Relationship Between Annual Canopy Photosynthesis and Ecosystem Respiration in Humid-Temperate Pastures

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Micrometeorological techniques (eddy covariance) were used to examine the effect of N fertilization on carbon dioxide flux from two pastures is central Pennsylvania that were managed for grazing and hay production.

Figure 1. Fertilizer application rates. The low-N pasture contained a high proportion of alfalfa in 2003-2004 and was not fertilized until 2005.

Year	High-N pasture	Low-N pasture
	kg N ha^{-1}	
2003-2007	83	26
2008-2011	217	85

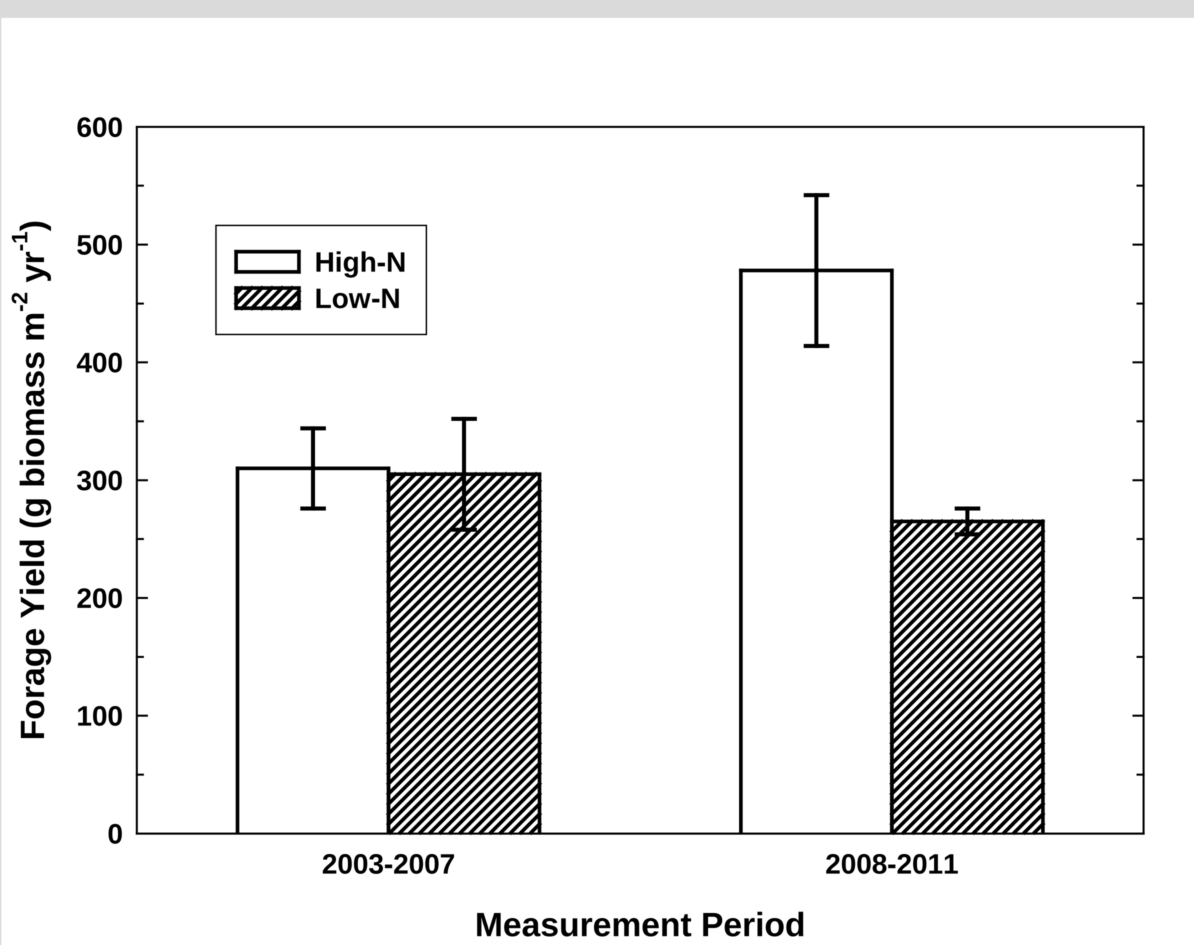

Figure 2. Increasing N fertilization rate increased forage yield on the High-N pasture by an average of 54% in 2008-2011compared with the same pasture in 2003-2007, and by 80% compared with the low-N pasture in 2008-2011. Forage yield in the low-N pasture decreased by 13% during 2008-2011 compared with 2003-2007.

