Data

Wind Station Data — □ ×

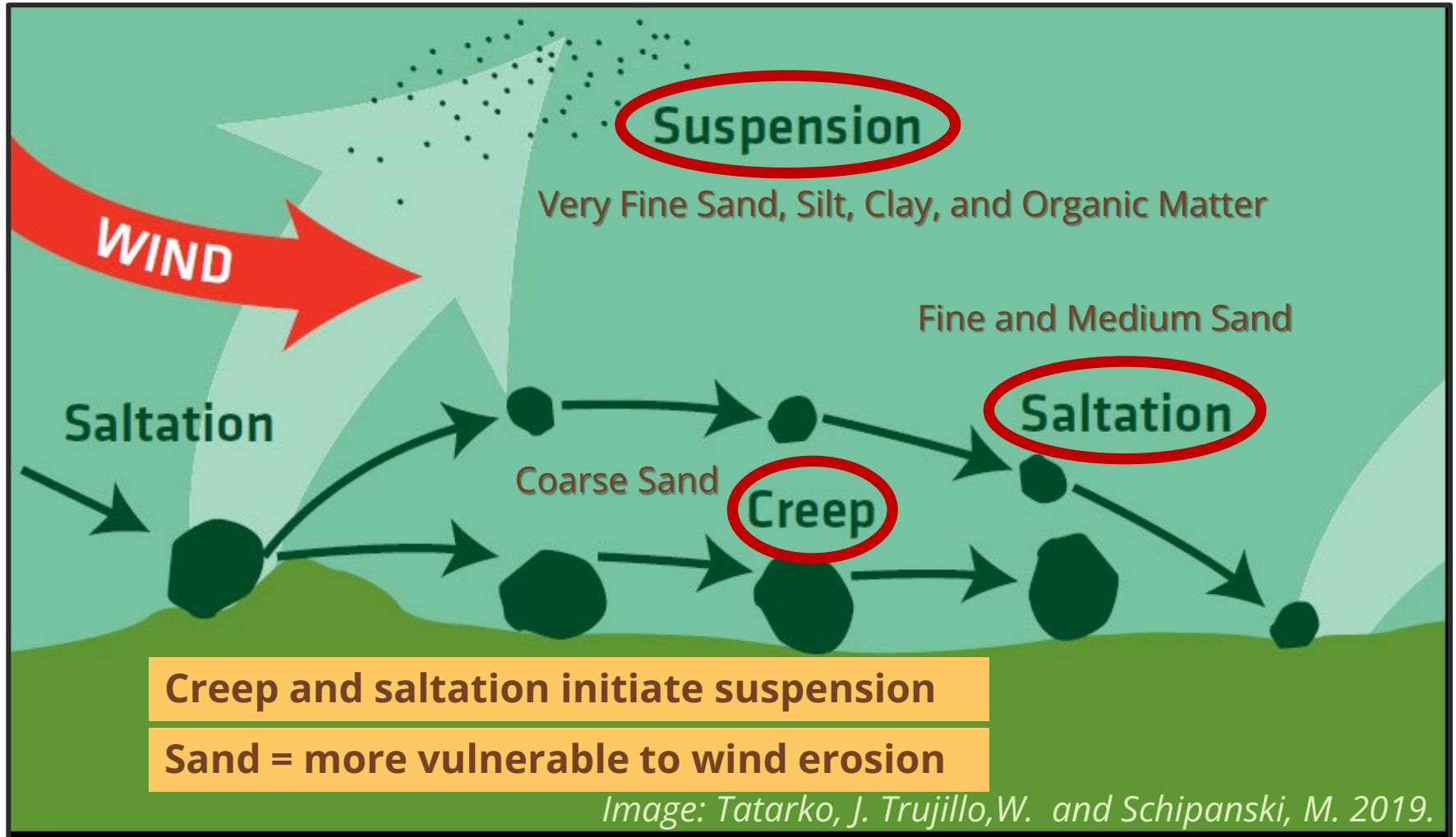
Station **US OR SALEM/MCNARY** Threshold m/s
 Elevation **61** Avg Energy **405**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winds > Threshold	8.3	7.5	5.8	3.3	1.6	1.0	0.9	0.8	1.6	2.9	7.1	8.7
Energy kJ/m²/day	996	725	564	222	66	31	29	24	71	242	861	1,023
Monthly Percent	20.5	14.9	11.6	4.6	1.4	0.6	0.6	0.5	1.5	5.0	17.7	21.1
Preponderance	8.7	7.3	5.0	2.8	1.5	1.3	1.6	2.0	3.3	6.2	7.9	9.3
PWED	S-180	S-180	S-180	S-180	S-180	N-0	NNE-22	N-0	S-180	S-180	S-180	S-180

