USDA Natural Resources Conservation Service
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Wind Erosion Solutions: Vegetation and Unsheltered Distance

With NRCS Agronomist Susan Tallman, CPAg

FARM PRODUCTION AND CONSERVATION
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SOLUTIONS

Increase high carbon residue

Increase vegetation

Decrease unsheltered distance

Increase surface roughness

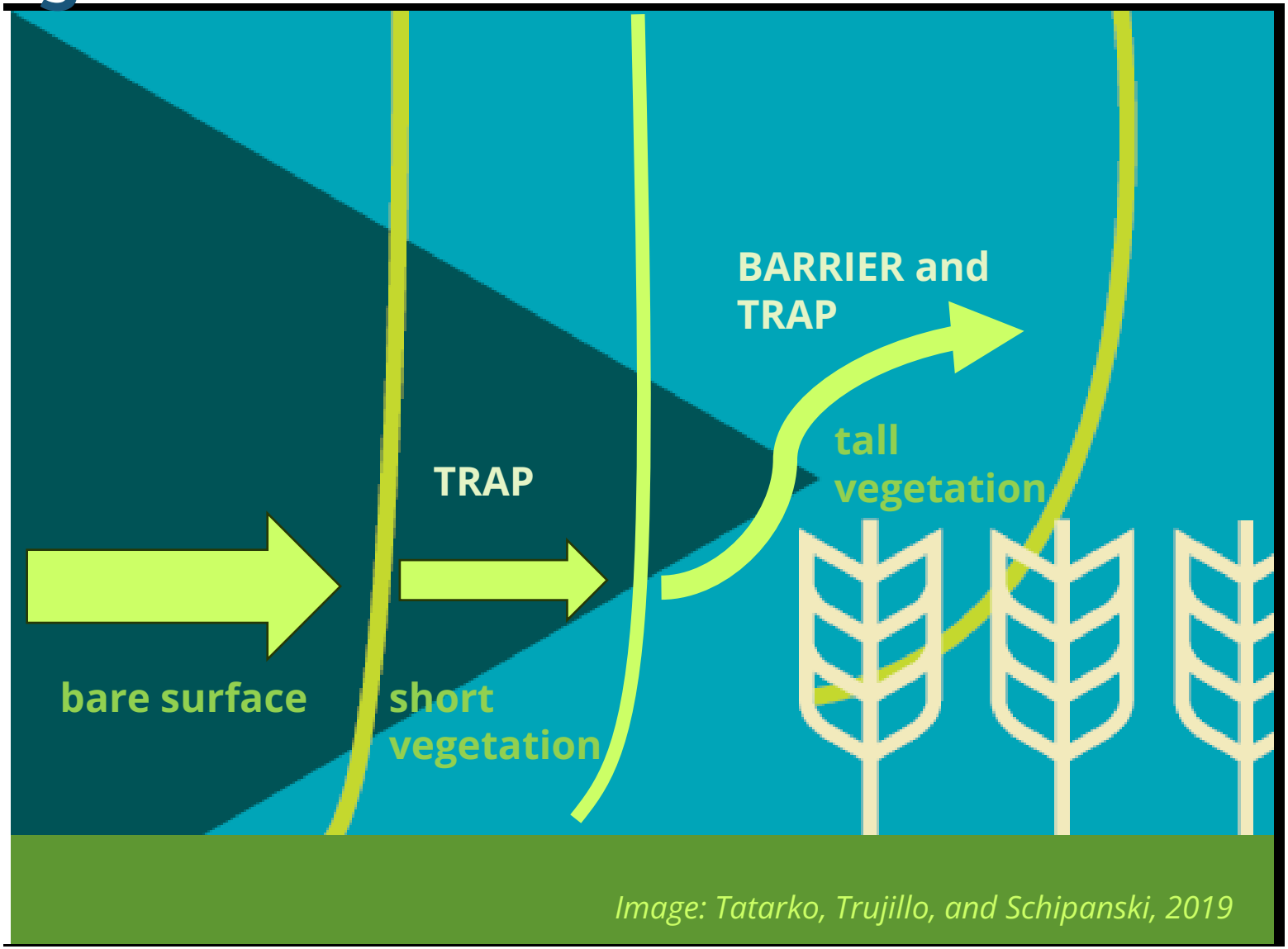
Increase soil moisture

Vegetation Definition

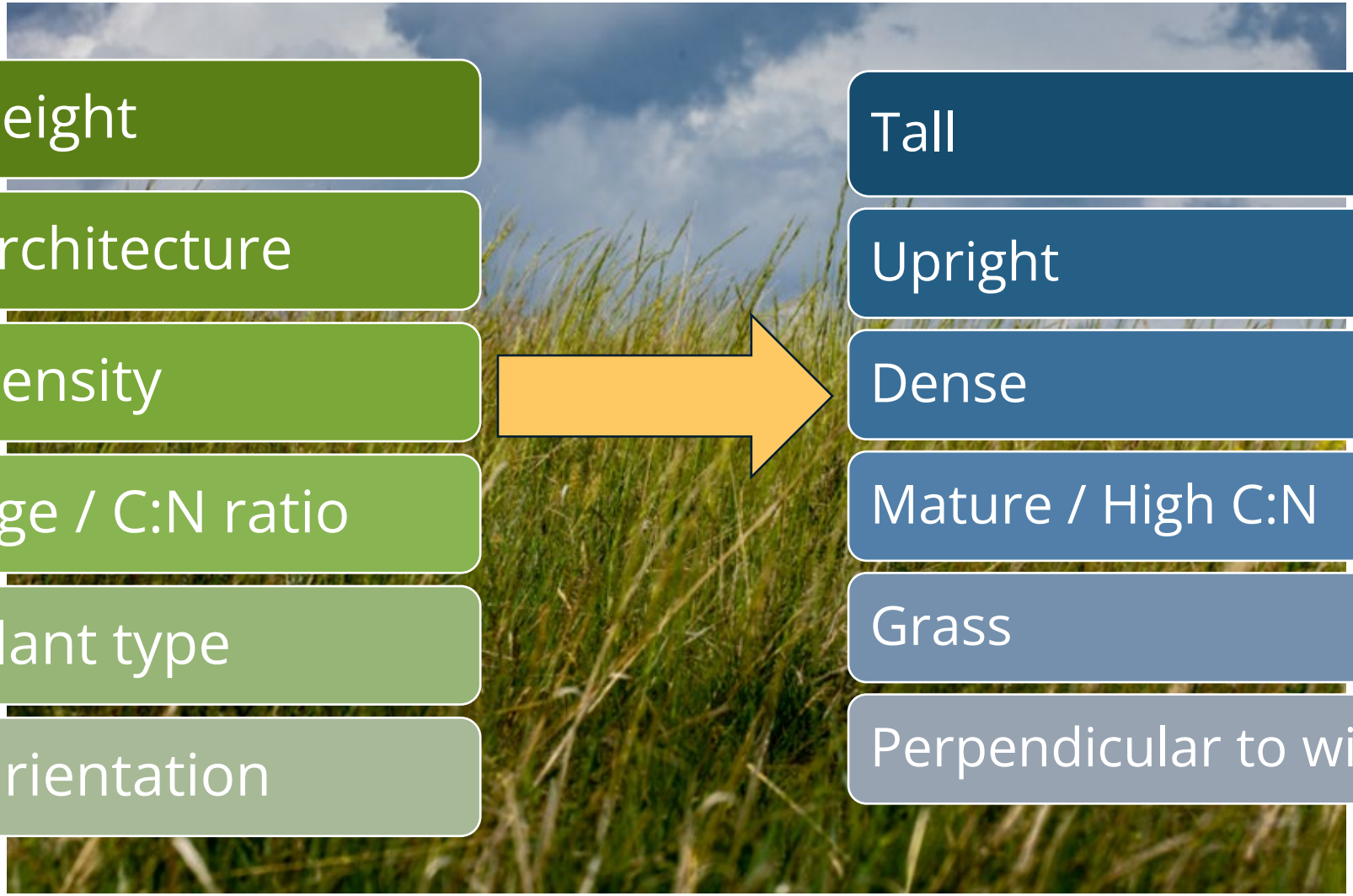
Any plant material in the field prior to a harvest operation.

- Perennial
- Annual
- Living
- Dry and mature

Vegetation Mechanism

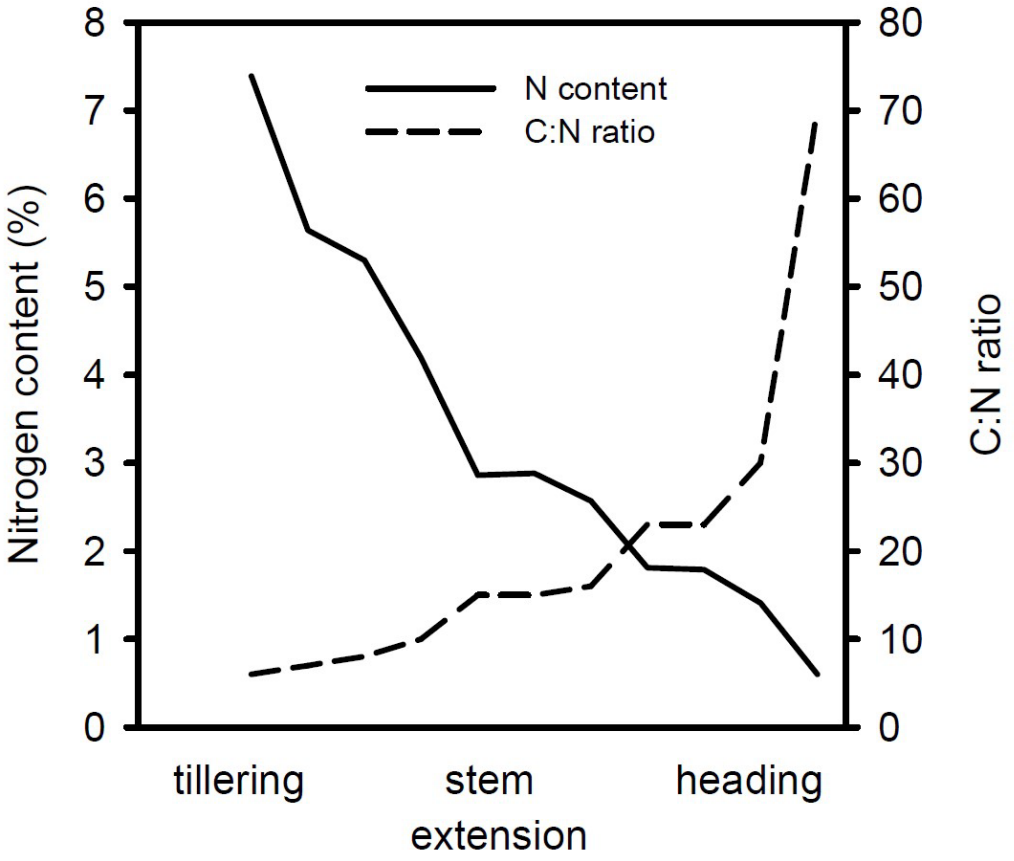


Ideal Vegetation for Erosion Control



Height	Tall
Architecture	Upright
Density	Dense
Age / C:N ratio	Mature / High C:N
Plant type	Grass
Orientation	Perpendicular to wind

C:N Ratio of Wheat Over Time



Wheat seedlings = 5:1

Mature wheat = 80:1

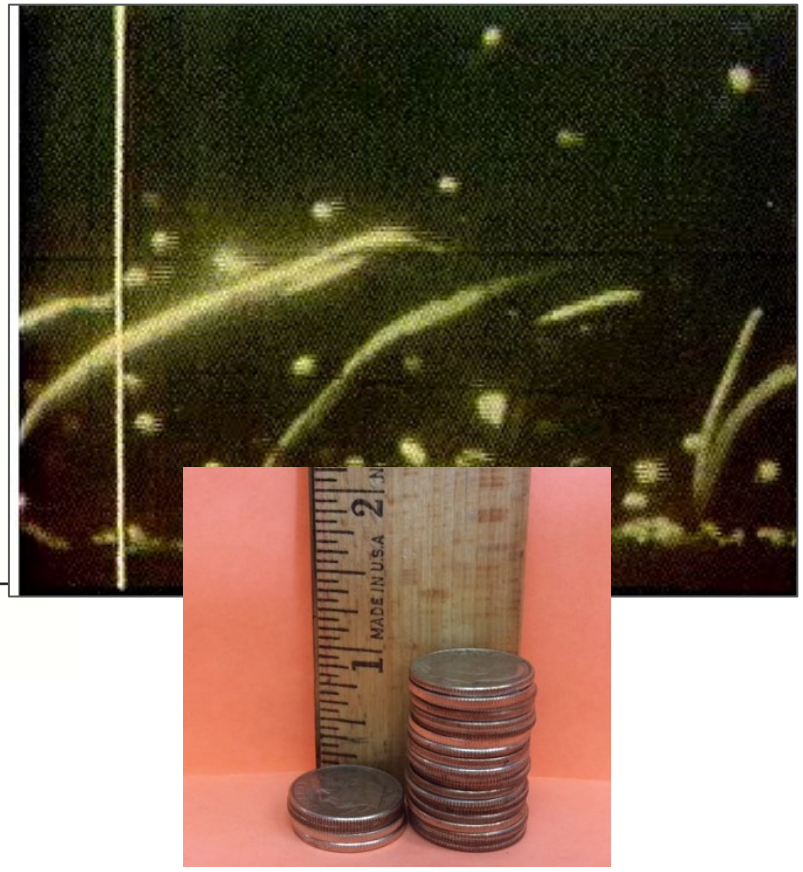
Figure 20 **Nitrogen content and C:N ratio of wheat plants at various growth stages**

Image: Anderson, G. 2009.

