Biosolids as a tool in soil conservation and carbon sequestration

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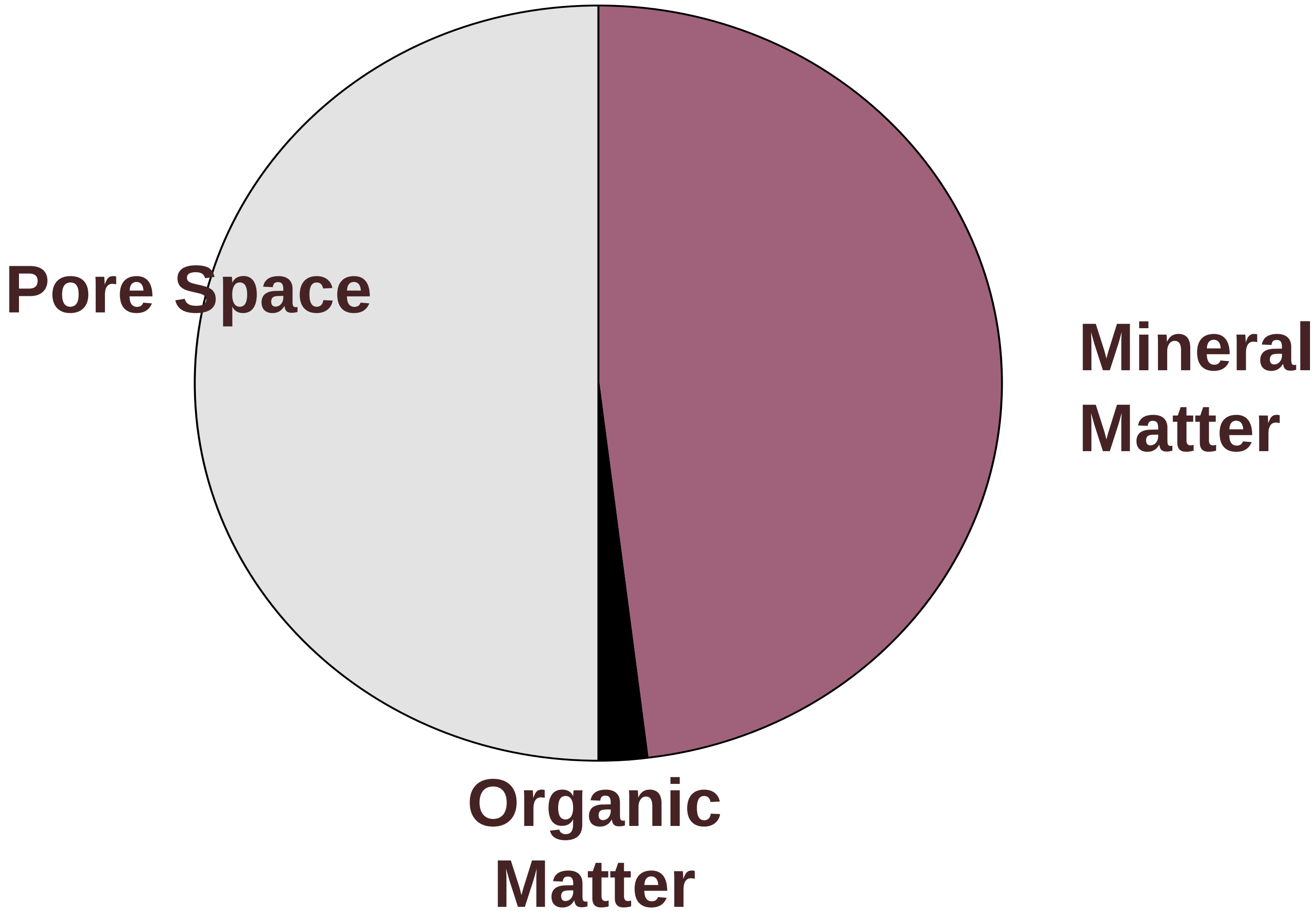
Soil Components



The Soil Ecosystem

Residue decomposition
Nutrient cycling
Aggregation and porosity
Enhance plant growth
Break down contaminants

The soil is the great connector of our lives, the source and destination of all. - Wendell Berry

Soil Organisms

Bacteria, fungi, actinomycetes, protozoa, nematodes, arthropods, earthworms

Pictures courtesy D. Collins, M. Fauci and D. Bezdicek

Soil Air and Water

- Water Movement
  How quickly water moves through soil
- Water Holding Capacity
  How much water a soil can hold available for plant growth

Pore Space and Air-Water Relations

- Soil acts like a sponge
- Macropores control infiltration and drainage
- Capillary pores control water holding capacity
- Micropores hold unavailable water

What Affects the Size of the Soil Pores?

- Soil texture
- Soil structure
- Compaction and disturbance
- Organic matter

To be a successful farmer one must first know the nature of the soil.
- Xenophon, 400 B.C.

