STS Ag team update. December 7, 2023.

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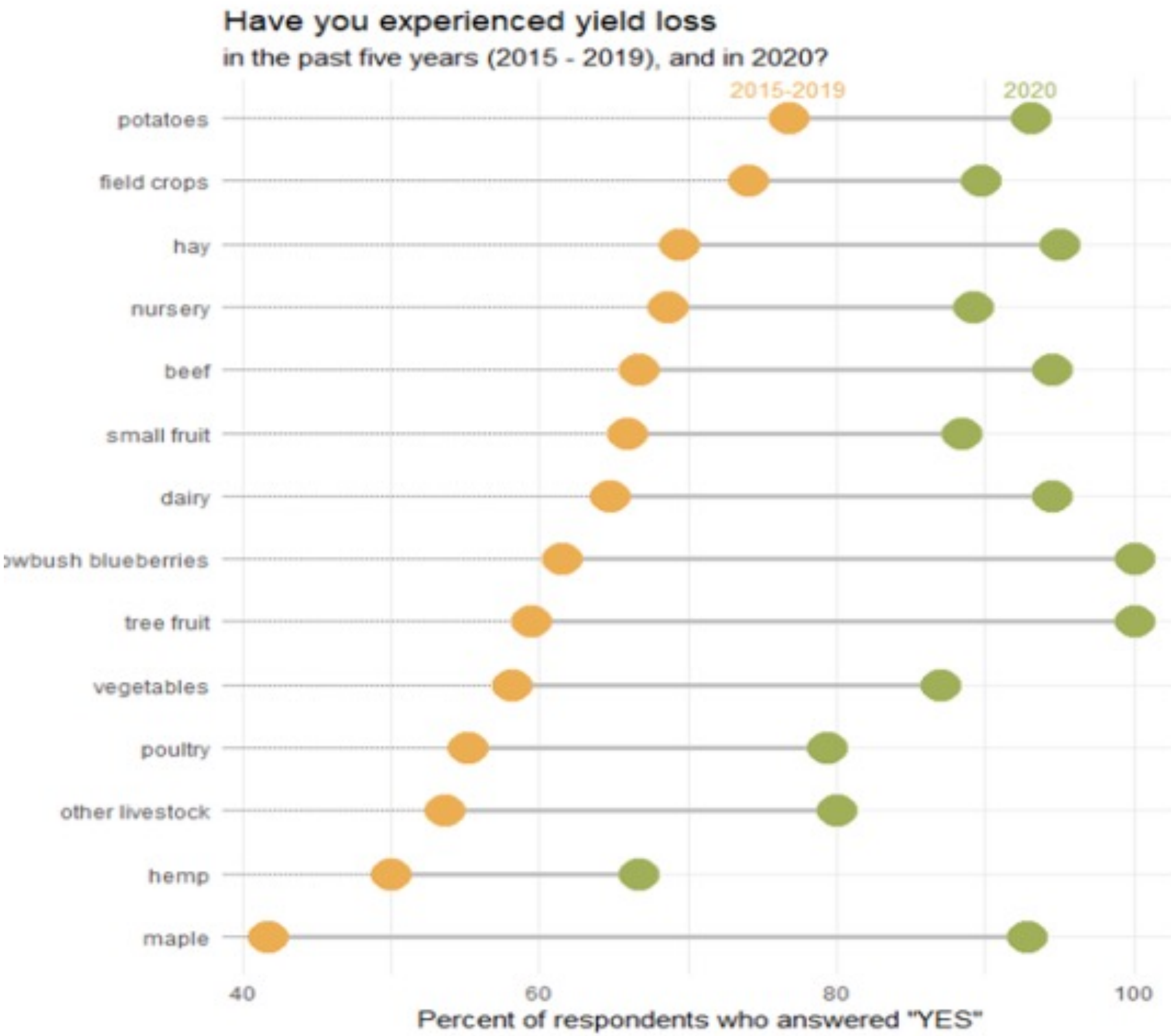
