Carbon sequestration and greenhouse gas emissions from soils

Charlotte Decock

Assistant Professor in Soil Health and Fertility

Cal Poly

How much carbon do we find in vineyard soils?

A lot of carbon is stored in vineyards

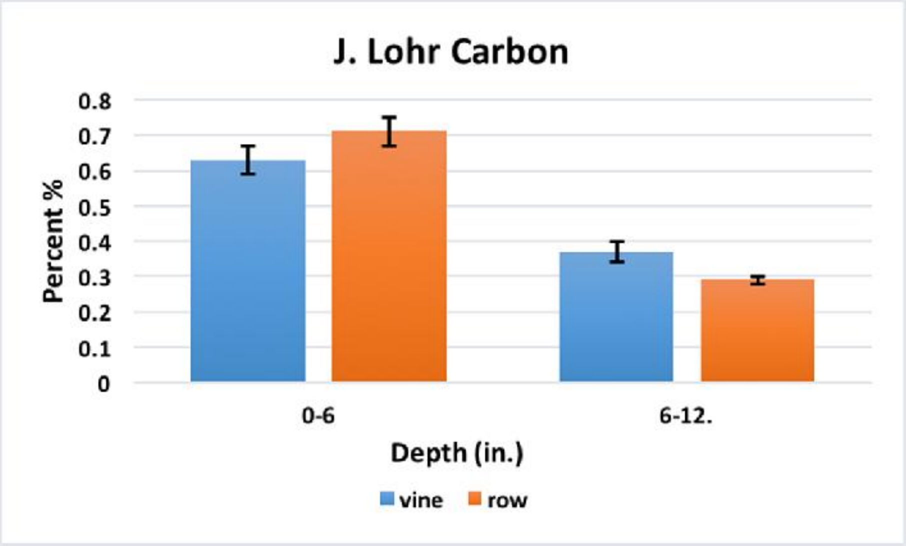
TABLE 4. Estimates of soil carbon at four depths for the total acreage of walnut and almond orchards and wine grape vineyards in California

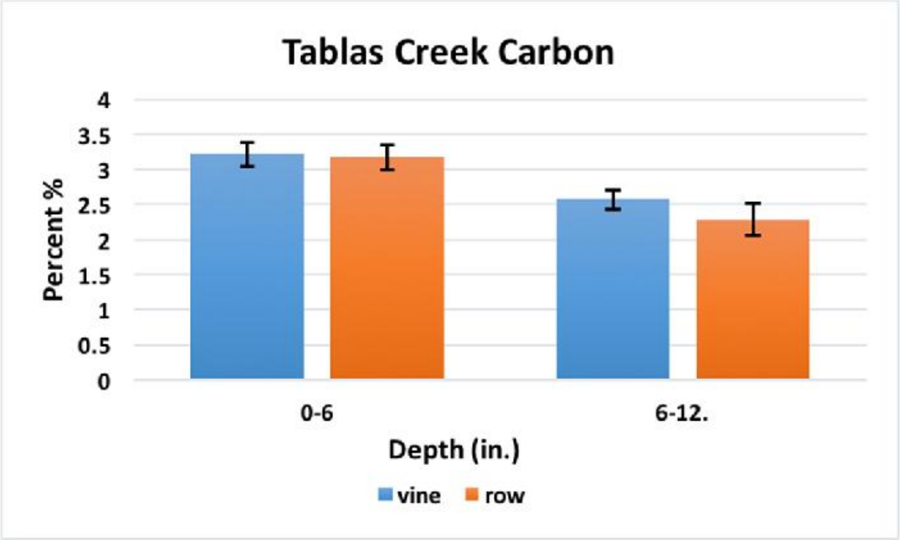
Crop	Estimated acreage	Carbon for total crop acreage at depth			Carbon for total crop acreage at 3.3 ft (1 meter) depth
		0–7.9 in.	7.9–19.7 in.	19.7–39.4 in.	
	× 10^4 *acre*	.... × 10^7 *tons*			× 10^6 *tons*
Walnuts	24.29	2.02	1.75	2.13	5.90
Almonds	74.13	1.62	1.36	2.28	5.25
Wine grapes	52.61	7.23	9.19	8.47	24.89
Total	151.03	10.87	12.30	12.87	36.03

Suddick *et al*. 2013

How much carbon do we find in vineyard soils?

