Plant-Based Diets are better for the Planet: Science-Based FAQs and Tips

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Overview

Raising animals for human consumption is the single largest driver of deforestation [1], habitat destruction [2], and species extinction [3] in the world. A plant-based diet is healthy [4–17], requires less greenhouse gas emissions [4–11,18–37], less land [6,8–11,30,31,33,34,36,38–41], less cropland [9,31,38,40], less water [6,8–11,31,33,34,39,41,42], less blue water [31,42,43], less energy [8,10,30,42], less fertilizer [9,42], less pesticide [42,44], less water pollution [6,30,31,45–48], less air pollution [49–53], costs less money [7,24,54,55], can feed more people [40,56], reduces exposure to toxic pollutants [57–62], advances environmental justice [49,63–67], protects biodiversity [2,3,35,39,68], reduces pandemic risk [69–71], and will be unavoidable to keep global warming to below 1.5 degrees [4,18–23,25–27,36,41,72], meet food demand in 2050 without deforestation [38,39], and stabilize biosphere integrity, freshwater use, and nitrogen flows [39].

Strategy co-benefits for environmental justice

- Black and African Americans are more exposed to fine particulate matter pollution (PM2.5) than white Americans yet are least responsible for it. This pollution is responsible for the majority of deaths from environmental causes in the United States and animal agriculture is the second leading emitter [63]. Eighty-three percent of agriculture air-quality related deaths could be avoided annually if the United States adopted a vegan diet [49].
- Concentrated animal feeding operations are disproportionately located near communities of color [64–67], leading to residents suffering from increased air pollution [50], respiratory illness [51–53], water contamination [45–47] (nitrate pollution causes cancer [73]), mental health issues [51,74], and elevated blood pressure [75]. According to one study, "No regulations address the agrochemical content of feedyard particulate matter emissions." … "Open-air beef cattle feedyards may collectively represent one of the largest unconstrained and unrecognized sources of pesticide, antimicrobial, and endocrine-disrupting chemical emissions on earth" [76].

- Transitioning to a plant-based diet has become more prevalent recently, especially among communities of color. According to surveys, a higher percentage of non-white Americans are voluntarily reducing their meat consumption compared to white Americans [77], while black Americans are over twice as likely to be strict vegetarian or vegan than the general American population [78]. Lower income Americans tend to be vegetarian or vegan more than higher income Americans. [79]

Reducing human exposure to toxic compounds through food

A study funded by the U.S Environmental Protection Agency for the purpose of examining behaviors that influence human exposure to environmental chemicals found that "a diet high in fish and animal products results in greater exposure to persistent organic compounds and metals than does a plant-based diet because these compounds bioaccumulate up the food chain" [57].
Unfortunately, this problem is made worse the better we get at recycling our food waste (e.g. composting and anaerobic digestion). Pathogens can be killed with the high temperatures of proper handling, but persistent organic pollutants and heavy metals can persist in the final product, and if used in agricultural soils, can be taken up again by the food system and accumulate [80].

Why should I care about climate change?

Climate change is projected to reduce food availability, force hundreds of millions of people into poverty and kill off the coral reefs [81], which support 25% of life in the ocean [82]. Hundreds of thousands of people will die annually between 2030 and 2050 [83,84] and millions will die annually by the end of the century (conservative estimates are over 9 million per year) [83]. Although emissions were lower in 2020 due to pandemic-related lockdowns, reductions were still not enough to prevent CO2 concentrations from rising, and methane emissions increased more than any year in history due more to livestock than oil and gas [85]. Even the pledges made by many nations, including the United States, are insufficient [72,86,87] and many nations including the United States are struggling to meet even their own pledges [87,88]. By 2033 we will have used up the carbon budget to prevent climate change if we continue business as usual [89]. This deadline was reiterated at a United Nations General Assembly High-level meeting [90]. The IPCC's latest assessment states, "If current pledges for 2030 are achieved but no more, researchers find very few (if any) ways to reduce emissions after 2030 sufficiently quickly to limit warming to 1.5°C" [72].

Climate change, diet change, and climate adaptation

Not only can diet change reduce emissions, but it can also make us less vulnerable to the effects of climate change. Taken directly from the IPCC, "Dietary change in regions with excess consumption of calories and animal-sourced foods to a higher share of plant-based foods with greater dietary diversity and reduced consumption of animal-sourced foods and unhealthy foods (as defined by scientific panels such as EAT-Lancet), has both mitigation and adaptation benefits"… "background climate-related disease burden of a population is often the best single indicator of vulnerability to climate change" … "cardiovascular diseases [CVD] comprised the largest proportion of climate-sensitive diseases" … "Climate change affects the risk of CVD through high temperatures and extreme heat" … "Unbalanced diets, such as diets low in fruits and vegetables and high in red and processed meat, are the number one risk factor for mortality globally and in most regions" ... "Reduction of red meat consumption reduces the risk of cardiovascular disease and colorectal cancer; and the consumption of more fruits and vegetables can reduce the risk of cardiovascular disease, type II diabetes, cancer, and all causes of mortality" … "Globally, it is estimated that transitioning to more plant-based diets - in line with WHO recommendations on healthy eating - could reduce global mortality by 6–10% [8.1 million per year] and food-related greenhouse gas emissions by 29–70% [3.3–8.0 GtCO2-eq] by 2050" [83] with the vegan diets showing the most reductions [32]. That's most of the conservative estimate of people that will die from climate change and most of food's emissions. In the United States, a vegan diet can reduce food-related greenhouse gas emissions by 78% (570 MtCO2-eq yr-1) and avoid over 460,000 deaths per year [7].

Climate change, diet change, and land use

The emission reduction estimates mentioned above are likely to be conservative because the researchers "did not account for the beneficial impacts of dietary change on land use through avoided deforestation" [7]. Taken from the IPCC, "When the transition to a low-meat diet reduces the agricultural area required, land is abandoned, and the re-growing vegetation can take up carbon until a new equilibrium is reached. This is known as the land-sparing effect." [32] This effect can be substantial. The IPCC mentions one study, stating "By avoiding meat from producers with above-median GHG emissions and halving animal-product intake, consumption change could free-up 21 million km2 of agricultural land and reduce GHG emissions by nearly 5 GtCO2-eq yr–1 or up to 10.4 GtCO2-eq yr–1 when vegetation carbon uptake is considered on the previously agricultural land (Poore and Nemecek 2018, 2019)" [32]

. This same study showed that a vegan diet had the highest mitigation potential of up to 14.7 GtCO2-eq yr–1 [31], which would make our food system carbon negative for over a century [91]. The United States could reduce their total emissions from all sectors of the economy by 24% (1,630 Mt CO2e yr-1) by switching to a vegan diet [91]. According to lead author, Joseph Poore, "For a typical average consumer, diet change isn't just the single biggest way to reduce your greenhouse gas emissions, it's the single biggest way to reduce your land use, your impact on biodiversity, the nitrogen and phosphorous pollution caused by your food, the acid rain, the water use" … "Put simply, avoiding meat and dairy products are probably the single biggest way to reduce your impact on the planet" [92]. Another study calculated the "GHG costs of dairy and beef about 3–4 times higher than previous estimates by the UN Food and Agriculture Organization" [28]. The IPCC itself says that diet change is not only one of "the most economically attractive and efficient options" we have [41], but "reduction of excess meat (and dairy) consumption is amongst the most effective measures to mitigate GHG emissions, with a high potential for environment, health, food security, biodiversity, and animal welfare co-benefits" [41].

Isn't reducing fossil fuels enough to address climate change?

Even if we eliminate fossil fuel use entirely, it still won't be enough. Future projections show that the food sector alone will use up the entire emissions budget we have left. A shift toward more plant based diets will be critical to get the total emission reductions we need [4,18–23,25–27,36,72]. Below are example quotes from several studies:

- "Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets" [19].
- "Our results demonstrate substantial carbon opportunity costs incurred by resource-intensive diets, comparable to the remaining carbon budget to 1.5 °C" [27]
- "Immediate and substantial reductions in wasted food and meat and dairy intake, are imperative to mitigating catastrophic climate change" [22]
- "GHG emissions cannot be sufficiently mitigated without dietary changes towards more plant-based diets" [18]
- "Absent deep cuts in non-CO2 emissions, CO2 abatement alone is unable to keep warming below even the 2°C threshold" [93]

The IPCC states, "All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR)" [72]. In other words, we are so late in addressing climate change that reducing emissions alone is no longer enough; we must now also remove greenhouse gases that we already put up. The IPCC goes on to say, "Most least-cost mitigation pathways to limit peak or end-of-century warming to 1.5°C make use of carbon dioxide removal (CDR), predominantly employing significant levels of bioenergy with carbon capture and storage (BECCS) and/or afforestation and reforestation (AR)", however, "pursuing such large-scale changes in land use would pose significant food supply, environmental and governance challenges … particularly if

synergies between land uses, the relevance of dietary changes for reducing land demand, and co-benefits with other sustainable development objectives are not fully recognized“ [72] . The IPCC later stated, “Shifting diets, and reducing food waste could enhance efficiencies and reduce agricultural land needs, and are therefore critical for enabling supply-side measures such as reforestation, restoration.” … “Animal protein requires more land than vegetable protein, so switching consumption from animal to vegetable proteins could reduce the pressure on land resources and potentially enable additional mitigation through expansion of natural ecosystems, storing carbon while supporting biodiversity, or reforestation to sequester carbon and enhance wood supply capacity for the production of biobased products substituting fossil fuels” [41].

In the United States, the Inflation Reduction Act of 2022 is considered to be “the single largest investment in climate and energy in American history” [94] and is estimated to reduce annual emissions by 1 Gt [87]. After full implementation of the Inflation Reduction Act, the United States will still need to reduce their emissions another 1.7 Gt by 2030 [87]. Diet change can reduce US emissions by 1.63 Gt [31], giving us a more realistic chance at reaching our 2030 goal. Globally, diet change could reduce up to 14.7 Gt [31], which would make up the majority of the emissions gap [87]. This could buy us more time and cut mitigation costs significantly [24].

Isn’t soy destroying the rainforest too?

Soy production does play a role in deforestation, however, 77% of soy is grown to feed livestock (e.g. chicken, pigs, fish, cows), 13% to soybean oil, 3% to industrial uses, and less than 7% is used to make food for human consumption such as edamame beans, tofu, soymilk, soy sauce, or tempeh. [95] Eating animals is the single largest driver of deforestation [1], habitat destruction [2], and species extinction [3] in the world.

Isn’t palm oil destroying the rainforest too?

Palm oil production does play role in deforestation, however, beef was responsible for over 4 times as much deforestation than palm oil.[1,96] Eating animals is the single largest driver of deforestation [1], habitat destruction [2], and species extinction [3] in the world.

Won’t a plant-based diet require more crop land?

A plant-based diet uses less cropland [9,31,38,40] and can free up all pasture land. Most crops produced in the United States are directed to animal feed. [56] One report estimated a vegan diet in the United States uses 50% less cropland [91].

Won’t a plant-based diet require more GMOs?

“Most of the GMO crops grown in the United States are used for animal food” and “more than 95% of animals used for meat and dairy in the United States eat GMO crops.” [97]

Wont a plant-based diet require more pesticides?

A plant-based diet requires fewer pesticides than an animal based diet [42]. One study found beef required as much as 10 times more pesticide than kidney beans per unit of protein [44]

Don’t almonds require a lot of water?

Almond milk requires less water than cow’s milk [31]. The majority of the world’s almonds are grown in California where droughts have been an issue, however more of California’s water is used to grow cattle feed than to grow almonds [98]. One study on planetary boundaries measured which environmental limits are we most in danger of crossing. Water use was one of the limits studied, however

the study concluded that climate change was a bigger threat [99]. Almonds produce at least 105 times fewer emissions than animal products according to a 2017 meta-analysis [30] ; and a 2018 meta-analysis showed nut trees could actually be carbon negative because trees pull CO2 from the air and sequester it into the soil [31].

What about avocados?

Avocados require less greenhouse gas emissions than animal based products [37]. Although avocados do require more water than many other fruits, it still uses less water than animal products [42,100].

What about fish?

Both farmed and wild caught fish require more greenhouse gas emissions than plant based alternatives [30,31]. Furthermore, wild fish cannot sustainably supply current demands (figure 19) [101]. Farmed fish require feed, just like livestock. Only "19% of protein and 10% of calories in feed for aquatic species are ultimately made available in the human food supply" [102]. Shifts to pescatarian diets will increase the existing competition for land resources, particularly in low and medium income countries, with negative impacts on food security [83]. Other facts about fish to consider:

- Most ocean plastic in the Great Pacific Garbage patch is from the fishing industry. [103]
- "The most common way people in the U.S. are exposed to mercury is by eating fish" – US EPA [104]

Isn’t a plant-based diet more expensive?

A plant-based diet in the United States can be 34% cheaper at the grocery store [54] if one has the privilege to shop at a grocery store, which unfortunately is not the case for many. Which is why it’s even more important for those that do have privilege to adjust their diets as much as they can. The United States could also save an additional $248 billion by 2050 from avoided healthcare costs [7], $40 billion in avoided climate change damages [7], and $38 billion per year in avoided animal product farm subsidies [55]. Oakland Unified School District saved $42,000 a year by increasing the amount of plant based food [105]. University of North Texas was able to reduce costs and increase sales with their all vegan café, benefiting both the students and the campus [106]. The Intergovernmental Panel on Climate Change's Sixth Assessment Report, which represents the work of hundreds of leading experts in climate science, states that “Demand-side climate-mitigation measures, like energy-efficiency improvements, reduced meat consumption and reduced food waste, were considered to be the most economically attractive and efficient options in order to support low GHG emissions, food security and biodiversity objectives. “ (Ch 17.3.3.1) and “reduction of excess meat (and dairy) consumption is among the most effective measures to mitigate GHG emissions, with a high potential for environment, health, food security, biodiversity, and animal welfare co-benefits” (Ch 12.4.4). [41]

What about cell-based meat?

Cell-based meat is actual meat grown artificially from cells. Since cell-based meat has not yet been commercialized (as of 2022), existing research about its production is based on a few anticipatory life cycle assessments which assumed hypothetical inputs, production processes, and technological advances. For example, LCAs assumed that the cell-based meat would be grown without fetal bovine serum [43]. Although some news reports claim some companies are currently trying to work on it, further technological developments will be required to remove all animal-based inputs including fetal bovine serum. Assuming they do this, current predictions show that cell-based meats will have lower emissions than beef but may not have lower emissions than other animal products like chicken [43]. However, one report predicts that if greater than 30% of process energy is sourced from sustainable sources like wind and solar, the emissions impact should outperform all animal products [107]. This is in line with the United States’ current goal to achieve 100% pollution-free electricity by 2035 to meet climate change goals [108]. The IPCC states, “Emerging food technologies such as cellular fermentation, cultured meat, plant-based alternatives to animal-based food products, and controlled-environment agriculture, can bring substantial reductions in direct GHG emissions from food production (limited evidence, high agreement). These technologies have lower land, water, and nutrient footprints, and address concerns over animal welfare.” [41]

What about plant-based meat?

Unlike tofu or bean burgers, plant-based meats are designed to mimic the taste and texture of meat; products like Beyond Meat, Gardein, No Evil, Impossible Foods, etc. A 2022 meta-analysis of 43 studies found plant-based animal product alternatives required less greenhouse gas emissions, water use, land use and were healthier than the products they were designed to replace [109]. A 2020 meta-analysis of 187 studies found that plant-based meat required less blue water, land, and emissions than all farmed animal products including farmed fish, despite high electricity use, but slightly more emissions than wild tuna and insects. Pulses (eg beans and lentils) required less emissions than all animal products including insects and wild tuna [43]. Other factors to keep in mind when considering tuna or insects:

Tuna:

- "The most common way people in the U.S. are exposed to mercury is by eating fish" – US EPA [104]
- "Baked cod, pan cooked ground beef, pan cooked liver (beef/calf), and canned tuna were the foods with the highest heavy metal concentrations." – 2021 study using US FDA data. [80]
- EPA and FDA both say to limit tuna intake because of the mercury content, especially for children and breast feeding mothers. [110]
- Tuna has more mercury than most fish because they are large predatory animals [111]

Insects:

- A 2021 systematic review looking at consumer acceptance of alternative proteins found "acceptance of insects is lowest, followed by acceptance of cultured meat. Pulses and plant-based alternative proteins have the highest acceptance level." [112]

Pandemics

Not only did people who follow a plant-based diet show 73% lower odds of moderate-to-severe COVID-19 severity [69], reducing consumption of animal protein can reduce risk from new pandemics in the future [70,71]. This is because most infectious diseases in people come from animals [113] and increasing demand for animal products has increased the risk [114–116].