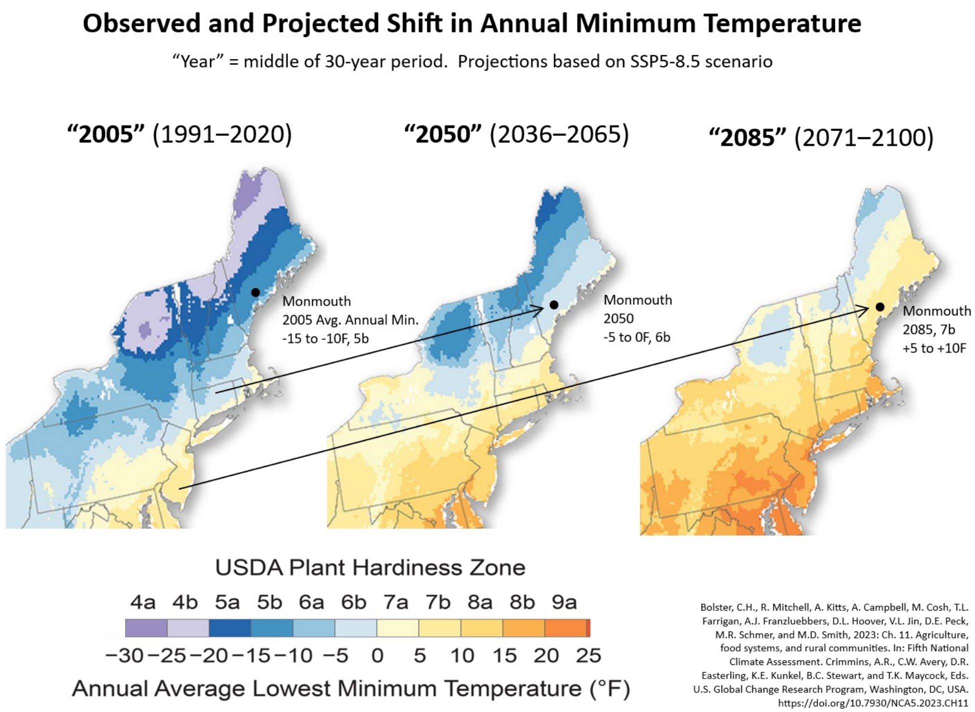
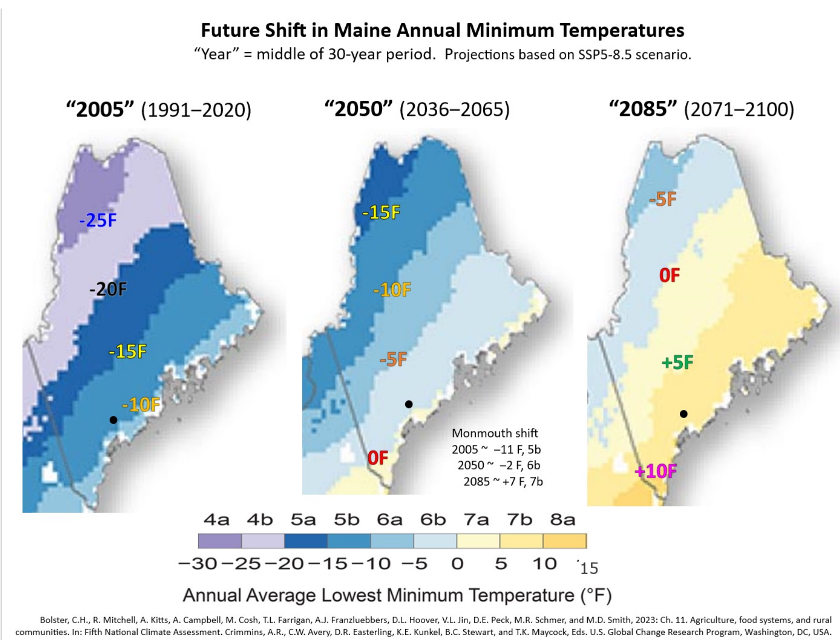
Weather variability is reducing Maine crop yields