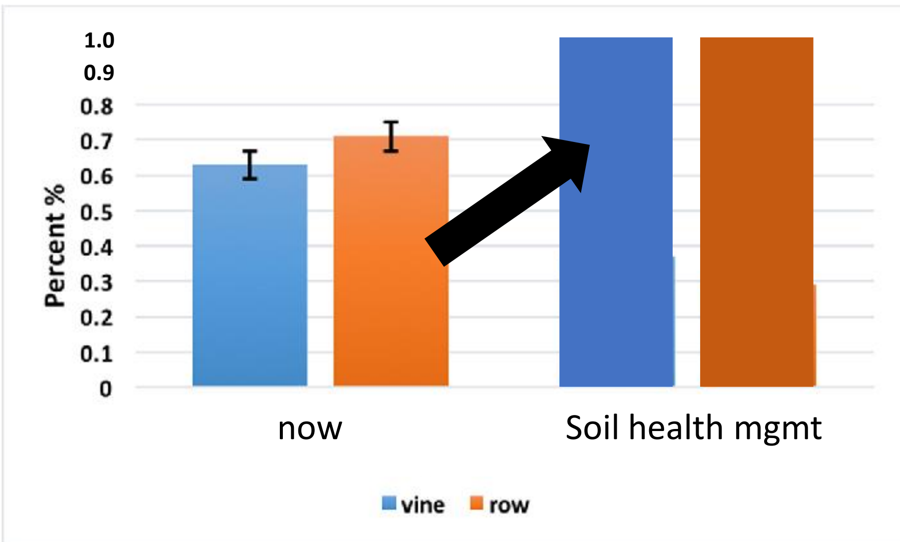
But, it varies from vineyard to vineyard…