Seedling tolerance

Table 502–1 Crop tolerance to blowing soil

Tolerant T	Moderate tolerance 2 ton/a	Low tolerance 1 ton/a	Very low tolerance 0 to 0.5 ton/a
Barley	Alfalfa (mature)	Broccoli	Alfalfa seedlings
Buckwheat	Corn	Cabbage	Asparagus
Flax	Onions (>30 days)	Cotton	Cantaloupe
Grain Sorghum	Orchard crops	Cucumbers	Carrots
Millet	Soybeans	Garlic	Celery
Oats	Sunflowers	Green/snap beans	Eggplant
Rye	Sweet corn	Lima beans	Flowers
Wheat		Peanuts	Kiwi fruit
		Peas	Lettuce
		Potatoes	Muskmelons
		Sweet potatoes	Onion seedlings (<30 days)
		Tobacco	Peppers
			Spinach
			Squash
			Strawberries
			Sugar beets
			Table beets
			Tomatoes
			Watermelons



Winter annual planting date

- First 6 to 8 weeks after seeding = greatest window for crop damage due to saltation
- More growth time = more erosion control

Planted Nov 1

Planted Sept 15

Timing of Fall Seeding and Soil Moisture

- Minimize disturbance prior to critical wind erosion period (Nov – April).
- Ok to seed in fall into adequate residue and moisture
- Consider waiting until spring if residue cover and soil moisture is low.

Crop and Soil Interactions

Image: Iowa State University

Sandy Soils

+

Vulnerable Crop Type

→

Seedling Damage or Death

Image: Univ of Georgia

Cover crops

- Minimum 6 – 8 weeks needed for cover crop growth for any erosion control to begin.
- Limit grazing of cover crop prior to critical wind erosion period.

Cover Crops – sugar beet example

Winter wheat grazing

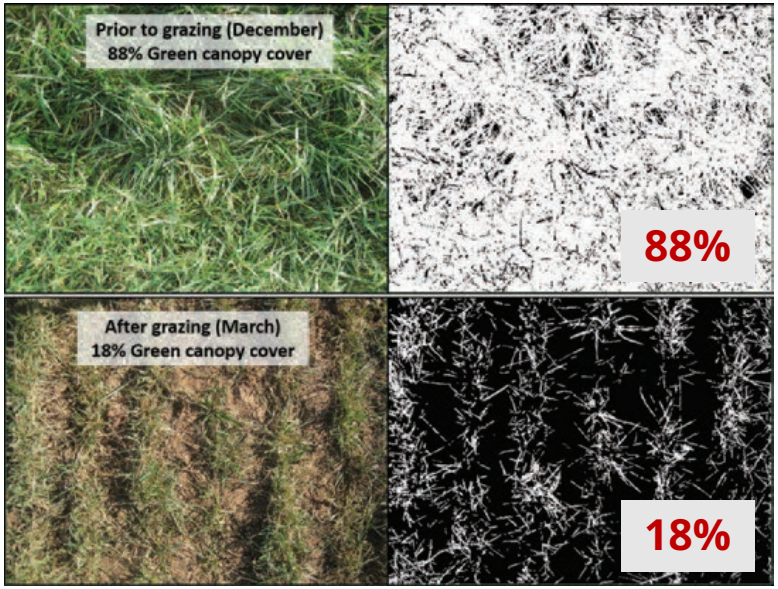
How much vegetation is enough???

Images: John Holman, Kansas State University, Feb 12, 2015

https://eupdate.agronomy.ksu.edu/article_new/how-overgrazing-can-affect-wheat-493-3

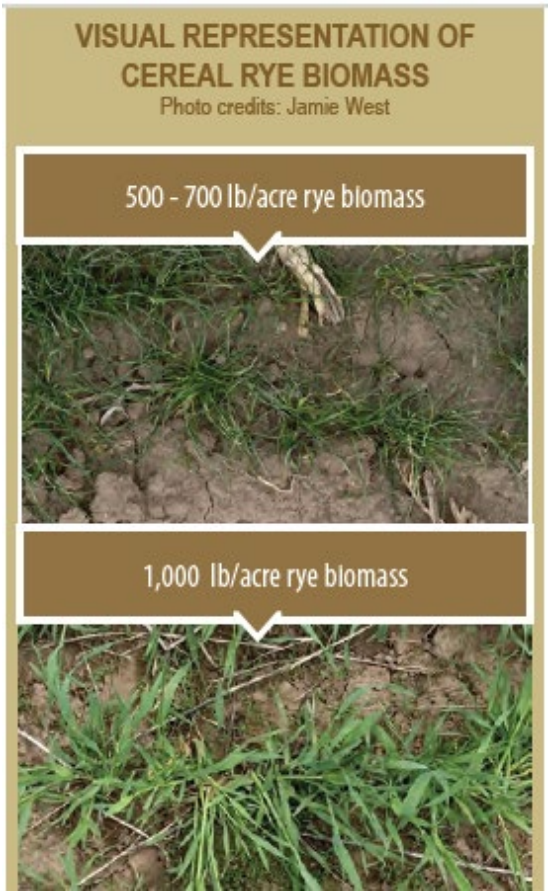
Measuring Canopy Cover
Canopeo app

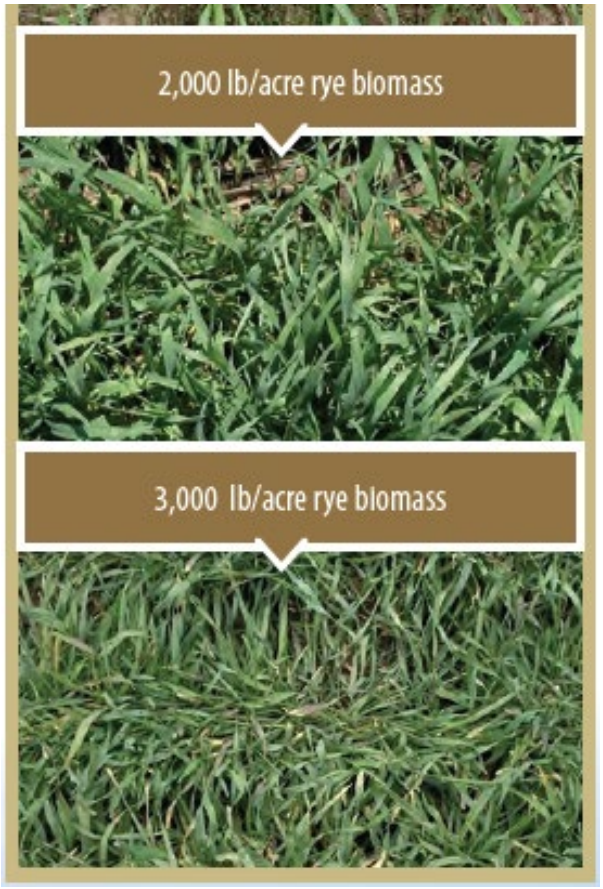
50% minimum



Images: Dual-purpose wheat: Improving grazing management using a smartphone app

1000 lb/ac Biomass Minimum





Images: Cereal Rye Cover Crop Management in Wisconsin, U of Wisconsin Extension Publication

Add perennials to crop rotation

- Allow for adequate regrowth prior to critical wind erosion period.
- Delay seeding and removal of perennial until after critical wind erosion period.

Return unsuitable cropland to permanent vegetation

- Sandy fields / susceptible wind erodibility group
- Tops of knolls and hills

Wind Erosion on Hills and Knolls

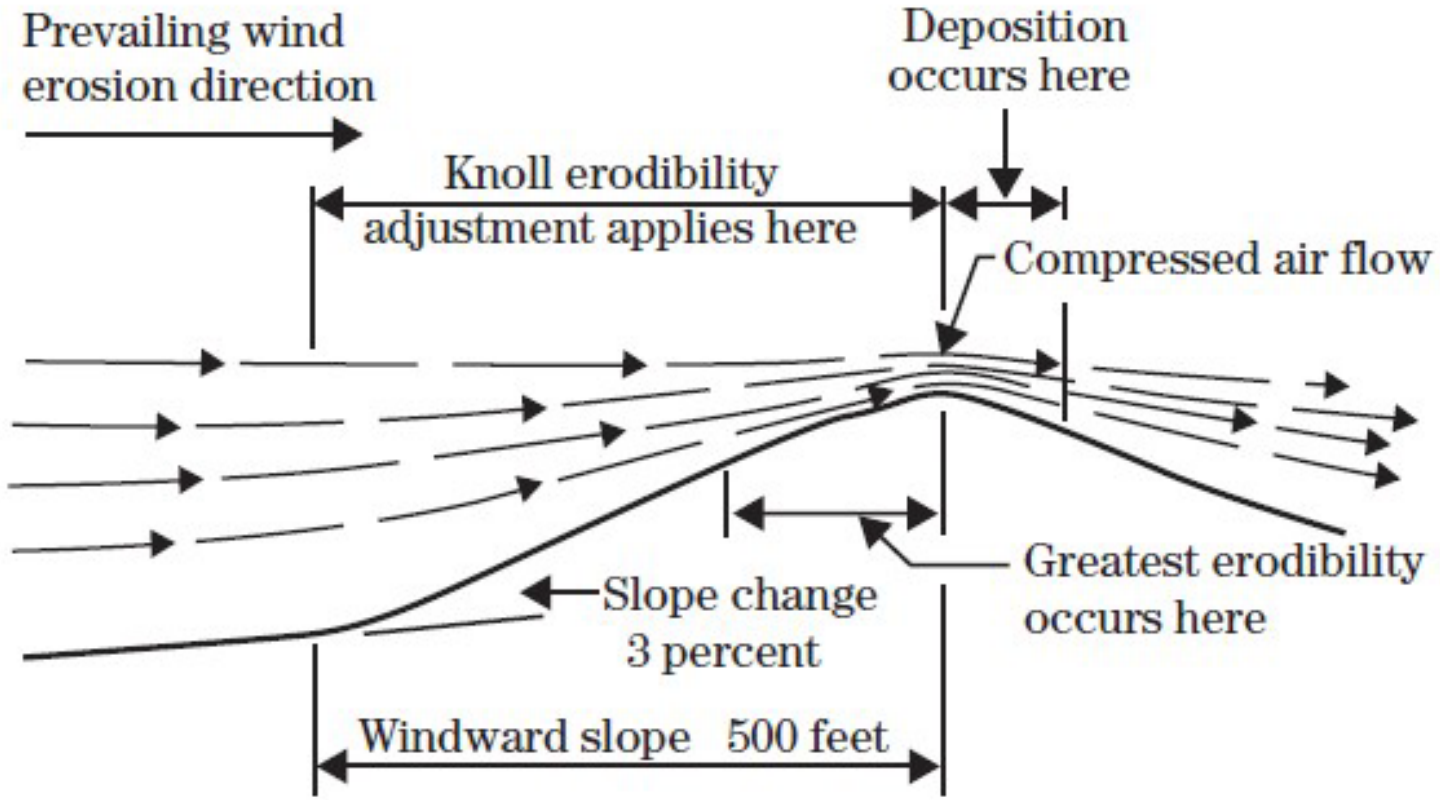


Image: NRCS National Agronomy Manual, 2002 (archived)

Increase vegetation

Pro

- Effective
- ~1 yr implementation
- Low cost

Con

- Annual vegetation requires enough time for adequate growth.
- Vulnerable to annual crop failure.