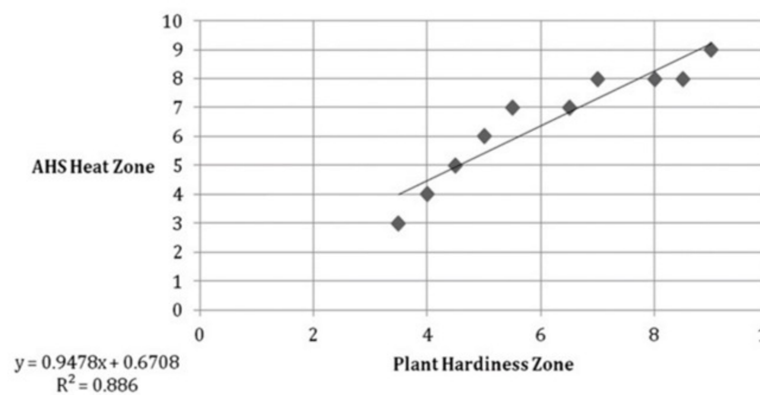


Survey responses are from BEFORE the very difficult weather for farmers in 2023 (May freeze, abundant and frequent rains in July and August, rainy weekends September and October that reduced PYO customer turnout.)



New opportunities for Maine agriculture are likely with warmer temperatures and longer growing seasons.