- Texture
- Structure
- Compaction
- Organic Matter

Texture: Soil Particle Sizes

Sand	.05-2 mm
Silt	.002-.05 mm
Clay	<.002 mm

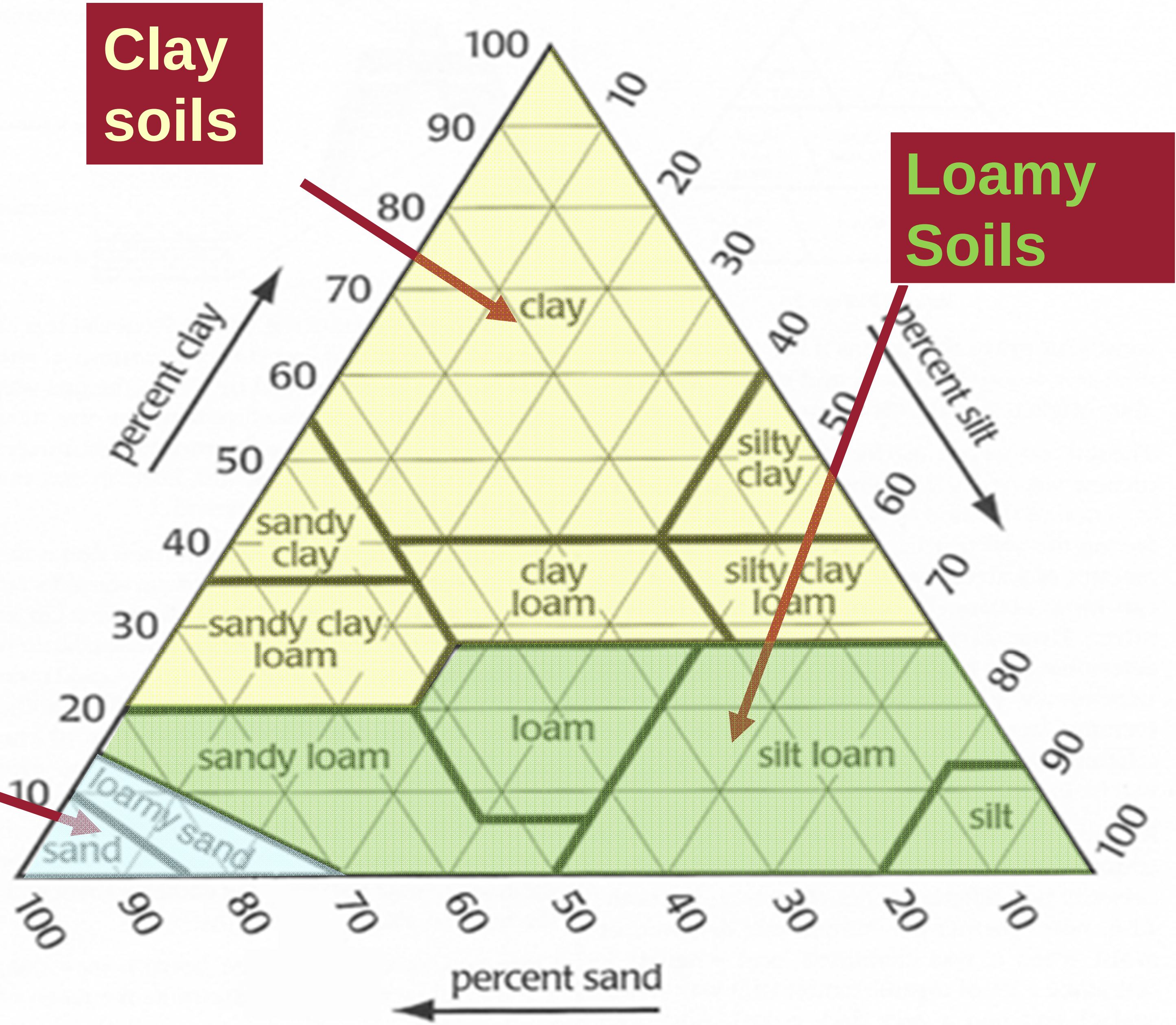
Coarse Fragments	>2 mm

Texture: Approximate Surface Areas of 1 gram Samples

Coarse sand:
one dollar

Fine clay:
soccer field

Textural Triangle



- Texture
- Structure
- Compaction
- Organic Matter

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Soil Structure

Aggregation of Sand, Silt, and Clay Particles

Structure affects:

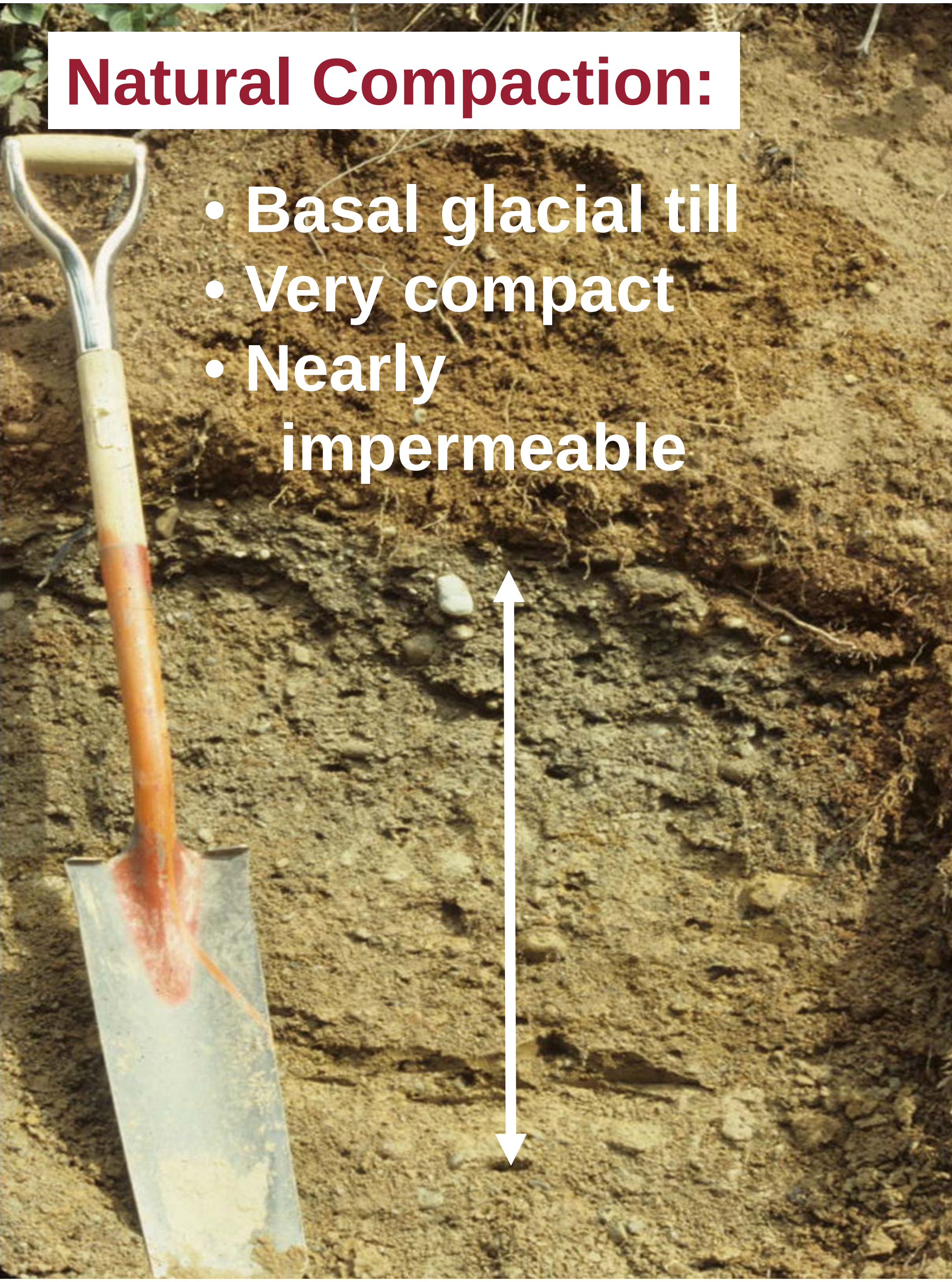
- Macroporosity
- Infiltration
- Aeration

Formation of Soil Structure

- Growth of roots and movement of organisms create pores and aggregates
- Soil bacteria make glues that stabilize aggregates
- Fungi help bind aggregates
- Physical, chemical processes also involved



- Texture
- Structure
- Compaction
- Organic Matter



Human Compaction:

- Clearing
- Construction
- Traffic

- Texture
- Structure
- Compaction
- Organic Matter

Why is Organic Matter Important?

