Ecosystem Services Provided by Perennial Grains in Michigan

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Perennials Grasses in Agriculture

- Natural ecosystems- <u>perennial dominated</u>
  - Tightly regulated processes
  - Minimal losses

- Agroecosystems - <u>Annual</u>, row cropping systems
  - Much greater losses
    - Removing nutrients at harvest
    - Internal inefficiencies with nutrient cycling
    - Lack of synchrony with nutrient supply and crop demand

- Annual crops commonly to take up less than 50% of the N applied as fertilizer (Cassman and Dobermann, 2002

Why not more perennials?

- Over 70% of human calories come from annual grains (Monfreda et al., 2008, Global Biogeochem Cycles)

- If perennials generally provide greater nutrient cycling efficiencies than annual crops, then why don't we utilize perennials more??
    - Lack of genetic resources: Likely specific reasons behind dominance of annual grains (Van Tassel et al., 2010, Evol Apps)

    - Potential to breed perennials for a wide range of agricultural products, including grain crops (Glover et al., 2010, Science)


Intermediate Wheatgrass *(Thinopyrum intermedium)*

Experimental Overview

Over-arching question:

"Is perenniality or management a larger driver of soil ecosystem services?"

- 2-way full-factorial split plot design
- 3 managements
  - Organic (80 lbs N/acre in chicken manure)
  - Low N Conventional (80 lbs N/acre in urea)
  - High N Conventional (120 lbs N/acre in urea)
- 2 plants
  - Annual wheat (Caledonia)
  - Intermediate wheatgrass

Measurements Taken

- Depth is important
  - 5 depths, up to 1 m
- 3 key agronomic functions
  - Nitrogen
    - Nitrate leaching
    - Soil N retention
  - Water
    - Soil moisture over 1 m
  - Carbon
    - Root biomass
    - Labile and total soil C
- Soil food webs
    - Bacterial and nematode communities
    - Soil enzyme activity