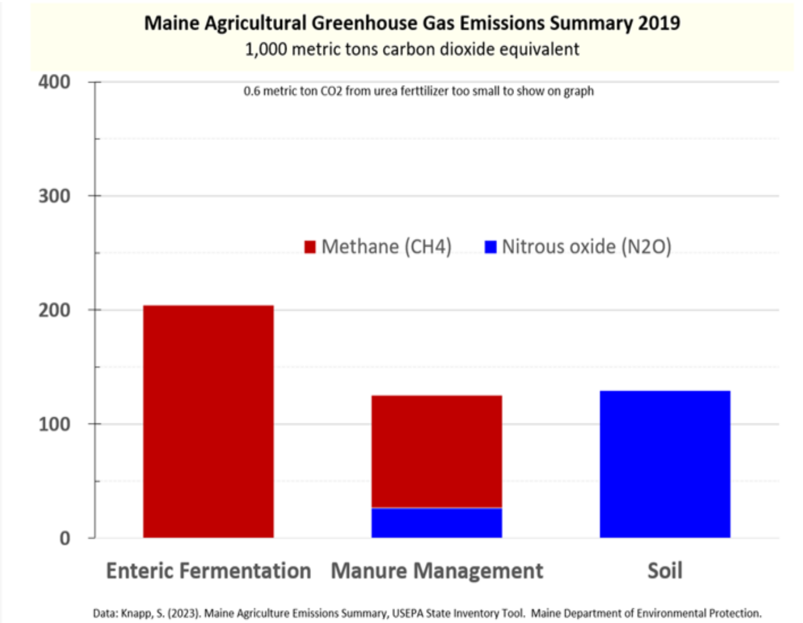


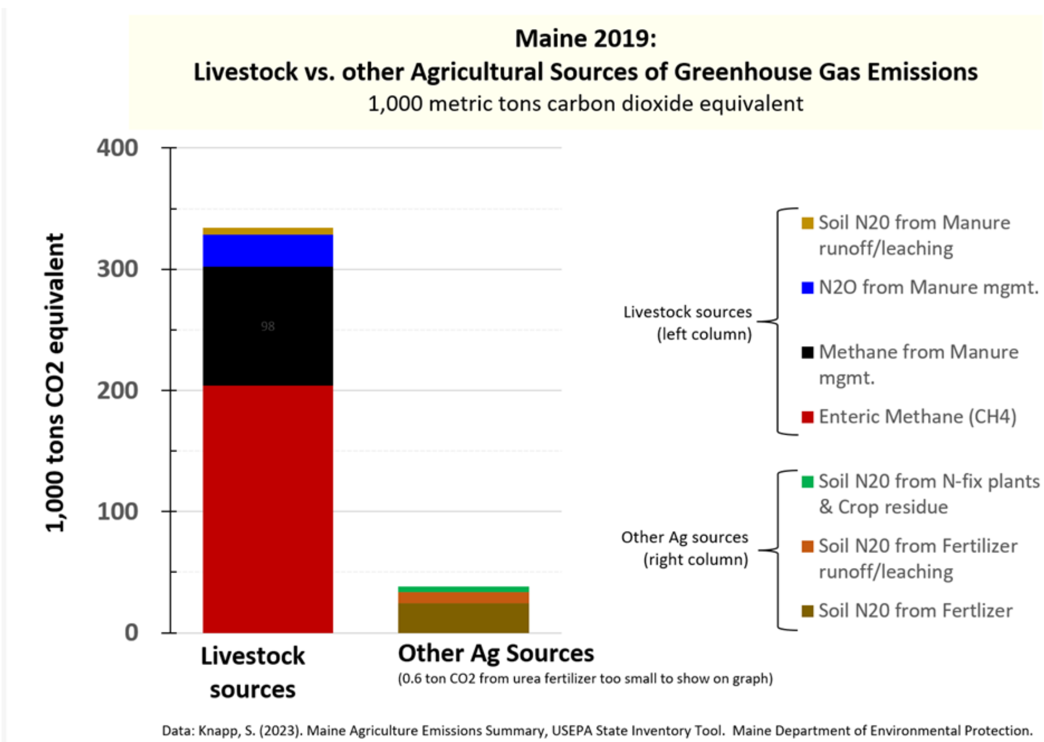
USDA Plant Hardiness Zones (average annual minimum temperature) are only one measure of agricultural climatic suitability, but they correlate with other measures (e.g. horticultural heat zone)

Global and national food production, supply, and pricing are threatened by climate change.

Keane and Neal (2020): **Technical progress and adaptation without global greenhouse gas emissions reductions will generate yield growth that lags far behind population growth. An optimistic projection of technical change, combined with moderate to substantial emissions reductions and adaptation could in combination achieve yield growth roughly in line with population growth**

However, this scenario deteriorated quickly under even slightly less optimistic technology projections. A striking feature was the wide variability of projections across climate models. Even the more optimistic emission / technology / adaptation scenarios pointed to adverse outcomes.





Livestock (primary dairy cows) are the primary source of Maine agricultural GHG emissions. Beef and milk are cited as the foods with the highest GHG emissions (e.g. Poore and Nemecek 2018). An alternate perspective is that ruminant methane emissions are converted to carbon dioxide within 12 years and are part of a biogenic carbon cycle whereby the carbon released is taken up by the plants used as livestock feed (Muñoz and Schmidt, 2016).

In this perspective livestock emissions do not add carbon to the atmosphere but simply recycle it. In addition, an alternate method to calculate the effect of livestock methane on global temperature has been developed that estimates much lower impact (Cain et al. 2019).