Wind Energy Comparison



Particle Transport



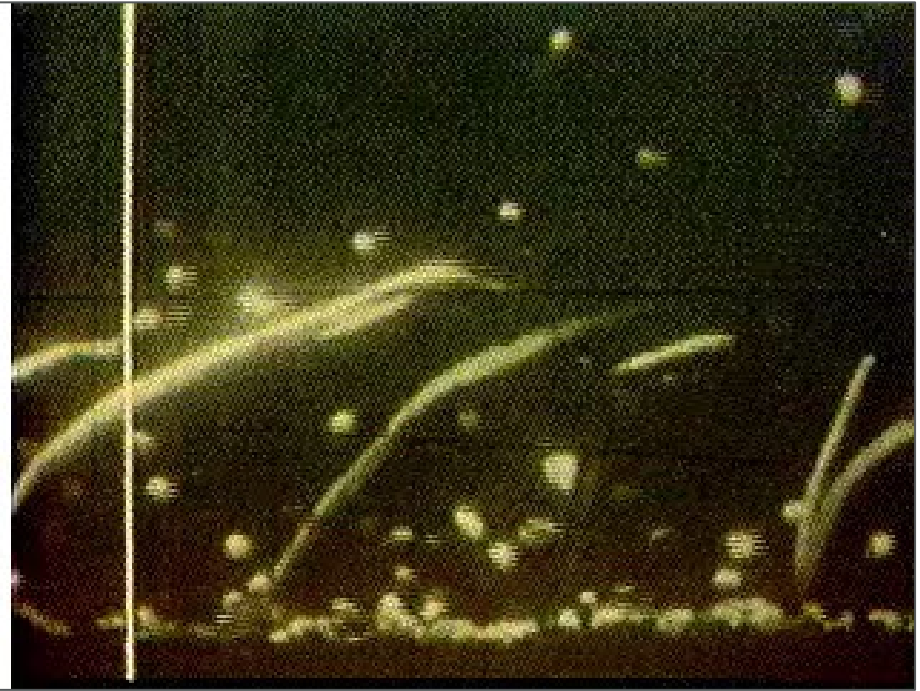
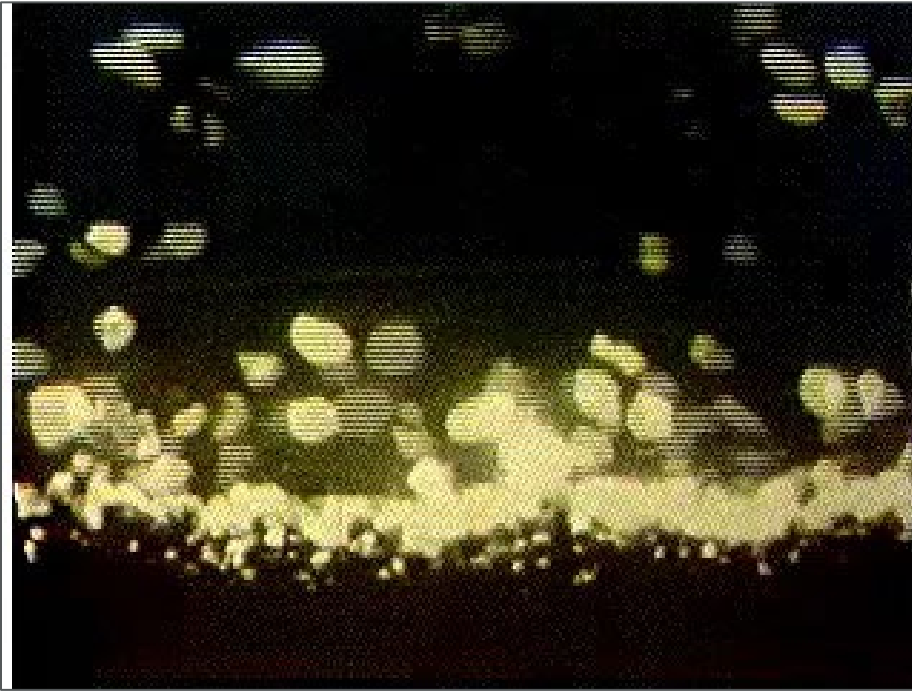
Exponential process = avalanche effect

