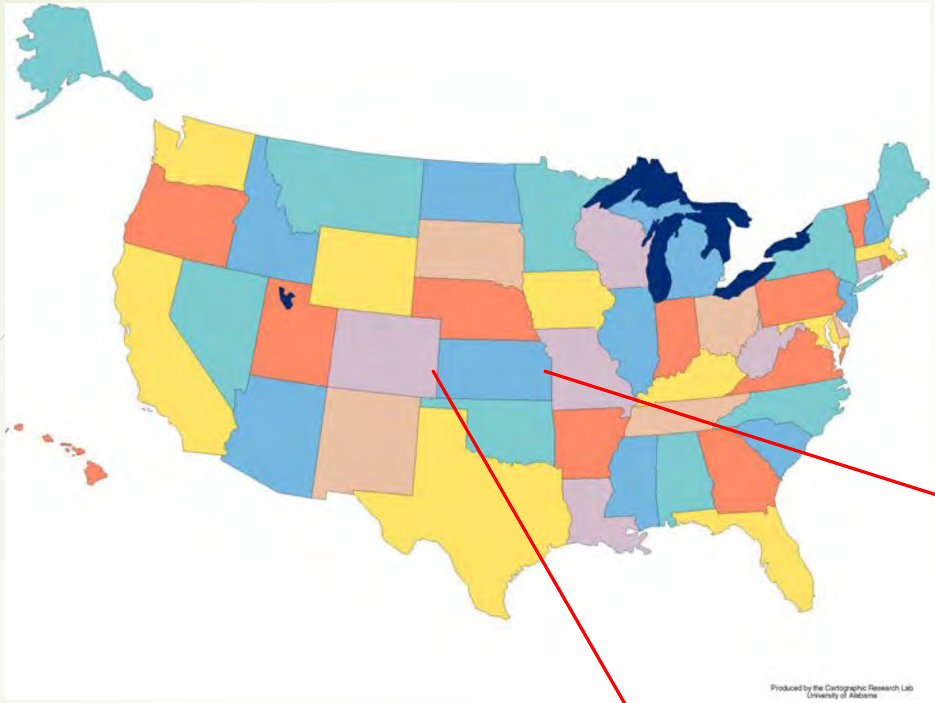
Keeping Roots in the Ground

Kernza® Perennial Grain--a work in progress

Tim Crews
The Land Institute



THE LAND INSTITUTE
Salina, Kansas,
USA

38° 49’ 27” N
97° 36’ 26” W

Elevation: 373 m

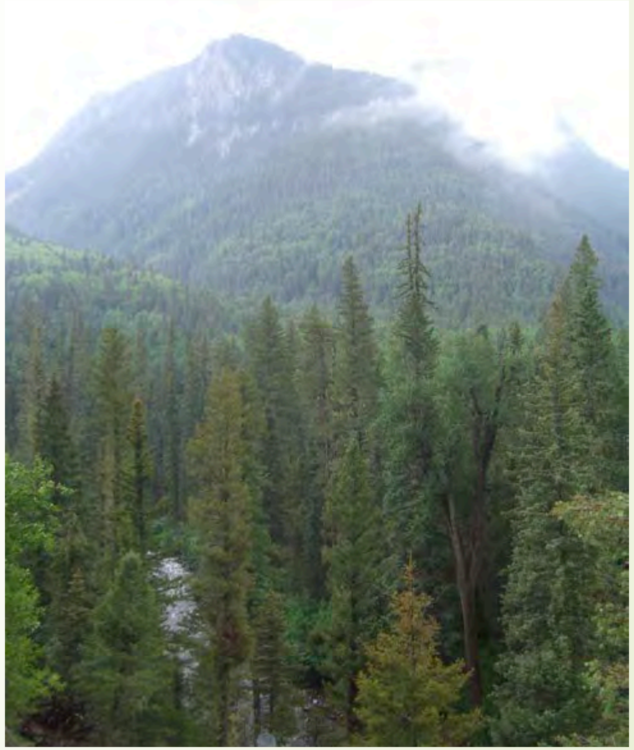


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Photo: Jim Richardson

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Natural Ecosystem | Agriculture

Perennial-High Diversity

Annual-Low Diversity

Perennial-Moderate Diversity

Ecosystem Services

Soil formation
Maximizes soil organic matter
Resistant to pathogens and insects
Nutrients retained
Weed establishment suppressed
High functioning soil microbiome
High precipitation use efficiency
No fossil fuel dependence

Ecosystem Dis-services

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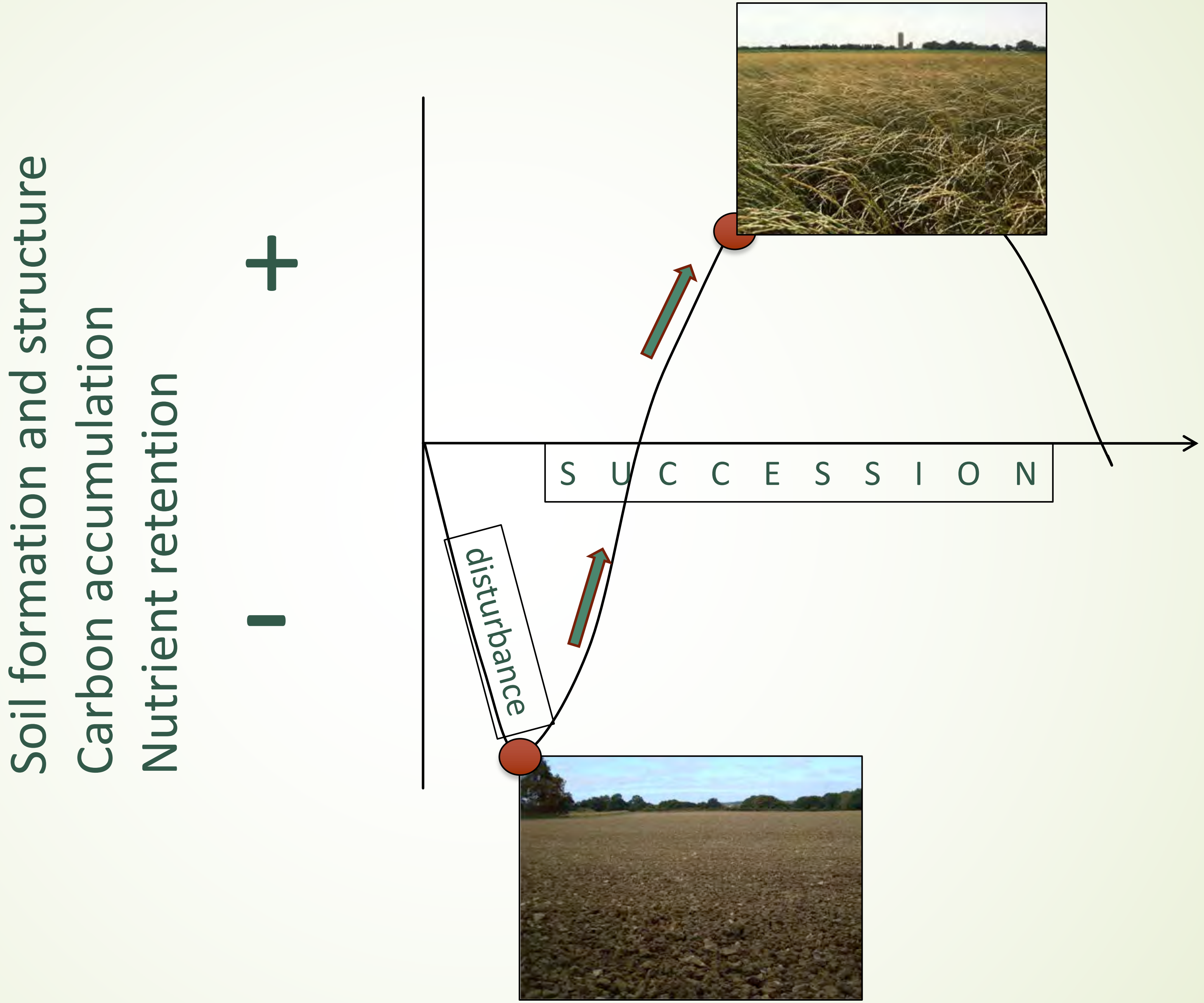


Soil formation and structure
Carbon accumulation
Nutrient retention
+
-
disturbance
S U C C E S S I O N

Perennial wheat

Perennial sorghum

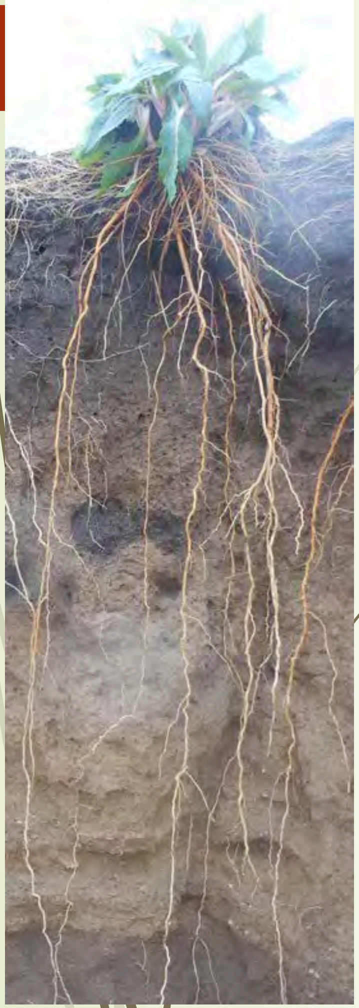
Perennial rice

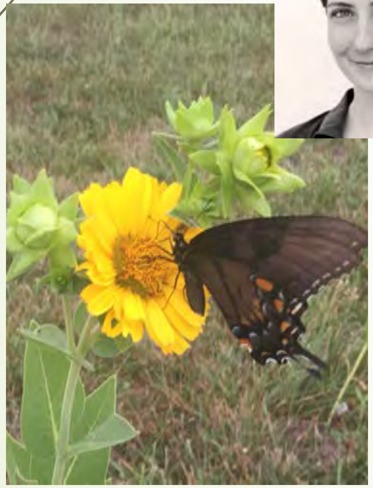
Wide hybridization

annual crop x perennial relative

de novo Domestication

Oilseeds





Silphium
Silphium integrifolium

Legumes

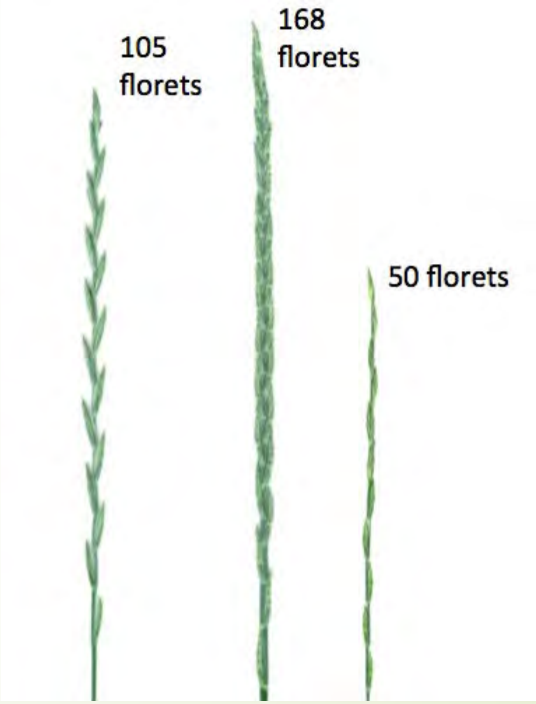
Lupinus polyphyllus

Medicago spp.