- Structure and macropores
- Water holding capacity
- Infiltration
- Nutrient supply
- Biological activity
- Improved root environment

Beneficial Reuse

- Biosolids can meet nutrient needs for most crops
- Organic matter recycled to soil

Long-term dryland wheat-fallow experiment 1994-present

Douglas County, WA

Alternating winter wheat and fallow

Biosolids applied every 4th year, crop harvested every 2 years

Long-term dryland wheat-fallow experiment

Biosolids rates:
  2, 3, 4.5 dry tons/a each application

Inorganic N 50 lb/a each crop

Zero-N control

Total biosolids applied 1994 – 2010: 10-22 tons/acre

Measurements

Grain yield

Grain protein

Soil N

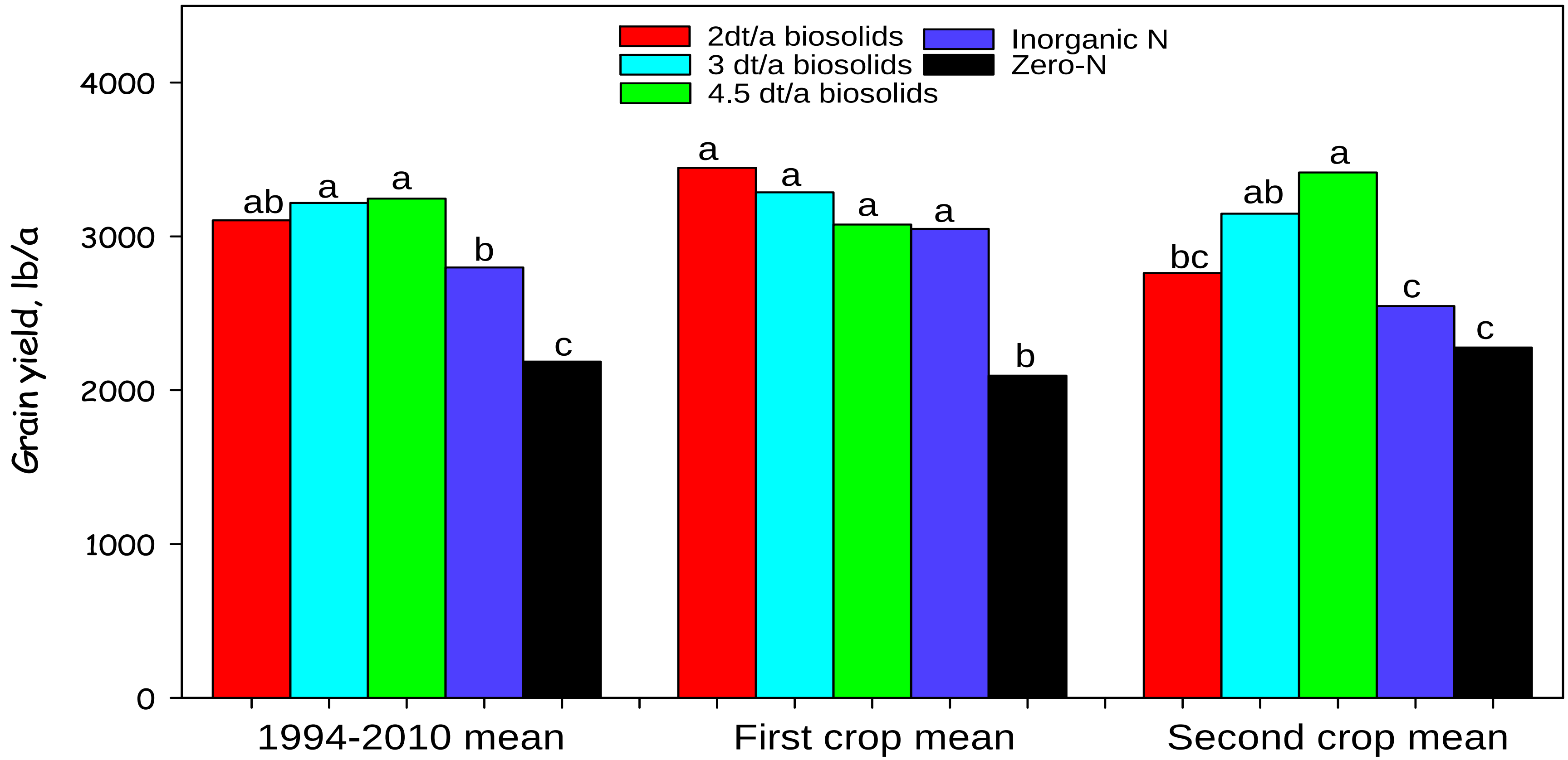
Soil C

Bulk Density

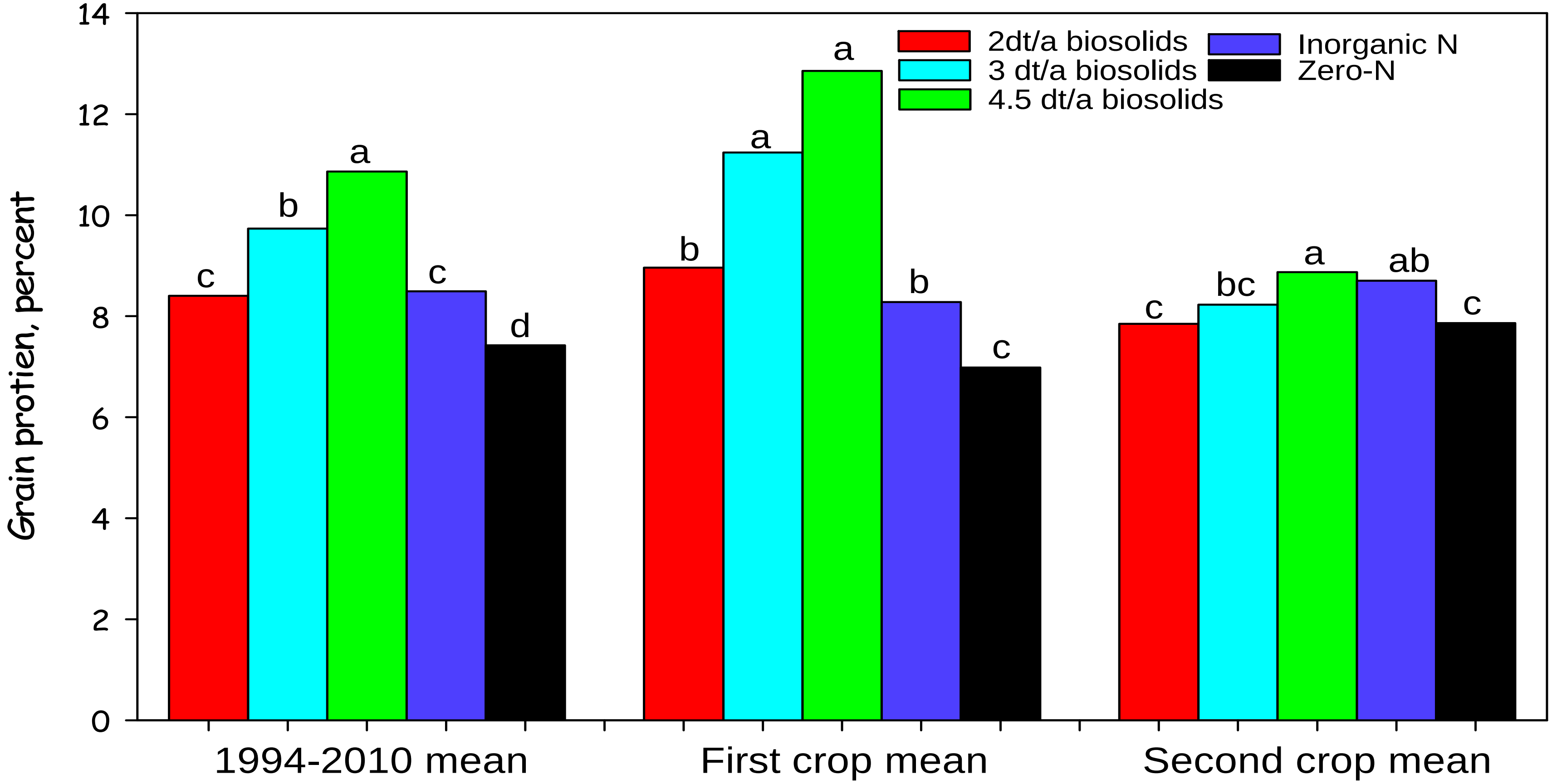
Microbes

Nutrients

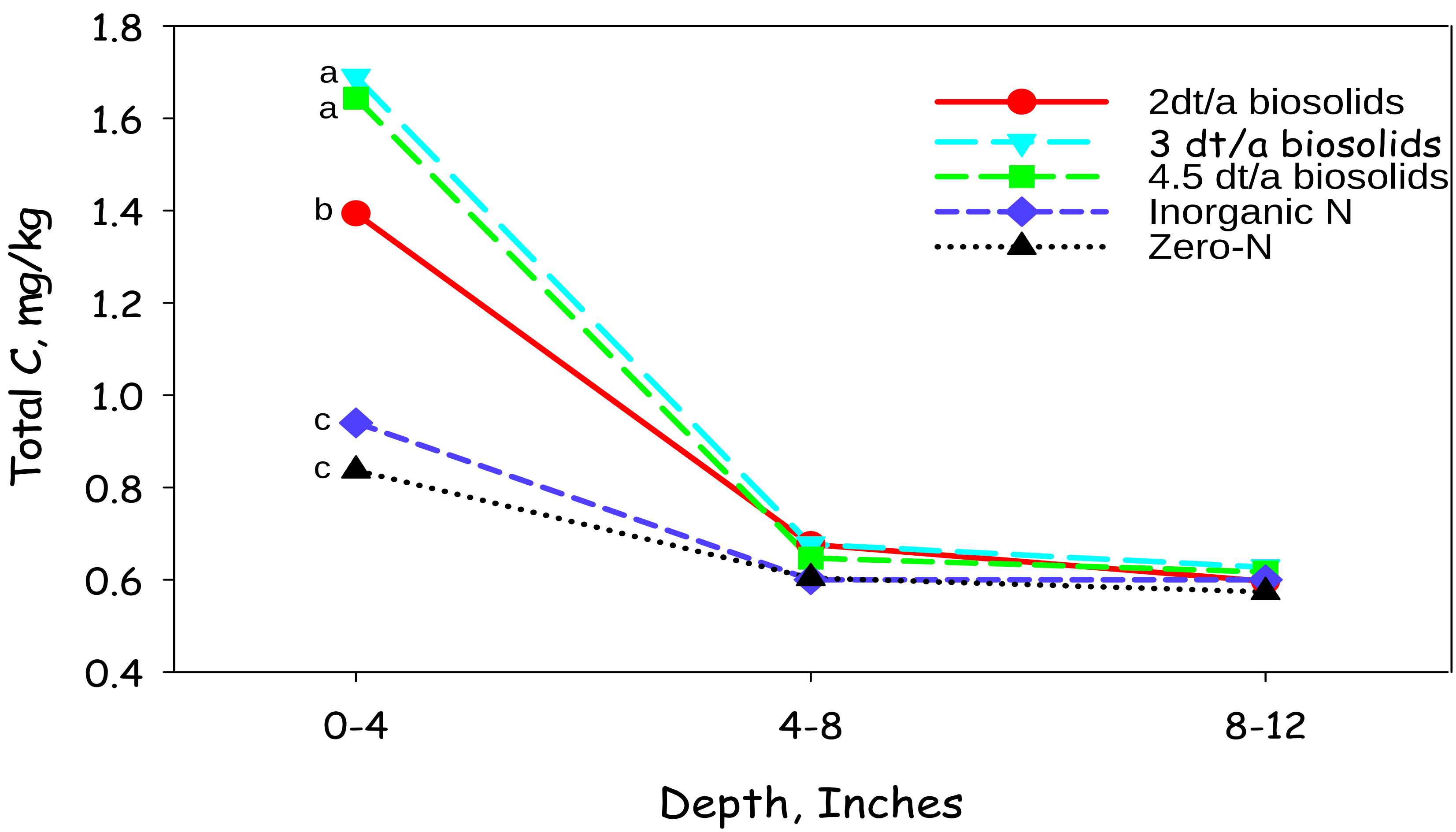
Biosolids had equal or greater grain yields than inorganic N treatment