More dust



Less dust

Particle Transport



Deposition



Photos: Larry Mayer, Billings Gazette, March 2015

Deposition – fine particles

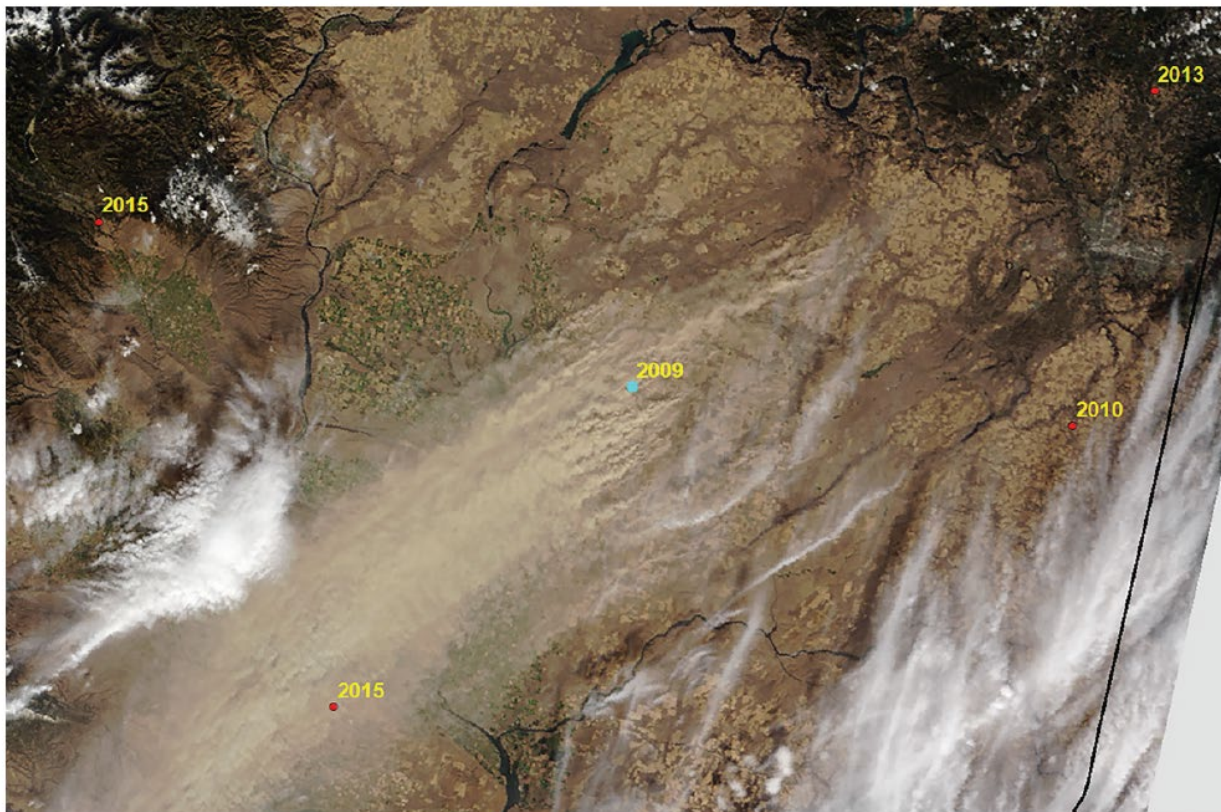


Fig. 2. Overlay of NASA MODIS true color observations of a 3 Oct 2009 dust storm in Washington that caused one death on Highway I-90. The dots in cyan and red indicate the locations of the 2009 wreck and four others in the same region, respectively.

Tong, D., et al. "How many people were killed by windblown dust events in the United States?." *Bulletin of the American Meteorological Society* 104.5 (2023): E1067-E1084.

SOLUTIONS



Increase high carbon residue



Increase vegetation



Decrease unsheltered distance



Increase surface roughness



Increase soil moisture



Increase high carbon residue



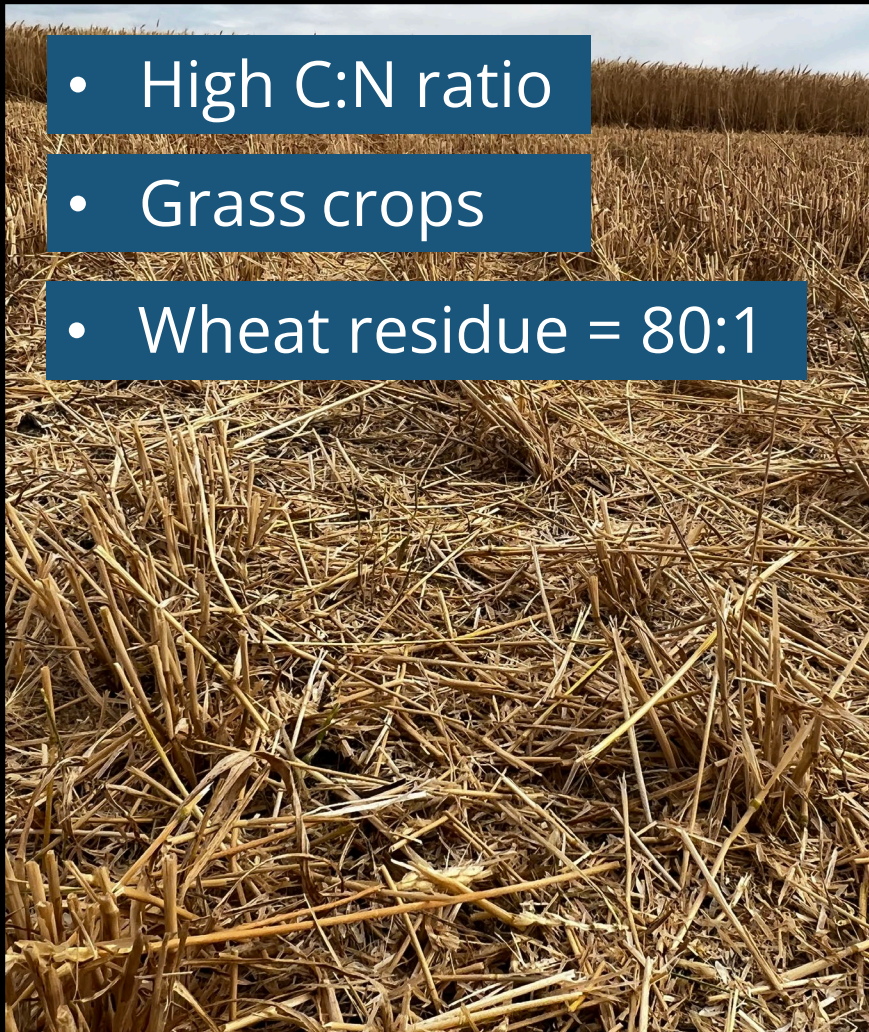
The cardinal rule of wind erosion control is to strive to keep the land covered with **vegetation** or **crop residue** at all times.



