

NEW ENGLAND FEEDING NEW ENGLAND

VOLUME 2

ESTIMATING PRODUCTION FOR 30% REGIONAL SELF-RELIANCE

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NEW ENGLAND FEEDING NEW ENGLAND

Project Editors
Scott Sawyer
Ellen Kahler

Maps
Elliot Pearson

What would it take for *30%* of the food consumed in New England to be regionally produced by *2030*?

What will it really take to grow, raise, produce, harvest, and catch more regional food and move it through a complex supply chain to our homes and other places we eat? What do we need to do in the near term, by 2030, to make tangible progress towards this bold goal? How might the increasing and escalating impacts of climate change impact our ability to feed ourselves? What can we do as a region to make our food system more equitable and fair, resilient and reliable? To answer these questions, the **New England State Food System Planners Partnership**—a collaboration between six state-level food system organizations—and Food Solutions New England—who are mobilizing their networks to strengthen and grow the New England regional food system—convened four teams of researchers.

This research volume examines the question: **Could the six New England states meet a goal of supplying 30% of the region's food by 2030?** A *Food Production Team* created a model of regional self-reliance—an estimate of the region's production of food commodities compared to its consumption of those same commodities—that outlined scenarios for how the six New England states could meet a goal of supplying 30% of our food from regional sources by 2030.

Researchers

RESEARCH TEAM LEADER
Christian J. Peters
Research Leader, Food Systems Research Unit
USDA Agricultural Research Service

Laura Barley
Farm Viability Planner
Massachusetts Department of Agriculture
formerly with American Farmland Trust

Ramon Borges-Mendez
Associate Professor of Urban Planning and Community Development
Clark University

Brian Donahue
Professor Emeritus of American Environmental Studies
Brandeis University
Food Solutions New England

Ashley C. McCarthy
Postdoctoral Research Associate
University of Vermont

Sarah Schumann
Principal
Shining Seas Consulting

Joshua Stoll
Assistant Professor, School of Marine Sciences
University of Maine

Eric von Wettberg
Associate Professor, Plant and Soil Science
University of Vermont

On the cover, clockwise from top left: Vermont dairy farm (Vermont Agency of Agriculture); Maine waterfront; Maine farmland (Richard Robles); The Town Dock in Narragansett, RI (RIFPC); Carlson Orchards in Harvard, Massachusetts (Nicole Cardwell); North End Farmers Market in Hartford, Connecticut (Joey Abad)

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1 Introduction

Can the six New England states provide *30%* of their food from regional farms and fisheries by *2030*?

This question guided research conducted by the New England State Food System Planners Partnership to help policy-makers, funders, food system businesses and stakeholders, community groups, and consumers understand the relative resilience of New England's food system. Why does this question matter? After all, America's food and beverage production capacity—farms, fisheries, processors, and manufacturers—is enormous, abundant, and diverse. Food imports from around the world have steadily increased. Our food distribution systems are timely and efficient. Our grocery stores and restaurants are stocked, affordable, and convenient. Even our waste disposal systems are a flush and weekly pickup away.

In most of our lived experiences, we have not had to answer the question—***Where does our food come from?***—with specificity, although our ancestors certainly could. And yet, accumulating evidence indicates that we are entering a new era of human experience. Due to linked challenges that are *simultaneously taking place everywhere across the planet*, Americans will no longer be able to reasonably expect that every food they want will be easily available for them to buy year-round.

New England Feeding New England

If where our food comes from suddenly mattered, would New England be prepared with a reliable, safe, and abundant food supply? What will it really take to grow, raise, produce, harvest, and catch more regional food and move it through supply chains to our homes and other places where we eat? There are very few examples of long-term planning for healthy, reliable food supplies. Unlike other systems that provide essential goods and services, like energy and water, *no one* is currently in charge of planning and preparing for healthy, reliable, and resilient long-term food supplies.

In 2014, Food Solutions New England published A New England Food Vision, which imagined what it would take to produce 50% of New England's food supply from regional sources by 2060. It found that the region *could* theoretically supply 50% of its food by focusing production on fruits, vegetables, dairy products, and grass-finished meats, while importing the majority of food grains, feed grains, oilseeds, and sweeteners. Based on a target of 2,300 calories per person per day, 4 million additional acres of land in agriculture would be required to do this (about three times more than is currently in active production, although about 6.8 million acres were in cropland and pasture in New England in 1945).

Volume 2 Research Summary

Could the six New England states meet a goal of supplying 30% of the region's food by 2030?

NEW ENGLAND'S FARMERS + FISHERMEN COULD MEET **30%** OF SERVINGS FOR A POPULATION GROWING FROM **15.3** MILLION TO **15.6** MILLION THIS WOULD REQUIRE MAXIMIZING USE OF **401,000** EXISTING UNDERUTILIZED ACRES + **588,000** *ADDITIONAL* ACRES OF CLEARED LAND

New England Feeding New England updates the analysis from *A New England Food Vision* and explores opportunities at an intermediate and more easily imaginable range: **what would it take for *30%* of the food consumed in New England to be regionally produced by *2030?*** To explore key questions about our long-term food supply, four research teams were assembled across New England:

1. **Dietary Patterns Team:** How would food consumption patterns have to change in order to make the best use of what regional food producers can grow, harvest, and catch? This Team developed dietary scenarios for "Unchanged Eating"—a continuation of how we currently eat—and "Resilient Eating"—a dietary pattern much more closely in alignment with U.S. Dietary Guidelines—in 2030 (see Volume 1).

2. **Food Production Team:** How much food do we produce in New England compared to how much food we consume? The Food Production Team analyzed current regional food self-reliance and developed a model to explore New England's potential to increase its self-reliance based on dietary scenarios prepared by the Dietary Patterns Team (Volume 2).

3. **Economic Impact Team:** Do we have the right mix of industries to ramp up food production? The Economic Impact Team estimated the number of people employed in New England's food system, the economic impact of food system activities, economic multipliers for each industry, and areas of growth or contraction (see Volume 3).

4. **Market Demand Team:** What market channels offer the best opportunities for sourcing local and regional food products? The Market Demand Team analyzed market concentration trends, sales data from retail food market channels, consumer expenditures for the six states, and explored specific challenges within each market channel (see Volume 4).

Volume 2 addresses the current and potential capacity of New England to source its own food. Our analysis measured **regional self-reliance** (RSR), an estimate of the region's production of food commodities compared to its consumption of those same commodities. The concept of regional self-reliance is akin to thinking about the portion of the national food supply that is domestically produced. However, while reliance on domestic sources can be determined from publicly available data on food production, imports, and exports, interstate trade of food is not tracked in the same way. We rarely know how much food was imported to or exported from a sub-national region. Thus, regional self-reliance is commonly estimated as the net balance of production to consumption.

Overview of the Approach

Our analysis measures regional self-reliance, an estimate of the region's production of food commodities compared to its consumption of those same commodities. We sought to understand the current balance of production to consumption and to explore possible pathways for the region to supply 30% of its food by 2030. This volume builds on the Unchanged Eating and Resilient Eating patterns developed by the Dietary Patterns Team (Volume 1), showing the scale of production changes needed to supply the region's food needs in 2030.

We started by estimating the region's self-reliance in the last decade, 2010-2019, by tabulating food production from farms and commercial fisheries and consumption from national per capita food supply data and regional population estimates. This analysis of current regional self-reliance compares the amount (weight) of food produced to the amount of food consumed for a wide range of commodities.

We then constructed a model to explore New England's potential to increase its self-reliance, considering changes in crop productivity, livestock management, and the use of agricultural land. We used this model to estimate how much additional land would need to be used for active agricultural production to supply 30% of the region's food. Here we considered the region's capacity to produce food in nutritionally meaningful units – food group *servings* and *kilocalories*.

