

ABSTRACT # 5062

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This matters because:

- NANI and NAPI, alone and in combination with climate and hydrology, have been shown to be good predictors of riverine N fluxes from watersheds and other regions.
- Significant regional variation exists in NANI and NAPI, with implications for the biogeochemistry of coastal waters
- Despite regional variation, NANI and NAPI levels indicate that N:P ratios of the delivered nutrients continue to be well in excess of the Redfield ratio (Howarth et al 2021) indicating an excess of N over P delivered to coastal waters, with some regions showing increasing trends.
- Identification of the major drivers of NANI & NAPI is important for development of effective regional environmental management.

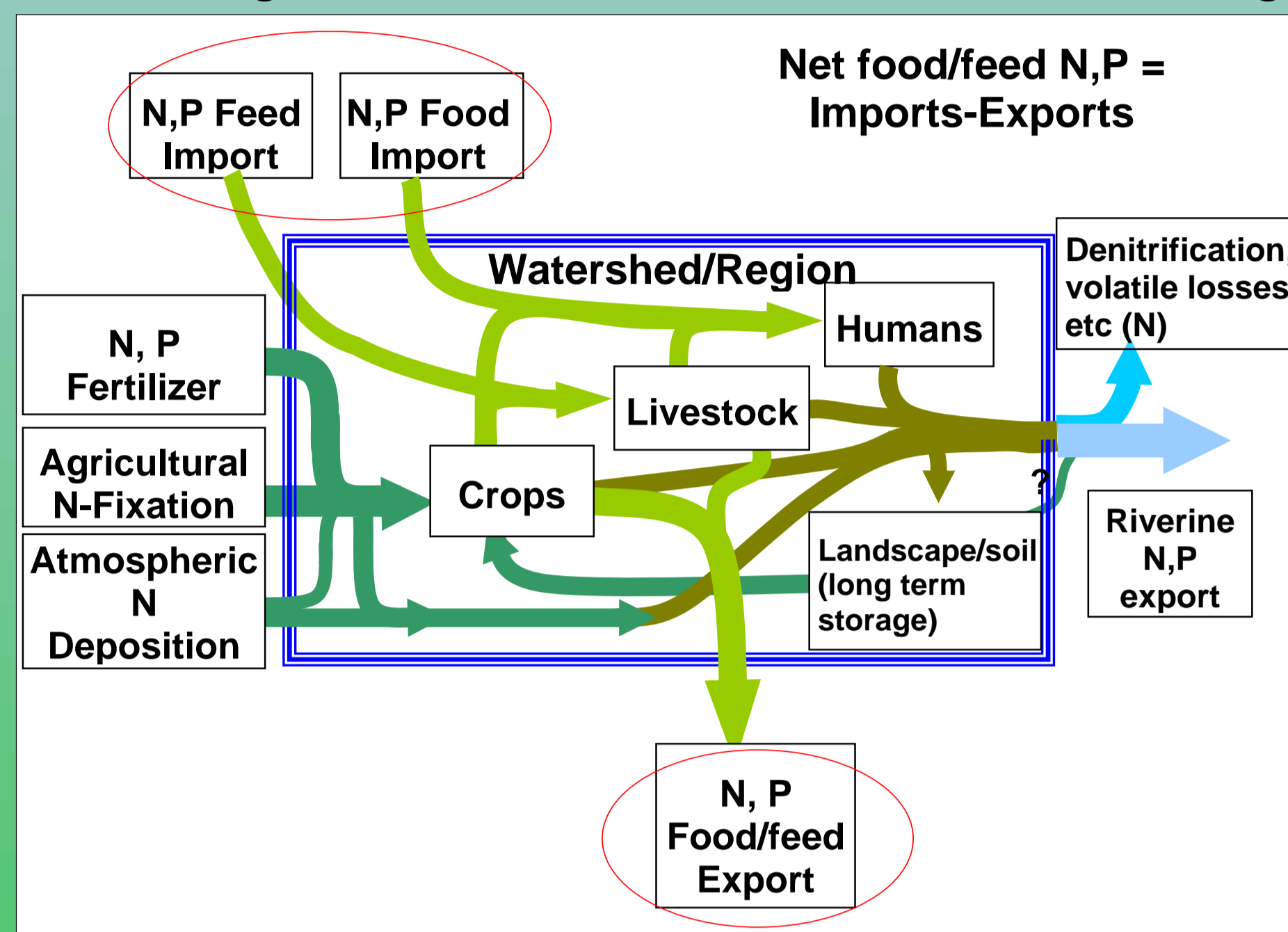
Introduction

Net Anthropogenic Nitrogen (N) and Phosphorus (P) inputs (NANI/NAPI), estimated from available county-level US census and agricultural census data and other sources, have been used successfully, together with climate data to estimate riverine nitrogen fluxes in the US, and in other countries using similar datasets.

NANI/NAPI comprise up to four terms
NAPI includes:
• mineral fertilizer inputs [1],
• net food/feed inputs to a region (calculated as the balance between local crop production and livestock and human food demand) [2,7]

Additionally, NANI includes:
• atmospheric N deposition [8-9]
• crop N fixation. [3]

Several studies have shown ~24-26% of NANI and 3-6% of NAPI typically is exported from watersheds in rivers within a few years [4,5,6].