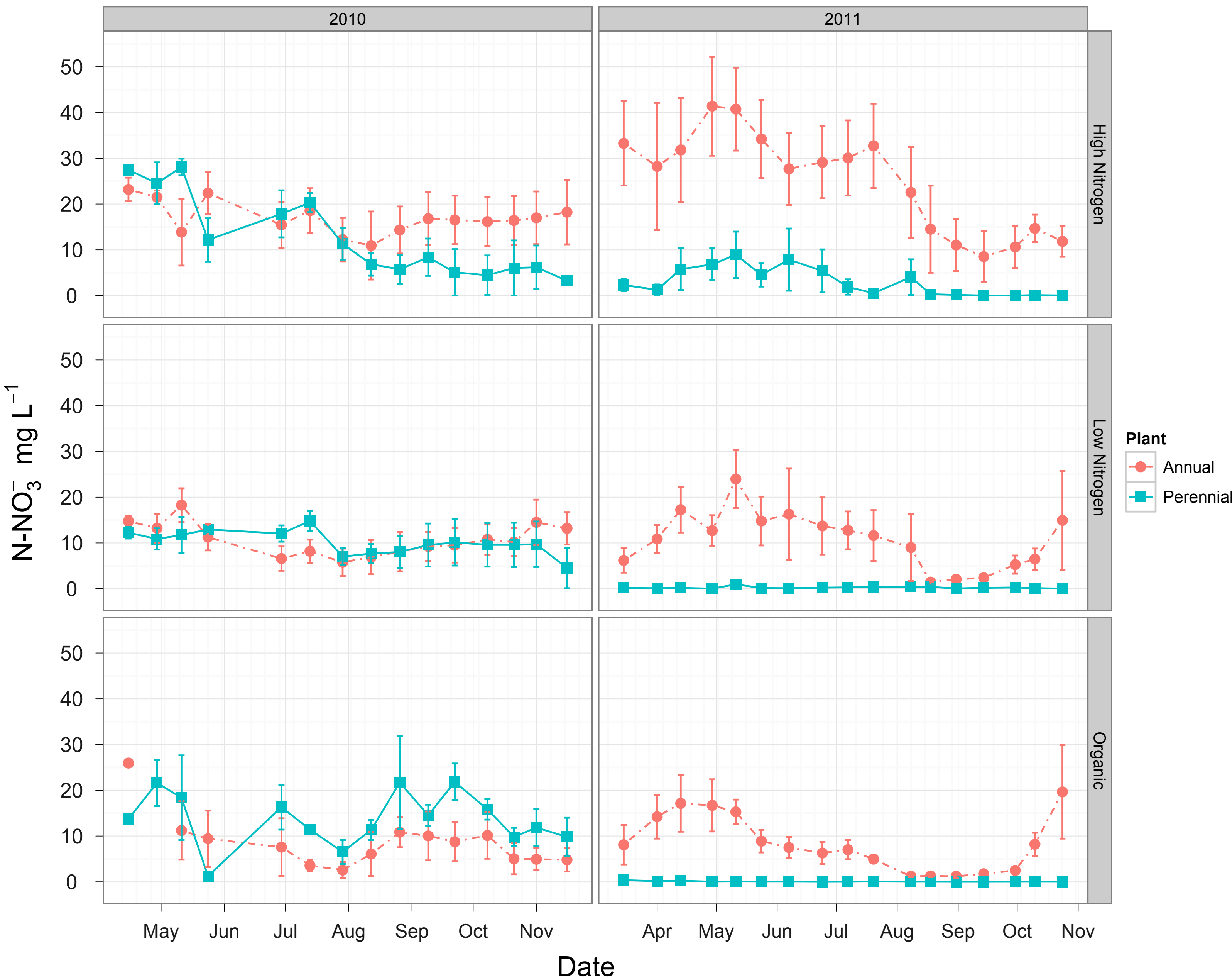

April 2010; 1st spring after planting


July 2010; 1st harvest

March 2010

Lysimeter bottle for collecting nitrate leached below rooting zone

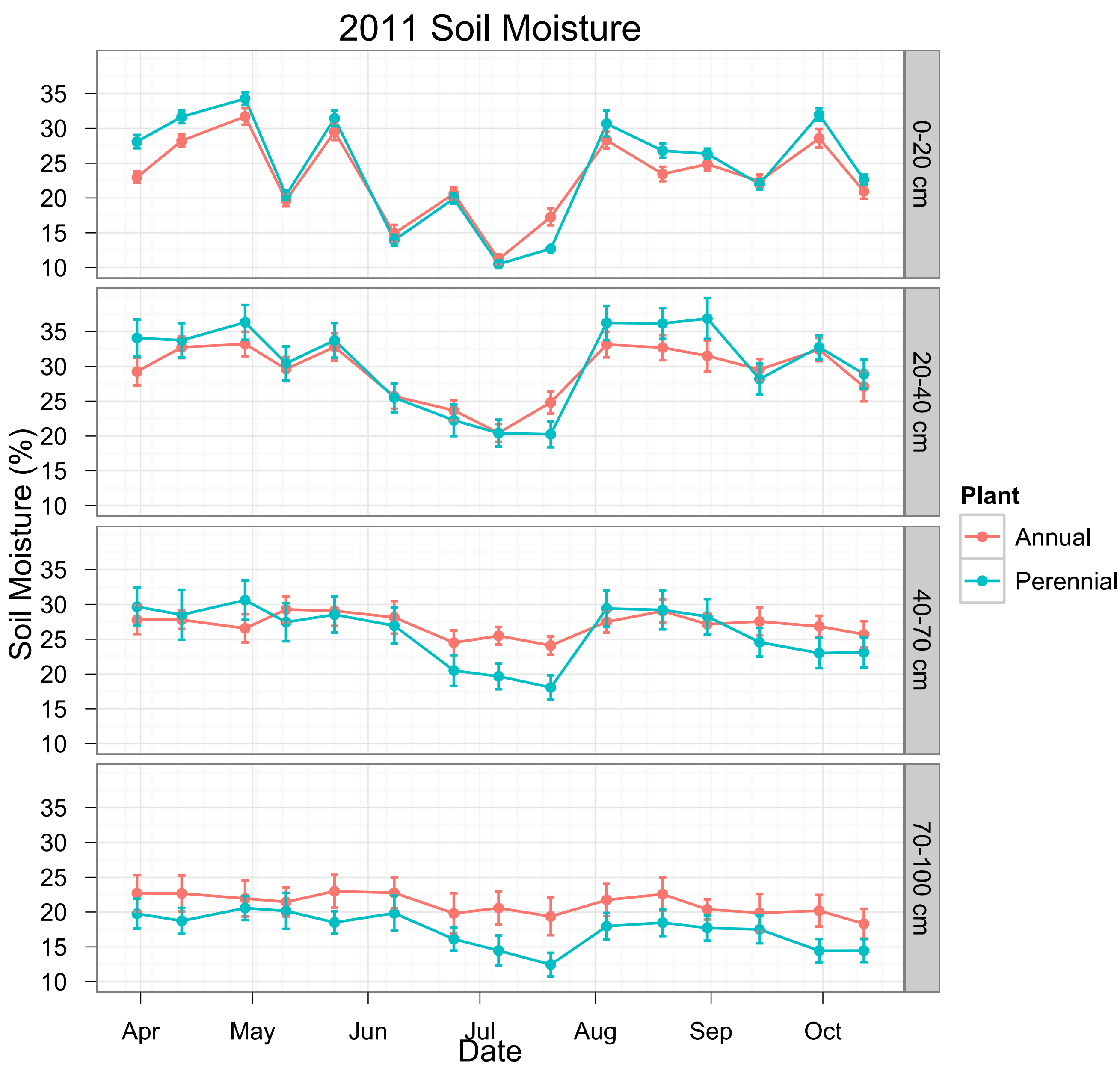
Nitrate Concentration Leached