While developing the model, we conducted a series of focus groups with producers from different sectors of the region's food system to get stakeholder input on the barriers to and opportunities for New England to produce a greater share of its food than it does today. Information from these focus groups helped place the model results in context.

Key Findings

On a weight basis, New England produced about 21% as much food as it consumed between 2010 and 2019 (Table 2, page 9). To be clear, this does not mean that the region supplied 21% of the food New Englanders ate because some of this food left the region to be consumed elsewhere. Unlike imports and exports that cross international borders, interstate shipments of food are *not* tracked in any uniform way. **Therefore, we do not know how much of the food produced in New England stays here.** The regional self-reliance percentages varied widely from food to food, showing a rather lop-sided capacity for self-reliance. A small number of foods were produced in large quantities relative to consumption and had self-reliance ratios near or exceeding 100% (e.g., cranberries, lobster). Most foods, however, had self-reliance ratios of less than 10% (e.g., beef, lettuce, wheat).

Looking ahead to 2030, our model scenarios show that New England could increase regional self-reliance without clearing more land for agriculture. That is, food output could be expanded by *increasing crop yields* and *intensifying land use*, using a greater share of the available land and using more of that land for fruits, vegetables, and other food crops than is currently done.

However, the 2030 model scenarios fell short of the 30% regional food consumption goal utilizing our existing land base and fisheries landings. Following current eating patterns (i.e., Unchanged Eating), the region could provide 27% of major food group ***servings*** by maintaining current production of dairy products and increasing production of vegetables, fruits, grains, and grass-based meat production. Following healthier eating patterns (i.e., Resilient Eating), the region could supply just 24% of major food group servings, due to higher consumption of fruits and vegetables. Both scenarios showed increased self-reliance compared to a 2019 baseline of 21%, by weight, of the major food groups.

TABLE 1: Land Required to Supply Food From New England Sources According to the Regional Self-Reliance Targets of Each Scenario (Acres)

Land Use Category	Specific Use	2017 Reference (Census of Agriculture)	Current Land: Unchanged Eating	Current Land: Resilient Eating	Reach 30%: Unchanged Eating	Reach 30%: Resilient Eating
Cultivated Cropland	Grains for food	30,426	89,442	71,792	96,167	126,011
	Vegetables	97,511	158,776	158,077	170,655	235,258
	Fruits	72,985	100,512	121,303	108,567	185,770
	Feed Grains + Oilseeds	191,275	240,182	204,316	335,429	338,416
	SUBTOTAL	**392,197**	**588,912**	**555,488**	**710,818**	**885,455**
Cropland - Perennial Forages	Hay + Other Perennial Forages	705,207	784,640	801,505	841,364	881,473
	Used for Pasture	53,973	-	-	-	-
	SUBTOTAL	**759,180**	**784,640**	**801,505**	**841,364**	**881,473**
Cropland - Non-Food or Non-productive Use*	Idle Cropland	160,954	96,281	95,120	108,802	123,855
	Summer Fallow	22,820	27,301	26,972	30,852	35,120
	Land on Which Crops Failed	18,885	22,594	22,321	25,532	29,064
	Non-Food Crops	35,851	42,891	42,374	48,469	55,175
	Seed Uses of Grains	1,774	2,638	2,210	3,454	3,717
	SUBTOTAL	**240,284**	**191,705**	**188,997**	**217,109**	**246,931**
Permanent Pasture	Used for Pasture	287,500	513,837	533,441	599,517	654,232
	Pasture Cover, Ungrazed	400,500	n/a	n/a	n/a	n/a
	SUBTOTAL	**688,000**	**513,837**	**533,441**	**599,517**	**654,232**
	TOTAL	**2,079,661**	**2,079,094**	**2,079,432**	**2,368,808**	**2,668,092**
	ADDITIONAL CLEARED LAND	**n/a**	**(567)**	**(230)**	**289,147**	**588,430**
	VIRTUAL LAND IMPORTS**	**n/a**	**95,248**	**101,422**	**-**	**19,057**

* Our model assumes that (a) future production would reduce the percentage of cropland that is idle, and (b) the percentage of land in summer fallow, failed crops, non-food crops, and seed uses of grains increases as cropland increases.
** The equivalent area of New England cropland needed to grow imported feed grains.

Reaching 30% of regional food self-reliance would require bringing approximately 290,000 acres based on the Unchanged Eating scenario and 590,000 acres based on Resilient Eating scenario of additional land into production from a variety of sources (Table 1). It would also require more intensive land use, with a larger share of the productive area in cultivated cropland, for example:

- Grazing or cutting hay on all land in the "Permanent pasture" category (i.e., no pasture cover goes unused);
- Leaving much less cropland idle (i.e., at a percentage that is more like the Corn Belt rather than New England);
- Tilling more land for cultivated crops.

Potential for 30% regional food self-reliance based on *calories* is much lower (Table 8, page 24). The model scenarios show that with existing land in production and given existing fisheries landings, New England could supply 13% under the Unchanged Eating scenario or 17% of its total calories under the Resilient Eating scenario. While higher than the 2019 baseline estimate of 9%, the scenarios show that New England has more limited capacity for meeting its food energy needs. This is partially due to the fact that calorically-dense foods often require large land footprints relative to other foods.

No single measure of self-reliance is definitive. For instance, weight is a convenient measure because it is available for most farm and fisheries products. However, weight is not helpful for understanding the proportion of nutritional needs met by regional production. Metrics such as edible energy (calories) or food group servings can be used to assess self-reliance in nutritional terms, which is more relevant to understanding the region's ability to feed itself. Thus, we did not create a model scenario based on weight to achieve 30% regional self-reliance. Ultimately, the selection of the appropriate basis upon which to measure self-reliance is context specific.

Conversations with stakeholders in the focus groups we conducted corroborate some of the key assumptions in the modeling of future self-reliance. Land access was mentioned as a barrier to farming in New England across sectors. In contrast, participants expressed confidence that potential exists to increase crop yields and livestock productivity. Likewise, ample water was seen as an important strength of the region considering future climate change. Seafood production is constrained by a number of factors including landing and processing infrastructure, off-shore wind energy generation, and out-of-region ownership of fishing vessels and permits. Most of the barriers and opportunities mentioned in these conversations related to social and economic factors, rather than biophysical factors, highlighting the importance of further research on the social, economic, and environmental dimensions of potential New England self-reliance.

Understanding Regional Self-Reliance

This volume addresses the current and potential capacity of New England to source its own food. Our analysis measured **regional self-reliance** (RSR), an estimate of the region's production of food commodities compared to its consumption of those same commodities. Conceptually, regional self-reliance is akin to a country's reliance on domestic food production, but at the sub-national scale. Methodologically, it is different. Whereas reliance on domestic sources can be determined from publicly available data on food production, imports, and exports, interstate trade of food is not tracked in the same way, at least not for all foods. Thus, regional self-reliance is commonly estimated as the net balance of production to consumption.

We followed such an approach here. To estimate "current" capacity, we used the last decade, 2010-2019, as a benchmark. We considered production from New England's farms and commercial fisheries, and we calculated consumption from national per capita food supply data and regional population estimates. Using the assessment of current capacity as a reference point, we constructed a biophysical model to simulate the potential to increase New England's self-reliance on its current footprint of agricultural land. While developing the model, we conducted a series of focus groups with producers from different sectors of the region's food system to get stakeholder input on the barriers to and opportunities for New England to produce a greater share of its food than it does today. Information from these focus groups helped refine the scenarios of future food production explored in the model.

Our approach can be categorized as a **"capacity study"** to understanding local food self-sufficiency, as compared to a "flow study" that traces the movement of materials or resources.[1] The advantage of this approach is that it allowed us to consider a wide range of foods across all food groups, essential to assessing the ability of New England to produce 30% of its food. A disadvantage of this approach is that we, generally, cannot say where food produced in New England is ultimately eaten. However, for our purposes, being comprehensive across the complete diet was more important than understanding the ultimate geographic fate of food produced in New England.