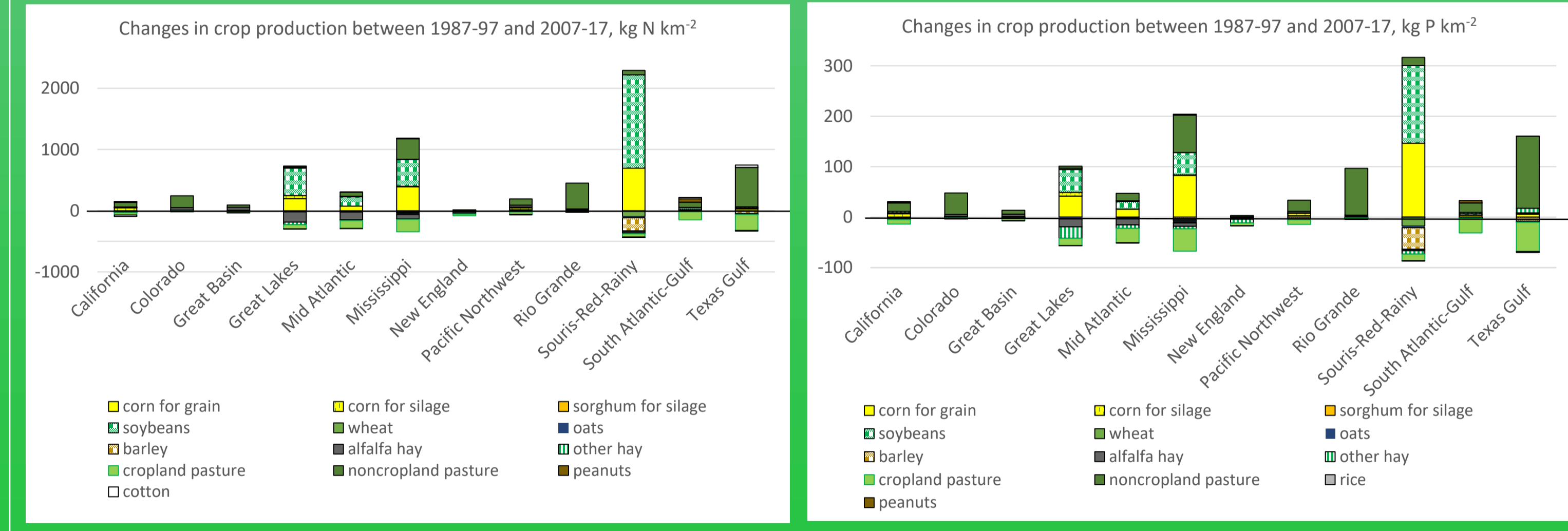
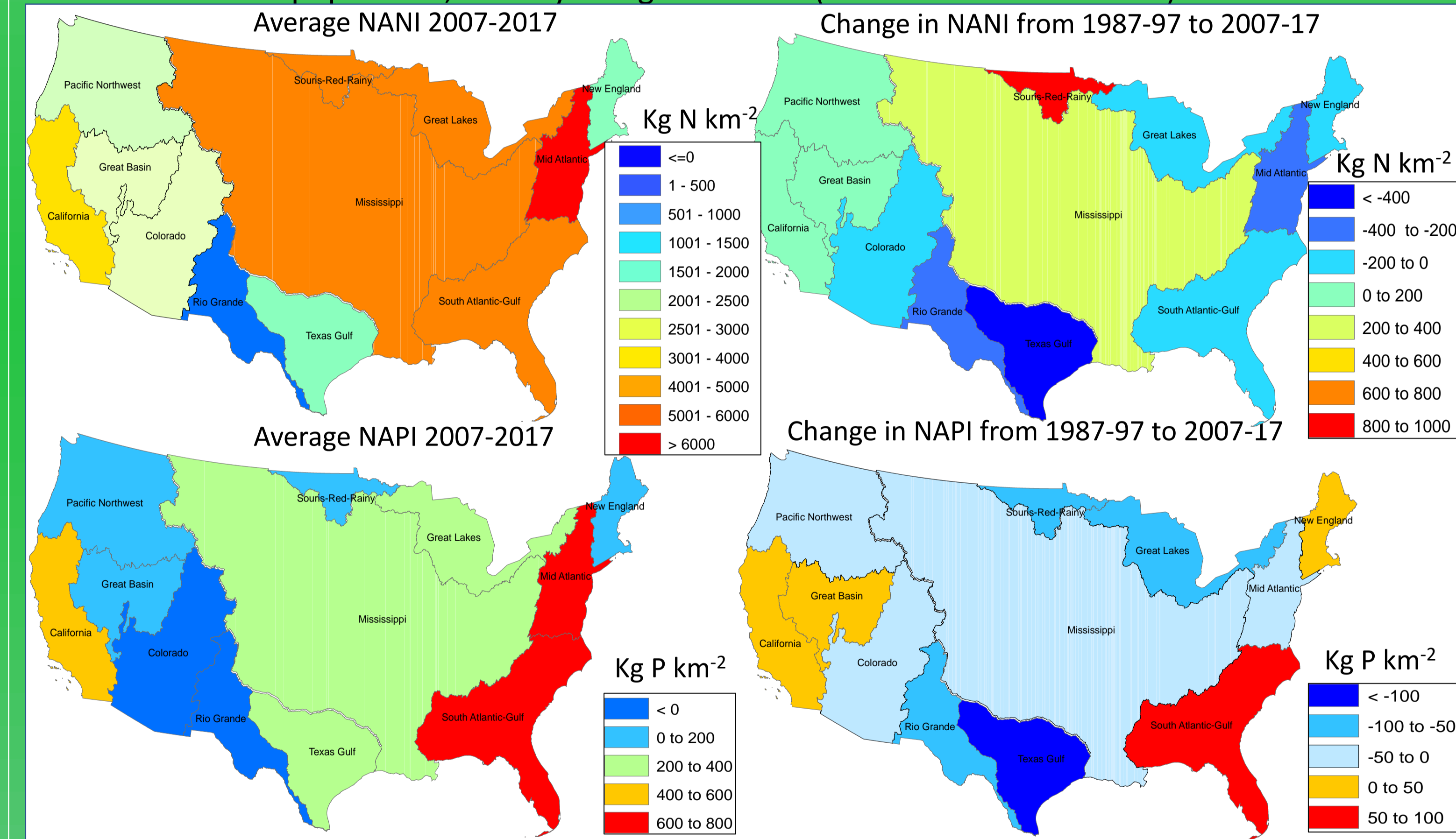


To examine regional changes in variables, we estimated the components of NANI & NAPI at the county level and then aggregated them to major water resource regions (WRRs) corresponding to 2-digit USGS hydrologic units, or combination of them, to correspond to some major river basins.