SOLUTIONS

Increase high carbon residue

Increase vegetation

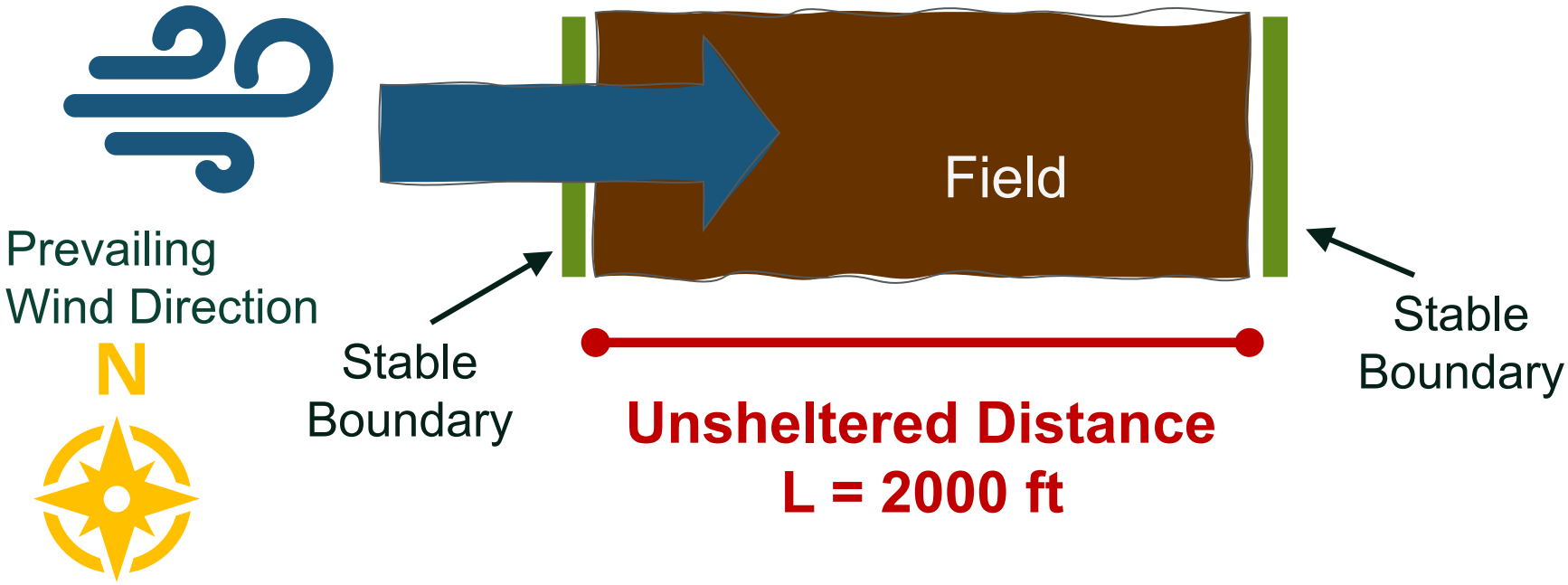
Decrease unsheltered distance

Increase surface roughness

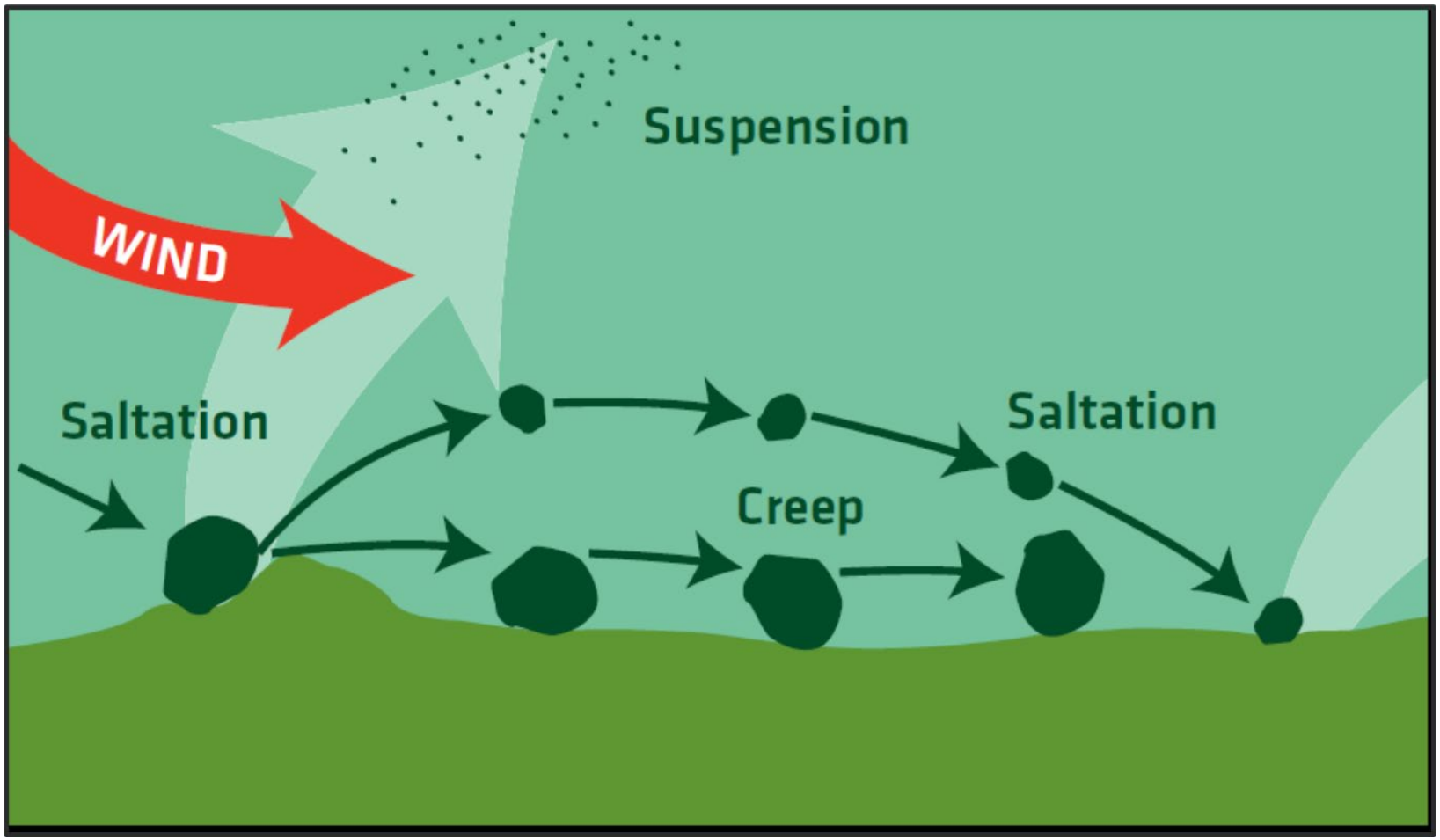
Increase soil moisture

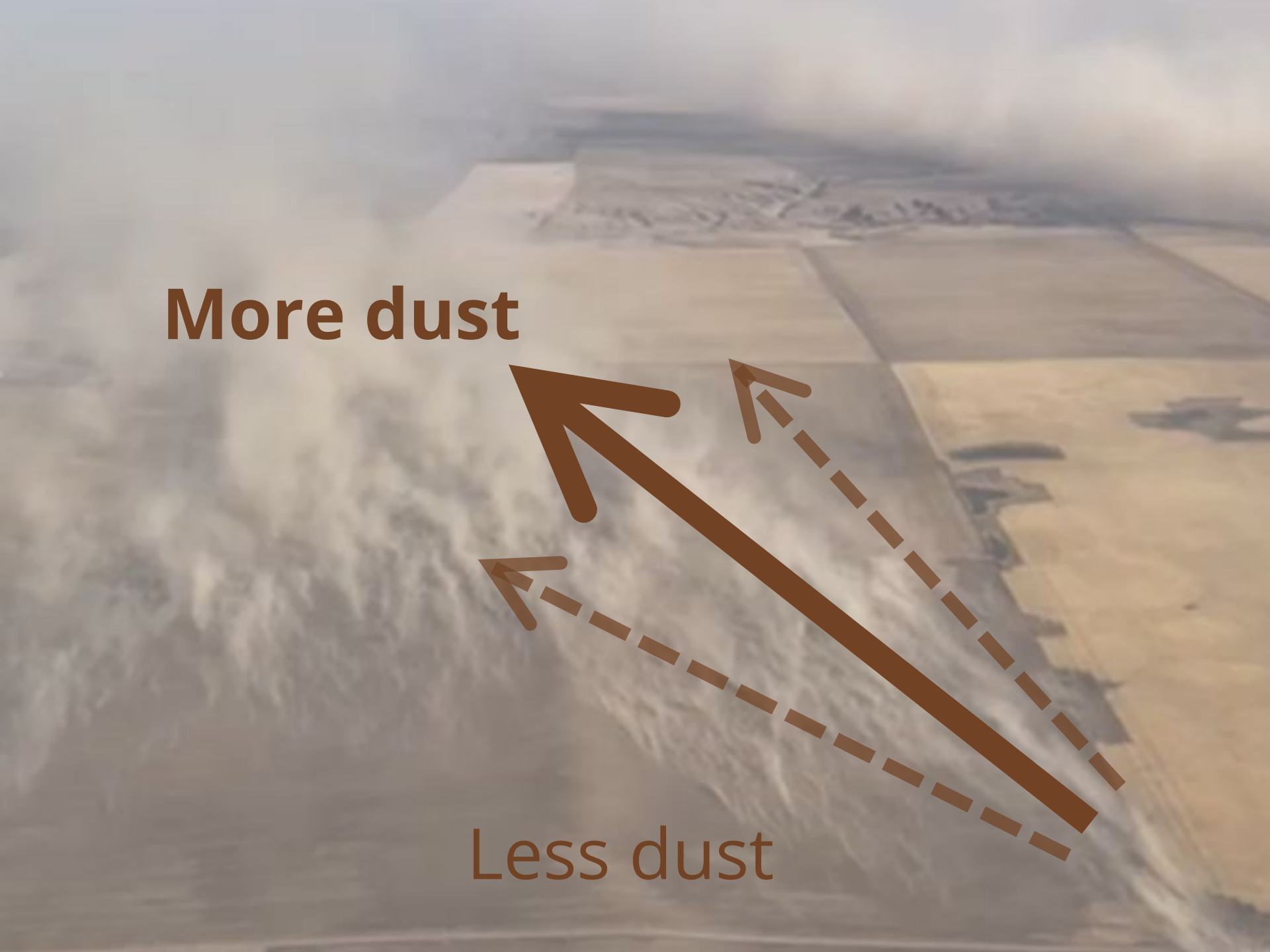
Unsheltered distance

The longest distance across a field from one stable boundary to the next, parallel to the prevailing wind.