Wheatgrass

Kernza
Thinopyrum intermedium

Breeding nursery of intermediate wheatgrass (*Thinopyrum intermedium*) that produces "Kernza®" perennial grain



Intermediate wheatgrass introduced to USA from the Caucasus region

Forage Variety Oahe released

Variety Clarke released

TLI submits "Kernza" trademark registration

Long Root Ale In Stores

1930 | 1943 | 1956 | 1969 | 1982 | 1995 | 2008

Today

The Rodale Institute evaluates 100 perennial grasses, chooses IWG

The Rodale Institute evaluates collections and identifies promising germplasm

The USDA BFPMC and Rodale Inst. perform two cycles of selection to improve IWG grain production

TLI performs ten cycles of selection to improve IWG

Breeding and agronomic research in Minnesota and Manitoba

Kernza's genome is sequenced

TLI hires Kernza commercialization manager to coordinate supply chain

Genomic selection begins

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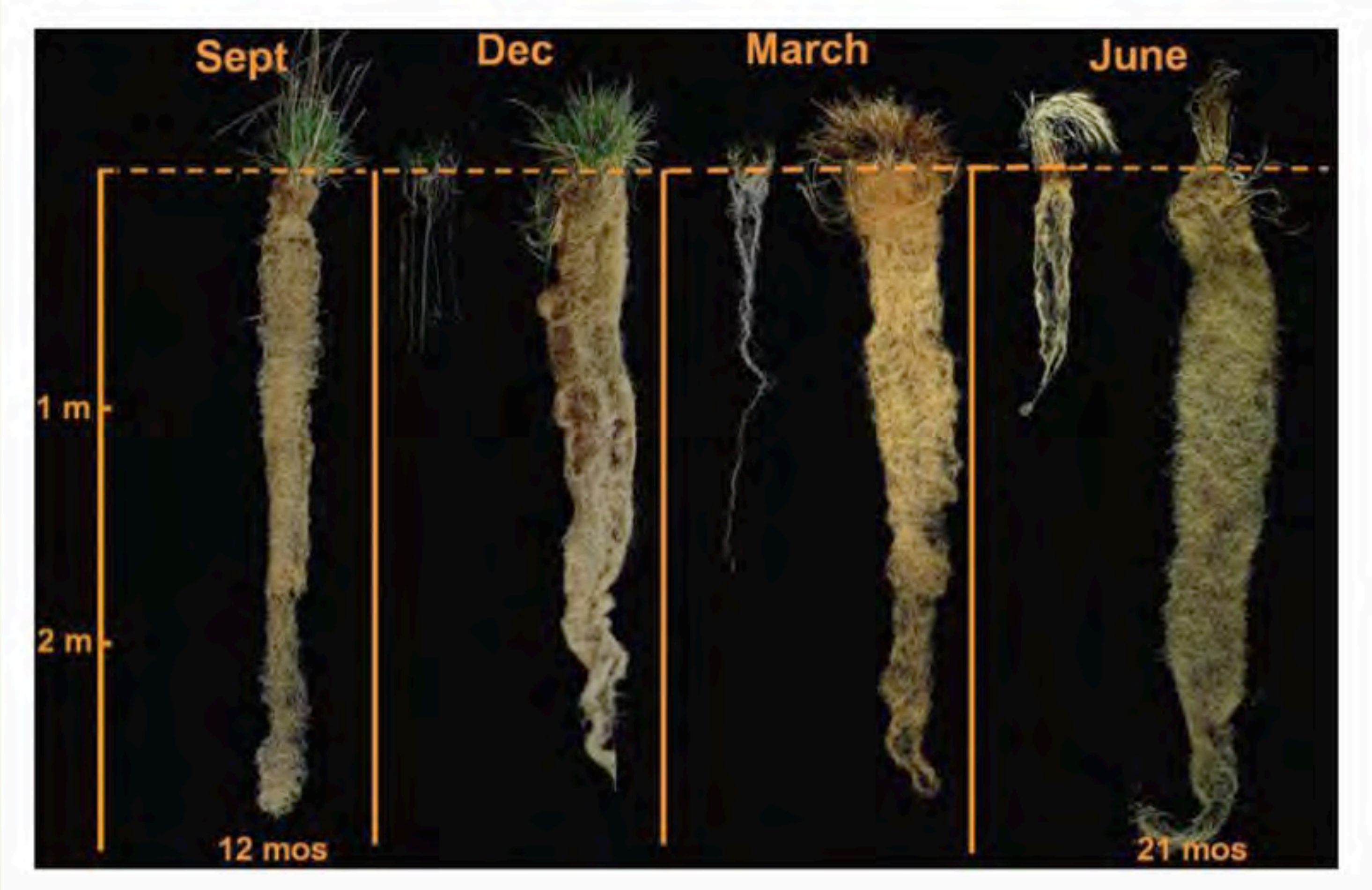
Rooting extent of Intermediate wheatgrass (*Thinopyrum intermedium* or Kernza®) compared to annual winter wheat over four seasons

