# Can Occasional Tillage and Cover Crops Help No-Till?

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AGRONOMY AND HORTICULTURE

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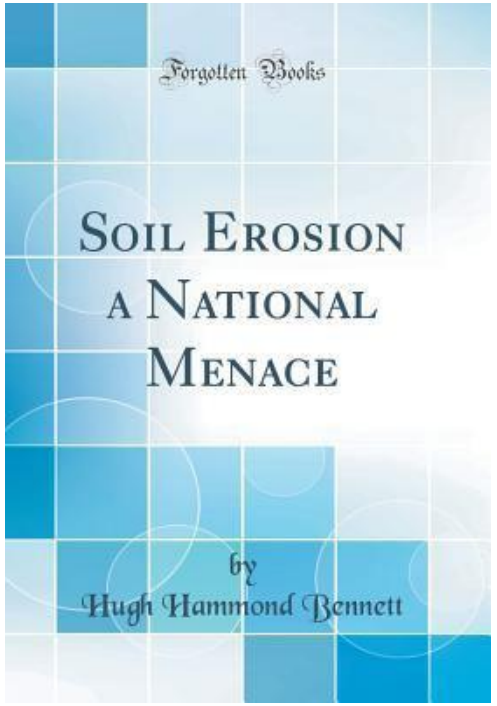
**“Out of the long list of nature’s gifts to man, none is perhaps so utterly essential to human life as soil.”**

**“Take care of the land and the land will take care of you.”**

**(Hugh Hammond Bennett, 1939. He is considered “The Father of Soil Conservation”)**

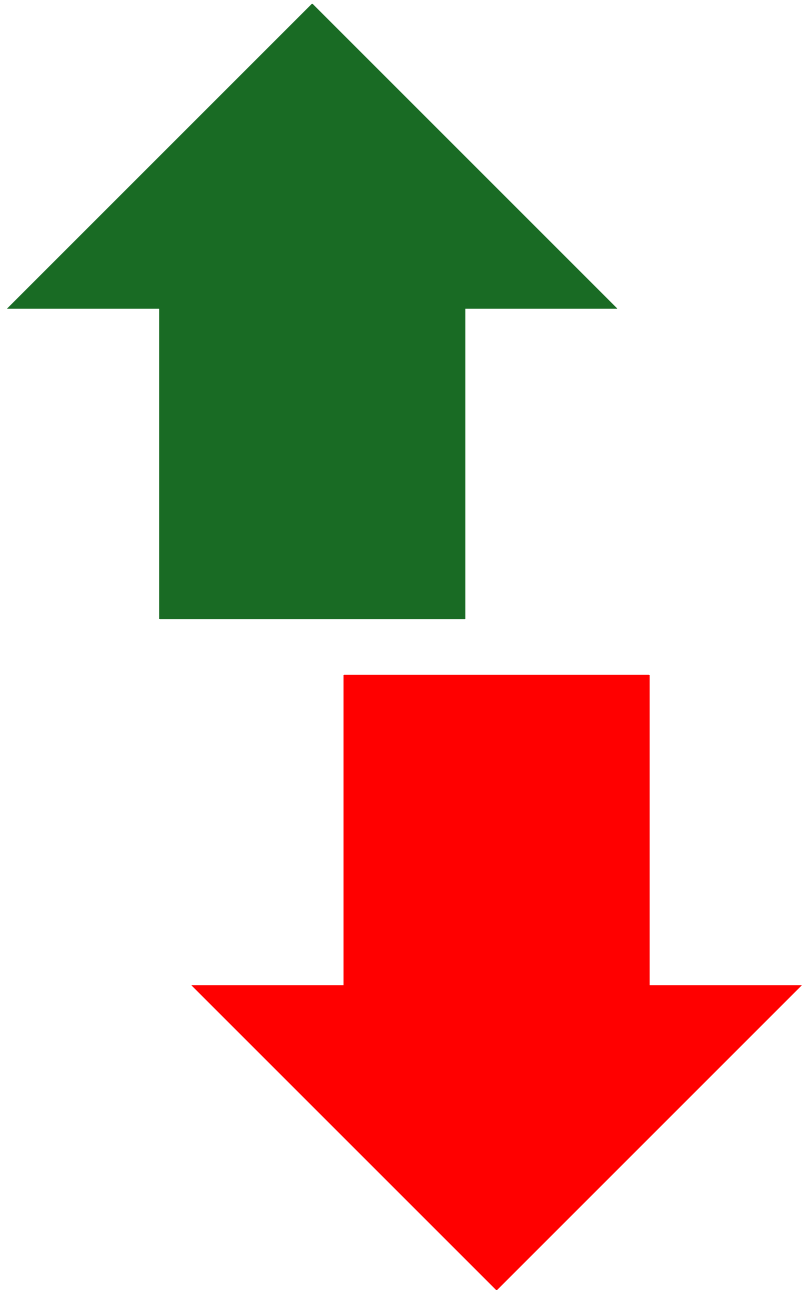




NO-TILL FARMING

# ARE OUR SOILS READY TO ADAPT TO EXTREME EVENTS?

# NO-TILL FARMING



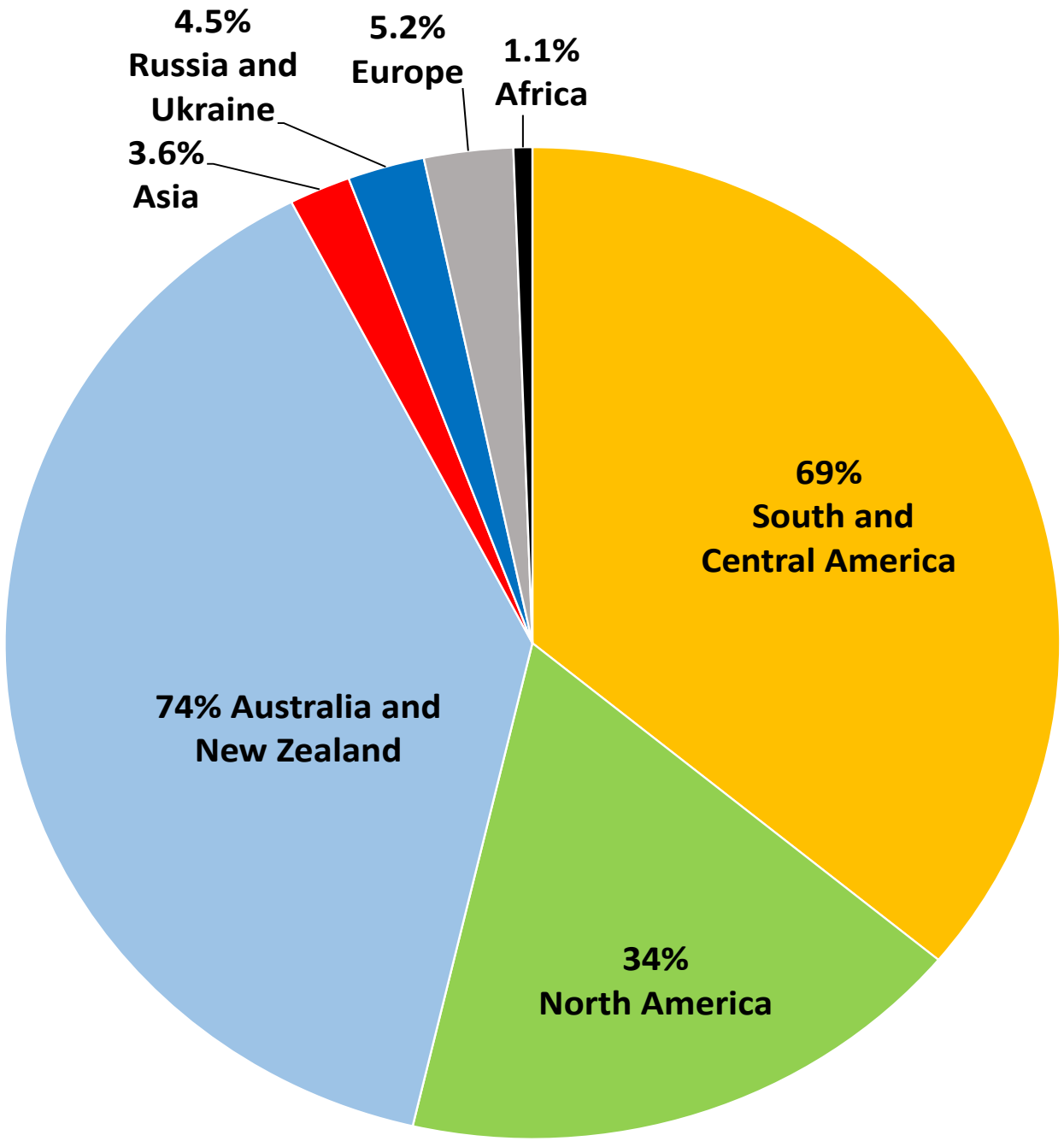
**BENEFITS:**

1. Erosion control
2. Water conservation
3. Improved near-surface soil properties
4. Reduced labor
5. Energy savings
6. Monetary savings

**CHALLENGES:**

1. Herbicide-resistant weeds
2. Carbon stratification
3. Nutrient (i., P) stratification
4. Acidification
5. Compaction
6. Runoff risks and losses of dissolved nutrients