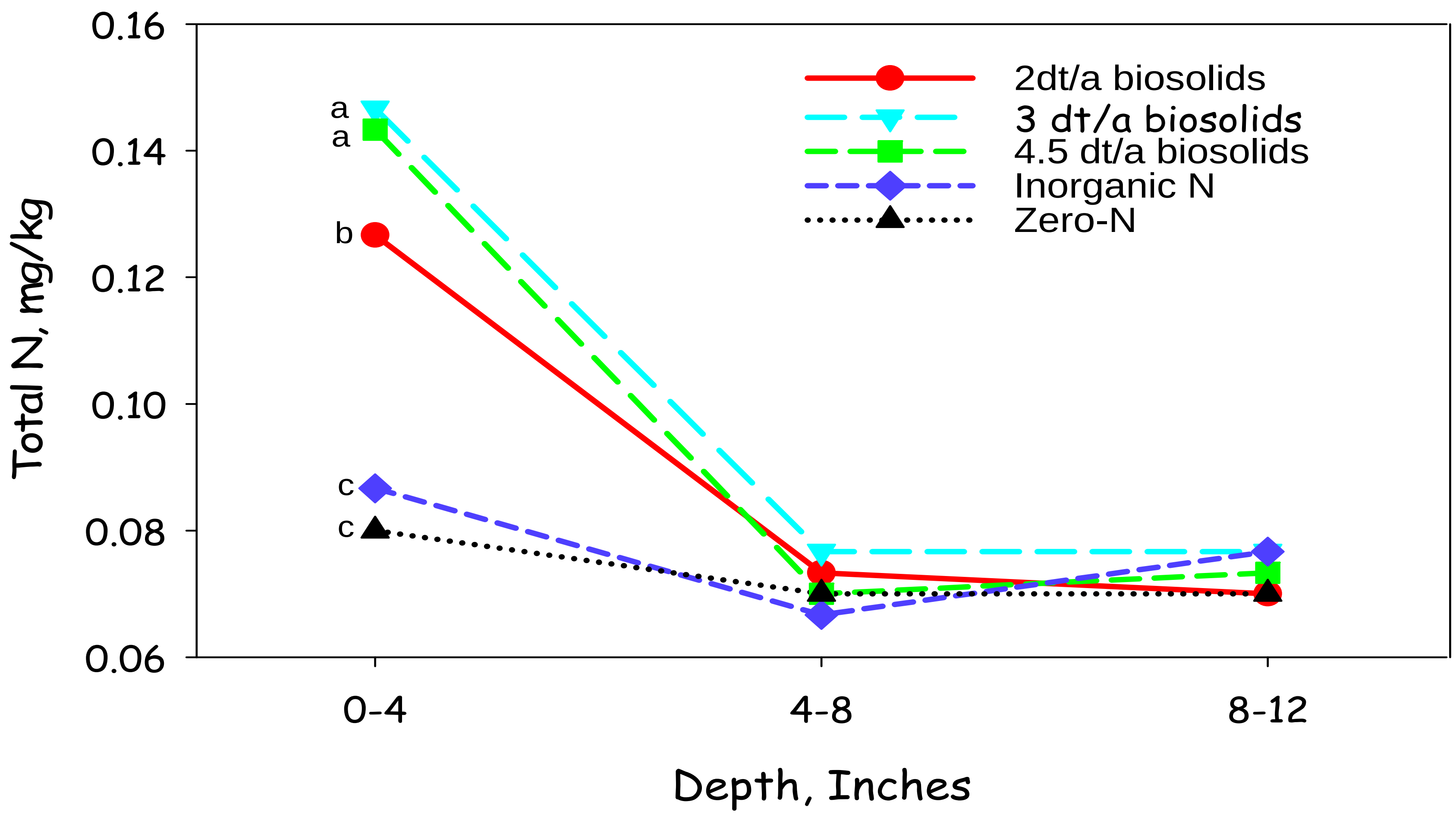
High biosolids rates increased grain protein



All biosolids application rates increased organic matter in the upper 4 inches of soil



Soil N showed similar trends to soil C



C and N accumulation in soil as % of biosolids C and N applied

Wheat: Applied every 4th year since 1994

N increase = **33**% of total N applied

C increase = **57%** of total C applied

Improves soil and sequesters carbon.

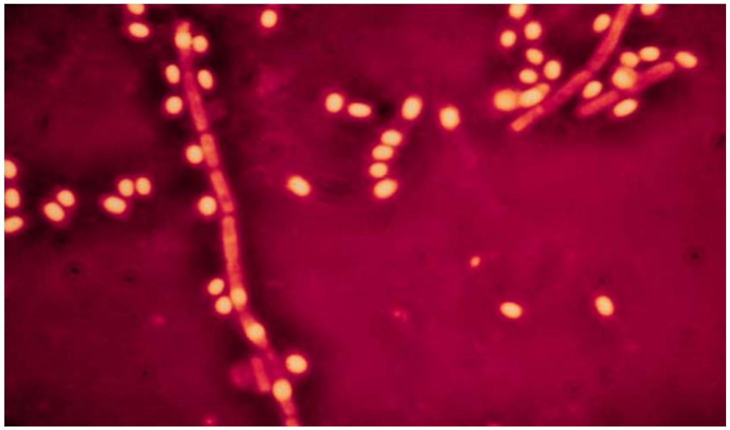
All rates of biosolids applications decreased soil bulk density

Lower bulk density means less compaction and a better environment for plant growth.