Perennial



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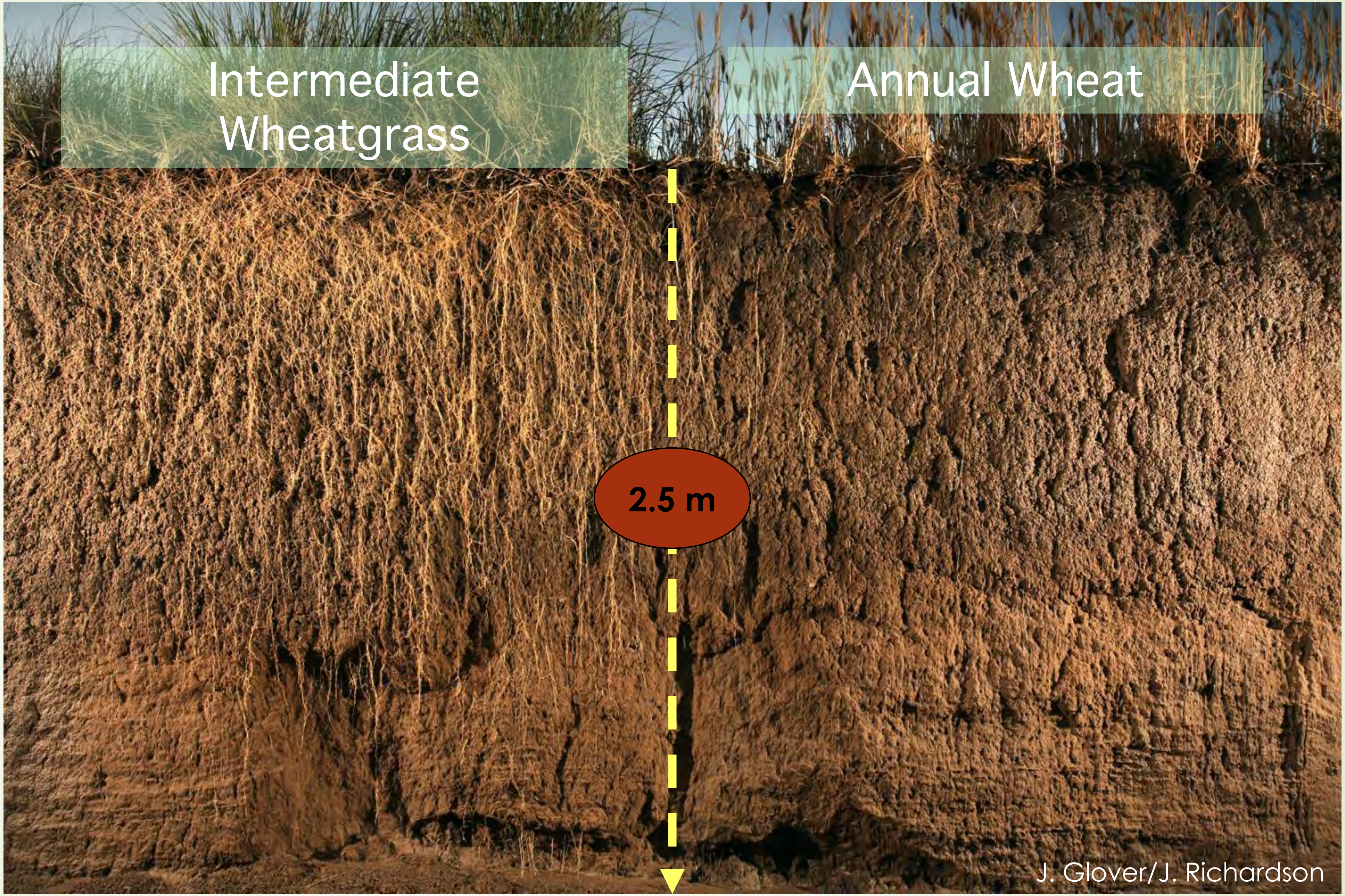
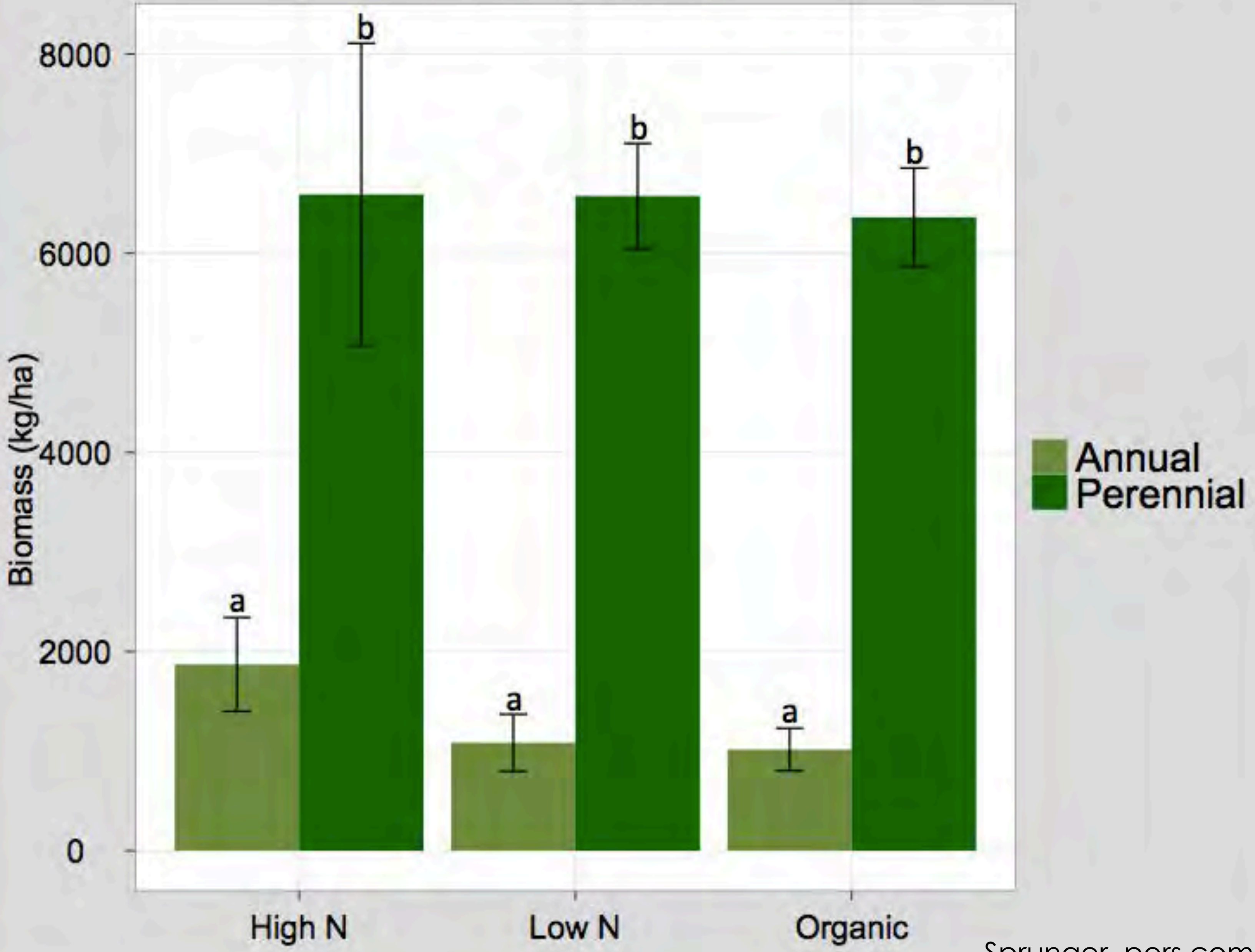
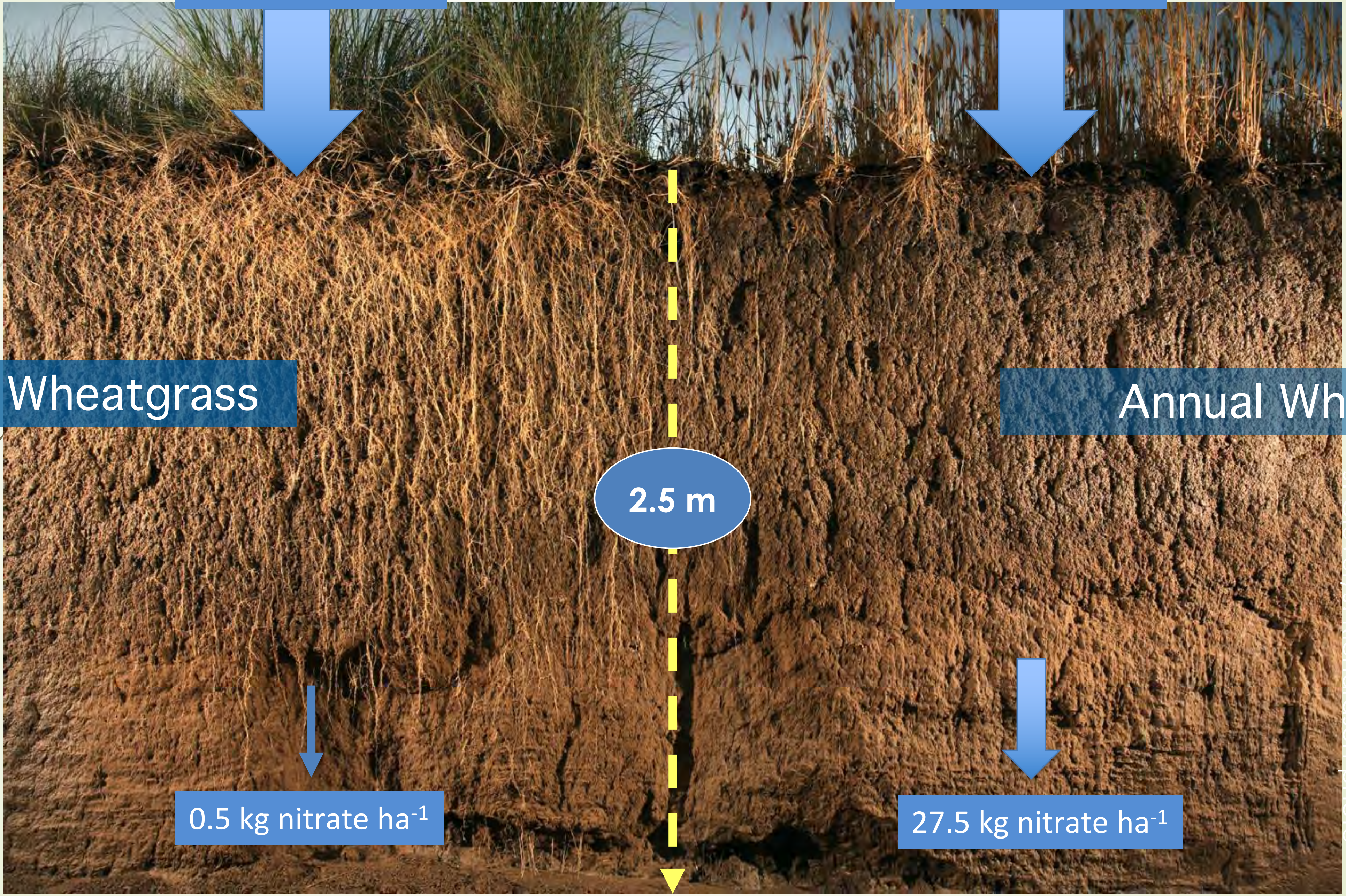

Intermediate Wheatgrass
Annual Wheat
2.5 m
J. Glover/J. Richardson

Total Root Biomass of annual wheat and perennial Kernza



Sprunger, pers com

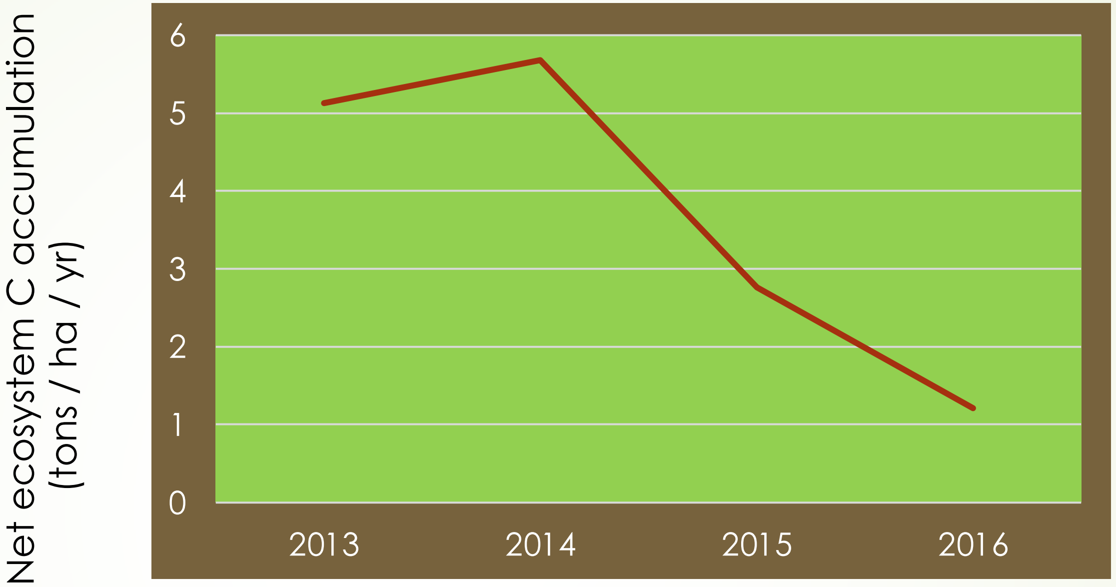
Ecosystem Services: Nitrate Retention



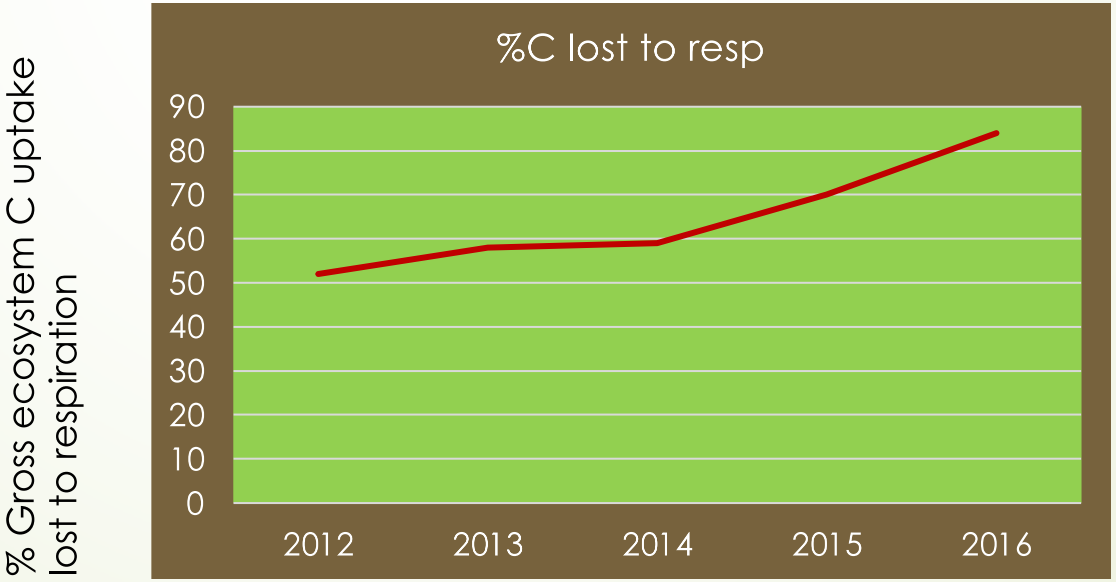
Culman et. al 2013

Ecosystem Services: C sequestration

Ecosystem carbon accumulation and % respiration losses measured in a Kernza (*Thinopyrum intermedium*) field in Salina, Kansas over five years by eddy co-variance