Food Commodity	Relative Nutritional Unit (NU) for weighting impacts	% of maximum across all 5 categories	Greenhouse gas emissions (kg CO_2 eq./NU)	Land use (m^2 /NU)	Terrestrial acidification (g SO_2 eq./NU)	Aquatic eutrophication (g PO_4 eq./NU)	Freshwater withdrawal (1000 gals per NU) vs. local water scarcity
Average of 42 foods	na	**10.2%**	**3.5**	**10**	**24**	**22**	**6.2**
Median of 42 foods	na	**4.0%**	**1.4**	**2.2**	**8.6**	**5.4**	**2.8**
Beef (beef herd)	0.50 kg fat-free, bone-free meat. 100 grams protein.	**74%**	50	164	160	151	4.6
Beef (dairy herd)	0.50 kg fat-free, bone-free meat. 100 grams protein.	**56%**	17	22	174	185	16
Lamb & Mutton	0.50 kg fat-free, bone-free meat. 100 grams protein.	**49%**	20	185	69	49	19
Shrimp & other crustaceans (farmed)	0.67 kg edible. 100 grams protein.	**44%**	18	2.0	90	154	23
Pork (pig meat)	0.63 kg fat-free, bone-free meat. 100 grams protein.	**24%**	7.6	11	88	47	11
Fish (farmed)	0.44 kg edible fish. 100 grams protein.	**19%**	6.0	3.7	29	103	4.8
Poultry meat	0.59 kg fat-free, bone-free meat. 100 grams protein.	**14%**	5.7	7.1	59	28	2.2
Eggs	0.91 kg. 100 grams protein.	**12%**	4.2	5.7	48	20	4.3
Cheese	0.46 kg. 100 grams protein.	**31%**	11	40	75	45	22
Cow Milk (pasteurized, 4% fat)	1 liter. 100 grams protein.	**7.9%**	3.2	9.0	20	11	5.2
Soymilk 1%	1 liter. 100 grams protein.	**1.0%**	1.0	0.7	2.6	1.1	0.3
Tree Nuts (almond, Brazil nut, cashew, pecan, walnut)	0.63 kg shell-free dried nuts. 100 grams protein.	**21%**	0.3	7.9	28	12	37
Peanuts & other groundnuts	0.39 kg shell-free dried nuts. 100 grams protein.	**5.1%**	1.2	3.5	8.6	5.4	6.2
Dry Beans (chickpea, fava bean, lentils)	0.48 kg dried without pod. 100 grams protein.	**4.4%**	0.8	7.3	10	8.0	2.8
Peas	0.45 kg. 100 grams protein.	**2.8%**	0.4	3.4	3.8	3.4	3.3
Tofu (soybean curd)	0.63 kg. 100 grams protein.	**2.3%**	2.0	2.2	4.2	3.9	0.8
Rice (flooded)	0.27 kg full grain. 1000 kcal.	**4.0%**	1.2	0.8	7.4	9.5	3.6
Wheat & Rye (bread)	0.37 kg. 1000 kcal.	**2.7%**	0.6	1.4	5.0	2.7	3.3
Oatmeal 2%	0.39 kg. 1000 kcal.	**2.4%**	1.0	2.9	4.1	4.3	1.9
Potatoes	1.43 kg. 1000 kcal.	**1.9%**	0.6	1.2	5.3	4.8	1.0

