Sustainable Nutrient Management: Environmental

Brian Horgan, University of Minnesota

Sustainable Turfgrass Systems

- More than inputs
- More than pest control
- More than conservation

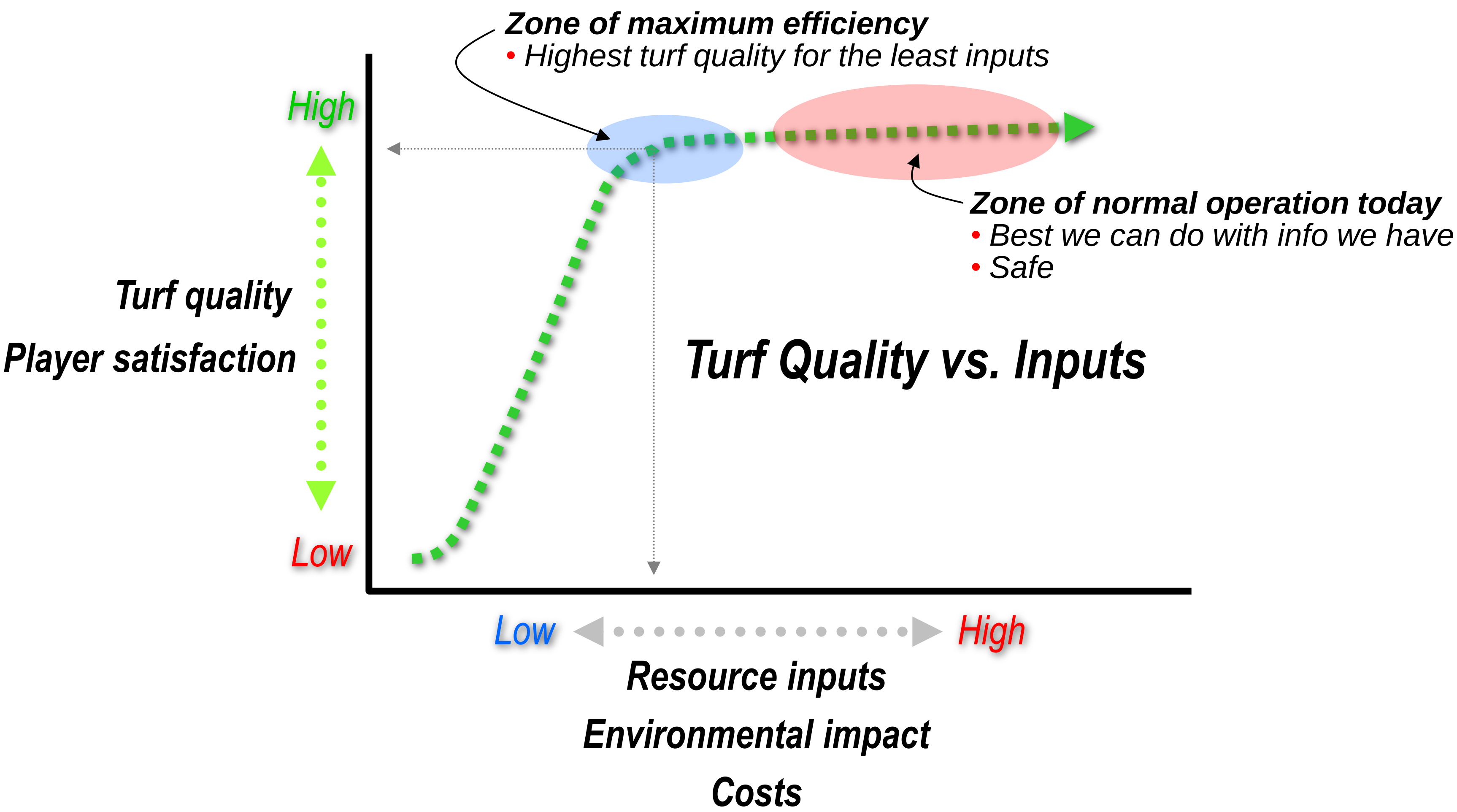
Is about connecting the landscape to the community in ways that benefits both. What value is turfgrass to the community?

Demands will increase…

- Growth and urbanization will increase need for human-managed landscapes dependent on energy intensive inputs (Milesi, et al., 2005).

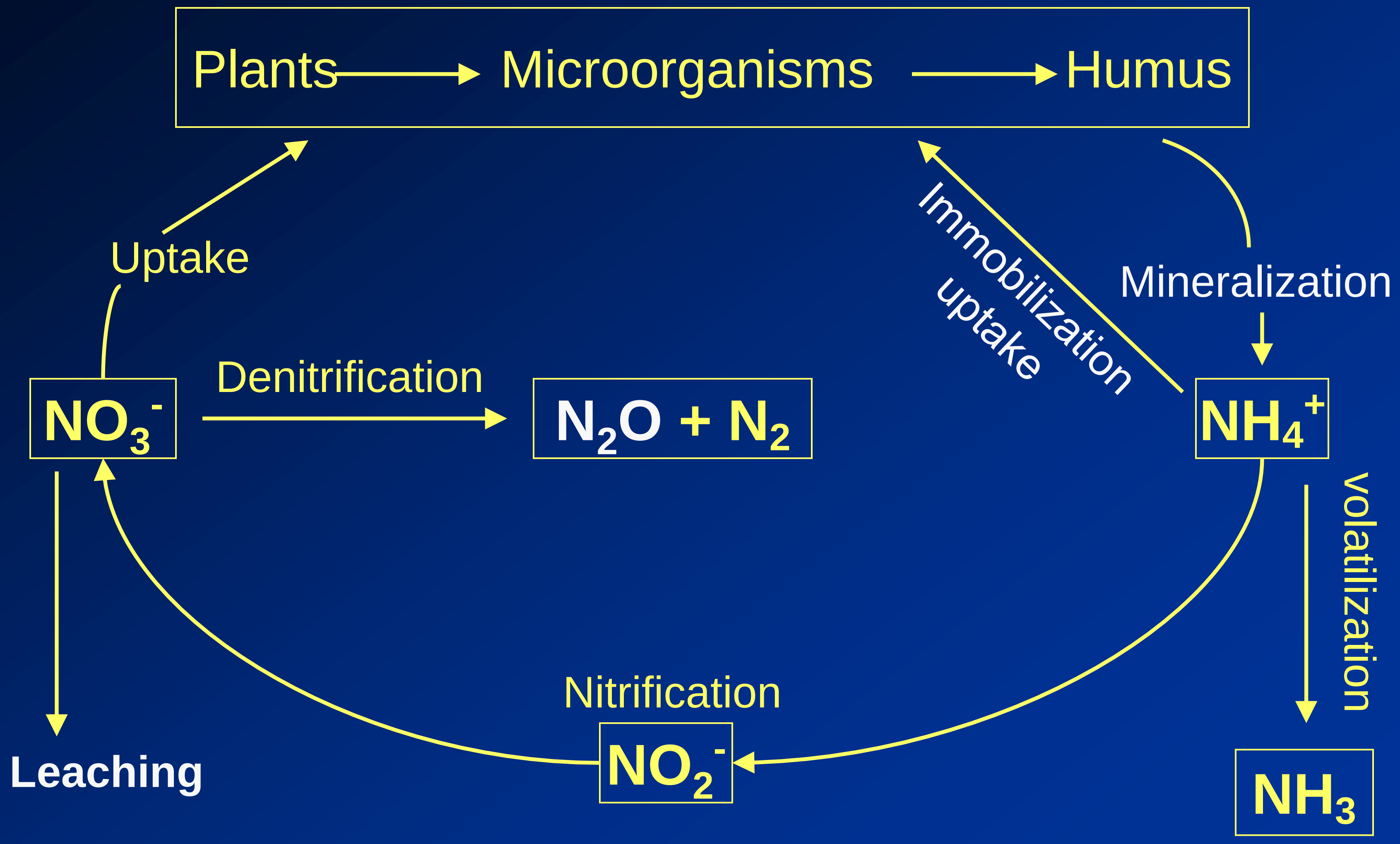
…while resources decrease.