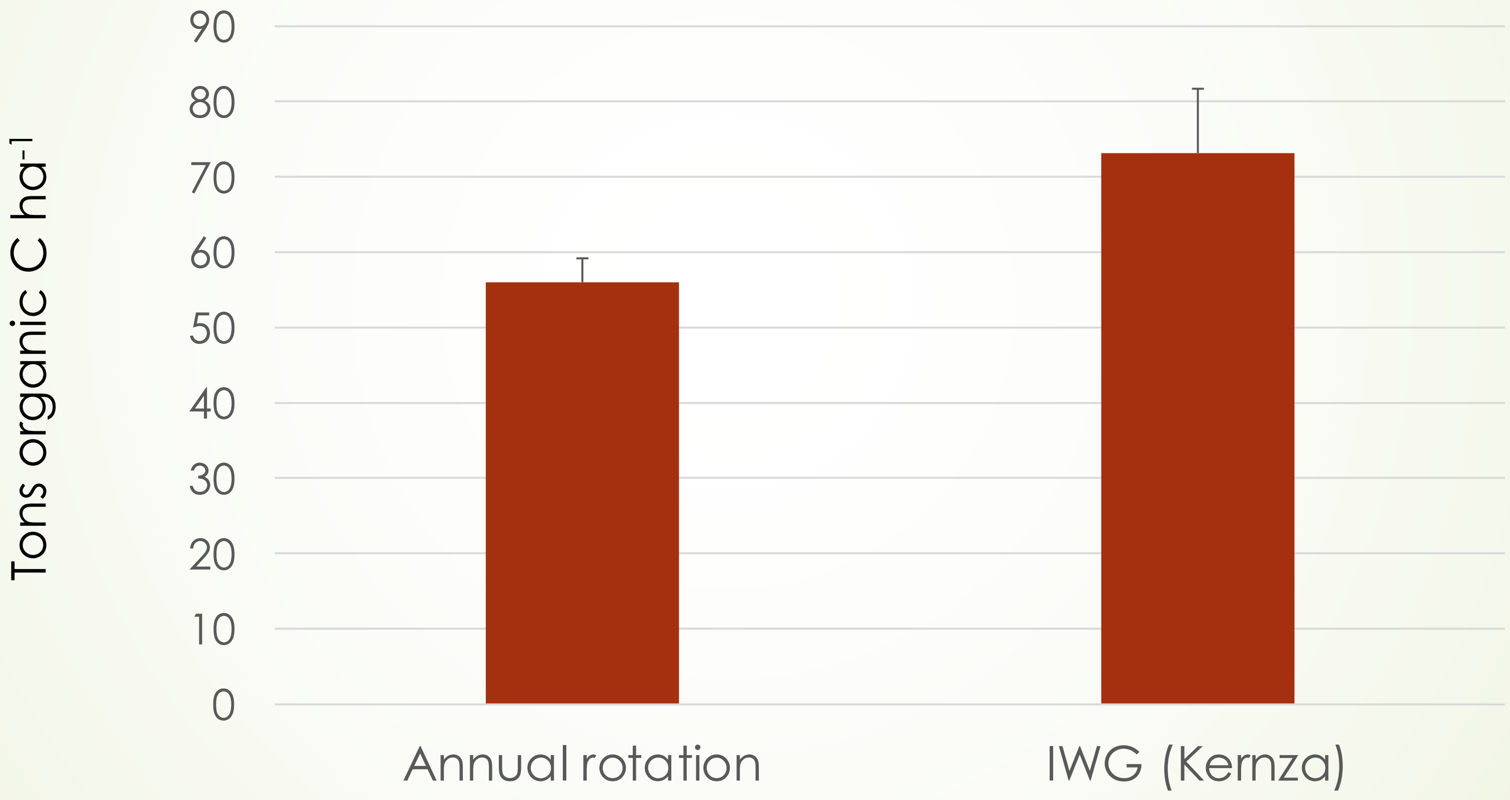
14.7 tons/ha (total)
3.7 tons/ha/yr
Range 5.68-1.21



de Oliveira et al. 2018

Soil Organic Carbon (tons ha^{-1}) After 16 Years of an Annual Crop Rotation (AN), And Perennial Intermediate Wheatgrass (IWG) in a Salina, Kansas Clay Loam

Kernza accumulation rate is 1.06 t yr^{-1} more than annual rotation



Crews, unpublished

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Perennial Kernza-alfalfa biculture plots

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Rob McClement

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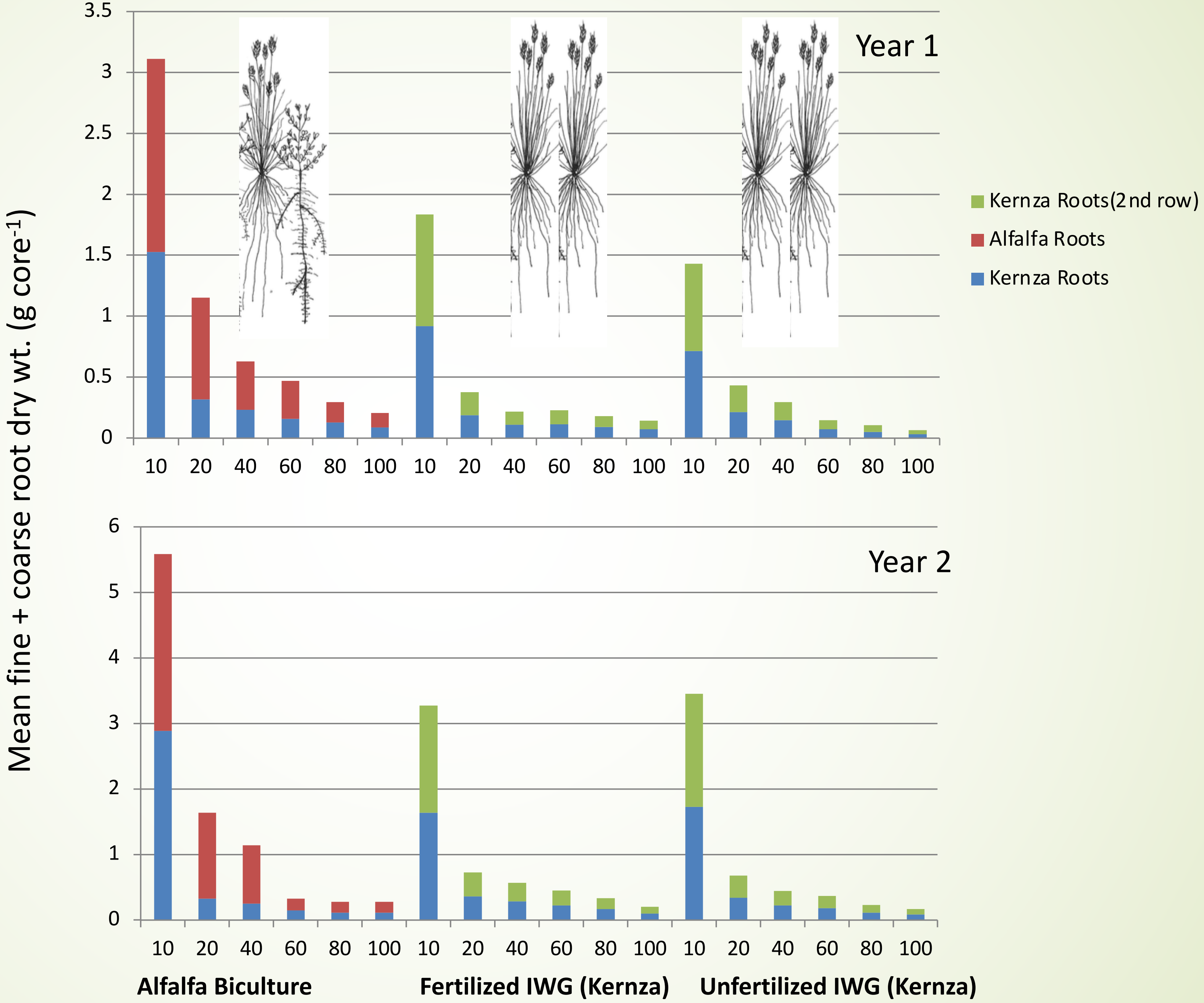
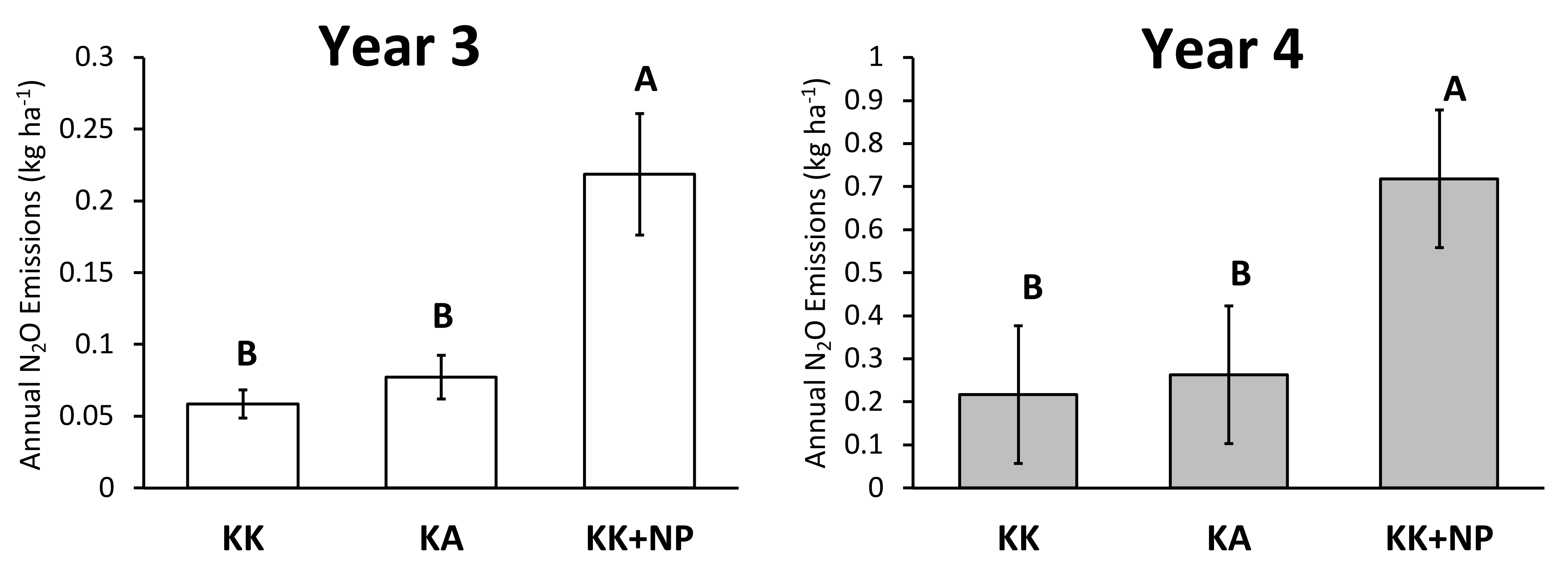
R-Tech Industries Ltd.