Residue = mature, dead plant material left after crop harvest

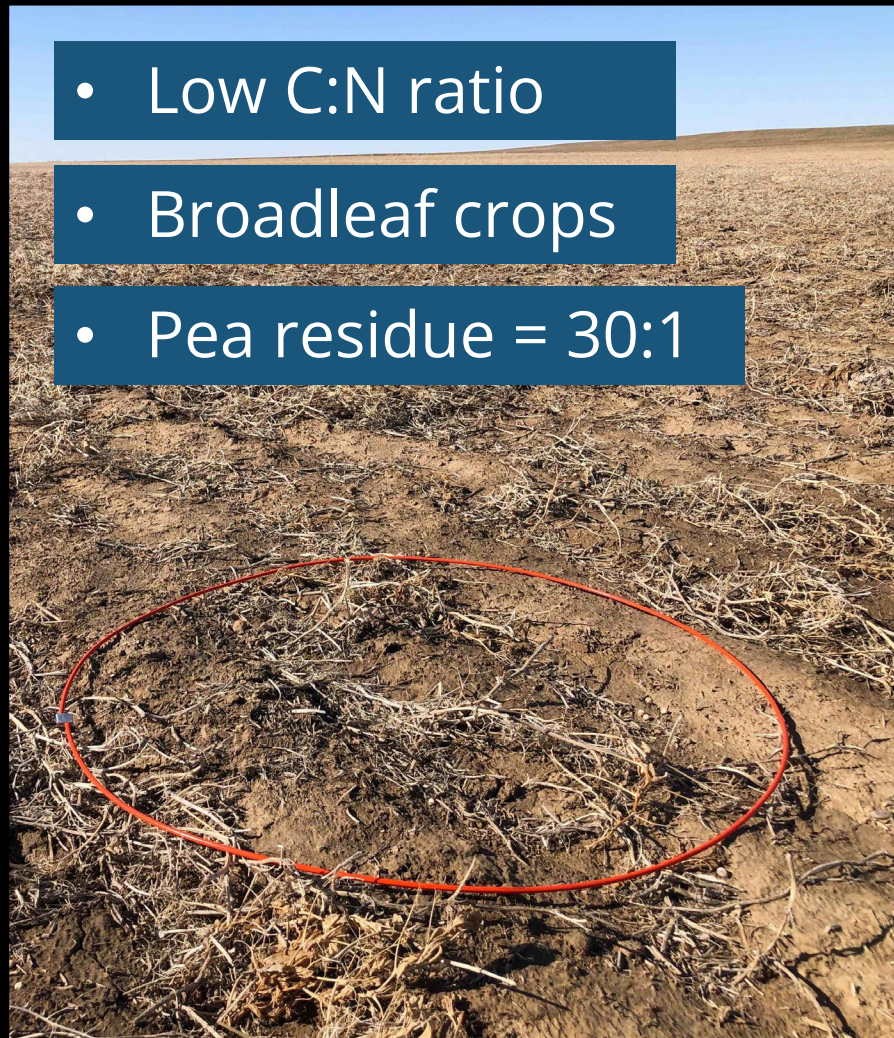
HIGH CARBON RESIDUE

- High C:N ratio
- Grass crops
- Wheat residue = 80:1

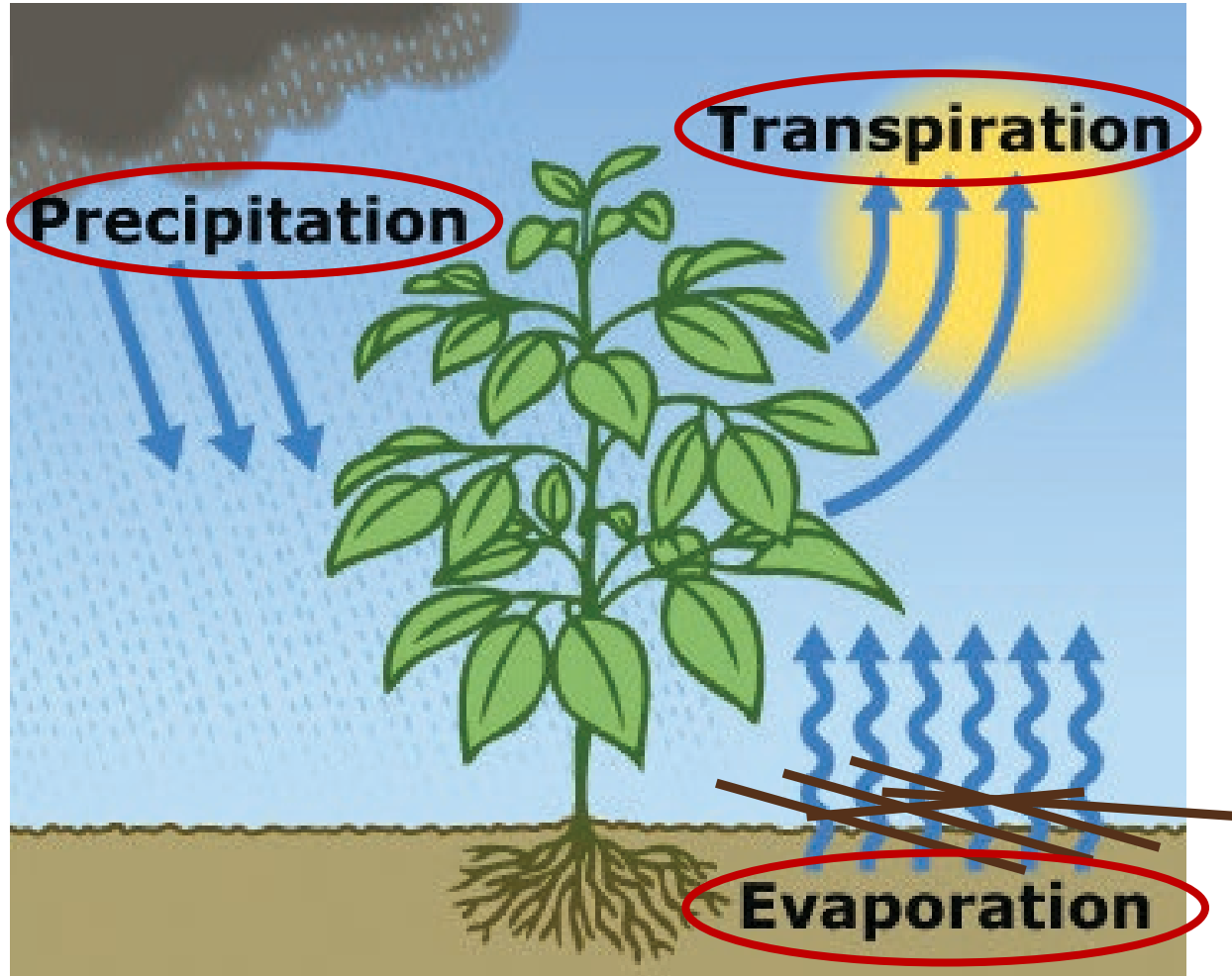