Components of total ecosystem CO_2 flux

- GPP = gross primary productivity (photosynthetic input)
- RE = ecosystem respiration: includes plant and soil respiration
- NEE = net ecosystem exchange: difference between GPP and RE
- Export = harvested biomass removed minus manure returned
- NBP = net biome productivity: net change in total ecosystem C

	High-N Pasture					Low-N Pasture				
Year	GPP	RE	NEE	Export	NBP	GPP	RE	NEE	Export	NBP
2003-2007	g CO_2 m^{-2} yr^{-1}									
Mean	-5004	5076	72	325	397	-4600	4419	-181	399	218
SE	264	225	77	46	80	359	264	106	73	44
2008-2011										
Mean	-5820	5847	27	476	503	-4584	4732	148	333	481
SE	181	127	127	41	150	237	363	180	18	169

Figure 3. Carbon balance (negative values equal C uptake, positive values equal C loss): Increasing N fertilization rate at the High-N site resulted in a 16% increase in GPP in 2008-2011 compared with 2003-2007. However, RE also increased by 15% so that NEE changed only slightly. Because of the greater forage yield, exported CO_2 also increased resulting in a greater overall loss of CO_2 from the system (greater NBP). For the low-N pasture, NBP was also greater in 2008-2011 than in 2003-2007 due to a 7% increase in RE.

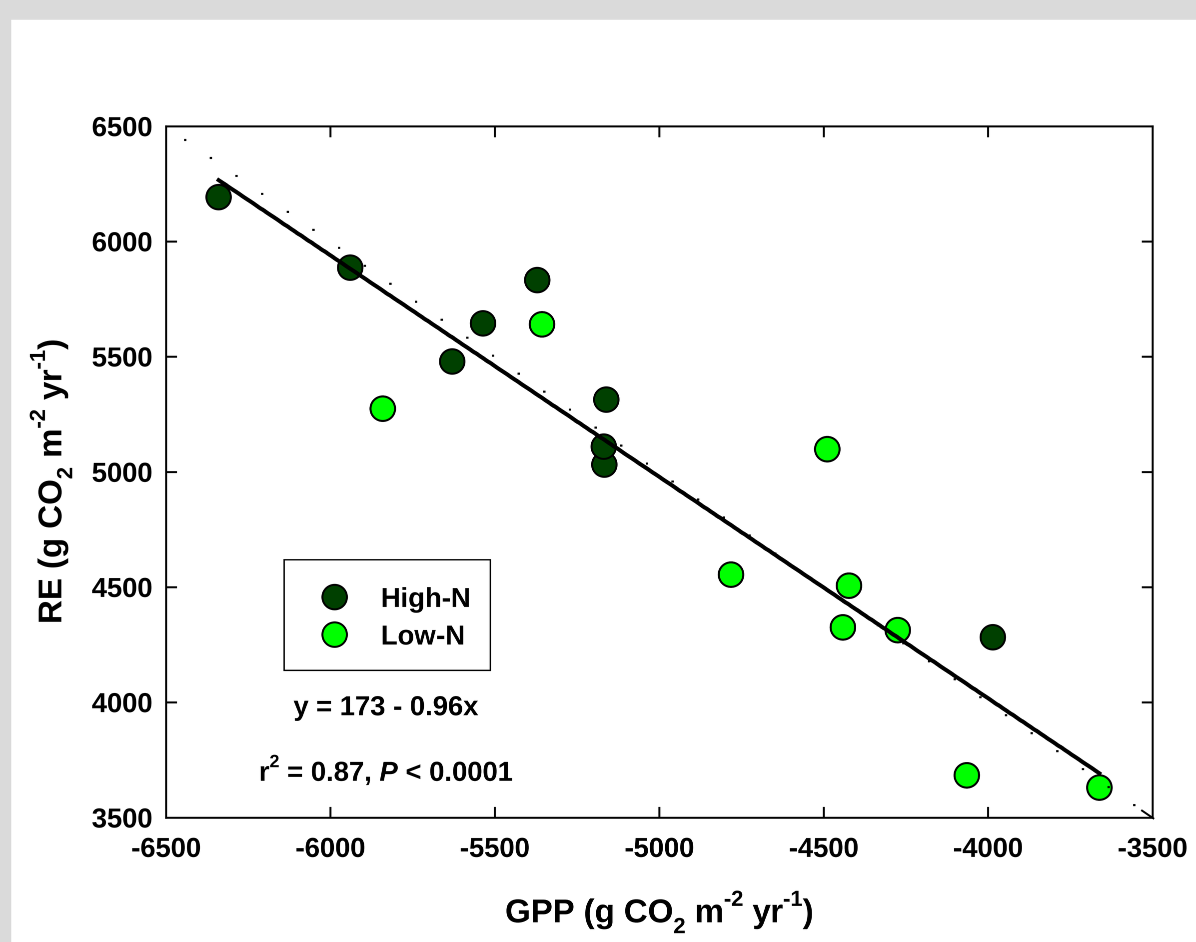

Figure 4. GPP and RE were highly correlated, consistent with studies which suggest that RE is dependent on photo assimilate supply. Pasture management did not appear to affect the relationship between GPP and RE.