Box 27 Homewood MB Canada R0G 0Y0 204 745-3767


Mean fine + coarse root dry wt. (g core-1)
Year 1
Year 2
Kernza Roots(2nd row)
Alfalfa Roots
Kernza Roots
3.5
3
2.5
2
1.5
1
0.5
0
6
5
4
3
2
1
0
10 20 40 60 80 100 10 20 40 60 80 100 10 20 40 60 80 100
Alfalfa Biculture
Fertilized IWG (Kernza)
Unfertilized IWG (Kernza)

N_2O emissions during two growing seasons in unfertilized Kernza-Kernza (KK), Kernza-alfalfa (KA), and fertilized Kernza-Kernza (KK+NP) plots



Research Collaborators

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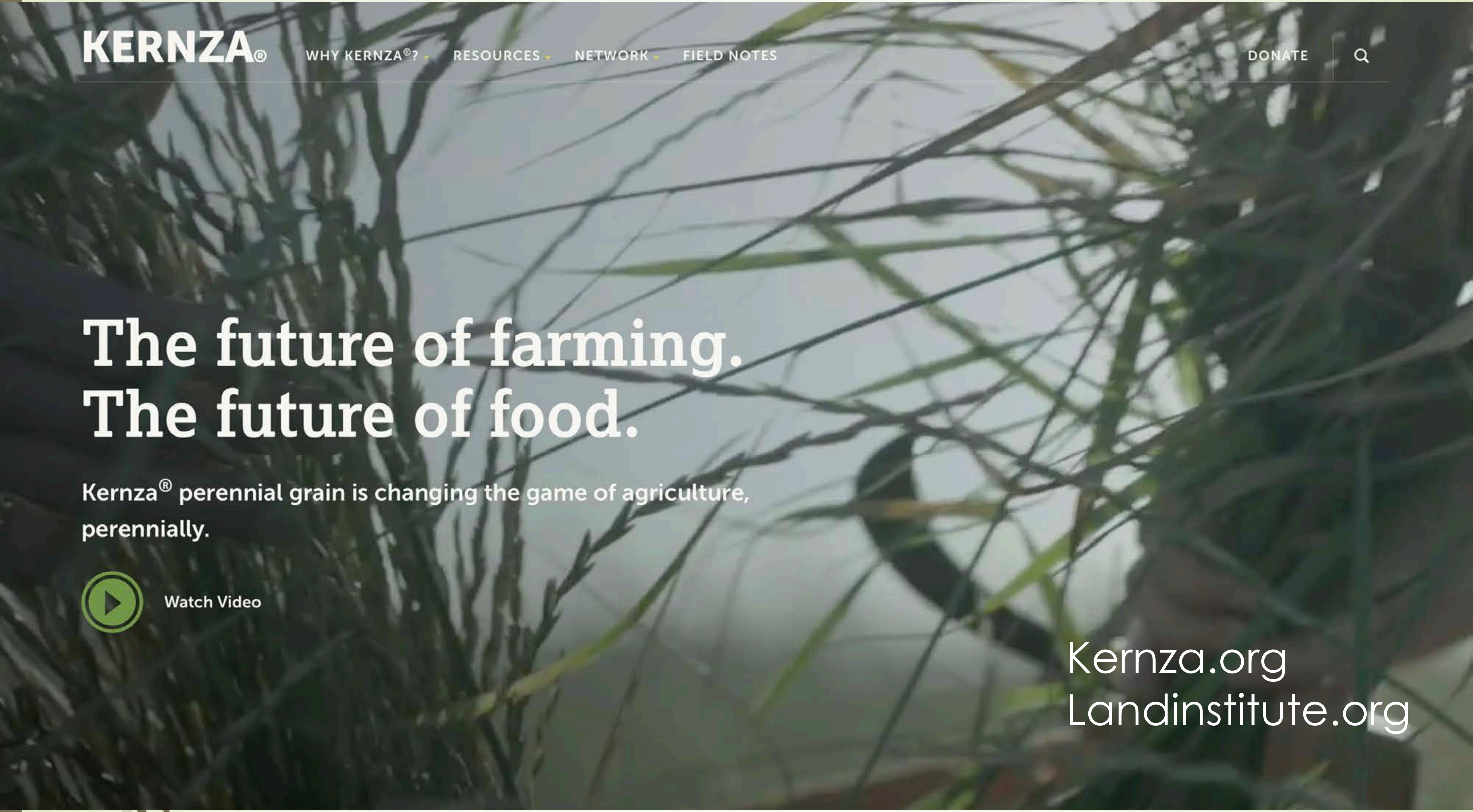
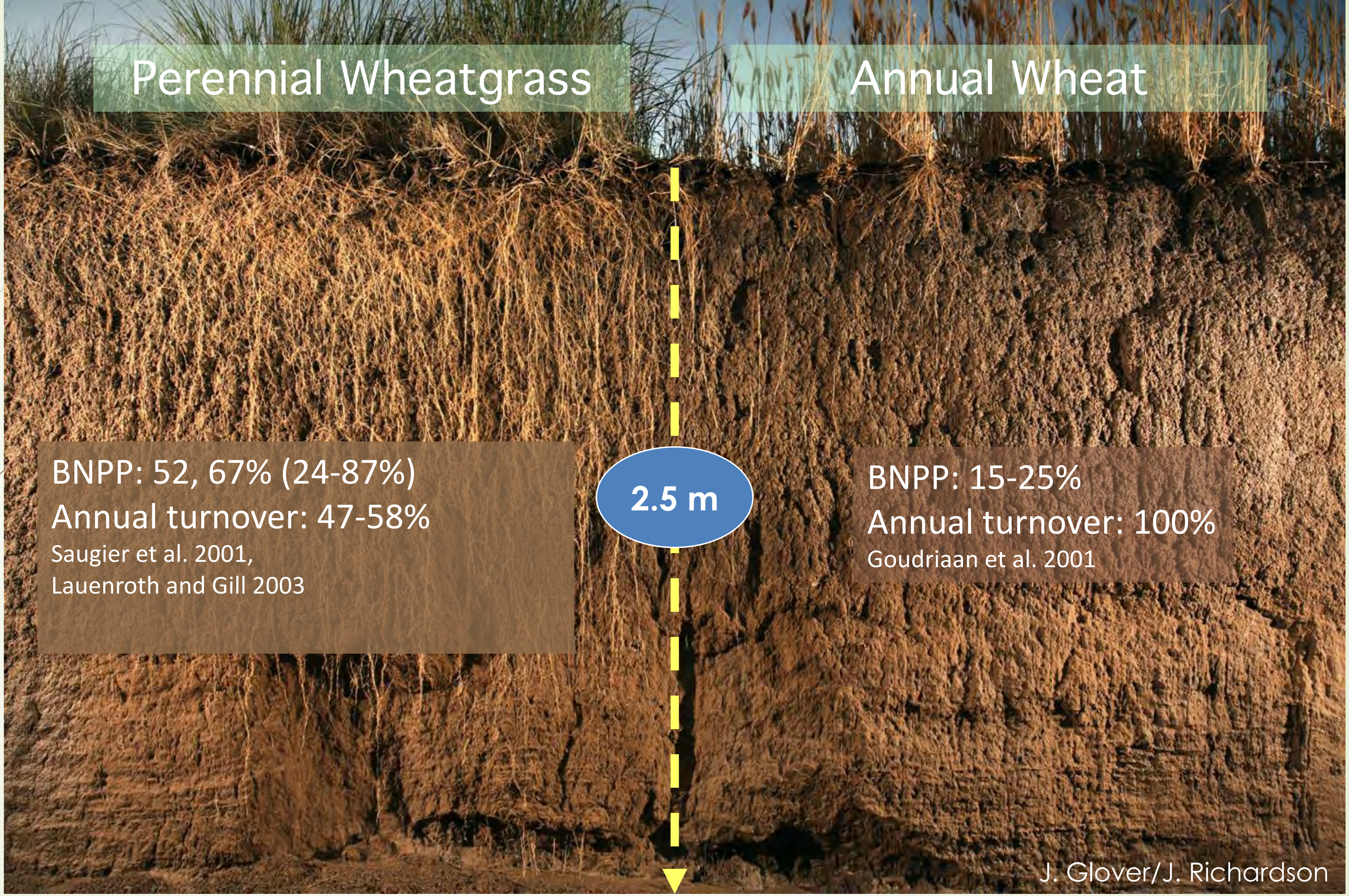

KERNZA®
WHY KERNZA®?
RESOURCES
NETWORK
FIELD NOTES
DONATE
The future of farming.
The future of food.
Kernza® perennial grain is changing the game of agriculture, perennially.
Watch Video
Kernza.org
Landinstitute.org



Belowground Allocation (% of NPP)

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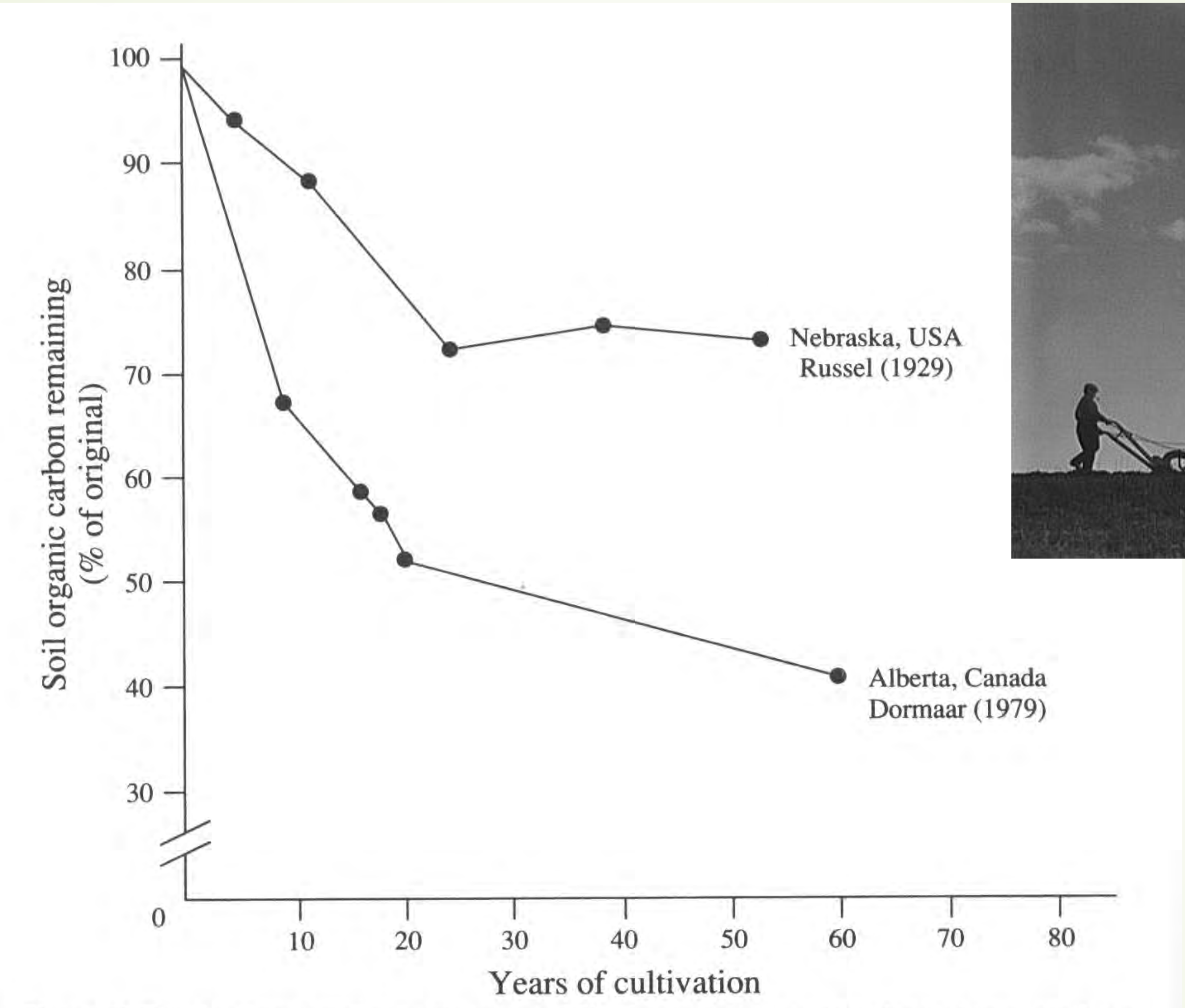

Schlesinger 1986

Loss of soil carbon to the atmosphere with plow conversion of perennial plant communities to annual agriculture.