The potential role of vineyards in climate change mitigation in SLO county

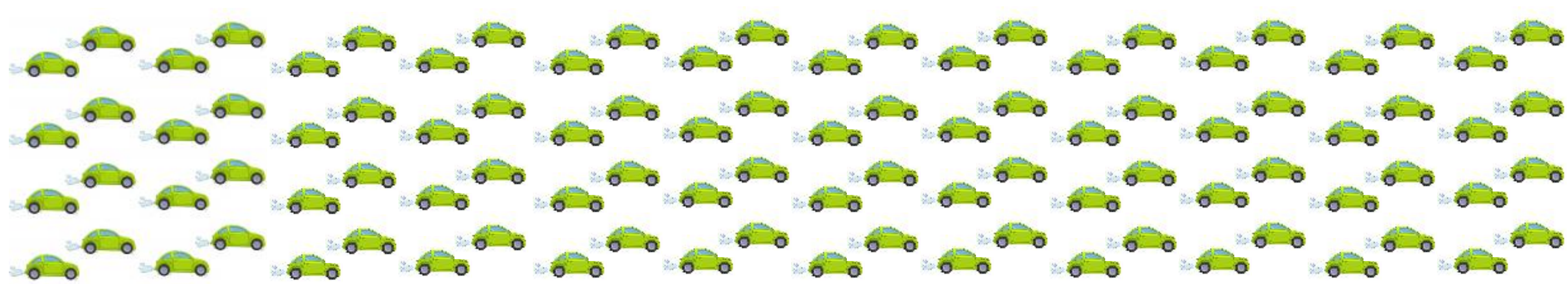
Per acre

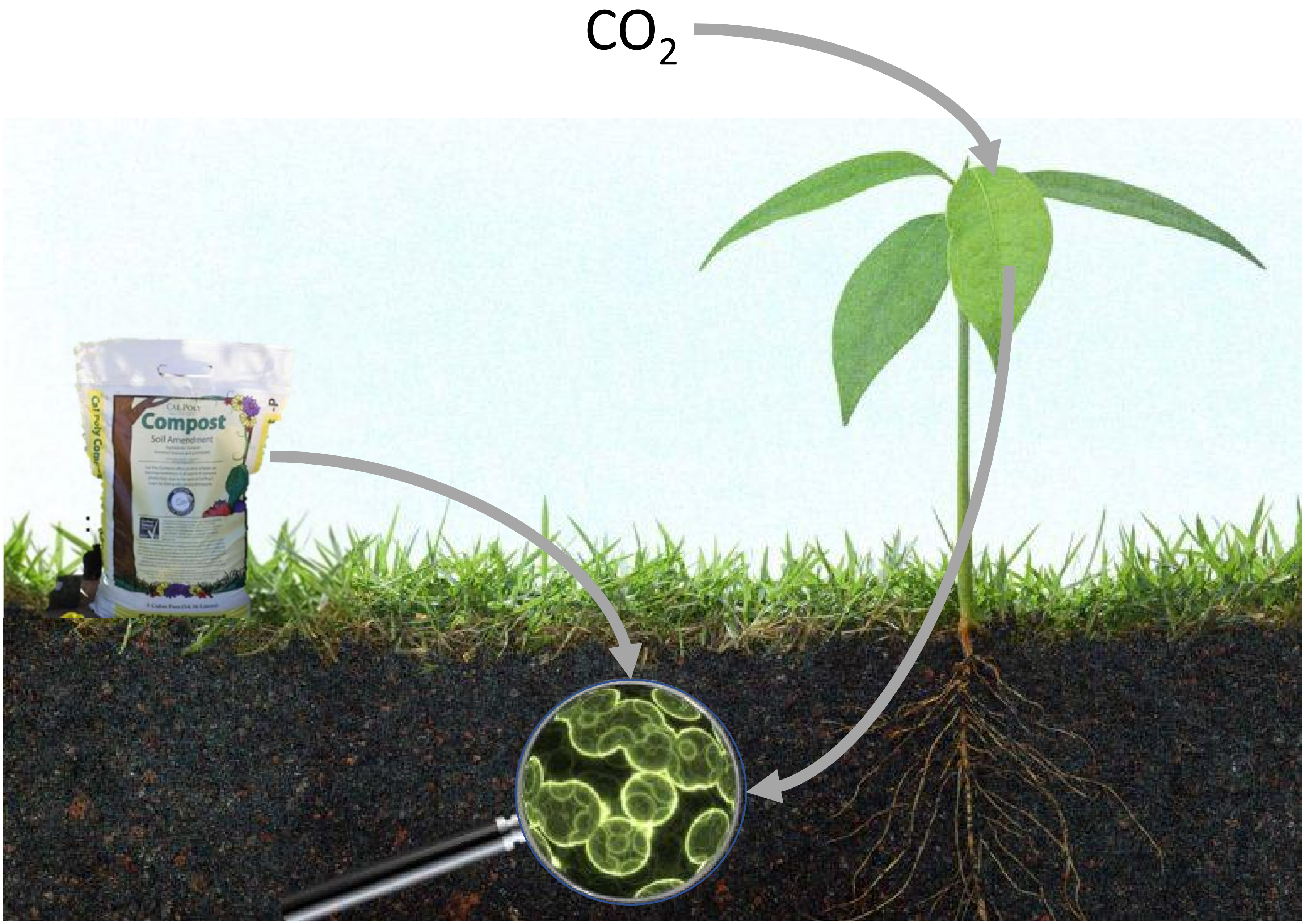


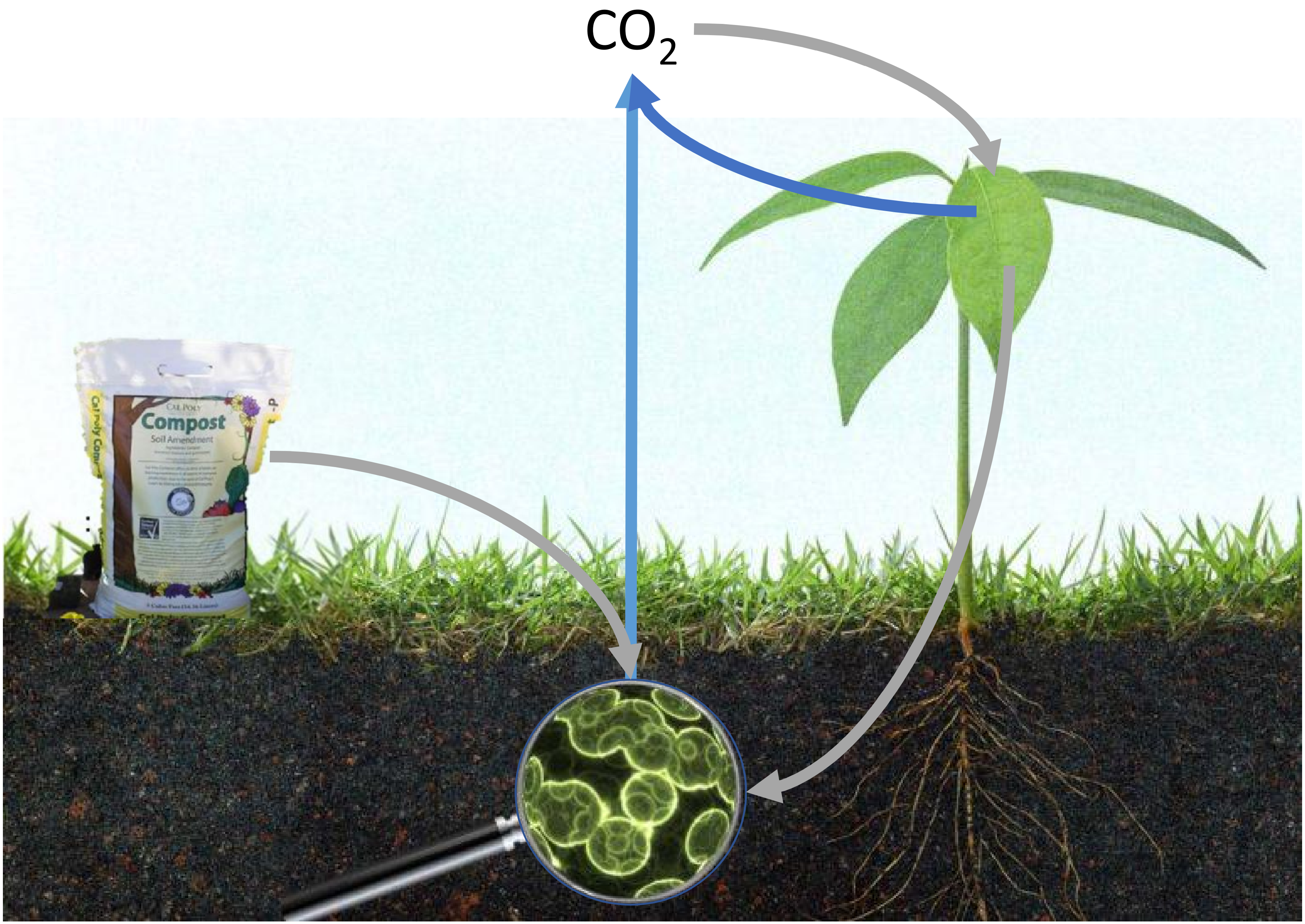
=

If this was accomplished on all vineyards in SLO county