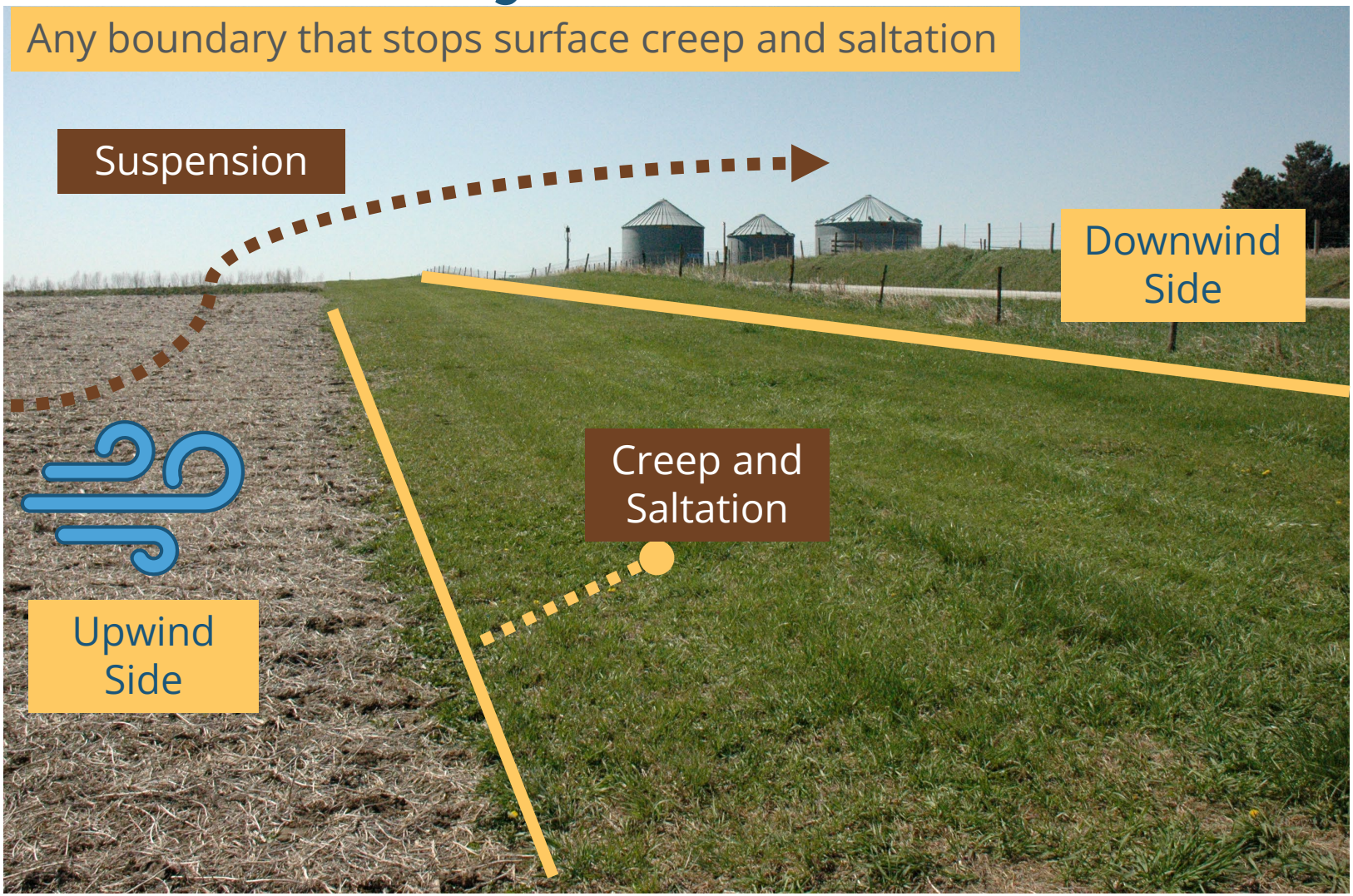
Mechanisms of Unsheltered Distance




More dust
Less dust

Stable boundary

Any boundary that stops surface creep and saltation



Examples of stable boundaries

TRAPS

Field Border

Crop Residue

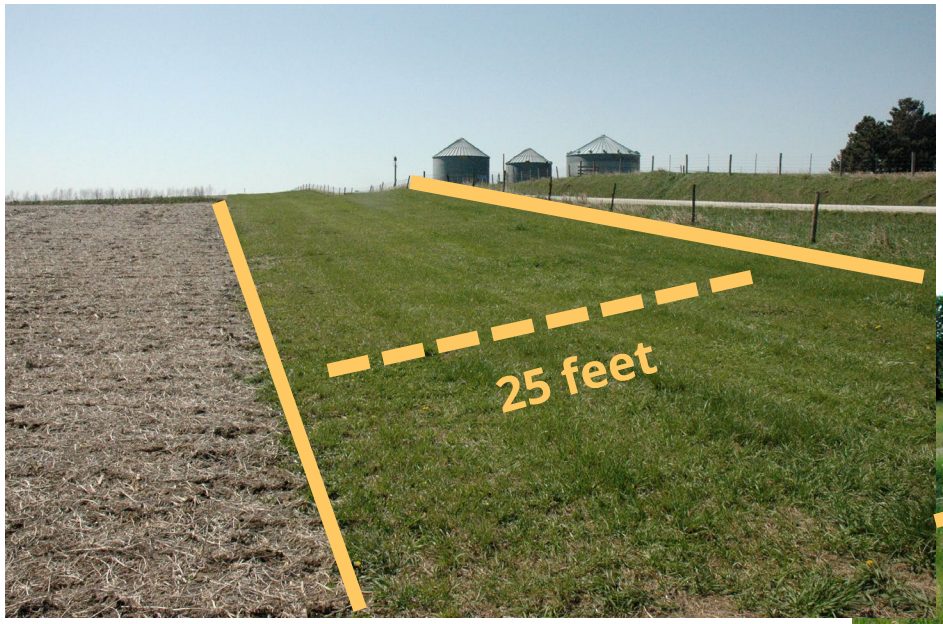
Cross Wind Trap Strip

BARRIERS

Windbreak

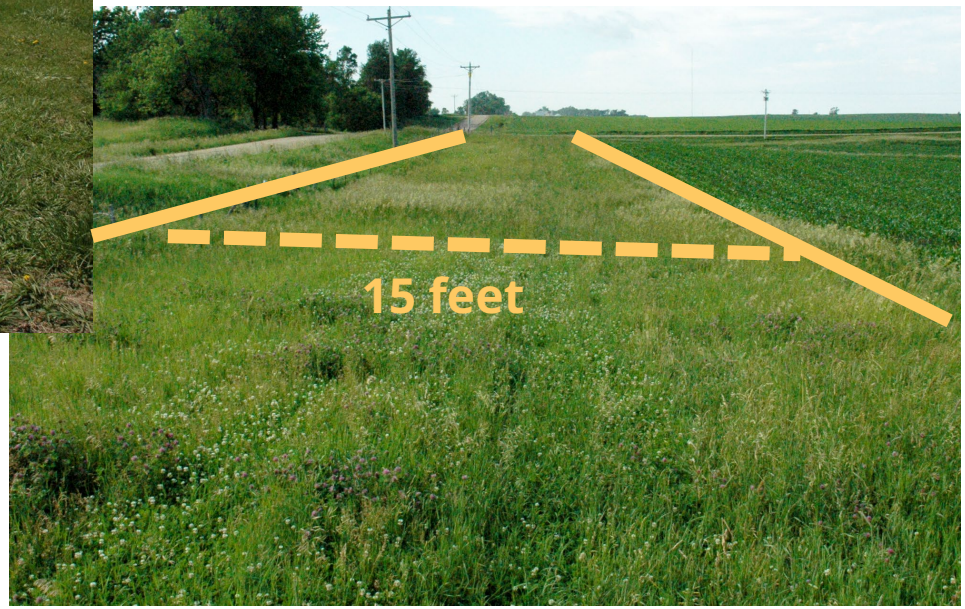
Herbaceous Wind Barriers

Stable Boundary Factors



- 25 feet wide if vegetation or residue < 1 ft tall

- 50% minimum density or vegetative cover, with minimum 50-70 stems/ft^2
- 15 feet wide if vegetation or residue > 1 ft tall



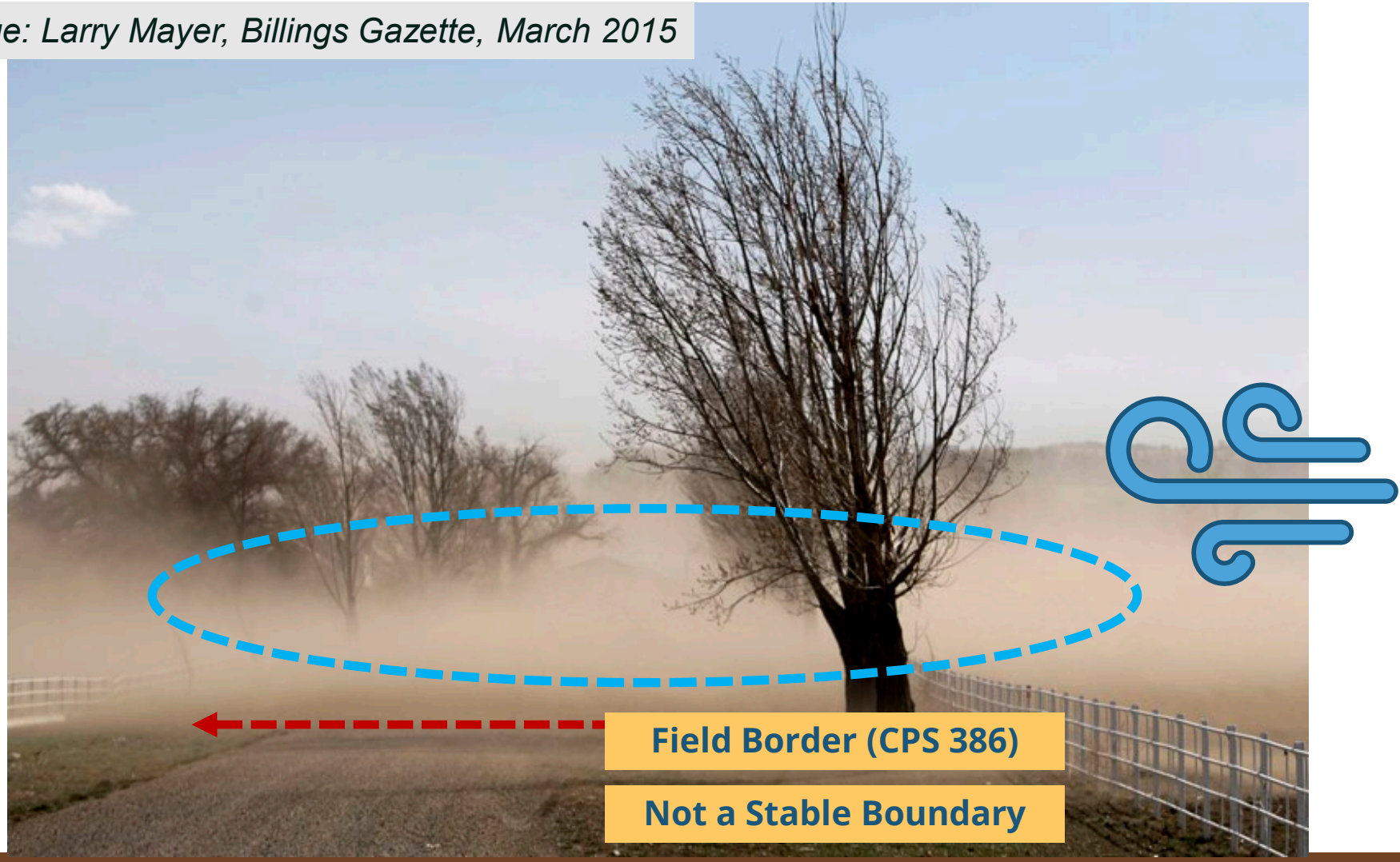
Roads and Fencelines as a Stable Boundary

Stable Boundary

Not a Stable Boundary

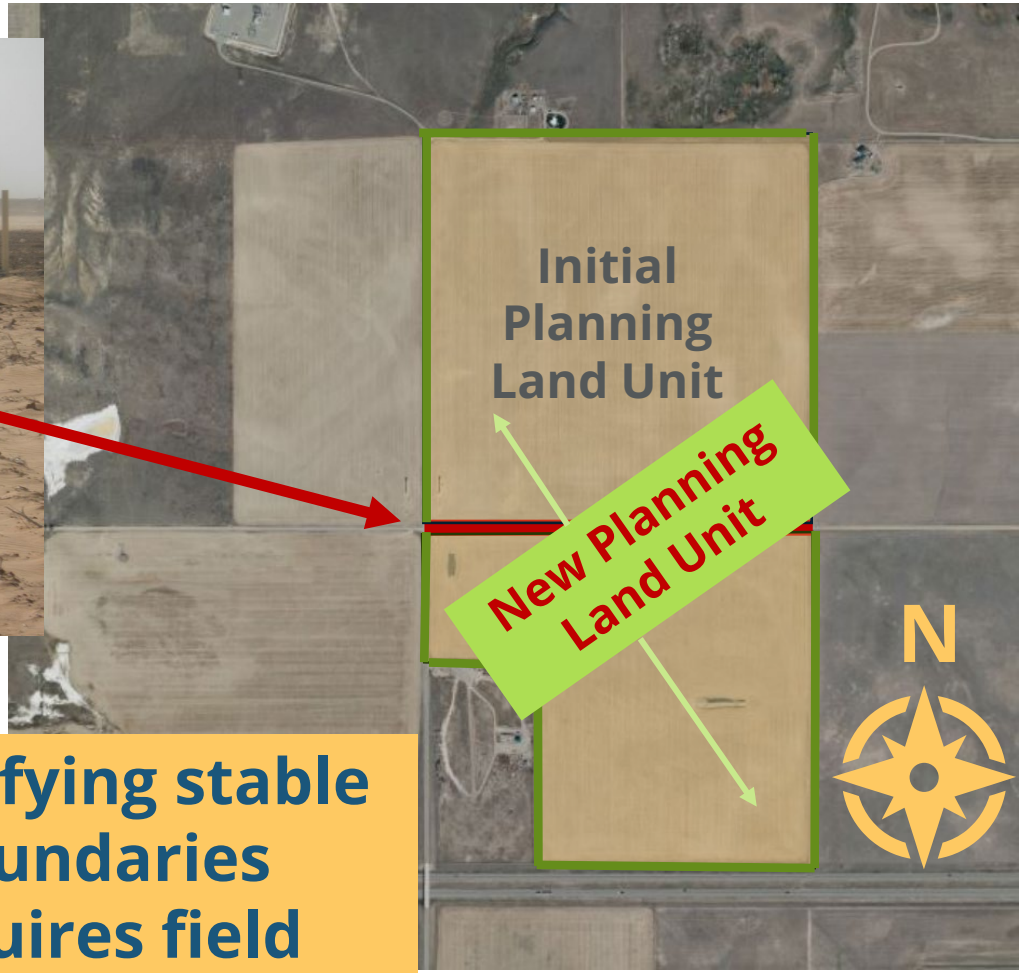
Stable Boundary?