Can’t I just buy local meat?

Transportation only makes up 4-6% of food’s overall emissions impact [117–119] and just 1% for red meat [118]. Processing, transport, packaging, and retail combined still contribute at most 8% of beef’s emissions [31]. Surprisingly, international transport make up only 3% of emissions from food [120] . The U.S. Environmental Protection Agency echos this, stating, “Despite the level of attention it receives, transportation from farm to retail (or food service) accounts for only approximately 6 percent of cradle-to-consumer food supply chain energy use” [121]. Shifting one day a week from red meat to plant-based food achieves more emissions reduction that buying all locally sourced food [118].

Can’t I just buy organic?

Organic animal products cause more emissions and require more land than conventional animal products [30]. While there are some benefits to organic farming of certain foods, transitioning to a fully organic food system without causing deforestation is only feasible without meat [38].

Can't I just buy grass fed beef?

Grass-fed beef causes more emissions [30,122], more water pollution, and requires more land [30]. If scaled up and promoted, US grown grass fed beef may only meet 27% of current beef demand [123]. This same study concluded, "only reductions in beef consumption can guarantee reductions in the environmental impact of US food systems" [123]. Currently, most "grass fed" beef labeled "product of USA" is imported.

What about holistic/regeneratively grazed beef?

Summary

Compared to conventional beef, utilizing certain practices, under certain limited circumstances, can help lower emissions from beef temporarily, however:

- Emissions reductions are either modest, will happen anyways with diet change (eg reducing the number of cows, manure emissions reduction, etc.) or are largely the result of practices that can be applied to plant agriculture without livestock (eg planting trees on farmland).
- Reductions are time limited, after which, emissions from beef systems will be worse than before.
- Not scalable / uses more land / only works on degraded land (options are limited; degraded cropland competes with other crops which just pushes the problem somewhere else)
- Still relies on external inputs not counted (e.g. feed or compost from offsite) which just pushes the problem somewhere else.
- A plant-based food system reduces more emissions and can sequester more carbon.
- Customers may get confused and choose not to reduce their beef consumption.

"Better management of grass-fed livestock, while worthwhile in and of itself, does not offer a significant solution to climate change as only under very specific conditions can they help sequester carbon. This sequestering of carbon is even then small, time-limited, reversible and substantially outweighed by the greenhouse gas emissions these grazing animals generate" - collaboration between the University of Oxford, the Swedish University of Agricultural Sciences (SLU) and Wageningen University and Research (WUR) [124].

Meta-analyses (by date):

- A 2022 meta-analysis of 22 studies found holistic management had no effect on soil carbon or animal productivity and that "Claims about increased production and climate resilience with HM [Holistic Management] are unfounded based on farm-scale studies." [125]
- A 2021 meta-analysis of 91 publications shows removing cows from the land entirely enhanced plant production and soil carbon storage across grassland worldwide [126].
- A 2020 meta-analysis of 287 papers found "the grazing impacts on the 15 soil properties had no significant changes over the last two decades" [127].
- A 2020 meta-analysis of 57 studies found that for the USA, Integrated Field Management and Intensive Rotational Grazing reduced emissions from extensive beef, but still resulted in more emissions per unit of beef on average compared to conventional beef. (Figure 4b) [128]. There were a few US farms that claimed net negative emissions, however:
    - Roundtree et al (2016) Emission reductions were due largely to reducing the cattle herd by 60%. A reduction in cattle would happen anyway in a transition to a plant-based food system. This farm also supplied half of their feed from off site, thus bringing in nutrients and carbon to the land but at the cost of land elsewhere. One can bring nutrients into plant-based agriculture land as well. The study also monitored results for only two years.
    - DeLonge et al (2013) Switched from using a livestock manure slurry (an emitter) to a compost operation mixing manure and plant waste diverted from a landfill and applied the compost to the land. The reductions were largely due to offsets from avoided emissions from the manure slurry as well as avoided methane emissions at the landfill. A plant-based food system would avoid emissions from manure slurries as well because manure slurries wouldn't exist, and composting plant material diverted from a landfill can be done in a plant-based food system. Applying this compost to land can sequester carbon without livestock.
    - Ryals & Silver (2013) Got their reductions by bringing in composted green waste from offsite (i.e. yard trimmings and food waste) and applying it to the land. This could be done in plant-based agriculture without livestock.
    - Drinkwater et al (1998) Doubled rates of carbon sequestration, but it was because they decided to grow legumes on the land instead of just cattle feed. Planting legumes also reduced pesticide use. Planting legumes will happen anyways with diet change. Legumes tend to be the main ingredient in plant-based meat alternatives due it's high protein content, and are even categorized as a "protein food" along with meat in the US dietary guidelines. [129]

  The meta-analysis concluded, "growth in beef demand will likely more than offset GHG emissions reductions and lead to further warming unless there is also reduced beef consumption." [128]

- A 2019 meta-analysis of 63 studies reported heavy grazing reduced soil carbon compared to moderate and light grazing. Impacts by moderate and light grazing on soil carbon was not statistically significant. The main reason for the reductions was because they decided to have fewer cows on the land. This would happen anyway with diet change. [130]
- A 2018 meta-analysis of 83 studies reported "grazing (below the carrying capacity of the systems) results in a decrease in SOC storage" [131].
- A 2018 meta-analysis of 64 publications found rotational grazing showed a 25% greater carbon soil storage than continuous grazing. "rotational grazing had greater SOC than continuous grazing and was not different from no grazing". This implies that this improved grazing strategy would be no better at sequestering carbon than no grazing [132].

Emission Reduction potential

- A 2017 literature review from a collaboration between Oxford, the Swedish University of Agricultural Sciences (SLU) and Wageningen University and Research (WUR) found certain practices under certain limited conditions could reduce emissions from the grazing sector by 20-60% [124]
- In 2020, a single publication studying the White Oak Pastures farm reported a sequestration of 2.29 Mg C ha−1 yr−1, resulting in 66% [133] less emissions than conventional beef, however:
    - Reduced number of cows. They reduced their cow per acre by 60% compared to conventional. This would happen anyways with diet change.
    - Relied on inputs not counted. Chicken and hog feed (mostly corn and soy) and hay were brought in from off-site. These additional nutrients enriched the land through compost or manure, but at the cost of land elsewhere which was not counted. This was no small amount since most of the animal products produced from the farm came from hogs and chicken, not cattle. As a comparison, another study showed compost alone, applied to a corn field rotating with tomatoes (with no livestock) resulted in 1.15 Mg C ha-1 yr-1 over 19 years sequestered [134]. Another study showed adding compost to a system with moderate spring grazing resulted in 1.58 Mg C ha−1 yr−1 over 10 years / .84 Mg C ha-1 yr-1 over 30 years sequestered compared to moderate spring grazing without compost, implying that the sequestration was more the result of applying compost to the land, rather than the cows themselves [135].
    - Legumes were planted on site which has the unique ability to fix nitrogen in the soil and increase soil carbon [136]. Planting legumes will happen automatically with diet change. A 2017 study showed planting legumes can sequester .66 Mg C ha-1 yr-1. [137] . One 2015 study showed that under proper targeting, legume sowing has the potential to sequester .35 Mg C ha-1yr-1 for North America [138]. A 2014 study showed farming practices like fertilizing crops based on soil tests and rotating cereals with legumes could make wheat production carbon negative [139].

- Nut bearing trees were planted on site. Nut trees will be planted with diet change anyways. Trees can sequester carbon on their own in plant-based agriculture without livestock. Planting trees is just a good idea in general. You can even do it in croplands. According to a 2017 study, 22% of US croplands were suitable for alley cropping of trees, which could sequester 1.2 Mg C ha-1 yr-1 without livestock present [140]. A 2018 meta-analysis shows nut trees were carbon negative [31].
- Relied on degraded cropland (competes with other crops)**.** This study started out on degraded cropland. Several studies that argue in favor of improved grazing are based on converting degraded cropland to grazing land, but that would put crops out of production and since demand for food is increasing [141,142], that would only create demand to grow those crops somewhere else. In other words, you may improve land in one place but at the cost of destroying land somewhere else, so you're not solving the problem, you're just moving the problem somewhere else.
- They "Rested" the land, meaning they prevented cows from grazing on the land for periods of time. This would happen anyways with diet change, i.e. more land would be rested. A 2020 study showed abandoning agricultural land could sequester 0.43 Mg C ha-1 yr-1 over 60 years [143]. A 2017 study concluded that "simply ending the land use is sufficient for forests to recover" [144]. A 2022 study found that "old forests continue to sequester carbon and fix nitrogen" [145] Other studies show habitat can be restored by removing livestock [146,147].
- White Oak Pastures is selling their ground beef for $8.99/lb. Plant based beef alternatives that are designed to mimic the taste and texture of beef, have been known to sell for as little as $6.80/lb. Beans are $0.86/lb .
- A note on White Oak Pastures: Several news articles came out claiming that Savory's method was carbon negative, citing a White Oak Pastures study in 2019. However, this study was not peer-reviewed and left out several key factors. The next year, a peer-reviewed study came out on White Oak Pastures showing only 66% less emissions than conventional methods (instead of the carbon negative claim as before) and required 2.5 times more land than conventional [133]. Even though the leading author of the first White Oak Pastures study was involved in this second peer-reviewed study, White Oak Pastures themselves still advertises their beef as "carbon negative" on their website.

- A 2019 meta-analysis showed legumes had 97% less emissions than red meat per serving [6]
- A 2017 study shows beans have 99% less emissions than conventional beef in the United States per unit of protein [148].
- A 2018 study showed a vegan diet reduces emissions (carbon opportunity cost plus production emissions) by 80% [28].
- A 2018 meta-analysis [31] looked at 38,700 farms and found the best production system they found for growing beef was still several times worse than plant-based alternatives. They also found that our entire agriculture sector could be a net sink due to carbon sequestration if we all adopted a vegan diet.[31]

- A 2022 study found “Cessation of grazing would decrease greenhouse gas emissions, improve soil and water resources, and would enhance/sustain native species biodiversity thus representing an important and cost-effective adaptive approach to climate change”. [149]

Requires more land/ not scalable

Grass-fed beef requires 25% more land than conventional [30] and if scaled up could only meet 27% of current beef demand [123]. White Oak Pastures showed that their regenerative beef requires 2.5 times more land than conventional beef [133], implying it would meet even less demand. In contrast, switching from conventional beef to beans would free up 42% of cropland [148]. Another study showed that changes in grazing management would only sequester carbon on 22% of grazing lands in North America [138]. Since holistic methods rely on already degraded land for their emissions reductions, if you don’t want to compete with other crops or require more land, then this method would be limited to degraded pastureland. One study estimated that only 27% of current pastureland is said to be degraded [124]. Holistic methods cannot supply enough animal protein to meet current demand, much less future demand without “catastrophic land use change and other environmental damage” [124].

A 2020 meta-analysis of 109 studies found that grazing cattle reduces the abundance and diversity of wildlife compared to removing livestock and allowing the land to rewild [150]. Only half of grazing lands were originally grassland. 32% of grazing lands used to be forests [28]. An IPCC 2022 report found that shifting to more plant-based diets can reduce agricultural land needs and are therefore critical to reforestation and restoration (page TS-86) [41].

Time limited

Carbon sequestration in soils reaches a saturation point where the soil can no longer absorb new carbon.[151–153] after which emissions are worse than before. Time limits range from 30-70 years [124], with one recent study showing sequestration may have peaked at 13 years [133]. As an example, 3 US studies reported a decrease in emissions from changes in grazing management (-15%[154], -16%[155], -66%[133]) but not counting sequestration would make these farms emit more (+30%[154] , +37%[155] , +44%[133]) than conventional beef. This implies that setting up this type of food system will create more emissions in the long run.

A note about Alan Savory

There was a lot of press around Alan Savory. He claimed holistic, regenerative grazing techniques was the answer to climate change. However,

- A review done the year after his talk “could find no peer-reviewed studies that show that this management approach is superior to conventional grazing systems in outcomes.” [156]

- A researcher at Chalmers University in 2016 wrote a review of Alan Savory's claims stating that "no review study has been able to demonstrate that holistic grazing is superior to conventional or continuous grazing" and that the claimed benefits of the method appear to be "exaggerated and/or lack scientific support" [157].
- A collaboration between the University of Oxford, the Swedish University of Agricultural Sciences (SLU) and Wageningen University and Research (WUR) , in their report in 2017 said "that the extremely ambitious claims that proponents of Savory's methods make are dangerously misleading" [124].

But I heard methane is short lived and cows don't add additional warming.

If you don't increase methane emissions, then methane should not add additional warming. However, there are several points to consider:

- Beef production globally is increasing which is adding more warming. There is no policy in place to discourage beef companies from continuing to increase production. I imagine it would be very difficult for a beef company to convince their shareholders that halting profit growth indefinitely is best for the company, especially when beef demand is expected to rise.
- Even if methane levels where kept constant, methane emissions still currently represents a third of warming, with livestock contributing almost as much methane warming (32%) [158] as fossil fuels (36%) [159]. So reducing methane emissions can help draw down this warming, and can do so quickly to provide immediate relief. If you reduce CO2 emissions, warming continues to rise for a time and then flattens out and doesn't cool for centuries. Which is why we must reduce CO2 emissions as quickly as possible. If you reduce methane emissions, it can create an immediate cooling effect because methane can fall out quickly if you don't replace it [160]. The United Nations Environment Programme has stated, "reducing methane emissions now would have an impact in the near term and is critical for helping keep the world on a path to 1.5°C "…. "Human-caused methane emissions could be reduced by as much as 45 percent within the decade. This would avert nearly 0.3°C of global warming by 2045, helping to limit global temperature rise to 1.5˚C"…."UNEP Food Systems and Agriculture Advisor James Lomax says the world needs to begin by "rethinking our approaches to agricultural cultivation and livestock production." That includes leveraging new technology, shifting towards plant-rich diets and embracing alternative sources of protein. Lomax says that will be key if humanity is to slash greenhouse gas emissions and limit global warming to 1.5°C" [158]. So we must reduce both CO2 and methane. According to a recent study that included aerosol cooling effects on radiative forcing, "CO2 abatement alone is unable to keep warming below even the 2 °C threshold" …. "non-CO2 targeted measures when combined with

decarbonization can provide net cooling by 2030 and reduce the rate of warming from 2030 to 2050 by about 50%, roughly half of which comes from methane" …. "these two strategies are complementary and not interchangeable" . [93]

- Reducing CO2 emissions does nothing to address the CO2 that already went up. Diet change, however, can not only reduce methane and cause cooling, but can free up land that can rewild and actually pull the carbon out of the air that already went up in a matter of a few decades. Deforestation puts large bursts of CO2 into the atmosphere, which could be avoided with diet change as animal agriculture is the leading driver of deforestation.
- The majority of greenhouse gases that could be reduced by shifting away from animal products is CO2 anyways, not methane. This is true when using GWP100 [161] or GWP* [19]. Whether you want to count methane or not, beef is still the most carbon intensive food you can put in your mouth [161].

But I heard grasslands store more carbon than forests

Dr. Frank Mitloehner at The Irish Farmers Association said, "grasslands can capture as much carbon as forests can.", referencing a study by Benjamin Houlton, PhD. UC Davis [162]. However, Dr. Houlton was talking about trees being vulnerable to forest fires in a future with climate change if we don't address climate change. He said "in a stable climate, trees store more carbon than grasslands" [163] In the situation of a devastating fire, trees naturally have more carbon to burn than grasslands because they start out with more carbon to begin with. Forests can store more carbon both above and below ground. Even if you don't count the trees, there is still more carbon stored below ground in forests than there is in the entire grassland system (above and below). Since trees can store more carbon, the trick then is to have forests, and not to let them go up in flames [162]. The USGS also found forests store many times more carbon above and below ground than grasslands (table 5.3) [164]. Old growth forests and large old trees are critical organisms connecting ecosystems and human health and continue to sequester carbon [145]. In 2022, The New York Times wrote an expose about Frank titled "He's an Outspoken Defender of Meat. Industry Funds His Research, Files Show" showing that he gets funded by the meat industry.

But I heard cows use land and crops unsuitable for humans

- By unit of protein, most livestock feed is human edible [165].
- At least one third of grassland could also be used as cropland [166].
- Even when only counting feed edible by humans, all livestock, including cows, still use more human edible protein than they produce in the United States [167] and globally [165,166]. This is also true by unit of calorie, zinc and iron [165].