# Percentage of cropland area in conservation tillage (*Kassam et al., 2022*)




**Conservation agriculture:**
**14.7% of global cropland area**

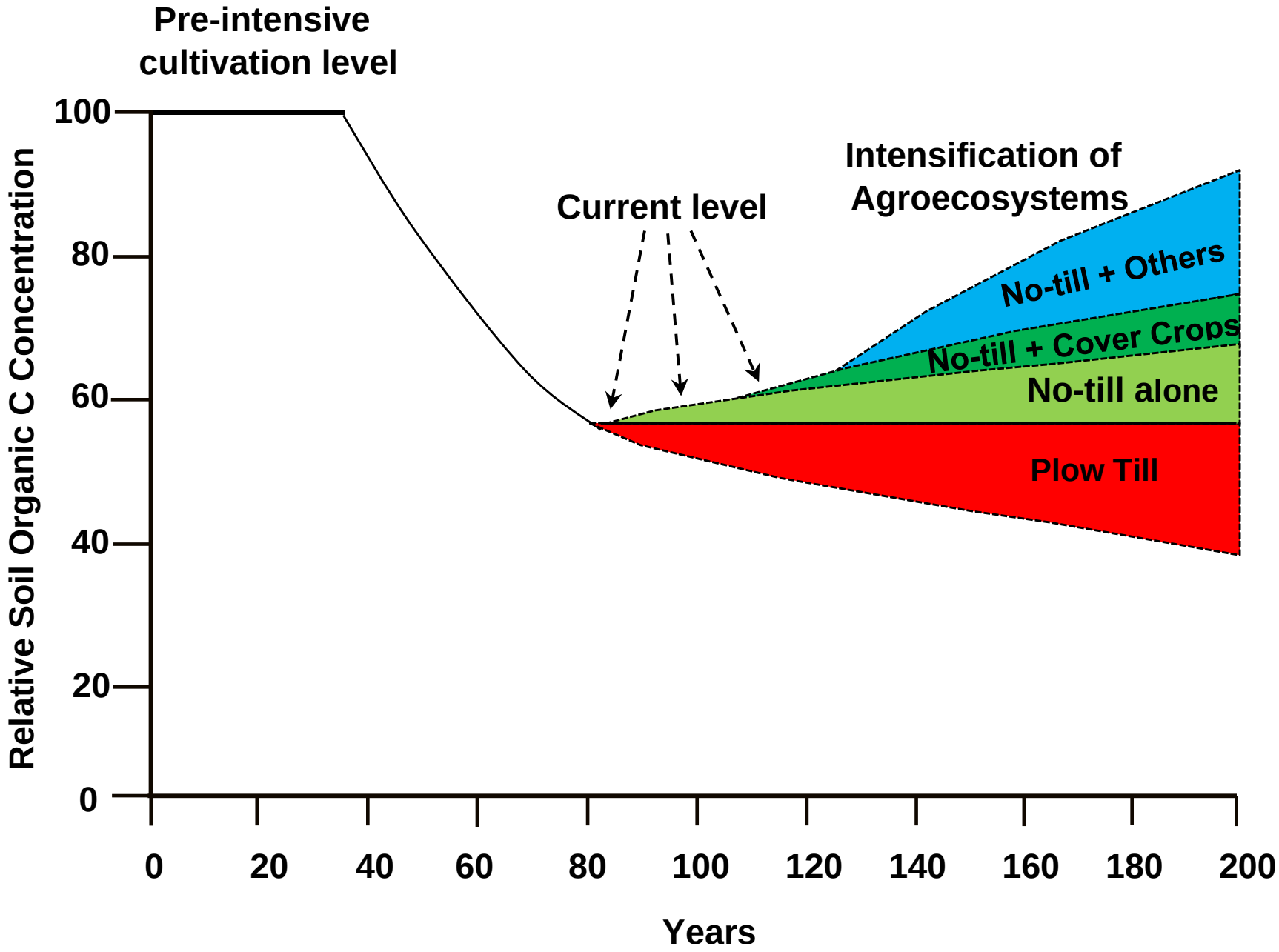
- **Why is no-till adoption rate inconsistent?**
- **Strict packaging?**
- **Local context or site-specificity?**

# What do we know about the no-till benefits? The case of soil C

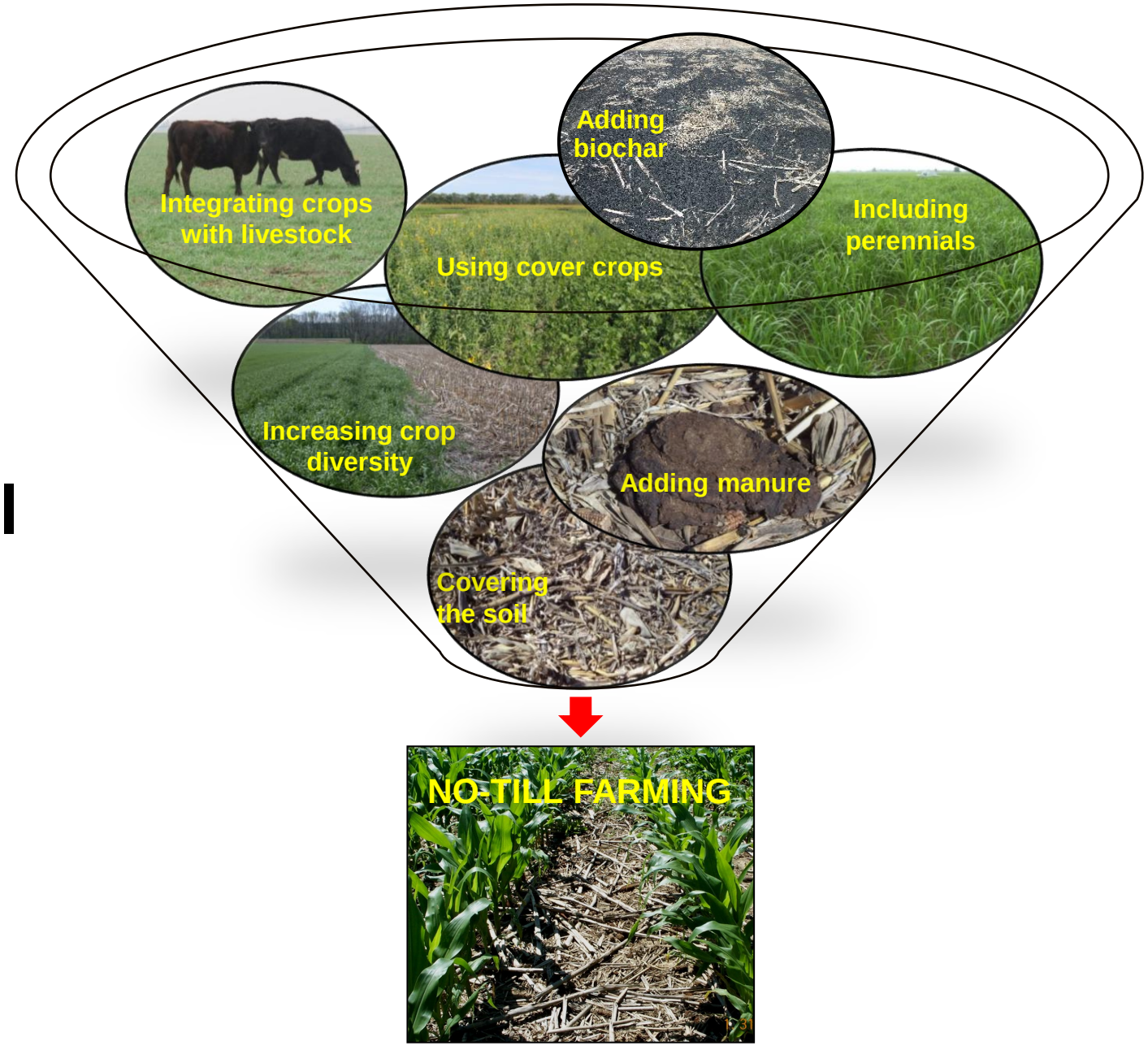
- **Soil C: No-till > tilled systems near the surface**
- **Soil C: No-till < tilled systems (bottom of plow layer)**
- **Soil-profile C (24 to 40 inches): No-till = Tilled systems**
- **Site-specificity?**


1. *Schlesinger, W. H. and Amundson, R. 2019. Managing for soil carbon sequestration: Let's get realistic. Global Change Biol. 25, 386–389.*
2. *VandenBygaart. A.J. 2016. The myth that no-till can mitigate global climate change. Agr. Ecosyst. Environ. 216, 98-99.*
3. *Powlson, D.S., Stirling, C.M., Jat, M.L., Gerard, B.G., Palm, C.A., Sanchez, P.A.,Cassman, K.G., 2014. Limited potential of no-till agriculture for climate change mitigation. Nat. Clim. Change 4, 678–683.*
4. *Du, Z., Angers, D. A., Ren, T., Zhang, Q., and Li, G. 2017. The effect of no-till on organic C storage in Chinese soils should not be overemphasized: A metaanalysis. Agric. Ecosyst. Environ. 236, 1–11.*