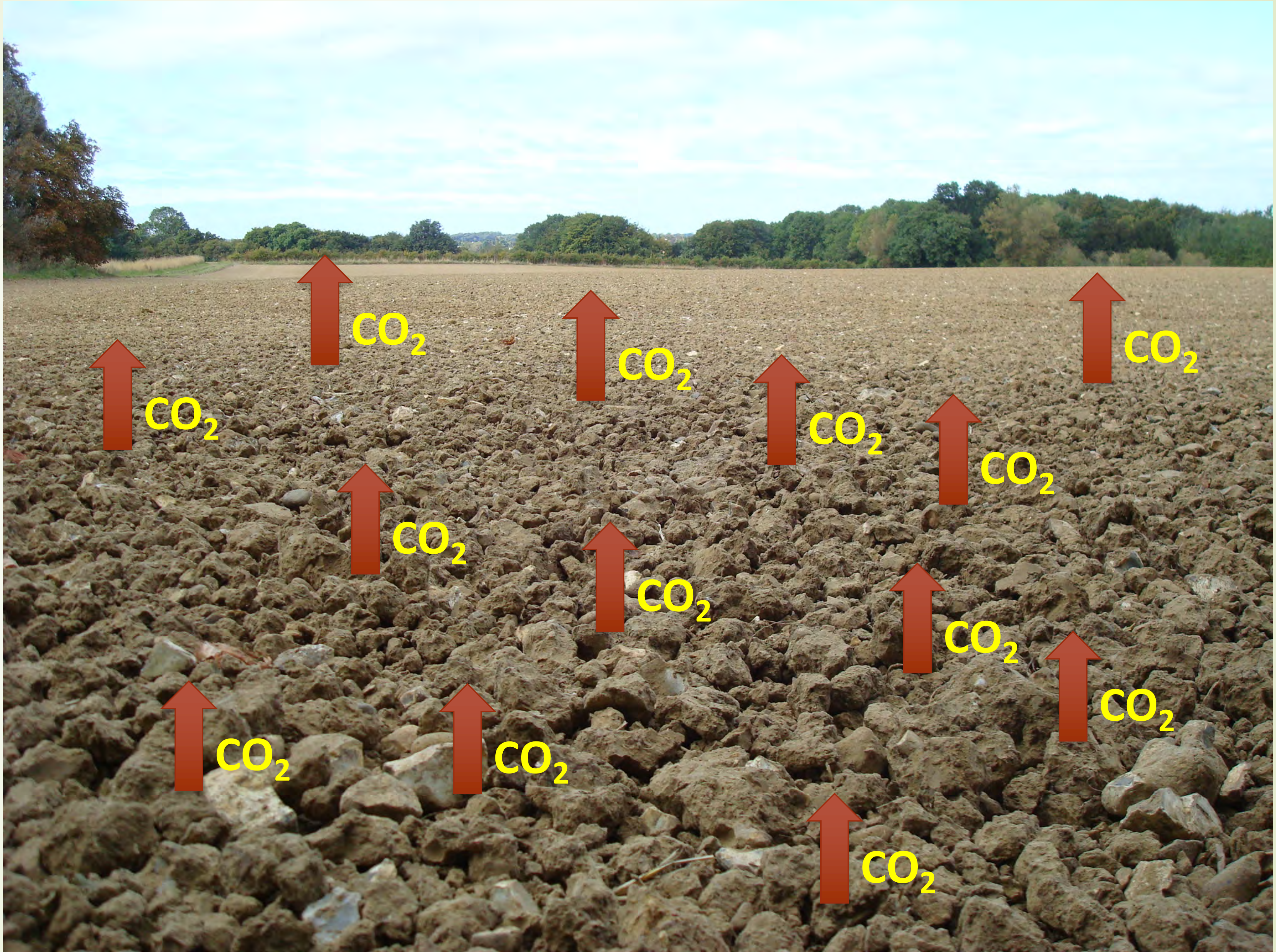

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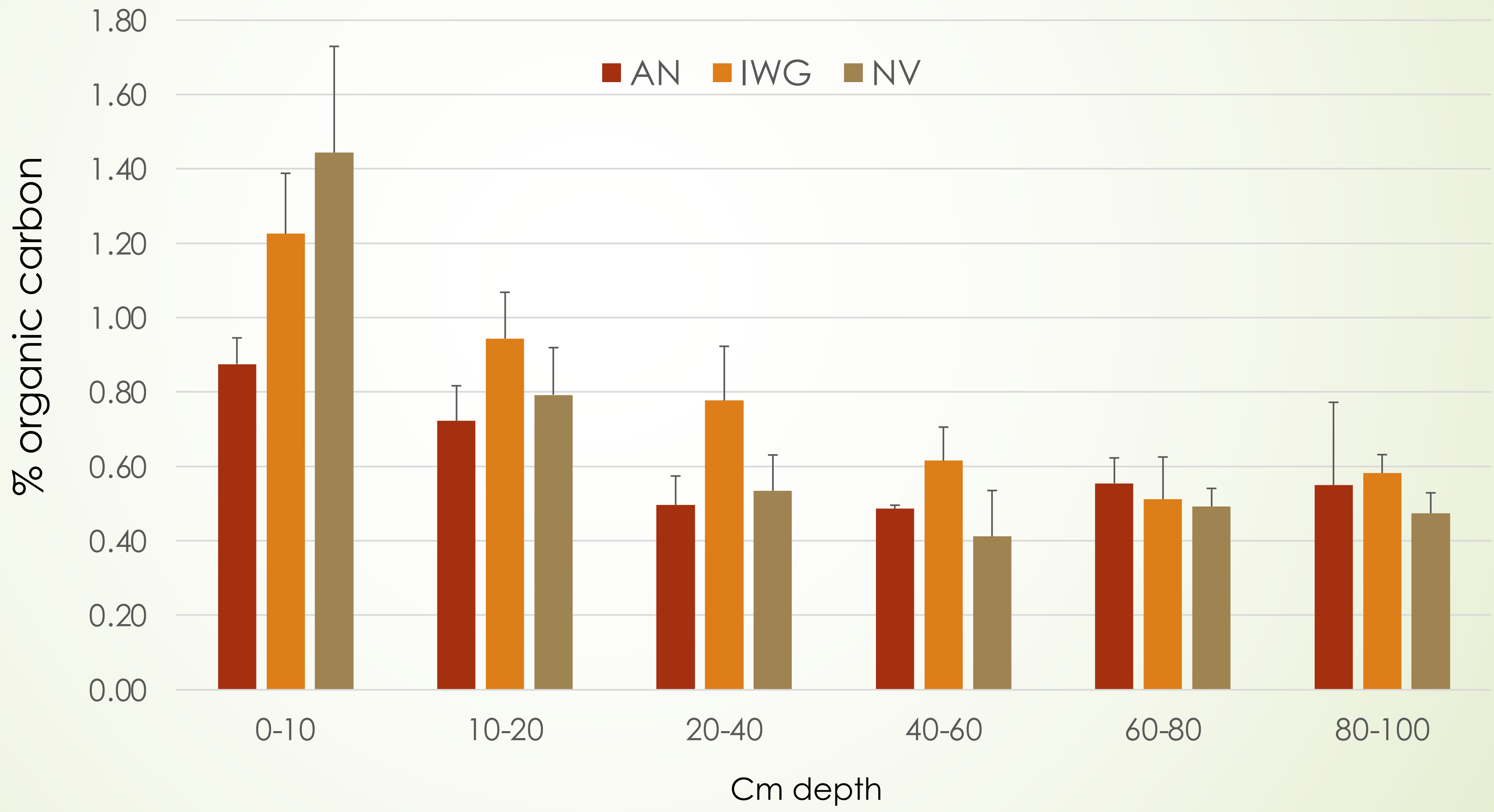
Table 2. Summary of field-based estimations of soil carbon accumulation rates in the conversion of annual agriculture to perennial grassland or perennial bioenergy crops.

Study Type	Geographic Areas	Mean C Accumulation t ha^{-1} $year^{-1}$	Depths [1] Sampled (cm)	No. Studies or Sites Included	Reference
Annual crops to perennial pasture or restored native grassland					
Meta-analysis	Central Europe, N. America, Russia	0.72	0–30	273	[93]
Meta-analysis	Russia	0.96	20	45	[95]
Meta-analysis	Tropical to temperate	0.33	5–300	39	[96]
Meta-analysis	Americas, U.K., Australia	1.01	NR [2]	23	[97]
Review	N. Midwest USA	0.44–0.5	25	39	[98]
Review	W. Canada	0.59	NR	17	[99]
Chronosequences	Illinois, USA	0.43	100	16	[100]
Review	France	0.50	NR	-	[101]
Review	NR	0.3–1.0	NR	-	[102]
Annual crops to perennial bioenergy crops					
Meta-analysis	NR	1.14–1.88	0–150	23	[103]
Meta-analysis	N. & S. America, Europe				
Miscanthus	S. Africa, Asia	1.09	100	13	[89]
Switchgrass		1.28	100	40	[89]

[1] When a range is reported, it indicates that multiple soil depths falling within the range were included in the study;
[2] NR = not reported.