One study factored in protein quality improvement of beef over cattle feed in the United States and found a net gain of 3 units of beef protein for every unit of human edible feed protein, however the gains were largely due to using distiller grain byproducts of corn ethanol production as a major feed component and claiming it as not human edible [167]. Corn ethanol requires cropland that could grow human food just as easily. A recent study shows increased demand for corn ethanol led to increased food prices [168] proving that ethanal corn is in direct competition with food crops and should be counted as human edible for these reasons. Many of the most productive crops, such as maize (corn) and soybeans, are responsible for a high proportion of losses to the food system via livestock and biofuel production. Shifting the use of crops as animal feed and biofuels would have tremendous benefits to global food security and the environment. The US agricultural system alone could feed 1 billion additional people by shifting crop calories to direct human consumption [56]. The United Nations estimated that if we keep eating meat, the world will need 70% more food by 2050 [141]. Globally, is we shifted the use of crops as animal feed and biofuels to crops meant for direct human consumption, we could we could, in principle, increase available food calories by as much as 70% by (which could feed an additional 4 billion people) [56].

Some say there is value in producing ethanol, claiming there are climate benefits from using ethanol over gasoline, however recent studies show corn ethanol emits more greenhouse gases than the gasoline it's meant to replace [168,169], meaning we should count animal products fed on ethanol grains as having even higher emissions, not discount them.

Furthermore, they also counted wheat forage as inedible. Wheat forage is the same as edible wheat, just harvested sooner. A lot of the times the main reason why a wheat farmer would decide to either let cows graze the wheat fields as pasture, harvest it early as hay forage for cows, or to let it grow longer to form wheat grain for humans is a purely economic decision based on current commodity prices, not the suitability of the land [170,171].

When looking at a scenario that did not use wheat forage or distiller grains from ethanol, the protein quality gain of beef over feed disappears [167].

Even if you count the gains, beef is still several times more carbon intensive per gram of protein than plant based alternatives [41,148,161,172].

Of the land that is unsuitable, shouldn't we use that land to grow meat? What if we maximized production on all land, including unsuitable land to feed more people? There was a lot of news around a study that looked at the "carrying capacity" of different diets [173]. Keep in mind, the scope of this study was only to estimate the maximum amount of land we could put into food production for each diet scenario, not what the environmental impacts would be of those diets. Even so, in the abstract of this study it says carrying capacity is highest for the vegetarian diet (no meat), meaning a diet without meat scored better than all other diets. Also, this study says the vegan diet still uses the least amount of total land (see fig 2) as well as the least amount of cropland (see figure 4) and can still feed 2.4 times the population (table 4) [173].

What many news headlines pointed out was that an omnivore diet was better for the environment than a vegan diet and referenced this study. A scenario where we eat some animal products (OMNI 40) could feed 2.6 times the population, where a vegan diet could feed 2.4 times the population, an 8% difference, which is what these news headlines were referring to. Keep in mind that the OMNI 40 diet still requires Americans to remove most of the meat from their diet, but the headlines failed to mention this. Furthermore, the vegan diet can provide more than enough food to feed the population into the future. One study projects US population will peak in 2062 at 1.2 times the population, far less than the 2.4 times the population a vegan diet could support [174]. Globally population will only increase by as much as 1.4 times the population [175]. Other studies have also shown that we can feed more people on a vegan diet than the current food system [40,56].

What if we rear livestock on only grassland, crop waste, food waste, and other byproducts?

Although a noble effort, a 2017 meta-analysis shows using agricultural wastes and byproducts as animal feeds could only reduce the environmental impacts of livestock production by 20%. Plant based foods have 80-99% less emissions than animal based foods [30]. Even if it were sustainable, it's still not scalable. A 2018 study showed that by using up all the grassland, crop wastes and food waste

for livestock feed would only satisfy a maximum of 37% of current US supply of animal products [176], meaning we would have to remove the majority of animal products from our diet. Furthermore, at least one third of grassland could be used as cropland [166] and crop waste, food waste, and other byproducts can be used as compost for growing plant-based foods.

But I heard removing animals would only reduce emissions by 2 or 3%?

The Cattlemen's Beef Board on their website [177] points to a study that claims removing animals from US agriculture would only reduce total emissions by 2.6% [178]. However, this study did not examine the emissions potential of dietary shifts. When asked, the authors said their study was "not intended to relate to studied vegetarian or vegan diets" [179]. Several research groups have published responses voicing concerns about this paper calling the scenario "unrealistic". [180–182] For example, the study assumes when animals are removed, farmers will just keep growing animal feed without animals to eat it, implying famers wouldn't change what crops they grow. If we expect humans to eat all of this feed, everyone would have to double their calorie intake. Obviously, this is unrealistic. Frank Mitloehner of UC Davis, an outspoken defender of meat, echoed this study as a way to convince people to keep eating beef and to not worry so much about environmental impacts from beef. In 2022, The New York Times wrote an expose about him titled "He's an Outspoken Defender of Meat. Industry Funds His Research, Files Show" showing that he gets funded by the meat industry.

The website also claims that beef production "is responsible for only 3.3% of greenhouse gas emissions in the U.S." referring to a study that did not compare diets, discounted grains from corn ethanal production (recent studies show corn ethanol emits more greenhouse gases than the gasoline it's meant to replace [168,169], meaning we should count animal products fed on ethanol grains as having even higher emissions, not discount them), and didn't count carbon opportunity cost of land. Also, it was funded by the beef industry, and was initiated, co-authored, and data obtained and provided by the National Cattlemen's Beef Association [183] , an industry group whose job is to "promote beef's image and defend beef's freedom to operate to enhance consumer, influencer and stakeholder trust in beef" [184]. The data was also not peer-reviewed. This presents a conflict of interest. Furthermore, the website's footnotes were either broken links, go to other beef industry websites, and/or were opinion blogs. By contrast, a different study that was co-authored by a vegan food company representative found that a global phaseout of animal agriculture could offset 68% of world CO2 emissions [185]. Although this study was peer-reviewed, it too presents a potential conflict of interest. It is possible that some studies with conflicts of interest can still provide sound science, however because of these conflicts, neither of these studies are considered nor referenced anywhere else in this document.

BeefResearch.org, which is run by the Cattlemen's Beef Board and National Cattlemen's Beef Association, which are both funded by the beef checkoff program, says on their website titled "Would Removing Beef from the Diet Actually Reduce Greenhouse Gas Emissions?" that, "According to the U.S. Environmental Protection Agency (EPA), beef cattle production was responsible for 1.9% of total U.S. GHG emissions" [186] and refers to an EPA site [187]. However, they didn't include beef from dairy cows, emissions from feed production, nor carbon opportunity cost of land. Also, the EPA site does not compare different diets and is not a life cycle assessment; nor was it meant to be.

Sometimes meat promoters will refer to an EPA chart showing agriculture is only 10% of emissions [188]. Again, this 10% figure is not a comparison of different diets, not a life cycle assessment, and does not include carbon opportunity cost of land and land use change. There is even a statement right under the chart that reads, "excluding emissions and removals from the land use, land use change and forestry sector".

EPA has never done a life cycle analysis of different diets. Perhaps they should. Furthermore, multiple studies have suggested that EPA is underestimating methane emissions from animal agriculture [189,190].

The UN Food and Agriculture Organization estimates livestock is responsible for 14.5% of global emissions. Many people use this as the absolute maximum amount of emissions reduction diet change could help with. However, this agency did not look at what would happen if we changed our diets, nor did it intend to. Perhaps they should. Although this estimate does include land use change, it does not include carbon opportunity cost of abandoned land from diet change. From the report, "Changes in soil and vegetation carbon stocks not involving land-use change can be significant but are not included" [191].

The reason why so many use this 14.5% number, is because the FAO is part of the United Nations, a trusted authority by many. But the FAO is not the United Nations main authority on climate change. For that, you must turn to the IPCC. The IPCC is also part of the United Nations, and their main purpose is to provide governments with scientific information that they can use to develop climate policies. The IPCC did in fact look at solutions to climate change, including diet change. They found that diet change is not only one of "the most economically attractive and efficient" options [41], but "reduction of excess meat (and dairy) consumption is amongst the most effective measures to mitigate GHG emissions, with a high potential for environment, health, food security, biodiversity, and animal welfare co-benefits" [41]. The IPCC talks about one scenario that only involves reducing animal product consumption by half [32] and it has the potential to reduce the majority of the emissions gap[87] we need to fill beyond national commitments. Imagine if many of us went completely vegan. This scenario was taken from a huge meta-analysis out of Oxford that looked at 570 studies, over 38,000 farms, and the lead author of that study, Joseph Poore, said himself that a vegan diet is the single biggest thing an average consumer can do to reduce their greenhouse gas emissions, equivalent to a total emission reduction of 24% for the United States and 28% [31,92] globally, not 14.5%.

So how can diet change reduce more emissions than the entire food sector? The IPCC explains this very simply, "When the transition to a low-meat diet reduces the agricultural area required, land is abandoned, and the re-growing vegetation can take up carbon" [32]. So diet change doesn't just reduce emissions from the food sector, it also removes carbon from the atmosphere, making the emission reduction potential beyond 14.5%. The FAO didn't account for this land-sparing effect. And they didn't intend to. It just wasn't part of their scope. They were just looking at direct emission sources, not solutions. We know growing trees and restoring nature is good for the climate, and these studies like the Oxford study and others are just factoring in this effect, and justifiably so. We need to reduce fossil fuels, yes, and fast. But reducing emissions is just not enough anymore because we've delayed action for so long. The IPCC, which comes from the same authority as the FAO, says that we need to remove carbon as well if we are going to stay below 1.5 degrees [72] and that diet change will be critical for this to happen [41].

Furthermore, one study did find "global-average GHG costs of dairy and beef are about 3–4 times higher than previous estimates by the UN Food and Agriculture Organization" and that the emissions impact from a person's diet was equivalent to GHG's typically assigned to a person's overall consumption of all goods, including energy consumption [28]. These researchers also put together a short paper that helps explain the study and the carbon opportunity cost concept in more simple terms [192].

How much of our diet do we need to change to reach sustainability goals?

One study estimates that the Eat Lancet diet could reduce enough emissions to keep us below 1.5 degrees of warming [19]. This diet, for the United States, involved a reduction of beef, lamb and pork by 84%, eggs by 63%, poultry by 57%, and dairy by 31% [4]. However, this is assuming that we also eliminate fossil fuel use entirely and it only gets us to a 50% chance at staying below 1.5 degrees of warming. Many people might agree that maybe we shouldn't leave our fate to just a 50% chance of success, and assuming that we will eliminate all fossil fuels when nations of the world can't even promise to reduce half the emissions we need [87], might make some think we probably need to change our diets even more. A completely vegan diet could get us to a 85% chance at staying below 1.5 degrees [91]. Also, another study showed that if we wanted to also transition our food system to completely organic farming practices without deforestation, the only diet scenarios that could pull it off were the vegetarian and vegan diet scenarios, with the vegan diet performing

better [38]. Also, many people will not change their diets so others will have to do more to make up for it. Some people may understandably want to go completely vegan and this behavior should be encouraged and supported. Just like we encourage people and businesses to reduce their fossil fuel use as far as is possible and practicable, they should also be encouraged to reduce their animal product consumption as far as is possible and practicable.

Is being 100% plant-based healthy?

The world's largest organization of nutrition and dietetics practitioners, the Academy of Nutrition and Dietetics, says that appropriately planned vegan diets are healthful, nutritionally adequate, and are appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence, older adulthood, and for athletes [13]. Other organizations also say a vegan diet can be healthy including the US Dietary Guidelines Advisory Committee [12], the British Dietetic Association [193], and the Dietitians of Canada [194]. Be sure to consult a registered dietician for further information. Many websites offer free guidance.

If we change to more plant-based diets, won't we waste more food?

Although fresh fruit and vegetable waste would increase with a change to a vegan diet, animal product waste would decrease, resulting in an overall decrease of emissions from not just our diets but from our food waste as well [31].

The largest share of food waste today is fruits and vegetables, but the largest share of environmental burden of food waste comes from animal products. A 2021 US EPA report stated, "Animal products have an outsized contribution to the environmental footprint of U.S. FLW [Food Loss and Waste], representing the greatest use of resources (land, water, fertilizer, energy) and GHG emissions among categories of FLW, but a relatively small share of FLW" [121] .

In addition to direct food waste, when we grow food to feed livestock instead of feeding humans directly, we end up with less food for humans overall. This can also be considered a form of food waste. A 2018 metanalysis showed that "meat, aquaculture, eggs, and

dairy use ~83% of the world's farmland and contribute 56-58% of food's different emissions, despite providing only 37% of our protein and 18% of our calories" [31]. One study found that "the opportunity cost of animal based diets exceeds all food losses" and "Replacing all animal-based items in the US diet with plant-based alternatives will add enough food to feed, in full, 350 million additional people" [40] Another study found "More than half of crop production by mass in the United States is directed to animal feed" and that "US croplands feed 5.4 people per hectare but could feed 16.1 people per hectare" [56].

Diet change and the USDA dietary guidelines

The Dietary Guidelines Advisory Committee (DGAC) was established jointly by the Secretaries of the U.S. Department of Health and Human Services (HHS) and the U.S. Department of Agriculture. In the committee's own words, "the major findings regarding sustainable diets where that a diet higher in plant-based foods, such as vegetables, fruits, whole grains, legumes, nuts, and seeds, and lower in calories and animal-based foods is more health promoting and is associated with less environmental impact than is the current U.S. diet." [8] The USDA and HHS, however, chose not to take action on the findings because they claimed they were not the right agency to give recommendations based on environmental protection (Letter from Tom Vilsack, Secretary of Agriculture and Sylvia Burwell, Secretary of Health and Human Services) [195]. Regardless, USDA staff still put out a report as far back as 2012 on USDA's website stating that "Consuming fewer livestock products can reduce emissions" [5]. Six months later, the same authors published a report with even bolder messaging: "Agricultural production and GHG mitigation goals cannot be reached simultaneously, even if optimistic technological advances are attained. However, healthier human diets would allow sufficient decreases in agricultural production to meet GHG mitigation goals." They recommend consumption of fewer livestock products. [36] The dietary guidelines does give guidance on both a healthy vegetarian and vegan eating pattern option (See appendix 5 of the 2015 Dietary Guidelines).

Diet change and other federal agencies

- US Dietary Guidelines Advisory Committee findings on sustainability[8],
- USDA findings on climate change and diet [5],

- US Department of Health and Human Services guidance: “most people in the United States don’t eat enough vegetables” [196],
- USDA: “about 90 percent of the U.S. population does not meet the recommendation for vegetables and 80 percent consumes too little fruit”. [197]
- USDA: “Long-term water security and river ecosystem health will ultimately require Americans to consume less beef” [198]
- Center for Disease Control and Prevention guidance: “Only 1 in 10 Adults Get Enough Fruits or Vegetables” [199],
- DHHS Food Service Guidelines for Federal Facilities: “Offer protein foods from plants such as legumes (beans and peas), nuts, seeds, and soy products, daily” [200]
- DHHS, CDC, and GSA Health and Sustainability Guidelines for Federal Concessions and Vending Operations: “A vegetarian entrée must be offered every day” [201]
- EPA ORD Report, From Farm to Kitchen: The Environmental Impacts of US Food Waste [121] :
    - *“Many of the studies presented in this report compared a variety of strategies—including closing yield gaps, increasing resource efficiency, dietary shifts, and reducing FLW—finding that only in combinations could these strategies achieve a sustainable agricultural future”* [121]
    - *Key finding:* “*Among food categories, animal products require the most land, water, fertilizer, and energy and emit the most GHGs per unit of food.”* [121]
    - *“Even if fossil fuel emissions were halted, current trends in the food system would prevent the achievement of [1.5 degrees of warming]”* [121]

Tips for universities/dining services

- Simply increasing plant-based items offered increased plant-based meal sales. Doubling the proportion of vegetarian meals on the menu from 25 to 50% (e.g., from 1 in 4 to 2 in 4 options) increased vegetarian meal sales (and decreased meat meal sales) by 14.9 and 14.5 percentage points in the observational study (2 cafeterias) and by 7.8 percentage points in the experimental study (1 cafeteria), equivalent to proportional increases in vegetarian meal sales of 61.8%, 78.8%, and 40.8%, respectively. Overall sales remained constant [202].
- Making the veggie dish the default instead of the meat-based dish at conferences increased veggie dish consumption [203].
- Just as satisfying if you replace two thirds of the meat with beans [204].

