Soil: Effects of Warming, Drying, Compaction and Microbes on Yield

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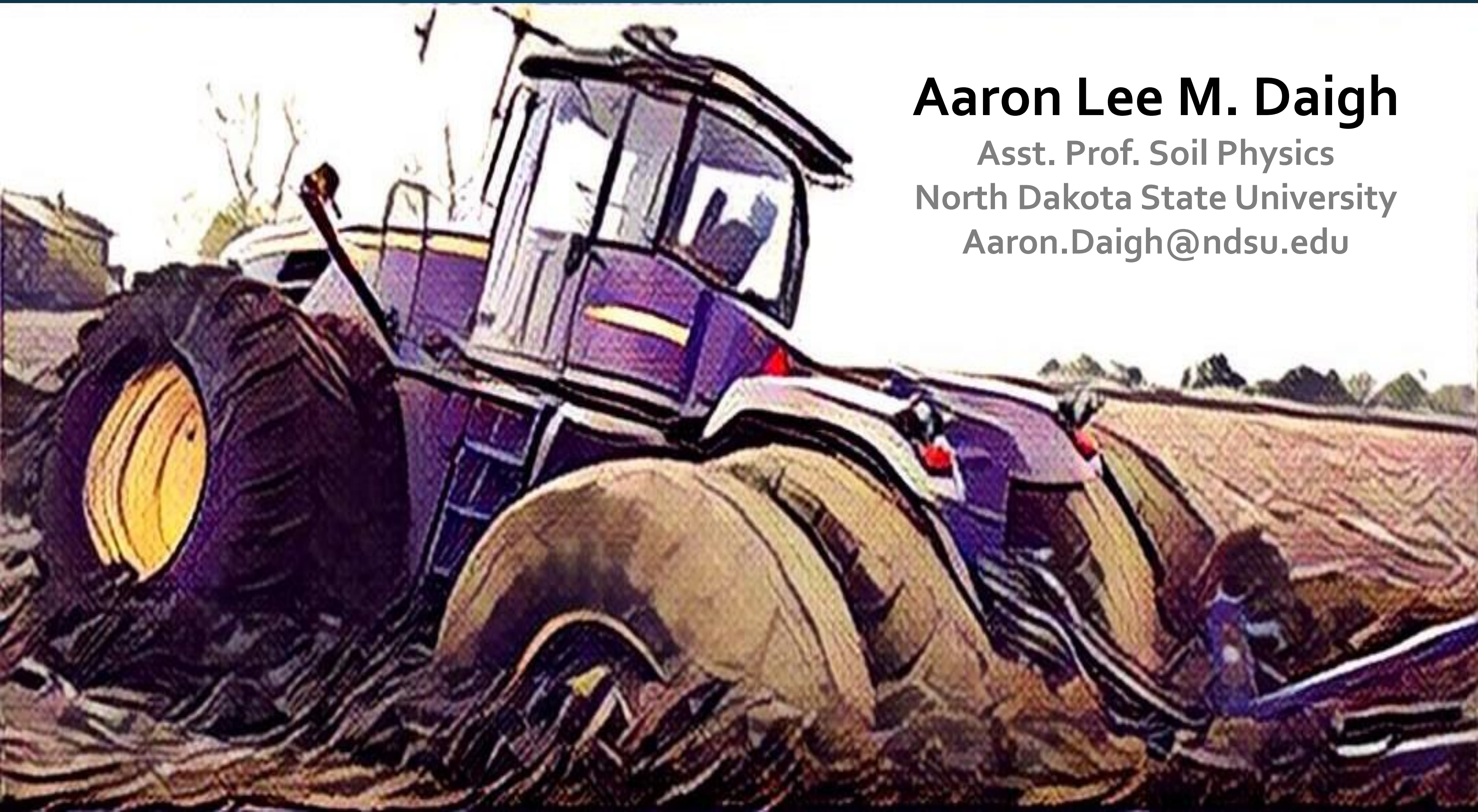
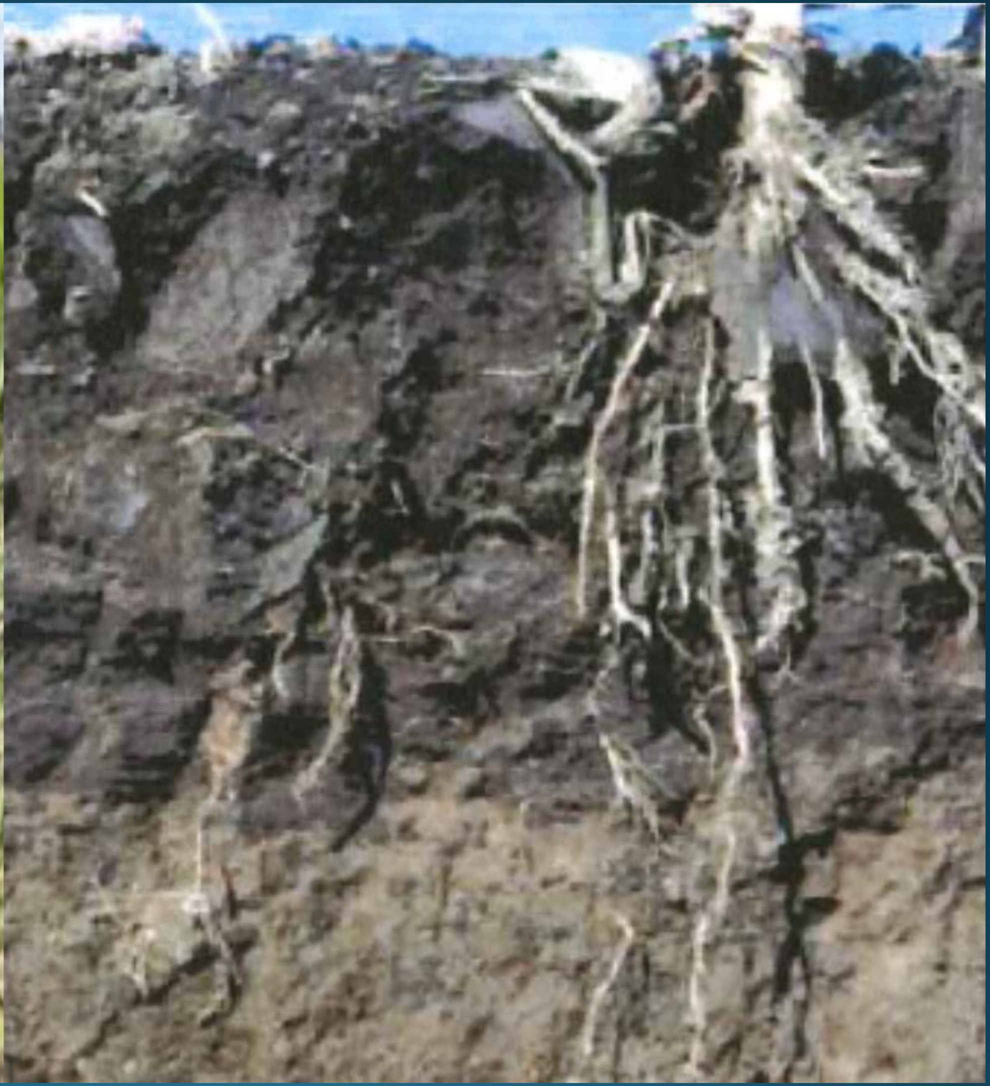
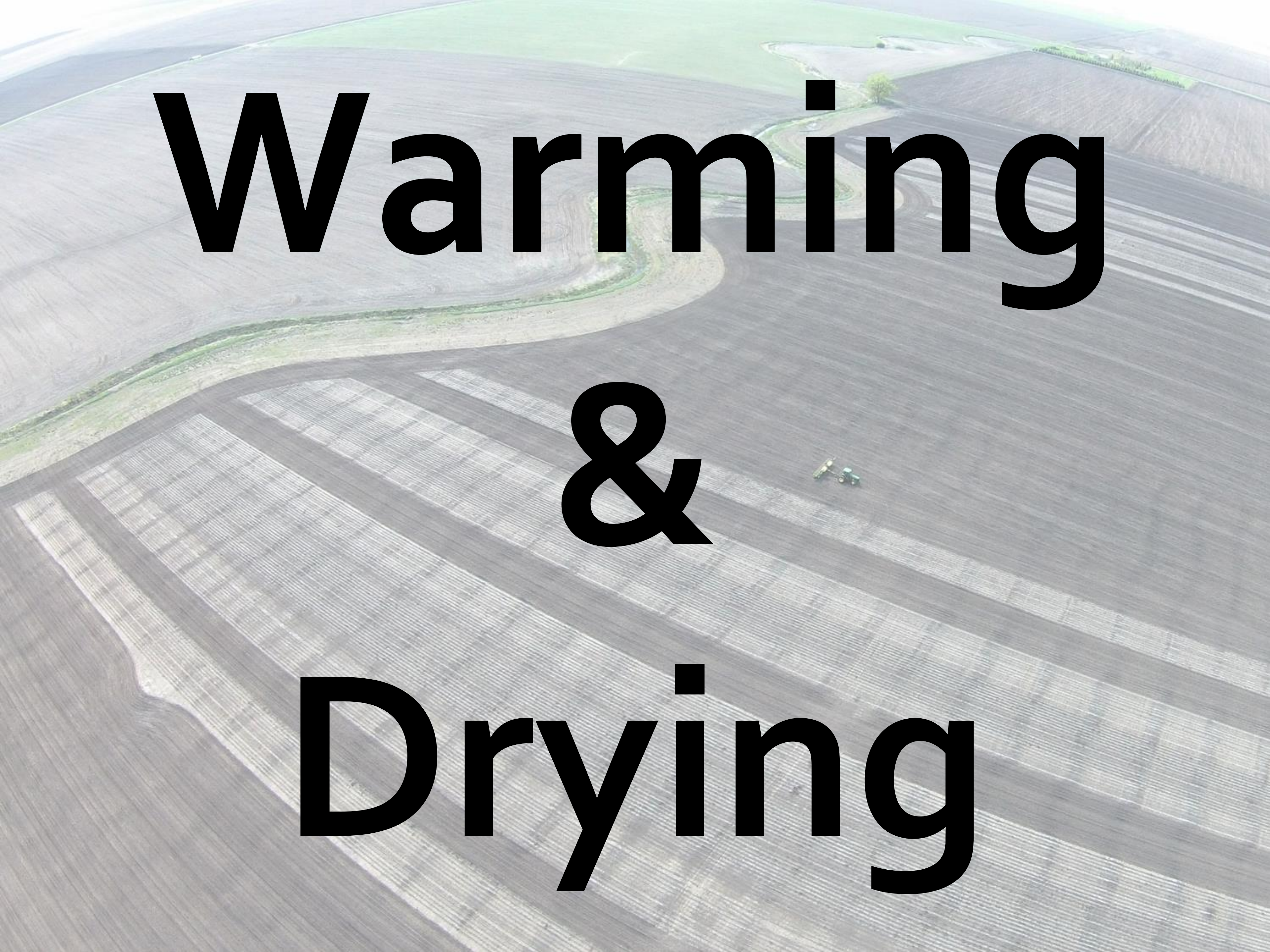
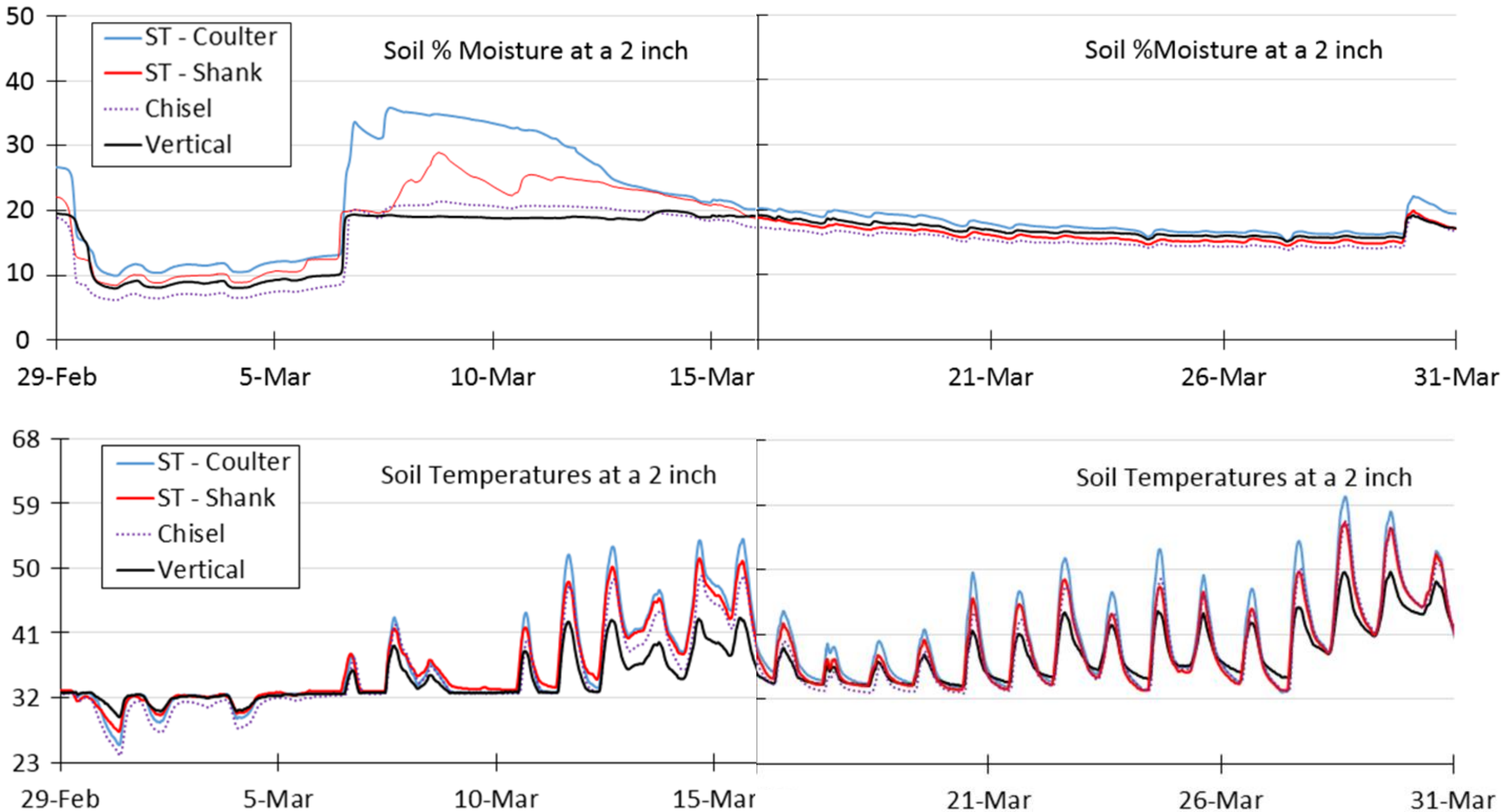