Collecting bulk density sample in 3 dry ton/acre biosolids treatment

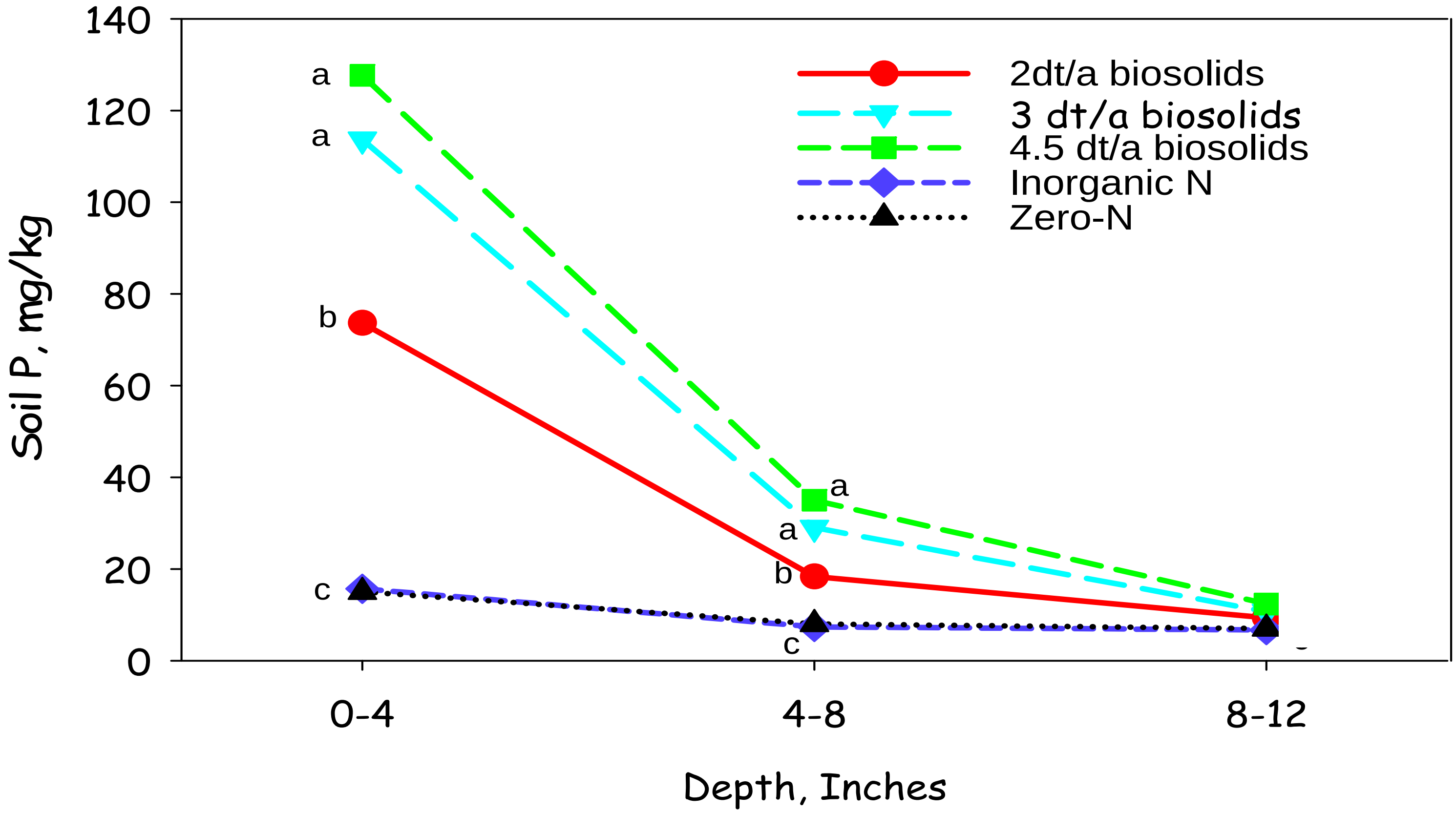
Changes in the soil microbial community were small

- Microbial biomass, bacteria, and bacteria:fungi ratio tended to increase with increasing biosolids rate
- Response to organic matter and nutrients



Photos by M. Fauci and D. Bezdicek

Soil test P increased in the biosolids treatments.



Biosolids increased Zn from borderline deficient to adequate levels.
Little Zn movement below 4 inches.

	0 to 4”	4 to8”	8 to 12”
Zero –N	1.0	0.3	0.2
Inorganic N	0.8	0.3	0.1
Biosolids 2 DT/a	4.9	0.7	0.5
Biosolids 3 DT/a	6.6	0.8	0.9
Biosolids 4.5 DT/a	8.0	0.7	0.2

Tall fescue experiment 1993 - 2011

Puyallup, Washington

Biosolids applications
  1993-2002

Residual measurements
  2003-2011

Tall Fescue Field Experiment

Biosolids applied to surface

Grass harvested at 30-45 day intervals during growing season

Forage yield, N concentration and N uptake measured.
Plant available N calculated

Biosolids application 1993-2002

7, 13, and 20 dry Mg/ha/yr (~ 300, 600, and 900 kg N/ha/yr)

Inorganic N treatment (400 kg/ha/yr)