The methods employed in this study are described in greater detail in each section. No single, standard method exists for calculating regional self-reliance. Hence, subsequent sections make a concerted effort to describe the methods and assumptions in sufficient detail to understand how we conducted the analyses and the limits of what they mean. The final section of this volume interprets the findings, compares the results to earlier work, and identifies key unanswered questions about the region's food production capacity.

Photo credit: MA Department of Agricultural Resources Commissioner Ashley Randle

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New England is very self-reliant when it comes to cranberries and maple syrup.

2 Current Self-Reliance From Farming and Fisheries

The first step to exploring how New England could meet the goal of supplying 30% of its food by 2030 was to establish a regional self-reliance (RSR) baseline to understand what share of regional consumption is currently being produced in the region. The baseline RSR helps us understand how close we are to the 30% goal and highlights the foods and food groups we are most self-reliant in and where there are opportunities for increased self-reliance.

Methods to Estimate Current RSR

We used a net-balance analysis to calculate the current RSR of each food and food group. A net-balance analysis compares production to consumption to determine the extent to which the region could meet regional consumption through regional production, assuming all food produced in the region is consumed within the region. Our approach was adapted from methods used in *Regional Self-Reliance of the Northeast Food System*.[2] The methods for conducting the analysis for terrestrial foods and seafood are described below.

First, we estimated current regional consumption in pounds of each food in the diet. For all terrestrial foods, we used the Food Availability (Per Capita) Data System, maintained by the USDA Economic Research Service, as a proxy for current consumption.

Food Availability data tracks the amount of food that enters the food supply on an annual basis. For each food category, we estimated current regional consumption using the mean per capita food availability from 2010-2019 and 2019 population data estimates from the U.S. Census Bureau. All terrestrial foods were converted to a farm weight basis (the weight of product that leaves the farm) to be comparable to production data.

We used an alternative approach to estimate seafood consumption because the Food Availability (Per Capita) Data System does not disaggregate seafood consumption beyond the general categories of finfish and shellfish. Regional consumption of seafood was calculated from 2017-2019 for the top-consumed species (n = 20) using Nielsen's retail scanner data.[3] Because Nielsen data reflects only retail sales, and only 56% of seafood is consumed through retail in the U.S. (with the remainder being consumed through food service and self-provisioning, as reported by Love et al. 2020), we adjusted our regional consumption estimates upward, dividing the mean per capita estimates from the Nielsen data for all seafood product categories by 0.56. Population estimates for our calculations were based on the 2019 population data estimates from the U.S. Census Bureau.

Second, we estimated current regional production in pounds of each food in the diet. For terrestrial foods, we estimated mean regional production from 2010-2019 using annual state-level production or yield and acreage data from the annual New England Agricultural Statistics Bulletins and the 2012 and 2017 Censuses of Agriculture. For crops that have multiple uses, such as corn, we allocated regional production to those different uses based on supply and use data from the USDA Feed Grains Yearbook. For example, approximately 14% of corn grain was used for food purposes while the remaining 86% was used for livestock feed and industrial uses. For seafood, we used data from the Atlantic Coastal Cooperative Statistics Program Data Warehouse (ACCSP) and the NOAA Fisheries Landings data portal to estimate the total landings by species for each New England state from 2010 to 2019. Seafood products primarily used as bait were removed (e.g., marine worms, herring, etc.). Data on salmon production was estimated based on the authors' knowledge of the sector in Maine because landings are not publicly available.

Finally, we calculated the RSR of each food, food group, and the whole diet. The RSR is calculated by dividing mean regional production by mean regional consumption and then multiplying by 100 (Equation 1).

EQUATION 1: Regional Self-Reliance Calculation

$$\textit{RSR Percentage} = \left(\frac{\textit{Production}}{\textit{Consumption}}\right) * 100$$

The results can be interpreted as the percentage of regional consumption that can be met through regional production. If the RSR is equal to or greater than 100, the region can meet all consumption through regional production. If the RSR is less than 100, the region cannot meet consumption through regional production. When calculating the current RSR, if current regional production of a food exceeded current regional consumption of that food, we restricted regional production to the amount needed to fully meet consumption to avoid overstating the ability to meet current consumption and food preferences. For example, New England's cranberry growers produce more than five times as many cranberries as New Englanders consume in a year. If we used the actual cranberry production data when calculating RSR, we would be assuming that consumers are willing to drastically increase their annual cranberry consumption. Instead, we restricted cranberry production to fully meet, but not exceed, current consumption to account for consumers' food preferences and avoid overstating RSR. The foods for which production exceeds consumption are noted in the results.

It is important to note the key assumptions underlying our net-balance analysis and RSR results:

» First, we assume that what is produced in the region is consumed in the region and we do not account for domestic or international trade, though in reality some food produced in New England is exported to other places.

» Second, we do not consider whether the food was processed or packaged within the region. For example, some cattle raised in the region may be slaughtered and processed outside of the region, but the analysis only accounts for where the animal or crop was raised, not where it was processed.

» Third, the results represent annual regional self-reliance and do not account for seasonal availability of fresh foods.

» Finally, the analysis and results only include raw agricultural and fisheries commodities (e.g., wheat, eggs, whole fish) that were grown, raised, or caught in the region; it does not include other food products that may have been produced in the region (e.g., locally baked bread or beer brewed in New England). **This is because no data exists to determine the percentage of regional inputs contained in regionally manufactured foods.** The RSR would be higher if we included regional production of manufactured or processed food products made from raw agricultural commodities sourced outside New England.

Current Estimation of Regional Self-Reliance

New England's overall RSR across all food groups was 20.7% over the period 2010 to 2019 (Table 2). This estimate should be interpreted as an upper bound since the production in New England may not always be available in the same form or at the same time of year that consumers demand it, and such concerns were beyond the scope of the analysis. Regional self-reliance varied considerably across food groups. The region was most self-reliant in dairy (45%) and vegetables (32%) and least self-reliant in sweeteners (1.1%), fats and oils (1.3%), and grains (1.8%).

Self-reliance also varied within food groups. For example, looking across the USDA MyPlate vegetable sub-groups, New England had a high self-reliance for starchy vegetables (82.3%) due to the high amounts of potato production in the region (particularly Maine), but the RSR for other vegetable sub-groups was quite low, especially for dry beans and peas (0.1%) which are not commonly produced in the region currently (Figure 1).

TABLE 2: New England Production, Consumption, and Regional Self-Reliance (RSR) by Food Group (Pounds), 2010-2019

Food Group	Mean Production	Mean Consumption	Mean RSR
Dairy	4,149,600,000	9,302,000,000	44.6%
Vegetables	1,821,300,000	5,746,800,000	31.7%
Fruits	237,800,000	3,705,200,000	6.4%
Proteins	257,800,000	6,336,600,000	4.1%
Grains	64,700,000	3,585,400,000	1.8%
Fats and Oils	15,000,000	1,184,000,000	1.3%
Sweeteners	20,700,000	1,900,700,000	1.1%
TOTAL	**6,566,800,000**	**31,760,800,000**	**20.7%**

Across key protein sources, New England was most self-reliant in seafood (31.8%) and eggs (19.1%) (Figure 2). Due to limited production, RSR for pork, chicken, and turkey were all below 1%. Regional self-reliance varied even more widely across individual foods. A small number of foods have RSR values greater than 100%, meaning that regional production exceeds consumption (Table 3). This includes a handful of crops, such as blueberries and cranberries, and several animal products, such as haddock and lobster. Of the remaining foods, most had very low RSR values, 5% or less, including most crops and all major meats. A modest number of foods sat in the mid-range, with RSR values between 20 and 50%.