- Three interventions reducing the portion size of meat servings reduced meat consumption in randomized trials. “Three interventions providing meat alternatives with supporting educational material were associated with reduced meat demand in pre-post design studies. Three of four interventions altering the sensory properties (e.g. visual presentation) of meat or meat alternatives at point of purchase reduced meat demand in randomized trials. Four interventions repositioning meat products to be less prominent at point of purchase were associated with lower meat demand, but only two such interventions reached statistical significance” [205].
- “Providing information on the environmental impact of meat consumption may reduce consumption, with 10 of 11 estimates suggesting reduced consumption”. “consumers tend to be unaware of the environmental impact of the production of meat “. “Individuals consider meat reduction to be one of the least effective methods for alleviating climate change when compared to other options (such as driving cars less), despite shifting to a plant-based diet being one of the highest impact actions that can be taken by an individual to reduce emissions” [206].
- Indulgent vegetable names increased vegetable consumption. [207]
- Foodprint seminar. Students were estimated to have significantly decreased their dietary carbon footprint by 14% [208].
- Interventions appealing to animal welfare consistently reduced meat consumption [209].
- 50-minute lecture on how food choices affect climate change, along with information about the health benefits of reduced meat consumption reduced meat purchases and increased purchases of plant-based alternatives [210]
- “Self-monitoring interventions and individual lifestyle counselling led to, or were associated with reduced meat consumption” [211]
- Diners who received the menu with the plant-based dishes in a vegetarian section were 56 percent less likely to order those dishes, implying vegetarian items should be spread throughout the menu instead of given their own section on the menu [212].
- A sign that said “Most people here choose to eat vegetables with their lunch” increased sales of meals with vegetables [213].
- Placing vegetarian options on the counter at least 6 feet in front of meat options can increase sales of vegetarian options by 5%. [214]
- Changing the price of meals to better reflect the cost of ingredients (i.e. increasing price of meat meals by 8% and decreasing price of vegetarian meals by 10%) increased vegetarian sales by 3%. Price change had no significant effect on total meal sales [215].

Tips for grocery/convenience stores

- In-person nutrition education on the nutrient composition of food purchases through talking with customers and signage resulted in greater purchasing of fruit and dark-green/yellow vegetables [216].
- Discounting fruits and vegetables led to increased purchasing and intake [217].
- Healthy samples (Studies 1–2) or samples framed as healthy (Study 3) increase healthy purchases [218].
- A supermarket discount intervention led to increases in purchases and intakes of F&V [219]
- Convenience store consumer demand for fresh fruits and vegetables in low-income communities was sufficient to cover direct operating costs of a produce case, but requires commitment of daily maintenance. 15 min of daily maintenance. High in demand were: granny smith apples, red delicious apples, bananas, green bell peppers, cabbages, collard greens, red seedless grapes, iceberg lettuce, mangos, mustard greens, yellow onions, oranges, Anjou pears, 10-poundbag, potatoes, and yams [220].
- Recipe samples, produce offered at check-out end caps, recipe signage and social marketing were effective in improving fruit and vegetable intake in rural communities [221].
- Lower prices increased sales of healthy foods. Women prioritize health over cost more so than men, suggesting efforts aimed to increase the perceived value of health over cost should be tailored towards men [222].
- Employee training including education on the health and financial benefits of fruits and vegetables, food demos, recipe cards, in-store announcements, and buffet bar with ready to eat fruit and vegetables in Latino food stores resulted in a self-reported increased intake of fruits and vegetables [223].
- Healthy recipes, in-store displays, bag stuffers, staff can explain and recommend healthy items, signage on windows, service counters, registers, and at point-of-purchase in stores in rural communities showed significant improvements in reported healthiness of purchases [224].
- Recreation center and corner store nutrition promotion and education using point-of purchase materials such as posters and flyers in stores and interactive sessions such as taste test (e.g. trail mix, peanut butter/banana/raisin roll-ups) and cooking demonstrations reduced overweight or obesity among already overweight low-income African American youth living in an environment where healthful foods are less available [225].
- Placement of fruits/vegetables near the front of corner stores increased purchase of produce by customers using WIC [226].
- Discount coupons and education about healthy food consumption encouraged low-income families to purchase healthier food in Alabama [227]
- Increased social media exposure increased daily fruit intake in low-income African American neighborhoods in Baltimore [228].

- Placing low-cost fruit and vegetables packs at checkout end-caps - and suggesting to shoppers to consider purchasing them increased overall and SNAP program sales. Last minute purchases of fruits and vegetables at checkout may help families use up remaining assistance benefit balances [229].
- A combination of a floor arrow saying "This way to healthy food", a sign that reads "Only a few left in Stock!", and mixing healthy granola bars in with candy bars resulted in an increase in sales of apples, oranges, bananas, and granola bars in convenience stores in rural central North Carolina [230].
- Urban farm/corner store collaboration in low-income urban setting sold 86% of all items delivered, store owner and farmer made profit and decided to continue the program after the trial was concluded. Exterior sign stating that it carried fresh produce from the farm, shelf labels, recipe cards, produce tasting event, refrigerated display, promotion by local neighborhood and business associations at meetings and in newsletters to local residents; and selecting a store that was relatively isolated from other food retailers were factors in its success [231].
- Recipe cards influenced desire to purchase fruits and vegetables by rural residents of high-obesity Kentucky counties. Trial did a combination of discounts, recipe cards and samples, signage, fruit and vegetables moved to the front of the store, and advertising [232].
- Offering smaller portions of meat resulted in a reduction in the volume of meat sold [233].
- Eco labels increased eco-friendly consumption by 5% [234].
- Sign at entrance saying "*For a healthy diet, try to buy at least five fruits and vegetables*. *Food is Good Medicine*." increase sales of healthy foods and fresh produce [235].
- 150% higher odds of purchasing produce at stores participating in intervention implemented in rural Native community [236]. Stores engaged in activities such as:
    - Basket of bananas or apples at the register counter
    - Price by individual piece
    - Signs that direct customers to the health zone area (candy aisle is a suggested place to put up directions to the store's fresh fruit)
    - Create a special health display at the end of the aisle or so that customers see it upon first entering the store
    - Recipe cards
    - Signs that advertise the store is participating in healthy initiative
    - Community board for flyers will encourage community members to see the store as an active part of their community
    - Replace cigarette and soda signs with healthy signs
    - Make WIC and snap signs more prominent
    - Paint mural on side of store

- Arrange parking lot to provide space for popup markets.
- Small signs placed directly under the item on the shelf
- Posters encouraging consumption of fruit and vegetables
- Volunteer party to help the store rearrange
- Displays
- Kick-off party with live music, interviews with media, cooking demos, recipe contests.
- Local advertising
- Food demos and taste tests
- Prescription vouchers for fruit and vegetables from medical providers

Tips for the home

- Add more vegetables to soups, stews, casseroles, stir-fries, and other dishes.
- Keep raw, cut-up vegetables, hummus, fruit, and trail mix handy for quick snacks.
- Save time by cooking frozen vegetables and potatoes in a microwave.
- Add dark leafy greens to salads and smoothies.
- Use beans or peas in salads (e.g., kidney or garbanzo beans), soups (e.g., split peas or lentils), and side dishes (e.g., baked beans or pinto beans).
- Stock up on frozen or low sodium canned vegetables for quick and easy cooking.
- Buy vegetables and fruit in season when they cost less and are likely to be at peak flavor.
- Buy easy to prepare vegetables like pre-washed salad greens and carrots.
- Switch out meat for plant-based proteins like beans, lentils, peas, tempeh, or tofu.
- Instead of cow's milk, try B12/Vitamin D/Calcium fortified plant-based milks.
- Instead of scrambled eggs, try scrambled tofu with nutritional yeast.
- When eating out, choose the vegan option.
- For those that wish to be 100% plant based, make sure to get all the nutrients you need. You will need to take a B12 supplement. Examples of nutrition resources for vegans include: veganhealth.org, theveganrd.com, pcrm.org, nutritionfacts.org, nutritionstudies.org

References

(1) Henders, S.; Persson, U. M.; Kastner, T. Trading Forests: Land-Use Change and Carbon Emissions Embodied in Production and Exports of Forest-Risk Commodities. *Environ. Res. Lett.* **2015**, *10* (12), 125012. https://doi.org/10.1088/1748-9326/10/12/125012.

(2) Machovina, B.; Feeley, K. J.; Ripple, W. J. Biodiversity Conservation: The Key Is Reducing Meat Consumption. *Science of The Total Environment* **2015**, *536*, 419–431. https://doi.org/10.1016/j.scitotenv.2015.07.022.

(3) Coimbra, Z. H.; Gomes-Jr, L.; Fernandez, F. A. S. Human Carnivory as a Major Driver of Vertebrate Extinction. *Perspectives in Ecology and Conservation* **2020**, *18* (4), 283–293. https://doi.org/10.1016/j.pecon.2020.10.002.

(4) Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S.; Garnett, T.; Tilman, D.; DeClerck, F.; Wood, A.; Jonell, M.; Clark, M.; Gordon, L. J.; Fanzo, J.; Hawkes, C.; Zurayk, R.; Rivera, J. A.; De Vries, W.; Majele Sibanda, L.; Afshin, A.; Chaudhary, A.; Herrero, M.; Agustina, R.; Branca, F.; Lartey, A.; Fan, S.; Crona, B.; Fox, E.; Bignet, V.; Troell, M.; Lindahl, T.; Singh, S.; Cornell, S. E.; Srinath Reddy, K.; Narain, S.; Nishtar, S.; Murray, C. J. L. Food in the Anthropocene: The EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems. *The Lancet* **2019**, *393* (10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4.

(5) USDA. *Publication : USDA ARS*. https://www.ars.usda.gov/research/publications/publication/?seqNo115=283360 (accessed 2021-12-27).

(6) Clark, M. A.; Springmann, M.; Hill, J.; Tilman, D. Multiple Health and Environmental Impacts of Foods. *Proc Natl Acad Sci USA* **2019**, *116* (46), 23357–23362. https://doi.org/10.1073/pnas.1906908116.

(7) Springmann, M.; Godfray, H. C. J.; Rayner, M.; Scarborough, P. Analysis and Valuation of the Health and Climate Change Cobenefits of Dietary Change. *Proc Natl Acad Sci USA* **2016**, *113* (15), 4146–4151. https://doi.org/10.1073/pnas.1523119113.

(8) Dietary Guidelines Advisory Committee. *Appendix E-2.37 | health.gov*. https://health.gov/our-work/nutrition-physical-activity/dietary-guidelines/previous-dietary-guidelines/2015/advisory-report/appendix-e-2/appendix-e-237 (accessed 2021-12-27).

(9) Springmann, M.; Wiebe, K.; Mason-D'Croz, D.; Sulser, T. B.; Rayner, M.; Scarborough, P. Health and Nutritional Aspects of Sustainable Diet Strategies and Their Association with Environmental Impacts: A Global Modelling Analysis with Country-Level Detail. *The Lancet Planetary Health* **2018**, *2* (10), e451–e461. https://doi.org/10.1016/S2542-5196(18)30206-7.

(10) Nelson, M. E.; Hamm, M. W.; Hu, F. B.; Abrams, S. A.; Griffin, T. S. Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. *Adv Nutr* **2016**, *7* (6), 1005–1025. https://doi.org/10.3945/an.116.012567.

(11) Ruini, L. F.; Ciati, R.; Pratesi, C. A.; Marino, M.; Principato, L.; Vannuzzi, E. Working toward Healthy and Sustainable Diets: The "Double Pyramid Model" Developed by the Barilla Center for Food and Nutrition to Raise Awareness about the Environmental and Nutritional Impact of Foods. *Front. Nutr.* **2015**, *2*. https://doi.org/10.3389/fnut.2015.00009.

(12) Dietary Guidelines Advisory Committee. *Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and Secretary of Health and Human Services*; U.S. Department of Agriculture, Agricultural Research Service, 2020. https://doi.org/10.52570/DGAC2020.

(13) Melina, V.; Craig, W.; Levin, S. Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. *Journal of the Academy of Nutrition and Dietetics* **2016**, *116* (12), 1970–1980. https://doi.org/10.1016/j.jand.2016.09.025.
(14) Tuso, P. A Plant-Based Diet, Atherogenesis, and Coronary Artery Disease Prevention. *TPJ* **2015**, *19* (1). https://doi.org/10.7812/TPP/14-036.
(15) Ornish, D. Mostly Plants. *The American Journal of Cardiology* **2009**, *104* (7), 957–958. https://doi.org/10.1016/j.amjcard.2009.05.031.
(16) Jackson, G. Erectile Dysfunction and Coronary Disease: Evaluating the Link. *Maturitas* **2012**, *72* (3), 263–264. https://doi.org/10.1016/j.maturitas.2012.03.012.
(17) CDC. *FastStats*. https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm (accessed 2022-01-01).
(18) Springmann, M.; Clark, M.; Mason-D'Croz, D.; Wiebe, K.; Bodirsky, B. L.; Lassaletta, L.; de Vries, W.; Vermeulen, S. J.; Herrero, M.; Carlson, K. M.; Jonell, M.; Troell, M.; DeClerck, F.; Gordon, L. J.; Zurayk, R.; Scarborough, P.; Rayner, M.; Loken, B.; Fanzo, J.; Godfray, H. C. J.; Tilman, D.; Rockström, J.; Willett, W. Options for Keeping the Food System within Environmental Limits. *Nature* **2018**, *562* (7728), 519–525. https://doi.org/10.1038/s41586-018-0594-0.
(19) Clark, M. A.; Domingo, N. G. G.; Colgan, K.; Thakrar, S. K.; Tilman, D.; Lynch, J.; Azevedo, I. L.; Hill, J. D. Global Food System Emissions Could Preclude Achieving the 1.5° and 2°C Climate Change Targets. *Science* **2020**, *370* (6517), 705–708. https://doi.org/10.1126/science.aba7357.
(20) Bryngelsson, D.; Wirsenius, S.; Hedenus, F.; Sonesson, U. How Can the EU Climate Targets Be Met? A Combined Analysis of Technological and Demand-Side Changes in Food and Agriculture. *Food Policy* **2016**, *59*, 152–164. https://doi.org/10.1016/j.foodpol.2015.12.012.
(21) Bajželj, B.; Richards, K. S.; Allwood, J. M.; Smith, P.; Dennis, J. S.; Curmi, E.; Gilligan, C. A. Importance of Food-Demand Management for Climate Mitigation. *Nature Clim Change* **2014**, *4* (10), 924–929. https://doi.org/10.1038/nclimate2353.
(22) Kim, B.; Neff, R.; Raychel Santo; Vigorito, J. The Importance of Reducing Animal Product Consumption and Wasted Food in Mitigating Catastrophic Climate Change. **2015**. https://doi.org/10.13140/RG.2.1.3385.7362.
(23) Röös, E.; Bajželj, B.; Smith, P.; Patel, M.; Little, D.; Garnett, T. Protein Futures for Western Europe: Potential Land Use and Climate Impacts in 2050. *Reg Environ Change* **2017**, *17* (2), 367–377. https://doi.org/10.1007/s10113-016-1013-4.
(24) Stehfest, E.; Bouwman, L.; van Vuuren, D. P.; den Elzen, M. G. J.; Eickhout, B.; Kabat, P. Climate Benefits of Changing Diet. *Climatic Change* **2009**, *95* (1–2), 83–102. https://doi.org/10.1007/s10584-008-9534-6.
(25) Harwatt, H.; Ripple, W. J.; Chaudhary, A.; Betts, M. G.; Hayek, M. N. Scientists Call for Renewed Paris Pledges to Transform Agriculture. *The Lancet Planetary Health* **2020**, *4* (1), e9–e10. https://doi.org/10.1016/S2542-5196(19)30245-1.
(26) Theurl, M. C.; Lauk, C.; Kalt, G.; Mayer, A.; Kaltenegger, K.; Morais, T. G.; Teixeira, R. F. M.; Domingos, T.; Winiwarter, W.; Erb, K.-H.; Haberl, H. Food Systems in a Zero-Deforestation World: Dietary Change Is More Important than Intensification for Climate Targets in 2050. *Science of The Total Environment* **2020**, *735*, 139353. https://doi.org/10.1016/j.scitotenv.2020.139353.
(27) Hayek, M. N.; Harwatt, H.; Ripple, W. J.; Mueller, N. D. The Carbon Opportunity Cost of Animal-Sourced Food Production on Land. *Nat Sustain* **2021**, *4* (1), 21–24. https://doi.org/10.1038/s41893-020-00603-4.