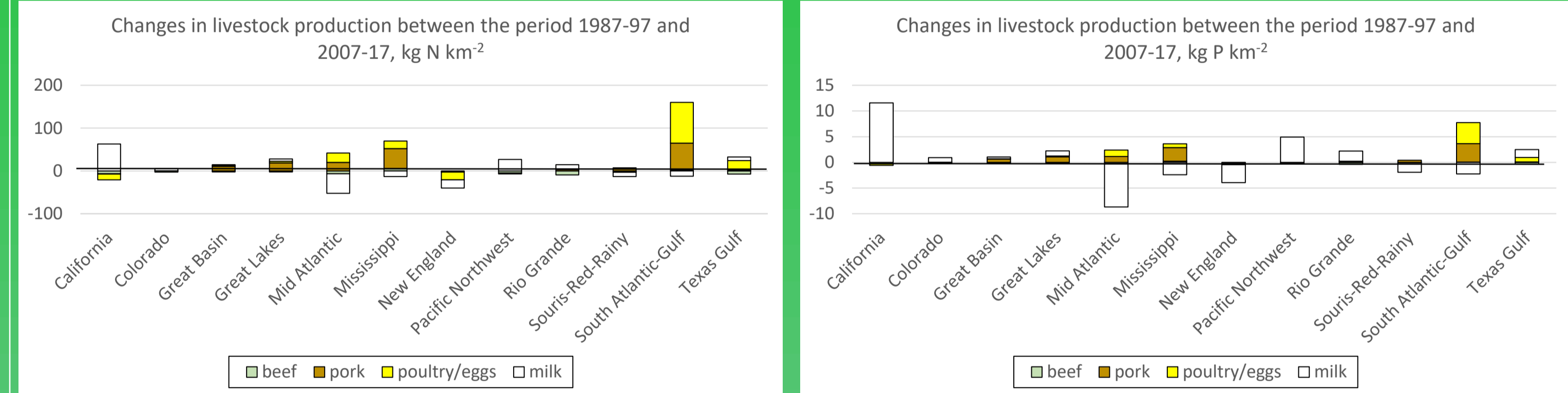
Aggregated regions considered here include the "Mississippi", which comprises 6 WRRs, and "Colorado", with 2 WRRs). Aggregated values of NANI have been used together with hydrological and climatic data to estimate riverine N fluxes in such regions. [4-6], [10]. Several studies have examined regionally-aggregated variables corresponding to large watersheds to relate NANI and NAPI to nutrient export to coastal waters. For example, Howarth et al. [4] showed significant variation in the N:P ratio of flows to coastal waters of the United states. This leads us to ask the question: **What are the major regional drivers of N and P across the United States?**



Both NANI & NAPI exhibit major regional and subregional variation (left panels, below) and have changed significantly from the 1980s to the 2010s (right panels). They are strongly driven by agricultural changes especially in the corn belt and other areas, but are also influenced by regional variation in human population, notably along the coasts (note differences in scale).