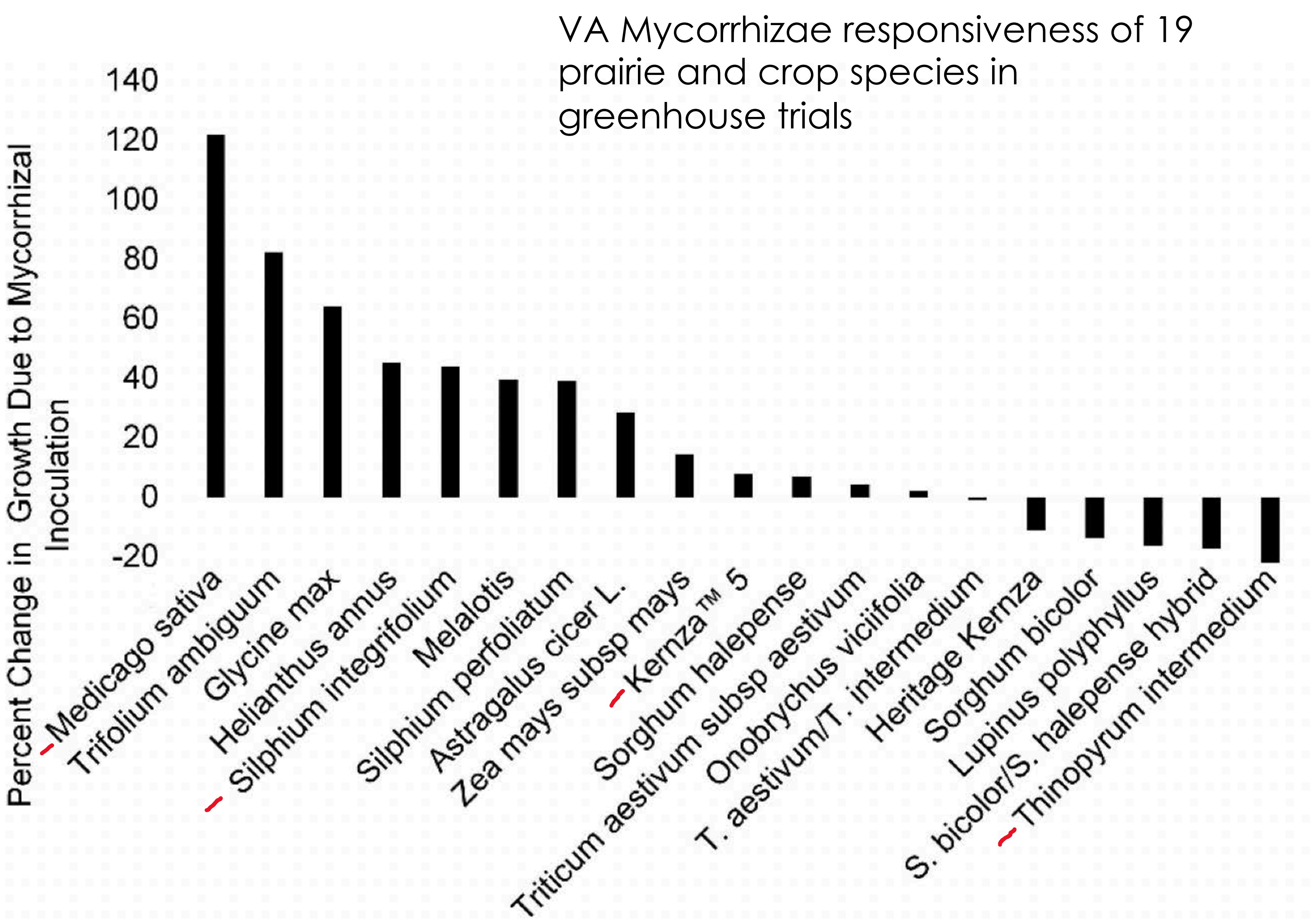
Crews and Rumsey 2017

Percent Soil Organic Carbon Levels After 16 Years of an Annual Crop Rotation (AN), Perennial Intermediate Wheatgrass (IWG) and Diverse Native Perennial Grassland Vegetation (NV)



Error bars = 1 S.E.

Photo: Jim Richardson



Koziol, Crews & Bever 2020

Natural Ecosystem

Perennial-High Diversity

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Soil formation
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No fossil fuel dependence

Agriculture

Annual-Low Diversity

Ecosystem Dis-services

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Perennial-Moderate Diversity

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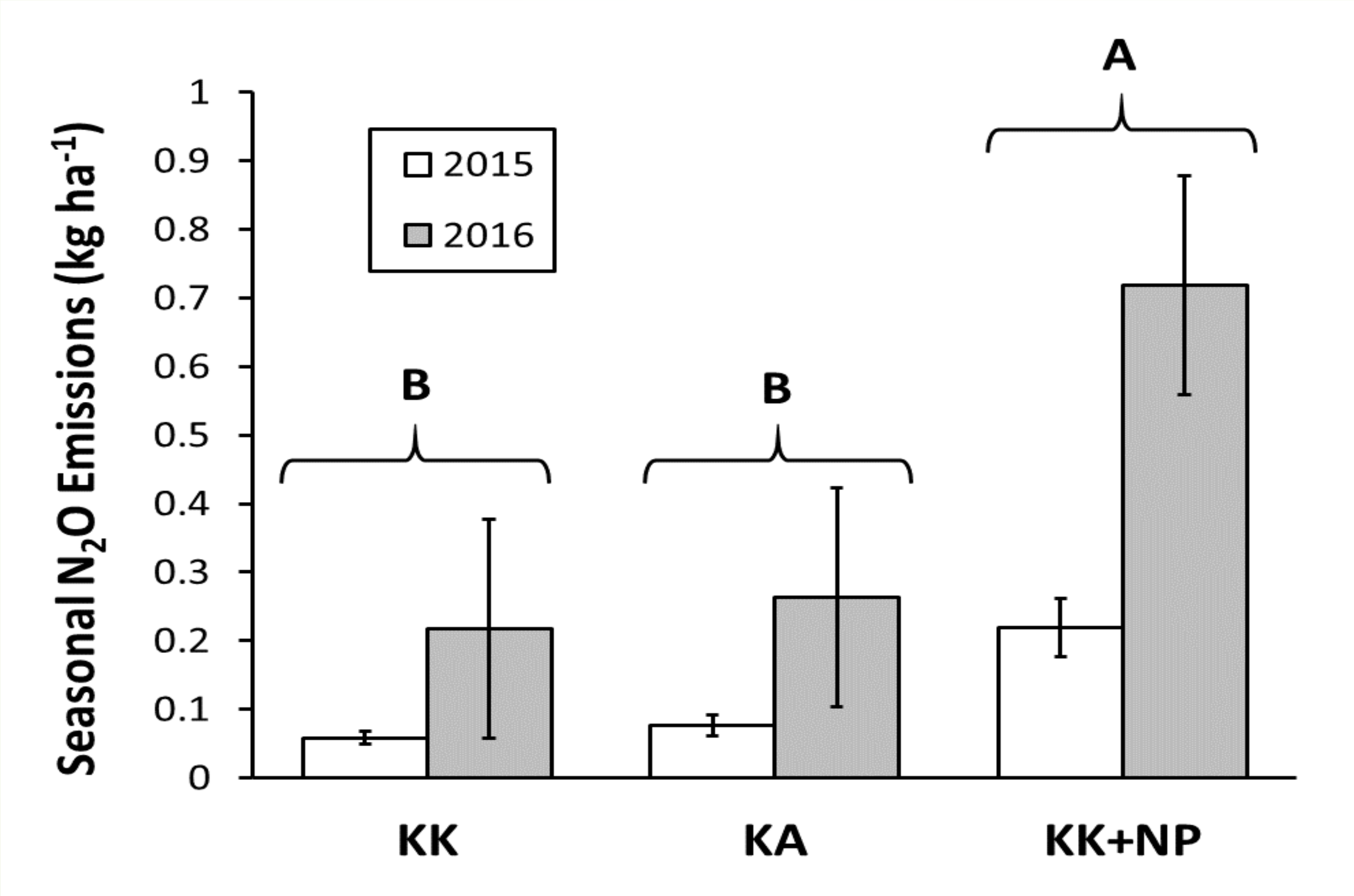
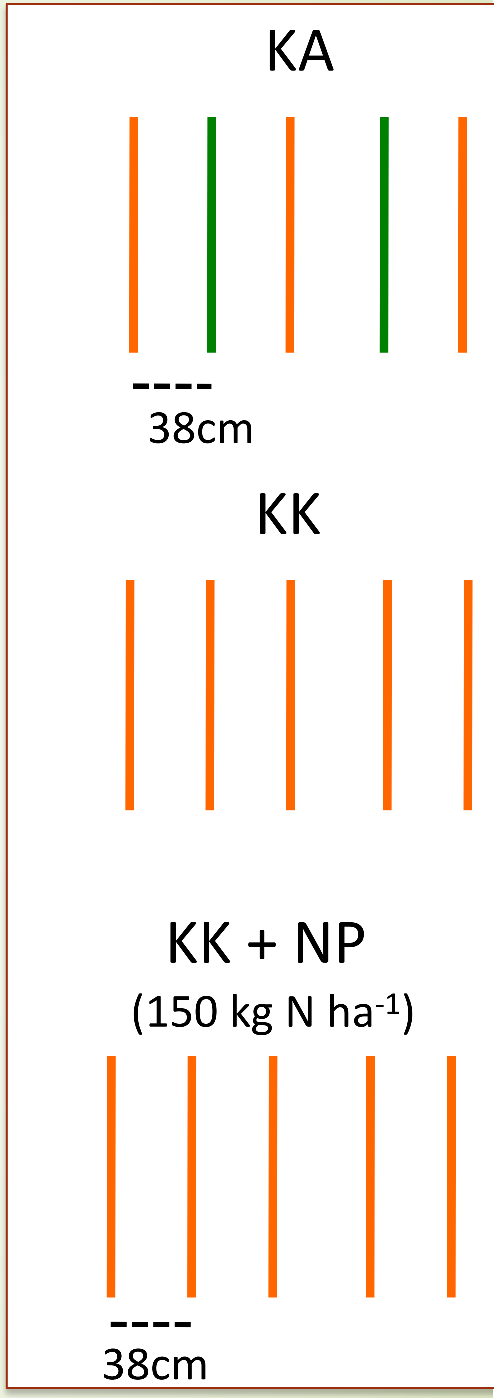
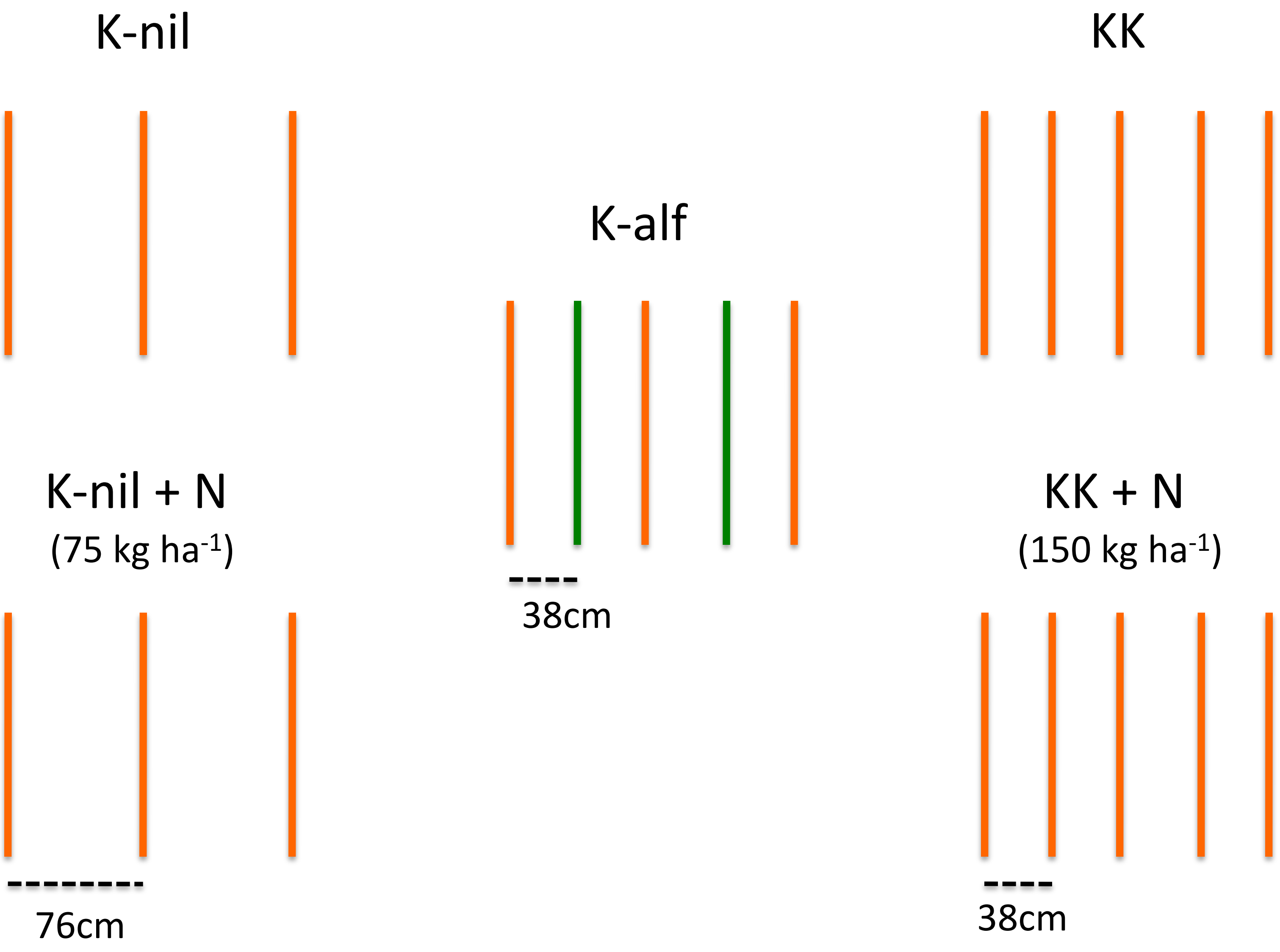
Perennial Kernza-alfalfa biculture plots