FIGURE 1: New England Regional Self-Reliance Percentage for Vegetable Subgroups

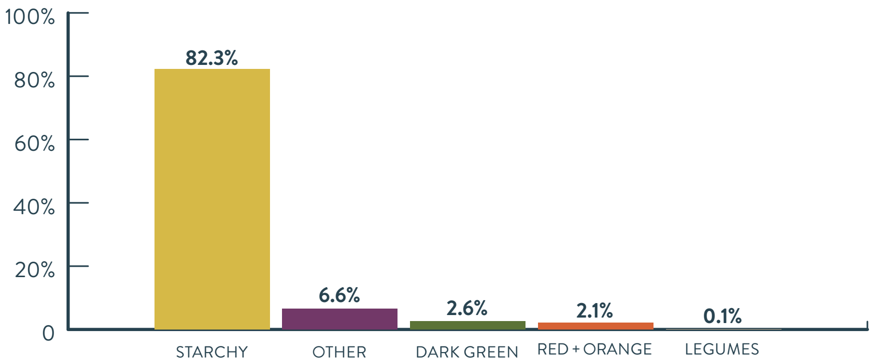
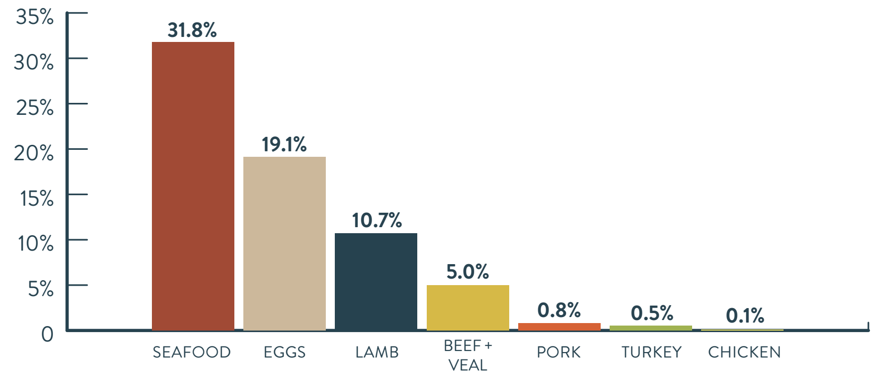


FIGURE 2: New England Regional Self-Reliance Percentage for Protein Subgroups



NOTE: NUTS AND SEEDS = 0.0%

Photo credit: Henry Gartley

Potatoes, particularly from Maine, are the top vegetable crop grown in New England.

Photo credit: Ink + Light Creative

Lobsters are the most valuable seafood harvested from coastal waters.

TABLE 3: Current Plant- and Animal-Based Foods Grouped by Regional Self-Reliance

No Production / No Data		Less Than 5%		5-20%	20-50%	50-100%	>100%
Plant-Based Foods							
Almonds	Avocados	Apricots	Artichokes	Brussels sprouts	Apples	Potatoes	Barley
Bananas	Cane and beet sugars	Asparagus	Beans (dry, lima, snap)	Cabbage	Beets		Blueberries
Coconut	Dates	Broccoli	Canola	Collard greens	Blackberries		Cranberries
Figs	Grapefruit	Cantaloupe	Carrots	Cucumbers	Eggplant		Edible syrups
Hazelnuts	Kiwi	Cauliflower	Celery	Endives and escarole	Kale		Rye
Lemons	Limes	Cherries	Corn	Mustard greens	Oats		
Macadamias	Mangoes	Corn sweeteners	Garlic	Peaches and nectarines	Squash		
Mushrooms	Olives	Grapes	Honeydew	Peppers (bell)	Sweet corn		
Oranges	Other nuts	Lettuce	Okra	Radishes			
Papayas	Peanuts	Onions	Pears	Spinach			
Peas (dry)	Pecans	Peas	Peppers (chile)				
Pineapple	Pistachios	Plums and prunes	Raspberries				
Pumpkins	Rice	Strawberries	Sweet potatoes				
Tangerines	Walnuts	Tomatoes	Turnip greens				
		Watermelon	Wheat				
Animal-Based Foods							
Anchovy		Beef		Eggs	Cod	Oysters	Clams
Catfish		Chicken		Lamb	Crab		Flounder
Crawfish		Lard			Dairy Products		Haddock
Herring		Pork			Halibut		Lobster
Tilapia		Shrimp			Honey		Mussels
Trout		Tuna			Salmon		Pollock
		Turkey			Tallow		Scallops
							Seafood (other)
							Whiting

This variation in RSR was particularly pronounced for seafood. Collectively, wild capture fisheries and aquaculture produced more than 150 species of finfish and invertebrates (a complete list of species grown and landed New England can be found in Appendix 3), but a comparison of landings with Nielsen scanner data (i.e., retail estimates) showed varying rates of representation within the regional marketplace for these species. The mix of species produced in the region does not align with the mix of species that New Englanders consume (Table 4). The wide variation in RSR at the product category level highlights this mismatch. For example, the RSRs for high-level benthic invertebrates such as lobsters and scallops were 1,163% and 3,155%, respectively. In contrast, the RSR for some popular product categories, such as cod (20%), tuna (4%), and salmon (23%), were well below 100%. Because we restricted the contribution of individual species to 100% of consumption, the regional RSR for all seafood was 31.8%, even though the total biomass of seafood produced exceeded the biomass consumed.

TABLE 4: New England Regional Mean Production, Consumption, and Self-Reliance of Blue Foods (Pounds), 2017-2019

Category	Mean Regional Production	Mean Regional Consumption (retail)	Mean RSR (to supply retail consumption)	Mean RSR (to supply retail + restaurant consumption)
Scallops	42,339,912	751,400	5,634.8%	3,155.5%
Lobsters	27,345,347	1,316,697	2,076.8%	1,163.0%
Haddock	7,314,790	440,491	1,660.6%	929.9%
Clams	19,183,769	1,179,354	1,626.6%	910.9%
Remaining Confidential + Other Species	84,889,019	9,688,121	876.2%	490.7%
Whiting	7,487,420	872,577	858.1%	480.5%
Mussels	2,593,706	421,161	615.8%	344.9%
Pollock	3,277,842	769,195	426.1%	238.6%
Flounder	2,464,118	737,562	334.1%	187.1%
Oysters	1,073,631	885,203	121.3%	67.9%
Crab	2,832,901	5,782,974	49.0%	27.4%
Halibut	59,754	127,939	46.7%	26.2%
Salmon	6,358,611	14,911,716	42.6%	23.9%
Cod	976,975	2,707,138	36.1%	20.2%
Tuna	1,131,269	16,319,694	6.9%	3.9%
Shrimp	28,639	22,560,240	0.1%	0.1%
Anchovy	4	1,320,793	0.0%	0.0%
Catfish	823	4,207,447	0.0%	0.0%
Crawfish	N/A	652,104	N/A	N/A
Herring	N/A	604,125	N/A	N/A
Tilapia	N/A	7,173,244	N/A	N/A
Trout	24	557,879	0.0%	0.0%
TOTAL	**209,358,552**	**93,987,053**	**222.8%**	**124.7%**

3 Modeling Future Production Scenarios to 30% Self-Reliance

Historical data can be used to estimate regional self-reliance for past years, and even to forecast self-reliance in the future. The purpose of this study, however, was to explore the potential of New England to supply a much greater share of its food than it has in recent years. A model was developed to estimate the region's capacity for self-reliance under scenarios of alternative land management and terrestrial agricultural productivity, with seafood continuing to contribute the same percentage of RSR that it did in 2010-2019.

We used the model to explore the region's potential to supply 30% of regional consumption according to two different scenarios of eating described in Volume 1 (Figure 3), one which reflects the current diet (Unchanged Eating) and another that reflects a healthier and more plant-based diet pattern (Resilient Eating). The model considers the capacity to increase self-reliance by improving crop yields and changing the mix of foods produced within the region. We considered pathways that limit agricultural production to the current footprint of cropland and pasture and pathways that require clearing additional land for agricultural production. Our target for reaching 30% of consumption was based on servings of food supplied by regional production, though we also calculated the proportion of calories that would be supplied under these scenarios.