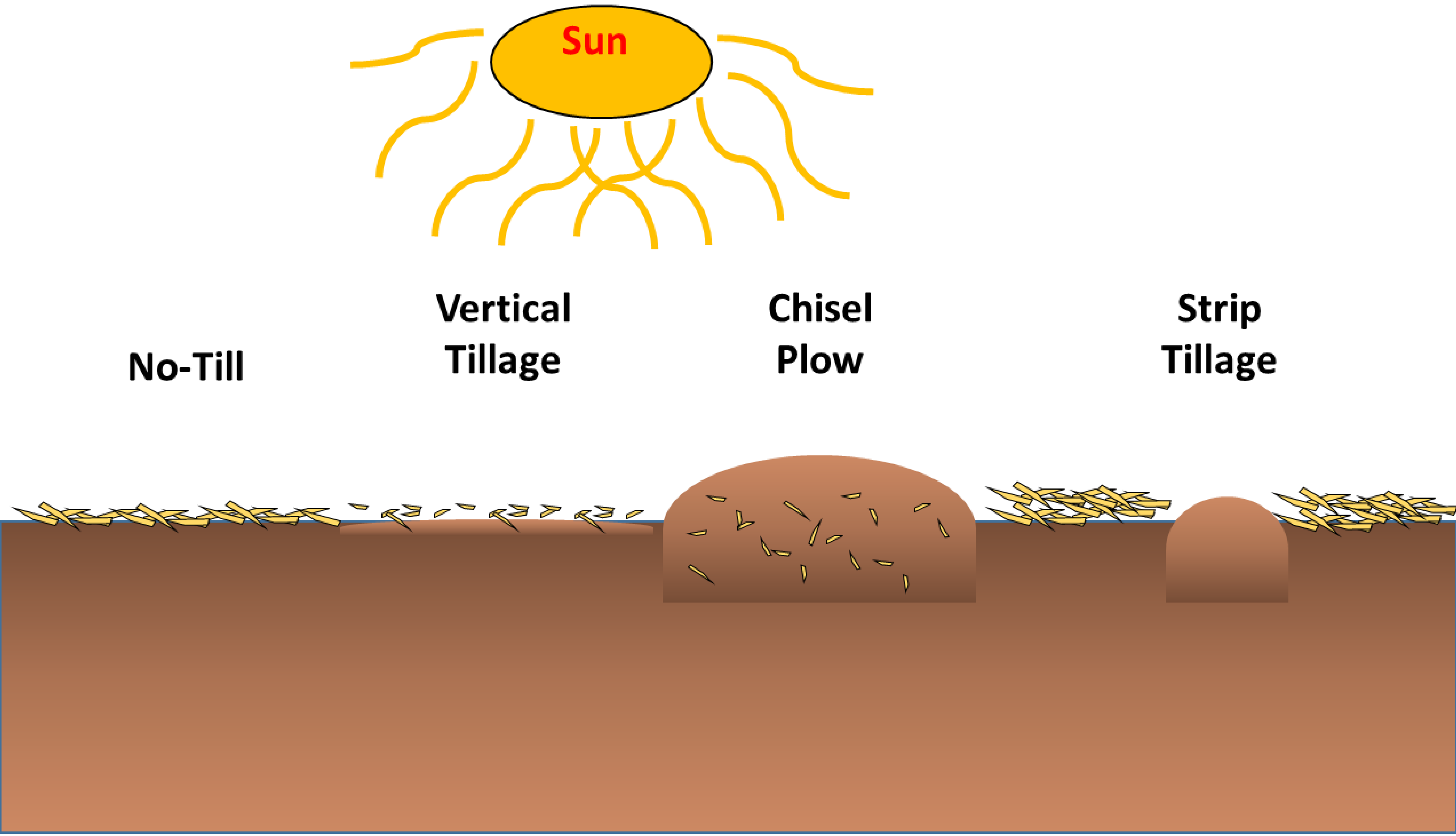
Family Feast Analogy

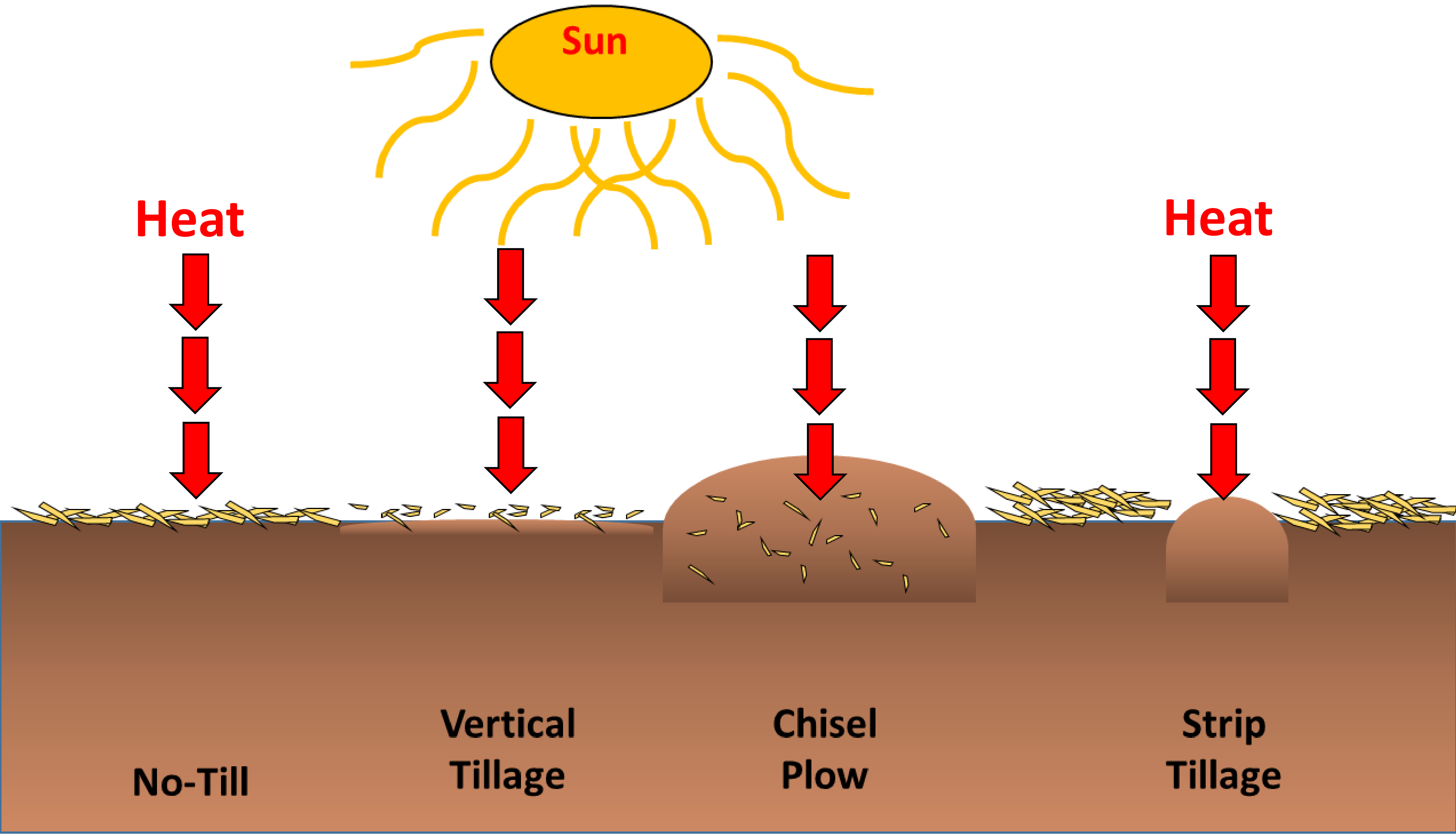



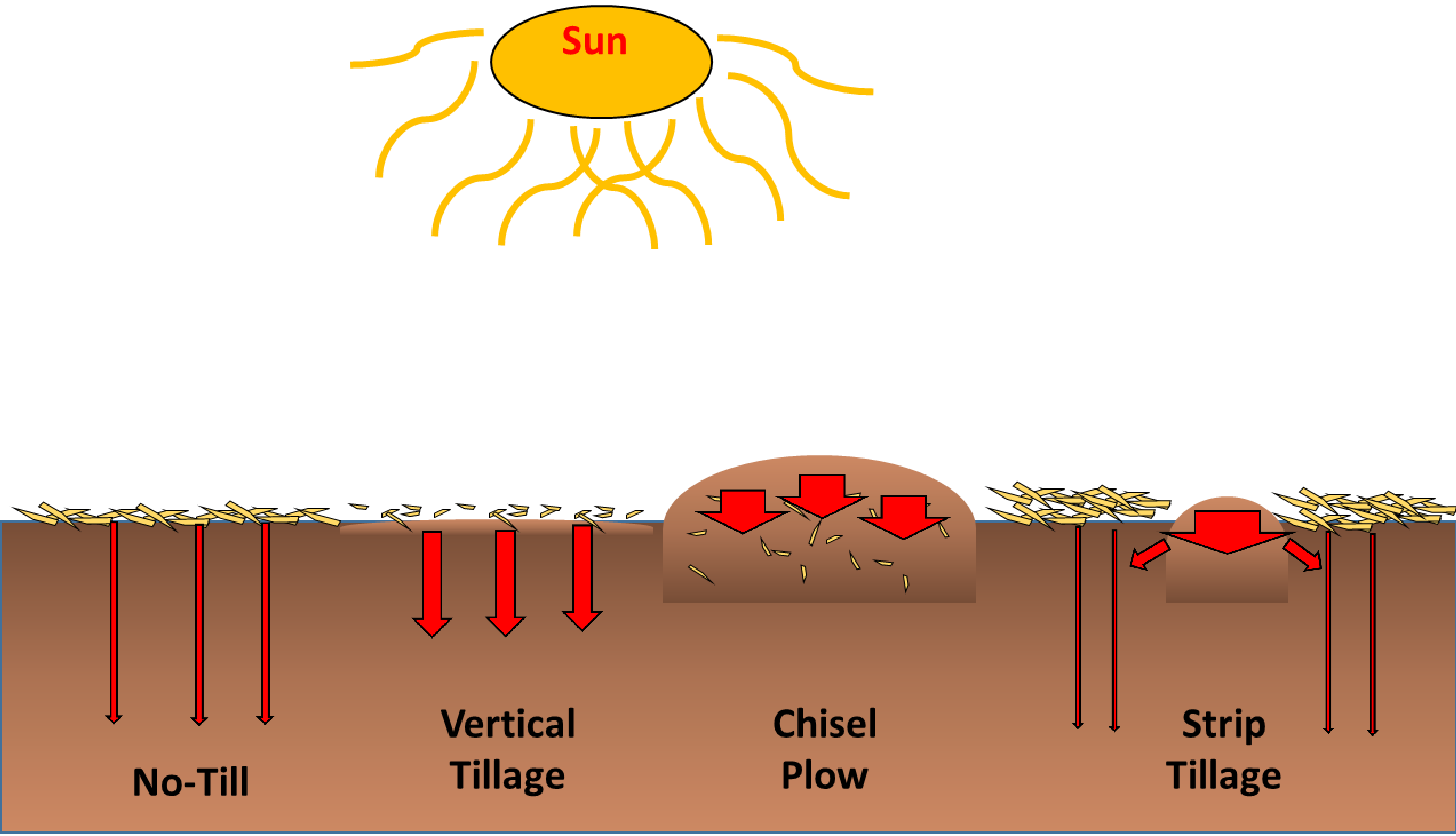



Warming
&
Drying

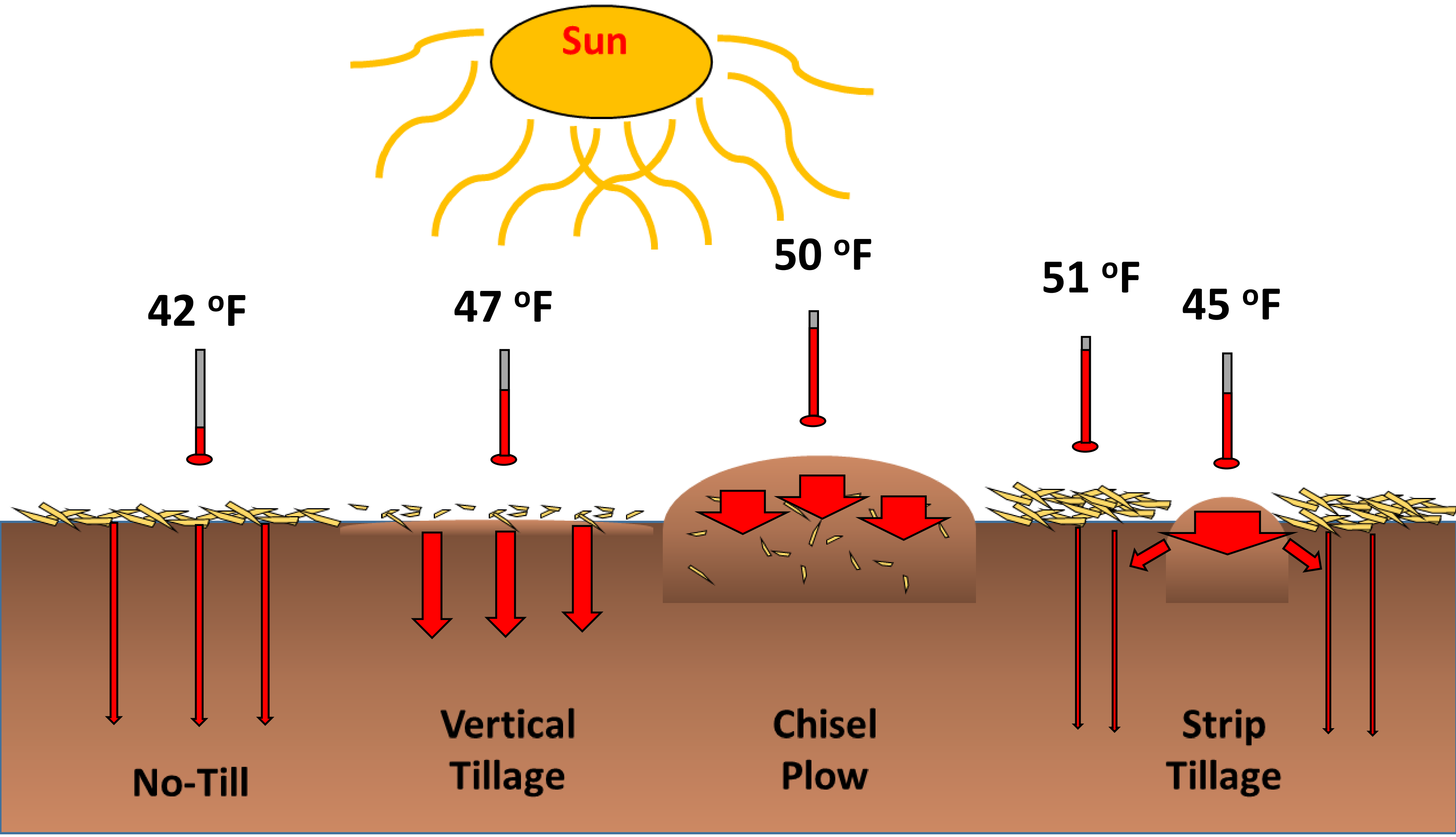

ST - Coulter
ST - Shank
Chisel
Vertical
Soil % Moisture at a 2 inch
Soil %Moisture at a 2 inch
50
40
30
20
10
0
29-Feb
5-Mar
10-Mar
15-Mar
21-Mar
26-Mar
31-Mar
ST - Coulter
ST - Shank
Chisel
Vertical
Soil Temperatures at a 2 inch
Soil Temperatures at a 2 inch
68
59
50
41
32
23
29-Feb
5-Mar
10-Mar
15-Mar
21-Mar
26-Mar
31-Mar

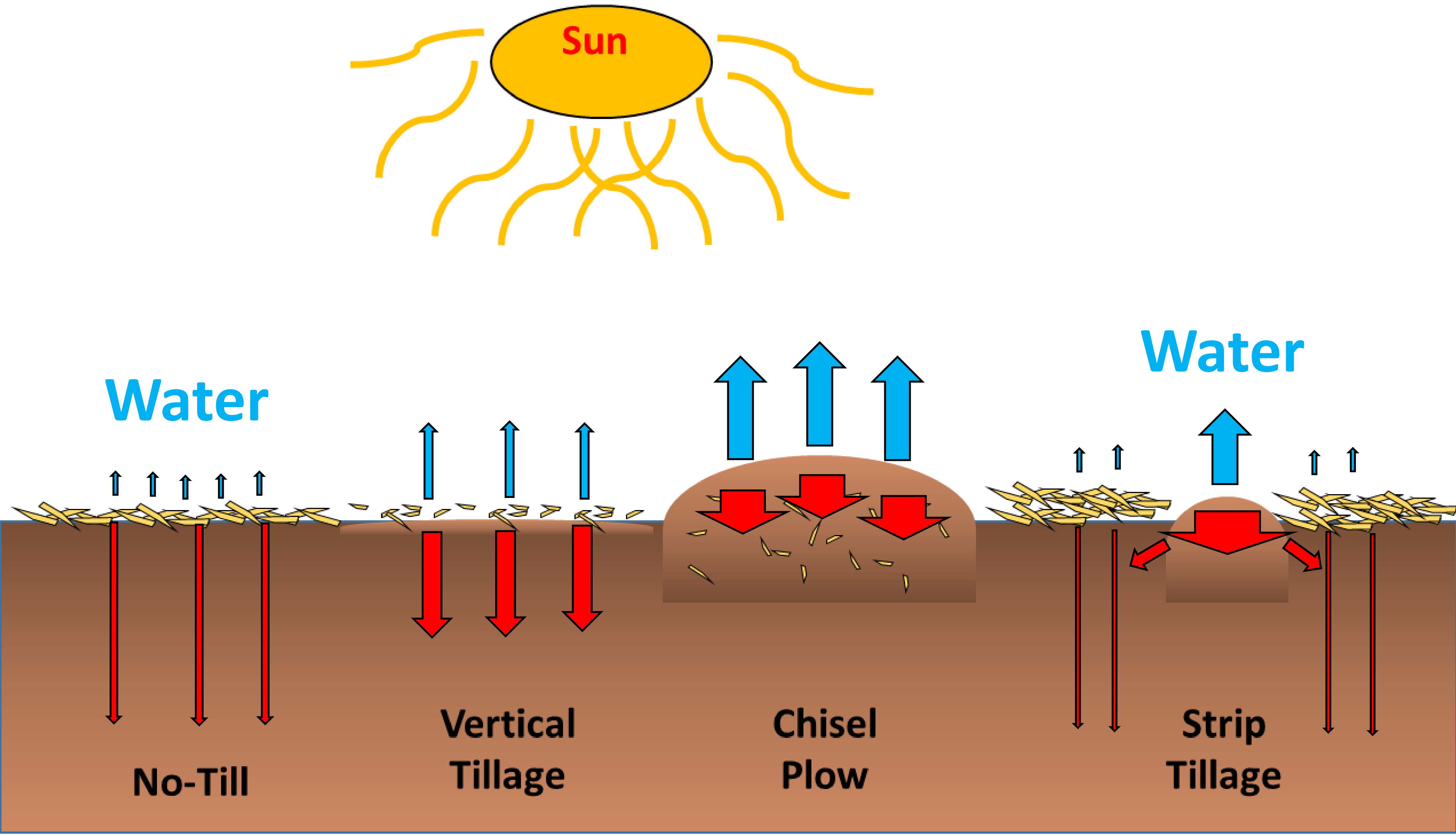

Sun
Vertical Tillage
Chisel Plow
Strip Tillage
No-Till


Sun
Heat
Heat
No-Till
Vertical Tillage
Chisel Plow
Strip Tillage

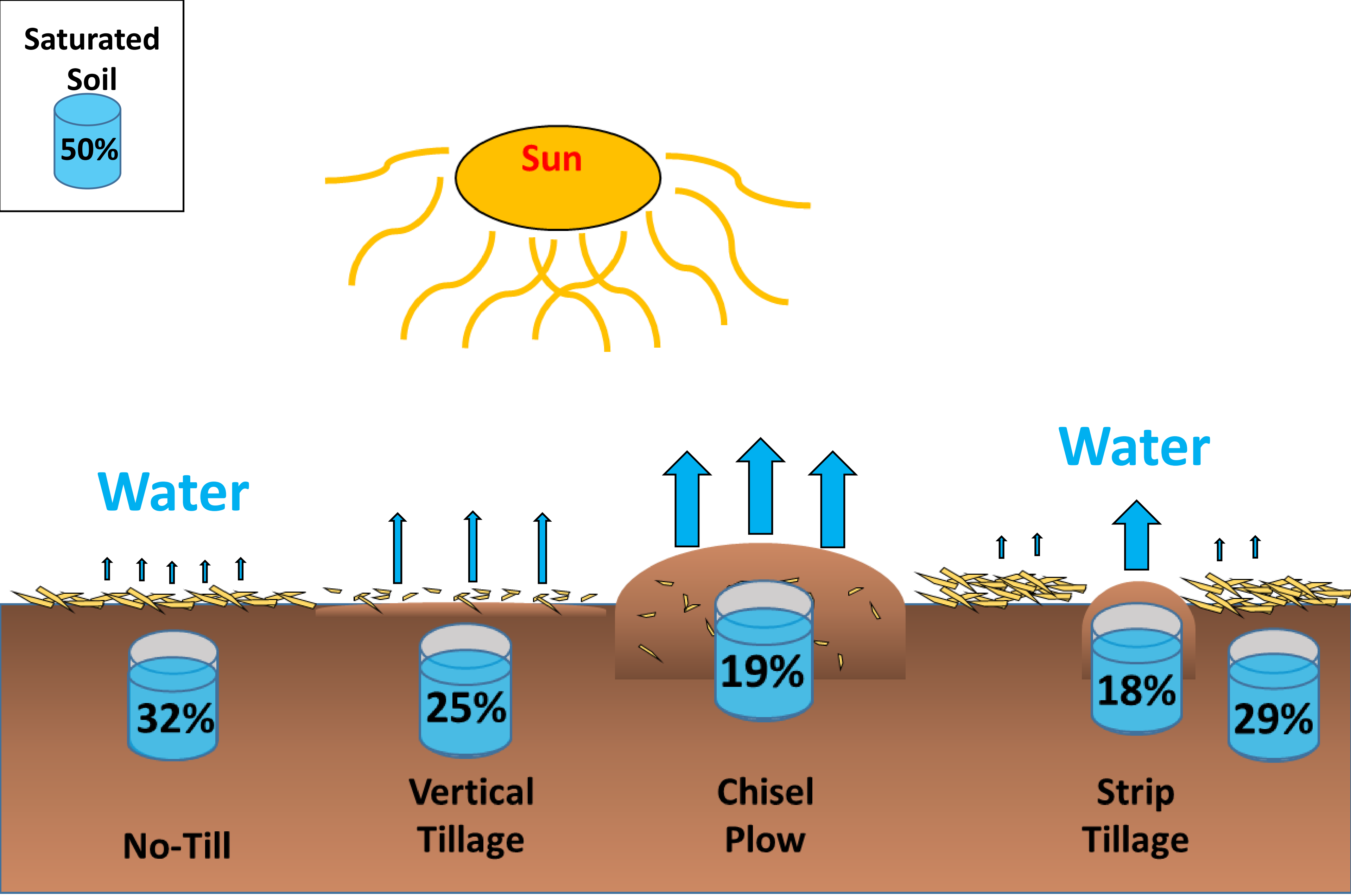


Sun
No-Till
Vertical
Tillage
Chisel
Plow
Strip
Tillage


Sun
42 °F
47 °F
50 °F
51 °F
45 °F
No-Till
Vertical Tillage
Chisel Plow
Strip Tillage