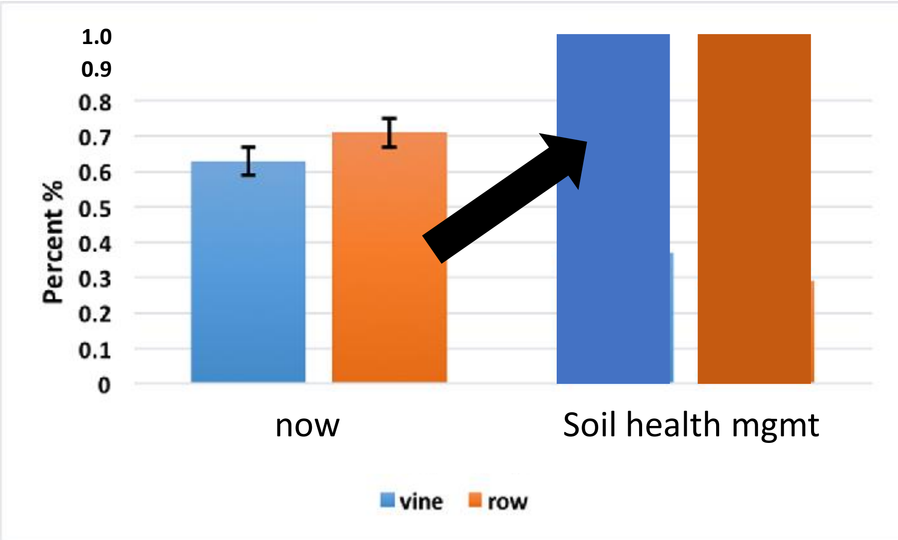
1000 x




CO_2
Compost
Soil Amendment


CO_2
Cal Poly
Compost
Soil Amendment

Carbon input from compost application



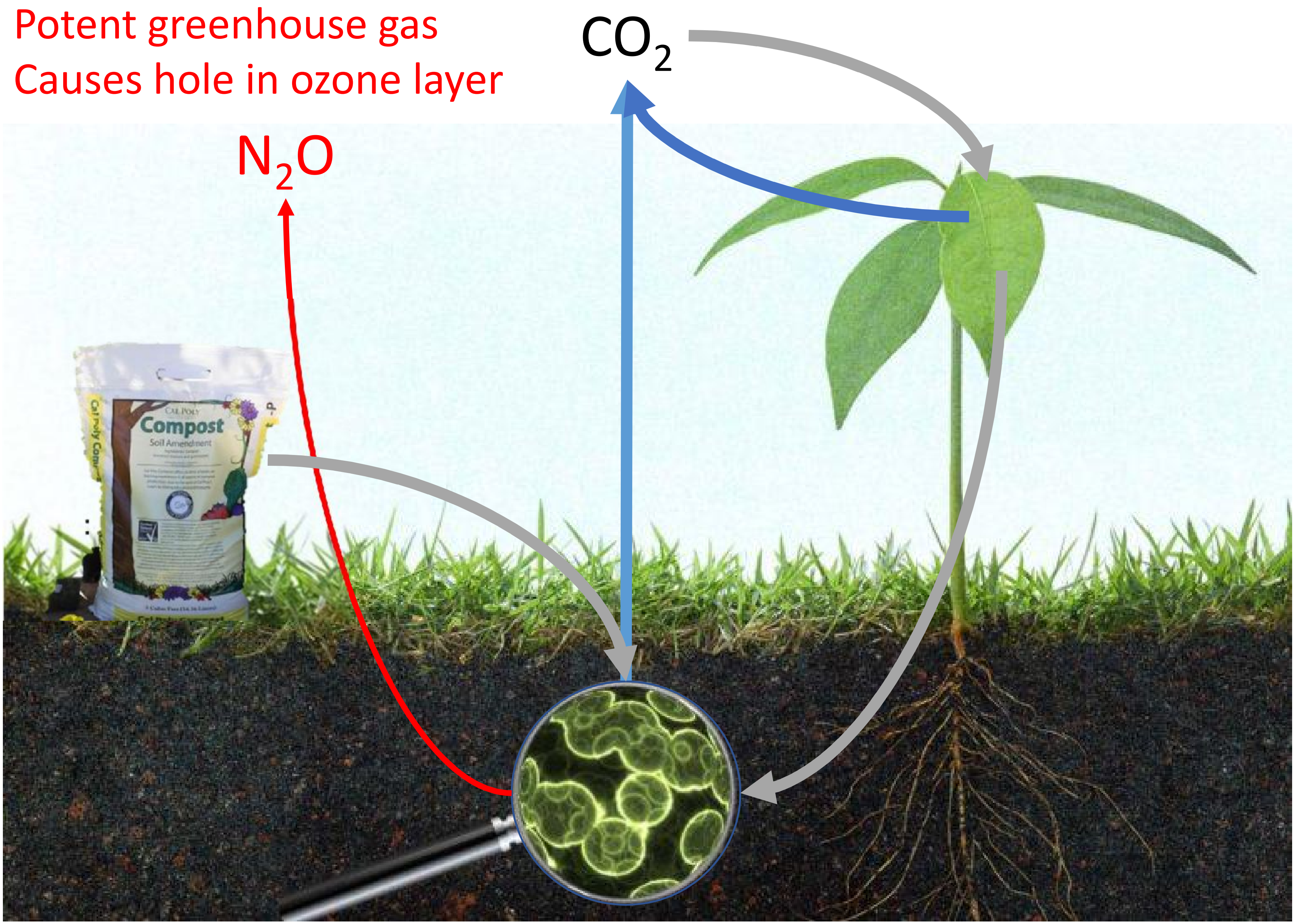
= Approx. 3 tons C