Methods

Scope of the Model

The potential of a region to supply its own food depends on its production capacity and the consumption patterns of its people. We relied on the estimates of the Dietary Patterns Team to represent alternative scenarios of regional consumption, one based on a continuation of eating patterns from 2019 (Unchanged Eating) and another based on closer compliance with national dietary guidelines (Resilient Eating). The development of these consumption scenarios is covered in Volume 1, and the remainder of this section will focus on assumptions related to production capacity.

A complete estimation of regional production capacity would account for the availability and productivity of the region's biophysical assets, its food system infrastructure, and the people who work in the system. No model fully accounts for all these factors. The analysis of regional inputs and outputs in Volume 3 provides insight into the value of food system activities to the regional economy. We chose, therefore, to focus on the region's biophysical potential. The Production Milestones Model (hereafter referred to as "the model") considered the capacity for terrestrial ecosystems and marine

FIGURE 3: Estimates of Shifts in Servings Required to Move From "Unchanged Eating" to "Resilient Eating" in 2030

	Unchanged Eating ≈2,940 calories		Resilient Eating ≈2,320 calories	
FRUITS	**0.8 cup** equivalent/day	*increases to*	**2 cups** equivalent/day	Fruit consumption would markedly increase.
VEGETABLES	**1.9 cups** equivalent/day	*increases to*	**3 cups** equivalent/day	Vegetable consumption would increase.
DAIRY	**1.5 cups** equivalent/day	*stays the same*	**1.5 cups** equivalent/day	Dairy consumption would stay roughly equivalent to how people currently eat.
PROTEINS	**1 cup** equivalent/day	*decreases to*	**0.8 cups** equivalent/day	Total protein consumption would decrease, but more seafood, nuts, and beans is encouraged.
GRAINS	**0.9 cup** equivalent/day	*stays the same*	**0.9 cups** equivalent/day	Grain consumption would stay about the same, but more whole grain consumption is encouraged.
SWEETENERS	**21.5 teaspoons** day	*decreases to*	**9.5 teaspoons** day	Additional calories from added sugars would dramatically decrease.
FATS AND OILS	**0.3 cup** equivalent/day	*decreases to*	**0.1 cup** equivalent/day	Fats and oils consumption would be cut in half.

ecosystems to produce primary food commodities, meaning crops, livestock products, and seafood landings. As reminder, manufactured foods were not included in the model due to a lack of available data.

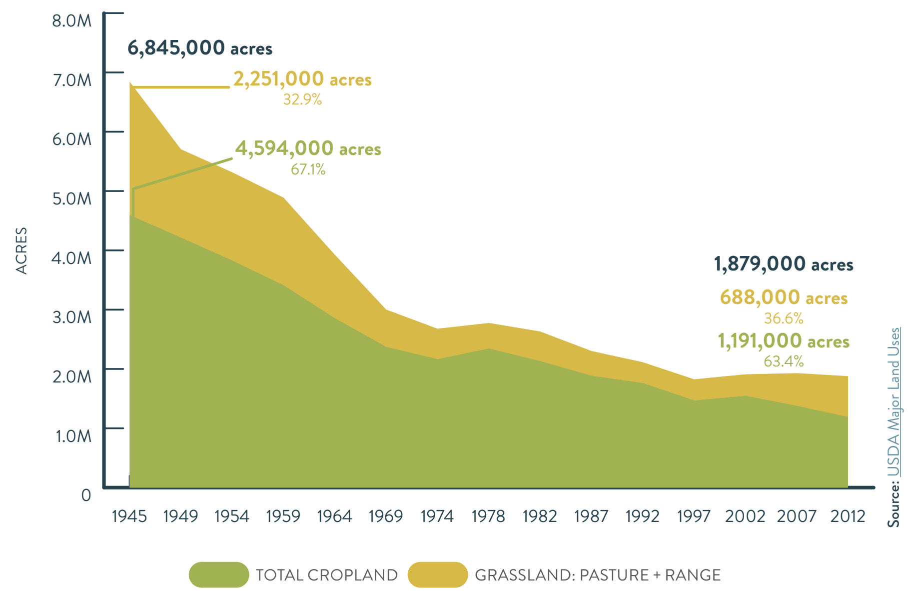
It should be noted that some New Englanders provide a share of their household food needs through gardening, hunting, recreational and subsistence fishing, or foraging. These activities can and do contribute a significant share of some household's food needs. However, limited data are available on these activities, and the total contribution of self-provisioning of food to regional food supplies is unknown. Thus, the model assessed only the potential of agriculture and commercial fisheries to supply regional food needs.

Key Assumptions About Terrestrial and Marine Ecosystems

A key question in a scenario analysis of potential food production is, "How much land is available for agriculture?" **Land use for agricultural purposes in the Northeastern U.S. peaked around 1880.** At that time, 43% of the land area was used as "improved farmland," an antiquated term analogous to cropland. However, the development of railroads and farming in the Midwestern U.S. led to the abandonment of many farms in the Northeast, leading to a long-term decline in agricultural land. By the end of the twentieth century, the area of cropland in the region had declined almost 75% from its peak.[4]

Long term land use trends for New England show that the area of total cropland and permanent pasture declined 73% from 1945 to 2012 (Figure 4). Cropland has decreased throughout this period, while grassland pasture decreased until the 1980s then began to increase in the early 2000s. Total land in cropland and grassland pasture across the six-state region has hovered around 1.9 million acres since 1997. Increasing land in production would reverse a decades long trend of land exiting agriculture. Therefore, we assumed that bringing new land into agricultural production would be possible but difficult, and our assessments of potential future self-reliance began with the capacity of land currently in agricultural production.

FIGURE 4: Agricultural Land Use in New England, 1945-2012



We assumed that increased productivity is possible in Northeastern agro-ecosystems. Improvement of crop yields and livestock feed conversion efficiency has been the principal reason that U.S. food production has continued to increase since the mid-twentieth century when the national area of cropland peaked.[5] Indeed, the study of yield gaps shows that room for improvement exists in increasing corn, soybean, wheat, and forage crops in the Northeastern U.S.[6] Therefore, we assume that it would be possible for New England to increase food production, by closing, even partially, the gaps between current and potential crop yields.

Likewise, we assumed that land use can be intensified. In this context, intensification means leaving less land idle and converting to crops that require more cultivation (e.g., field crops or vegetables vs. hay crops or grazing land). Thirteen percent of New England cropland lies idle or fallow, meaning it is not planted, harvested, or grazed (authors' calculations from USDA National Agricultural Statistics Service, 2019). Less than half of the Northeastern pasture gets used for grazing.[7] Increasing the proportion of land that is actively used and the proportion of land used for food rather than feed production has the potential to increase food output without increasing the area of agricultural land. Therefore, we assumed that land use can be intensified.

Because our research timeline did not allow for extensive marine modeling, our projections were based on a default estimate for seafood landings volume that is equal to 2010-2019 averages (inclusive of both wild capture and aquaculture), with no changes assumed to occur in New Englanders' seafood preferences. This methodological choice belies the complex and dynamic nature of marine food production. To compensate for this omission, the **Volume 2 Supplement, Increasing Regional Self-Reliance Through Seafood,** provides a qualitative consideration of how marine food production could conceivably change by 2030.

Modeling Two Scenarios: Unchanged Eating and Resilient Eating

Overall Strategy

Scenario analysis is both an art and a science. The calculations made are rigorous, but the assumptions sketch out a future that may be possible, but not necessarily probable. In addition, one can be overwhelmed if presented with too many scenarios. Therefore, we developed two consumption scenarios, with two production pathways each, designed to focus attention on the possibility of increasing regional self-reliance through terrestrial food production that adhere to the following assumptions:

- Maintain production of the region's major foods
- Increase production of foods that have low to moderate self-reliance
- Aim to enhance the diversity of foods grown in the region
- Emphasize land-efficient foods but make sustainable use of available pasture
- Focus on core food groups rather than oils and sweeteners

As explained in the previous section, one production pathway maintains agricultural land use at the current footprint of cropland and pasture cover in New England and the other explores the additional land required to meet 30% regional self-reliance. Both pathways allow for increased land use intensity and improvement of crop yields.