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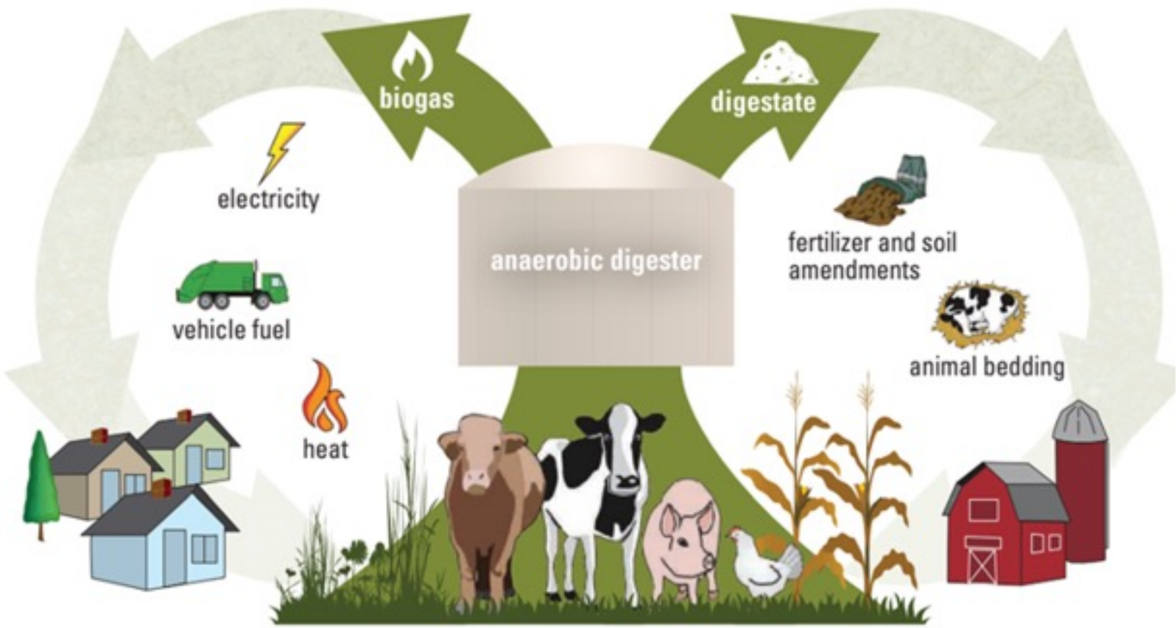
Median of 42 foods	na	**4.0%**	**1.4**	**2.2**	**8.6**	**5.4**	**2.8**
Corn (cornmeal)	0.22 kg. 1000 kcal.	**0.9%**	0.4	0.7	2.6	0.9	0.6
Cassava	1 kg. 1000 kcal.	**1.2%**	1.4	1.9	3.5	0.7	0.0
Tomatoes	1 kg	**4.3%**	2.1	0.8	17	7.5	1.4
Brassicas (broccoli, kale, Brussel sprout, cabbage, cauliflower)	1 kg	**2.7%**	0.5	0.6	8.2	5.0	2.2
Other Vegetables (cucumber, green beans, green peas, lettuce)	1 kg	**1.8%**	0.5	0.4	6.4	2.3	1.3
Onions & Leeks	1 kg	**1.1%**	0.5	0.4	3.6	3.2	0.3
Root Vegetables (beet, carrot, onion, rutab., sw.pot., turnip)	1 kg	**0.8%**	0.4	0.3	2.9	1.6	0.3
Berries and Grapes	1 kg	**5.3%**	1.5	2.4	12	6.1	5.6
Apples	1 kg	**2.3%**	0.4	0.6	3.5	1.5	3.4
Bananas	1 kg	**1.7%**	0.9	1.9	6.4	3.3	0.2
Citrus fruit	1 kg	**1.5%**	0.4	0.9	4.0	2.2	1.2
Olive oil	1.0 liter refined oil	**33%**	5.4	26	38	37	47
Sunflower oil	1.0 liter refined oil	**16%**	3.6	18	28	51	9.6
Canola oil (rapeseed)	1.0 liter refined oil	**9.2%**	3.8	11	29	19	2.8
Soybean oil	1.0 liter refined oil	**8.4%**	6.3	11	16	12	3.9
Palm oil	1.0 liter refined oil	**6.4%**	7.3	2.4	18	11	0.0
Cane sugar	1 kg	**7.3%**	3.2	2.0	18	17	4.3
Beet sugar	1 kg	**4.0%**	1.8	1.8	13	5.4	2.5
Dark Chocolate	50 grams	**2.1%**	2.3	3.5	2.3	4.4	0.0
Coffee	1 cup from 15 grams roasted, ground beans	**0.5%**	0.4	0.3	1.3	1.7	0.0
Beer (5% alcohol, barley)	200 ml	**0.3%**	0.2	0.2	1.3	0.5	0.0
Wine (12.5% alcohol)	80 ml	**0.2%**	0.1	0.1	1.0	0.4	0.0