Many years of compost application are required to see such a significant increase in soil C content

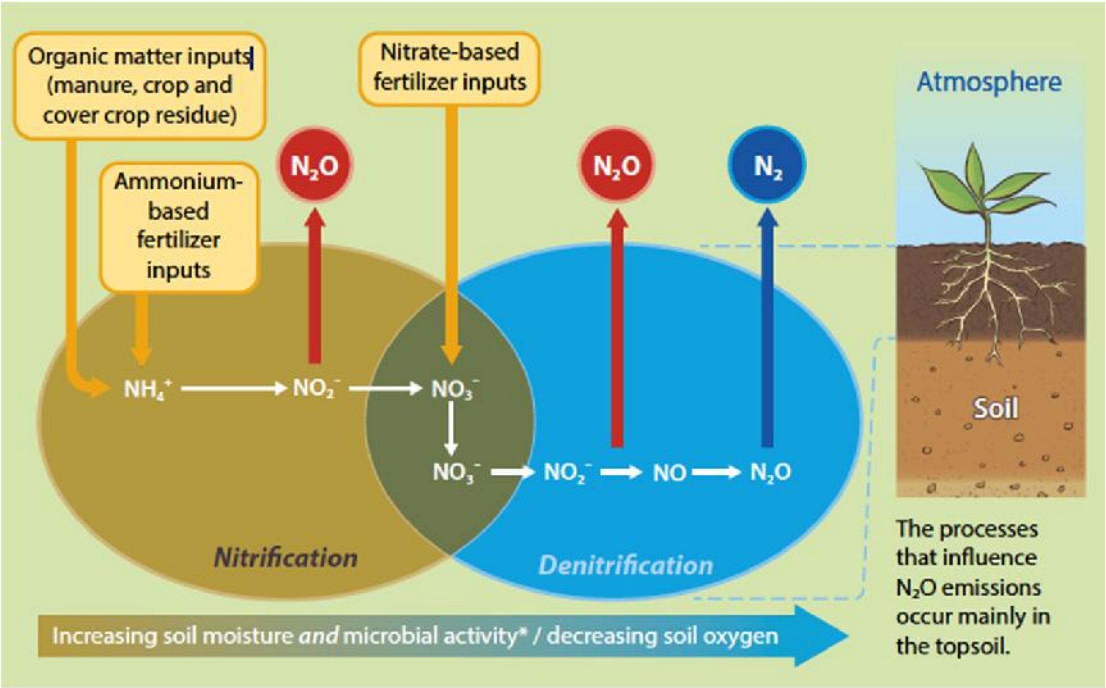
tons compost/acre	tons C/acre added
0	0
2	0.19
4	0.38
6	0.58

How to determine if the soil is actively sequestering C?