Image: Larry Mayer, Billings Gazette, March 2015



Boundaries and planning

Not a Stable Boundary



Identifying stable boundaries requires field observation.

Cross Wind Trap Strips (589)

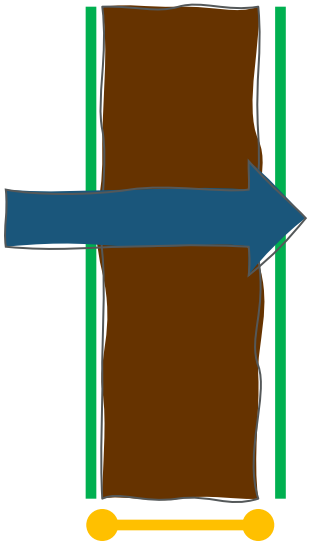
Image: Tatarko, J. Trujillo,W. and Schipanski, M. 2019.

- 25 feet wide if vegetation < 1 ft
- 15 feet wide if vegetation > 1 ft
- 50% minimum cover and 50-70 stems per ft^2

Field Orientation

Prevailing Wind
from the West

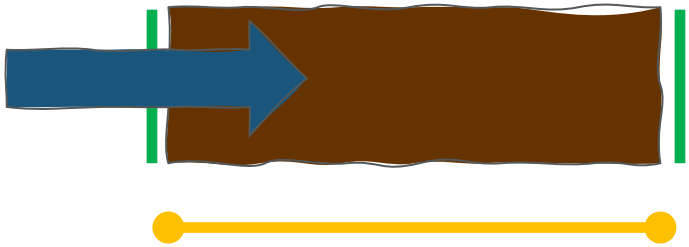
LESS EROSIVE



L = 1000 ft

North to South
Field Orientation

MORE EROSIVE

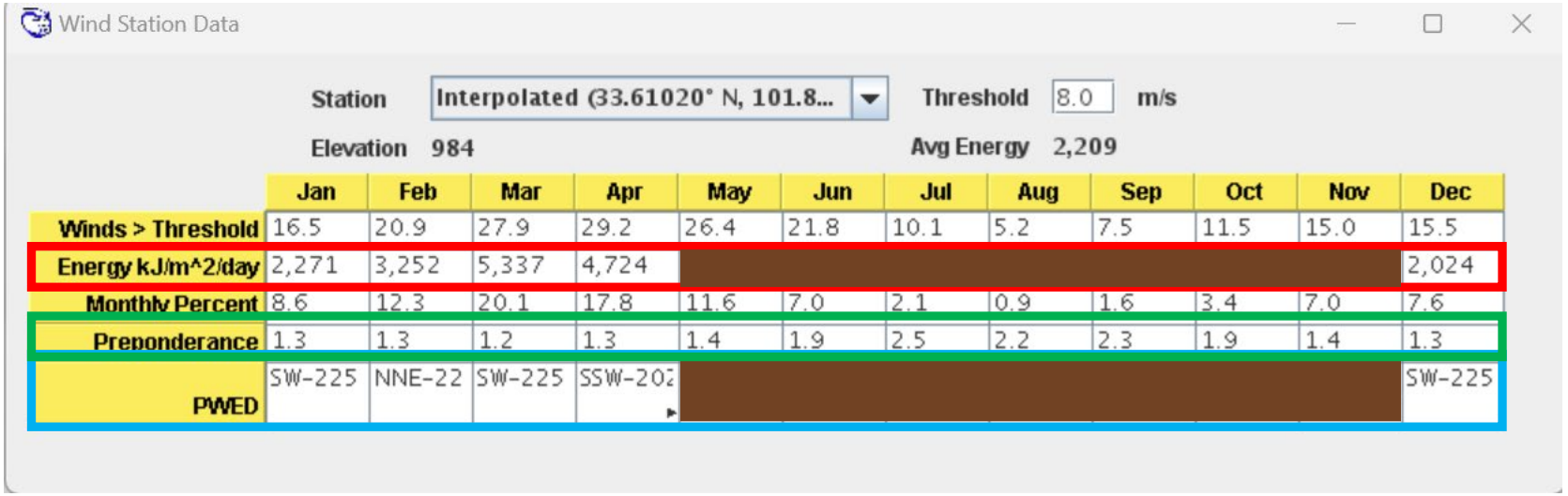


L = 5000 ft

East to West
Field Orientation

Wind Preponderance

Lubbock, TX



	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/m^2/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-20								SW-225

Critical Erosion Period = December through April

Prevailing Wind Direction = from the southwest, at 225°

Wind Preponderance

Preponderance - the prevalence of the prevailing wind erosion direction for the month (maximum ratio of parallel to perpendicular erosion forces). A preponderance value of 1.0 indicates no prevailing wind erosion direction. A value of 2.0 indicates a prevailing wind erosion direction, with wind erosion forces twice as great parallel as perpendicular to prevailing wind erosion direction.

Source: WEPS 1.5 User Manual

How likely is it that the wind will blow from the prevailing wind direction compared to the perpendicular direction?

- **≤1 = not likely, no prevailing wind direction**
- **2 = twice as likely**
- **3 = three times as likely**
- **4 = four times as likely**

Preponderance and Conservation Planning

- Locations with a strong preponderance during the critical wind erosion period will have greater response to conservation practices that decrease the unsheltered distance.
  - Cross wind trap strips (589)
  - Stripcropping (585)
  - Windbreaks and barriers (380)
  - Herbaceous wind barriers (603)
- For locations with preponderance less than 1, when using practices that decrease unsheltered distance:
  - May be less effective than locations with strong preponderance
  - Use in conjunction with field-scale treatments such as residue, vegetation, random roughness, soil moisture, etc.
  - Consider using barriers on multiple sides of field
  - Consider decreasing total field size

Lubbock, TX

Wind Station Data

Station: Interpolated (33.61020° N, 101.8... Threshold: 8.0 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/m^2/day	2,271	3,252	5,337	4,724	3,067	1,863	556	231	436	903	1,843	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	1.3
PWED	SW-225	NNE-22	SW-225	SSW-202	S-180	S-180	S-180	S-180	SSW-202	S-180	SSW-202	SW-225

Havre, MT

Wind Station Data

Station: Interpolated (48.62825° N, 110.1... Threshold: 8.0 m/s

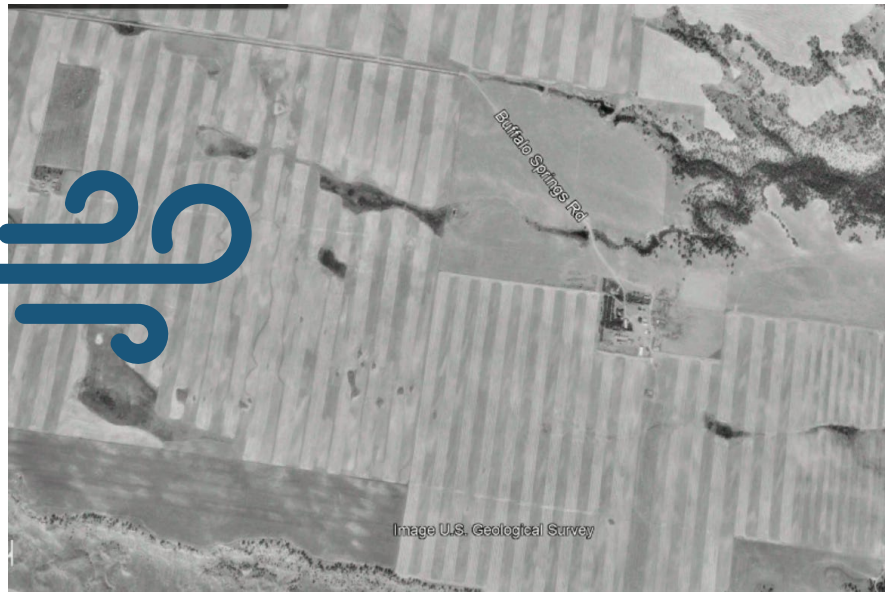
Elevation: 742 Avg Energy: 10,330

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winds > Threshold	40.9	35.1	34.2	37.2	35.3	32.0	23.8	22.9	31.1	37.3	40.2	43.1
Energy kJ/m^2/day	15,823	9,932	10,081	11,190	10,333	9,208	5,070	4,762	7,302	10,798	12,952	16,504
Monthly Percent	12.8	8.0	8.1	9.0	8.3	7.4	4.1	3.8	5.9	8.7	10.4	13.3
Preponderance	4.3	3.2	2.8	2.3							3.8	3.8
PWED	W-270	W-270	W-270	WNW-29	WNW-29	W-270	WNW-29	WNW-29	WNW-29	W-270	W-270	W-270

Stripcropping (CPS 585)

Effective stripcropping requires adequate residue or vegetation in alternating strips during the critical wind erosion period.

Stripcropping (585)