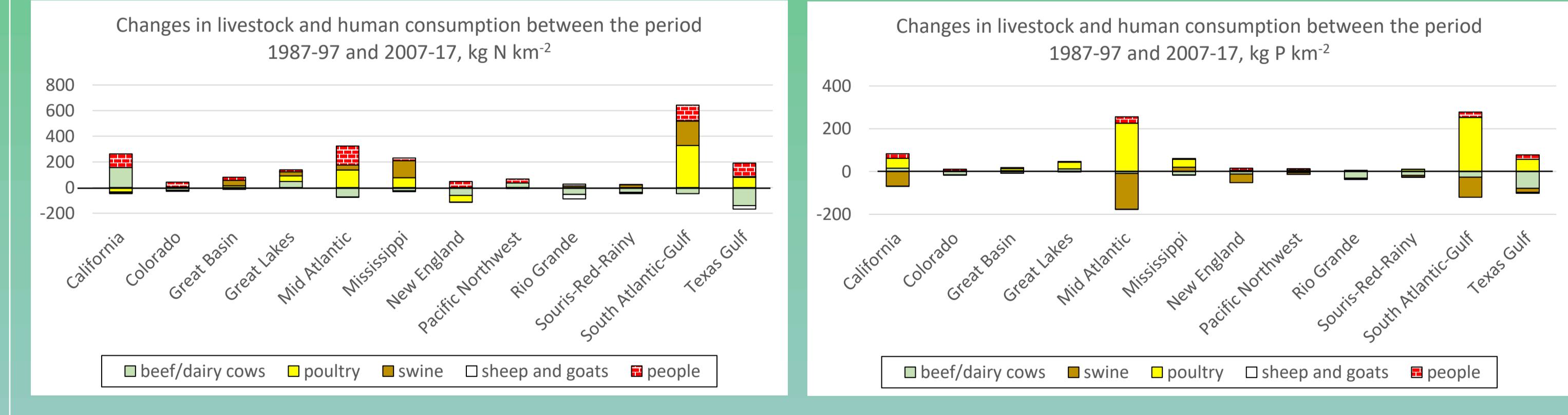


Corn and soybeans are major components of crop production across most regions of the US, and have seen considerable increases in the central regions of the country between the 1980s and 2010s, transitioning from other crops like barley. Other important shifts include changes in cropland and non-cropland pasture for grazing. These changes are manifest in the corresponding trends of N and P (note differences in scale).



Meat and other animal products have also changed dramatically between the 1980s and 2010s. Beef has generally shown declines, but pork and poultry has increased, particularly in the southeast, central mid-Atlantic regions. It should be noted that crop production dwarfs livestock production in terms of the contribution to nutrient accounting, and that the biggest impact of livestock production is on NANI over NAPI, due to the nitrogen content of animal protein, though in dairy states milk production (high P content) is an exception (again, note differences in scale).

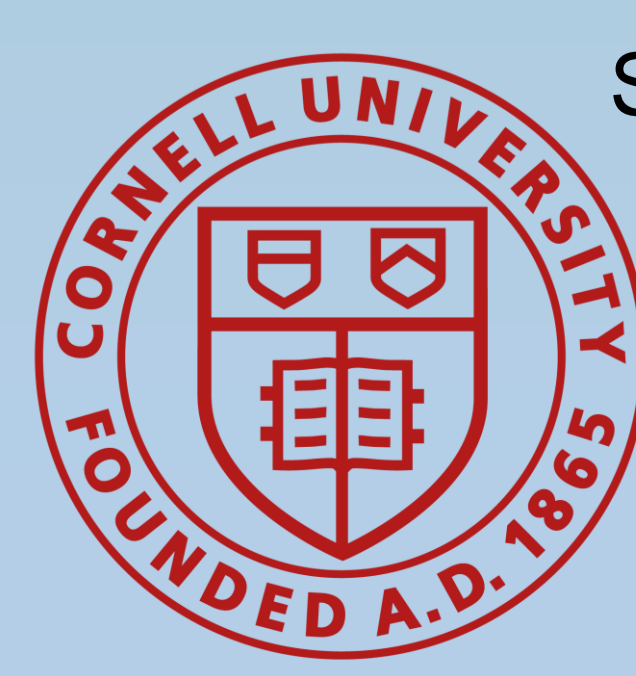
The largest components of NANI are typically N fertilizer (Nfert) and crop N fixation (Nfix). P fertilizer is the dominant component of NAPI. Net food/feed inputs (NFF), representing the deficit between local production and consumption, is negative in regions of high agricultural production, and positive in areas of high population and livestock density. The net effect of increases and decreases represents the change in NANI/NAPI between the decades. Net food/feed has become more negative, indicating an excess of local agricultural production vs consumption. Fertilizer has increased in many crop production regions, and N deposition has trended downward in most regions over time.



Human consumption has increased in all regions reflecting regional trends in populations shifts. Livestock consumption associated with poultry has apparently replaced swine in some southeastern regions, and cattle, sheep and goat production has declined in most regions, possibly reflecting dietary preferences. Note differences in scale.

Take home messages:

- Regional variations in agriculture and human population drive associated variations in NANI and NAPI across the US
- Human and livestock demand in excess of local crop production represents interregional transfers or imports of nutrients.
- Corn and soybeans have shown significant increases in many regions, with associated increases in fertilizer (particularly N fertilizer)
- There have been significant regional shifts in livestock production (e.g. beef -> pork, poultry); associated feed consumption dwarfs production.



Scan the qr code for more references and a copy of the poster. Our lab website is: <https://www.research.howarthlab.org/NANI/NAPI.php>

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