(28) Searchinger, T. D.; Wirsenius, S.; Beringer, T.; Dumas, P. Assessing the Efficiency of Changes in Land Use for Mitigating Climate Change. *Nature* **2018**, *564* (7735), 249–253. https://doi.org/10.1038/s41586-018-0757-z.
(29) Clune, S.; Crossin, E.; Verghese, K. Systematic Review of Greenhouse Gas Emissions for Different Fresh Food Categories. *Journal of Cleaner Production* **2017**, *140*, 766–783. https://doi.org/10.1016/j.jclepro.2016.04.082.
(30) Clark, M.; Tilman, D. Comparative Analysis of Environmental Impacts of Agricultural Production Systems, Agricultural Input Efficiency, and Food Choice. *Environ. Res. Lett.* **2017**, *12* (6), 064016. https://doi.org/10.1088/1748-9326/aa6cd5.
(31) Poore, J.; Nemecek, T. Reducing Food's Environmental Impacts through Producers and Consumers. *Science* **2018**, *360* (6392), 987–992. https://doi.org/10.1126/science.aaq0216.
(32) IPCC, U. N. *IPCC special report: Climate Change and Land*. UNEP - UN Environment Programme. http://www.unep.org/resources/report/ipcc-special-report-climate-change-and-land (accessed 2021-12-26).
(33) Chai, B. C.; van der Voort, J. R.; Grofelnik, K.; Eliasdottir, H. G.; Klöss, I.; Perez-Cueto, F. J. A. Which Diet Has the Least Environmental Impact on Our Planet? A Systematic Review of Vegan, Vegetarian and Omnivorous Diets. *Sustainability* **2019**, *11* (15), 4110. https://doi.org/10.3390/su11154110.
(34) Rosi, A.; Mena, P.; Pellegrini, N.; Turroni, S.; Neviani, E.; Ferrocino, I.; Di Cagno, R.; Ruini, L.; Ciati, R.; Angelino, D.; Maddock, J.; Gobbetti, M.; Brighenti, F.; Del Rio, D.; Scazzina, F. Environmental Impact of Omnivorous, Ovo-Lacto-Vegetarian, and Vegan Diet. *Sci Rep* **2017**, *7* (1), 6105. https://doi.org/10.1038/s41598-017-06466-8.
(35) Steinfeld, H.; Gerber, P.; Wassenaar, T.; Castel, V.; Rosales, M.; de Haan, C. Livestock's Long Shadow Https://Www.Fao.Org/3/A0701e/A0701e00.Htm. **2006**.
(36) Grosso, S. J. D.; Cavigelli, M. A. Climate Stabilization Wedges Revisited: Can Agricultural Production and Greenhouse-gas Reduction Goals Be Accomplished? *Frontiers in Ecology and the Environment* **2012**, *10* (10), 571–578. https://doi.org/10.1890/120058.
(37) Heller, M. C.; Keoleian, G. A. Greenhouse Gas Emission Estimates of U.S. Dietary Choices and Food Loss: GHG Emissions of U.S. Dietary Choices and Food Loss. *Journal of Industrial Ecology* **2015**, *19* (3), 391–401. https://doi.org/10.1111/jiec.12174.
(38) Erb, K.-H.; Lauk, C.; Kastner, T.; Mayer, A.; Theurl, M. C.; Haberl, H. Exploring the Biophysical Option Space for Feeding the World without Deforestation. *Nat Commun* **2016**, *7* (1), 11382. https://doi.org/10.1038/ncomms11382.
(39) Gerten, D.; Heck, V.; Jägermeyr, J.; Bodirsky, B. L.; Fetzer, I.; Jalava, M.; Kummu, M.; Lucht, W.; Rockström, J.; Schaphoff, S.; Schellnhuber, H. J. Feeding Ten Billion People Is Possible within Four Terrestrial Planetary Boundaries. *Nat Sustain* **2020**, *3* (3), 200–208. https://doi.org/10.1038/s41893-019-0465-1.
(40) Shepon, A.; Eshel, G.; Noor, E.; Milo, R. The Opportunity Cost of Animal Based Diets Exceeds All Food Losses. *Proc Natl Acad Sci USA* **2018**, *115* (15), 3804–3809. https://doi.org/10.1073/pnas.1713820115.
(41) IPCC. *Climate Change 2022: Mitigation of Climate Change*. https://www.ipcc.ch/report/ar6/wg3/ (accessed 2022-05-10).
(42) Marlow, H. J.; Harwatt, H.; Soret, S.; Sabaté, J. Comparing the Water, Energy, Pesticide and Fertilizer Usage for the Production of Foods Consumed by Different Dietary Types in California. *Public Health Nutr.* **2015**, *18* (13), 2425–2432. https://doi.org/10.1017/S1368980014002833.

(43) Santo, R. E.; Kim, B. F.; Goldman, S. E.; Dutkiewicz, J.; Biehl, E. M. B.; Bloem, M. W.; Neff, R. A.; Nachman, K. E. Considering Plant-Based Meat Substitutes and Cell-Based Meats: A Public Health and Food Systems Perspective. *Front. Sustain. Food Syst.* **2020**, *4*, 134. https://doi.org/10.3389/fsufs.2020.00134.
(44) Sabaté, J.; Sranacharoenpong, K.; Harwatt, H.; Wien, M.; Soret, S. The Environmental Cost of Protein Food Choices. *Public Health Nutr.* **2015**, *18* (11), 2067–2073. https://doi.org/10.1017/S1368980014002377.
(45) Burkholder, J.; Libra, B.; Weyer, P.; Heathcote, S.; Kolpin, D.; Thorne, P. S.; Wichman, M. Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality. *Environmental Health Perspectives* **2007**, *115* (2), 308–312. https://doi.org/10.1289/ehp.8839.
(46) Burkholder, J. M.; Mallin, M. A.; Glasgow, H. B.; Larsen, L. M.; McIver, M. R.; Shank, G. C.; Deamer-Melia, N.; Briley, D. S.; Springer, J.; Touchette, B. W.; Hannon, E. K. Impacts to a Coastal River and Estuary from Rupture of a Large Swine Waste Holding Lagoon. *J. environ. qual.* **1997**, *26* (6), 1451–1466. https://doi.org/10.2134/jeq1997.00472425002600060003x.
(47) R. L. Huffman. SEEPAGE EVALUATION OF OLDER SWINE LAGOONS IN NORTH CAROLINA. *Transactions of the ASAE* **2004**, *47* (5), 1507–1512. https://doi.org/10.13031/2013.17630.
(48) Leavey-Roback, S. L.; Krasner, S. W.; Suffet, I. (Mel) H. Veterinary Antibiotics Used in Animal Agriculture as NDMA Precursors. *Chemosphere* **2016**, *164*, 330–338. https://doi.org/10.1016/j.chemosphere.2016.08.070.
(49) Domingo, N. G. G.; Balasubramanian, S.; Thakrar, S. K.; Clark, M. A.; Adams, P. J.; Marshall, J. D.; Muller, N. Z.; Pandis, S. N.; Polasky, S.; Robinson, A. L.; Tessum, C. W.; Tilman, D.; Tschofen, P.; Hill, J. D. Air Quality–Related Health Damages of Food. *Proc Natl Acad Sci USA* **2021**, *118* (20), e2013637118. https://doi.org/10.1073/pnas.2013637118.
(50) Von Essen, S. G.; Auvermann, B. W. Health Effects from Breathing Air Near CAFOs for Feeder Cattle or Hogs. *Journal of Agromedicine* **2005**, *10* (4), 55–64. https://doi.org/10.1300/J096v10n04_08.
(51) Bullers, S. Environmental Stressors, Perceived Control, and Health: The Case of Residents Near Large-Scale Hog Farms in Eastern North Carolina. *Hum Ecol* **2005**, *33* (1), 1–16. https://doi.org/10.1007/s10745-005-1653-3.
(52) Cole, D.; Todd, L.; Wing, S. Concentrated Swine Feeding Operations and Public Health: A Review of Occupational and Community Health Effects. *Environmental Health Perspectives* **2000**, *108* (8), 685–699. https://doi.org/10.1289/ehp.00108685.
(53) Wing, S.; Wolf, S. Intensive Livestock Operations, Health, and Quality of Life among Eastern North Carolina Residents. *Environmental Health Perspectives* **2000**, *108* (3), 233–238. https://doi.org/10.1289/ehp.00108233.
(54) Springmann, M.; Clark, M. A.; Rayner, M.; Scarborough, P.; Webb, P. The Global and Regional Costs of Healthy and Sustainable Dietary Patterns: A Modelling Study. *The Lancet Planetary Health* **2021**, *5* (11), e797–e807. https://doi.org/10.1016/S2542-5196(21)00251-5.
(55) Simon, D. R. *Meatonomics: How the Rigged Economics of Meat and Dairy Make You Consume Too Much-- and How to Eat Better, Live Longer, and Spend Smarter*; Conari Press: San Francisco, CA, 2013.
(56) Cassidy, E. S.; West, P. C.; Gerber, J. S.; Foley, J. A. Redefining Agricultural Yields: From Tonnes to People Nourished per Hectare. *Environ. Res. Lett.* **2013**, *8* (3), 034015. https://doi.org/10.1088/1748-9326/8/3/034015.

(57) Vogt, R.; Bennett, D.; Cassady, D.; Frost, J.; Ritz, B.; Hertz-Picciotto, I. Cancer and Non-Cancer Health Effects from Food Contaminant Exposures for Children and Adults in California: A Risk Assessment. *Environ Health* **2012**, *11* (1), 83. https://doi.org/10.1186/1476-069X-11-83.
(58) US EPA, O. *Learn about Dioxin*. https://www.epa.gov/dioxin/learn-about-dioxin (accessed 2022-01-14).
(59) Menzel, J.; Abraham, K.; Dietrich, S.; Fromme, H.; Völkel, W.; Schwerdtle, T.; Weikert, C. Internal Exposure to Perfluoroalkyl Substances (PFAS) in Vegans and Omnivores. *International Journal of Hygiene and Environmental Health* **2021**, *237*, 113808. https://doi.org/10.1016/j.ijheh.2021.113808.
(60) *Polychlorinated Biphenyls (PCBs) Toxicity: What Are Routes of Exposure for PCBs? | Environmental Medicine | ATSDR*. https://www.atsdr.cdc.gov/csem/polychlorinated-biphenyls/what_routes.html (accessed 2022-01-14).
(61) Domingo, J. L. Polybrominated Diphenyl Ethers in Food and Human Dietary Exposure: A Review of the Recent Scientific Literature. *Food and Chemical Toxicology* **2012**, *50* (2), 238–249. https://doi.org/10.1016/j.fct.2011.11.004.
(62) US EPA, O. *How People are Exposed to Mercury*. https://www.epa.gov/mercury/how-people-are-exposed-mercury (accessed 2022-01-14).
(63) Tessum, C. W.; Apte, J. S.; Goodkind, A. L.; Muller, N. Z.; Mullins, K. A.; Paolella, D. A.; Polasky, S.; Springer, N. P.; Thakrar, S. K.; Marshall, J. D.; Hill, J. D. Inequity in Consumption of Goods and Services Adds to Racial–Ethnic Disparities in Air Pollution Exposure. *Proc Natl Acad Sci USA* **2019**, *116* (13), 6001–6006. https://doi.org/10.1073/pnas.1818859116.
(64) Wing, S.; Cole, D.; Grant, G. Environmental Injustice in North Carolina's Hog Industry. *Environmental Health Perspectives* **2000**, *108* (3), 225–231. https://doi.org/10.1289/ehp.00108225.
(65) Kravchenko, J.; Rhew, S. H.; Akushevich, I.; Agarwal, P.; Lyerly, H. K. Mortality and Health Outcomes in North Carolina Communities Located in Close Proximity to Hog Concentrated Animal Feeding Operations. *North Carolina Medical Journal* **2018**, *79* (5), 278–288. https://doi.org/10.18043/ncm.79.5.278.
(66) Wilson, S. M.; Howell, F.; Wing, S.; Sobsey, M. Environmental Injustice and the Mississippi Hog Industry. *Environmental Health Perspectives* **2002**, *110* (suppl 2), 195–201. https://doi.org/10.1289/ehp.02110s2195.
(67) Mirabelli, M. C.; Wing, S.; Marshall, S. W.; Wilcosky, T. C. Race, Poverty, and Potential Exposure of Middle-School Students to Air Emissions from Confined Swine Feeding Operations. *Environmental Health Perspectives* **2006**, *114* (4), 591–596. https://doi.org/10.1289/ehp.8586.
(68) Environment, U. N. *Food system impacts on biodiversity loss*. UNEP - UN Environment Programme. http://www.unep.org/resources/publication/food-system-impacts-biodiversity-loss (accessed 2021-12-27).
(69) Kim, H.; Rebholz, C. M.; Hegde, S.; LaFiura, C.; Raghavan, M.; Lloyd, J. F.; Cheng, S.; Seidelmann, S. B. Plant-Based Diets, Pescatarian Diets and COVID-19 Severity: A Population-Based Case–Control Study in Six Countries. *BMJNPH* **2021**, *4* (1), 257–266. https://doi.org/10.1136/bmjnph-2021-000272.

(70) Intergovernmental Science-Policy Platform On Biodiversity And Ecosystem Services (IPBES). *Workshop Report on Biodiversity and Pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)*; Zenodo, 2020. https://doi.org/10.5281/ZENODO.4147317.
(71) White, R. J.; Razgour, O. Emerging Zoonotic Diseases Originating in Mammals: A Systematic Review of Effects of Anthropogenic Land-use Change. *Mam Rev* **2020**, *50* (4), 336–352. https://doi.org/10.1111/mam.12201.
(72) IPCC. *Global Warming of 1.5 °C —*. https://www.ipcc.ch/sr15/ (accessed 2022-05-03).
(73) Temkin, A.; Evans, S.; Manidis, T.; Campbell, C.; Naidenko, O. V. Exposure-Based Assessment and Economic Valuation of Adverse Birth Outcomes and Cancer Risk Due to Nitrate in United States Drinking Water. *Environmental Research* **2019**, *176*, 108442. https://doi.org/10.1016/j.envres.2019.04.009.
(74) Nicole, W. CAFOs and Environmental Justice: The Case of North Carolina. *Environmental Health Perspectives* **2013**, *121* (6). https://doi.org/10.1289/ehp.121-a182.
(75) Wing, S.; Horton, R. A.; Rose, K. M. Air Pollution from Industrial Swine Operations and Blood Pressure of Neighboring Residents. *Environmental Health Perspectives* **2013**, *121* (1), 92–96. https://doi.org/10.1289/ehp.1205109.
(76) Smith, P. N. The Meat of the Matter: Environmental Dissemination of Beef Cattle Agrochemicals. *Environ Toxicol Chem* **2021**, *40* (4), 965–966. https://doi.org/10.1002/etc.4965.
(77) Inc, G. *Nearly One in Four in U.S. Have Cut Back on Eating Meat*. Gallup.com. https://news.gallup.com/poll/282779/nearly-one-four-cut-back-eating-meat.aspx (accessed 2021-12-30).
(78) *The Vegetarian Resource Group (VRG)*. https://www.vrg.org/press/201511press.htm (accessed 2021-12-30).
(79) Inc, G. *Snapshot: Few Americans Vegetarian or Vegan*. Gallup.com. https://news.gallup.com/poll/238328/snapshot-few-americans-vegetarian-vegan.aspx (accessed 2022-01-01).
(80) Thakali, A.; MacRae, J. D. A Review of Chemical and Microbial Contamination in Food: What Are the Threats to a Circular Food System? *Environmental Research* **2021**, *194*, 110635. https://doi.org/10.1016/j.envres.2020.110635.
(81) Intergovernmental Panel on Climate Change. *Summary for Policymakers — Global Warming of 1.5 °C https://www.ipcc.ch/sr15/chapter/spm/*. https://www.ipcc.ch/sr15/chapter/spm/ (accessed 2022-01-24).
(82) *Coral reefs support 25% of life in the ocean -- but they need our help. | Office of National Marine Sanctuaries*. https://sanctuaries.noaa.gov/news/dec15/coral-bleaching.html (accessed 2022-01-25).
(83) IPCC. *Climate Change 2022: Impacts, Adaptation and Vulnerability*. https://www.ipcc.ch/report/ar6/wg2/ (accessed 2022-03-26).
(84) *Climate change and health*. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health (accessed 2022-01-25).
(85) *Despite pandemic shutdowns, carbon dioxide and methane surged in 2020 - Welcome to NOAA Research*. https://research.noaa.gov/article/ArtMID/587/ArticleID/2742/Despite-pandemic-shutdowns-carbon-dioxide-and-methane-surged-in-2020 (accessed 2022-01-25).
(86) Wise, J. COP26 Summit: Leaders Frustrated at Watered down Climate Deal. *BMJ* **2021**, n2803. https://doi.org/10.1136/bmj.n2803.