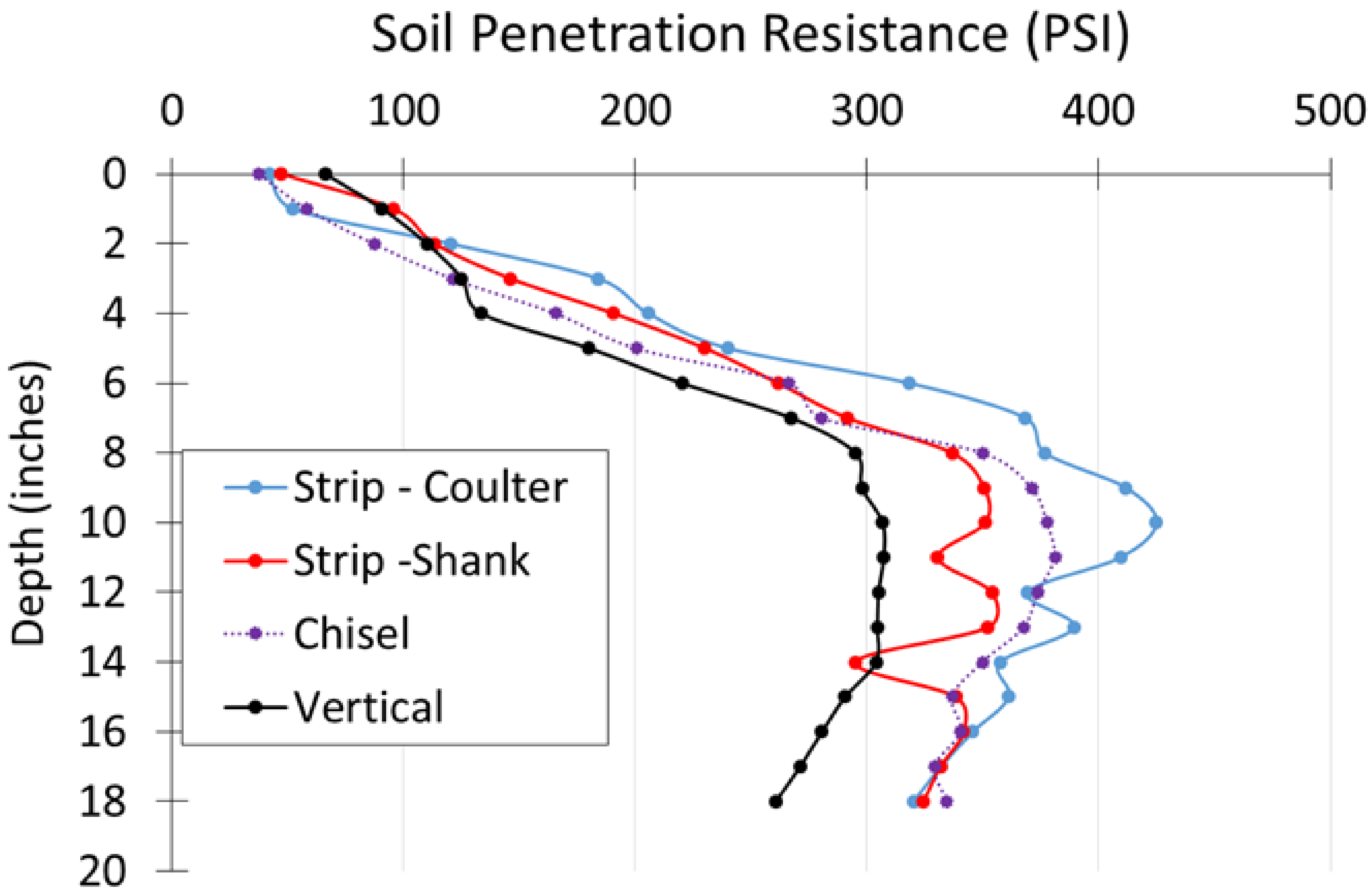
Sun
Water
Water
Vertical
Tillage
Chisel
Plow
Strip
Tillage
No-Till



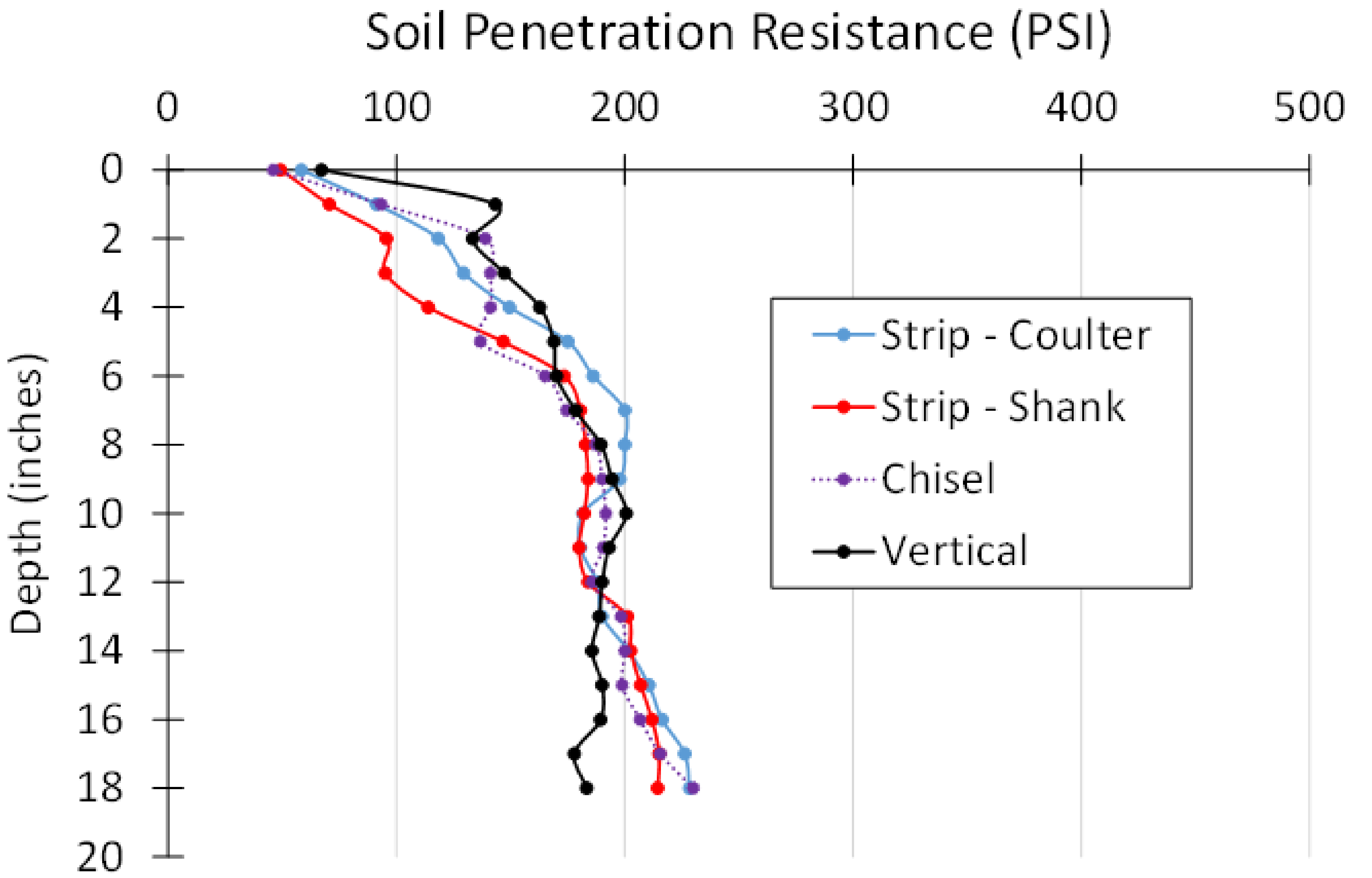
Saturated Soil
50%
Sun
Water
Water
32%
25%
19%
18%
29%
No-Till
Vertical Tillage
Chisel Plow
Strip Tillage

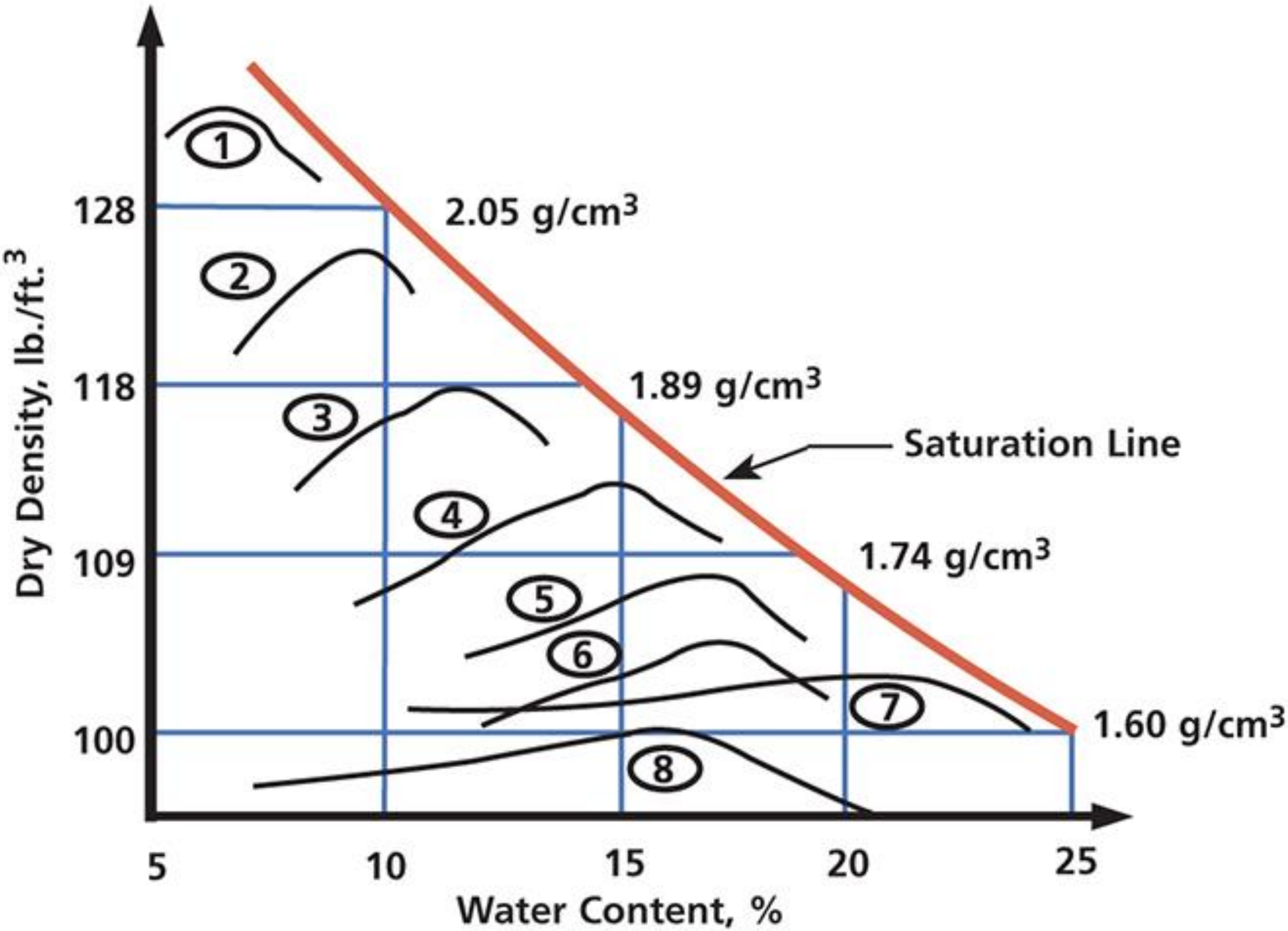
Compaction

Sandy Loam near Barney, ND. Measured at Planting.