# How can we enhance no-till potential?



# Some tools for no-till intensification



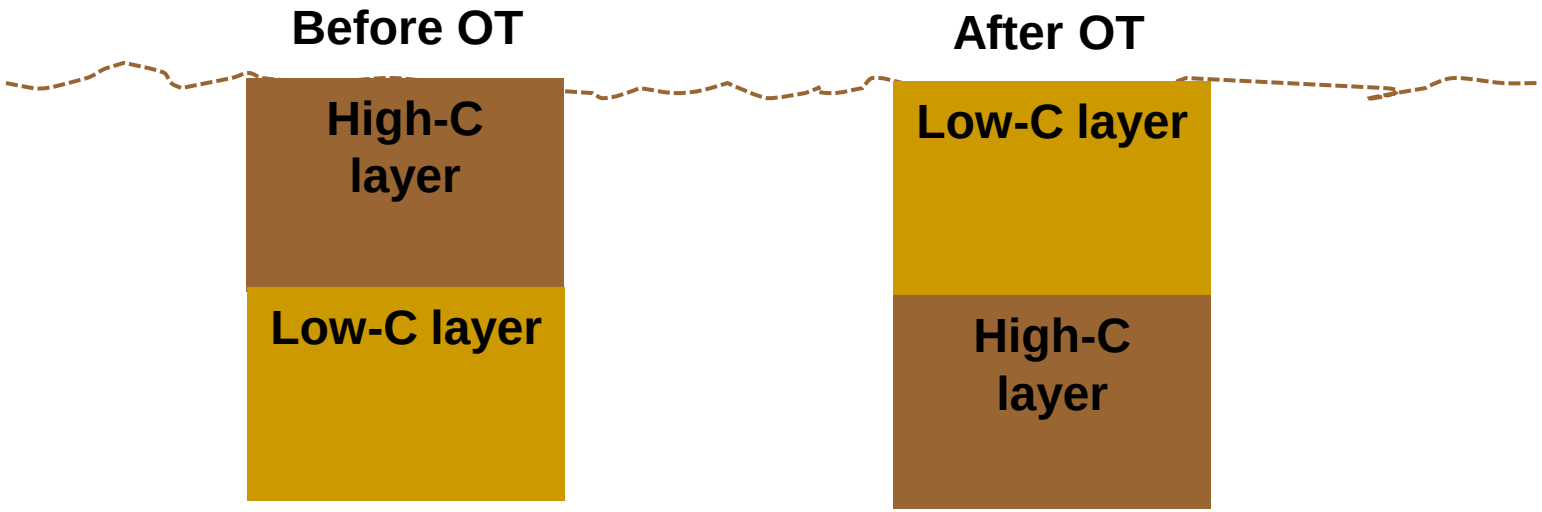

**SOIL HEALTH AND ECOSYSTEM SERVICES**

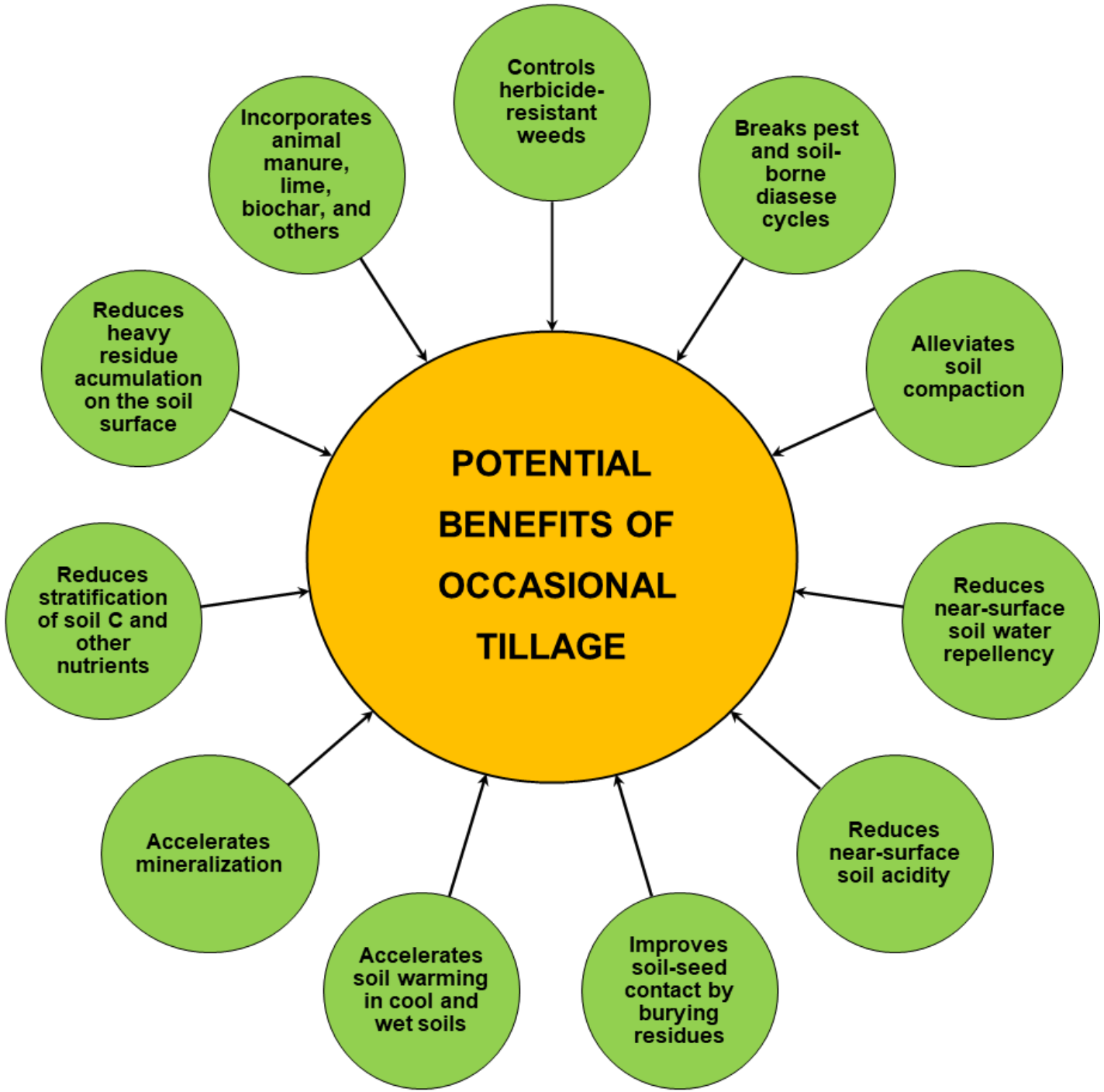
# Would occasional tillage be another tool to enhance no-till performance?

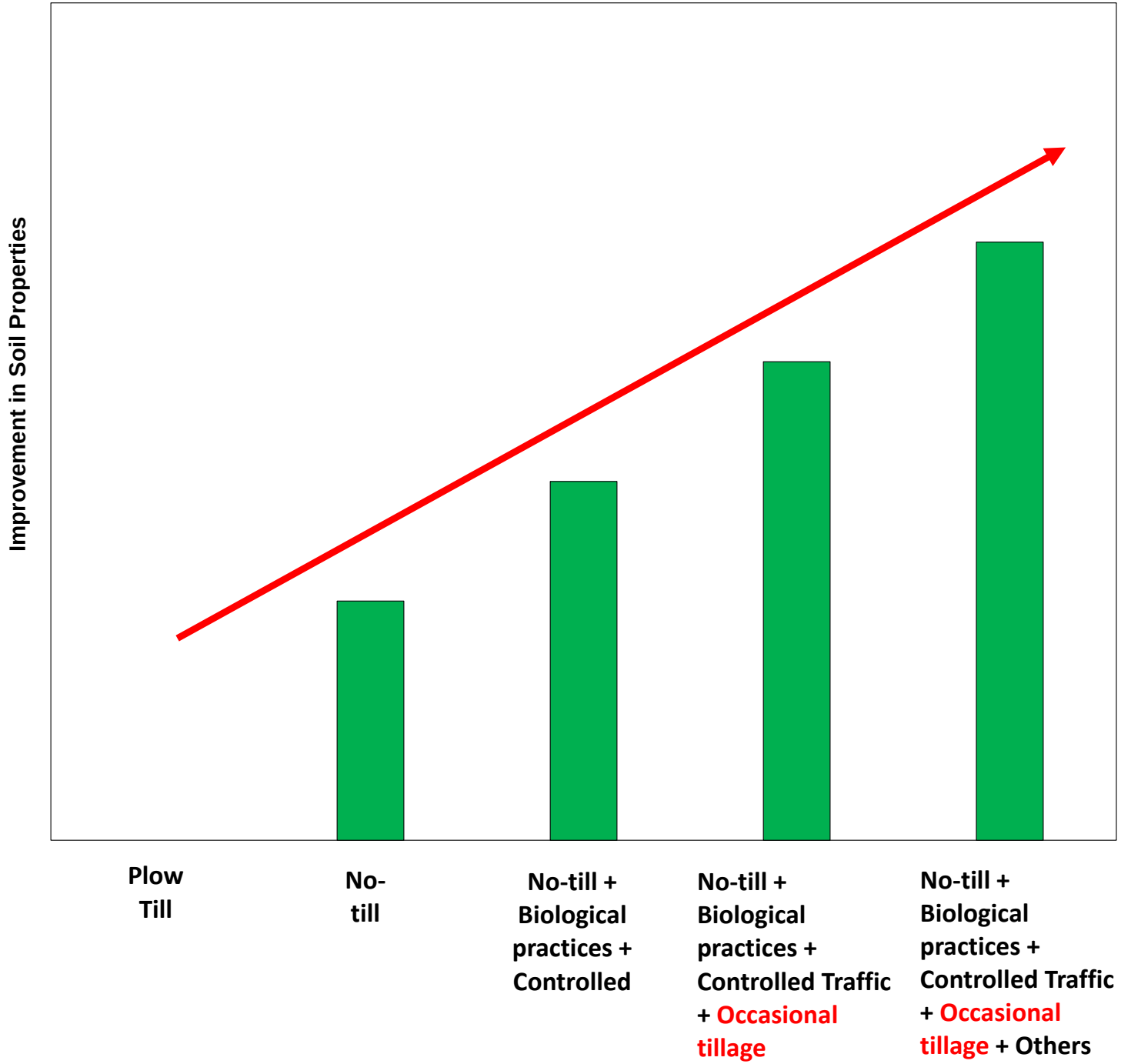
## What is occasional tillage (OT)?

**How about improving the unimproved layer by inverting the soil?**

**Why not improve soil properties to greater depths?**




POTENTIAL BENEFITS OF OCCASIONAL TILLAGE
Controls herbicide-resistant weeds
Breaks pest and soil-borne diasese cycles
Alleviates soil compaction
Reduces near-surface soil water repellency
Reduces near-surface soil acidity
Improves soil-seed contact by burying residues
Accelerates soil warming in cool and wet soils
Accelerates mineralization
Reduces stratification of soil C and other nutrients
Reduces heavy residue acumulation on the soil surface
Incorporates animal manure, lime, biochar, and others


Improvement in Soil Properties
Plow Till
No-till
No-till + Biological practices + Controlled
No-till + Biological practices + Controlled Traffic + Occasional tillage
No-till + Biological practices + Controlled Traffic + Occasional tillage + Others

# What does research really say about OT?

1. **Is OT a sacrilege?**
2. **Does it undo all the C gains and other ecosystem services of long-term no-till systems?**

# Experiments in eastern Nebraska (2 and 5 years)

- 2 locations in eastern Nebraska

Rogers Memorial Farm (RMF), 12 mi east of Lincoln: grain sorghum-soybean

ARDC, 35 mi NNE of Lincoln: corn-soybean

- Upland loess soils, deep, well or moderately well drained
- Mean precipitation ~29”
- Five tillage treatments conducted in spring (RMF) and fall of 2003

- Continuous no-till
- All tillage in late Oct-Nov or early Mar
- Moldboard plow: 8” depth
- Disk tillage: 4” depth