Zero-N treatment

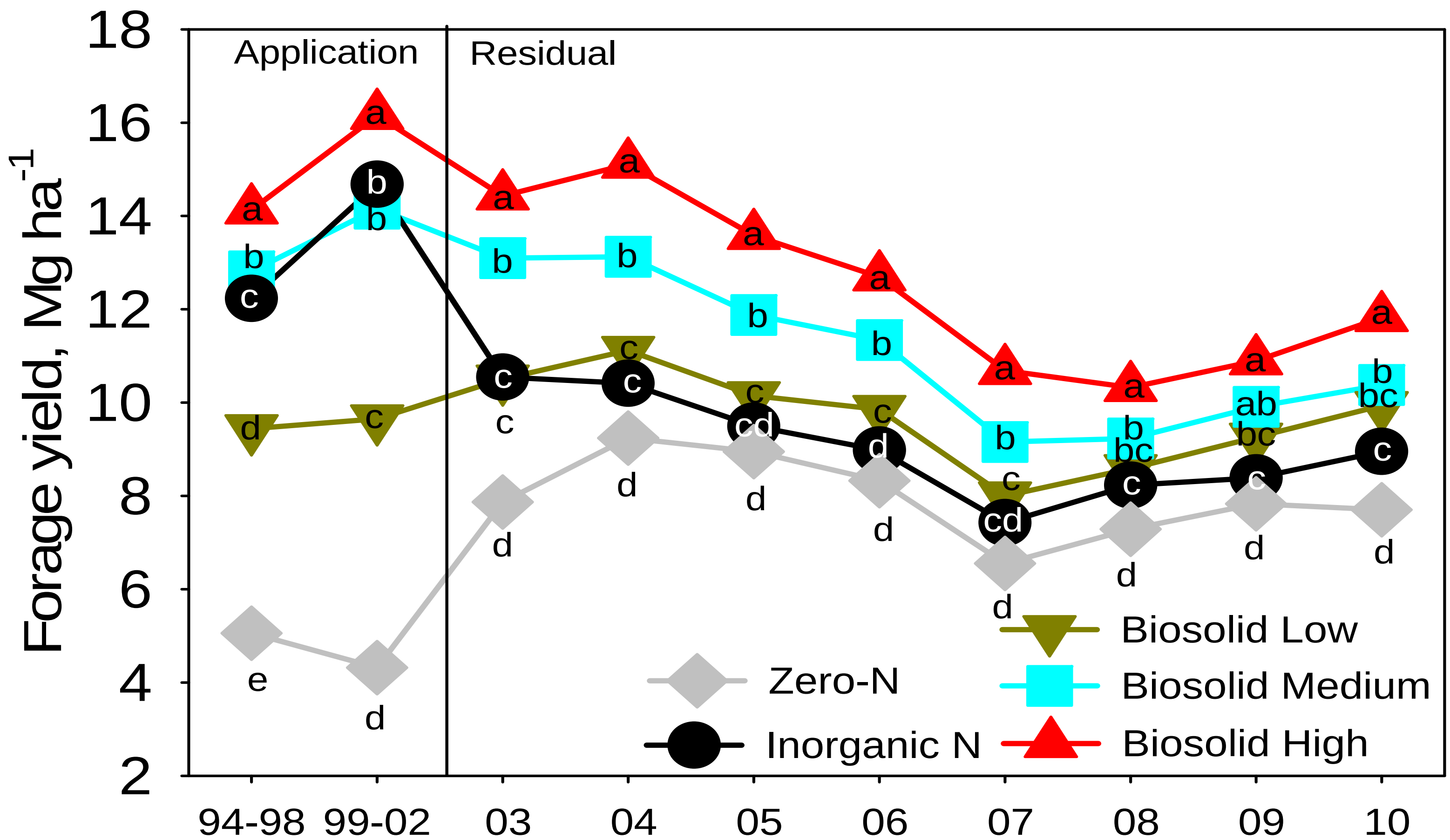
Total biosolids applied: 67-200 Mg/ha

Residual N phase 2003-2011

All plots receive 180 lb inorganic N/acre/yr, split over 6 dates.