N2O emissions during two growing seasons in unfertilized Kernza-Kernza (KK) and Kernza-alfalfa (KA) Plots and fertilized Kernza-Kernza plots

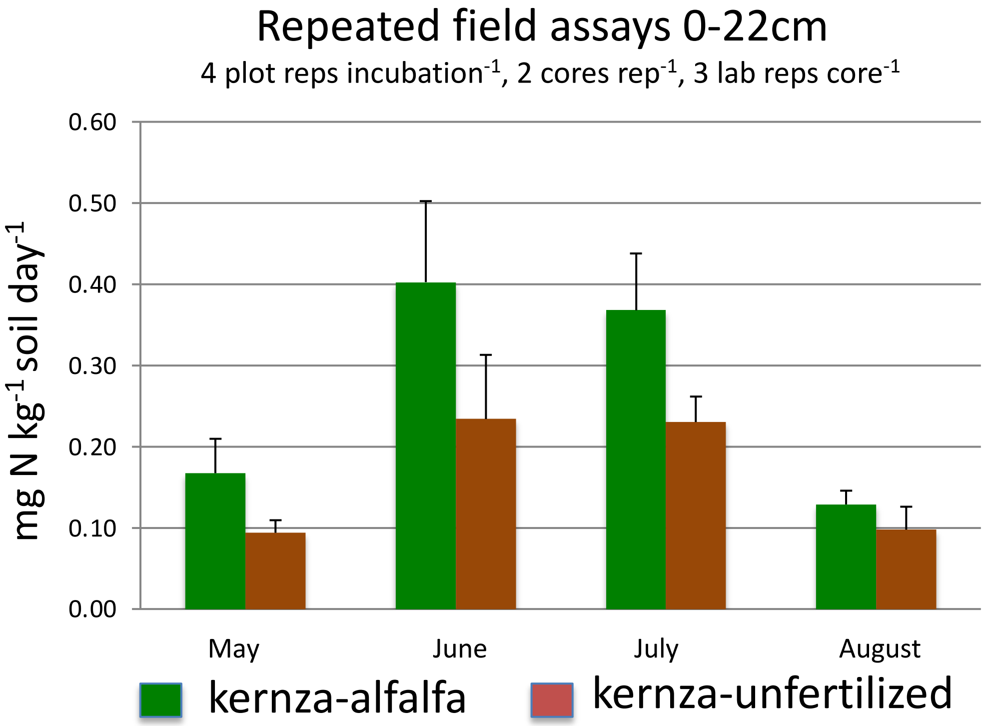


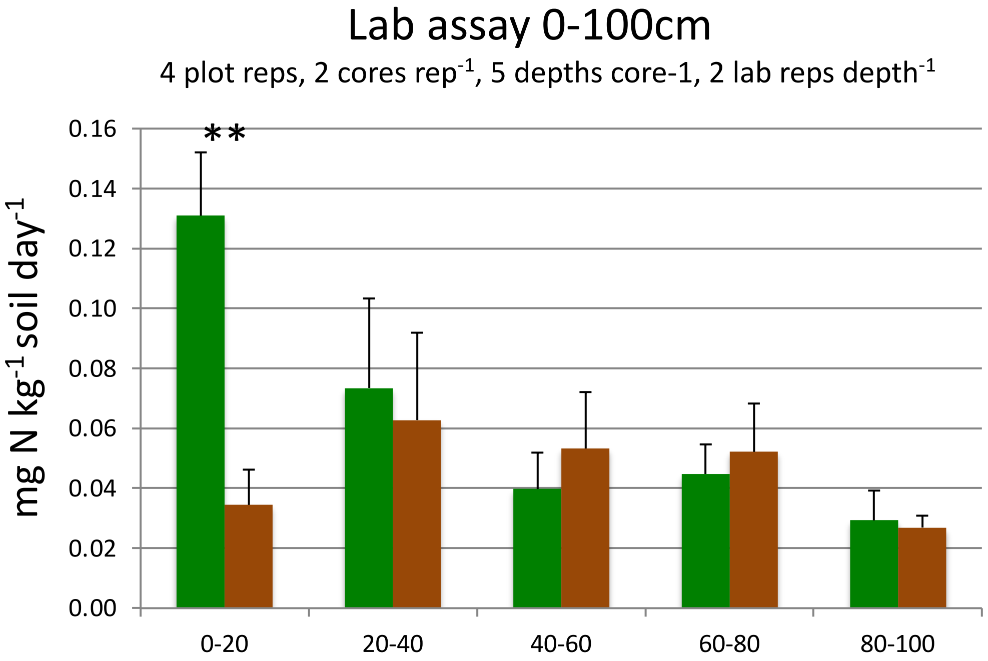


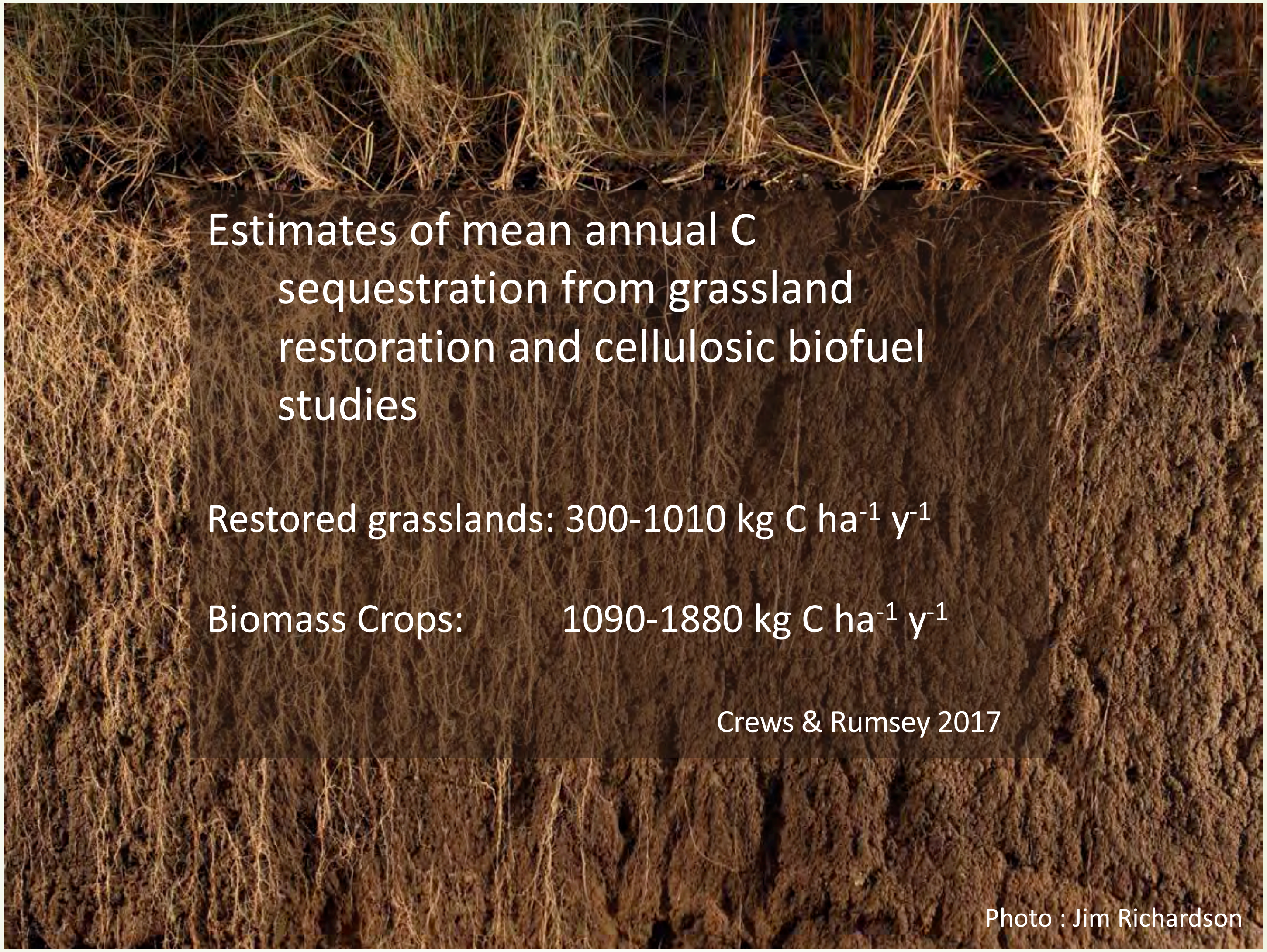
Kernza (K) and Kernza-alfalfa(A) intercrop treatments



Net N mineralization in field and lab soil incubations







Estimates of mean annual C sequestration from grassland restoration and cellulosic biofuel studies

Restored grasslands: 300-1010 kg C ha^{-1} y^{-1}

Biomass Crops: 1090-1880 kg C ha^{-1} y^{-1}

Crews & Rumsey 2017

Photo : Jim Richardson

nparison of wheat (annual) and Kernza (perennial) biomass and grain yi in Michigan