- **Total and organic carbon and nitrogen**
  - Indication of carbon stocks
- **Permanganate oxidizable carbon**
  - Indication of active carbon that could likely become sequestered
- **Mineralizable carbon (respiration)**
  - Indication of microbial activity and carbon decomposition
- **Soil aggregate fractionation**
  - Indication of soil structure and protection of carbon in the soil


Potent greenhouse gas
Causes hole in ozone layer
CO_2
N_2O
Compost
Soil Amendment

Drivers of N_2O emissions

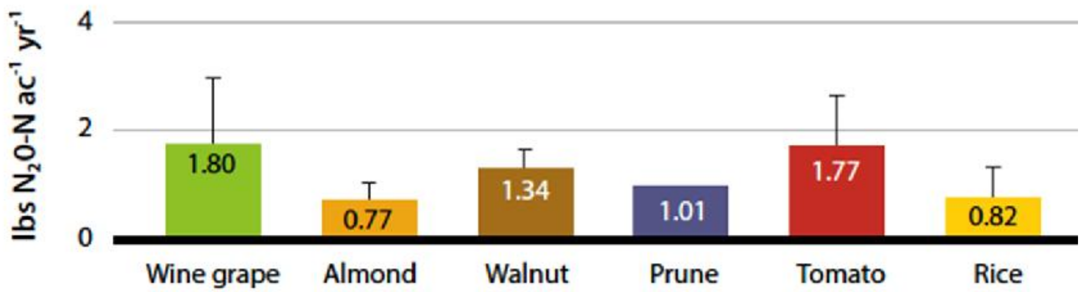


Direct controls on N_2O production	Farm management controls
Soil moisture	Irrigation
Availability of NO_3, NH_4	Fertilizer input, crop N uptake, residue input
Availability of soil carbon	Tillage, residue inputs
Microbial activity	Soil amendments (i.e., compost, manure)
Soil pH	Fertilizer input, soil amendment
Soil temperature	Residue cover

Verhoeven *et al*. 2017

N_2O in California cropping systems

Comparison with other cropping systems

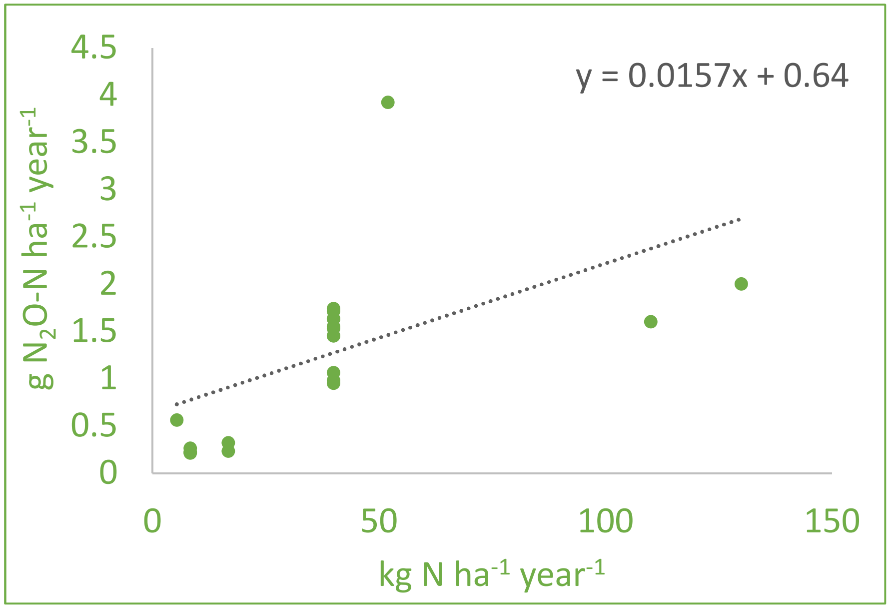


Studies in wine grapes

Study	County	Soil texture class (soil series)	Irrigation method	N application (method)*	Observation†	Annual N_2O emissions (pounds per acre)	Emission factor‡
Garland et al. (2014)	Colusa	Silty clay (Willows)	Surface drip	4.5 (Fg); 42 (cc)	Year 1	3.50 ± 0.50	7.5%
	Colusa	Silty clay (Willows)	Surface drip	5 (Fg)	Year 2	0.50 ± 0.09	10.4%
Verhoeven and Six (2014)	Sacramento	Sandy clay loam (Dierssen)	Surface drip	8.6 (Fg); 107 (cc)	Year 1	1.79 ± 0.17	na¶
	Sacramento	Sandy clay loam (Dierssen)	Surface drip	9.0 (Fg); 121 (cc)	Year 2	1.43 ± 0.50	1.5%
Garland et al. (2011)	Colusa	Silty clay (Willows)	Surface drip	4.5 (Fg)	No till	0.16±0.02§	na
	Colusa	Silty clay (Willows)	Surface drip	4.5 (Fg)	Conv. till	0.11±0.04§	na