- "…energy-intensive products used to maintain turfgrass will be much less available…" Busey and Parker (1992)



Zone of maximum efficiency
• Highest turf quality for the least inputs
High
Turf quality
Player satisfaction
Low
Zone of normal operation today
• Best we can do with info we have
• Safe
Turf Quality vs. Inputs
Low
High
Resource inputs
Environmental impact
Costs

The Nitrogen Cycle

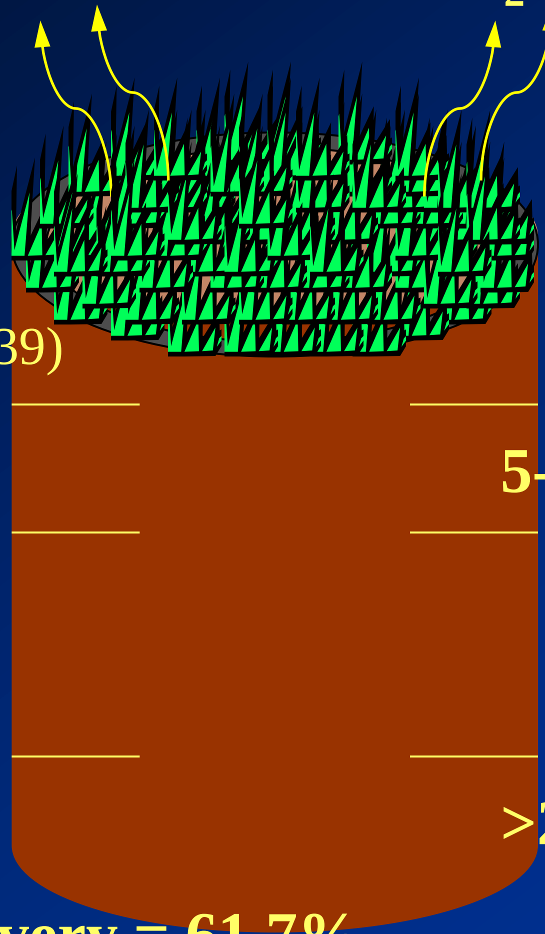


Summer: Balance of Fertilizer Applied

N_2 = 15.0% (±0.77)

N_2O = 5.6% (±2.4)

plant = 21.6% (±2.3)



0-5cm = 14.5% (±0.39)

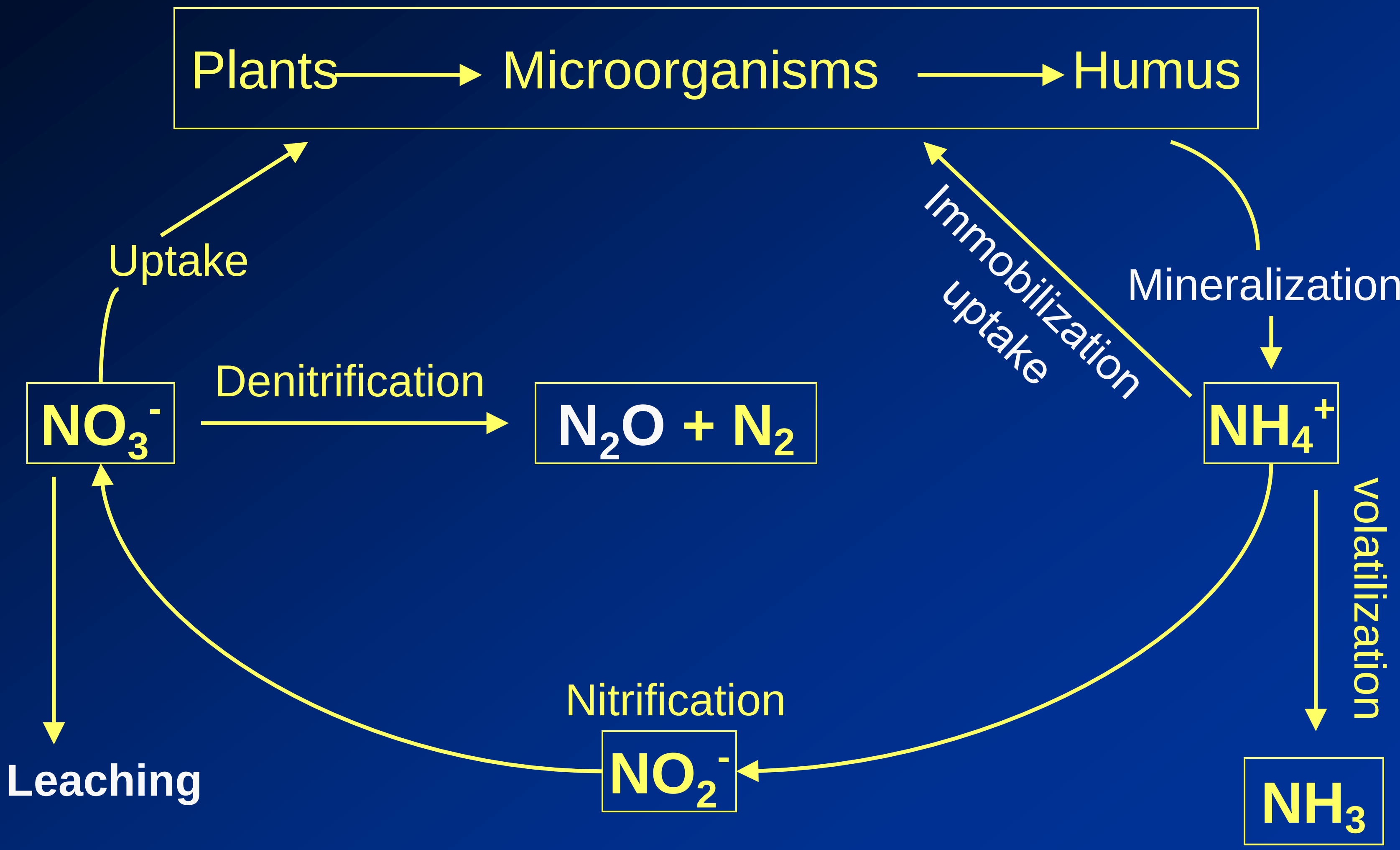
5-10cm = 1.5% (±0.08)

10-20cm = 2.5% (±0.37)

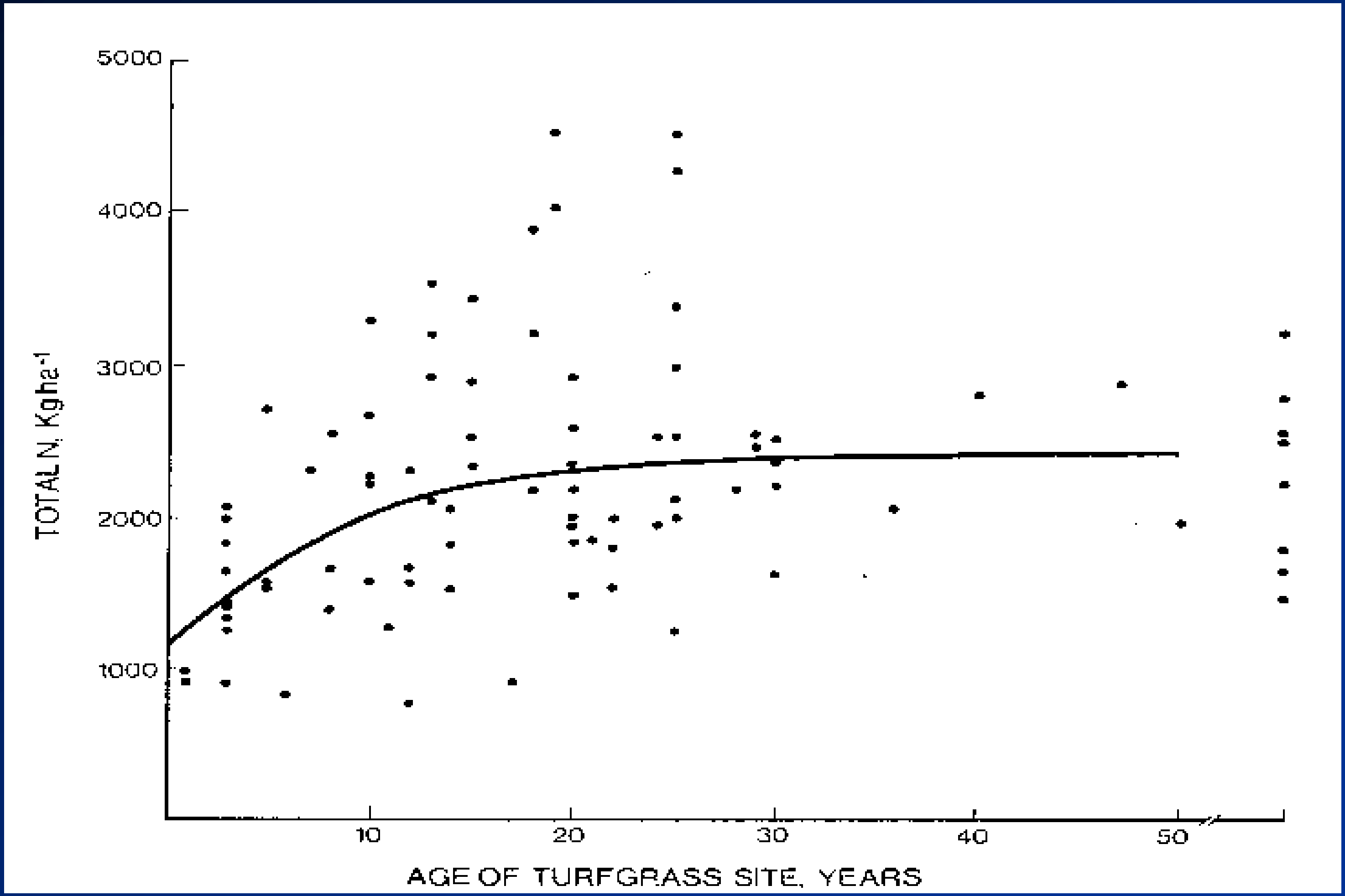
>20 cm = 1.0% (±0.13)