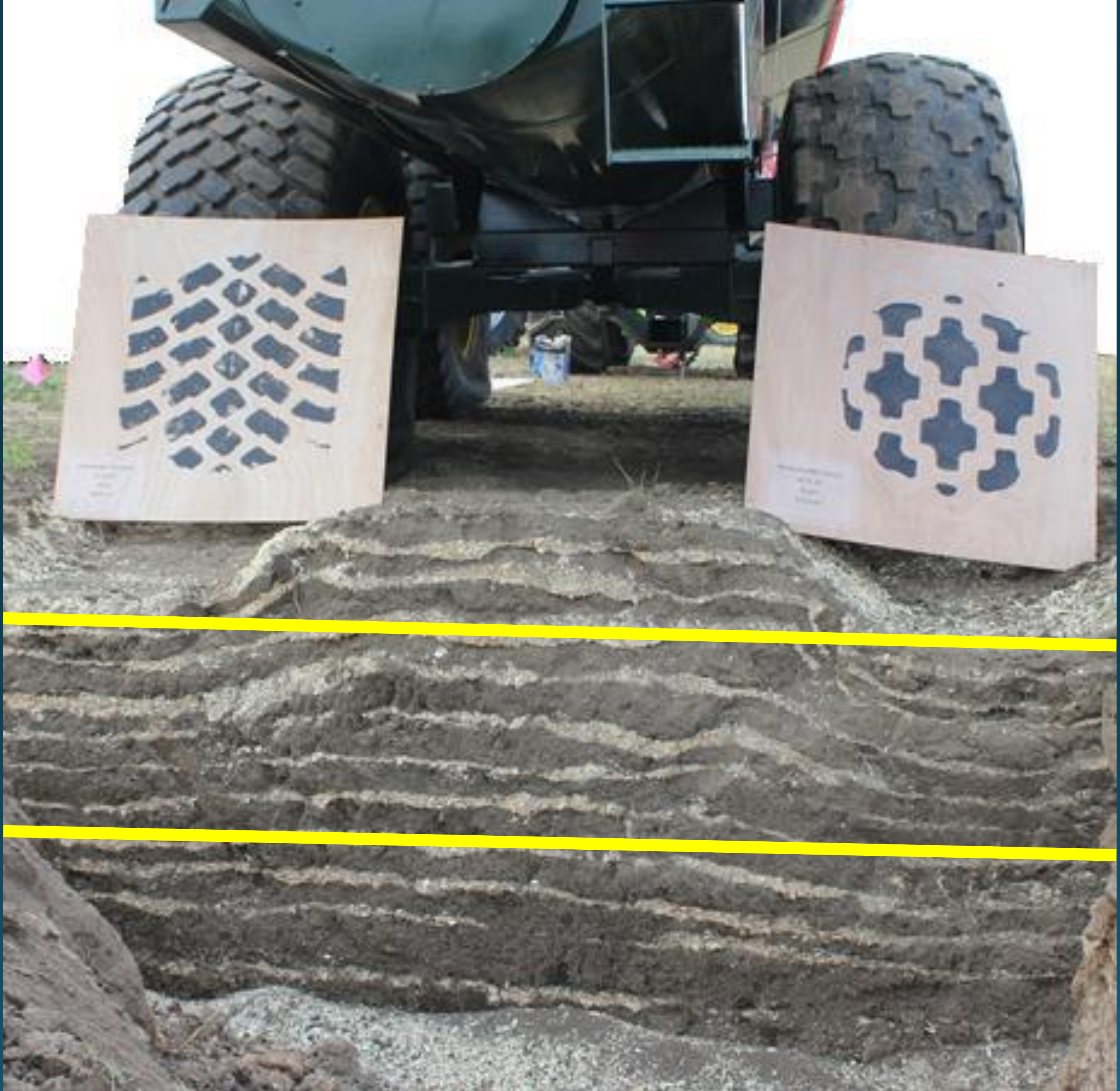


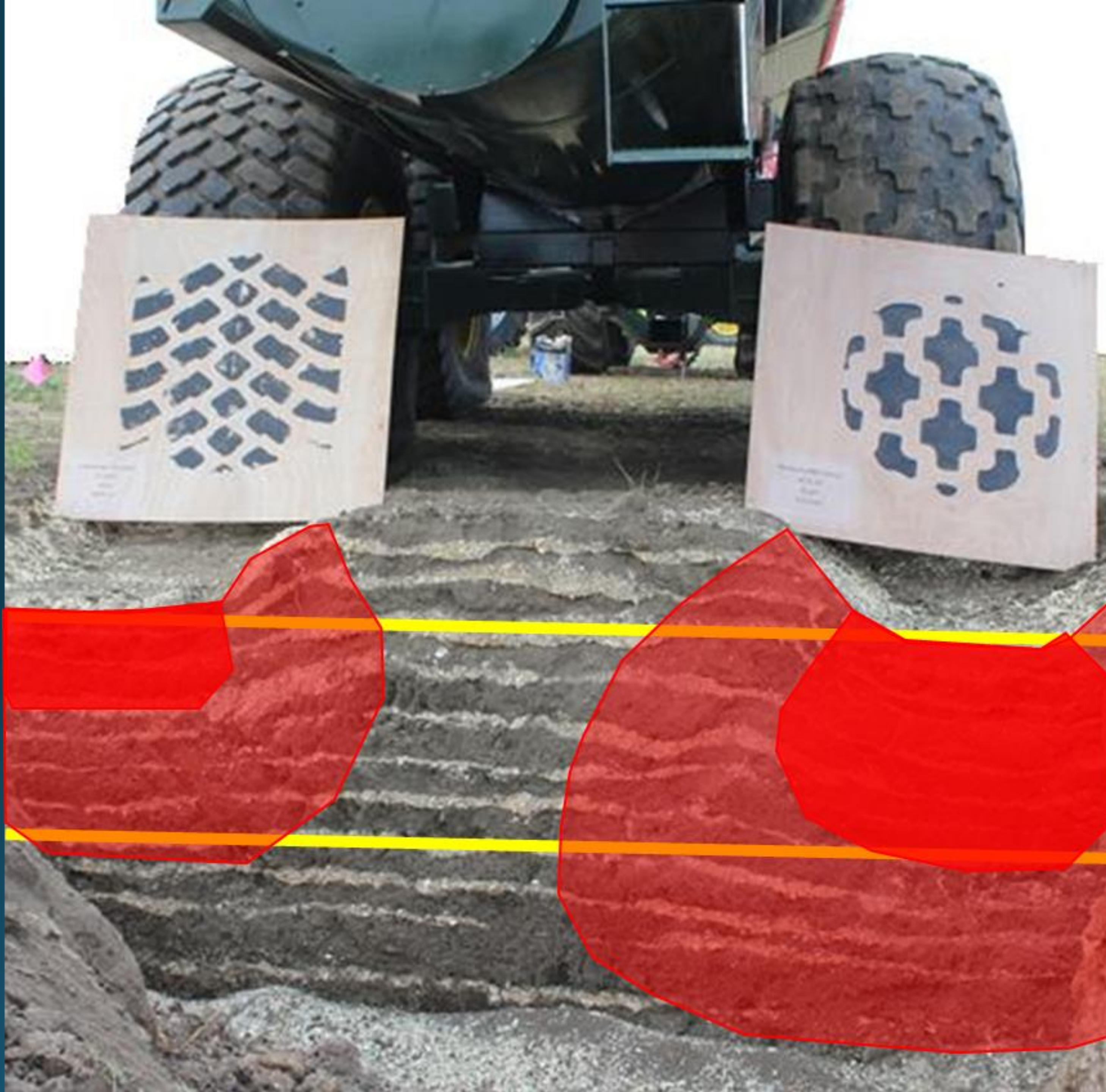
Silty Clay near Mooreton, ND. Measured at Planting.





(adapted from Abramson et al., 1995)





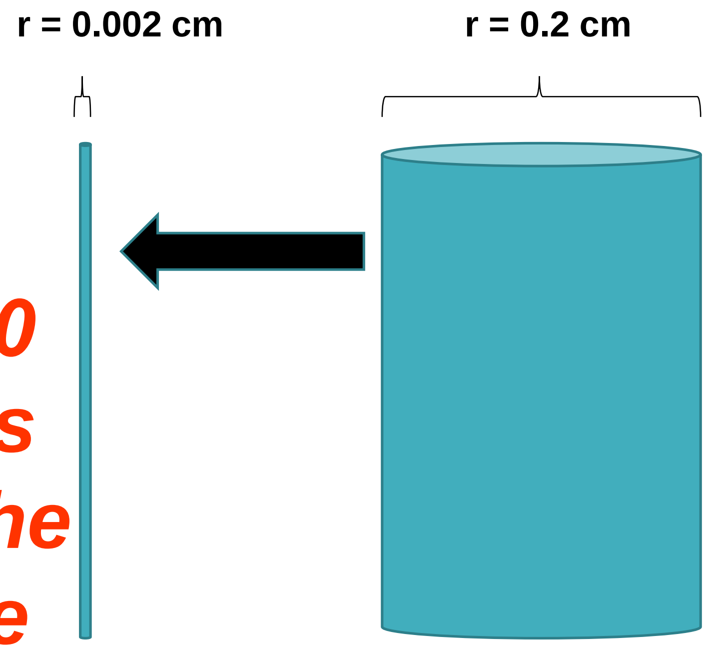
3-D images of the macropore system in soil cores taken from a clay soil in Finland.

Left: Control (non-compacted) soil.

Right: Soil from plots where heavy machinery drove over the ground in an experimental treatment 29 years earlier.

X-ray, computed tomography (CT) scans by Mathieu Lamandé.
https://www.soils.org/discover-soils/story/medical-imaging-helps-reveal-lasting-impacts-soil-compaction

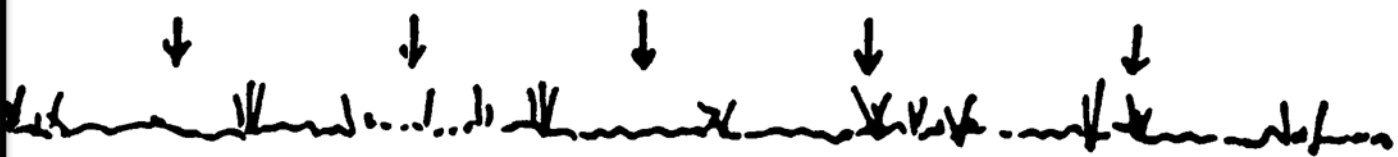
Saturated Water Flow in two Different Pores