Verhoeven *et al*. 2017 Cal Ag

Fg = fertigation; cc = cover crop



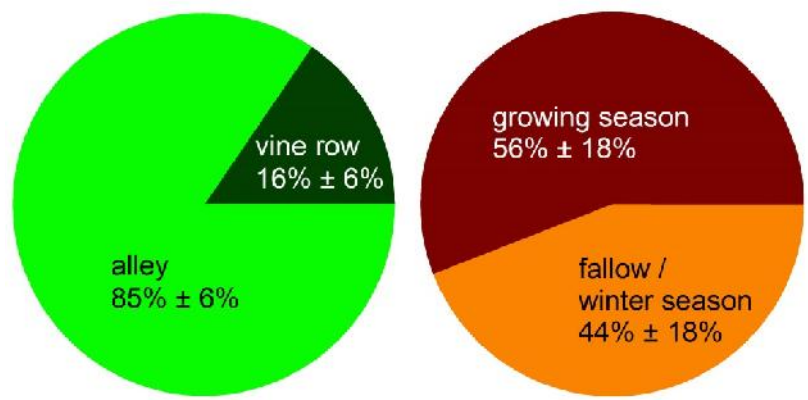
In general, emissions increase with increasing N input rate

IPCC proposed an emission factor (EF) of 1%, meaning that 1% of fertilizer N applied is emitted as N_2O

There is a lot of variability in EFs between vineyards

N_2O emissions occur in both the growing and the dormant season

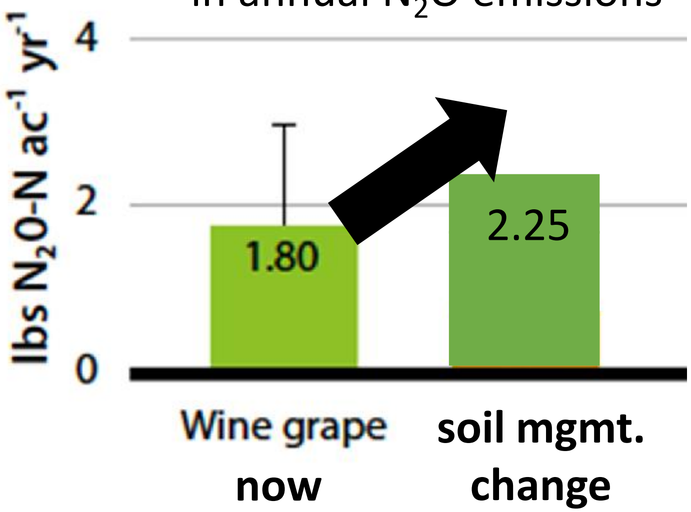
A large portion of emissions comes from the alley => alley management is important



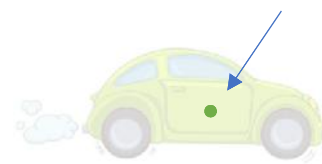
Potential effects on GHG budget

N_2O has a global warming potential **298 times** the global warming potential of CO_2

Assuming a 25% increase in annual N_2O emissions



Small emissions <u>per acre per year</u>;



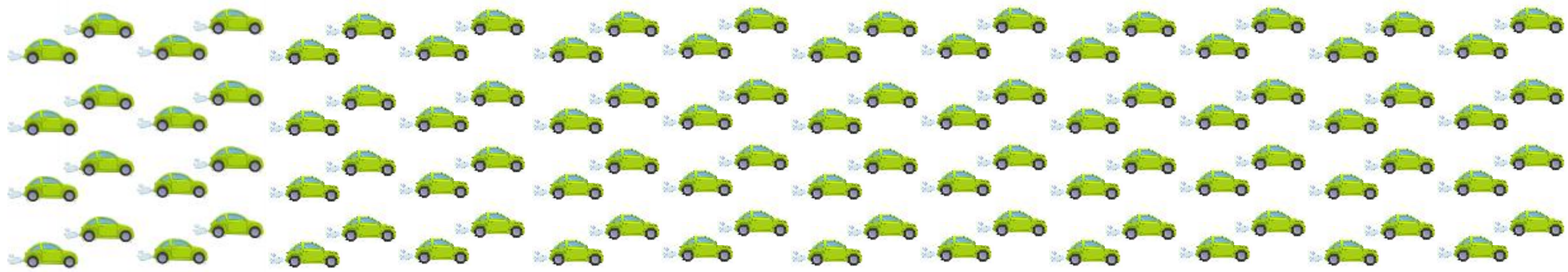
BUT

Effect of building soil carbon could be negated after many years of enhanced N_2O emissions