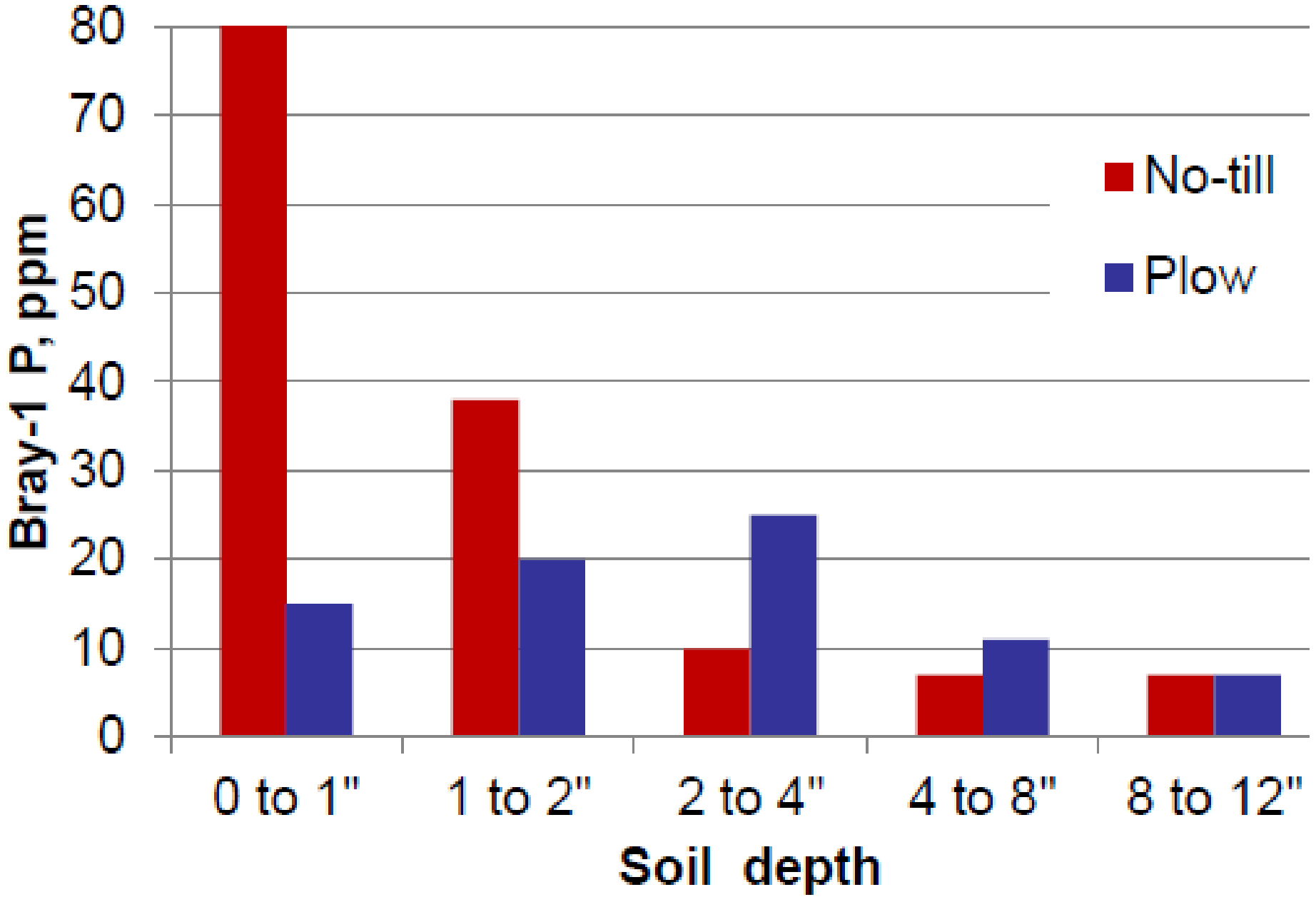
# Twisted shank chisel tillage

- **Rogers Memorial Farm**
  **8”**
  **12” depth**
- **ARDC**
  **8” depth**

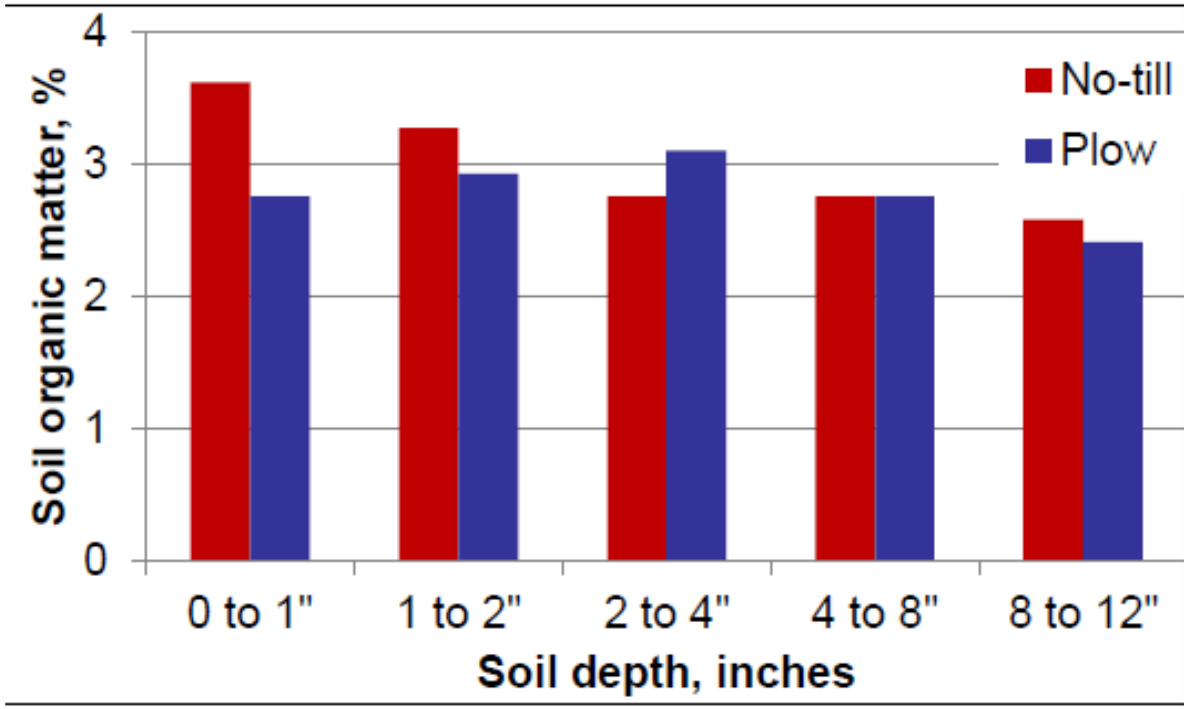
# Results after 2 and 5 years

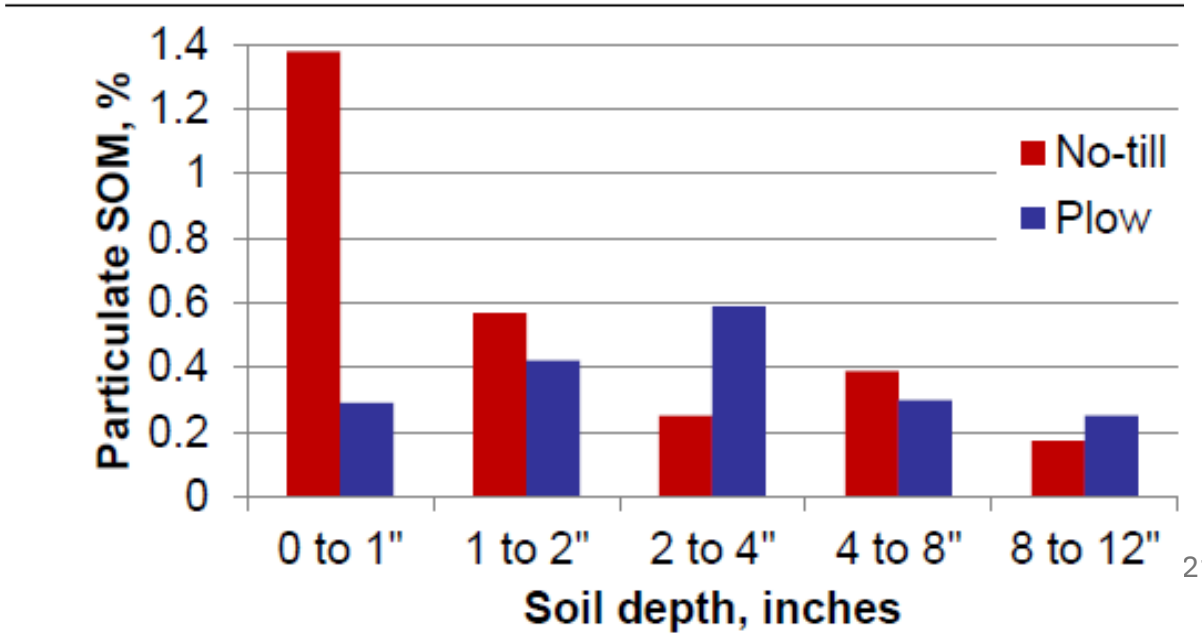
- **Grain yield: tillage effects were significant for only 2 site-years**
- **Overall site years, yield was 4.4 and 7% more with MP compared with continuous no-till**

# How about the redistribution of P?

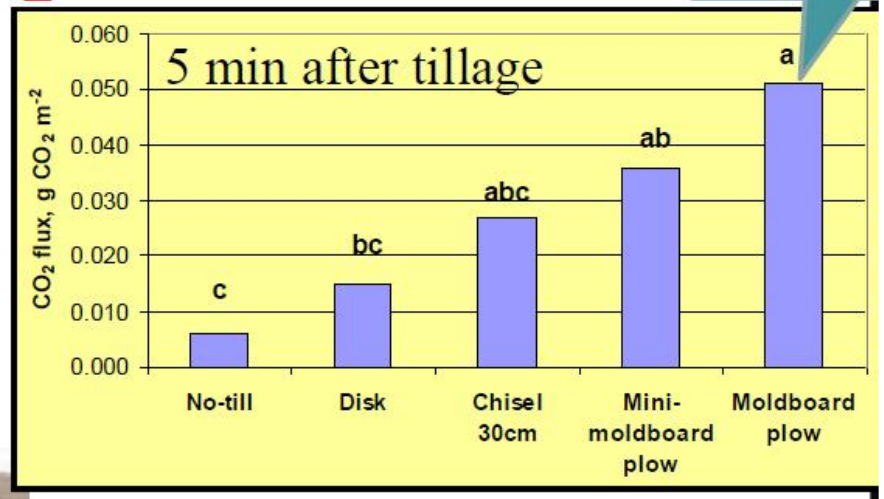


# How about the redistribution of organic matter?



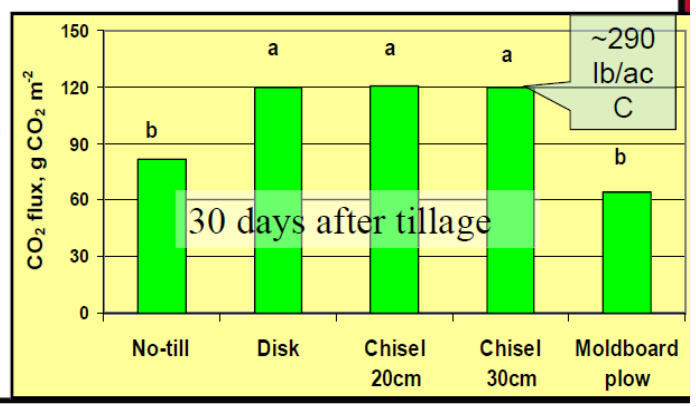



# Cumulative $CO_2$ flux after tillage




# Cumulative $CO_2$ flux after tillage

- At 6 and 30 days after tillage
  - similar for NT and MP
  - 64% more with disk and chisel at RMF
- low flux compared with studies of one-time **summer** tillage of NT.