(87) Environment, U. N. *Emissions Gap Report 2022*. UNEP - UN Environment Programme. http://www.unep.org/resources/emissions-gap-report-2022 (accessed 2022-10-27).
(88) Climate Tracker. *Glasgow's 2030 credibility gap: net zero's lip service to climate action*. https://climateactiontracker.org/publications/glasgows-2030-credibility-gap-net-zeros-lip-service-to-climate-action/ (accessed 2022-01-24).
(89) Friedlingstein, P.; Jones, M. W.; O'Sullivan, M.; Andrew, R. M.; Bakker, D. C. E.; Hauck, J.; Le Quéré, C.; Peters, G. P.; Peters, W.; Pongratz, J.; Sitch, S.; Canadell, J. G.; Ciais, P.; Jackson, R. B.; Alin, S. R.; Anthoni, P.; Bates, N. R.; Becker, M.; Bellouin, N.; Bopp, L.; Chau, T. T. T.; Chevallier, F.; Chini, L. P.; Cronin, M.; Currie, K. I.; Decharme, B.; Djeutchouang, L.; Dou, X.; Evans, W.; Feely, R. A.; Feng, L.; Gasser, T.; Gilfillan, D.; Gkritzalis, T.; Grassi, G.; Gregor, L.; Gruber, N.; Gürses, Ö.; Harris, I.; Houghton, R. A.; Hurtt, G. C.; Iida, Y.; Ilyina, T.; Luijkx, I. T.; Jain, A. K.; Jones, S. D.; Kato, E.; Kennedy, D.; Klein Goldewijk, K.; Knauer, J.; Korsbakken, J. I.; Körtzinger, A.; Landschützer, P.; Lauvset, S. K.; Lefèvre, N.; Lienert, S.; Liu, J.; Marland, G.; McGuire, P. C.; Melton, J. R.; Munro, D. R.; Nabel, J. E. M. S.; Nakaoka, S.-I.; Niwa, Y.; Ono, T.; Pierrot, D.; Poulter, B.; Rehder, G.; Resplandy, L.; Robertson, E.; Rödenbeck, C.; Rosan, T. M.; Schwinger, J.; Schwingshackl, C.; Séférian, R.; Sutton, A. J.; Sweeney, C.; Tanhua, T.; Tans, P. P.; Tian, H.; Tilbrook, B.; Tubiello, F.; van der Werf, G.; Vuichard, N.; Wada, C.; Wanninkhof, R.; Watson, A.; Willis, D.; Wiltshire, A. J.; Yuan, W.; Yue, C.; Yue, X.; Zaehle, S.; Zeng, J. *Global Carbon Budget 2021*; preprint; Antroposphere – Energy and Emissions, 2021. https://doi.org/10.5194/essd-2021-386.
(90) *Only 11 Years Left to Prevent Irreversible Damage from Climate Change, Speakers Warn during General Assembly High-Level Meeting | Meetings Coverage and Press Releases*. https://www.un.org/press/en/2019/ga12131.doc.htm (accessed 2022-01-24).
(91) *WWF (2020) Bending the Curve: The Restorative Power of Planet-Based Diets. WWF Report.* Dropbox. https://www.dropbox.com/s/6krwxnkguerh2z3/Planet%20Based%20Diets%20-%20Data%20and%20Viewer.xlsx?dl=0 (accessed 2022-06-27).
(92) Breeze, N. *Lecture 3: Joseph Poore - Environmental Impact of Food*. https://climateseries.com/lectures/34-joseph-poore-climatechange-food-impact (accessed 2022-06-27).
(93) Dreyfus, G. B.; Xu, Y.; Shindell, D. T.; Zaelke, D.; Ramanathan, V. Mitigating Climate Disruption in Time: A Self-Consistent Approach for Avoiding Both near-Term and Long-Term Global Warming. *Proc. Natl. Acad. Sci. U.S.A.* **2022**, *119* (22), e2123536119. https://doi.org/10.1073/pnas.2123536119.
(94) *Inflation Reduction Act of 2022*. Energy.gov. https://www.energy.gov/lpo/inflation-reduction-act-2022 (accessed 2022-11-25).
(95) *Soy: food, feed, and land use change | TABLE Debates*. https://www.tabledebates.org/building-blocks/soy-food-feed-and-land-use-change (accessed 2022-01-24).
(96) Weisse, M.; Goldman, E. D. Just 7 Commodities Replaced an Area of Forest Twice the Size of Germany Between 2001 and 2015 Https://Www.Wri.Org/Insights/Just-7-Commodities-Replaced-Area-Forest-Twice-Size-Germany-between-2001-and-2015. **2021**.
(97) Nutrition, C. for F. S. and A. GMO Crops, Animal Food, and Beyond Https://Www.Fda.Gov/Food/Agricultural-Biotechnology/Gmo-Crops-Animal-Food-and-Beyond. *FDA* **2022**.
(98) California, S. of. *Agricultural Land & Water Use Estimates*. https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Agricultural-Land-And-Water-Use-Estimates (accessed 2022-02-03).

(99) Steffen, W.; Richardson, K.; Rockström, J.; Cornell, S. E.; Fetzer, I.; Bennett, E. M.; Biggs, R.; Carpenter, S. R.; de Vries, W.; de Wit, C. A.; Folke, C.; Gerten, D.; Heinke, J.; Mace, G. M.; Persson, L. M.; Ramanathan, V.; Reyers, B.; Sörlin, S. Planetary Boundaries: Guiding Human Development on a Changing Planet. *Science* **2015**, *347* (6223), 1259855. https://doi.org/10.1126/science.1259855.
(100) Frankowska, A.; Jeswani, H. K.; Azapagic, A. Life Cycle Environmental Impacts of Fruits Consumption in the UK. *Journal of Environmental Management* **2019**, *248*, 109111. https://doi.org/10.1016/j.jenvman.2019.06.012.
(101) *The State of World Fisheries and Aquaculture 2020*; FAO, 2020. https://doi.org/10.4060/ca9229en.
(102) Fry, J. P.; Mailloux, N. A.; Love, D. C.; Milli, M. C.; Cao, L. Feed Conversion Efficiency in Aquaculture: Do We Measure It Correctly? *Environ. Res. Lett.* **2018**, *13* (2), 024017. https://doi.org/10.1088/1748-9326/aaa273.
(103) Lebreton, L.; Slat, B.; Ferrari, F.; Sainte-Rose, B.; Aitken, J.; Marthouse, R.; Hajbane, S.; Cunsolo, S.; Schwarz, A.; Levivier, A.; Noble, K.; Debeljak, P.; Maral, H.; Schoeneich-Argent, R.; Brambini, R.; Reisser, J. Evidence That the Great Pacific Garbage Patch Is Rapidly Accumulating Plastic. *Sci Rep* **2018**, *8* (1), 4666. https://doi.org/10.1038/s41598-018-22939-w.
(104) US EPA, O. *Health Effects of Exposures to Mercury*. https://www.epa.gov/mercury/health-effects-exposures-mercury (accessed 2022-01-25).
(105) *Shrinking Carbon and Water Footprints of School Food*. Friends of the Earth. https://foe.org/resources/shrinking-carbon-water-footprint-school-food/ (accessed 2022-01-25).
(106) *UNT Chef Dining Director and Project Director.mp4*. Google Docs. https://drive.google.com/file/d/1RBi4M6l4ygxPv0CKw0jteyPdp_MNu2cH (accessed 2022-01-25).
(107) *LCA of cultivated meat. Future projections for different scenarios*. CE Delft - EN. https://cedelft.eu/publications/rapport-lca-of-cultivated-meat-future-projections-for-different-scenarios/ (accessed 2022-01-25).
(108) *FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies*. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/ (accessed 2022-01-25).
(109) Bryant, C. J. Plant-Based Animal Product Alternatives Are Healthier and More Environmentally Sustainable than Animal Products. *Future Foods* **2022**, *6*, 100174. https://doi.org/10.1016/j.fufo.2022.100174.
(110) US EPA, O. *EPA-FDA Advice about Eating Fish and Shellfish*. https://www.epa.gov/fish-tech/epa-fda-advice-about-eating-fish-and-shellfish (accessed 2022-01-25).
(111) Nutrition, C. for F. S. and A. Mercury Levels in Commercial Fish and Shellfish (1990-2012) Https://Www.Fda.Gov/Food/Metals-and-Your-Food/Mercury-Levels-Commercial-Fish-and-Shellfish-1990-2012. *FDA* **2022**.
(112) Onwezen, M. C.; Bouwman, E. P.; Reinders, M. J.; Dagevos, H. A Systematic Review on Consumer Acceptance of Alternative Proteins: Pulses, Algae, Insects, Plant-Based Meat Alternatives, and Cultured Meat. *Appetite* **2021**, *159*, 105058. https://doi.org/10.1016/j.appet.2020.105058.

(113) *Zoonotic Diseases | One Health | CDC*. https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html (accessed 2021-12-31).
(114) *World Livestock 2013 // Changing disease landscapes*. https://www.fao.org/ag/againfo/resources/en/publications/world_livestock/2013.htm (accessed 2021-12-31).
(115) *Unite human, animal and environmental health to prevent the next pandemic – UN Report*. UN Environment. http://www.unep.org/news-and-stories/press-release/unite-human-animal-and-environmental-health-prevent-next-pandemic-un (accessed 2021-12-31).
(116) World Health Organization. *Report of the WHO/FAO/OIE Joint Consultation on Emerging Zoonotic Diseases*; WHO/CDS/CPE/ZFK/2004.9; World Health Organization, 2004. https://apps.who.int/iris/handle/10665/68899 (accessed 2021-12-31).
(117) *Department of Environmental Quality : Environmental Footprints of Food : Food Environmental Impacts and Actions : State of Oregon*. https://www.oregon.gov/deq/mm/food/pages/product-category-level-footprints.aspx (accessed 2022-01-12).
(118) Weber, C. L.; Matthews, H. S. Food-Miles and the Relative Climate Impacts of Food Choices in the United States. *Environ. Sci. Technol.* **2008**, *42* (10), 3508–3513. https://doi.org/10.1021/es702969f.
(119) Mohareb, E. A.; Heller, M. C.; Guthrie, P. M. Cities' Role in Mitigating United States Food System Greenhouse Gas Emissions. *Environ. Sci. Technol.* **2018**, *52* (10), 5545–5554. https://doi.org/10.1021/acs.est.7b02600.
(120) Guo, X.; Broeze, J.; Groot, J. J.; Axmann, H.; Vollebregt, M. A Worldwide Hotspot Analysis on Food Loss and Waste, Associated Greenhouse Gas Emissions, and Protein Losses. *Sustainability* **2020**, *12* (18), 7488. https://doi.org/10.3390/su12187488.
(121) US EPA, O. *From Farm to Kitchen: The Environmental Impacts of U.S. Food Waste*. https://www.epa.gov/land-research/farm-kitchen-environmental-impacts-us-food-waste (accessed 2021-12-26).
(122) Klopatek, S. C.; Marvinney, E.; Duarte, T.; Kendall, A.; Yang, X. (Crystal); Oltjen, J. W. Grass-Fed vs. Grain-Fed Beef Systems: Performance, Economic, and Environmental Trade-Offs. *Journal of Animal Science* **2022**, *100* (2), skab374. https://doi.org/10.1093/jas/skab374.
(123) Hayek, M. N.; Garrett, R. D. Nationwide Shift to Grass-Fed Beef Requires Larger Cattle Population. *Environ. Res. Lett.* **2018**, *13* (8), 084005. https://doi.org/10.1088/1748-9326/aad401.
(124) Garnett, T.; Godde, C.; Muller, A.; Röös, E.; Smith, P.; De Boer, I. J. M.; Ermgassen, E. zu; Herrero, M.; Middelaar, C. van; Schader, C.; Zanten, H. van. *Grazed and Confused?*. Oxford Martin School. https://www.oxfordmartin.ox.ac.uk/publications/grazed-and-confused/ (accessed 2022-01-16).
(125) Hawkins, H.-J.; Venter, Z.-S.; Cramer, M. D. A Holistic View of Holistic Management: What Do Farm-Scale, Carbon, and Social Studies Tell Us? *Agriculture, Ecosystems & Environment* **2022**, *323*, 107702. https://doi.org/10.1016/j.agee.2021.107702.
(126) Su, J.; Xu, F. Root, Not Aboveground Litter, Controls Soil Carbon Storage under Grazing Exclusion across Grasslands Worldwide. *Land Degrad Dev* **2021**, *32* (11), 3326–3337. https://doi.org/10.1002/ldr.4008.
(127) Lai, L.; Kumar, S. A Global Meta-Analysis of Livestock Grazing Impacts on Soil Properties. *PLoS ONE* **2020**, *15* (8), e0236638. https://doi.org/10.1371/journal.pone.0236638.

(128) Cusack, D. F.; Kazanski, C. E.; Hedgpeth, A.; Chow, K.; Cordeiro, A. L.; Karpman, J.; Ryals, R. Reducing Climate Impacts of Beef Production: A Synthesis of Life Cycle Assessments across Management Systems and Global Regions. *Glob. Change Biol.* **2021**, *27* (9), 1721–1736. https://doi.org/10.1111/gcb.15509.
(129) *Home | Dietary Guidelines for Americans*. https://www.dietaryguidelines.gov/ (accessed 2022-01-25).
(130) Tang, S.; Wang, K.; Xiang, Y.; Tian, D.; Wang, J.; Liu, Y.; Cao, B.; Guo, D.; Niu, S. Heavy Grazing Reduces Grassland Soil Greenhouse Gas Fluxes: A Global Meta-Analysis. *Science of The Total Environment* **2019**, *654*, 1218–1224. https://doi.org/10.1016/j.scitotenv.2018.11.082.
(131) Abdalla, M.; Hastings, A.; Chadwick, D. R.; Jones, D. L.; Evans, C. D.; Jones, M. B.; Rees, R. M.; Smith, P. Critical Review of the Impacts of Grazing Intensity on Soil Organic Carbon Storage and Other Soil Quality Indicators in Extensively Managed Grasslands. *Agriculture, Ecosystems & Environment* **2018**, *253*, 62–81. https://doi.org/10.1016/j.agee.2017.10.023.
(132) Byrnes, R. C.; Eastburn, D. J.; Tate, K. W.; Roche, L. M. A Global Meta-Analysis of Grazing Impacts on Soil Health Indicators. *J. Environ. Qual.* **2018**, *47* (4), 758–765. https://doi.org/10.2134/jeq2017.08.0313.
(133) Rowntree, J. E.; Stanley, P. L.; Maciel, I. C. F.; Thorbecke, M.; Rosenzweig, S. T.; Hancock, D. W.; Guzman, A.; Raven, M. R. Ecosystem Impacts and Productive Capacity of a Multi-Species Pastured Livestock System. *Front. Sustain. Food Syst.* **2020**, *4*, 544984. https://doi.org/10.3389/fsufs.2020.544984.
(134) Tautges, N. E.; Chiartas, J. L.; Gaudin, A. C. M.; O'Geen, A. T.; Herrera, I.; Scow, K. M. Deep Soil Inventories Reveal That Impacts of Cover Crops and Compost on Soil Carbon Sequestration Differ in Surface and Subsurface Soils. *Glob Change Biol* **2019**, *25* (11), 3753–3766. https://doi.org/10.1111/gcb.14762.
(135) Ryals, R.; Hartman, M. D.; Parton, W. J.; DeLonge, M. S.; Silver, W. L. Long-Term Climate Change Mitigation Potential with Organic Matter Management on Grasslands. *Ecological Applications* **2015**, *25* (2), 531–545. https://doi.org/10.1890/13-2126.1.
(136) *One crop, two ways, multiple benefits: Pulse crop adds long-term nitrogen, carbon to soil*. ScienceDaily. https://www.sciencedaily.com/releases/2016/01/160106125159.htm (accessed 2022-02-23).
(137) Conant, R. T.; Cerri, C. E. P.; Osborne, B. B.; Paustian, K. Grassland Management Impacts on Soil Carbon Stocks: A New Synthesis. *Ecol Appl* **2017**, *27* (2), 662–668. https://doi.org/10.1002/eap.1473.
(138) Henderson, B. B.; Gerber, P. J.; Hilinski, T. E.; Falcucci, A.; Ojima, D. S.; Salvatore, M.; Conant, R. T. Greenhouse Gas Mitigation Potential of the World's Grazing Lands: Modeling Soil Carbon and Nitrogen Fluxes of Mitigation Practices. *Agriculture, Ecosystems & Environment* **2015**, *207*, 91–100. https://doi.org/10.1016/j.agee.2015.03.029.
(139) Gan, Y.; Liang, C.; Chai, Q.; Lemke, R. L.; Campbell, C. A.; Zentner, R. P. Improving Farming Practices Reduces the Carbon Footprint of Spring Wheat Production. *Nat Commun* **2014**, *5* (1), 5012. https://doi.org/10.1038/ncomms6012.
(140) Griscom, B. W.; Adams, J.; Ellis, P. W.; Houghton, R. A.; Lomax, G.; Miteva, D. A.; Schlesinger, W. H.; Shoch, D.; Siikamäki, J. V.; Smith, P.; Woodbury, P.; Zganjar, C.; Blackman, A.; Campari, J.; Conant, R. T.; Delgado, C.; Elias, P.; Gopalakrishna, T.; Hamsik, M. R.; Herrero, M.; Kiesecker, J.; Landis, E.; Laestadius, L.; Leavitt, S. M.; Minnemeyer, S.; Polasky, S.; Potapov, P.; Putz, F. E.; Sanderman, J.; Silvius, M.; Wollenberg, E.; Fargione, J. Natural Climate Solutions. *Proc Natl Acad Sci USA* **2017**, *114* (44), 11645–11650. https://doi.org/10.1073/pnas.1710465114.