1996

L = 175 ft

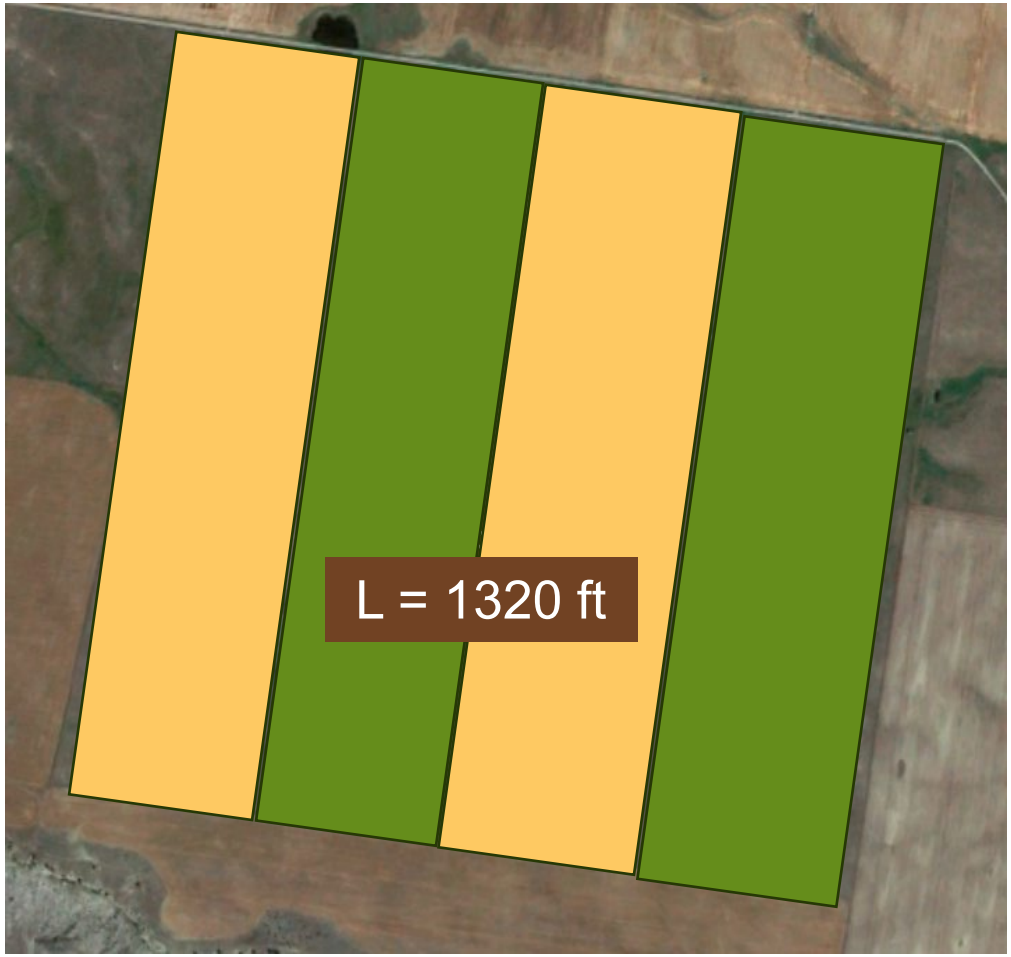
LESS EROSIVE

2019

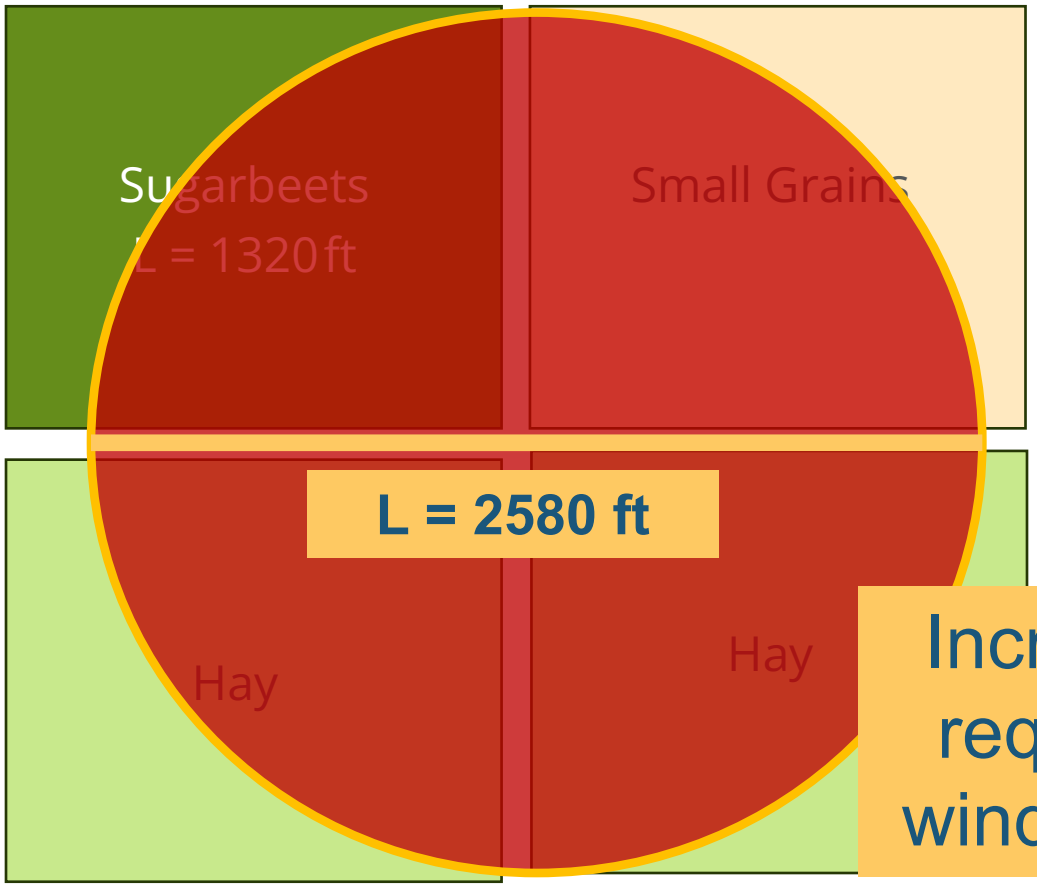
L = 5280 ft

MORE EROSIVE

Decrease Field Size



Unintended consequences



Increased field size requires increased wind erosion control.

Decrease unsheltered distance

Pro

- Effective if predominant prevailing wind
- Good strategy for redundancy.
- Good options for low residue systems.

Con

- Not as effective if no distinct prevailing wind direction.
- Farmer reluctance.
- Must correspond with production equipment.

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Windbreaks and Barriers

FARM PRODUCTION AND CONSERVATION
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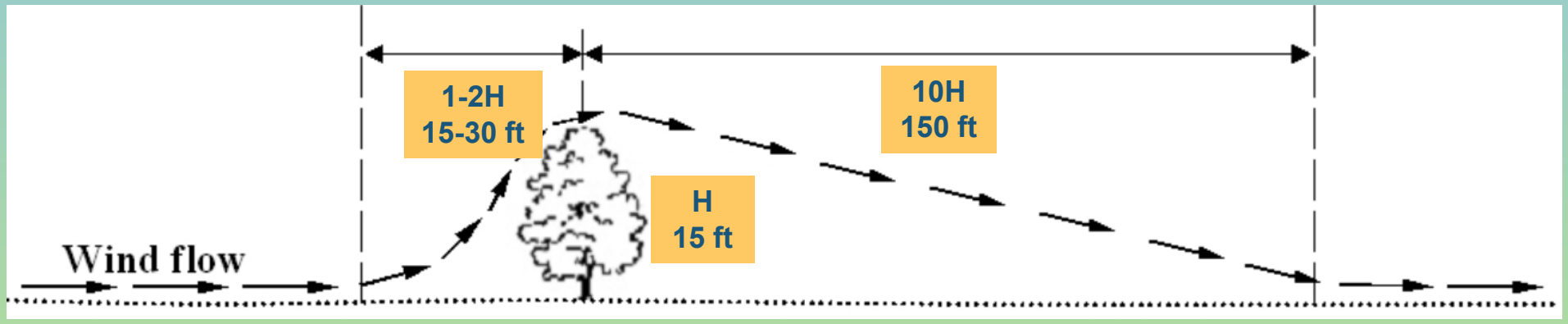
Windbreak-Shelterbelt Establishment and Renovation (CPS 380)

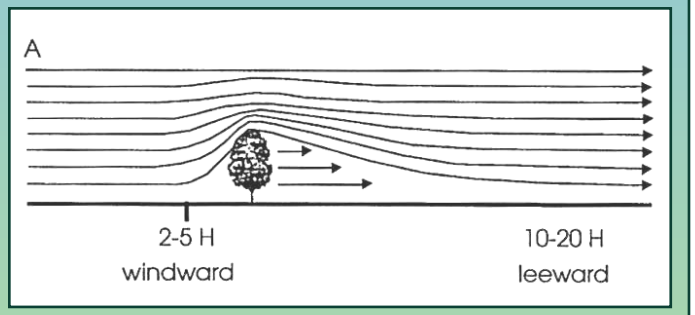
Wind barrier = Any structure designed to reduce the wind speed on the downwind side of the barrier.

Barrier Mechanisms



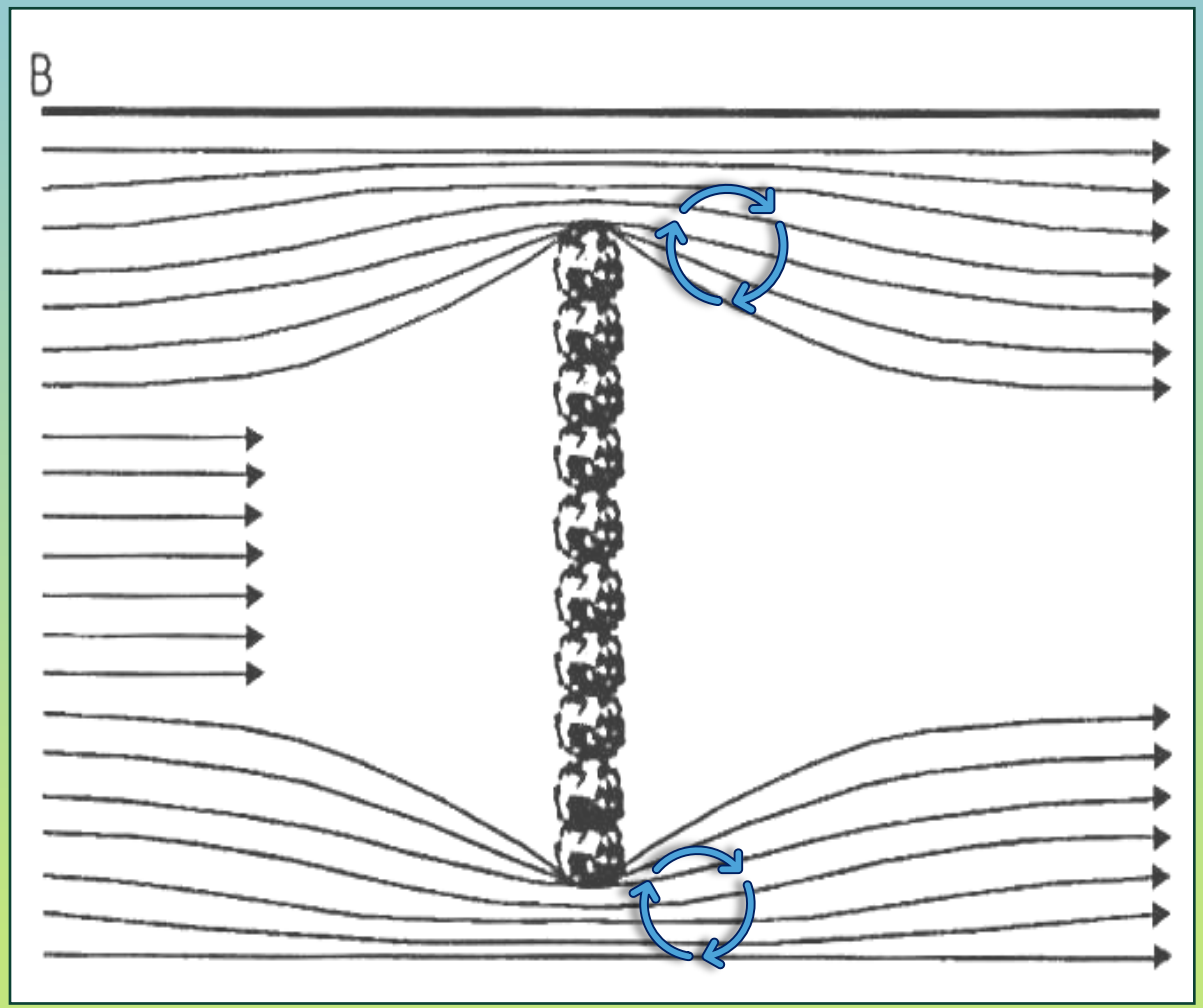
Horizontal area of protection = 10 times the height of the barrier