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# Soil microbial effects

- Biomass was generally less at 0-4” depth for all soil microbial types at 5 yr after one-time MP and MMP tillage compared with NT.

- Why?? Agronomic significance?? SOC significance??

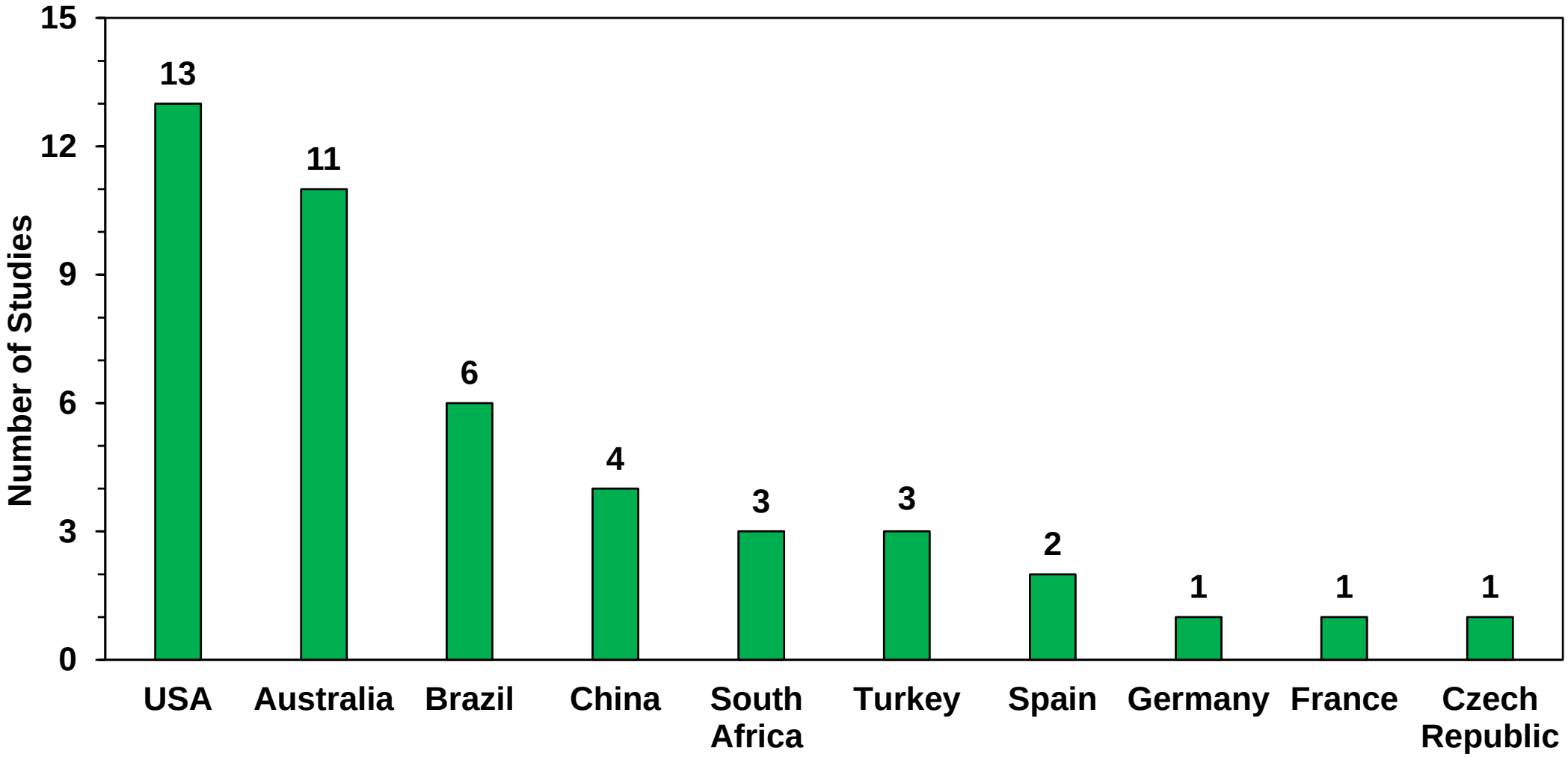
| Tillage effect (%Δ) on microbial biomass at 5 yr, 0-4” depth | | |
|---|---|---|
| MP, RMF | MP, ARDC | MMP, ARDC |
| Bacteria | | |
| -15 | -27** | -9** |
| Actinomycetes | | |
| -8 | -17** | -9** |
| Fungi | | |
| 0 | -34 | -16 |
| Bacteria | | |
| -16 | -27** | -12 |

# Conclusions

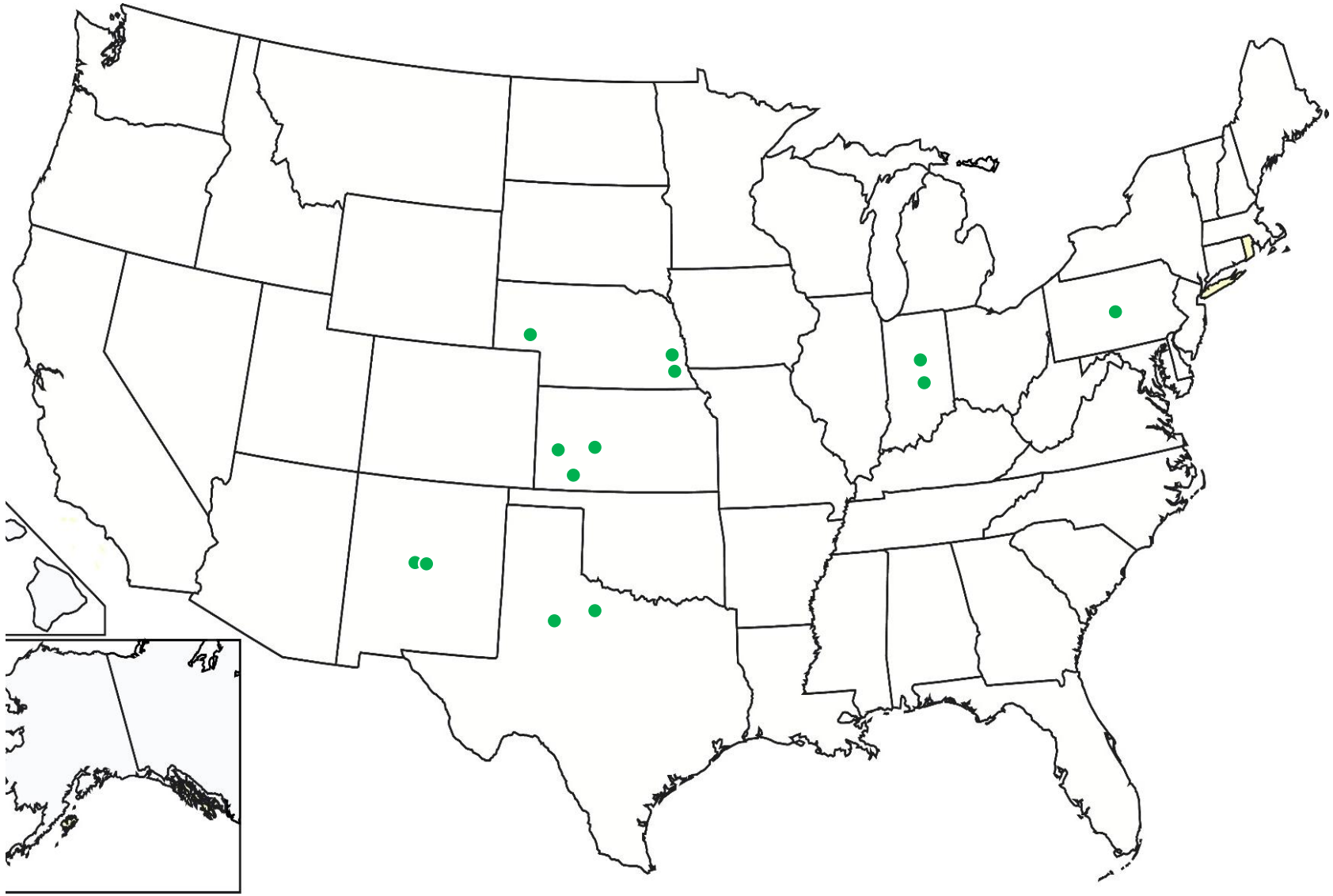
- One time tillage of NT on silty clay loam soil can be done without detrimental agronomic effects
  - ➢Assumes erosion is controlled
- Grain production over 5 years may be increased with 1-time MP or MMP tillage
- Little or no effects detected after 5 years on soil organic C and other properties