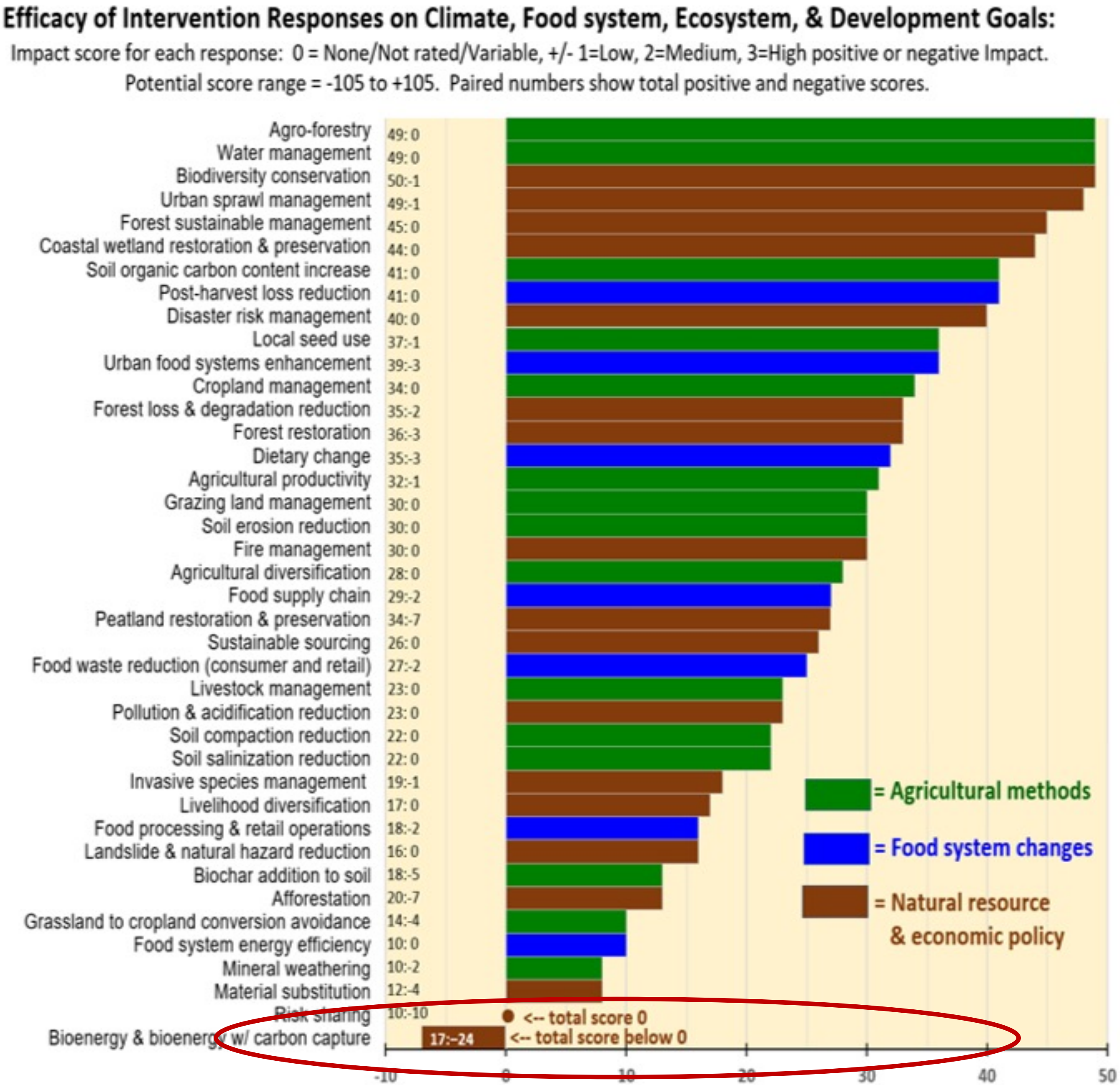
Maine dairy farmers have adopted feed additives for methane reduction

Anaerobic manure digesters can also serve to reduce GHG emissions from livestock manure AND food waste.

Does promotion of anaerobic manure digesters act as a disincentive against a more plant-based diet? (if that is an objective)



New technology may allow for reduced GHG emission from synthetic N fertilizer production



Adapted from: McElwee P, Calvin K, Campbell D, et al. 2020.

Bio energy carbon capture and sequestration (BECCS) creates negative consequences for land use and food supply.

It may have utility within defined geographic or economic domains (and possibly Maine agriculture) but at the global level it appears to be an ineffective and deleterious response for climate change mitigation or adaptation.

Other topics,
each with complexities
and trade-offs

Opportunities, Constraints, Information gaps on soil carbon sequestration

Multiple benefits from biochar

Crushed rock mineralization

Renewable Energy On Farms