Total LFN recovery = 61.7%

The Nitrogen Cycle



Age -vs- N Accumulation in Turf



Total N in surface soil (0-10 cm) as a function of age. Porter et al., 1980

Age -vs- Carbon Storage in Turf

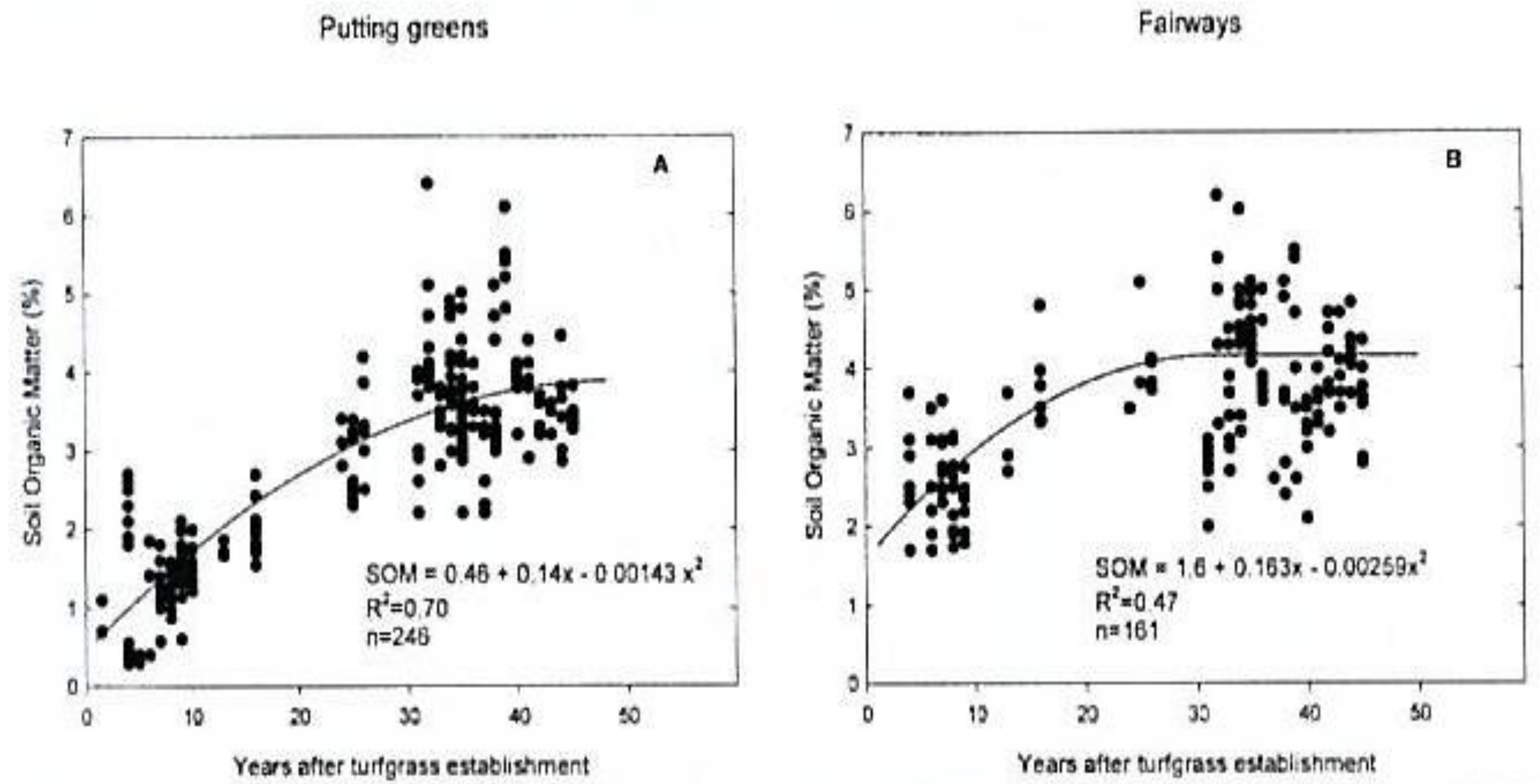


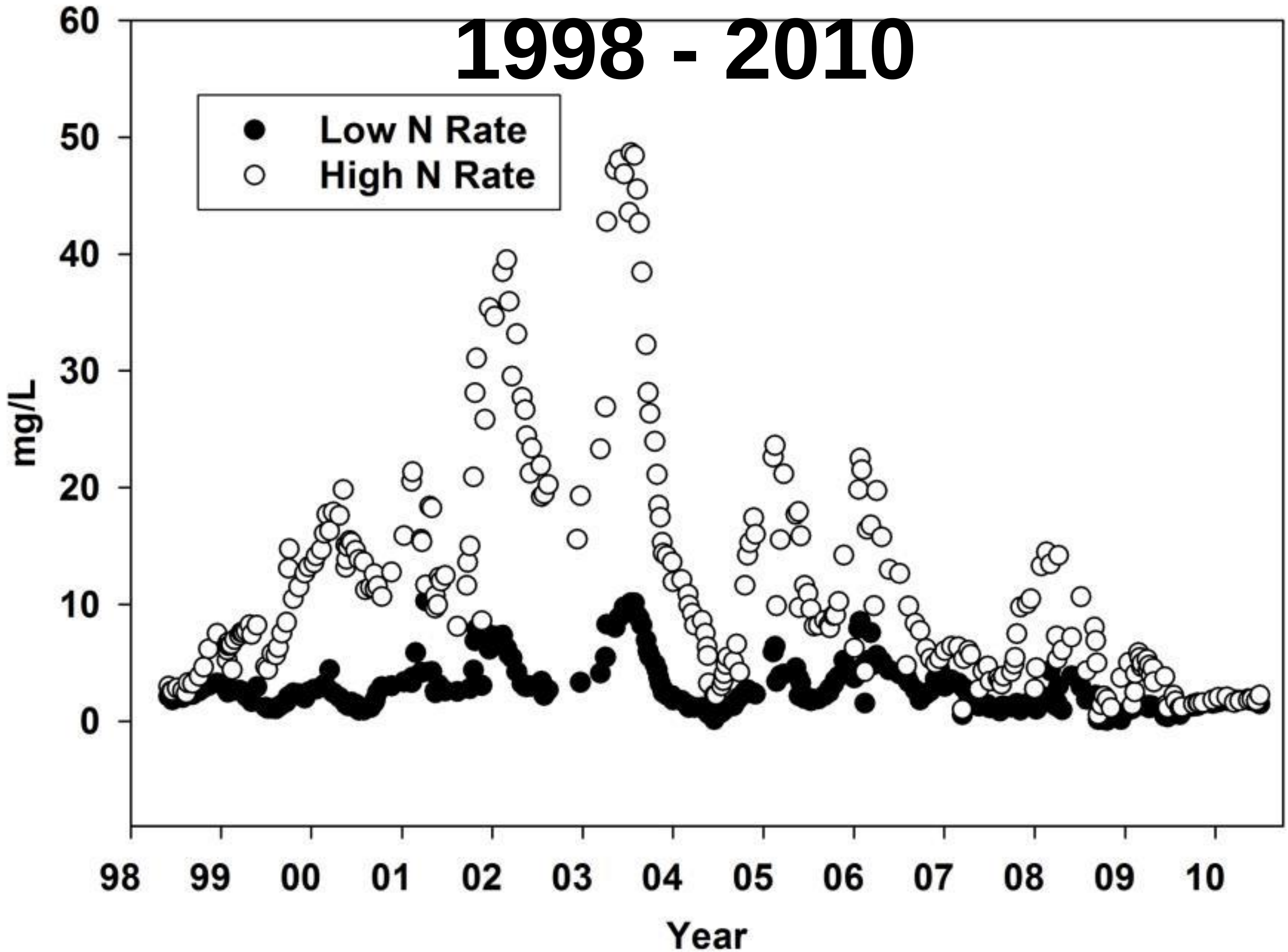
Fig. 1. Changes in soil organic matter with time since turfgrass establishment in (A) putting greens of 16 golf courses in Colorado and (B) fairways of 13 golf courses in Colorado. Data were based on soil-testing results from these golf courses sampled to 11.4-cm depth.