# How about other studies?

# A global review of OT studies up to 2024

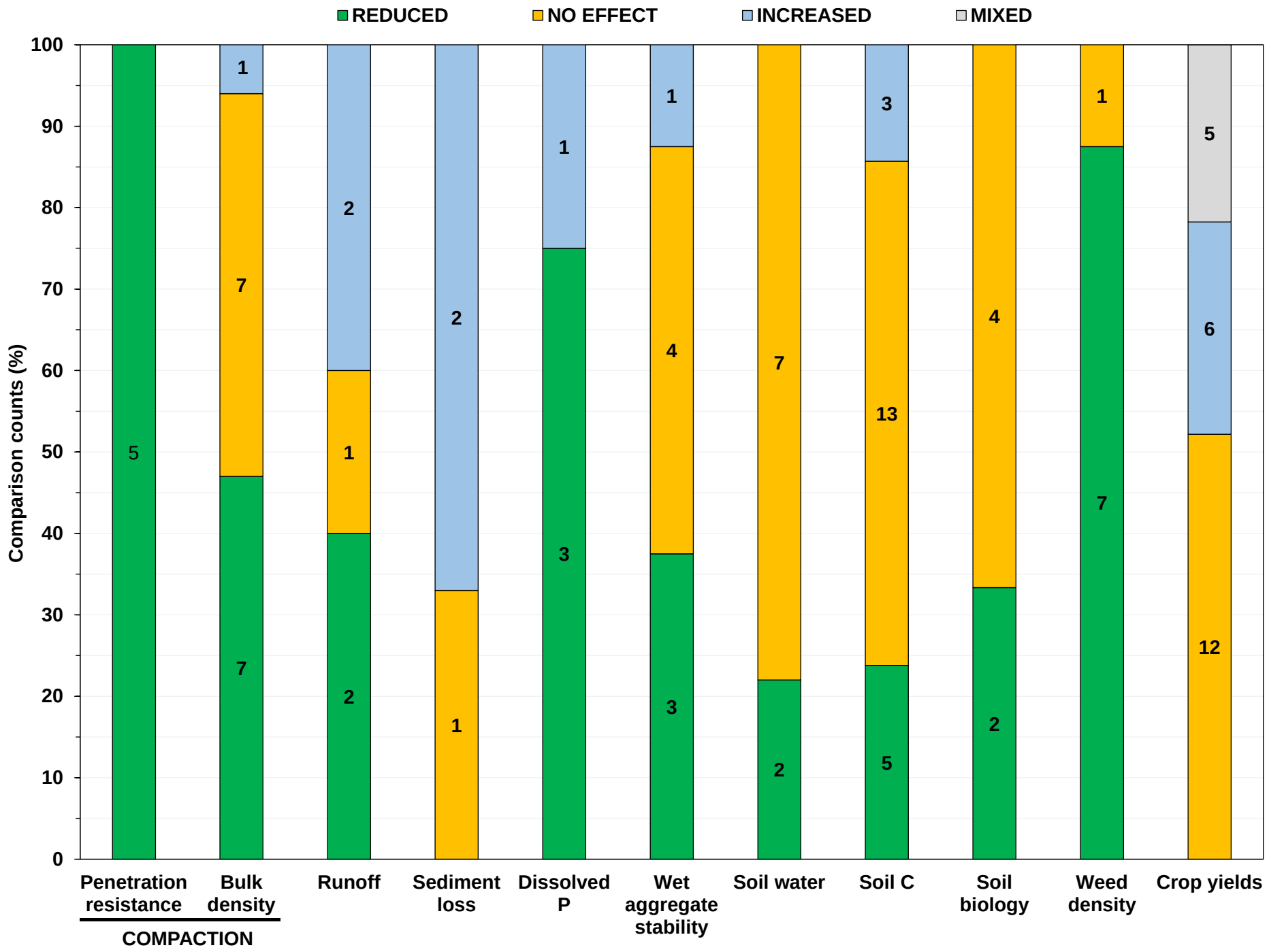


# Location of OT studies in the US



# RESULTS:

## Comparison of no-till with OT vs no-till without OT



# Does OT increase greenhouse gas fluxes?

| LOCATION | SOIL | TILLAGE TOOL | YEARS AFTER OT | EFFECT | SOURCE |
|---|---|---|---|---|---|
| Australia | 3 clayey soils | Cultivator and disk | 4 | • Increased $CO_2$ fluxes in 1 of 3 soils<br>• No effect on $N_2O$ fluxes | Melland et al. 2017 |
| Nebraska | 2 silty clay loams | MP, miniMP, and chisel | 2 and 2.5 | • Small increase in $CO_2$ fluxes | Quincke et al. 2007 |

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Agronomy Journal

ARTICLE

Soil Tillage, Conservation, & Management

# A single tillage in a long-term no-till system on dryland crop performance

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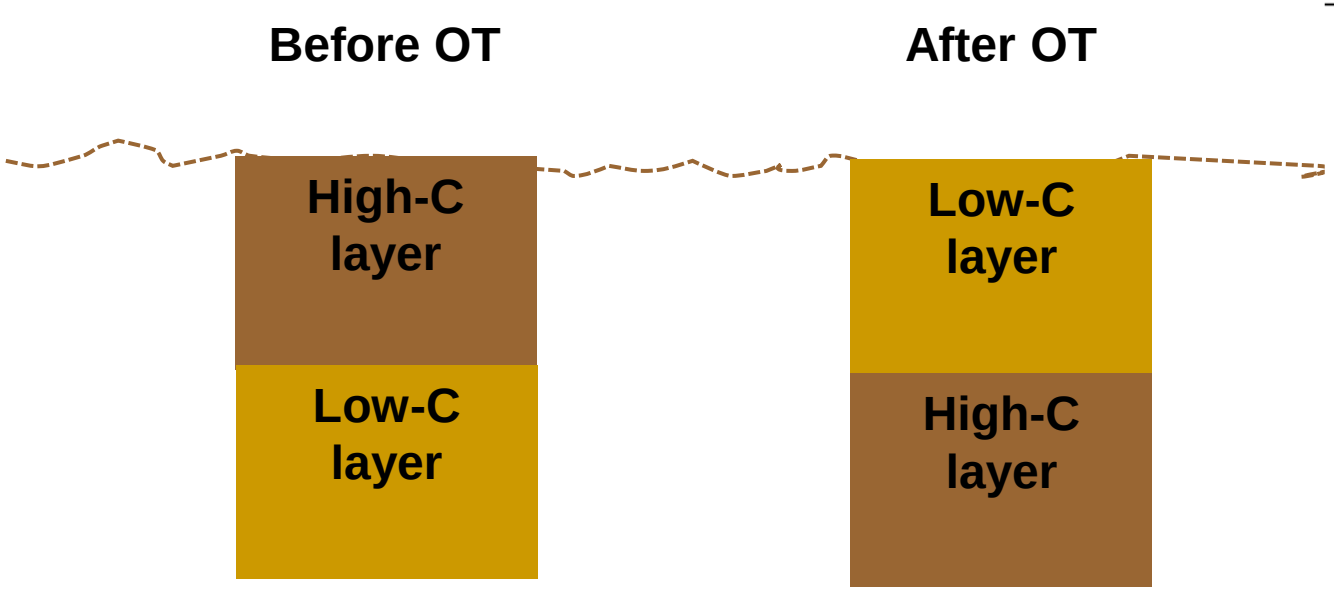
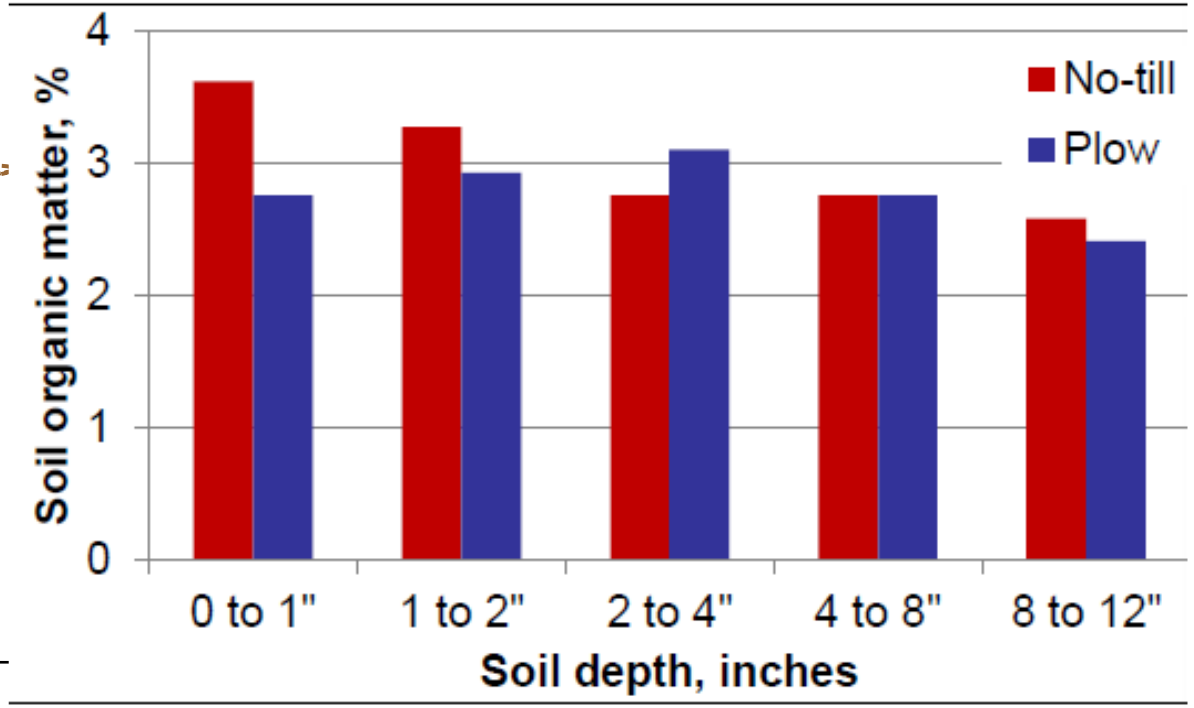
**Abstract**