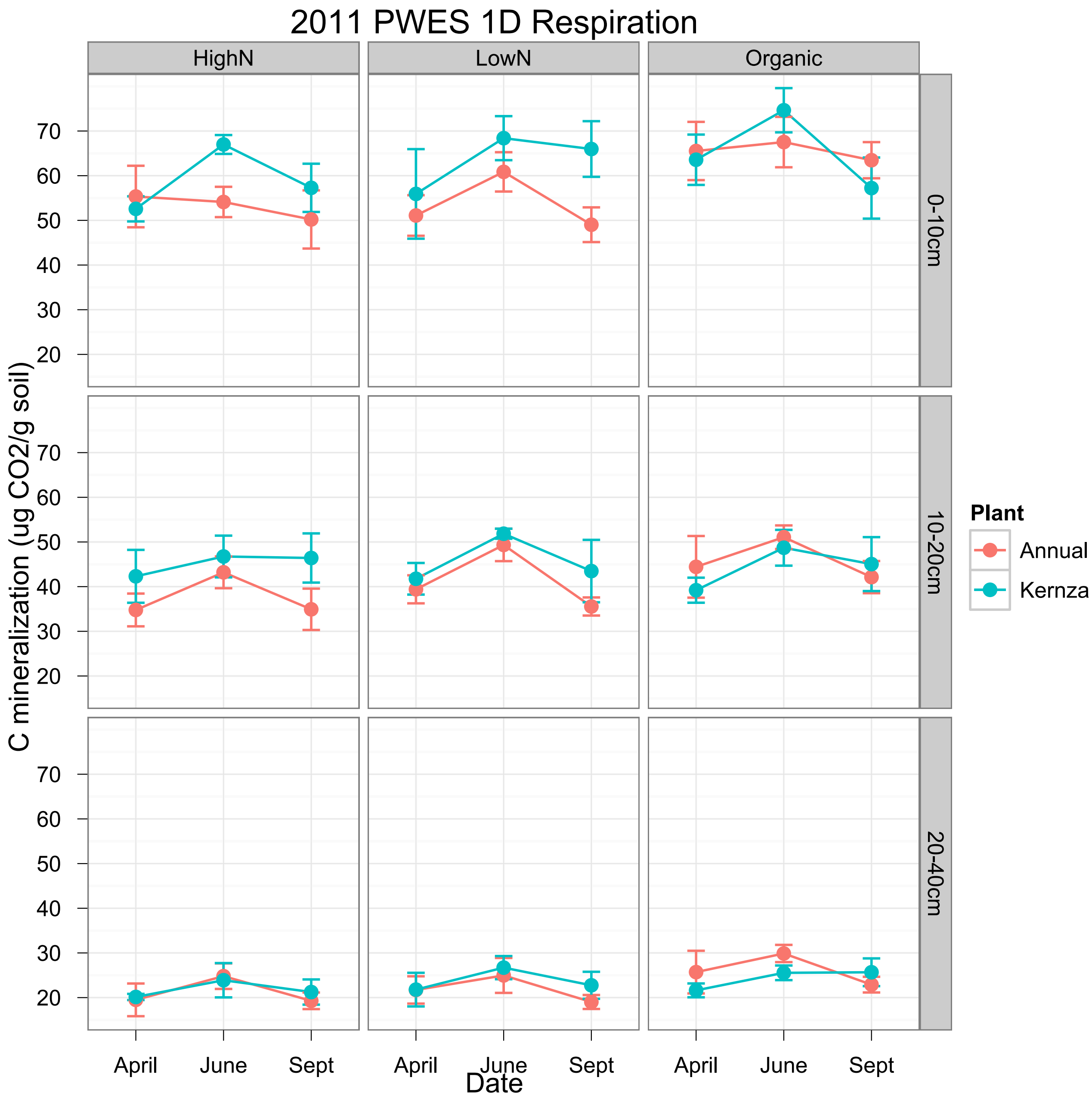
Total Nitrate Leached

Plant	Management	Total N Leached ($kg\ NO_3^-\ ha^{-1}\ yr^{-1}$)	Percent Decrease
Annual	High N	49.1	--
Annual	Low N	22.6	--
Annual	Organic	12.4	--
Perennial	High N	7.7	84
Perennial	Low N	2.3	90
Perennial	Organic	4.2	66