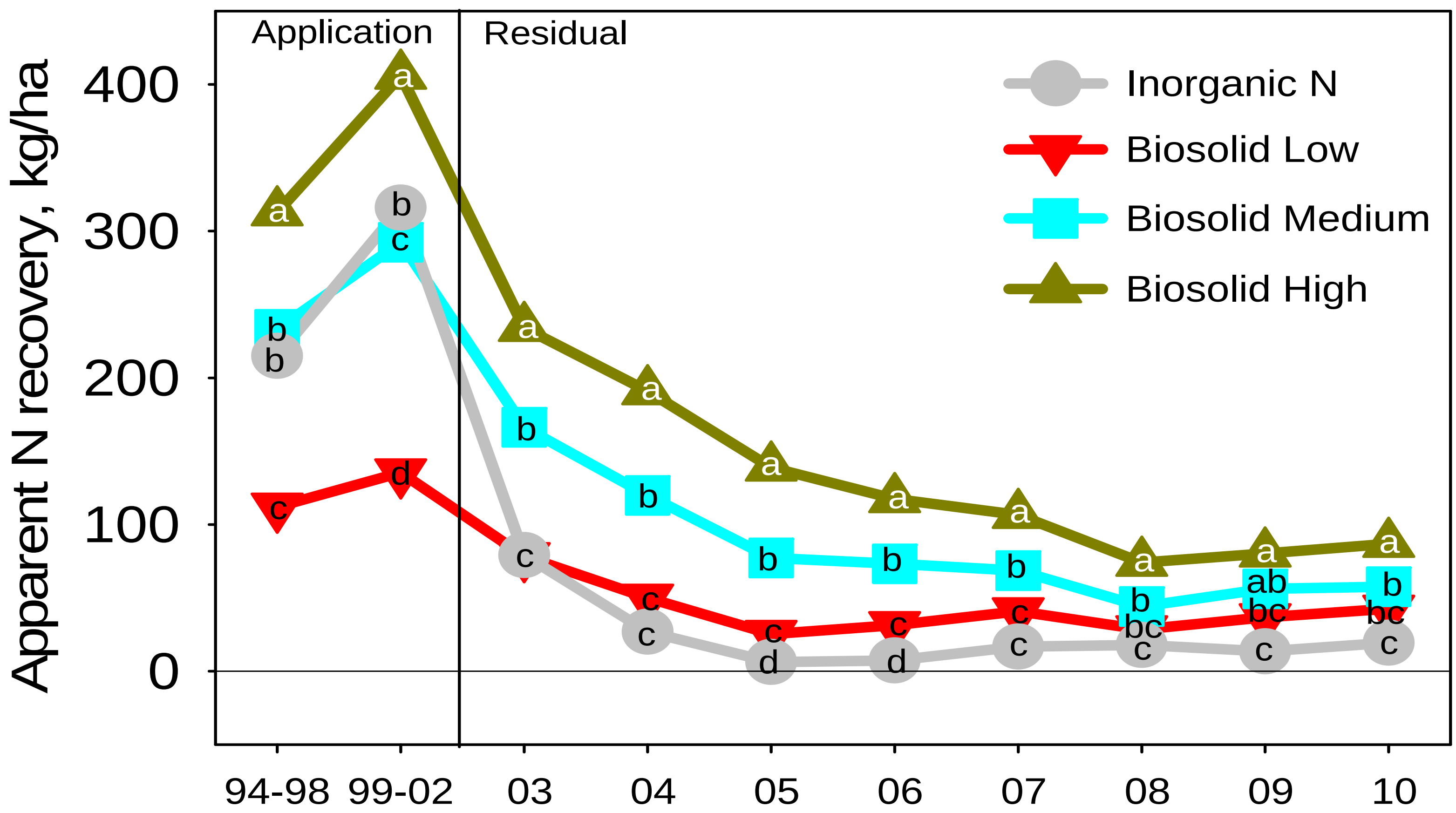
No biosolids applied

Biosolids applications led to long-term yield increase during residual period



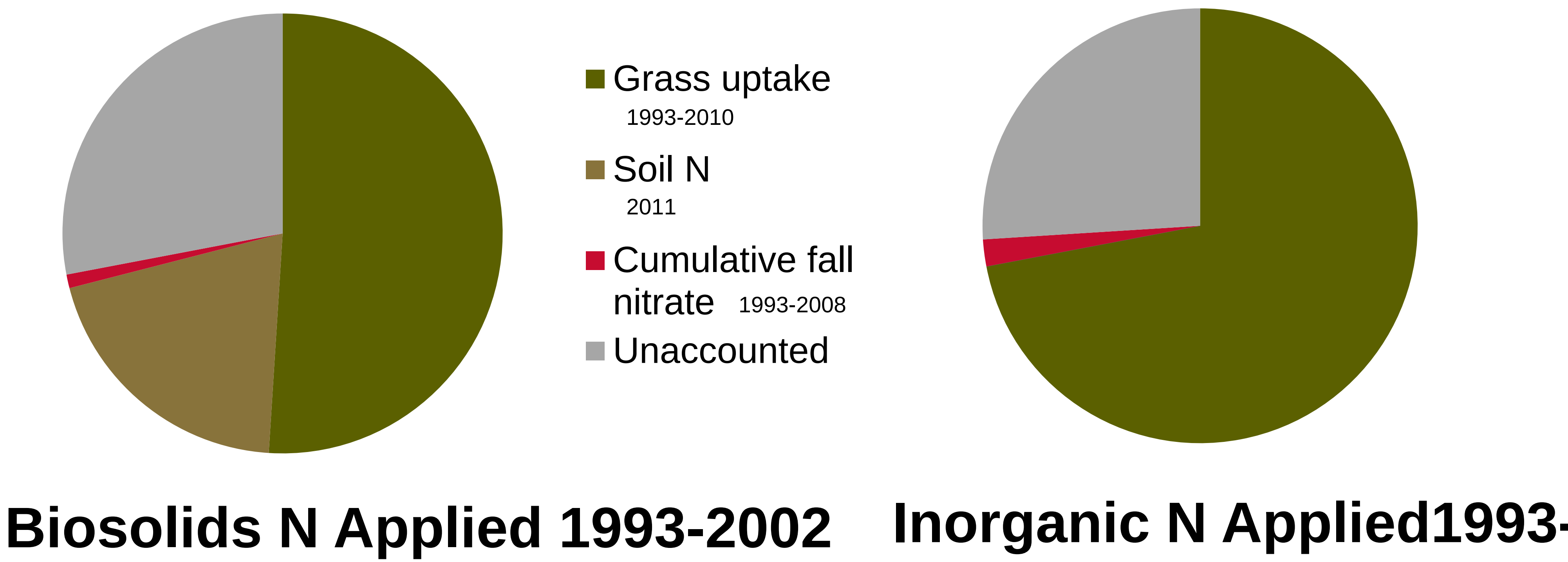
2012 fwc3 forage yield 20jun12

Apparent N recovery also showed a long-term increase

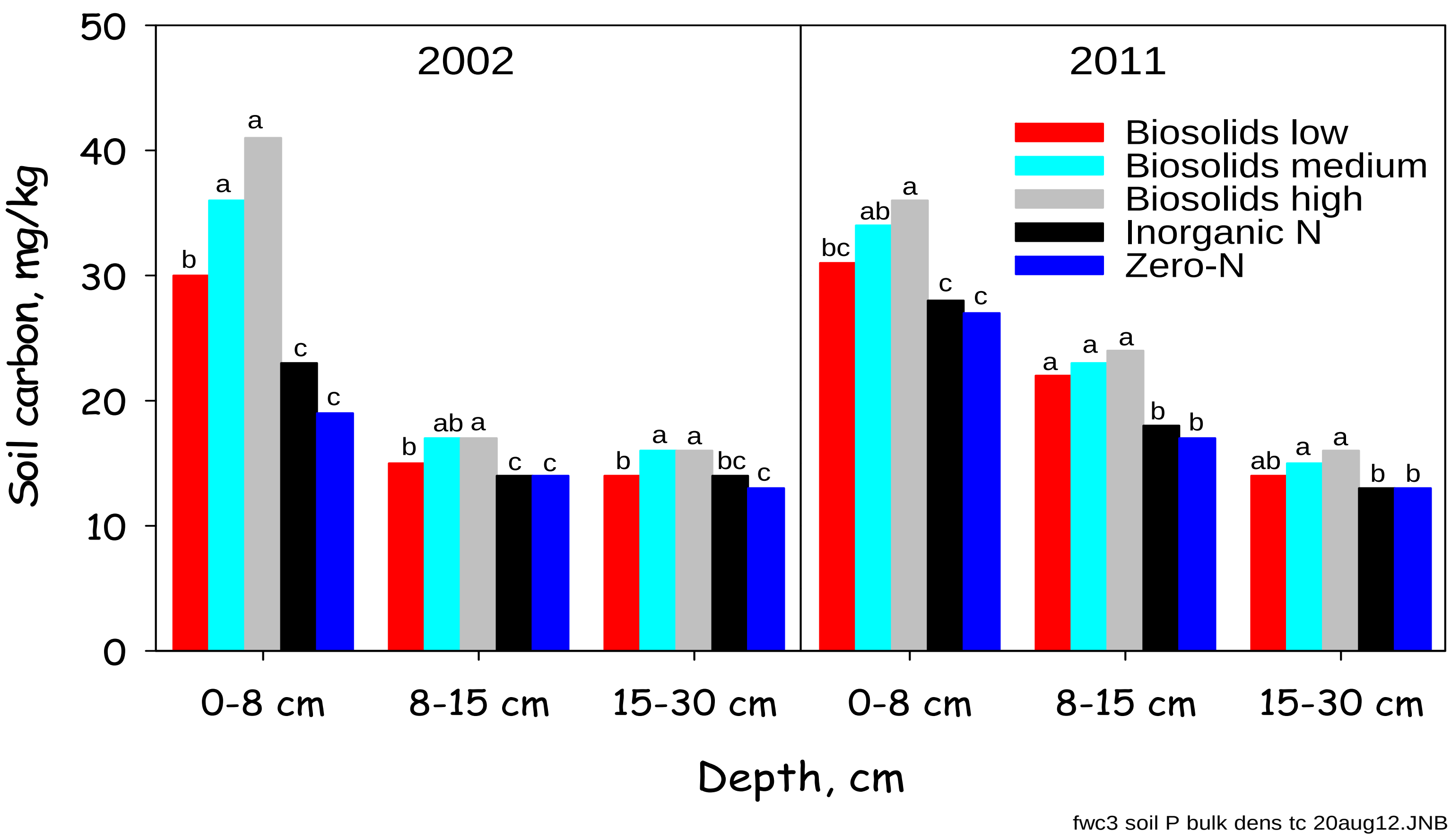


2012 fwc3 asa 3

Fate of N applied in biosolids and inorganic N, 1993-2010



Soil carbon was higher in biosolids treatments 9 years after the final biosolids applications.



C and N accumulation in soil as % of biosolids C and N applied

Tall fescue: Applied for 10 years, measured 9 years after final application.

N increase = **20%** of total N applied

C increase = **29%** of total C applied