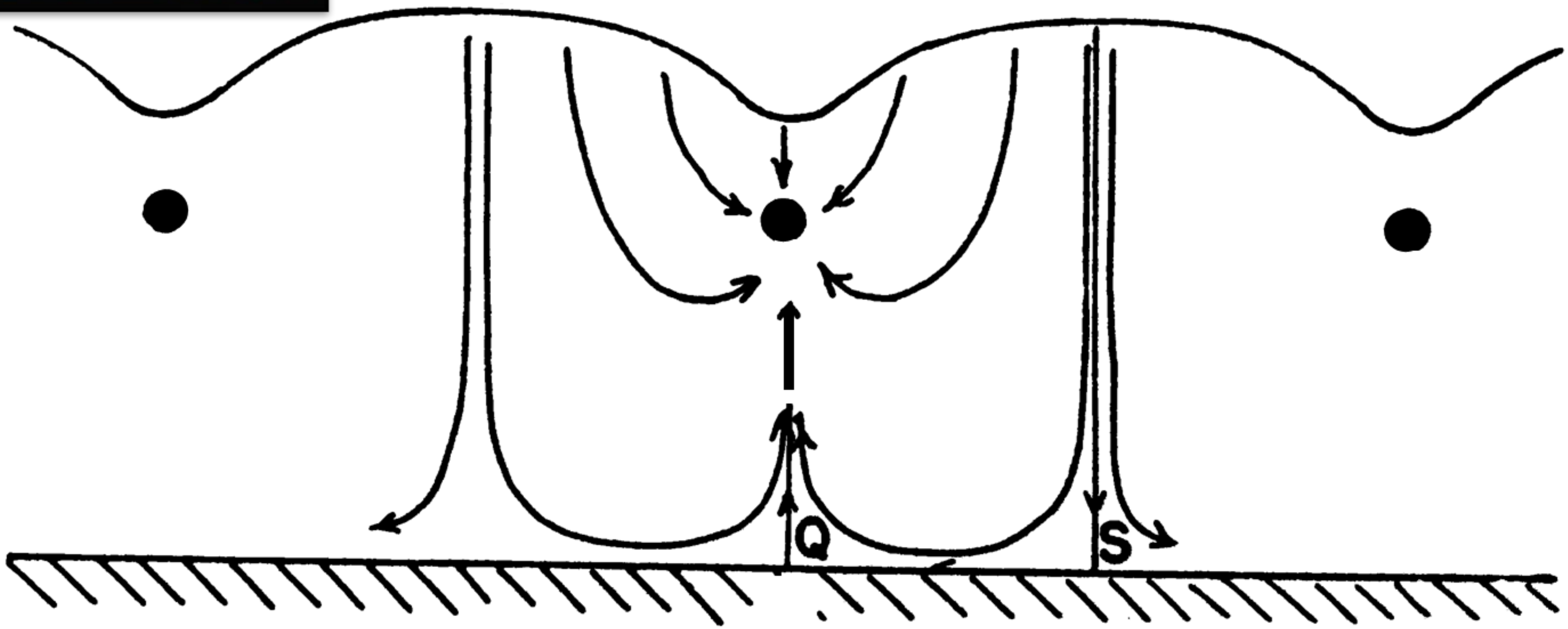


10,000 times more flow…

…than 10,000 smaller pores that take up the same volume

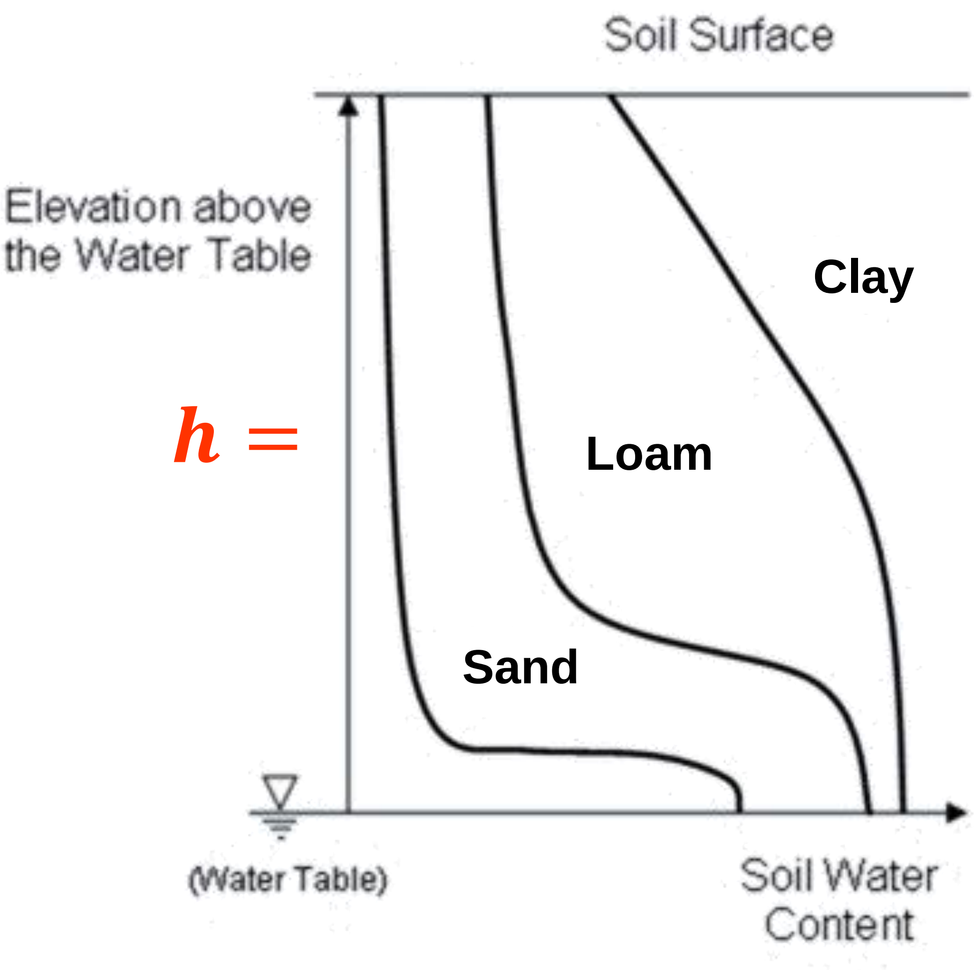
Large Pores Needed for Good Drainage

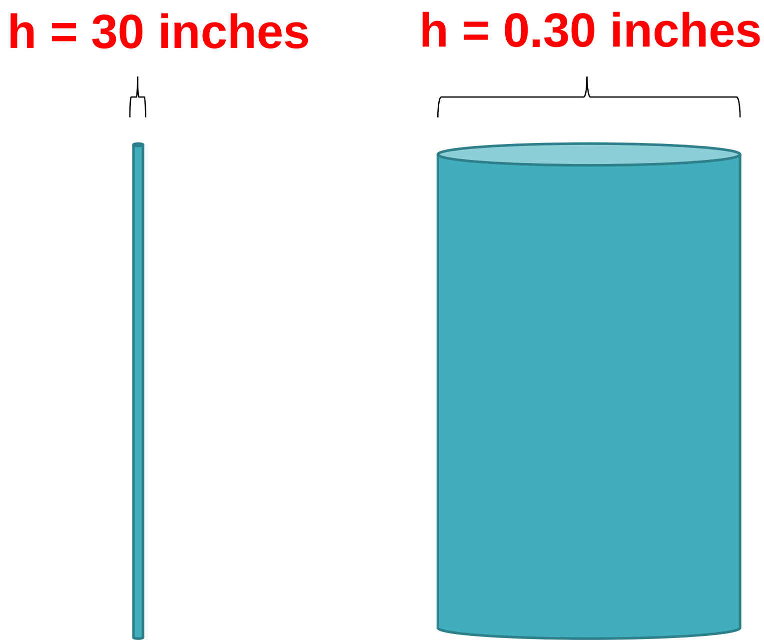




Small Pores Store and Rise Water

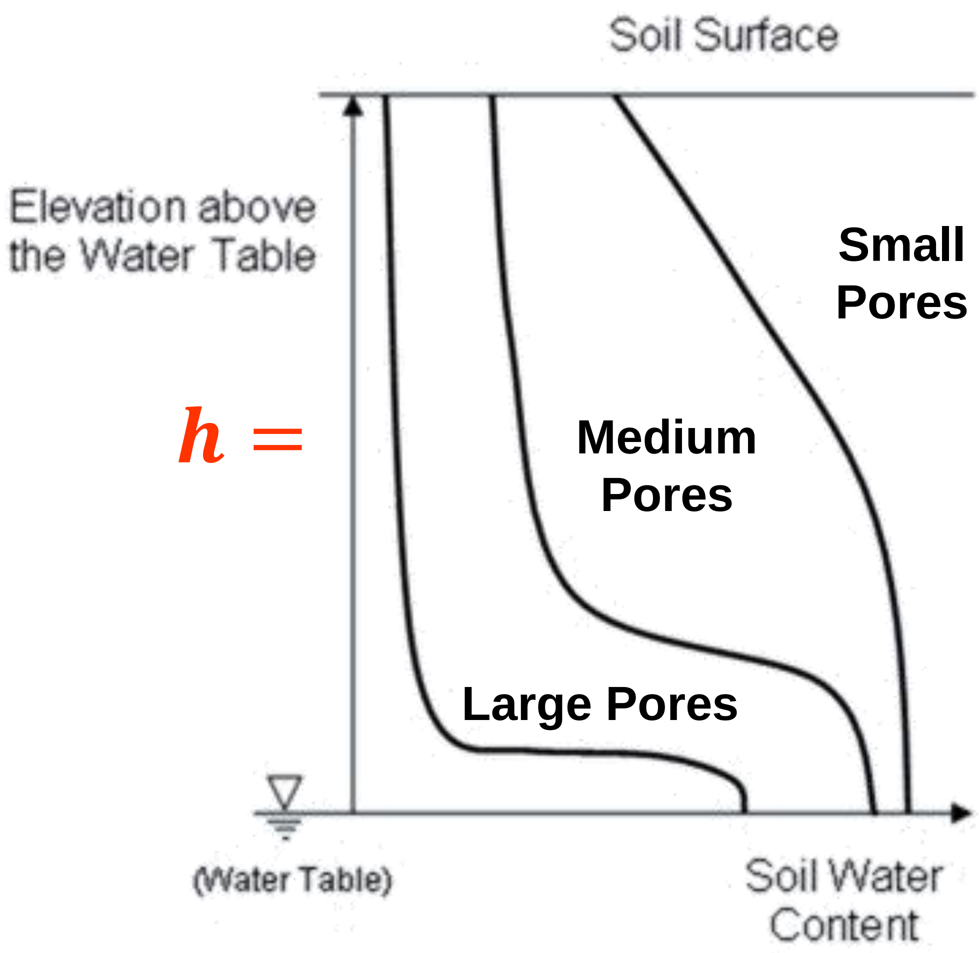
$h =$

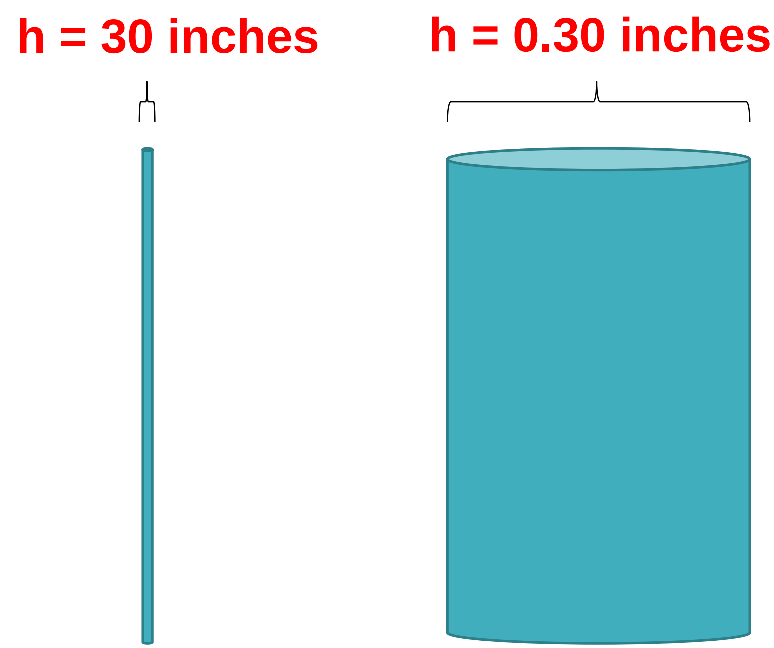




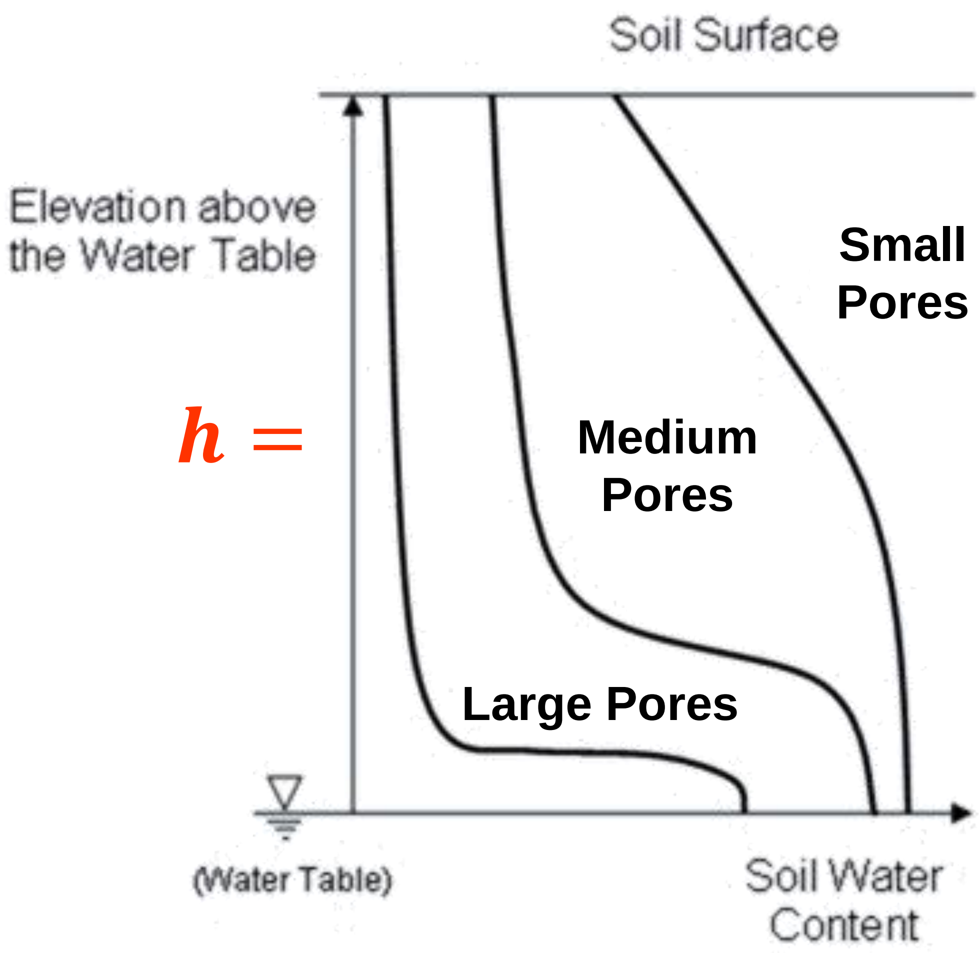
Small Pores Store and Rise Water

$h =$





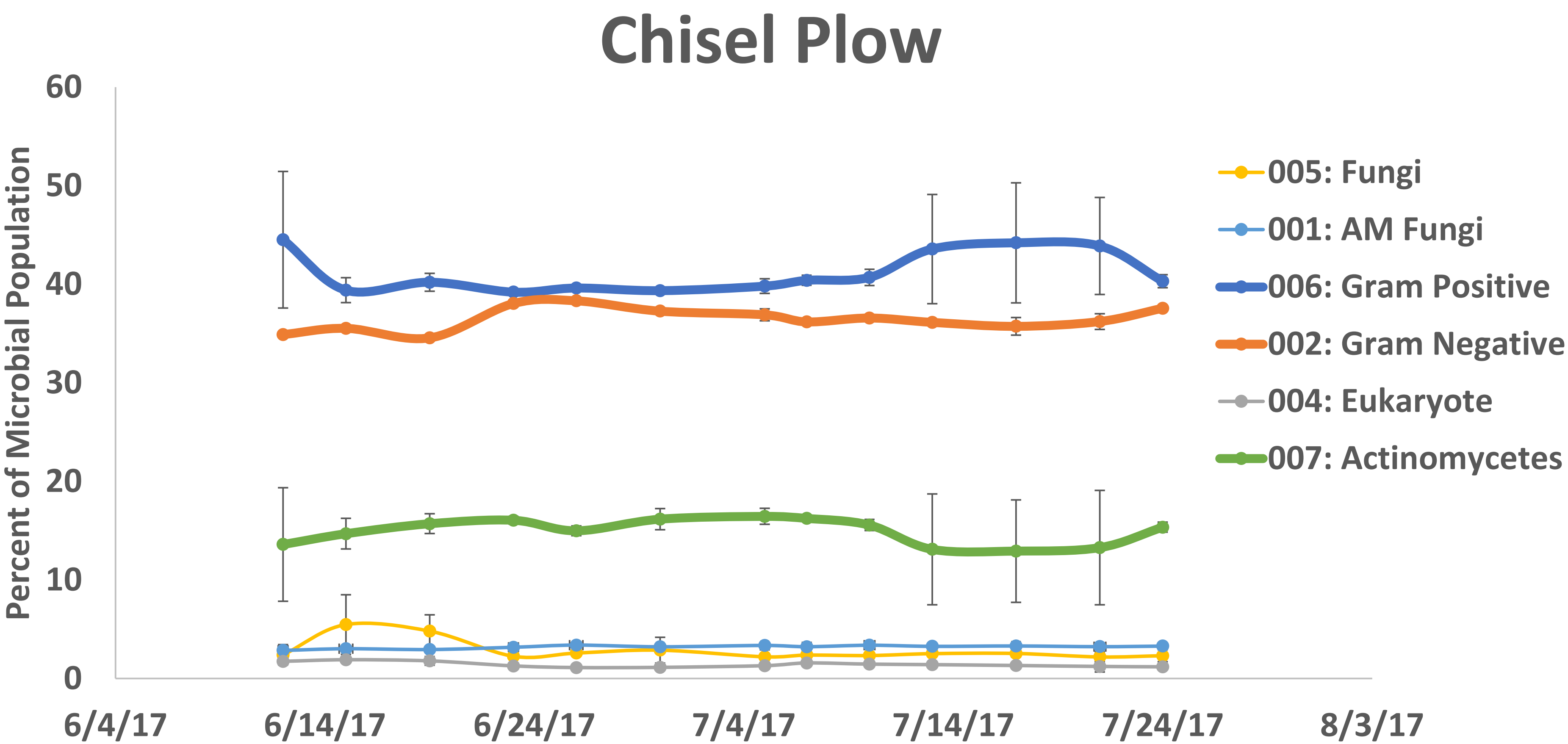
Small Pores Store and Rise Water



Microbes

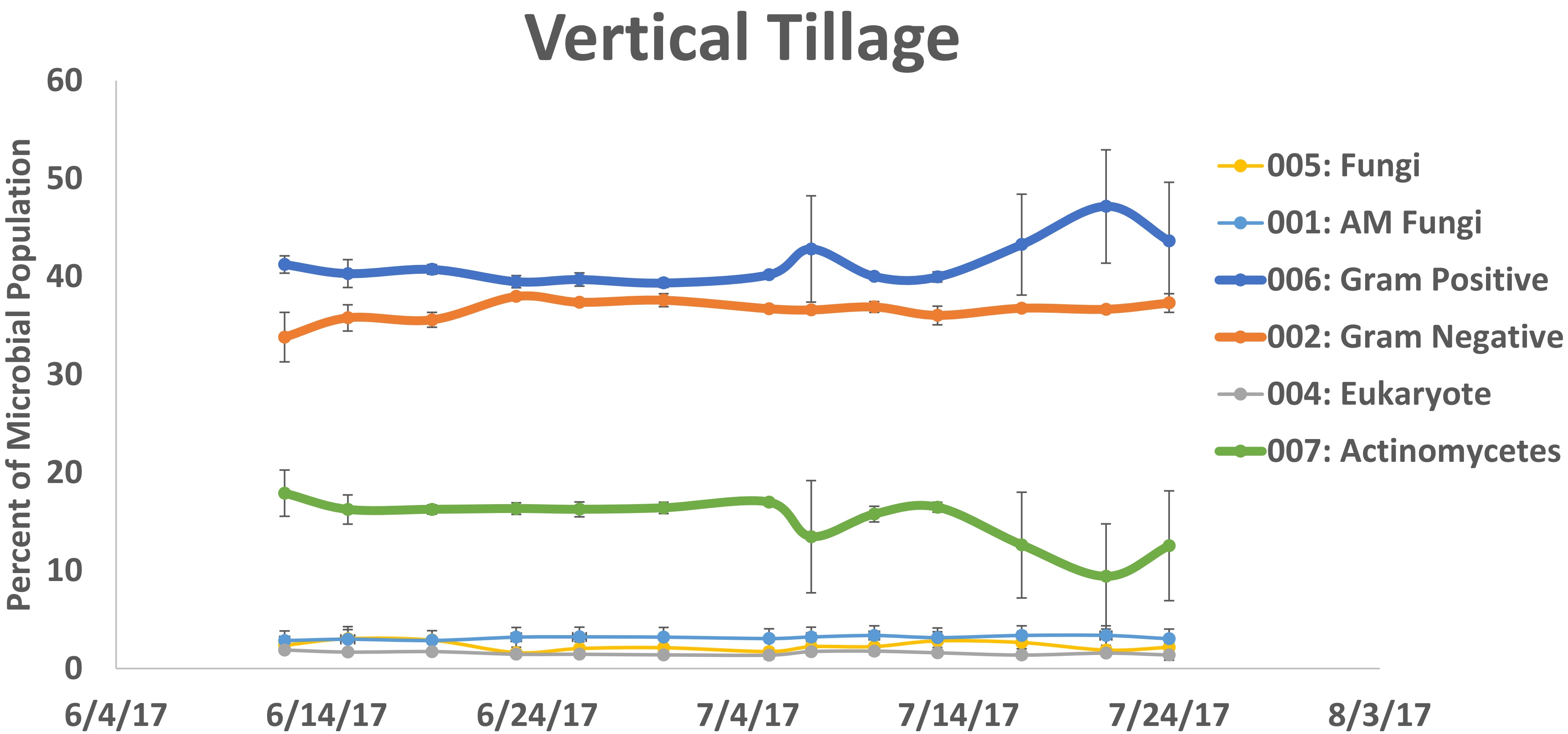
Microbial Communities in 2017

Silty Clay planted to Soybean



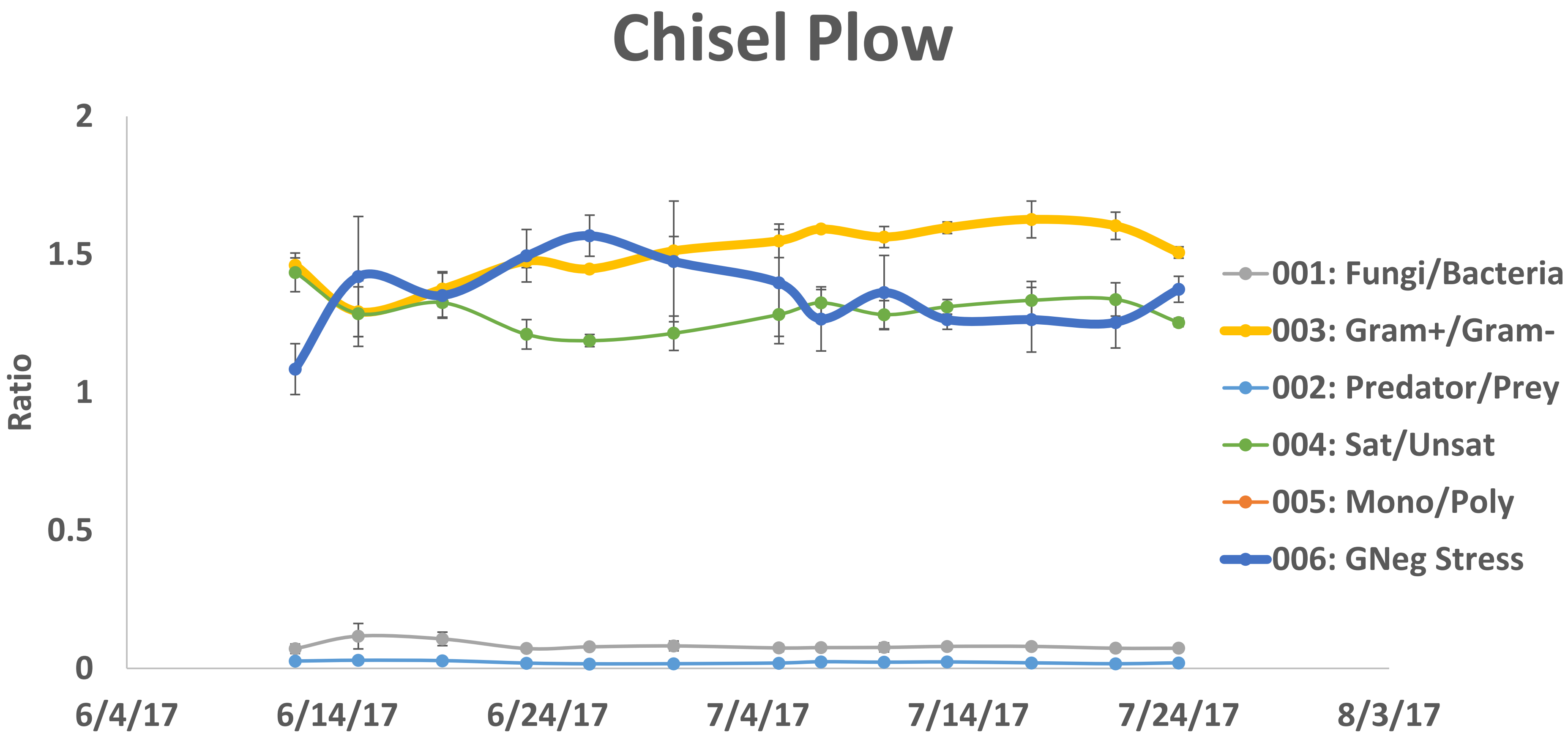
Microbial Communities in 2017

Silty Clay planted to Soybean



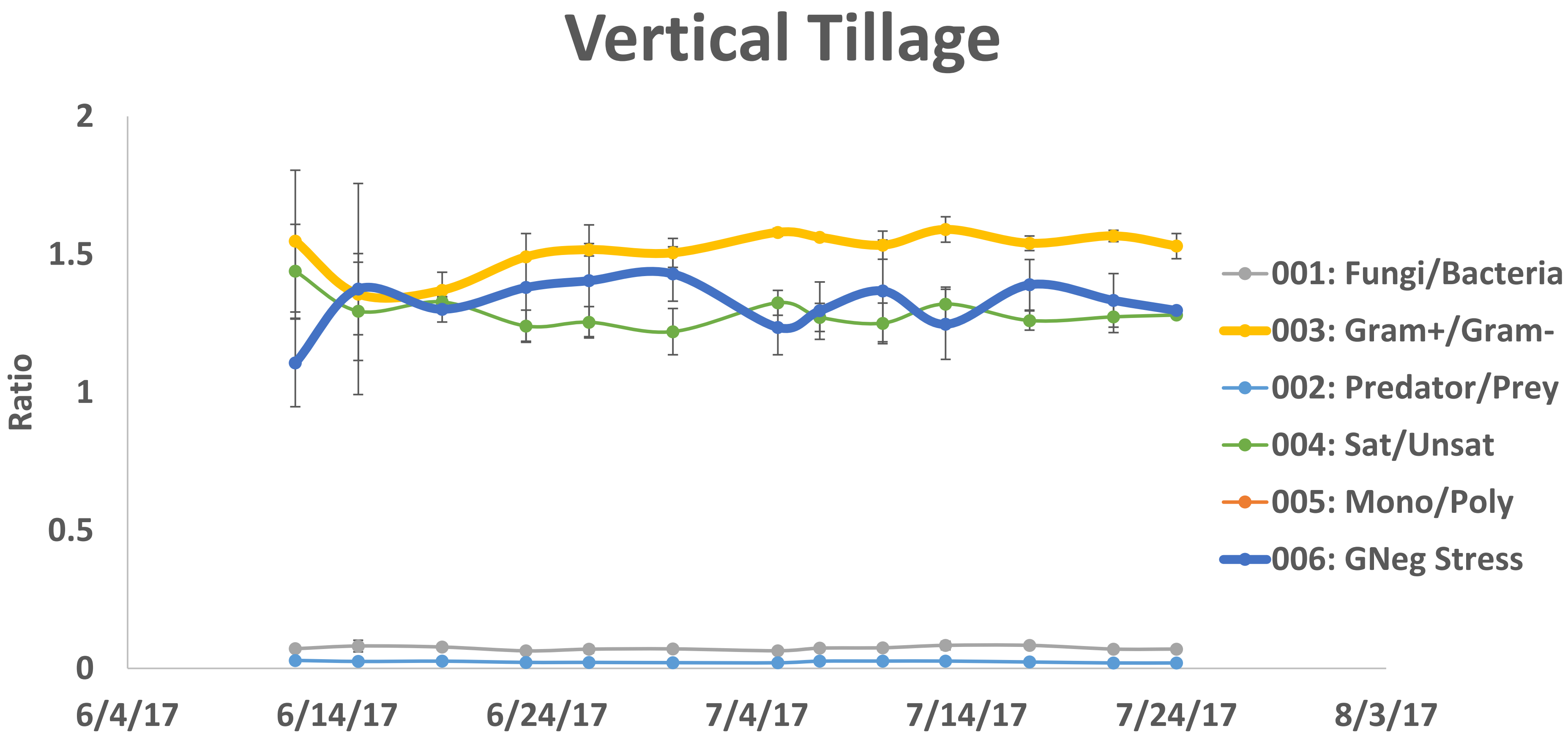
Microbial Ratios in 2017

Silty Clay planted to Soybean