LOW CARBON RESIDUE

- Low C:N ratio
- Broadleaf crops
- Pea residue = 30:1



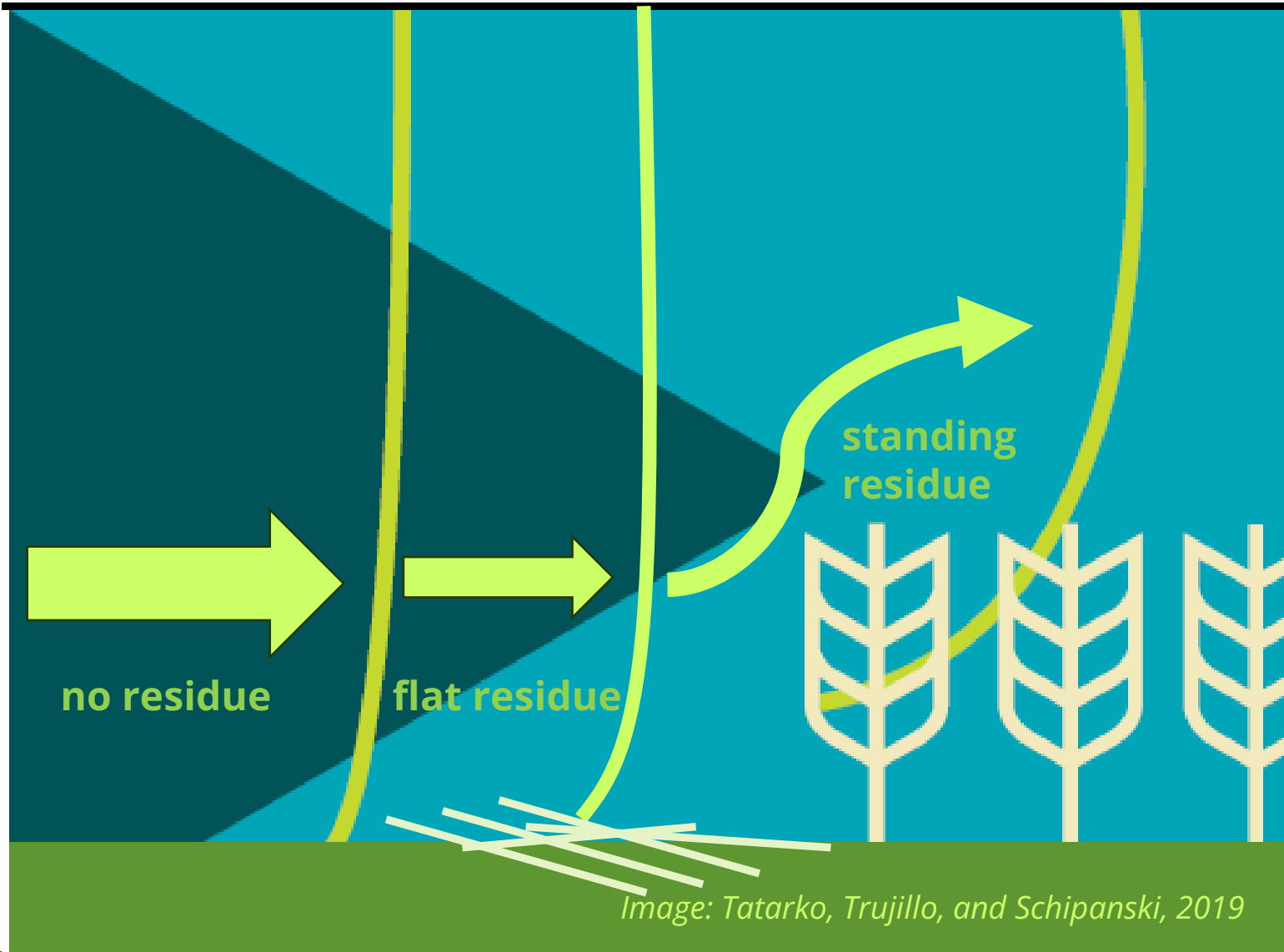
Residue and ET



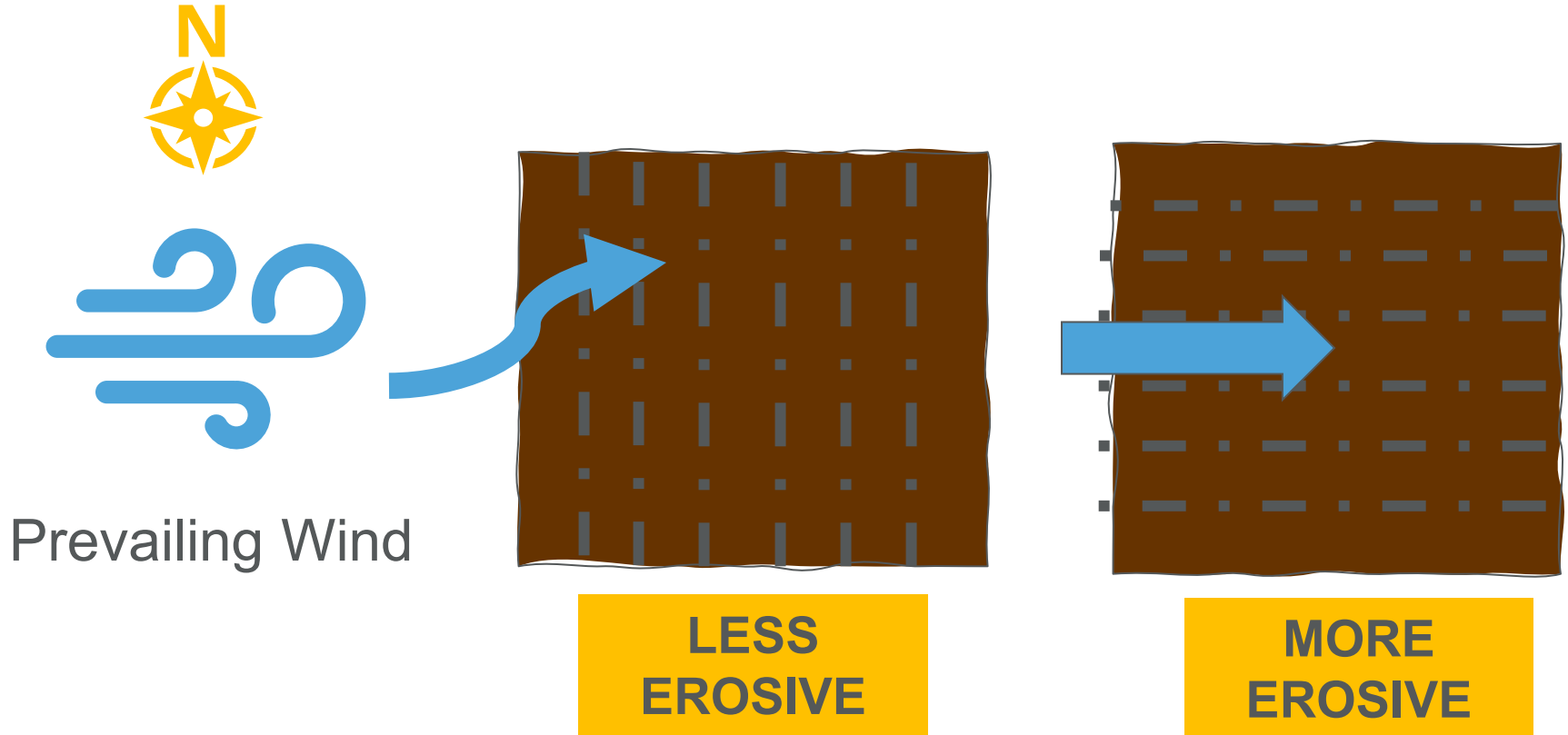
Source: USGS public domain



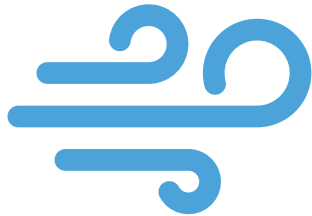
Standing residue is 2-5x more effective than flat

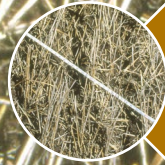


Row Orientation



Row Orientation





Increase high carbon residue

How much is enough?