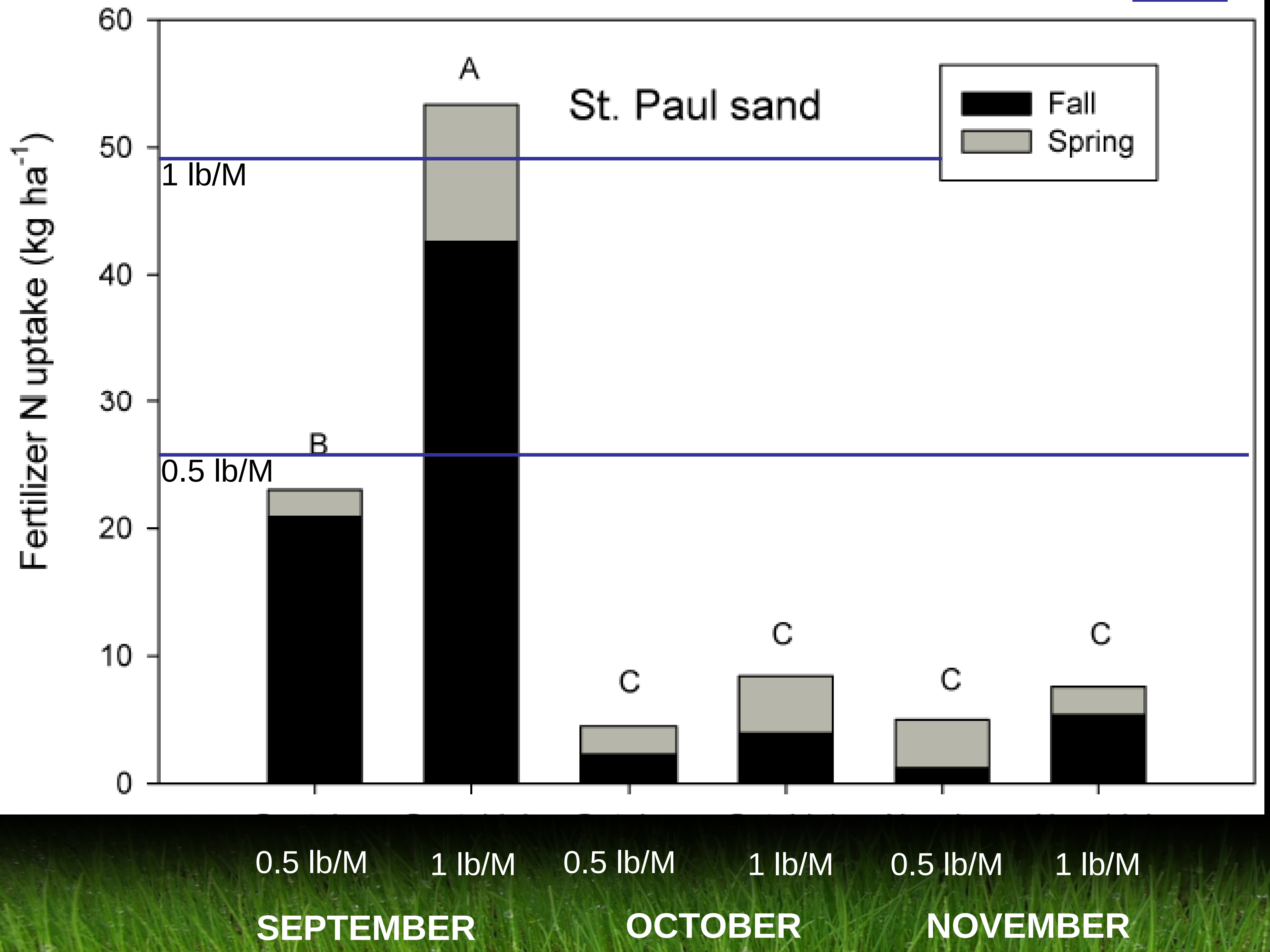
Qian and Follett, 2002

Older Turf Sites

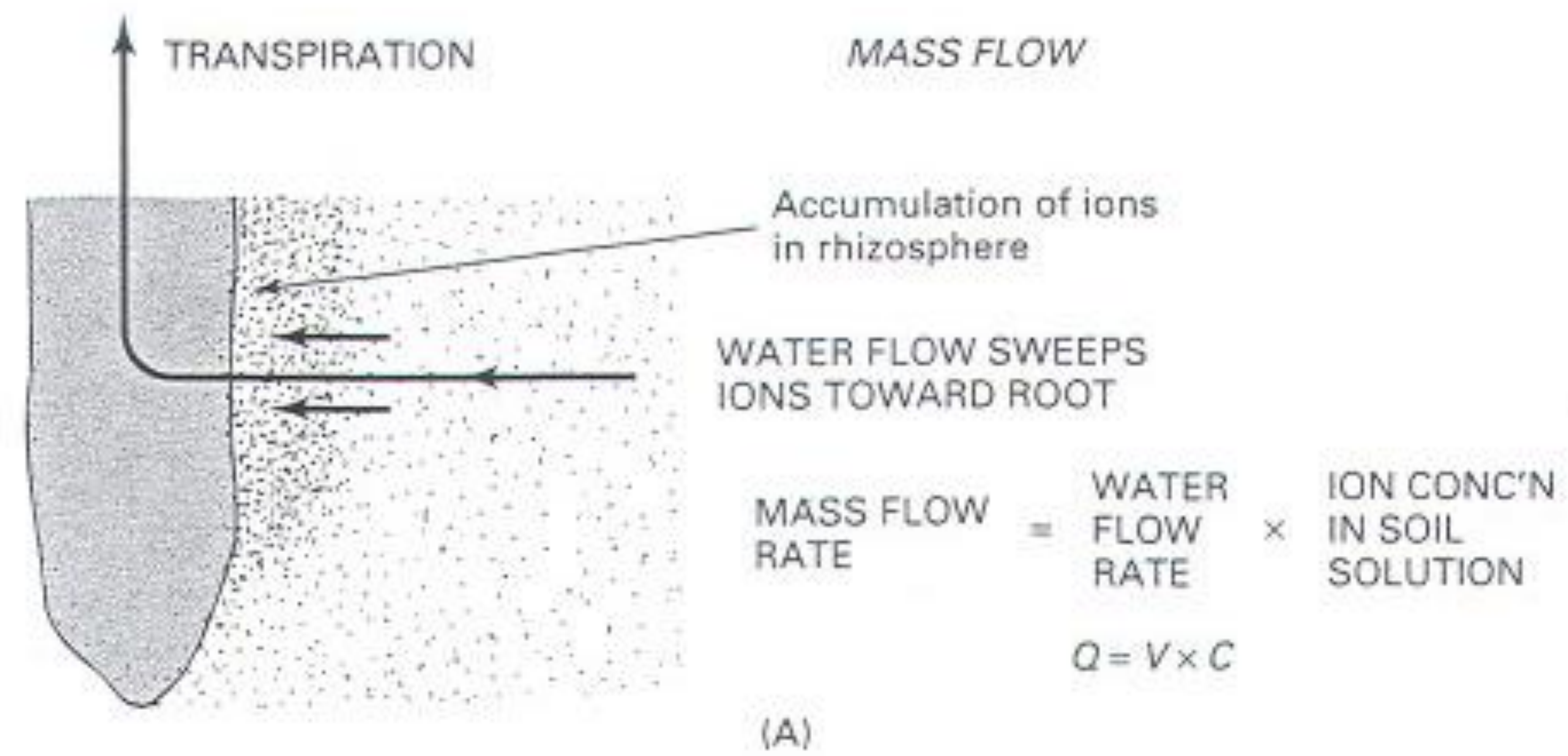
"Older turf sites should be fertilized at a rate equal to the rate of removal by the plant and loss to the atmosphere. Thus old turf sites should be fertilized **less** to reduce the potential for NO_3^- leaching."

Petrovic, A.M., 1990.