Our model did not consider possible changes to seafood production that could result either from deliberate measures to increase self-reliance through seafood (akin to the five assumptions listed for terrestrial foods above) or from external drivers of change that may affect the seafood system in coming years. Instead, we assumed a steady level of seafood production equal to today's baseline.

Scenario Descriptions

We considered two contrasting diet scenarios to explore the potential for the region to supply up to 30% of its food needs under different patterns of food consumption (Table 5). A third scenario is included as a reference point (Reference scenario), as a benchmark against which these two scenarios can be compared.

TABLE 5: Future Production Potential Scenarios

Scenario	Reference Eating Pattern	Scenario 1: Unchanged Eating Regional Self-Reliance	Scenario 2: Resilient Eating Regional Self-Reliance
Population	15,264,141 people	15,623,015 people	15,623,015 people
Per Capita Consumption	Equal to Unchanged Eating	Equal to Unchanged Eating	Equal to Resilient Eating
Food Losses and Waste	No change. Reflect current levels of food losses and waste.	No change. Reflect current levels of food losses and waste.	No change. Reflect current levels of food losses and waste.
Crop Yields	Mean 2010-2019	Close half the yield gap for maize, soybean, wheat, forages, and pasture. Yields of fruit and vegetables increase at a linear rate, doubling over 30 years.	Close half the yield gap for maize, soybean, wheat, forages, and pasture. Yields of fruit and vegetables increase at a linear rate, doubling over 30 years.
Livestock Feed Requirements	Assumes all meat is grain finished.	Assumes baseline production of meat is grain finished. Assumes any additional production of ruminant meats is grass-finished.	Assumes baseline production of meat is grain finished. Assumes any additional production of ruminant meats is grass-finished.
Land Available	Cropland and pasture on farms.	All cropland and pasture cover. One variant of this pathway also includes clearing additional land.	All cropland and pasture cover. One variant of this pathway also includes clearing additional land.

The **Reference scenario** estimates the land requirements to supply the level of regional self-reliance observed for the benchmark year 2019. In this scenario, regional consumption is estimated based on per capita eating patterns from the Unchanged Eating scenario estimated in Volume 1 and the New England population of 2019. Production levels are set to the ten-year average for 2010-2019. Land requirements for each food are based on ten-year average crop yields and livestock feed requirements from the published literature, assuming reliance on grain-finished meats. The scenario restricts land to the area of cropland and pasture on farms.

The scenarios for increased regional self-reliance, **Scenario 1: Unchanged Eating** and **Scenario 2: Resilient Eating**, differ from each other only in terms of per capita eating patterns but differ from the Reference eating pattern in important ways. Consumption is estimated based on the region's estimated population in 2030. Estimated land requirements are based on the target self-reliance ratio for each food and regional productivity under improved yields, in which yield gaps are closed by half (where data are available) or where yields are assumed to double by 2050.

We considered two variations—or pathways—for each Scenario. One pathway restricts land to the existing area of cropland and pasture cover in New England, including land that is cleared but may not be used as part of existing farms. The other pathway allows additional land to be brought into production that has suitable soils but is currently forested in order to achieve the 30% RSR target.

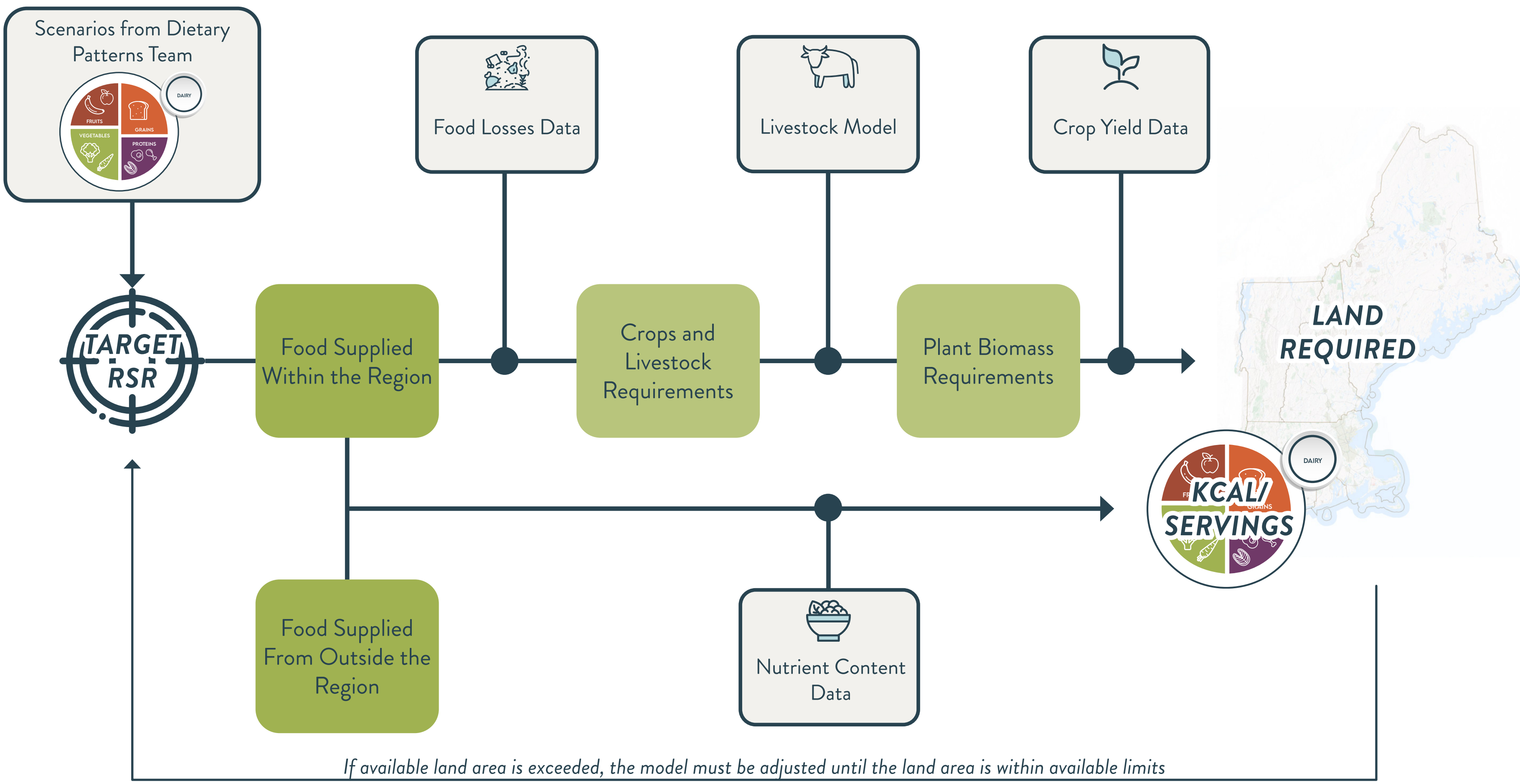
Model Design

Structure of the Model

The production milestones model is a spreadsheet model based on earlier models used to estimate the carrying capacity of U.S. farmland[8] and the land requirements for achieving the New England Food Vision. The model estimates the land requirements of a partially regionalized diet.

As shown in Figure 4, the model is meant to be used iteratively. A user starts by entering a target percent self-reliance for each food group in the diet (Target RSR). This target for the food group is converted into a target mass of food, by multiplying the percent self-reliance by the estimated consumption of each food commodity within that food group. Any remaining food needed to meet regional consumption levels is assumed to come from outside the region.