(141) *World must sustainably produce 70 per cent more food by mid-century – UN report*. UN News. https://news.un.org/en/story/2013/12/456912 (accessed 2022-01-25).
(142) van Dijk, M.; Morley, T.; Rau, M. L.; Saghai, Y. A Meta-Analysis of Projected Global Food Demand and Population at Risk of Hunger for the Period 2010–2050. *Nat Food* **2021**, *2* (7), 494–501. https://doi.org/10.1038/s43016-021-00322-9.
(143) Bell, S.; Terrer, C.; Rosell-Melé, A.; Barriocanal, C. *Abandoned but Not Forgotten: Uncovering the Soil Organic Carbon Dynamics and Sequestration Potential of Abandoned Agricultural Lands*; other; Soil Science, 2020. https://doi.org/10.1002/essoar.10501878.1.
(144) Meli, P.; Holl, K. D.; Rey Benayas, J. M.; Jones, H. P.; Jones, P. C.; Montoya, D.; Moreno Mateos, D. A Global Review of Past Land Use, Climate, and Active vs. Passive Restoration Effects on Forest Recovery. *PLoS ONE* **2017**, *12* (2), e0171368. https://doi.org/10.1371/journal.pone.0171368.
(145) Gilhen-Baker, M.; Roviello, V.; Beresford-Kroeger, D.; Roviello, G. N. Old Growth Forests and Large Old Trees as Critical Organisms Connecting Ecosystems and Human Health. A Review. *Environ Chem Lett* **2022**. https://doi.org/10.1007/s10311-021-01372-y.
(146) U.S. Fish and Wildlife Service. *Southwestern Willow Flycatcher Recovery Plan - Appendix G Https://Www.Fws.Gov/Southwest/Es/Arizona/Documents/SpeciesDocs/SWWF/Final%20Recovery%20Plan/Recovery%20Plan%20Appendices/G_LivestockGrazing.Pdf*; Albuquerque, New Mexico, 2002. https://www.fws.gov/southwest/es/arizona/Documents/SpeciesDocs/SWWF/Final%20Recovery%20Plan/Recovery%20Plan%20Appendices/G_LivestockGrazing.pdf.
(147) Kauffman, J. B.; Thorpe, A. S.; Brookshire, E. N. J. LIVESTOCK EXCLUSION AND BELOWGROUND ECOSYSTEM RESPONSES IN RIPARIAN MEADOWS OF EASTERN OREGON. *Ecological Applications* **2004**, *14* (6), 1671–1679. https://doi.org/10.1890/03-5083.
(148) Harwatt, H.; Sabaté, J.; Eshel, G.; Soret, S.; Ripple, W. Substituting Beans for Beef as a Contribution toward US Climate Change Targets. *Climatic Change* **2017**, *143* (1–2), 261–270. https://doi.org/10.1007/s10584-017-1969-1.
(149) Kauffman, J. B.; Beschta, R. L.; Lacy, P. M.; Liverman, M. Livestock Use on Public Lands in the Western USA Exacerbates Climate Change: Implications for Climate Change Mitigation and Adaptation. *Environmental Management* **2022**, *69* (6), 1137–1152. https://doi.org/10.1007/s00267-022-01633-8.
(150) Filazzola, A.; Brown, C.; Dettlaff, M. A.; Batbaatar, A.; Grenke, J.; Bao, T.; Peetoom Heida, I.; Cahill, J. F. The Effects of Livestock Grazing on Biodiversity Are Multi-trophic: A Meta-analysis. *Ecol Lett* **2020**, *23* (8), 1298–1309. https://doi.org/10.1111/ele.13527.
(151) Intergovernmental Panel on Climate Change. *Climate Change 2014 Mitigation of Climate Change: Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, 2014. https://doi.org/10.1017/CBO9781107415416.
(152) Godde, C. M.; de Boer, I. J. M.; Ermgassen, E. zu; Herrero, M.; van Middelaar, C. E.; Muller, A.; Röös, E.; Schader, C.; Smith, P.; van Zanten, H. H. E.; Garnett, T. Soil Carbon Sequestration in Grazing Systems: Managing Expectations. *Climatic Change* **2020**, *161* (3), 385–391. https://doi.org/10.1007/s10584-020-02673-x.

(153) Smith, P. Do Grasslands Act as a Perpetual Sink for Carbon? *Glob Change Biol* **2014**, *20* (9), 2708–2711. https://doi.org/10.1111/gcb.12561.
(154) Pelletier, N.; Pirog, R.; Rasmussen, R. Comparative Life Cycle Environmental Impacts of Three Beef Production Strategies in the Upper Midwestern United States. *Agricultural Systems* **2010**, *103* (6), 380–389. https://doi.org/10.1016/j.agsy.2010.03.009.
(155) Lupo, C. D.; Clay, D. E.; Benning, J. L.; Stone, J. J. Life-Cycle Assessment of the Beef Cattle Production System for the Northern Great Plains, USA. *J. Environ. Qual.* **2013**, *42* (5), 1386–1394. https://doi.org/10.2134/jeq2013.03.0101.
(156) Carter, J.; Jones, A.; O'Brien, M.; Ratner, J.; Wuerthner, G. Holistic Management: Misinformation on the Science of Grazed Ecosystems. *International Journal of Biodiversity* **2014**, *2014*, 1–10. https://doi.org/10.1155/2014/163431.
(157) Nordborg, M.; Röös, E. *Holistic Management – a Critical Review of Allan Savory's Grazing Method. Https://Research.Chalmers.Se/En/Publication/244566*; 2016.
(158) *Methane emissions are driving climate change. Here's how to reduce them.* UNEP. http://www.unep.org/news-and-stories/story/methane-emissions-are-driving-climate-change-heres-how-reduce-them (accessed 2022-12-23).
(159) UNEP. *Facts about Methane*. UNEP - UN Environment Programme. http://www.unep.org/explore-topics/energy/facts-about-methane (accessed 2022-12-23).
(160) *Climate metrics for ruminant livestock*. Oxford Martin School. https://www.oxfordmartin.ox.ac.uk/publications/climate-metrics-for-ruminant-livestock/ (accessed 2022-12-23).
(161) Poore, J.; Nemecek, T. Reducing Food's Environmental Impacts through Producers and Consumers. *Science* **2018**, *360* (6392), 987–992. https://doi.org/10.1126/science.aaq0216.
(162) Dass, P.; Houlton, B. Z.; Wang, Y.; Warlind, D. Grasslands May Be More Reliable Carbon Sinks than Forests in California. *Environ. Res. Lett.* **2018**, *13* (7), 074027. https://doi.org/10.1088/1748-9326/aacb39.
(163) Kerlin, K. E. *Grasslands More Reliable Carbon Sink Than Trees*. UC Davis. https://www.ucdavis.edu/climate/news/grasslands-more-reliable-carbon-sink-than-trees (accessed 2022-01-25).
(164) Liu, S.; Liu, J.; Young, C. J.; Werner, J. M.; Wu, Y.; Li, Z.; Dahal, D.; Oeding, J.; Schmidt, G. L.; Sohl, T. L.; Hawbaker, T. J.; Sleeter, B. M. Baseline Carbon Storage, Carbon Sequestration, and Greenhouse-Gas Fluxes in Terrestrial Ecosystems of the Western United States.
(165) Berners-Lee, M.; Kennelly, C.; Watson, R.; Hewitt, C. N. Current Global Food Production Is Sufficient to Meet Human Nutritional Needs in 2050 Provided There Is Radical Societal Adaptation. *Elementa: Science of the Anthropocene* **2018**, *6*, 52. https://doi.org/10.1525/elementa.310.
(166) Mottet, A.; de Haan, C.; Falcucci, A.; Tempio, G.; Opio, C.; Gerber, P. Livestock: On Our Plates or Eating at Our Table? A New Analysis of the Feed/Food Debate. *Global Food Security* **2017**, *14*, 1–8. https://doi.org/10.1016/j.gfs.2017.01.001.
(167) Baber, J. R.; Sawyer, J. E.; Wickersham, T. A. Estimation of Human-Edible Protein Conversion Efficiency, Net Protein Contribution, and Enteric Methane Production from Beef Production in the United States. *Translational Animal Science* **2018**, *2* (4), 439–450. https://doi.org/10.1093/tas/txy086.

(168) Lark, T. J.; Hendricks, N. P.; Smith, A.; Pates, N.; Spawn-Lee, S. A.; Bougie, M.; Booth, E. G.; Kucharik, C. J.; Gibbs, H. K. Environmental Outcomes of the US Renewable Fuel Standard. *Proceedings of the National Academy of Sciences* **2022**, *119* (9), e2101084119. https://doi.org/10.1073/pnas.2101084119.
(169) Giles, C. *Next Generation Compliance: Environmental Regulation for the Modern Era*, 1st ed.; Oxford University PressNew York, 2022. https://doi.org/10.1093/oso/9780197656747.001.0001.
(170) Reagan Noland; Clark Neely; Bill Thompson. *Wheat Hay vs. Grain: A comparison of economic opportunity*. Texas A&M Agrilife Extension. https://agrilife.org/texasrowcrops/2019/04/03/wheat-hay-vs-grain-a-comparison-of-economic-opportunity/ (accessed 2023-01-12).
(171) *Evaluating Winter Wheat for Use as Forage or Grain*. CropWatch. https://cropwatch.unl.edu/2019/evaluating-winter-wheat-use-forage-or-grain (accessed 2023-01-12).
(172) Tilman, D.; Clark, M. Global Diets Link Environmental Sustainability and Human Health. *Nature* **2014**, *515* (7528), 518–522. https://doi.org/10.1038/nature13959.
(173) Peters, C. J.; Picardy, J.; Darrouzet-Nardi, A. F.; Wilkins, J. L.; Griffin, T. S.; Fick, G. W. Carrying Capacity of U.S. Agricultural Land: Ten Diet Scenarios. *Elementa: Science of the Anthropocene* **2016**, *4*, 000116. https://doi.org/10.12952/journal.elementa.000116.
(174) Vollset, S. E.; Goren, E.; Yuan, C.-W.; Cao, J.; Smith, A. E.; Hsiao, T.; Bisignano, C.; Azhar, G. S.; Castro, E.; Chalek, J.; Dolgert, A. J.; Frank, T.; Fukutaki, K.; Hay, S. I.; Lozano, R.; Mokdad, A. H.; Nandakumar, V.; Pierce, M.; Pletcher, M.; Robalik, T.; Steuben, K. M.; Wunrow, H. Y.; Zlavog, B. S.; Murray, C. J. L. Fertility, Mortality, Migration, and Population Scenarios for 195 Countries and Territories from 2017 to 2100: A Forecasting Analysis for the Global Burden of Disease Study. *The Lancet* **2020**, *396* (10258), 1285–1306. https://doi.org/10.1016/S0140-6736(20)30677-2.
(175) *World Population Prospects - Population Division - United Nations*. https://population.un.org/wpp/ (accessed 2023-03-07).
(176) Van Zanten, H. H. E.; Herrero, M.; Van Hal, O.; Röös, E.; Muller, A.; Garnett, T.; Gerber, P. J.; Schader, C.; De Boer, I. J. M. Defining a Land Boundary for Sustainable Livestock Consumption. *Glob Change Biol* **2018**, *24* (9), 4185–4194. https://doi.org/10.1111/gcb.14321.
(177) https://www.beefboard.org/2019/09/19/is-beef-to-blame-for-climate-change/. *Is Beef to Blame for Climate Change?*. Beef Checkoff. https://www.beefboard.org/2019/09/19/is-beef-to-blame-for-climate-change/ (accessed 2022-03-30).
(178) White, R. R.; Hall, M. B. Nutritional and Greenhouse Gas Impacts of Removing Animals from US Agriculture. *Proc Natl Acad Sci U S A* **2017**, *114* (48), E10301–E10308. https://doi.org/10.1073/pnas.1707322114.
(179) White, R. R.; Hall, M. B. Reply to Van Meerbeek and Svenning, Emery, and Springmann et al.: Clarifying Assumptions and Objectives in Evaluating Effects of Food System Shifts on Human Diets. *Proc. Natl. Acad. Sci. U.S.A.* **2018**, *115* (8). https://doi.org/10.1073/pnas.1720895115.
(180) Van Meerbeek, K.; Svenning, J.-C. Causing Confusion in the Debate about the Transition toward a More Plant-Based Diet. *Proc. Natl. Acad. Sci. U.S.A.* **2018**, *115* (8). https://doi.org/10.1073/pnas.1720738115.
(181) Springmann, M.; Clark, M.; Willett, W. Feedlot Diet for Americans That Results from a Misspecified Optimization Algorithm. *Proc. Natl. Acad. Sci. U.S.A.* **2018**, *115* (8). https://doi.org/10.1073/pnas.1721335115.
(182) Emery, I. Without Animals, US Farmers Would Reduce Feed Crop Production. *Proc. Natl. Acad. Sci. U.S.A.* **2018**, *115* (8). https://doi.org/10.1073/pnas.1720760115.

(183) Rotz, C. A.; Asem-Hiablie, S.; Place, S.; Thoma, G. Environmental Footprints of Beef Cattle Production in the United States. *Agricultural Systems* **2019**, *169*, 1–13. https://doi.org/10.1016/j.agsy.2018.11.005.
(184) Battagliese, T.; Stackhouse-Lawson, K. R.; Rotz, C. A. Employment History - KIMBERLY STACKHOUSE-LAWSON, PH.D. 4. https://agsci.colostate.edu/ansci/wp-content/uploads/sites/21/2020/06/Stackhouse-Lawson-CV_Redacted.pdf.
(185) Eisen, M. B.; Brown, P. O. Rapid Global Phaseout of Animal Agriculture Has the Potential to Stabilize Greenhouse Gas Levels for 30 Years and Offset 68 Percent of CO2 Emissions This Century. *PLOS Clim* **2022**, *1* (2), e0000010. https://doi.org/10.1371/journal.pclm.0000010.
(186) *Beef Research - Removing Beef From The Diet*. Beef Research. https://www.beefresearch.org/resources/beef-sustainability/fact-sheets/removing-beef-from-the-diet (accessed 2022-01-25).
(187) US EPA, O. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019*. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2019 (accessed 2021-12-26).
(188) *Greenhouse Gas Inventory Data Explorer | US EPA*. https://cfpub.epa.gov/ghgdata/inventoryexplorer/ (accessed 2022-01-25).
(189) Miller, S. M.; Wofsy, S. C.; Michalak, A. M.; Kort, E. A.; Andrews, A. E.; Biraud, S. C.; Dlugokencky, E. J.; Eluszkiewicz, J.; Fischer, M. L.; Janssens-Maenhout, G.; Miller, B. R.; Miller, J. B.; Montzka, S. A.; Nehrkorn, T.; Sweeney, C. Anthropogenic Emissions of Methane in the United States. *Proceedings of the National Academy of Sciences* **2013**, *110* (50), 20018–20022. https://doi.org/10.1073/pnas.1314392110.
(190) Hayek, M. N.; Miller, S. M. Underestimates of Methane from Intensively Raised Animals Could Undermine Goals of Sustainable Development. *Environ. Res. Lett.* **2021**, *16* (6), 063006. https://doi.org/10.1088/1748-9326/ac02ef.
(191) *Tackling Climate Change through Livestock*. https://www.fao.org/3/i3437e/i3437e00.htm (accessed 2022-03-29).
(192) Searchinger, T. D.; Wirsenius, S.; Beringer, T.; Dumas, P. Explaining the Contributions and Findings of "Assessing the Efficiency of Changes in Land Use for Mitigating Climate Change" Nature 564, Pp 249–253 (2018) Https://Research.Chalmers.Se/En/Publication/507822. **2018**.
(193) BDA. *British Dietetic Association confirms well-planned vegan diets can support healthy living in people of all ages*. https://www.bda.uk.com/resource/british-dietetic-association-confirms-well-planned-vegan-diets-can-support-healthy-living-in-people-of-all-ages.html (accessed 2022-04-01).
(194) Dietitians of Canada. *What You Need to Know About Following a Vegan Eating Plan - Unlock Food*. https://www.unlockfood.ca/en/Articles/Vegetarian-and-Vegan-Diets/What-You-Need-to-Know-About-Following-a-Vegan-Eati.aspx (accessed 2022-04-01).
(195) *2015 Dietary Guidelines: Giving You the Tools You Need to Make Healthy Choices*. https://www.usda.gov/media/blog/2015/10/06/2015-dietary-guidelines-giving-you-tools-you-need-make-healthy-choices (accessed 2021-12-31).
(196) USHHS. *Increase consumption of dark green vegetables, red and orange vegetables, and beans and peas by people aged 2 years and over — NWS-08 - Healthy People 2030 | health.gov*. https://health.gov/healthypeople/objectives-and-data/browse-objectives/nutrition-and-healthy-eating/increase-consumption-dark-green-vegetables-red-and-orange-vegetables-and-beans-and-peas-people-aged-2-years-and-over-nws-08 (accessed 2021-12-27).