1998 - 2010
Low N Rate
High N Rate
mg/L
60
50
40
30
20
10
0
98
99
00
01
02
03
04
05
06
07
08
09
10
Year

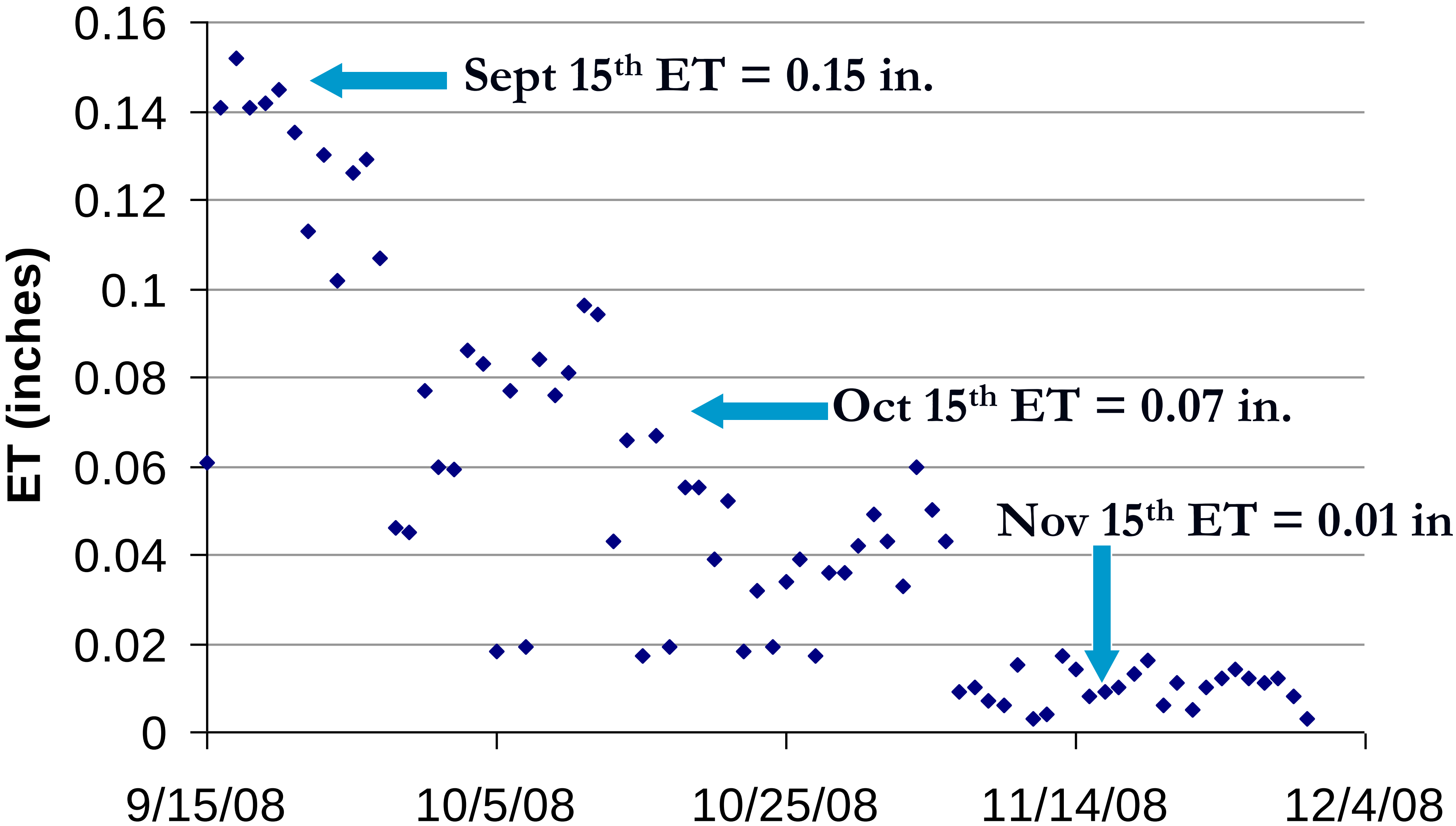

St. Paul sand
Fall
Spring
Fertilizer N uptake (kg ha-1)
60
50
40
30
20
10
0
A
B
C
C
C
C
1 lb/M
0.5 lb/M
0.5 lb/M
1 lb/M
0.5 lb/M
1 lb/M
0.5 lb/M
1 lb/M
SEPTEMBER
OCTOBER
NOVEMBER