FIGURE 5: Flow Diagram of the Production Milestones Model



Food loss data are used to convert food consumed into the quantities of crop and livestock products that must enter the food system to create that food. For livestock products, a further step converts the mass of meat, milk, or eggs into the requisite amount of feed and forage to support livestock production. The total plant biomass requirements are converted into an estimate of land area by dividing plant biomass by regional crop and pasture yields. If the estimated area of land exceeds the available area, a user must experiment with alternate RSR targets until the land is within the available limits.

Nutrient content data are used to convert the estimated mass of food supplied from within the region and from outside the region into kilocalories and servings. This allows the model to estimate regional self-reliance in units that are more nutritionally relevant than pounds or kilograms.

Data Sources

Input data for the model comes from a range of sources (Table 6), including publicly available data sources and estimates from the peer-reviewed literature.

On the consumption side of the food system, many estimates were obtained either from another research team (i.e., Volume 1) or from the carrying capacity model by Peters et al. (2016).[9] However, the original sources of these data are primarily from federal databases on loss-adjusted food supplies and nutritional composition of foods. Indeed, Kantor (1998) pioneered this approach to estimate the amounts of edible servings of food in the food supply.[10] Here we used this approach *in reverse* to estimate the supply of food needed to provision a given amount of food intake, following established methods.

TABLE 6: Principal Data Sources for the Production Milestones Model

Metric	Data Source	Description	Units	Geographic Scale
Food Losses and Waste	Loss-adjusted food supply[11]	Estimates of loss at level of primary production, retail, and consumer/food service	Percent loss of food between stages of the food system	U.S.
	Technical report[12]	Conversion factors for yields of processed product from agricultural commodities	Percent yield per unit mass of agricultural commodity	
Nutrient Composition	Nutrient database for standard reference[13]	Composition of major food commodities	Serving size in grams, energy in kilocalories	U.S.
Yield	Annual survey data[14]	Crop yield	Tons acre, cwt acre, pounds acre	New England
	Census of Agriculture[15]	Crop yields derived from estimates of production and area harvested		
Livestock Feed Requirements	Peer-reviewed article[16]	Feed conversion efficiency of major livestock classes	lb crop lb liveweight^{-1}, lb crop lb milk^{-1}, lb crop lb eggs^{-1}	U.S.
	Peer-reviewed article[17]	Feed conversion efficiency of grass-finished beef	lb crop lb liveweight^{-1}	New England and New York
Land Use	Census of Agriculture[18]	Land use on farms	Acres	State
	Major Land Uses[19]	Agggregated land use data for federal and non-federal land		

On the production side of the food system, data on yield and land use were obtained from three federal data sources, the Census of Agriculture, annual production surveys, and the Major Land Uses data. Analogous data on livestock feeding practices are not available from federal sources. Thus, estimates of livestock feed requirements were obtained from the peer-reviewed literature from prior work estimating feed needs for contemporary livestock production practices[20] and for grass-finished beef systems.[21]

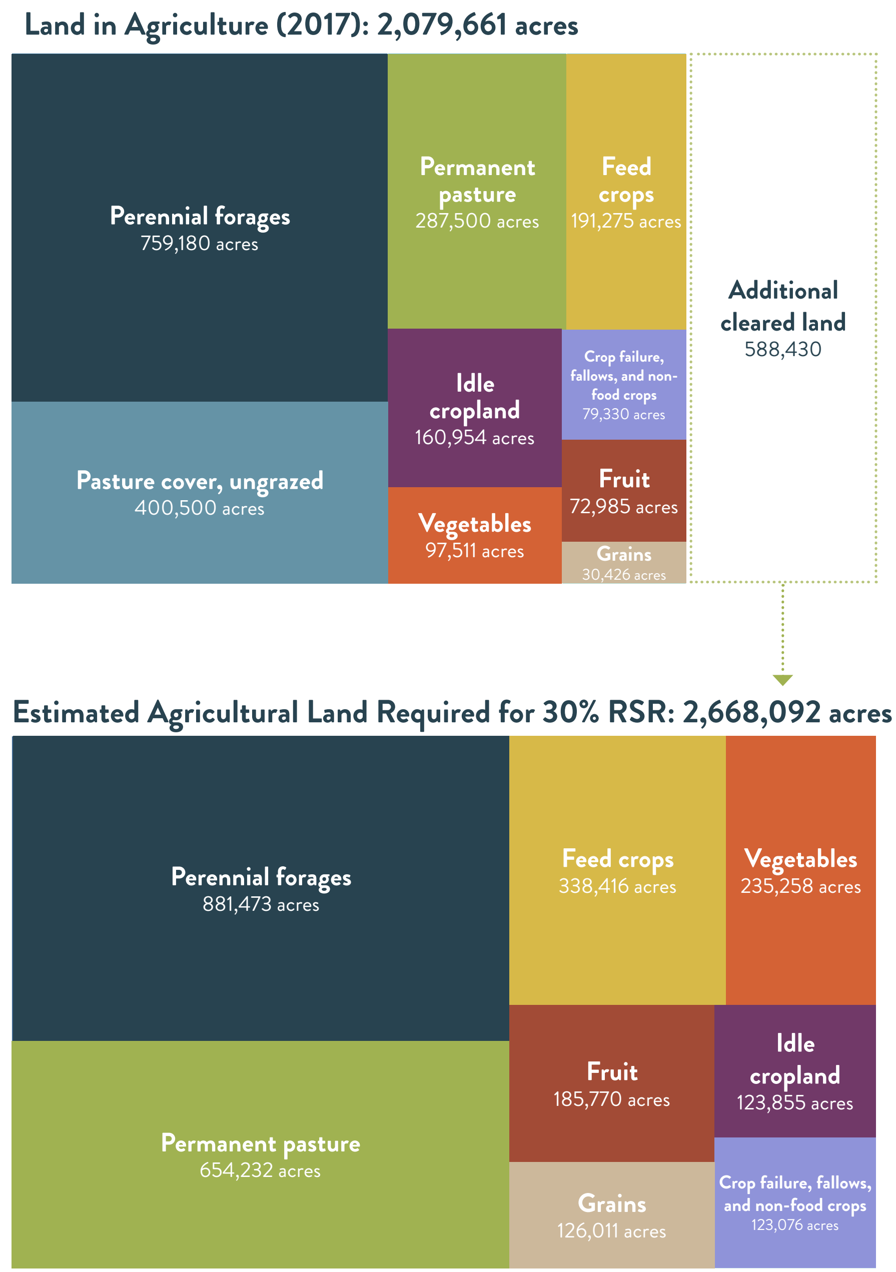
Land Availability

Estimates of potential regional self-reliance are only considered valid if the land requirements do not exceed the area of land available. The model partitions land into three major categories, cultivated cropland (annual crops plus berries, orchards, and vineyards), perennial forage cropland, and grazing land. We assumed that cultivated cropland could be used for any crop or for grazing, whereas land in perennial forage cropland would be restricted to hay crops or grazing, and grazing land can only be used for pasturing livestock.

For two of the scenario variations, we assume that the total footprint of land is fixed but that there is room to increase the intensity of use (Figure 6). Cultivated cropland could be expanded by 200,000 acres through converting idle land and the highest quality hay crop and pasture to cultivated uses. Perennial forage cropland can be maintained by expanding onto the best available land in pasture cover. The area of land in pasture cover would contract by 100,000 acres.

For the pathway variations that strive to reach 30% regional self-reliance, the model permits forested land with prime farmland soils to be brought back into production. According to the 2017 summary of the National Resources Inventory, there are approximately 800,000 acres of such land in the region.[22] Our scenarios allow for up to 60% of this land to be used for cultivated crop production.