Air Flow Patterns



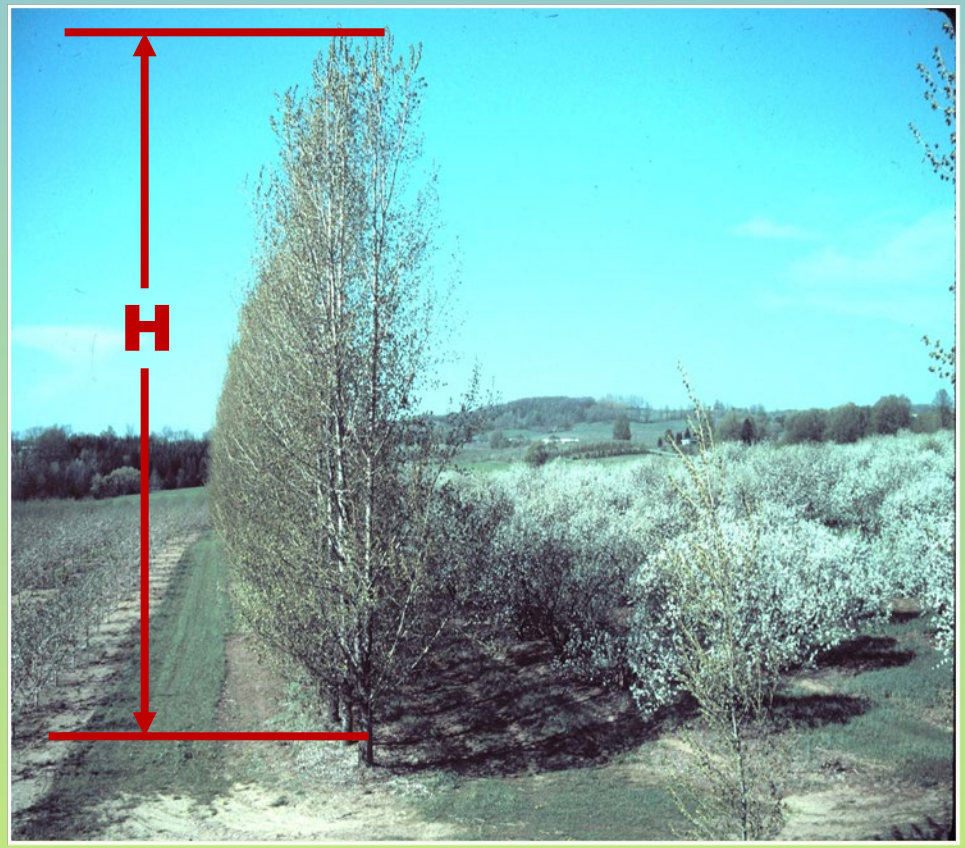
Side view

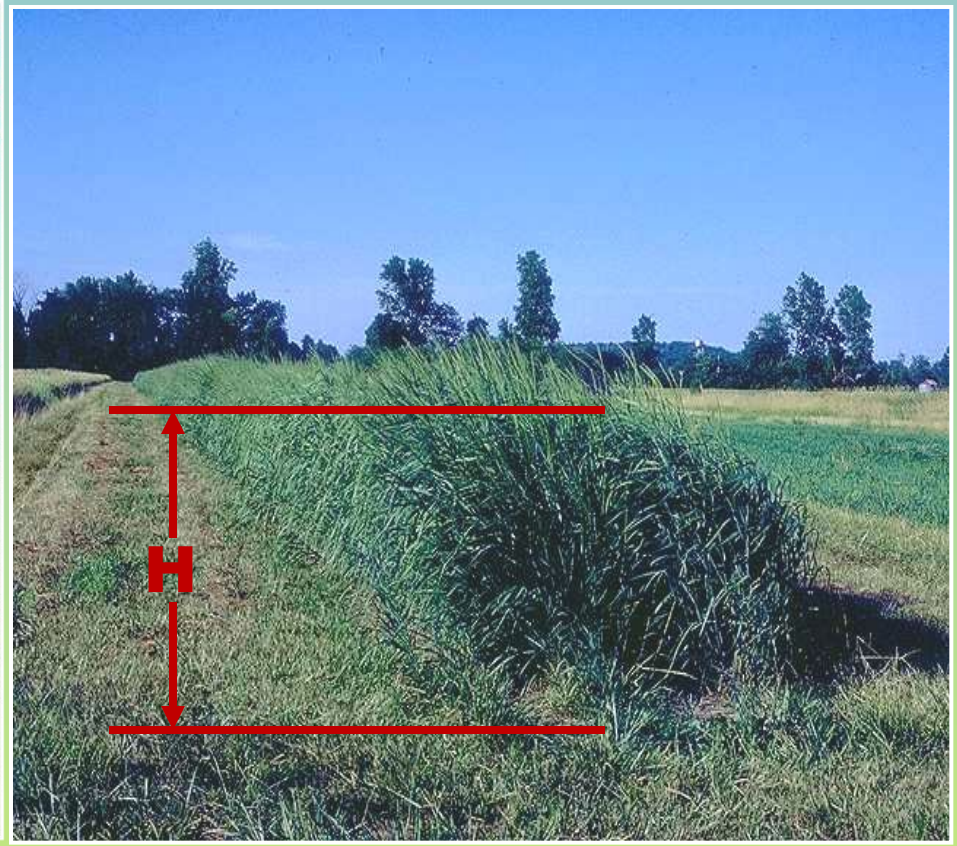
- Traps creep and saltation from upwind
- Stops creep, saltation and suspension downwind



Overhead view

What is H?





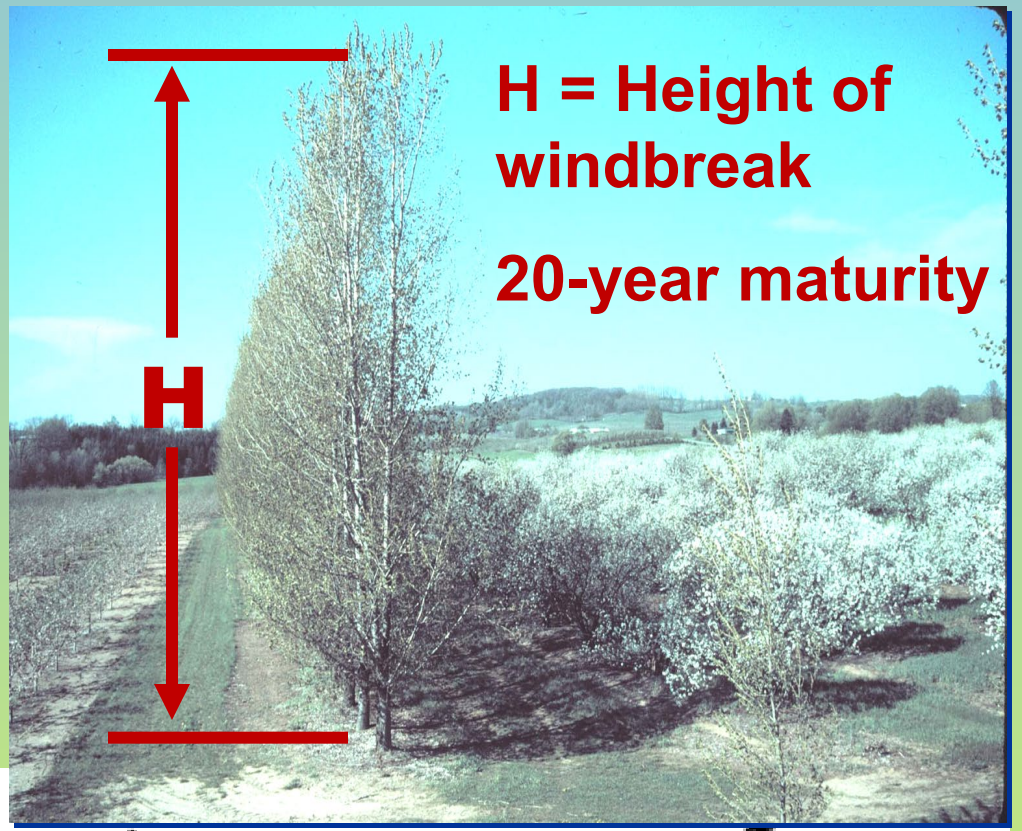
H = Effective Height of the Barrier

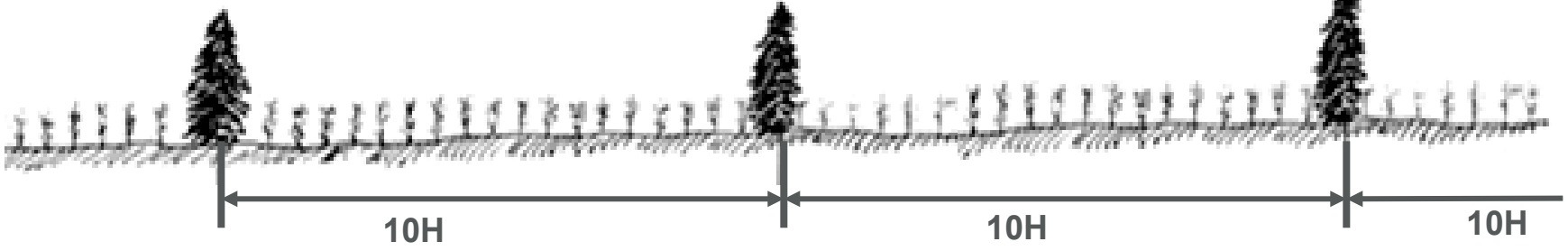
Why Is Barrier Height Important?

Element: Height

Match height to achieve desired protected area

The height determines the distance of the sheltered zone. For example, select the tallest trees suited to the site for large fields and fewest barriers.



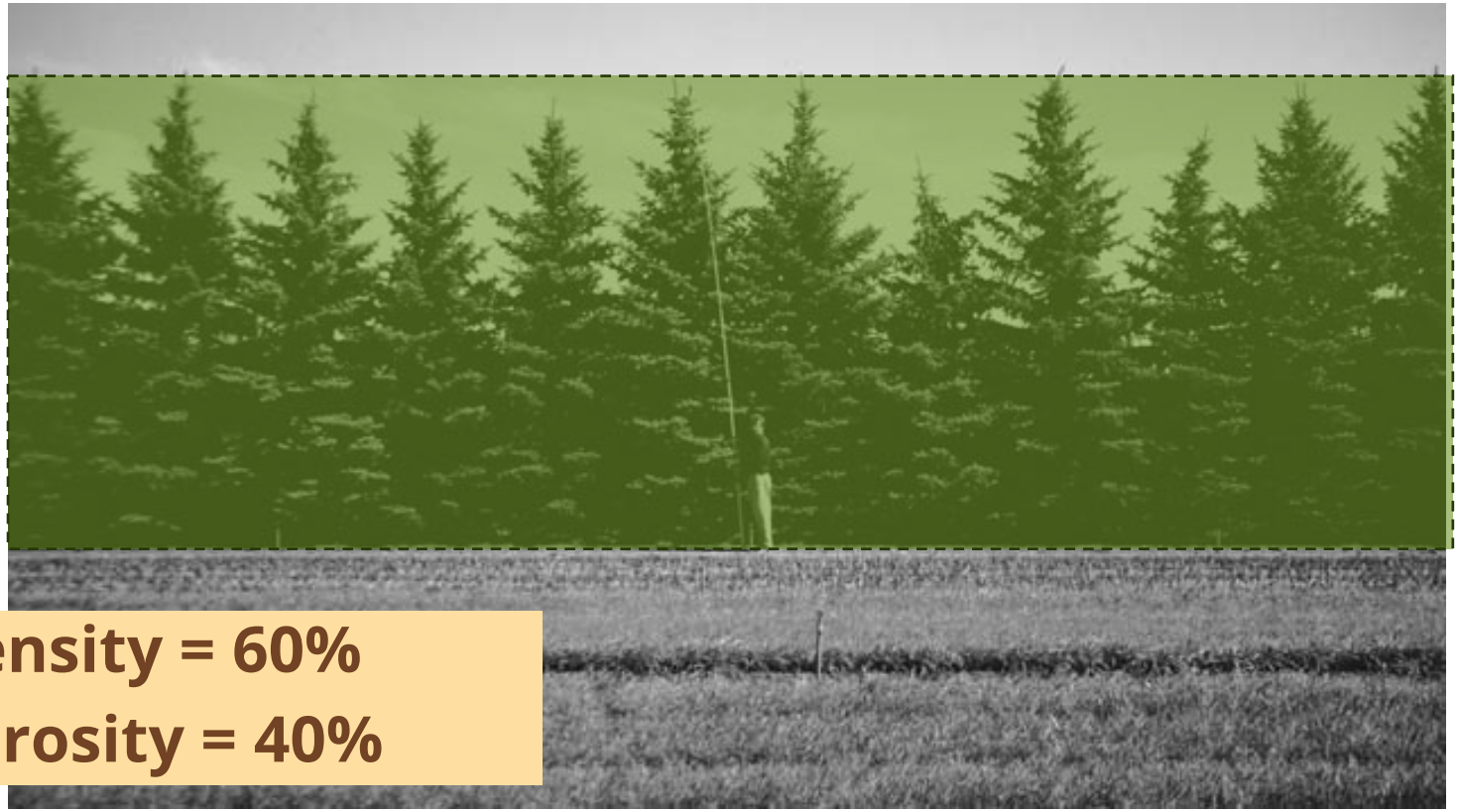


Barrier Density and Porosity

Density = solid portion

Porosity = open portion

Density + Porosity = 100%



- **Density = 60%**
- **Porosity = 40%**

Single-row windbreak of blue spruce with H = 20 ft.