Mass Flow



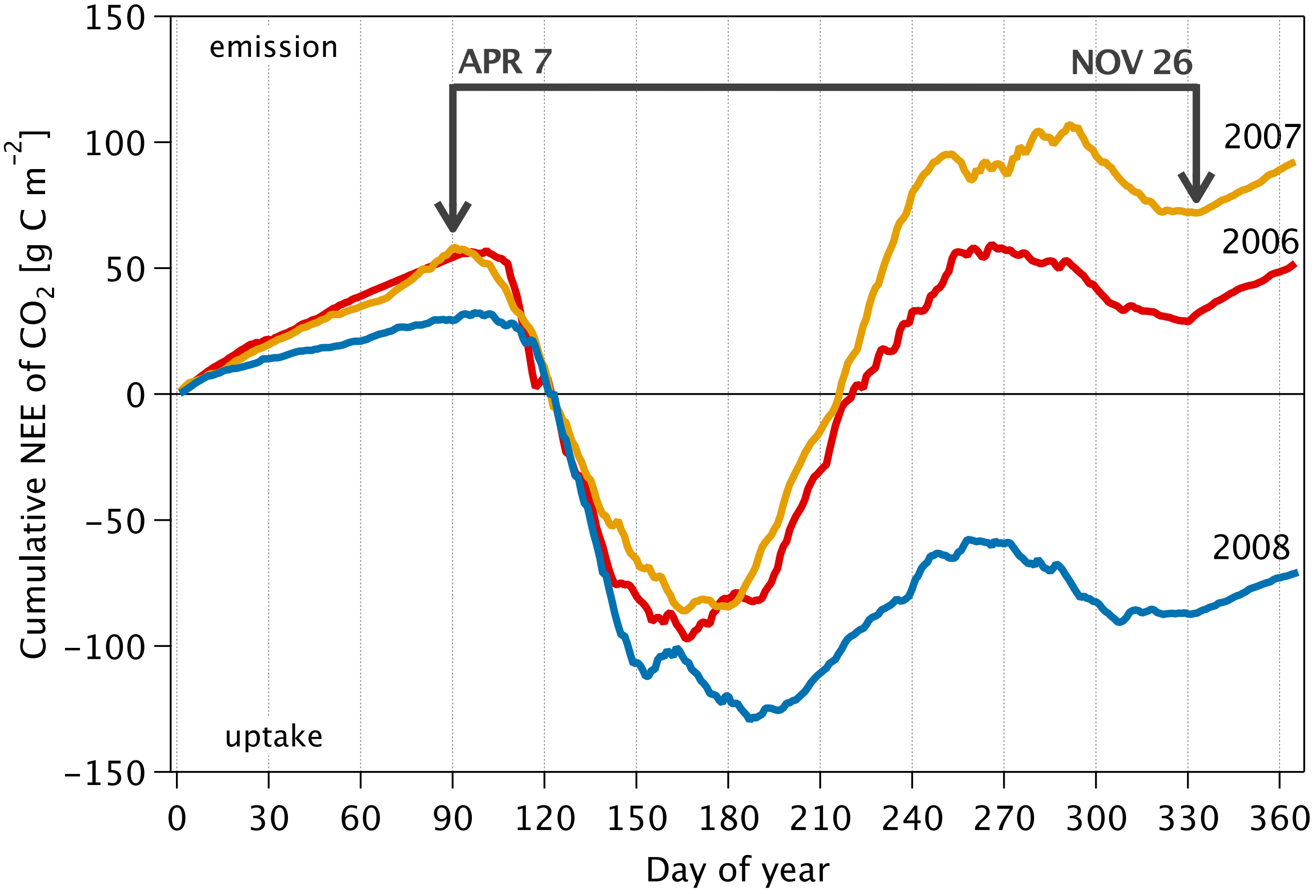
Mass flow accounts for 85% of N uptake

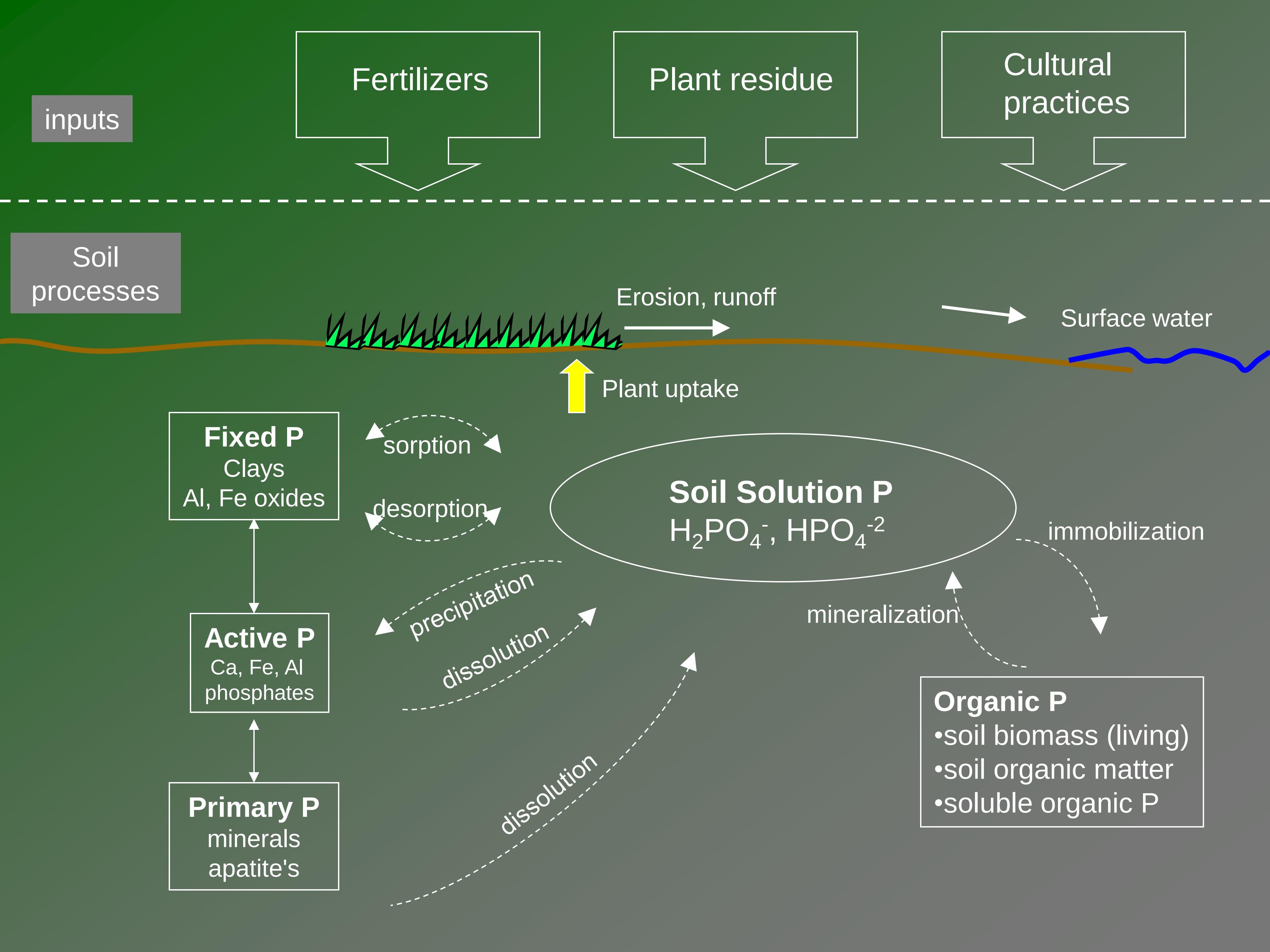
ET Madison, WI



Growing–season length

	2006	2007	2008
Winter days	131	124	132
Growing–season days	234	241	234





inputs
Fertilizers
Plant residue
Cultural practices
Soil processes
Erosion, runoff
Surface water
Plant uptake
Fixed P
Clays
Al, Fe oxides
sorption
desorption
Soil Solution P
$H_2PO_4^-$, HPO_4^{-2}
immobilization
mineralization
precipitation
dissolution
Active P
Ca, Fe, Al phosphates
Primary P
minerals
apatite's
dissolution
Organic P
•soil biomass (living)
•soil organic matter
•soluble organic P

Lake Ecosystem Degradation & Restoration

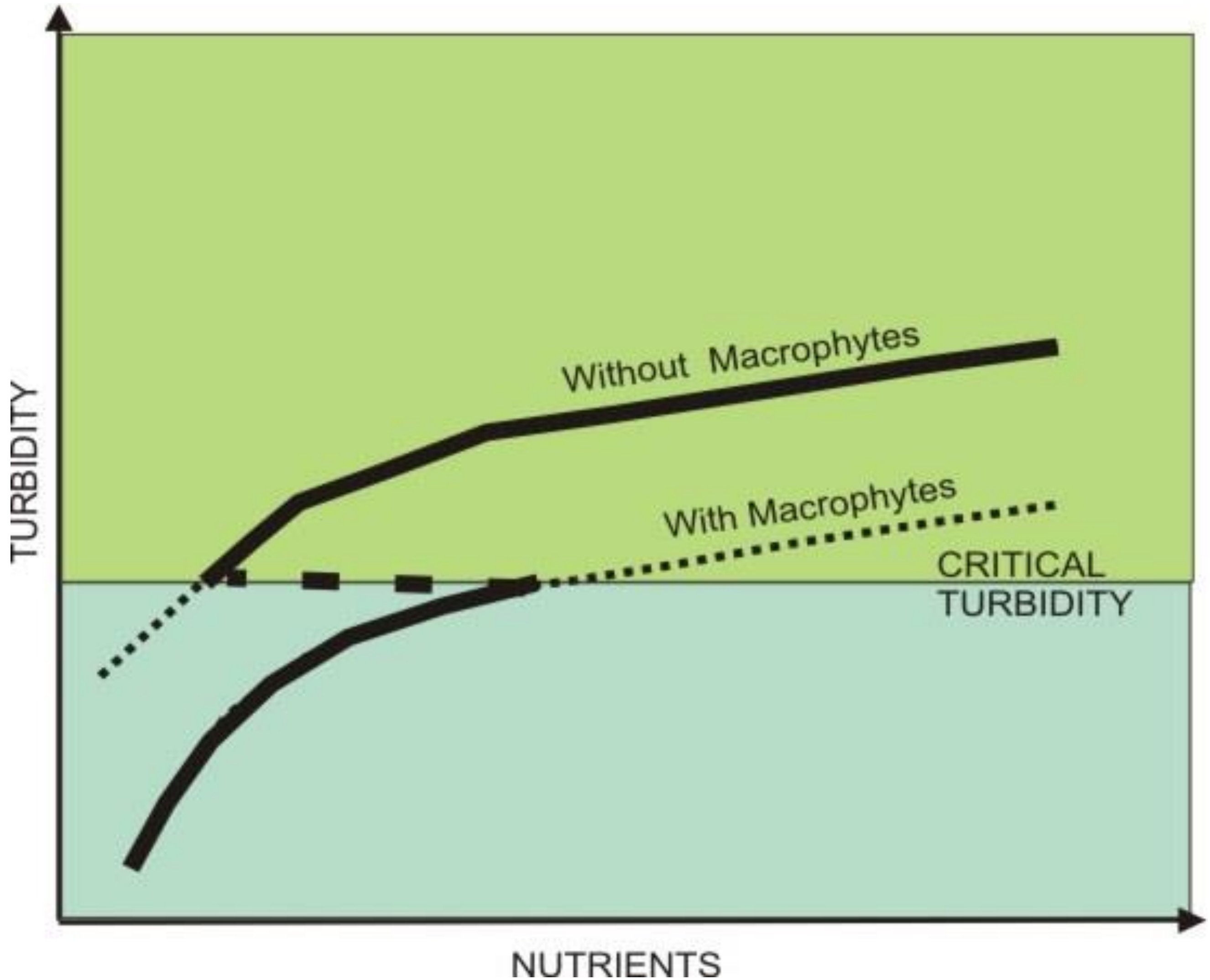
Shallow eutrophic lakes exist in 2 states:

1. **Clear and dominated by macrophytes**
   - dense growths of rooted plants that stabilize sediments, slowing nutrient recycling and shelter phytoplankton grazers.

2. **Turbid and dominated by phytoplankton**
   - dense phytoplankton growth driven by nutrient recycling from sediments.
   - shading by phytoplankton blocks the growth of attached plants.