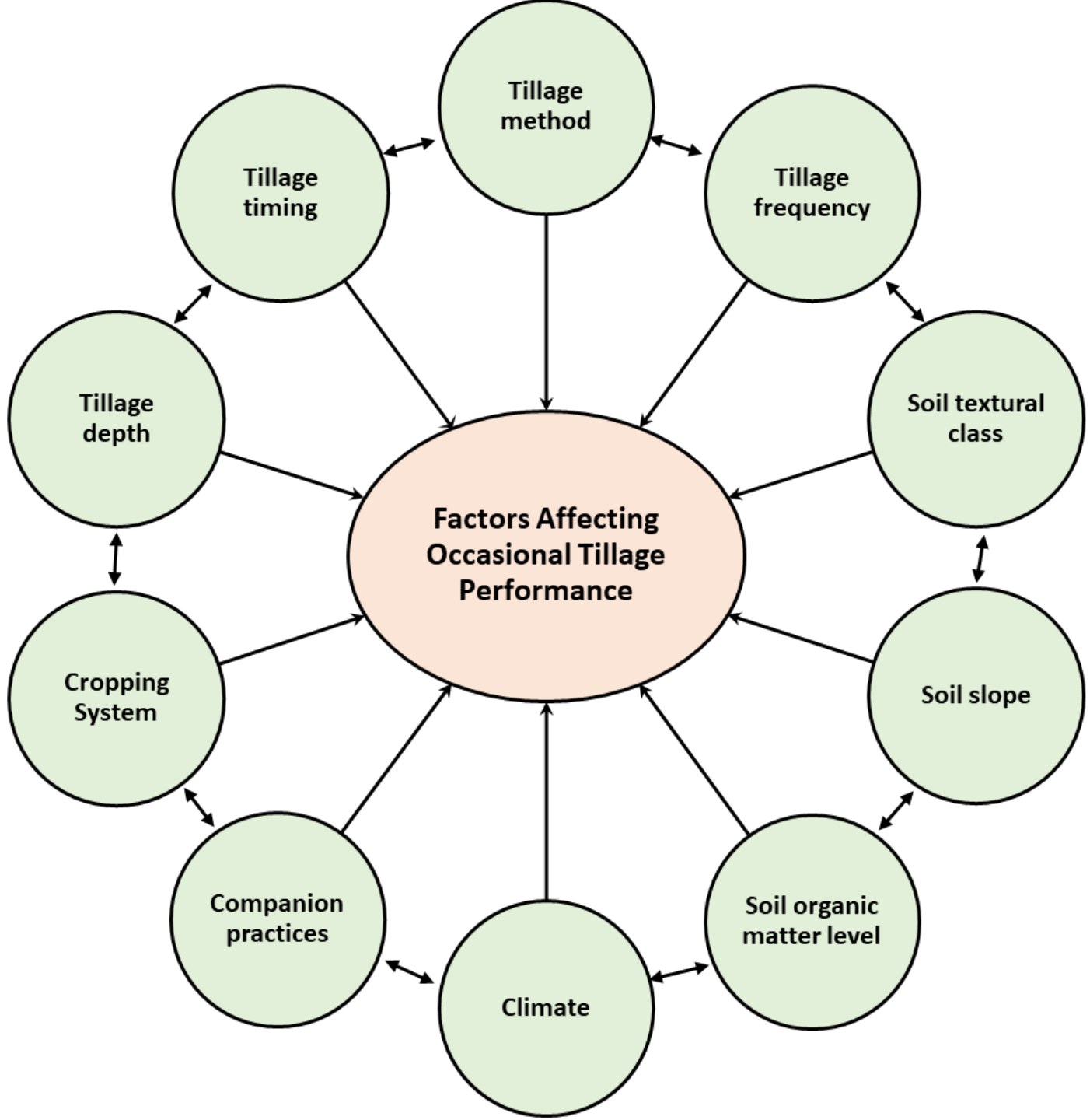
A no-till system may cause stratification of soil organic C and lack effective control of herbicide-resistant weeds. An occasional tillage is proposed to alleviate these, but only limited information is available on the effect of a single or occasional tillage on crop yield in a no-till wheat grain–sorghum–fallow (WSF) rotation. The objective of this research was to determine the effect of a single tillage to a 10-cm depth of a long-term (>6 yr) continuous no-till WSF system on grain yield, soil water, and water use of grain sorghum (*Sorghum bicolor* L.) and winter wheat (*Triticum aestivum* L.) for up to 3 yr after the single tillage operation. This research was conducted at Garden City and Tribune, KS. The three tillage treatments were a single tillage in May or June during fallow (June tillage), a single tillage after wheat harvest (July tillage), and a complete NT system. Grain yield of sorghum varied from average of 3.40 Mg ha$^{-1}$ at Garden City in 2014 to 8.04 Mg ha$^{-1}$ at Tribune in 2016. Grain yield of winter wheat varied from average of 0.47 Mg ha$^{-1}$ at Garden City in 2014 to 5.21 Mg ha$^{-1}$ at Tribune in 2016. There was no significant effect from a single tillage (June tillage or July tillage) on crop yield, yield components, biomass, available soil water (ASW), and water use compared with continuous no-till. Therefore, we have concluded that a single tillage of a long-term no-till dryland WSF system can be done without affecting crop performance.

# Does OT improve the unimproved deep layers? The case of soil C




| LOCATION | SOIL | TILLAGE TOOL AND DEPTH | DEPTH (INCH) | EFFECT ON SOIL ORGANIC C | SOURCE |
|---|---|---|---|---|---|
| Turkey | Clayey | Moldboard plow to 30-33 cm depth | 0-4 | Reduced or no effect | Celik et al., 2021 |
| | | | 4-8 | Increased: from 0.80% to 1.13% | |
| | | | 8-12 | Increased: from 0.73% to 0.95% | |


Tillage method
Tillage timing
Tillage frequency
Tillage depth
Soil textural class
Factors Affecting Occasional Tillage Performance
Cropping System
Soil slope
Companion practices
Soil organic matter level
Climate

# How long do the benefits from OT last?
# The case of weed management

| LOCATION | TILLAGE TOOL | EFFECT ON WEEDS | | SOURCE |
|---|---|---|---|---|
| | | YEAR 1 | After YEAR 1 | |
| Kansas | Sweep plow | Controlled | Controlled in Year 2 | Obour et al., 2021 |
| Nebraska | Moldboard plow | Controlled | Controlled by 41% in Year 3 | Kettler et al., 2000 |
| 5 soils in Australia | Chisel plow | Controlled | Variable effect in Year 2 | Crawford et al., 2015 |
| 14 soils in Australia | Chisel plow | Controlled | Variable or no effect | Dang et al., 2018 |

# How long do the negative effects last?

- **OT effects: Short-lived.**
- **Soil properties: Recover to pre-OT levels within 1 or 2 yr.**
- **OT effects: Deeper in the soil in yr 1 and then shallower.**

# How often should OT be used?

- **OT once in 5 or 10 yr: Suggested option.**
- **How about the short-lived effect of OT (i.e., 2 or 3 yr)?**
- **Frequent tillage of no-till vs. soil benefits.**
- **OT rotated every 4 or 5 yr, like extended crop rotations?**
- **Short-term tillage (NT-OT, NT-NT-OT) may increase crop yields in high input systems but how about soil recovery?**
- **More long-term studies to establish optimum OT return periods for different ecoregions.**

# How does OT tool affect benefits?

- **OT impact = *f* (depth of soil disturbance).**
- **OT tool selection: What is your goal?**
- **Inversion vs. shallow tillage: C stratification and weed seed burial.**
- **Tradeoffs: Inversion vs shallow tillage.**

# When should OT be performed?

- **OT in fall or spring? Consider soil wetness and long-term weather forecast such as rainfall probability.**
- **Soil exposure and erosion risks (i.e., heavy rainstorms).**
- **OT and companion practice (s).**
- **Timing and success of OT: Soil conditions, weather forecast, and companion practices.**

# Where can OT fit?

- Consider soil resilience
- Erosion-prone soils X
- Shallow and sandy soils X
- Low C soils X
- Low-residue input systems X

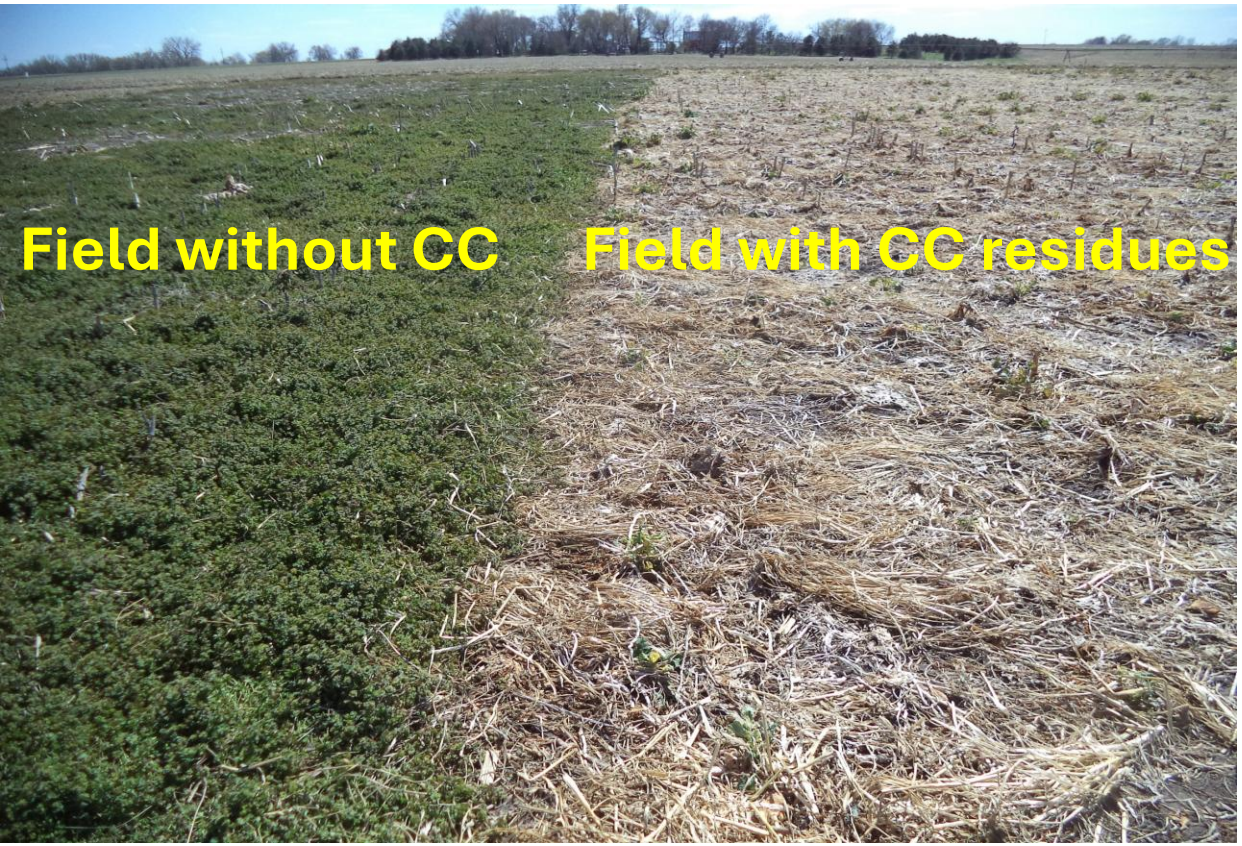
# Do you really need OT in your no-till farm?