60% cover

10" height, <15" row spacing

15" height, \geq 15" row spacing

Anchored

Conservation Tillage



No till with stripper header





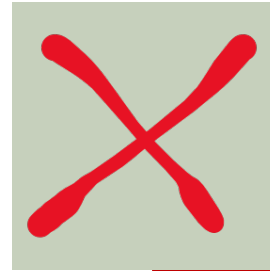


Increase high carbon residue



Pro

- Effective
- ~1 yr implementation
- Low cost
- Best for large-scale commodity crop systems



Con

- Management
- Markets
- Equipment
- Economics in high-value crop systems
- Crop failure is biggest risk
- Requires redundancy in dry climates



Crop Rotation



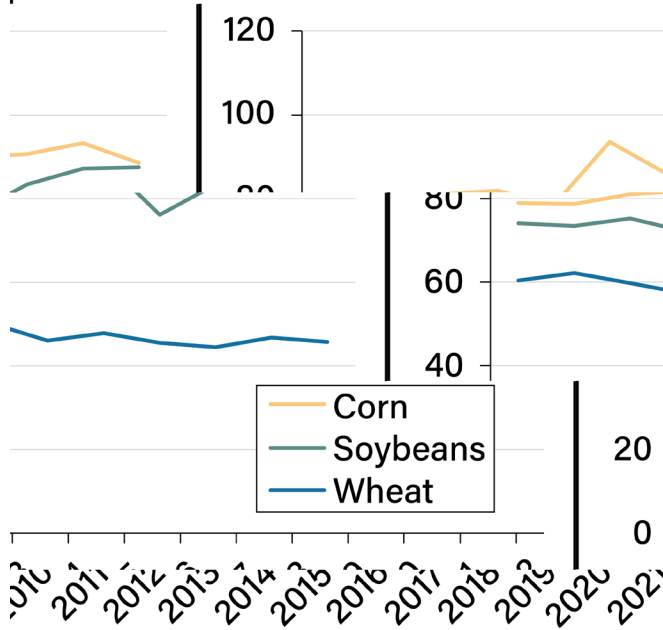
Historical rotation changes



Increase in soybean acres

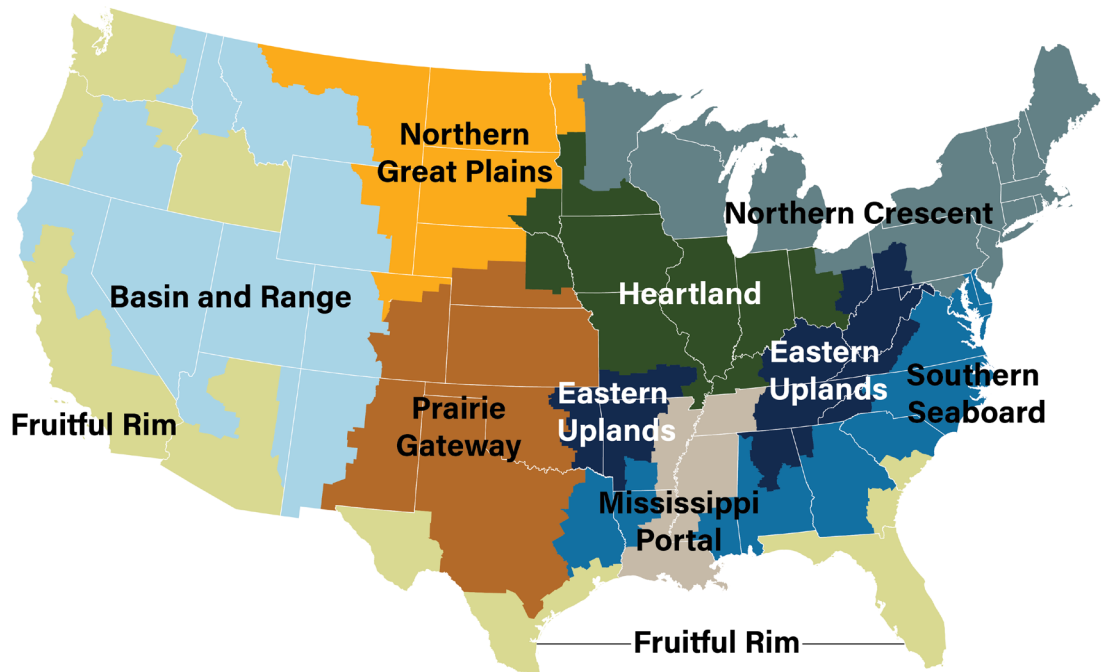
U.S. soybean acreage increased an [unclear] 2002-2022

Acres (millions)



rice using data from USDA, National Agricultural
ication.