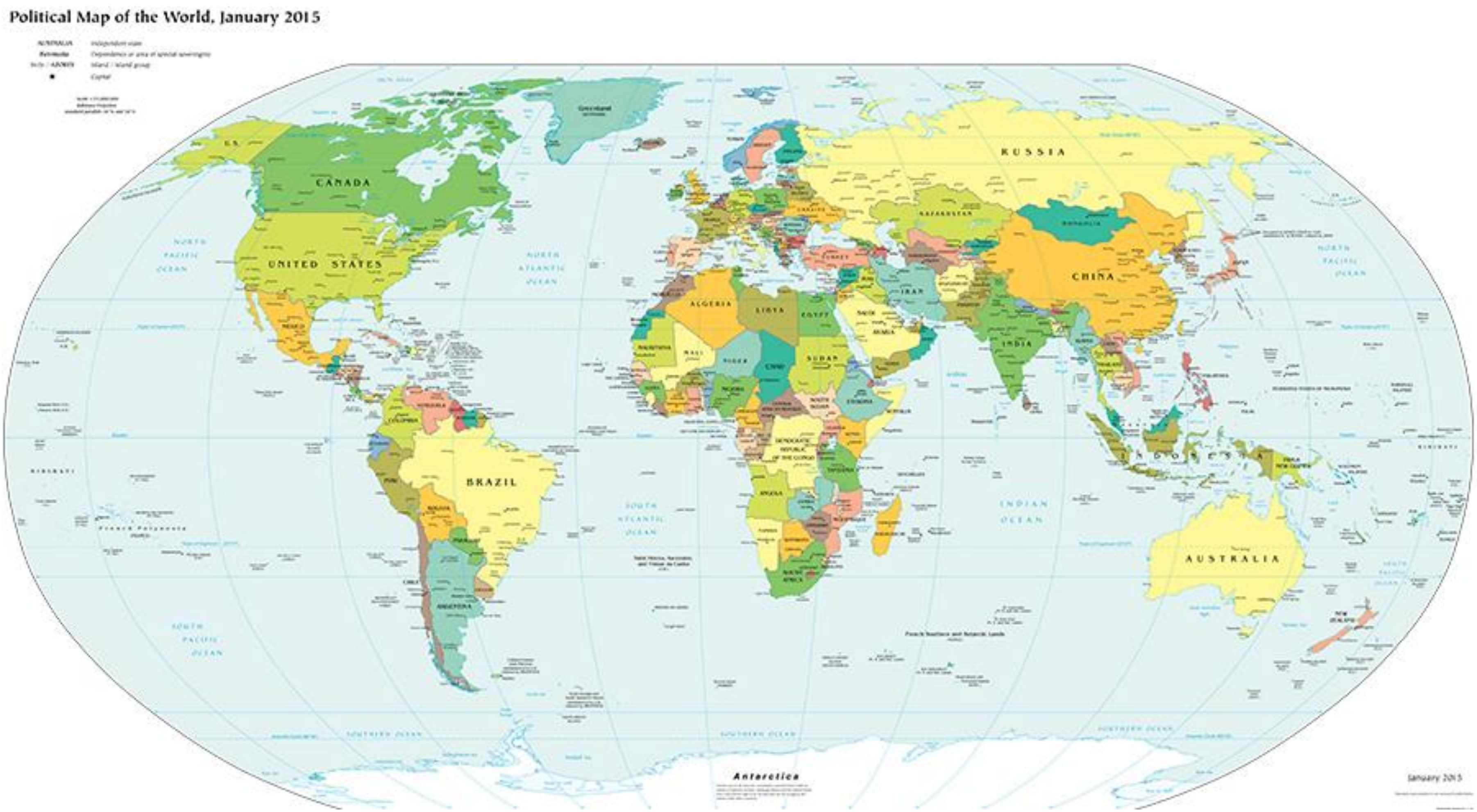


Microbial Ratios in 2017

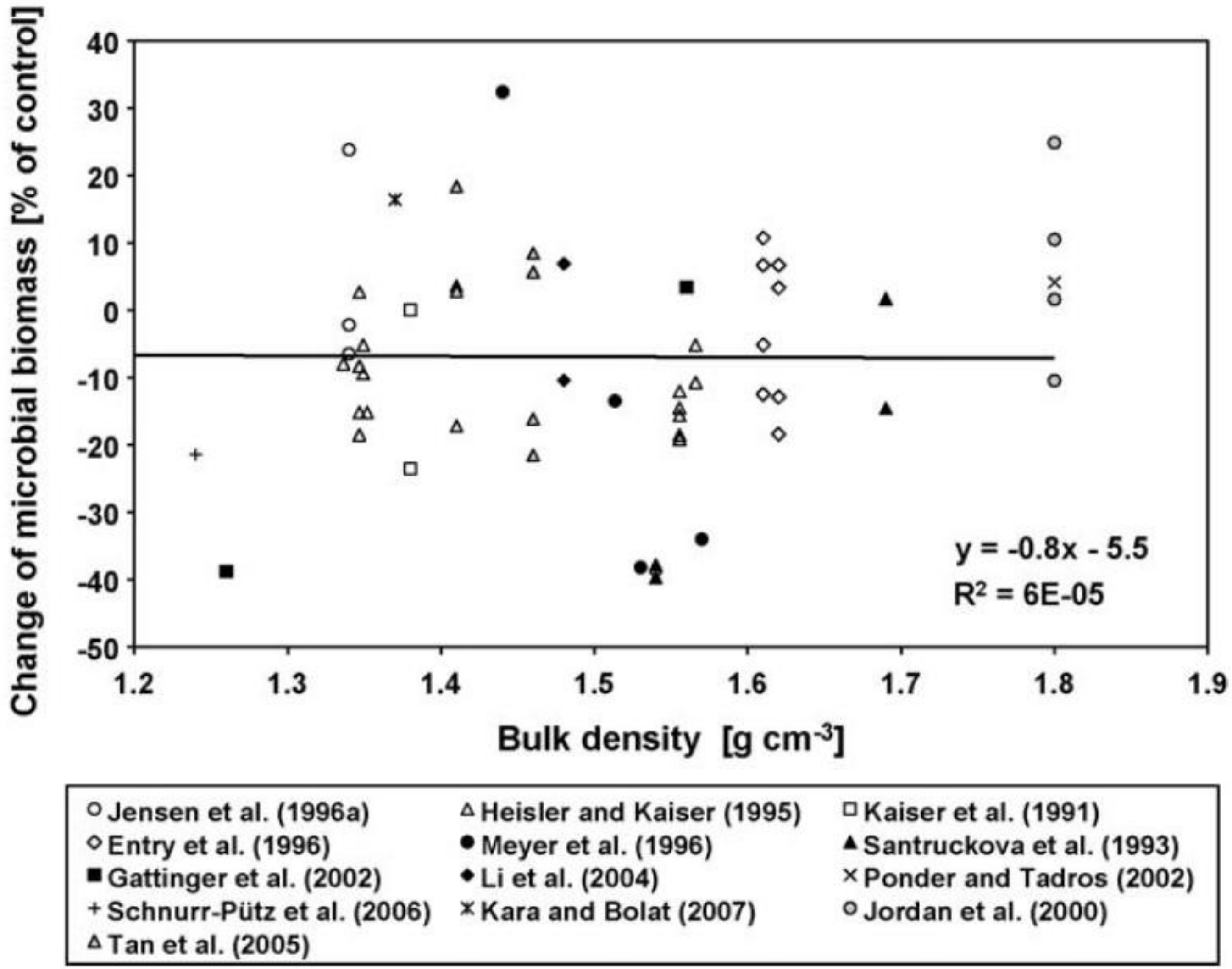
Silty Clay planted to Soybean



Where is our Understanding of Soil Microbiology?... Another Analogy

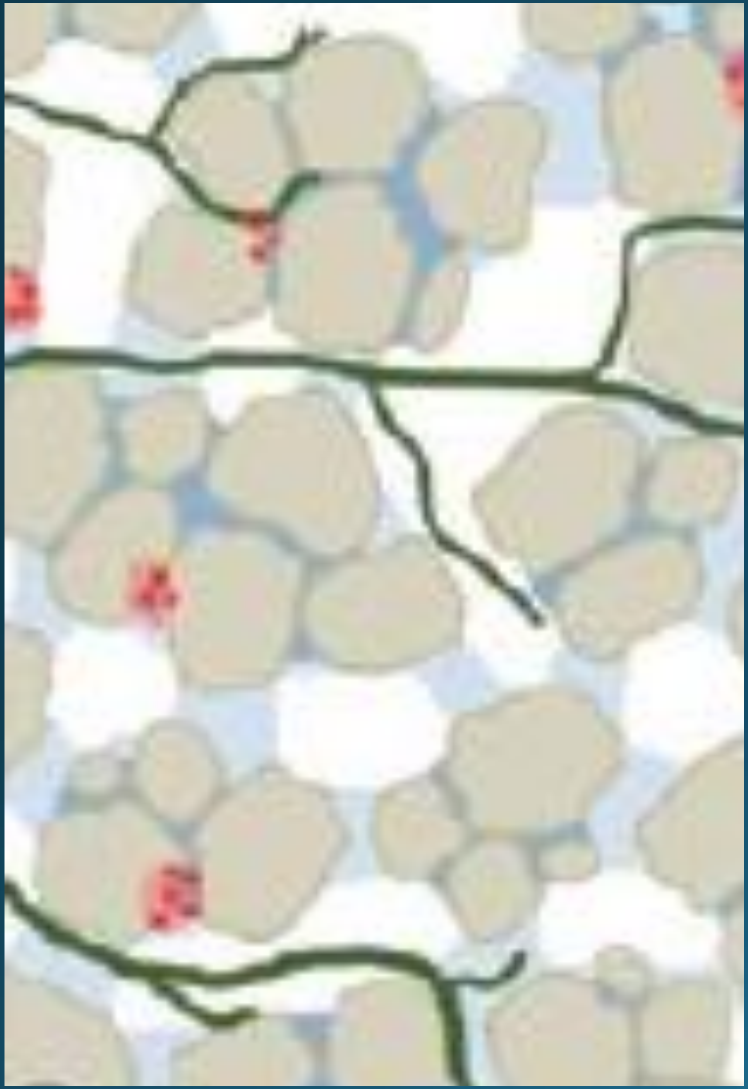


Where is our Understanding of Soil Microbiology?... Another Analogy



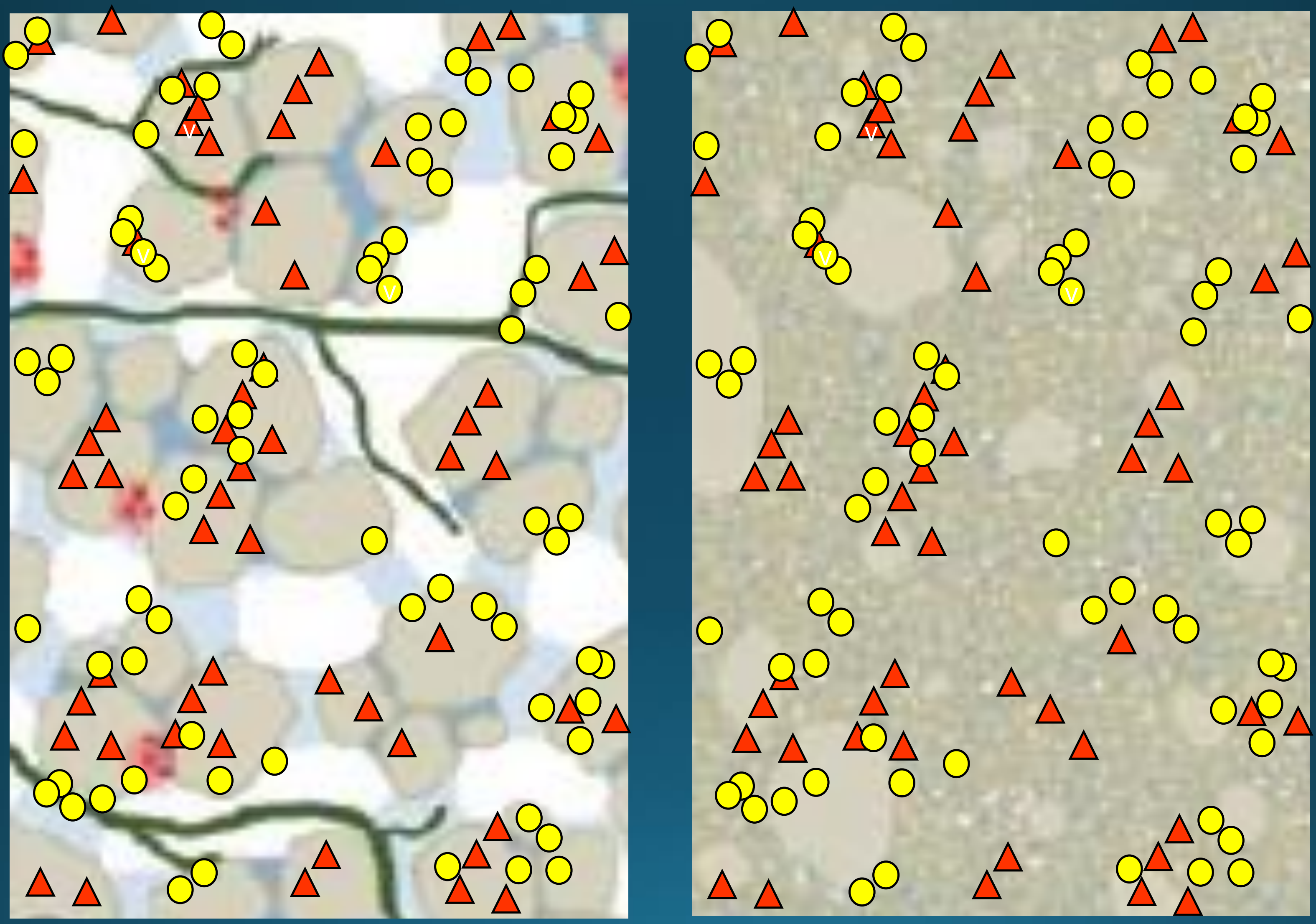
Change of microbial biomass [% of control]
40
30
20
10
0
-10
-20
-30
-40
-50
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
Bulk density [g cm-3]
y = -0.8x - 5.5
R² = 6E-05
Jensen et al. (1996a)
Heisler and Kaiser (1995)
Kaiser et al. (1991)
Entry et al. (1996)
Meyer et al. (1996)
Santruckova et al. (1993)
Gattinger et al. (2002)
Li et al. (2004)
Ponder and Tadros (2002)
Schnurr-Pütz et al. (2006)
Kara and Bolat (2007)
Jordan et al. (2000)
Tan et al. (2005)