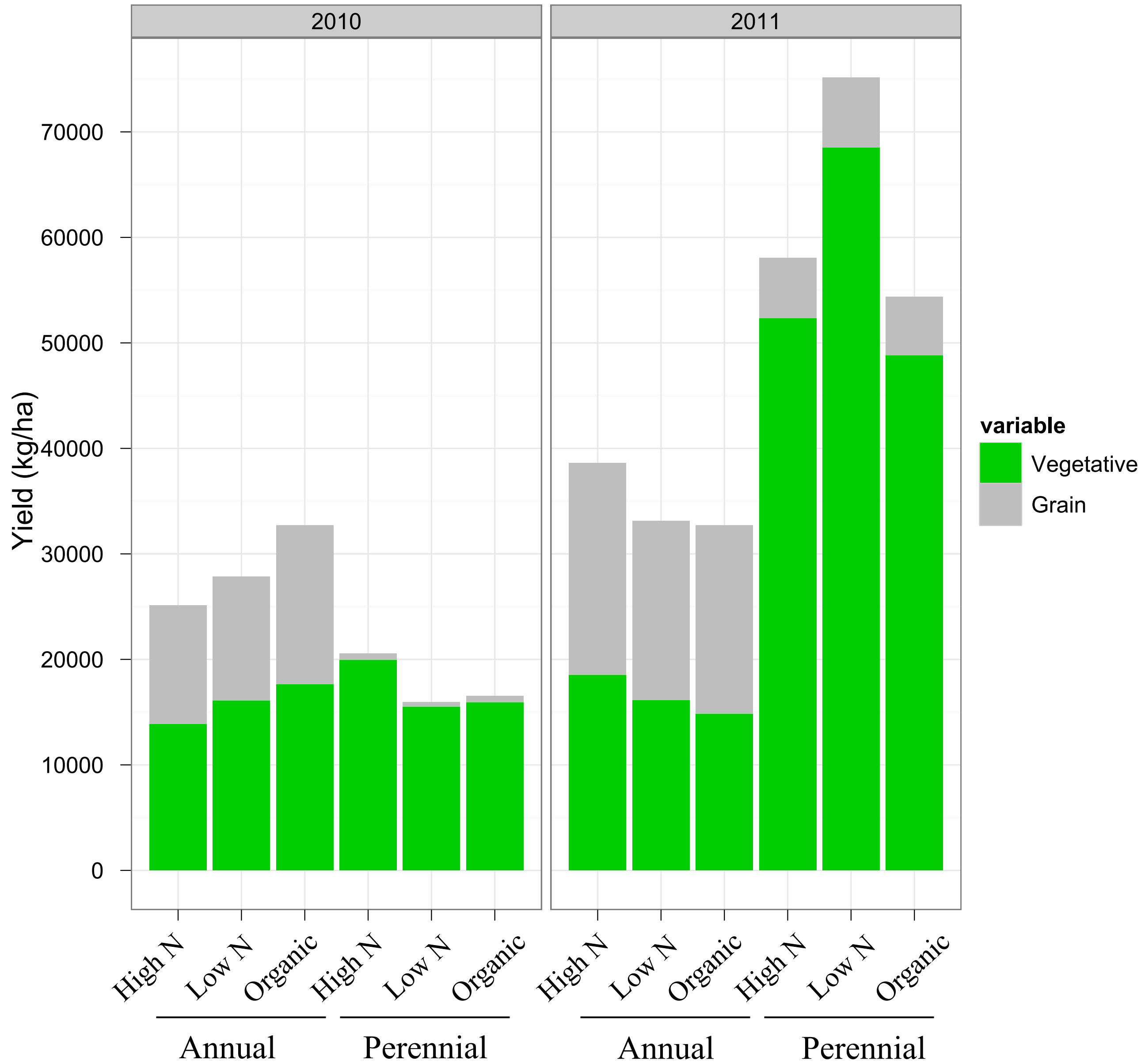
Soil Moisture



Soil Labile Carbon



Yield Data



2010
2011
Yield (kg/ha)
70000
60000
50000
40000
30000
20000
10000
0
High N
Low N
Organic
High N
Low N
Organic
Annual
Perennial
High N
Low N
Organic
High N
Low N
Organic
Annual
Perennial
variable
Vegetative
Grain

Other findings

- Soil nematodes communities were significantly affected by perenniality, not management
- Soil enzyme activity was similar across trts, but trends were associated with both management and perenniality
- Microbial community and soil N data still in process

Overall Conclusions

- Perennial nature was a larger driver of key ecosystem services than management
- More plant breeding is needed, but great potential exists for perennial grains to help mitigate negative consequences of row crop agriculture
- Trade-offs with food security?

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