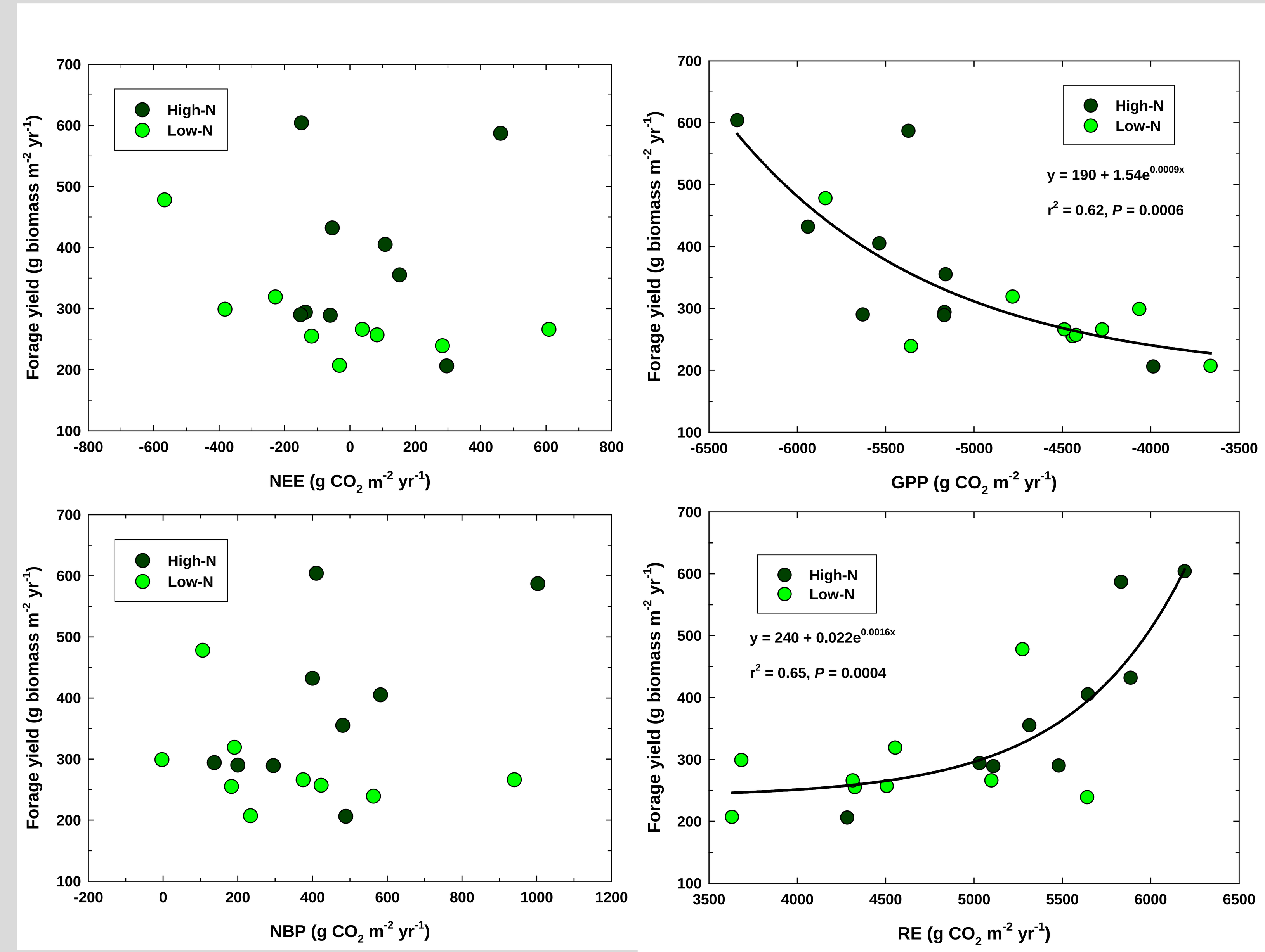

Figure 5. Forage yield was highly correlated with both GPP and RE. However, there was no significant relationship between forage yield and either NEE or NBP, suggesting that increasing pasture productivity does not necessarily increase soil C sequestration.