Wind Effects of "Wide" Forest Block

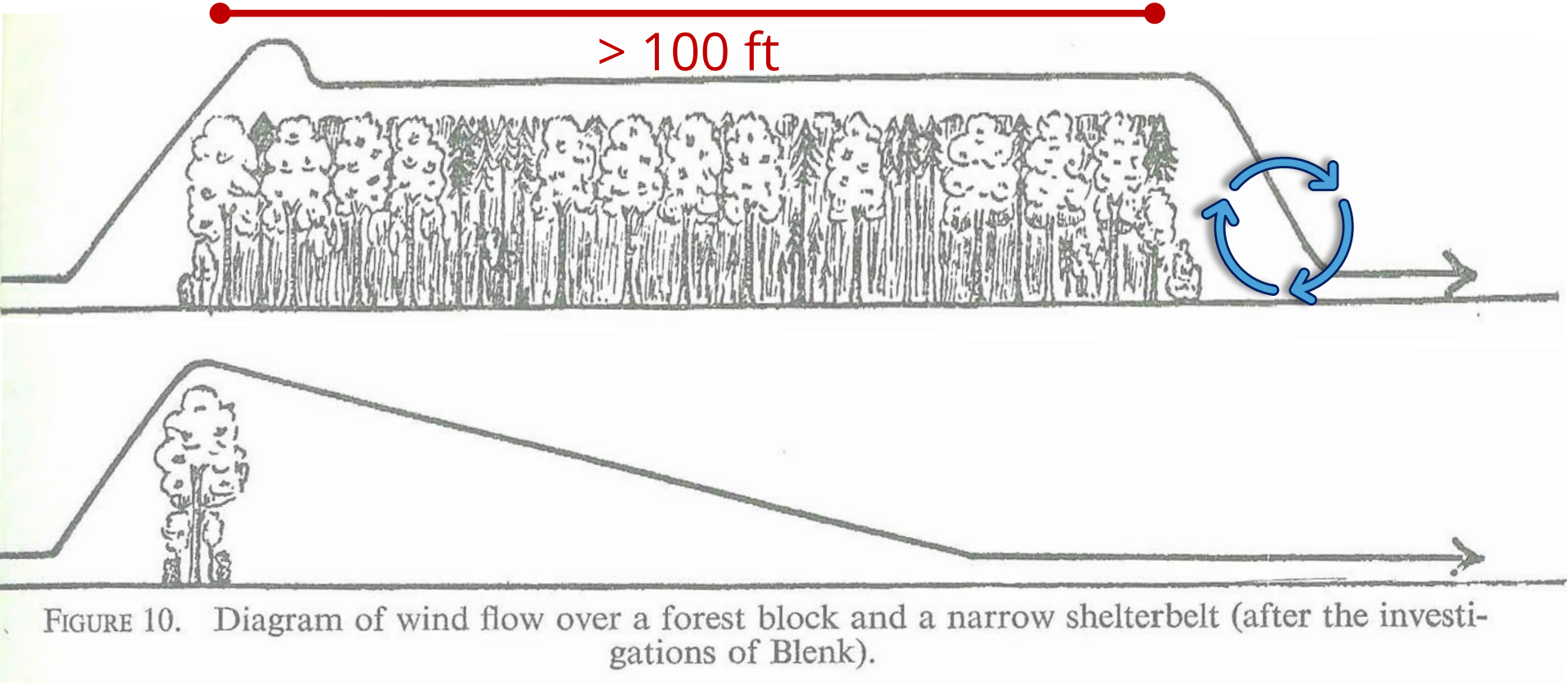


FIGURE 10. Diagram of wind flow over a forest block and a narrow shelterbelt (after the investigations of Blenk).

Best density for erosion control = 40 - 60%

Barrier Width

The width of a barrier is defined as the total distance from one side of the barrier to the other.

Orientation

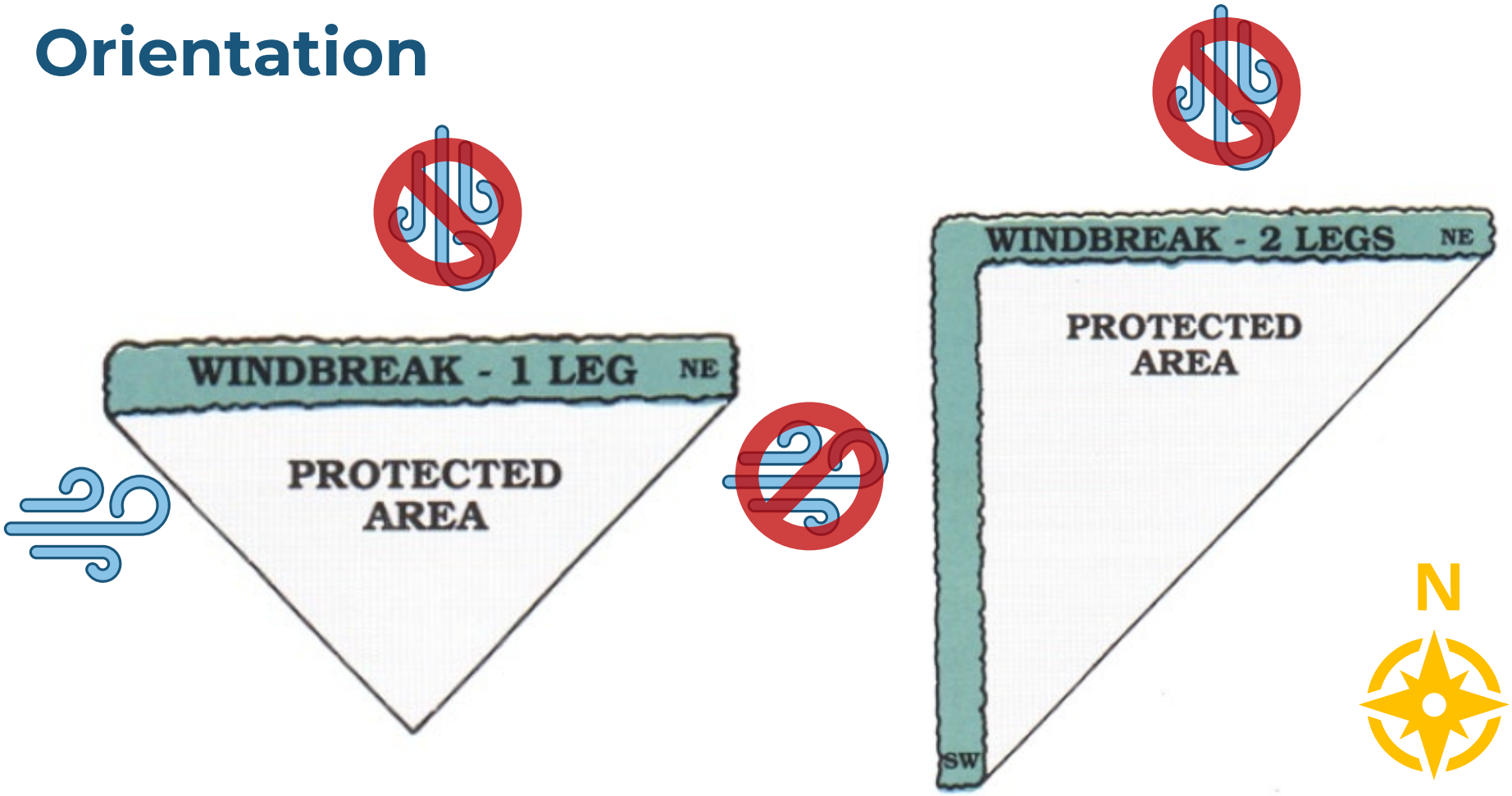
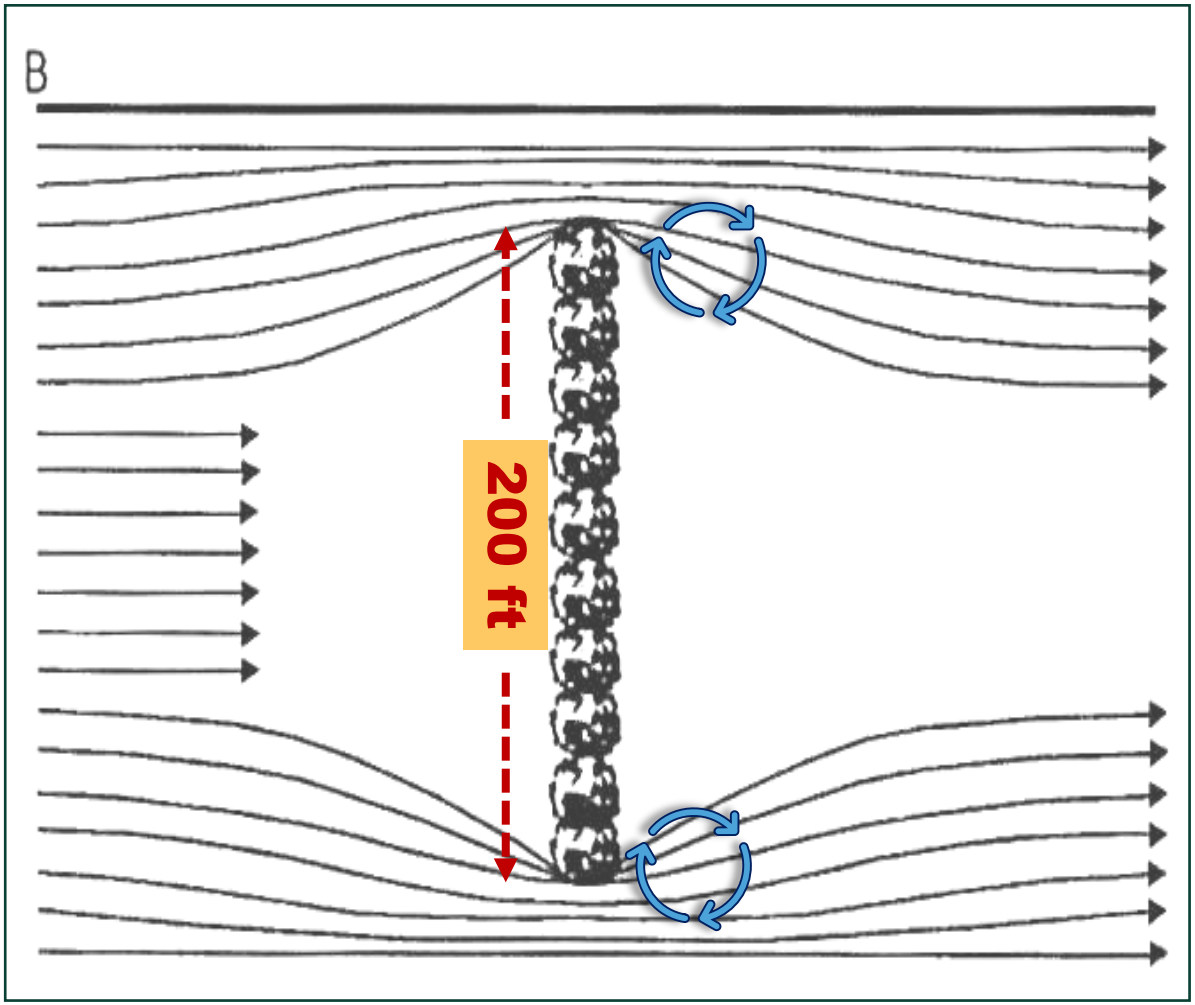


Image: How Windbreaks Work, Dr. James Brandle, Dr. Xinhua Zhou, Dr. Laurie Hodges; University of Nebraska Extension EC 02-1763-X

Length

Length > 10 H
H = 20 ft
L = 200 ft



Field Observation and Barrier Factors

- Height
- Density
- Width
- Orientation
- Length

Landscape Changes

2006
LESS EROSIVE

2016
MORE EROSIVE

USDA National Agroforestry Center.
Windbreaks of the Great Plains.

Herbaceous Wind Barriers (CPS 603)

- Linear plantings of upright annual or perennial vegetation.
- Oriented perpendicular to prevailing winds.
- 1.5 ft minimum height
- Density of 50 to 60% during critical wind erosion period.
- Spacing not more than 10 times the barrier height.

Ryegrass in Georgia

Ryegrass and carrots in Michigan

Corn rows in North Dakota

Perennial grass

References

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QUESTIONS?