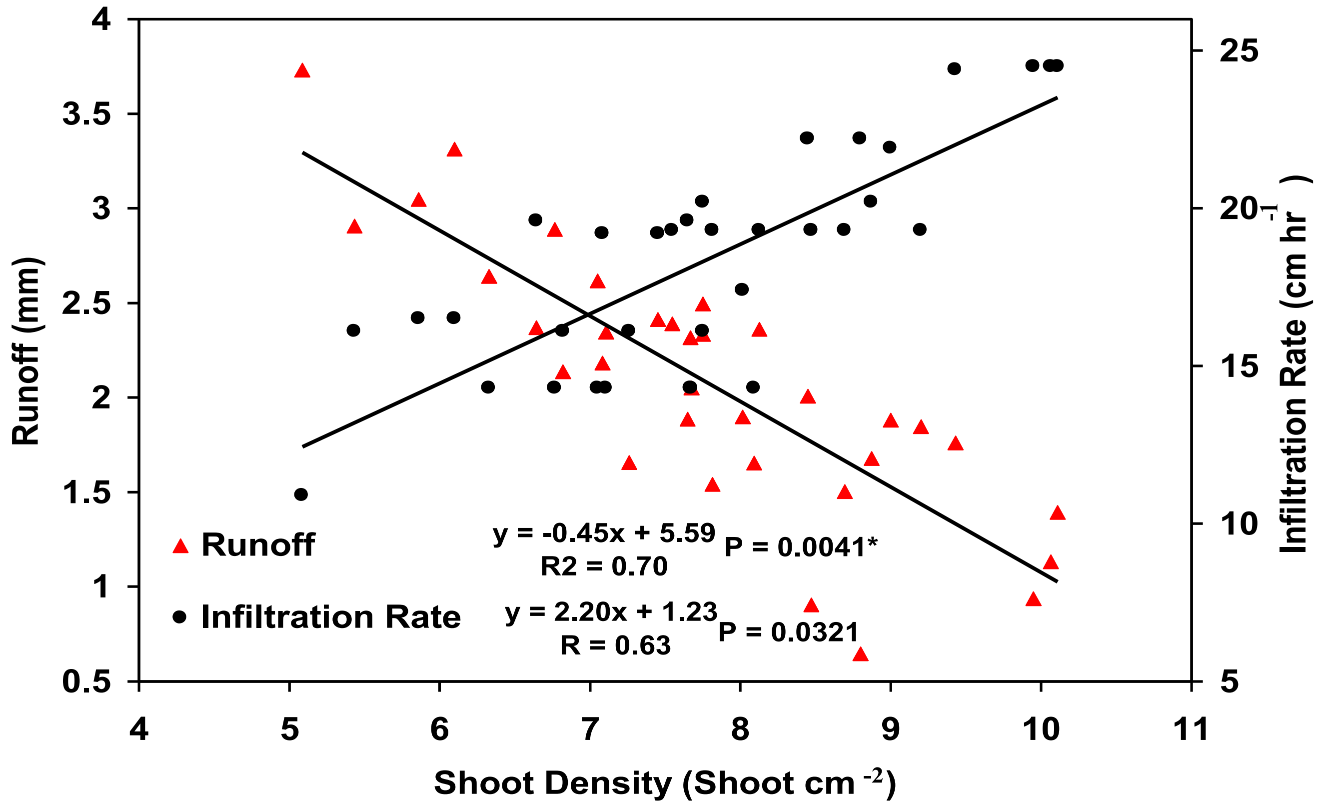
The existence of alternative stable states makes lake restoration notoriously difficult

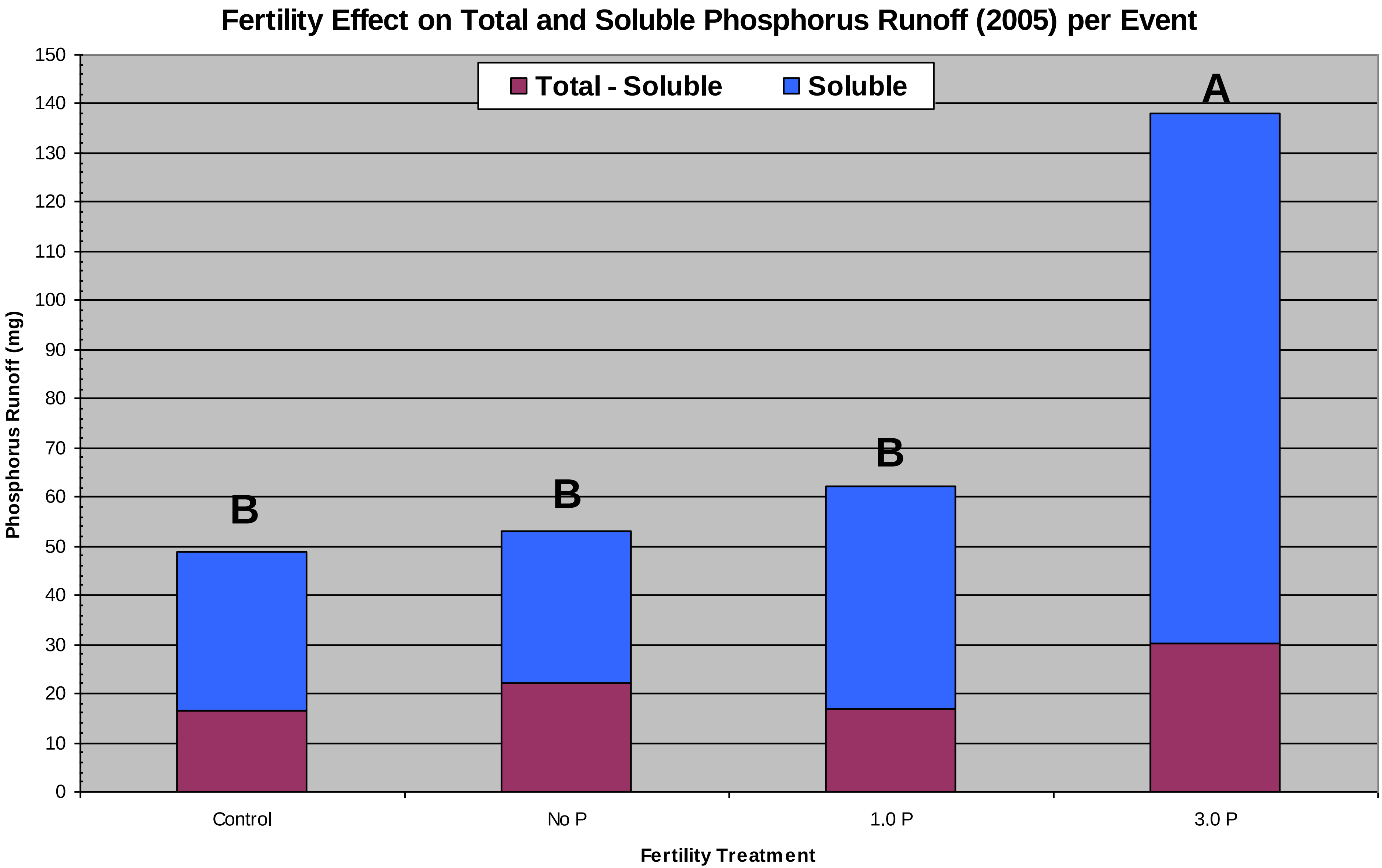
Multiple attempts, multiple techniques often necessary to "flip" the system.

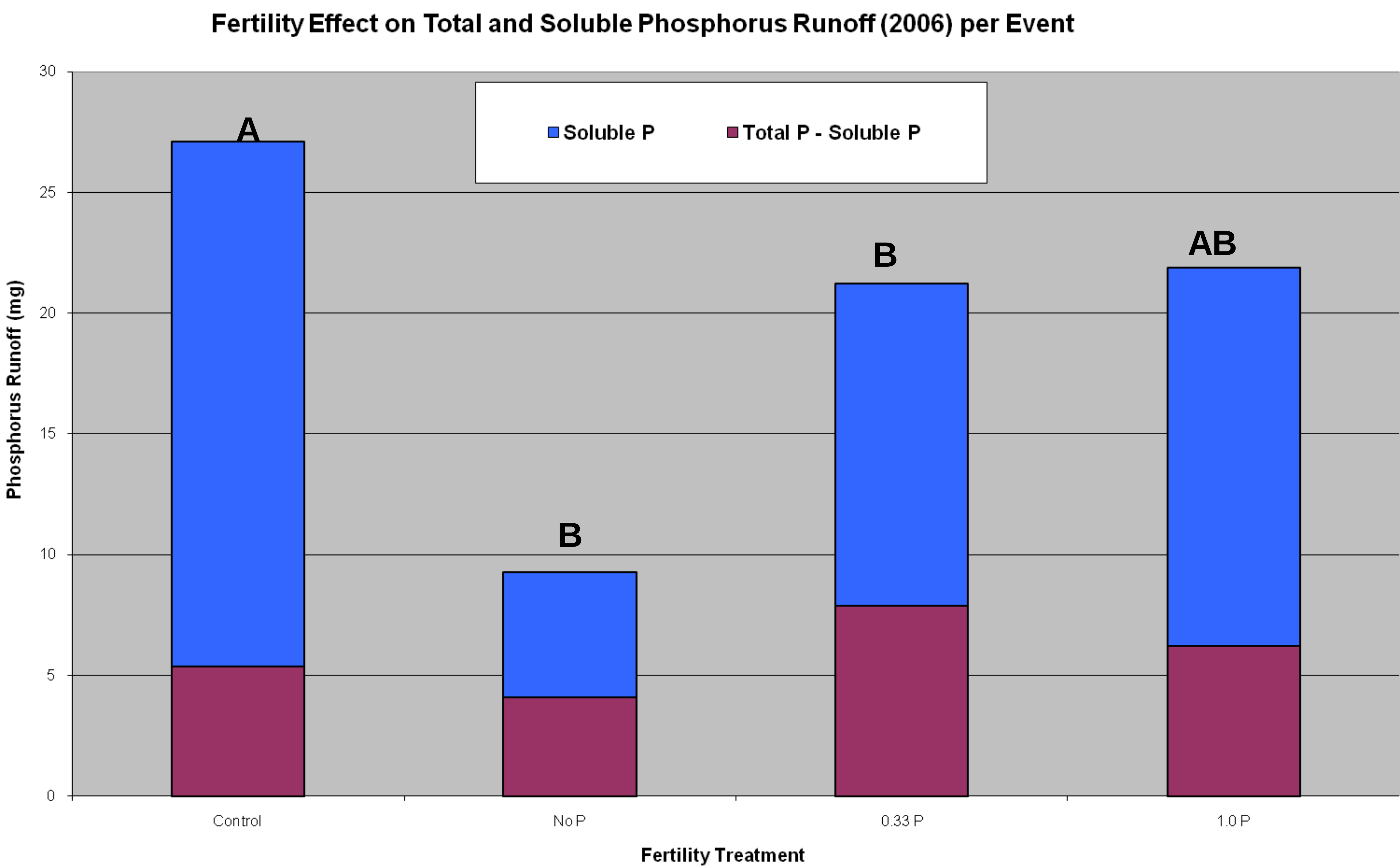


Significant Runoff Factors

(Easton and Petrovic, 2004)