Researchers looked at soybean production changes across farm resource regions designated by USDA, Economic Research Service



Source: USDA, Economic Research Service.

Statistics Service, Crop Production publi

Vaiknoras, K. & Hubbs, T. (2023). *Characteristics and Trends of U.S. Soybean Production Practices, Costs, and Returns Since 2002*. U.S. Department of Agriculture, Economic Research Service. ERR-316.

HIGH CARBON RESIDUE



GRASS RESIDUE

LOW CARBON RESIDUE



BROADLEAF RESIDUE



Increase high carbon residue

**MINIMUM 60% COVER 10-15" TALL
WITH HIGH RESIDUE CROPS**

Crop Rotation Guidelines

50% or more of the rotation years in high carbon residue crops with proper residue management.

No two low carbon residue crops or fallow grown in sequence.

Northern Plains Crop Rotation - Before

Spring
Wheat

Pea

Fallow

- **1 High Carbon Residue Crop** (60% cover and 10" height)
- **2 Low Carbon Residue Crops or Fallow**
- **3 years total**

33% of rotation is high carbon residue crop

Northern Plains Crop Rotation - After

Spring
Wheat

Pea

Oats

- **2 High Carbon Residue Crops** (60% cover and 10" height)
- **1 Low Carbon Residue Crop or Fallow**
- **3 years total**

67% of rotation is high carbon residue crop

Corn Belt Example - Before



Silage
Corn



Soybean

- **0 High Carbon Residue Crop** (corn silage has less than 60% cover and 15" height)
- **2 Low Carbon Residue Crop or Fallow**
- **2 years total**

0% of rotation is high carbon residue crop

Silage Corn vs Grain Corn

50% or more of the rotation in high carbon residue crops **with proper residue management.**



**MORE
EROSIVE**



**LESS
EROSIVE**

Image: UNL Crop watch

Corn Belt Example - After



Grain
Corn



Soybean

- **1 High Carbon Residue Crop** (grain corn has 60% cover and 15" height)
- **1 Low Carbon Residue Crop or Fallow**
- **2 years total**

50% of rotation is high carbon residue crop

Complex Rotations

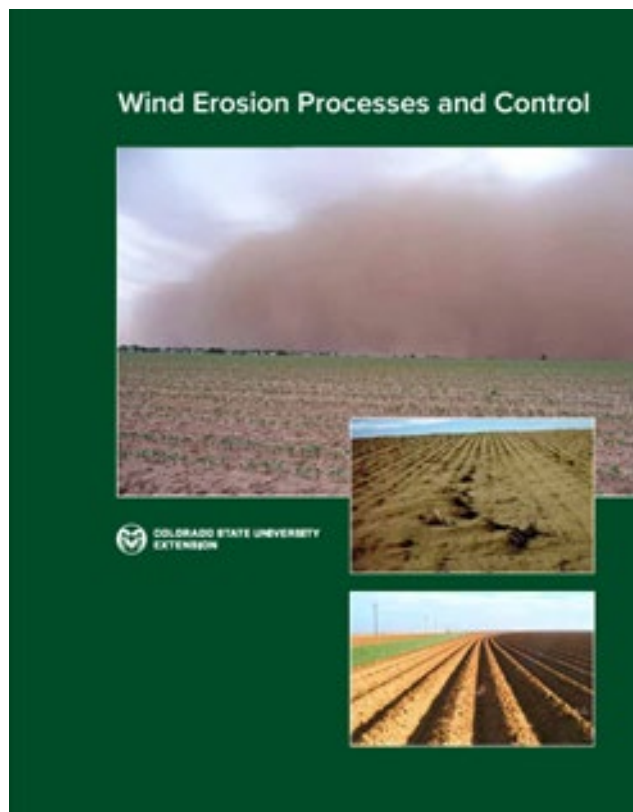


- **4 High Carbon Residue Crop** (60% cover and 10 - 15" height)
- **1 Low Carbon Residue Crop or Fallow**
- **5 years total**

80% of rotation is high carbon residue crop

Image: Dakotalakes.com

Additional Resources



Wind Erosion Processes and Control,
an extension guide from Colorado State
and USDA-ARS



3 Part Video Series from USDA-
ARS Wind Erosion Research Unit

1. Wind Erosion: The Problem

2. The Processes Involved with
Wind Erosion of Soil

3. How to Control Wind Erosion

References

[Beck, D. 2014. Managing agricultural ecosystems. Dakota Lakes Research Farm.](#)

Tatarko, J. Trujillo, W. and Schipanski, M. 2019. Wind erosion processes and control. Colorado State University Extension Publication.

Tong, D., et al. "How many people were killed by windblown dust events in the United States?." [Bulletin of the American Meteorological Society 104.5 \(2023\): E1067-E1084](#)

USDA-NRCS. 2011. [National Agronomy Manual.](#)

QUESTIONS?