Well Aggregated

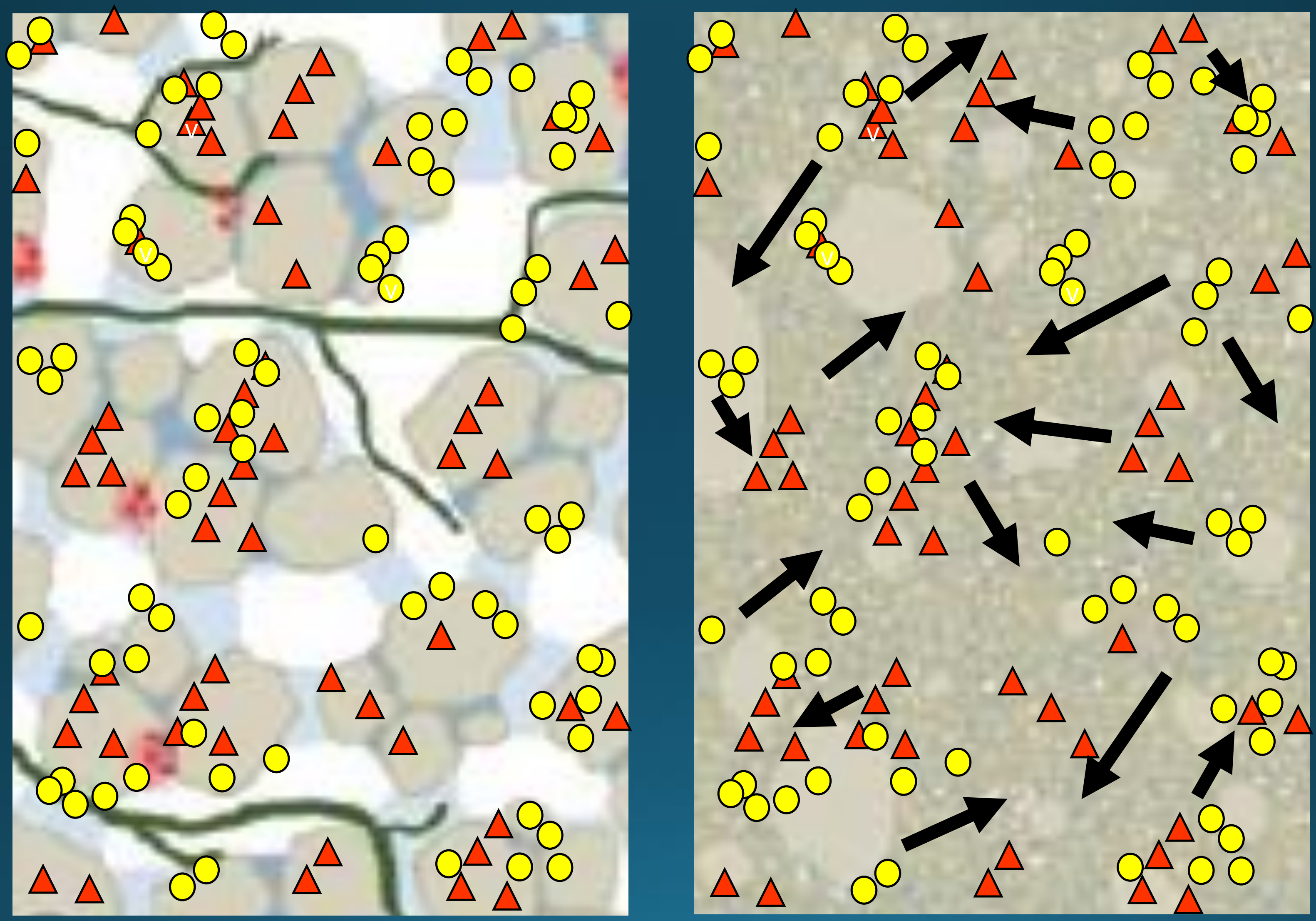


Poorly Aggregated

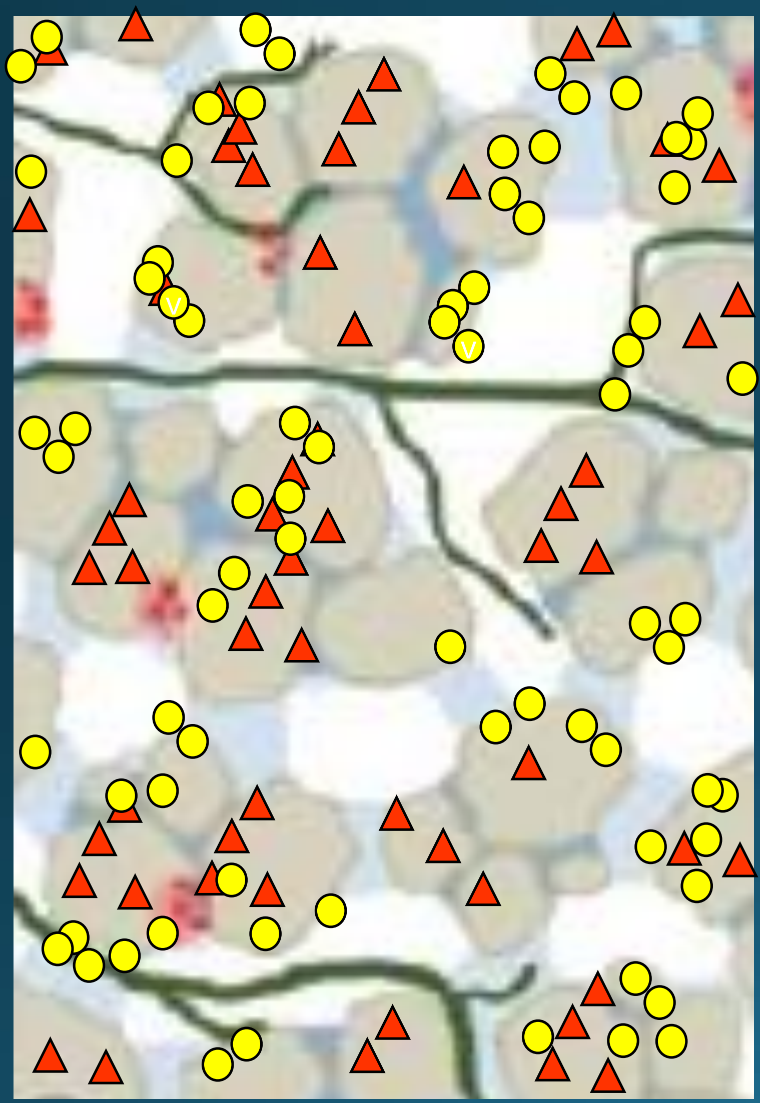
Randomly Insert Two Species of Microbes

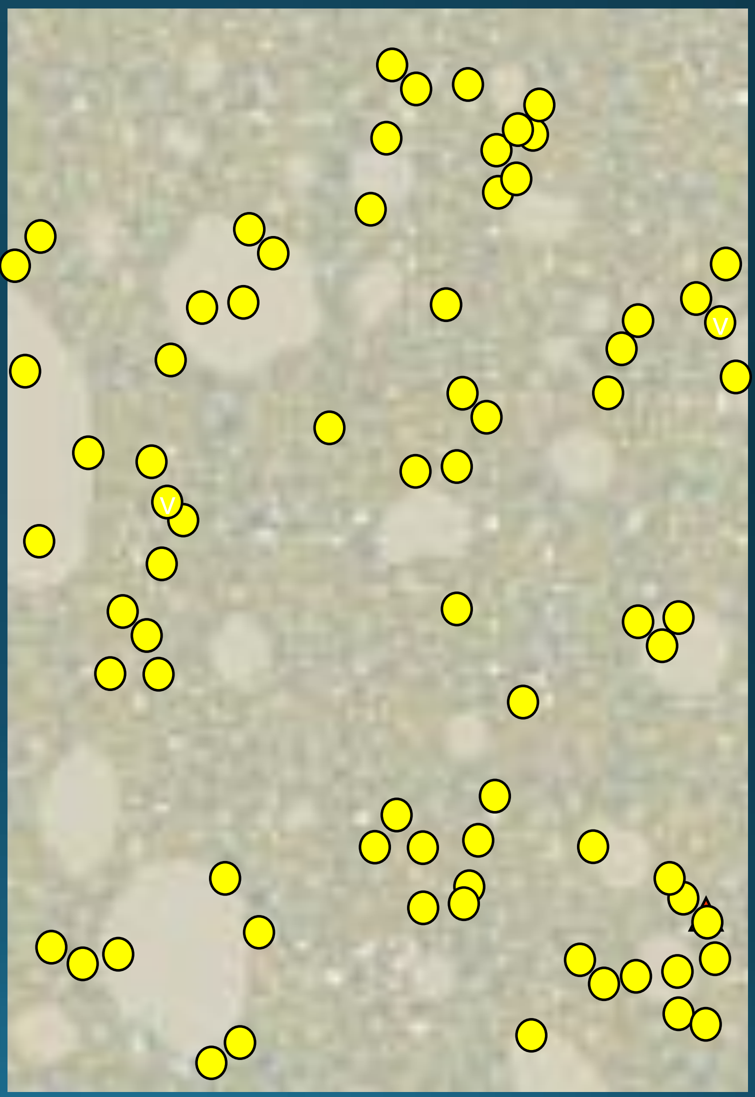


Microbes Move

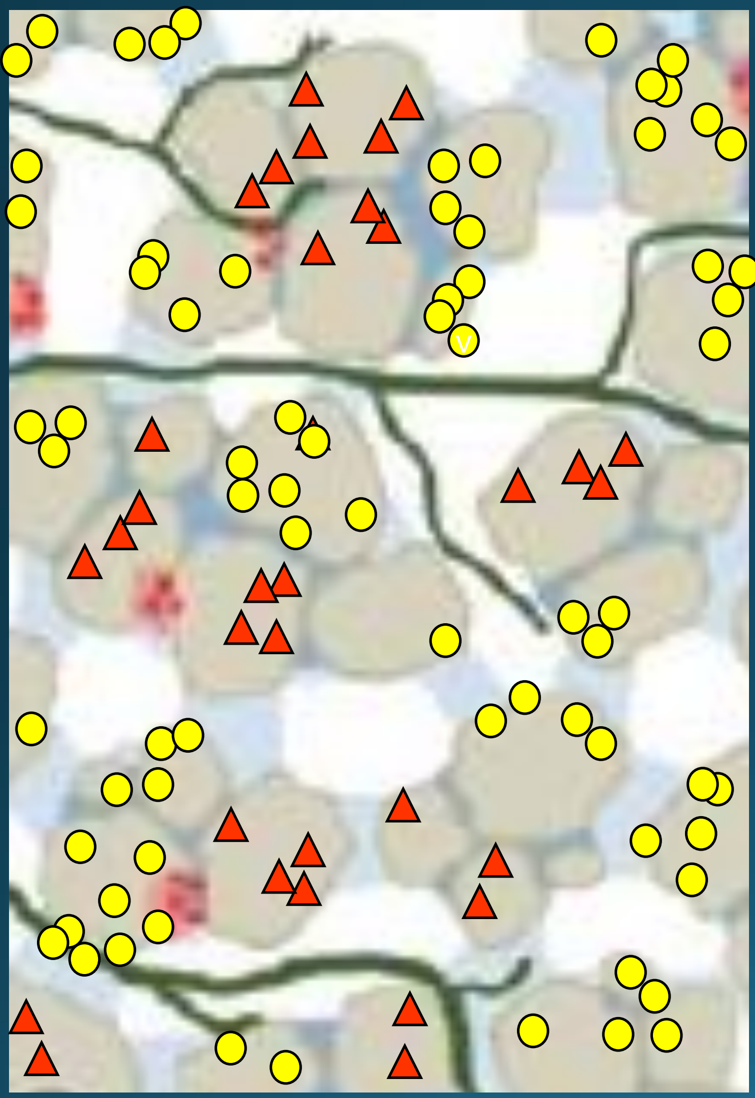


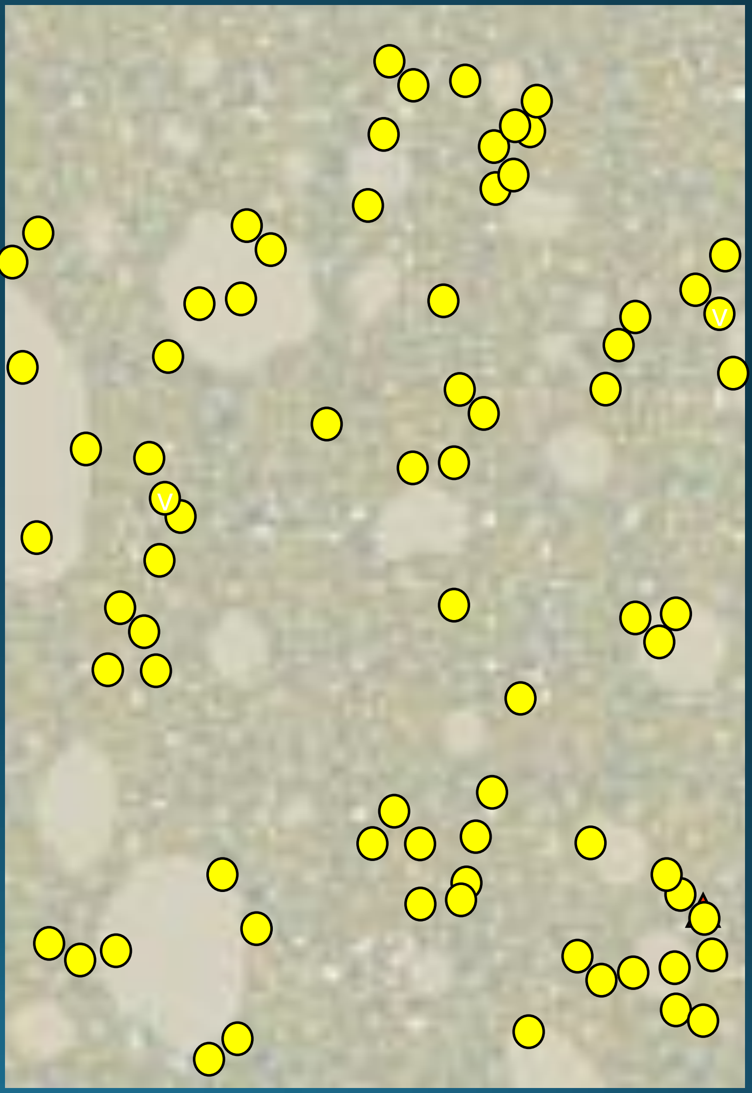
Microbe Competition

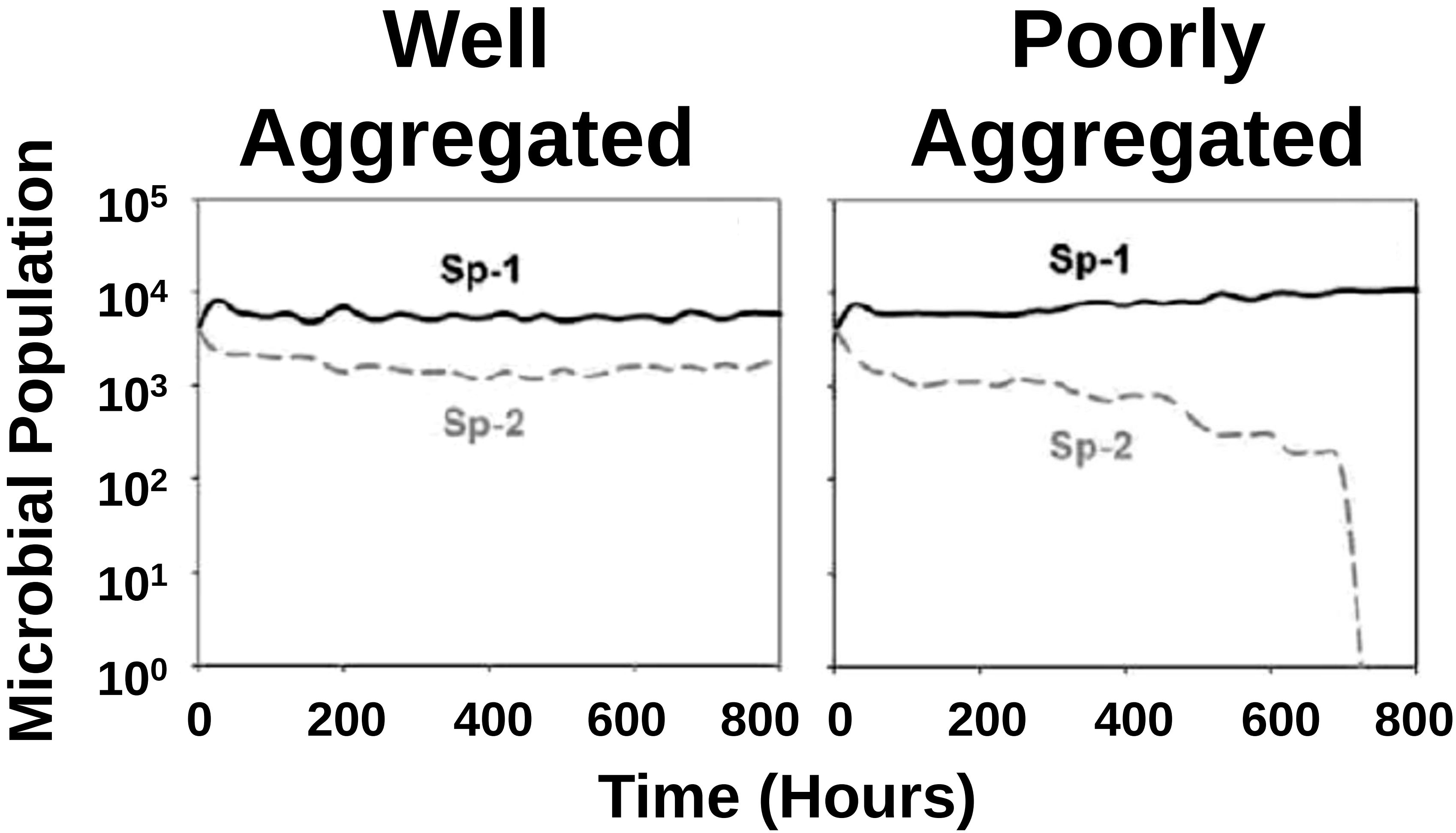




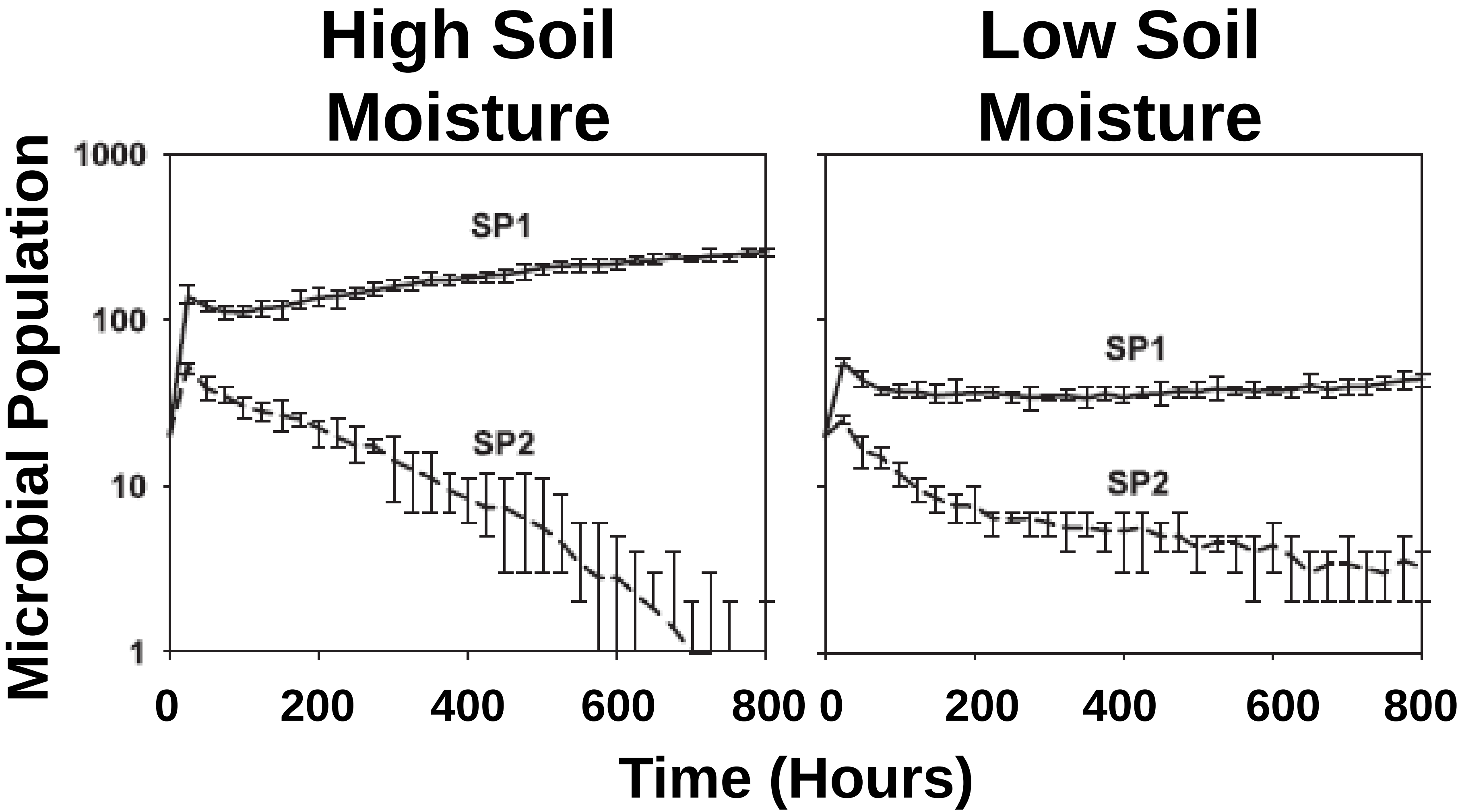
Aggregation Promotes Microbial Diversity







Well
Aggregated
Poorly
Aggregated
Microbial Population
10^5
10^4
10^3
10^2
10^1
10^0
Sp-1
Sp-2
Sp-1
Sp-2
0
200
400
600
800
0
200
400
600
800
Time (Hours)



High Soil Moisture
Low Soil Moisture
Microbial Population
1000
100
10
1
SP1
SP2
SP1
SP2
0
200
400
600
800
0
200
400
600
800
Time (Hours)

Crop Yield

Loam/Clay Loam near Fergus Falls, MN & Sandy Loam near Barney, ND.