Fertility Effect on Total and Soluble Phosphorus Runoff (2005) per Event
Total - Soluble
Soluble
Phosphorus Runoff (mg)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
B
B
B
A
Control
No P
1.0 P
3.0 P
Fertility Treatment



Fertility Effect on Total and Soluble Phosphorus Runoff (2006) per Event
Soluble P
Total P - Soluble P
Phosphorus Runoff (mg)
30
25
20
15
10
5
0
A
B
B
AB
Control
No P
0.33 P
1.0 P
Fertility Treatment

Management Practices to Mitigate Chemical Transport with Runoff

Aeration: Solid Tine vs. Hollow Tine

Solid Tine Aeration

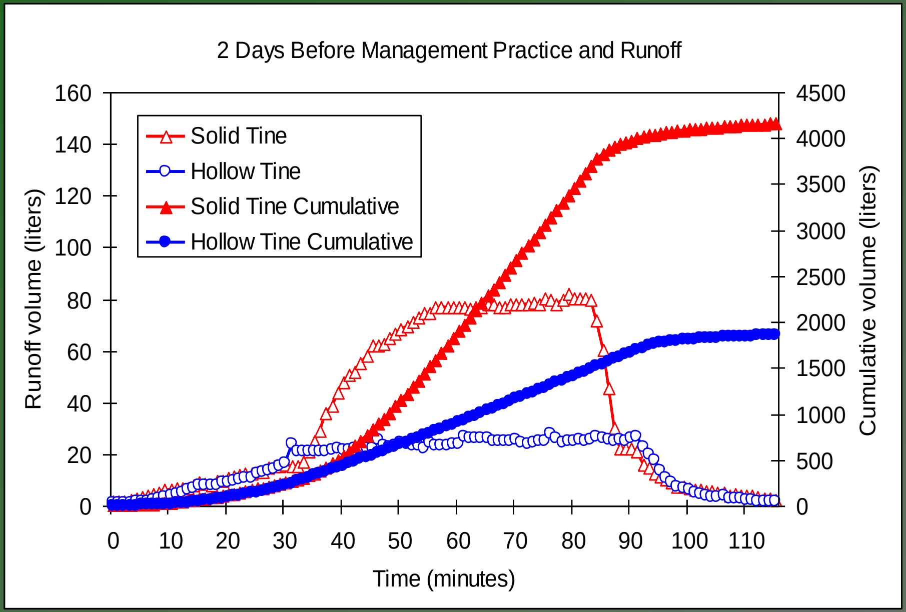
vs.

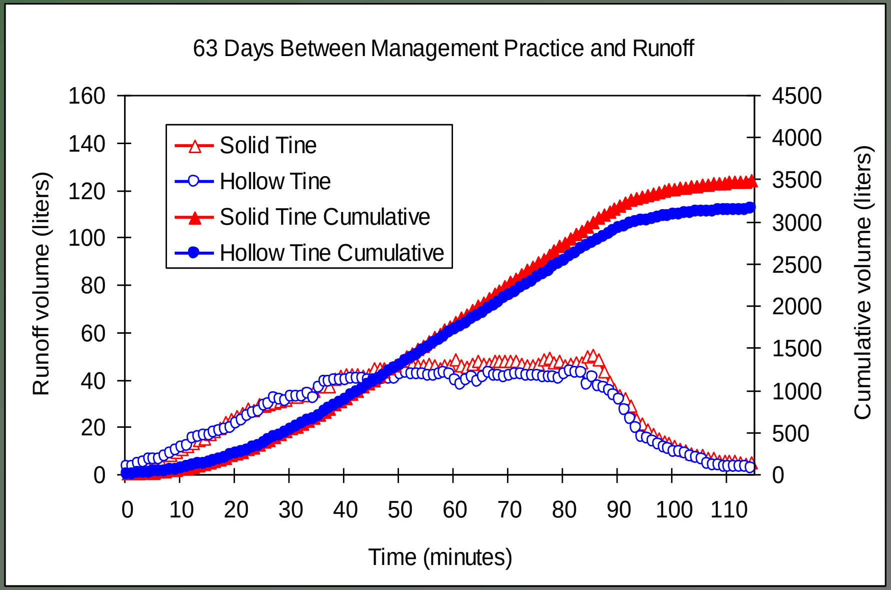
Hollow Tine Aeration

Hollow vs. Solid Tine Aerification

Reduced Runoff Volumes with Hollow Tine

(2 and 63 days between aerification and runoff)





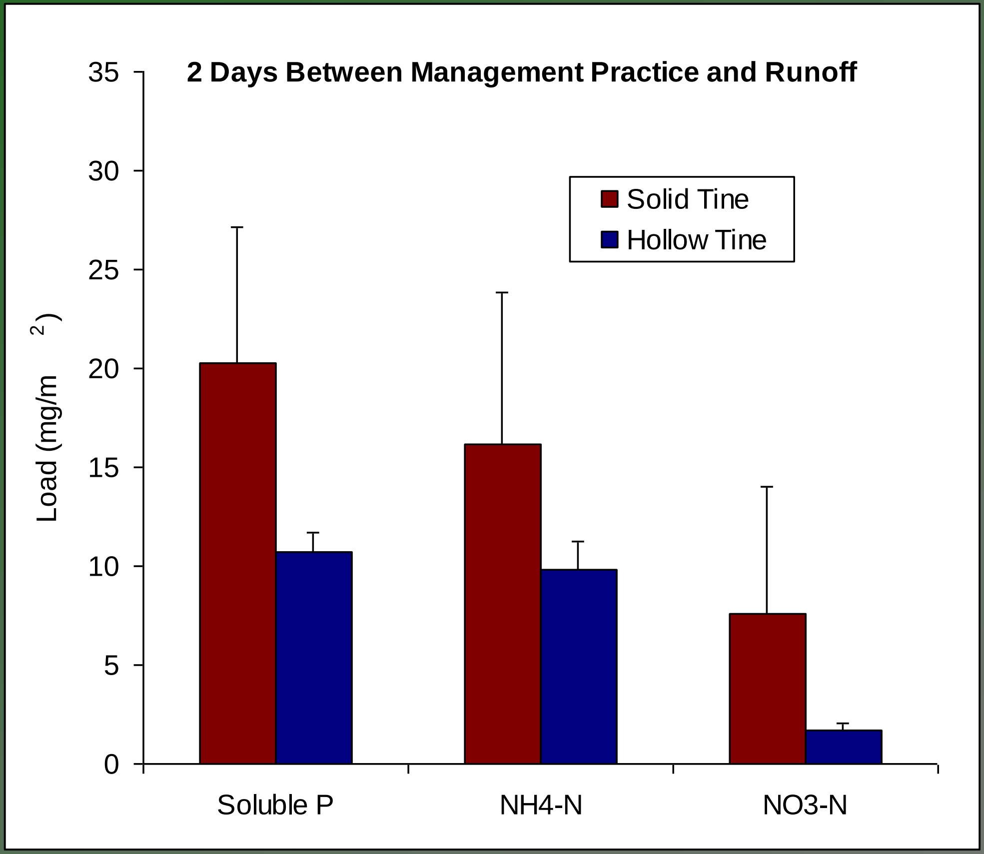
<u>Runoff volume</u>

➔ 55% reduction with hollow tine aerification (2 d)

➔ 10% reduction with hollow tine aerification (63 d)

Hollow vs. Solid Tine Aerification

Reduced Nutrient Loss in Runoff with Hollow Tine



2 Days Between Management Practice and Runoff

Soluble-P
- 44% reduction with HT

NH_4-N
- 39% reduction with HT

NO_3-N
- 77% reduction with HT

What We've Learned

- **Reducing runoff volume** with management practices will reduce chemical loading offsite
- **Soil test** to determine P need
- Fertilize when plants **actively growing**
- Consider environmental **site-risk assessment**
- Proper fertilization will **prevent** degradation of water quality

Good but can be Better

- Fate and transport is complex
- Long term research is vital to tell the story
- Connect golf courses as a community and environmental asset
- Disproportionality theory
- Simple adjustments in practices can yield huge environmental benefits