Hypothetical budget for SLO county vineyards

If soil organic carbon in the topsoil was increased by 0.3 %-units on all vineyards over the course of 10 years

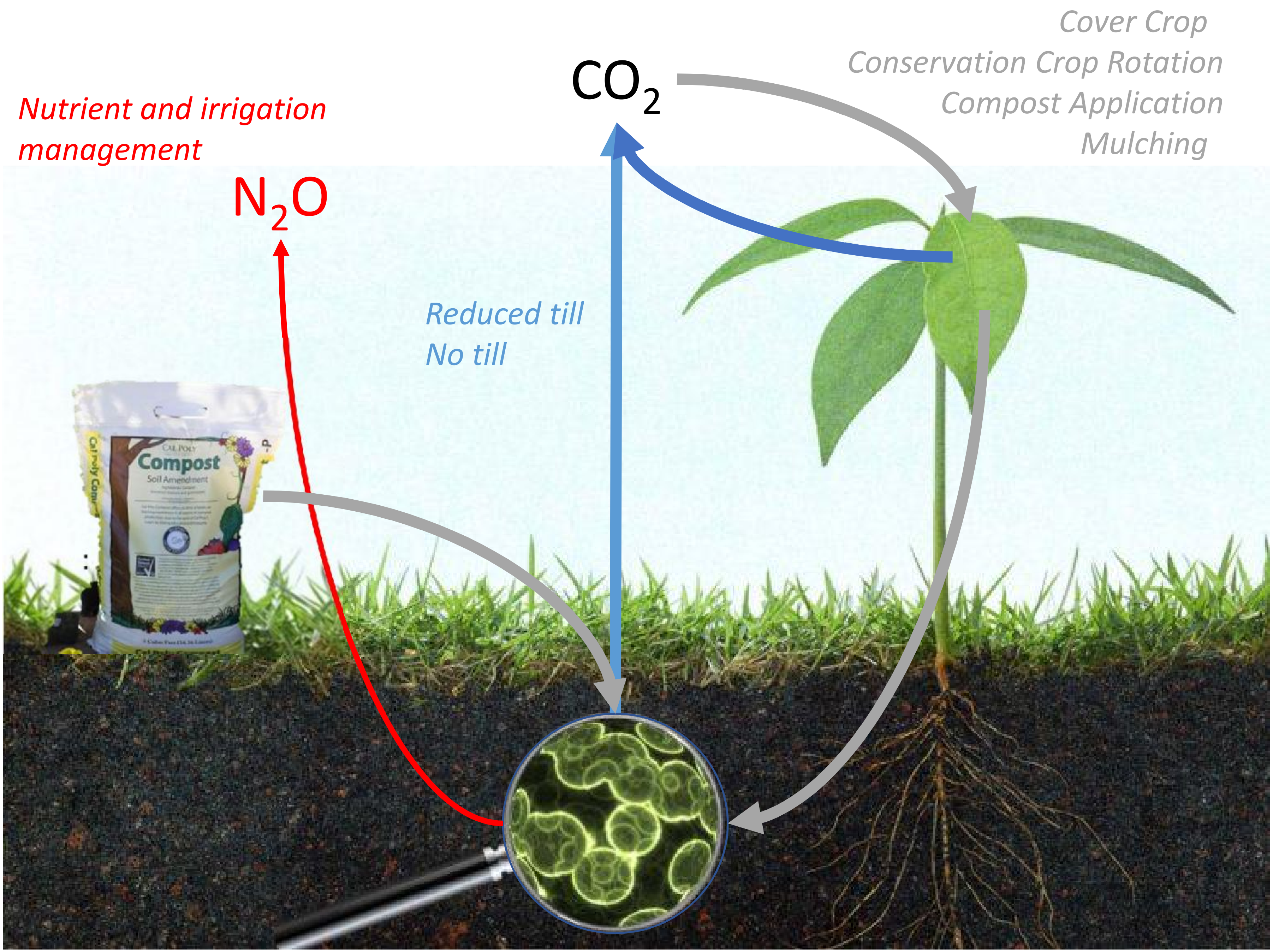
1000 x



*If the increase in soil organic carbon caused in increase in annual N_2O emissions by 25% over these **10 years***

– 1000 x

= annual emissions of 88 000 cars sequestered



Cover Crop
Conservation Crop Rotation
Compost Application
Mulching
CO_2
Nutrient and irrigation management
N_2O
Reduced till
No till
Compost
Soil Amendment

Conclusions

To reduce greenhouse gas emissions from agricultural soils, a **long-term commitment** to soil health management is essential

An updated list of eligible practices to reduce greenhouse gas emissions from soil is available at this workshop