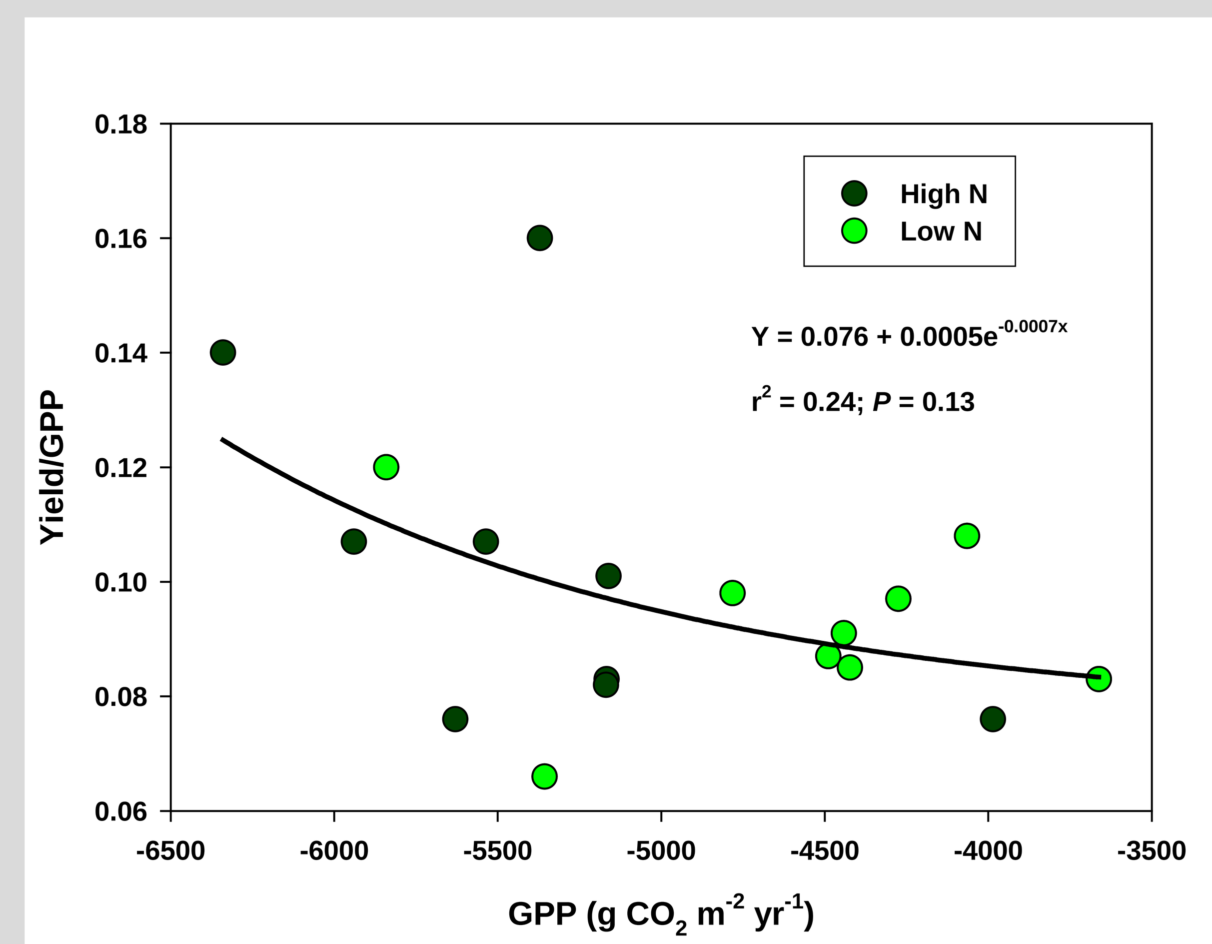

Figure 6. With low fertility, on average less than 10% of assimilated CO_2 (GPP) was recovered in harvested forage biomass. Increasing N fertilization increased average harvested biomass as a proportion of GPP to 12%.

Summary

This study found a close, nearly 1:1 relationship between GPP and RE that was not affected by N application rate. Increased N fertility was not able to change a pasture that had previously been a net source of CO_2 to the atmosphere to a net sink. Including other C inputs and outputs, such as forage removal or manure deposition caused N fertilization to increase the net loss of C from the ecosystem because of the increased forage yield and subsequent removal of harvested C.