- **What is the reason (goal) for considering OT in your farm?**
- **Have you exhausted other alternatives?**

# What are the alternatives to OT?

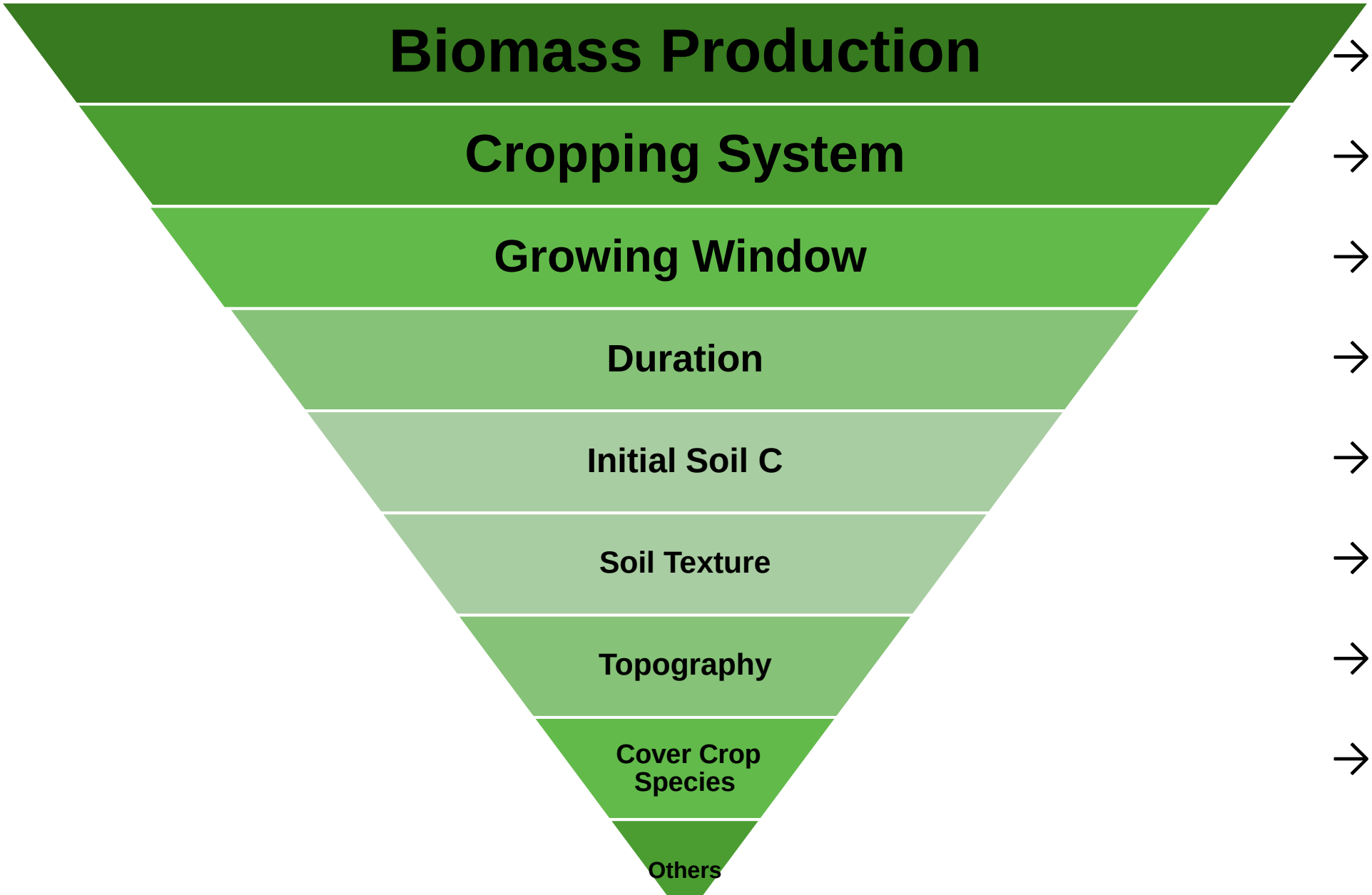
1. Controlled traffic
2. Cover crops (CCs)
3. Diversified crop rotations
4. Reduced till (i.e., strip tillage)
5. Integrated weed management

# Cover crops and weeds: Case studies in Nebraska




# CCs and soil compaction

# Factors that influence CC effects




→ >1 ton/ac?

→ Corn, small grains,…

→ Late termination

→ >5 yr?

→ <1% C?

→ Medium-textured…

→ Eroded soils

→ Grasses > Legumes?

# Long-term CC experiment

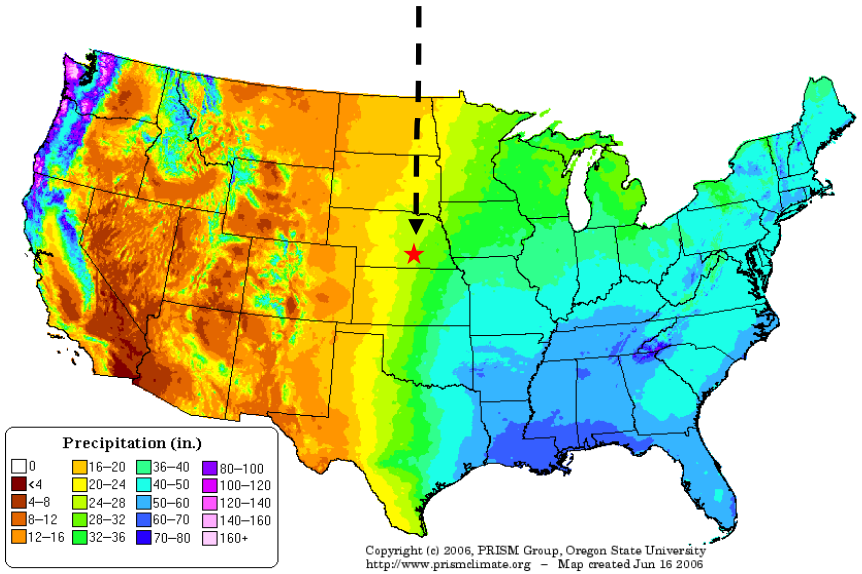

# Long-term CC experiment

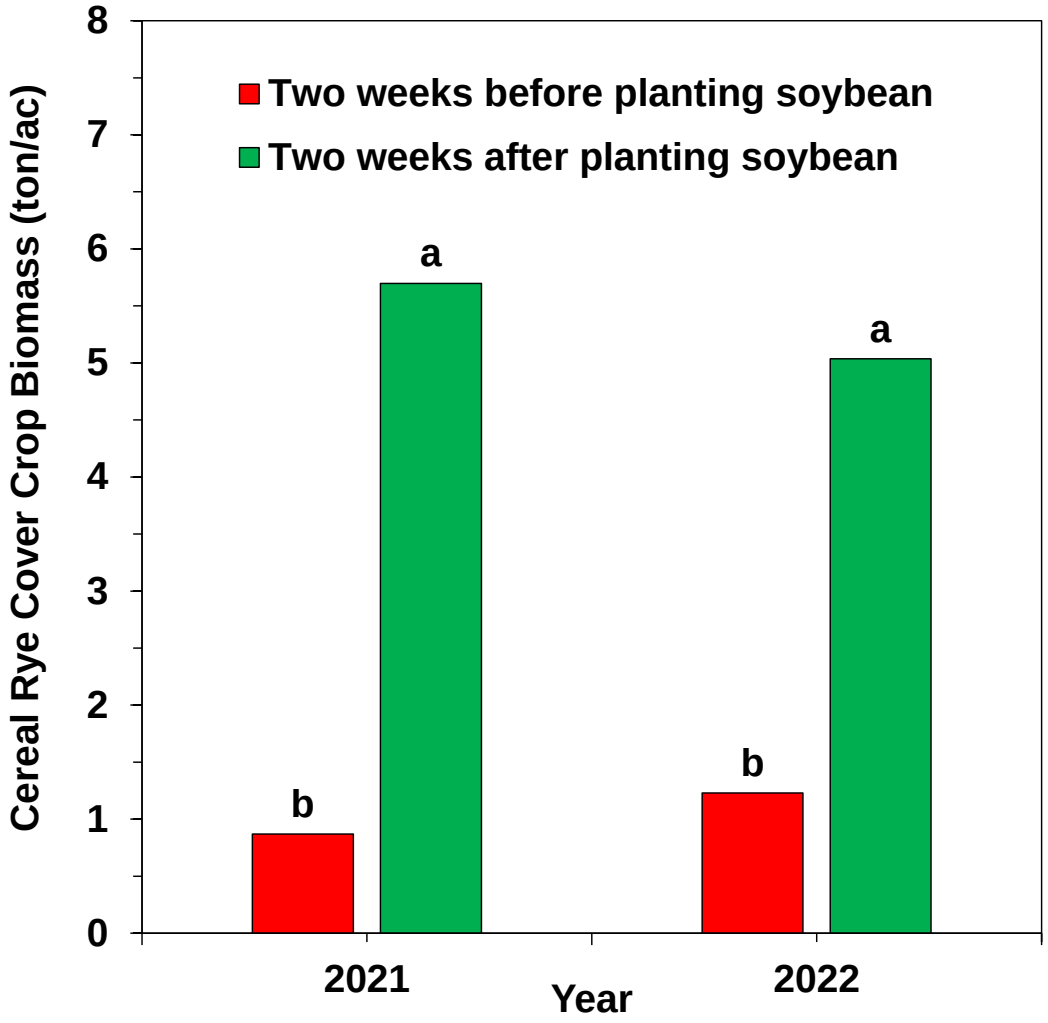
# Cover crop management options

- **Planting after corn silage or seed corn: Continuous corn or corn-soybean**
- **After small grains in summer**
- **Replacing fallow in wheat-fallow systems**
- **Fertilizing and irrigating**
- **Interseeding and terminating late**
- **Planting green**

**Planting green = Delaying CC termination until or after crop planting**

# Planting green project in south central Nebraska: 2 Years




| Treatment | No effect on total C (%) after 2 years |
|---|---|
| No CC | 2.05ns |
| 2 wks before planting | 2.01 |
| 2 wks after planting | 1.96 |

# PLANTING GREEN: LITERATURE REVIEW

- **Reviewed published literature**
- **Planting green effects on CC biomass, soil erodibility, water, soil C, nitrate leaching, weed suppression, insects, diseases and pests, and crop yields compared with traditional CC termination.**
- **Searched all journal articles published until July 10, 2024.**
- **Row crop systems.**

*Blanco-Canqui, H., and A.J. Jhala. 2024. Planting green and ecosystem services under row crop production systems. CABI Reviews 19:1.*

**Most studies:**

- **U.S. temperate regions**
- **short term (<3 yr)**
- **winter rye CC in no-till corn and soybean systems**

# Review Results

| Ecosystem service | Studies | Impact of Planting Green |
|---|---|---|
| Biomass production | 18 | It generally increases (1.1 to 11.3 times; 0.06 ton biomass $ac^{-1}$ $day^{-1}$ ) |
| Soil C and other properties | 6 | Improves or has no effect |
| Soil water | 4 | Reduces in most cases when growing |
| Nitrate leaching | 4 | May or may not reduce |
| Weed suppression | 8 | Suppresses weeds by as much as 97% |
| Diseases and pests | 11 | May or may not cause incidence |
| Crop yields | 19 | • Reduces in 32%<br>• No effect in 16%<br>• Mixed effect in 52% |

# Conclusions

- **OT once in 5 or 10 yr may not undo no-till benefits**
- **OT addresses some challenges (i.e., compaction, weeds, stratification), but benefits often last <2 yr**
- **Can OT have a place in no-till farming? Yes?**
- **Consider the problem in question, local situation, and the various Rs of OT (type, timing, depth, frequency,…….,)**
- **More data (>10 yr) to design OT for different soils and crops**
- **Planting green boosts biomass production and suppresses weeds. Consider duration, initial soil C, and other site-specific factors**

# Take-home message

**Occasional tillage and cover crops can help no-till, but need to consider local conditions, which determine the extent of benefits**

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