Tillage Operation	2015 Corn Yields (bu/ac)	
	Fergus Falls, MN	Barney, ND
Chisel Plow	199.9 a	155.2 a
Strip Tillage with Shank	193.8 b	154.7 a
Strip Tillage with Coulter	199.4 a	149.5 a
Vertical Tillage	200.7 a	154.4 a

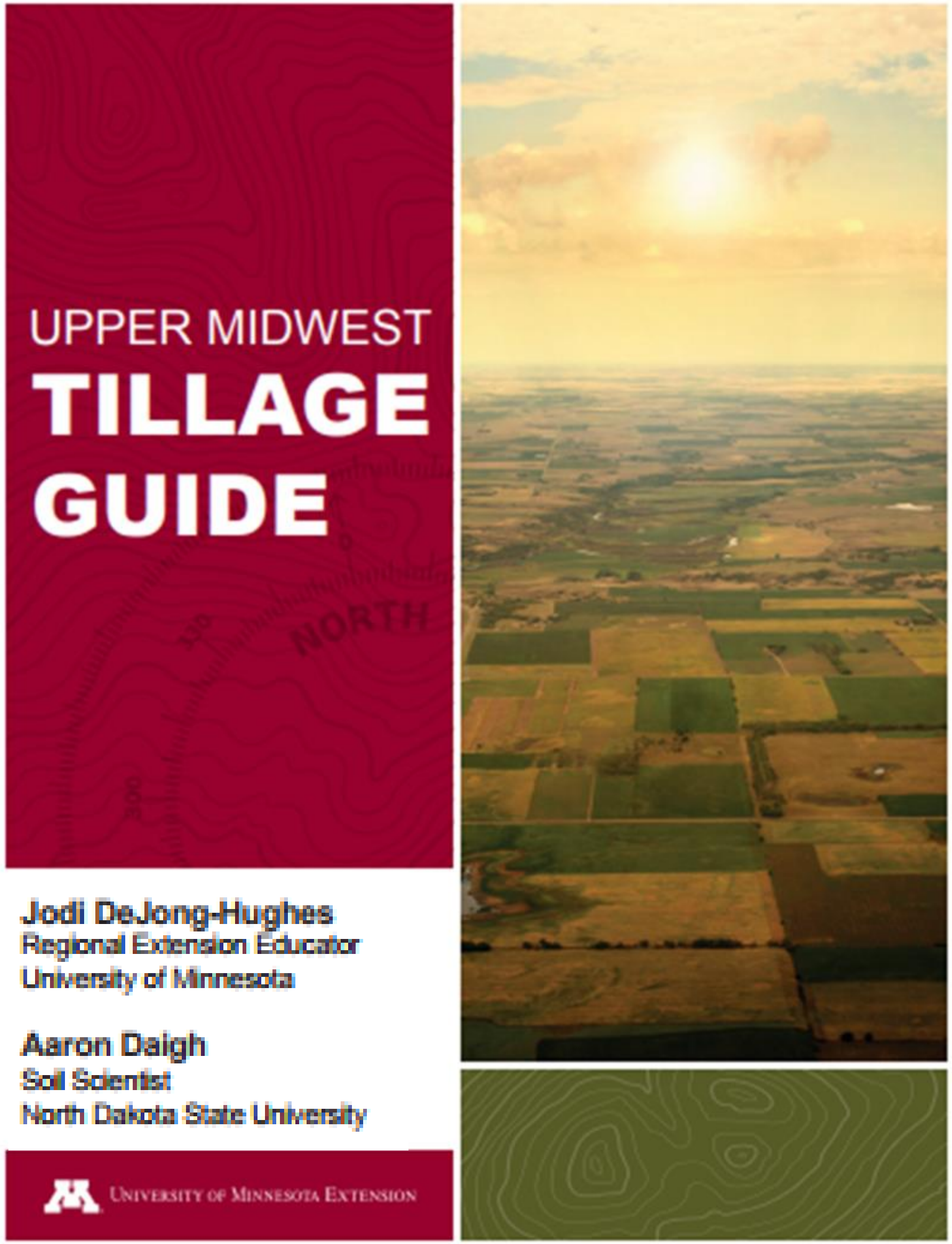
Tillage Operation	2016 Soybean Yields (bu/ac)	
	Fergus Falls, MN	Barney, ND
Chisel Plow	48.6 a	53.4 a
Strip Tillage with Shank	49.6 a	53.3 a
Strip Tillage with Coulter	48.7 a	54.0 a
Vertical Tillage	51.8 a	48.9 a

Tillage Operation	2017 Corn Yields (bu/ac)	
	Fergus Falls, MN	Barney, ND
Chisel Plow	190.6 a	198.4 ab
Strip Tillage with Shank	188.7 ab	191.9 b
Strip Tillage with Coulter	184.9 b	201.3 a
Vertical Tillage	183.9 b	199.3 a

Silty Clay near Mooreton, ND.

Tillage Operation	2016 Corn Yields (bu/ac)			
	Saline & Tiled	Non-saline & Tiled	Saline	Non-saline
Chisel Plow	176.0 a	183.3 ab	194.3 b	202.0 a
Strip Tillage with Shank	176.6 a	188.9 ab	196.5 ab	204.4 a
Strip Tillage with Coulter	188.1 a	195.7 a	204.9 a	216.7 a
Vertical Tillage	167.9 a	175.8 b	189.8 b	191.3 b

Tillage Operation	2017 Soybean Yields (bu/ac)			
	Saline & Tiled	Non-saline & Tiled	Saline	Non-saline
Chisel Plow	38.3 a	42.6 a	30.6 a	36.7 a
Strip Tillage with Shank	38.3 a	40.3 a	30.6 a	35.1 a
Strip Tillage with Coulter	41.4 a	43.7 a	35.2 a	36.7 a
Vertical Tillage	39.3 a	43.9 a	28.6 a	34.6 a
Average	39.3	42.6	31.2	35.8



https://www.extension.umn.edu/agriculture/soils/tillage/

Figure 4. Corn yield response to tillage for 18 site years across three locations in North Dakota and one location in Minnesota through 2005 to 2012.

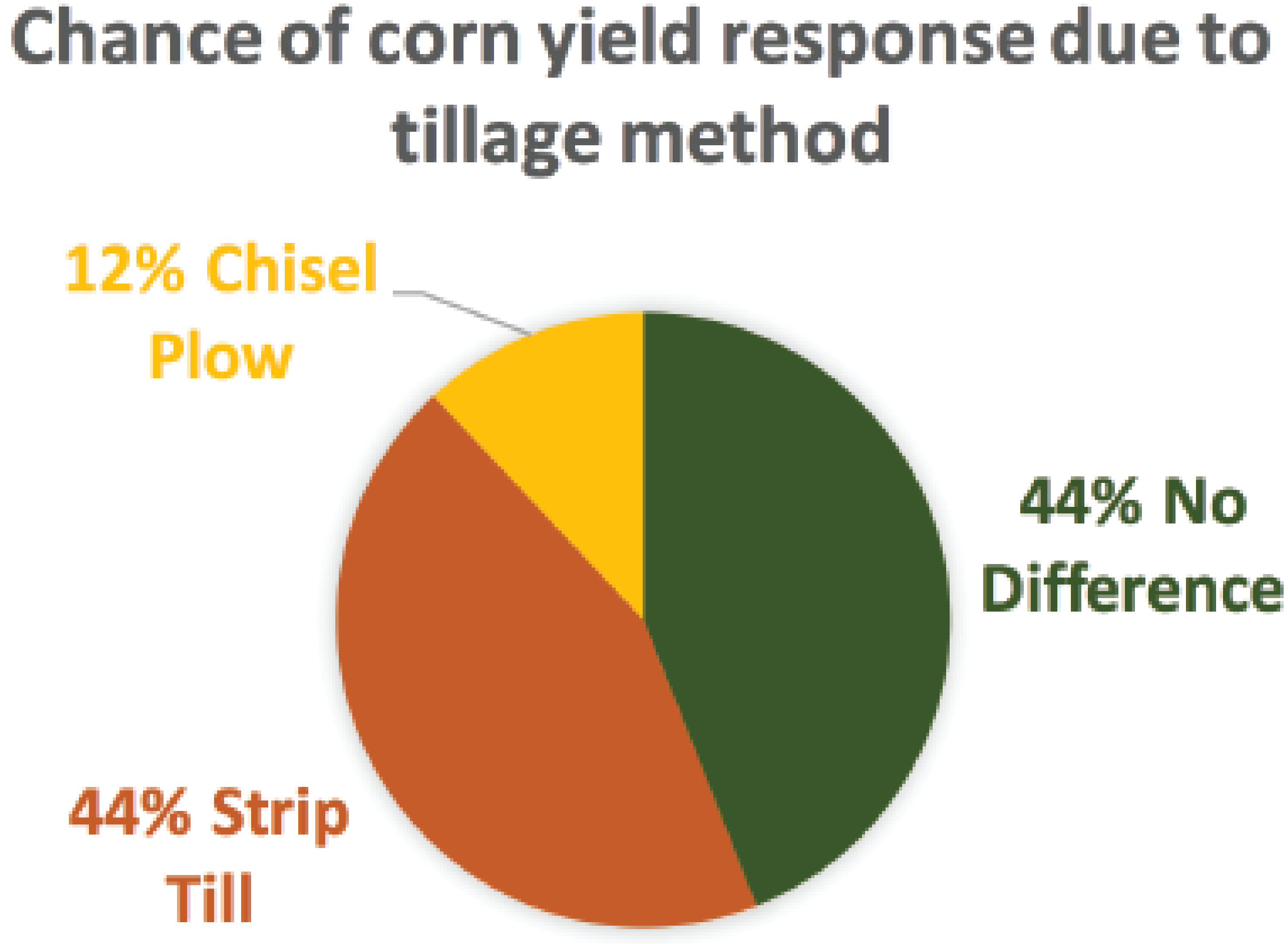


Table 5. Cost of equipment options and number of tillage passes using four management options when planting corn.

	Strip Till	Chisel Plow + Field Cultivation	Disk Rip + Field Cultivation	Moldboard Plow + Field Cultivation
Planter (tillage specific)	$20.15	$19.90	$19.90	$19.90
Side dress N Fertilizer	$11.15	$0	$0	$0
Broadcast Fertilizer	$0	$4.90	$4.90	$4.90
Anhydrous Ammonia	$0	$12.20	$12.20	$12.20
Primary Tillage	$17.50*	$16.45	$17.80	$18.80
Secondary Tillage (1st pass)	$0	$14.05	$14.05	$14.05
Secondary Tillage (2nd pass)	$0	$0	$0	$0
Combine w/o chopping	$34.75	$0	$0	$0
Combine with chopping head	$0	$40.10	$40.10	$40.10
TOTAL COST/AC	**$83.20**	**$107.60**	**$108.95**	**$124.00**
# of passes	4	6	6	7

Figure 3. Soybean yield response to tillage for 17 site years across three locations in North Dakota and one location in Minnesota during 2005 to 2012.

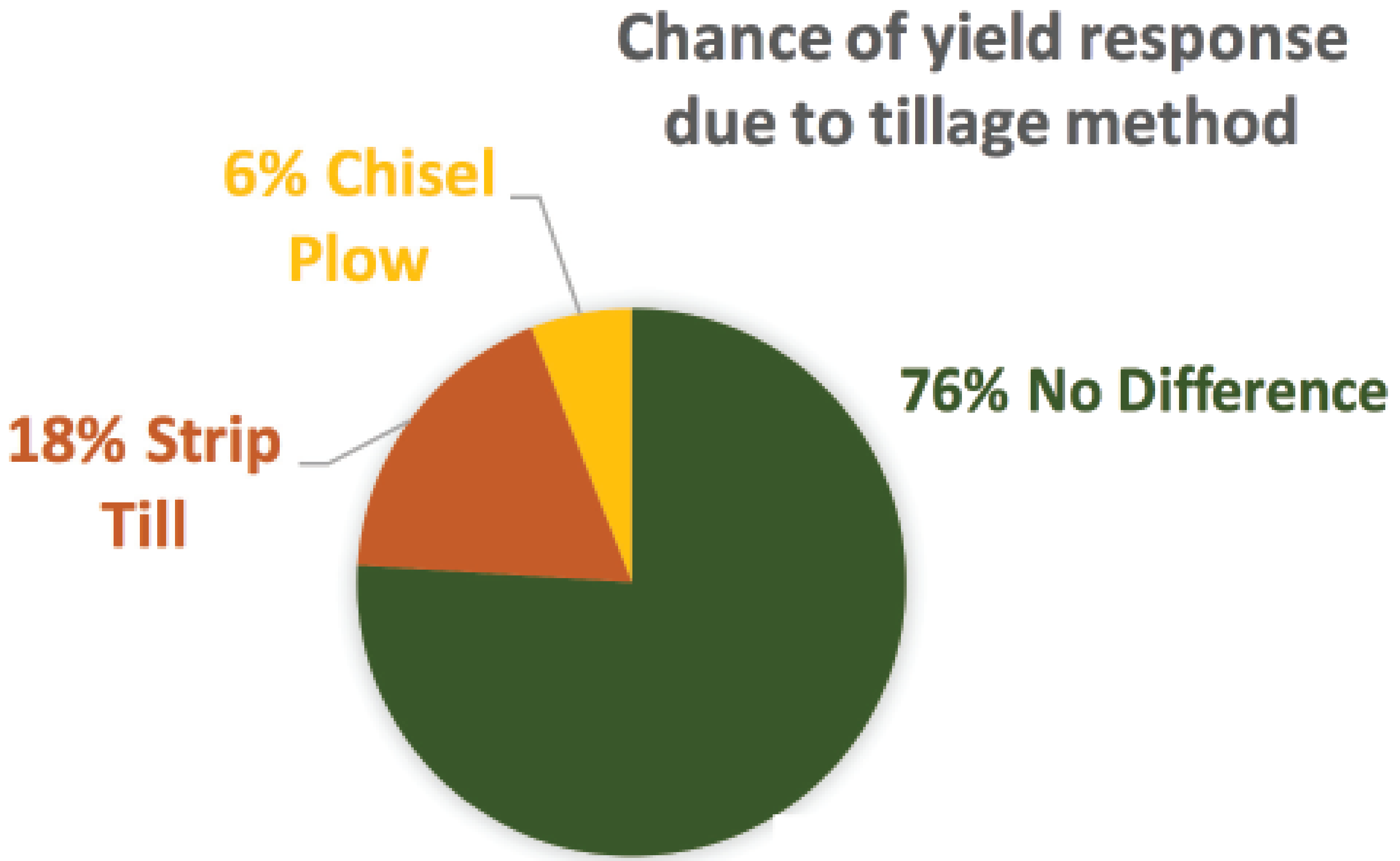


Table 4. Cost of equipment options and number of tillage passes using four management options when planting soybeans.

	No-Till	Vertical Till or Field Cultivation	Chisel Plow + Field Cultivation	Strip Till
Planter (tillage specific)	$20.15	$19.90	$19.90	$20.15
Primary Tillage	$0	$14.05	$16.45	$17.15
Secondary Tillage	$0	$0	$14.05	$0
Combine	$34.75	$34.75	$34.75	$34.75
TOTAL COST/AC	**$54.90**	**$68.70**	**$85.15**	**$72.05**
# of passes	2	3	4	3

What can you expect from ruts?

Jodi DeJong-Hughes: 2010 & 2011 Data

- Seven Locations in MN
- Rutted areas vs. Non-rutted areas
- First year after: Corn
- Second year after: Soybean
- ***RESULTS:***
    - Early and Late Stand did not differ
    - Grain Moisture did not differ
    - **Plant height significantly lower in rutted areas**
    - **Growth stage significantly lagged behind in rutted areas**
    - **Corn Yields: 17% (27.3 bu/ac) lower in rutted areas.**
    - **Soybean Yields: 16% (4 bu/ac) lower in rutted areas.**

What can you expect from ruts?

Next year's crop yields will not be as high as you want…

No matter what you do

Non-compacted areas

Rutted areas

Tilled Soils need to Settle

Tilled Soils need to Settle

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JOURNAL OF SOIL AND WATER CONSERVATION
The science and art of natural resource management for sustainability

FEATURE

Fluffy soil syndrome: When tilled soil does not settle

Aaron Lee M. Daigh and Jodi DeJong-Hughes

Soil tillage is one of the most common management practices in any crop production system across the world. Over the centuries, tillage tools have evolved from simple tools for preparing a soft, weed-free area for easy planting to sophisticated implements for managing high levels of crop residues, facilitating the warming of frigid soils, and incorporating some forms of fertilizers. On one hand, a producer who tills can increase their potential for a high yielding crop during the upcoming growing season. On the other hand, tillage can innately induce some well-known challenges (Triplett and Dick 2008):

1. Risk of increasing wind and water erosion
2. Accelerating the oxidation of soil organic matter
3. Limiting the formation of stable soil aggregates
4. Risk of compacting the subsoil just below the depth of tillage

Many more advantages and disadvantages associated with soil tillage exist, but this

Figure 1

Tilled fields in western Minnesota with (a and b) visual symptoms of poor particle-to-particle contact effects on crop performance (fluffy soil syndrome [FSS]). These aerial photographs were taken in July of 2015 and show healthy plant growth within compacted tire pathways and poor plant growth between tire pathways. The areas along the low-lying depressions likely provided wetting and drying cycles that alleviated some of the FSS. The effect of FSS on crop performance can be difficult for producers to see in their fields from the roads, but is unmistakable from aerial images.

(a)

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