(197) *USDA ERS - Fruit and Vegetable Affordability*. https://www.ers.usda.gov/amber-waves/2021/july/for-supplemental-nutrition-assistance-program-snap-households-fruit-and-vegetable-affordability-is-partly-a-question-of-budgeting/ (accessed 2022-08-12).
(198) Richter, B. D.; Bartak, D.; Caldwell, P.; Davis, K. F.; Debaere, P.; Hoekstra, A. Y.; Li, T.; Marston, L.; McManamay, R.; Mekonnen, M. M.; Ruddell, B. L.; Rushforth, R. R.; Troy, J. T. Water Scarcity and Fish Imperilment Driven by Beef Production. *Nature Sustainability* **2020**, *3*, 319–328.
(199) CDC. *Only 1 in 10 Adults Get Enough Fruits or Vegetables*. Centers for Disease Control and Prevention. https://www.cdc.gov/nccdphp/dnpao/images/news/shopping-for-produce.jpg (accessed 2021-12-27).
(200) CDC. *Comprehensive Model*. Centers for Disease Control and Prevention. https://www.cdc.gov/nutrition/food-service-guidelines/federal-facilities.html (accessed 2022-09-01).
(201) *Health and sustainability guidelines for federal concessions and vending operations*. https://stacks.cdc.gov/view/cdc/34375 (accessed 2022-09-01).
(202) Garnett, E. E.; Balmford, A.; Sandbrook, C.; Pilling, M. A.; Marteau, T. M. Impact of Increasing Vegetarian Availability on Meal Selection and Sales in Cafeterias. *Proc Natl Acad Sci USA* **2019**, *116* (42), 20923–20929. https://doi.org/10.1073/pnas.1907207116.
(203) Hansen, P. G.; Schilling, M.; Malthesen, M. S. Nudging Healthy and Sustainable Food Choices: Three Randomized Controlled Field Experiments Using a Vegetarian Lunch-Default as a Normative Signal. *Journal of Public Health* **2021**, *43* (2), 392–397. https://doi.org/10.1093/pubmed/fdz154.
(204) Spencer, M.; Kurzer, A.; Cienfuegos, C.; Guinard, J.-X. Student Consumer Acceptance of Plant-Forward Burrito Bowls in Which Two-Thirds of the Meat Has Been Replaced with Legumes and Vegetables: The Flexitarian Flip™ in University Dining Venues. *Appetite* **2018**, *131*, 14–27. https://doi.org/10.1016/j.appet.2018.08.030.
(205) Bianchi, F.; Garnett, E.; Dorsel, C.; Aveyard, P.; Jebb, S. A. Restructuring Physical Micro-Environments to Reduce the Demand for Meat: A Systematic Review and Qualitative Comparative Analysis. *The Lancet Planetary Health* **2018**, *2* (9), e384–e397. https://doi.org/10.1016/S2542-5196(18)30188-8.
(206) Grundy, E.; Slattery, P.; Saeri, A. K.; Watkins, K.; Houlden, T.; Farr, N.; Askin, H.; Lee, J.; Mintoft-Jones, A.; Cyna, S.; Dziegielewski, A.; Gelber, R.; Rowe, A.; Mathur, M. B.; Timmons, S.; Zhao, K.; Wilks, M.; Peacock, J.; Harris, J.; Rosenfeld, D. L.; Bryant, C. J.; Moss, D.; Noetel, M. *Interventions That Influence Animal-Product Consumption: A Meta-Review*; preprint; Open Science Framework, 2021. https://doi.org/10.31219/osf.io/mcdsq.
(207) Turnwald, B. P.; Bertoldo, J. D.; Perry, M. A.; Policastro, P.; Timmons, M.; Bosso, C.; Connors, P.; Valgenti, R. T.; Pine, L.; Challamel, G.; Gardner, C. D.; Crum, A. J. Increasing Vegetable Intake by Emphasizing Tasty and Enjoyable Attributes: A Randomized Controlled Multisite Intervention for Taste-Focused Labeling. *Psychol Sci* **2019**, *30* (11), 1603–1615. https://doi.org/10.1177/0956797619872191.
(208) Malan, H.; Amsler Challamel, G.; Silverstein, D.; Hoffs, C.; Spang, E.; Pace, S. A.; Malagueño, B. L. R.; Gardner, C. D.; Wang, M. C.; Slusser, W.; Jay, J. A. Impact of a Scalable, Multi-Campus "Foodprint" Seminar on College Students' Dietary Intake and Dietary Carbon Footprint. *Nutrients* **2020**, *12* (9), 2890. https://doi.org/10.3390/nu12092890.

(209) Mathur, M. B.; Peacock, J.; Reichling, D. B.; Nadler, J.; Bain, P. A.; Gardner, C. D.; Robinson, T. N. Interventions to Reduce Meat Consumption by Appealing to Animal Welfare: Meta-Analysis and Evidence-Based Recommendations. *Appetite* **2021**, *164*, 105277. https://doi.org/10.1016/j.appet.2021.105277.
(210) Jalil, A. J.; Tasoff, J.; Bustamante, A. V. Eating to Save the Planet: Evidence from a Randomized Controlled Trial Using Individual-Level Food Purchase Data. *Food Policy* **2020**, *95*, 101950. https://doi.org/10.1016/j.foodpol.2020.101950.
(211) Bianchi, F.; Dorsel, C.; Garnett, E.; Aveyard, P.; Jebb, S. A. Interventions Targeting Conscious Determinants of Human Behaviour to Reduce the Demand for Meat: A Systematic Review with Qualitative Comparative Analysis. *Int J Behav Nutr Phys Act* **2018**, *15* (1), 102. https://doi.org/10.1186/s12966-018-0729-6.
(212) Bacon, L.; Krpan, D. (Not) Eating for the Environment: The Impact of Restaurant Menu Design on Vegetarian Food Choice. *Appetite* **2018**, *125*, 190–200. https://doi.org/10.1016/j.appet.2018.02.006.
(213) Thomas, J. M.; Ursell, A.; Robinson, E. L.; Aveyard, P.; Jebb, S. A.; Herman, C. P.; Higgs, S. Using a Descriptive Social Norm to Increase Vegetable Selection in Workplace Restaurant Settings. *Health Psychology* **2017**, *36* (11), 1026–1033. https://doi.org/10.1037/hea0000478.
(214) Garnett, E. E.; Marteau, T. M.; Sandbrook, C.; Pilling, M. A.; Balmford, A. Order of Meals at the Counter and Distance between Options Affect Student Cafeteria Vegetarian Sales. *Nat Food* **2020**, *1* (8), 485–488. https://doi.org/10.1038/s43016-020-0132-8.
(215) Garnett, E. E.; Balmford, A.; Marteau, T. M.; Pilling, M. A.; Sandbrook, C. Price of Change: Does a Small Alteration to the Price of Meat and Vegetarian Options Affect Their Sales? *Journal of Environmental Psychology* **2021**, *75*, 101589. https://doi.org/10.1016/j.jenvp.2021.101589.
(216) Milliron, B.-J.; Woolf, K.; Appelhans, B. M. A Point-of-Purchase Intervention Featuring In-Person Supermarket Education Affects Healthful Food Purchases. *Journal of Nutrition Education and Behavior* **2012**, *44* (3), 225–232. https://doi.org/10.1016/j.jneb.2011.05.016.
(217) Geliebter, A.; Ang, I. Y. H.; Bernales-Korins, M.; Hernandez, D.; Ochner, C. N.; Ungredda, T.; Miller, R.; Kolbe, L. Supermarket Discounts of Low-Energy Density Foods: Effects on Purchasing, Food Intake, and Body Weight: Supermarket Discounts of Low-Energy Density Foods. *Obesity* **2013**, *21* (12), E542–E548. https://doi.org/10.1002/oby.20484.
(218) Tal, A.; Wansink, B. An Apple a Day Brings More Apples Your Way: Healthy Samples Prime Healthier Choices: HEALTHY SAMPLES PRIME HEALTHIER CHOICES. *Psychol. Mark.* **2015**, *32* (5), 575–584. https://doi.org/10.1002/mar.20801.
(219) Bernales-Korins, M.; Ang, I. Y. H.; Khan, S.; Geliebter, A. Psychosocial Influences on Fruit and Vegetable Intake Following a NYC Supermarket Discount: Psychosocial Influences on F&V Discount and Intake. *Obesity* **2017**, *25* (8), 1321–1328. https://doi.org/10.1002/oby.21876.
(220) Jetter, K. M.; Cassady, D. L. Increasing Fresh Fruit and Vegetable Availability in a Low-Income Neighborhood Convenience Store: A Pilot Study. *Health Promotion Practice* **2010**, *11* (5), 694–702. https://doi.org/10.1177/1524839908330808.
(221) Gustafson, A.; McGladrey, M.; Stephenson, T.; Kurzynske, J.; Mullins, J.; Peritore, N.; Cardarelli, K.; Vail, A. Community-Wide Efforts to Improve the Consumer Food Environment and Physical Activity Resources in Rural Kentucky. *Prev. Chronic Dis.* **2019**, *16*, 180322. https://doi.org/10.5888/pcd16.180322.

(222) Privitera, G. J.; Gillespie, J. J.; Zuraikat, F. M. Impact of Price Elasticity on the Healthfulness of Food Choices by Gender. *Health Education Journal* **2019**, *78* (4), 428–440. https://doi.org/10.1177/0017896918813009.
(223) Ayala, G. X.; Baquero, B.; Laraia, B. A.; Ji, M.; Linnan, L. Efficacy of a Store-Based Environmental Change Intervention Compared with a Delayed Treatment Control Condition on Store Customers' Intake of Fruits and Vegetables. *Public Health Nutr.* **2013**, *16* (11), 1953–1960. https://doi.org/10.1017/S1368980013000955.
(224) Martínez-Donate, A. P.; Riggall, A. J.; Meinen, A. M.; Malecki, K.; Escaron, A. L.; Hall, B.; Menzies, A.; Garske, G.; Nieto, F. J.; Nitzke, S. Evaluation of a Pilot Healthy Eating Intervention in Restaurants and Food Stores of a Rural Community: A Randomized Community Trial. *BMC Public Health* **2015**, *15* (1), 136. https://doi.org/10.1186/s12889-015-1469-z.
(225) Shin, A.; Surkan, P. J.; Coutinho, A. J.; Suratkar, S. R.; Campbell, R. K.; Rowan, M.; Sharma, S.; Dennisuk, L. A.; Karlsen, M.; Gass, A.; Gittelsohn, J. Impact of Baltimore Healthy Eating Zones: An Environmental Intervention to Improve Diet Among African American Youth. *Health Educ Behav* **2015**, *42* (1_suppl), 97S-105S. https://doi.org/10.1177/1090198115571362.
(226) Thorndike, A. N.; Bright, O.-J. M.; Dimond, M. A.; Fishman, R.; Levy, D. E. Choice Architecture to Promote Fruit and Vegetable Purchases by Families Participating in the Special Supplemental Program for Women, Infants, and Children (WIC): Randomized Corner Store Pilot Study. *Public Health Nutr.* **2017**, *20* (7), 1297–1305. https://doi.org/10.1017/S1368980016003074.
(227) Banerjee, T.; Nayak, A. Believe It or Not: Health Education Works. *Obesity Research & Clinical Practice* **2018**, *12* (1), 116–124. https://doi.org/10.1016/j.orcp.2017.09.001.
(228) Trude, A. C.; Surkan, P. J.; Anderson Steeves, E.; Pollack Porter, K.; Gittelsohn, J. The Impact of a Multilevel Childhood Obesity Prevention Intervention on Healthful Food Acquisition, Preparation, and Fruit and Vegetable Consumption on African-American Adult Caregivers. *Public Health Nutr.* **2018**, 1–16. https://doi.org/10.1017/S1368980018003038.
(229) Payne, C.; Niculescu, M. Can Healthy Checkout End-Caps Improve Targeted Fruit and Vegetable Purchases? Evidence from Grocery and SNAP Participant Purchases. *Food Policy* **2018**, *79*, 318–323. https://doi.org/10.1016/j.foodpol.2018.03.002.
(230) Chapman, L. E.; Sadeghzadeh, C.; Koutlas, M.; Zimmer, C.; De Marco, M. Evaluation of Three Behavioural Economics 'Nudges' on Grocery and Convenience Store Sales of Promoted Nutritious Foods. *Public Health Nutr.* **2019**, *22* (17), 3250–3260. https://doi.org/10.1017/S1368980019001794.
(231) Gudzune, K. A.; Welsh, C.; Lane, E.; Chissell, Z.; Anderson Steeves, E.; Gittelsohn, J. Increasing Access to Fresh Produce by Pairing Urban Farms with Corner Stores: A Case Study in a Low-Income Urban Setting. *Public Health Nutr.* **2015**, *18* (15), 2770–2774. https://doi.org/10.1017/S1368980015000051.
(232) Liu, E.; Stephenson, T.; Houlihan, J.; Gustafson, A. Marketing Strategies to Encourage Rural Residents of High-Obesity Counties to Buy Fruits and Vegetables in Grocery Stores. *Prev. Chronic Dis.* **2017**, *14*, 170109. https://doi.org/10.5888/pcd14.170109.
(233) Vandenbroele, J.; Slabbinck, H.; Van Kerckhove, A.; Vermeir, I. Curbing Portion Size Effects by Adding Smaller Portions at the Point of Purchase. *Food Quality and Preference* **2018**, *64*, 82–87. https://doi.org/10.1016/j.foodqual.2017.10.015.

(234) Vlaeminck, P.; Jiang, T.; Vranken, L. Food Labeling and Eco-Friendly Consumption: Experimental Evidence from a Belgian Supermarket. *Ecological Economics* **2014**, *108*, 180–190. https://doi.org/10.1016/j.ecolecon.2014.10.019.
(235) Gustafson, C. R.; Kent, R.; Prate, M. R. Retail-Based Healthy Food Point-of-Decision Prompts (PDPs) Increase Healthy Food Choices in a Rural, Low-Income, Minority Community. *PLoS ONE* **2018**, *13* (12), e0207792. https://doi.org/10.1371/journal.pone.0207792.
(236) MacKenzie, O. W.; George, C. V.; Pérez-Escamilla, R.; Lasky-Fink, J.; Piltch, E. M.; Sandman, S. M.; Clark, C.; Avalos, Q. J.; Carroll, D. S.; Wilmot, T. M.; Shin, S. S. Healthy Stores Initiative Associated with Produce Purchasing on Navajo Nation. *Current Developments in Nutrition* **2019**, *3* (12), nzz125. https://doi.org/10.1093/cdn/nzz125.