FIGURE 6: Agricultural Land Use in 2017 and Estimated Agricultural Land Required for Meeting 30% RSR by 2030



Results

Regional Self-Reliance by Food Group

Under Scenario 1 (Unchanged Eating) and Scenario 2 (Resilient Eating), the total *servings* (Table 9, page 22) and *kilocalories* (Table 10, page 24) of food supplied from within New England increased for all food groups relative to the Reference. These changes were very small for the dairy and sweeteners food groups, but they were much larger for grains, vegetables, fruit, protein, and oils. The absolute increases in servings and kilocalories are hard to interpret, and it may be easier to understand the relative changes.

Comparing the scenarios side by side (Table 7) shows that regional self-reliance can be increased substantially for grains, vegetables, fruit, protein, and oils. Higher levels of RSR could be achieved for fruits and vegetables under Scenario 1, because the level of consumption in the diet was much lower for these foods than under Scenario 2, which conforms with the Dietary Guidelines for Americans. Likewise, Scenario 2 attains a higher level of RSR for protein rich foods than Scenario 1, because it has lower consumption of meat. The RSR for fats and oils increases under both scenarios, relative to the reference, because higher crop yields permit greater production of oilseeds (feed crops for the livestock) enabling an increased supply of plant oils as a byproduct.

TABLE 7: Regional Self-Reliance by Food Group and Scenario

Food Group	Reference	Scenario 1: Unchanged Eating		Scenario 2: Resilient Eating	
		A: Current Land	B: Reach 30% RSR	A: Current Land	B: Reach 30% RSR
Grains	1.6%	10.0%	10.7%	8.9%	15.2%
Vegetables	28.3%	44.3%	45.6%	31.9%	40.0%
Fruit	8.7%	23.7%	26.8%	15.7%	25.5%
Dairy	50.0%	53.8%	61.2%	53.4%	59.7%
Protein-Rich Foods	3.2%	5.4%	5.7%	8.0%	9.5%
Fats and Oils	3.6%	9.4%	9.9%	17.5%	19.1%
Sweeteners	0.9%	0.9%	0.9%	1.7%	1.7%

Overall Regional Self-Reliance

Two estimates of aggregate regional self-reliance are provided for each scenario (Table 8). One approach estimates self-reliance based on the total edible energy, kilocalories, provided from regionally sourced foods. The other approach takes the average of the percent RSR of the five major food groups: grains, vegetables, fruit, dairy, and protein-rich foods (a category that includes meat, poultry, beans, and seafood). Neither approach is necessarily superior. However, the servings-based approach consistently yielded higher levels of RSR than the calories-based approach. This is true for two reasons: First, the servings-based approach only considers the core food groups, whereas the calories-based estimate also includes fats and sweeteners

TABLE 8: Regional Self-Reliance by Scenario as a Percentage of Servings Supplied for the Major Food Groups and Total Food Energy

Scenario	RSR of Five Core Food Groups by Servings	RSR of Total kcal in Diet
Reference	18.3%	8.3%
Unchanged Eating: Pathway A-Current Land	27.4%	13.4%
Unchanged Eating: Pathway B-Reach 30% RSR	30.0%	14.5%
Resilient Eating: Pathway A-Current Land	23.6%	16.8%
Resilient Eating: Pathway B-Reach 30% RSR	30.0%	20.9%

TABLE 9: Billions of **SERVINGS** of Food Supplied From Within New England and From Outside the Region, by Scenario

Food Group	Diet Scenario	Land Use Pathway	Supplied From Within New England	% From Within New England	Supplied From Outside the Region	% From Outside the Region	Total Supply of Servings
GRAINS	Reference		0.6	1.6%	39.4	98.4%	40.0
	1: Unchanged Eating	A: Current Land	4.1	10.0%	36.9	90.0%	41.0
	1: Unchanged Eating	B: Reach 30% RSR	4.4	10.7%	36.6	89.3%	41.0
	2: Resilient Eating	A: Current Land	3.3	8.9%	33.7	90.2%	37.0
	2: Resilient Eating	B: Reach 30% RSR	5.6	15.2%	31.4	84.8%	37.0
VEGETABLES	Reference		2.7	28.3%	6.9	71.7%	9.6
	1: Unchanged Eating	A: Current Land	4.4	44.3%	5.5	55.7%	9.9
	1: Unchanged Eating	B: Reach 30% RSR	4.5	45.6%	5.4	54.4%	9.9
	2: Resilient Eating	A: Current Land	4.7	31.9%	9.9	68.1%	14.6
	2: Resilient Eating	B: Reach 30% RSR	5.8	40.0%	8.8	60.0%	14.6
FRUIT	Reference		0.4	8.7%	4.2	91.3%	4.6
	1: Unchanged Eating	A: Current Land	1.1	23.7%	3.6	76.3%	4.7
	1: Unchanged Eating	B: Reach 30% RSR	1.3	26.8%	3.5	73.2%	4.7
	2: Resilient Eating	A: Current Land	1.8	15.7%	9.6	84.3%	11.4
	2: Resilient Eating	B: Reach 30% RSR	2.9	25.5%	8.5	74.5%	11.4
DAIRY	Reference		4.0	50.0%	4.1	50.0%	8.2
	1: Unchanged Eating	A: Current Land	4.5	53.8%	3.9	46.2%	8.4
	1: Unchanged Eating	B: Reach 30% RSR	5.2	61.2%	3.3	38.8%	8.4
	2: Resilient Eating	A: Current Land	4.5	53.4%	4.0	46.6%	8.5
	2: Resilient Eating	B: Reach 30% RSR	5.1	59.7%	3.4	40.3%	8.5
PROTEIN-RICH FOODS	Reference		1.4	3.2%	43.6	96.8%	45.0
	1: Unchanged Eating	A: Current Land	2.5	5.4%	43.6	94.6%	46.1
	1: Unchanged Eating	B: Reach 30% RSR	2.6	5.7%	43.4	94.3%	46.1
	2: Resilient Eating	A: Current Land	2.8	8.0%	31.9	92.0%	34.6
	2: Resilient Eating	B: Reach 30% RSR	3.3	9.5%	31.4	90.5%	34.6

TABLE 9: Billions of **SERVINGS** of Food Supplied From Within New England and From Outside the Region, by Scenario

Food Group	Diet Scenario	Land Use Pathway	Supplied From Within New England	% From Within New England	Supplied From Outside the Region	% From Outside the Region	Total Supply of Servings
FATS AND OILS	Reference		13.2	3.6%	350.6	96.4%	363.8
	1: Unchanged Eating	A: Current Land	35.0	9.4%	337.4	90.6%	372.4
	1: Unchanged Eating	B: Reach 30% RSR	36.9	9.9%	335.5	90.1%	372.4
	2: Resilient Eating	A: Current Land	28.3	17.5%	133.3	82.5%	161.6
	2: Resilient Eating	B: Reach 30% RSR	30.8	19.1%	130.7	80.9%	161.6
SWEETENERS	Reference		1.0	0.9%	119.3	99.1%	120.3
	1: Unchanged Eating	A: Current Land	1.1	0.9%	122.0	99.1%	123.1
	1: Unchanged Eating	B: Reach 30% RSR	1.1	0.9%	122.0	99.1%	123.1
	2: Resilient Eating	A: Current Land	1.1	1.7%	61.8	98.3%	62.8
	2: Resilient Eating	B: Reach 30% RSR	1.1	1.7%	61.8	98.3%	62.8

TABLE 10: FOOD ENERGY (Calories) Supplied From Within New England and From Outside the Region, by Scenario

Food Group	Diet Scenario	Land Use Pathway	Supplied From Within New England	% From Within New England	Supplied From Outside the Region	% From Outside the Region	Total Supply of Food Energy
GRAINS	Reference		66.7	1.7%	3,966.2	98.3%	4,033.0
	1: Unchanged Eating	A: Current Land	419.0	10.2%	3,708.8	89.8%	4,127.8
	1: Unchanged Eating	B: Reach 30% RSR	449.6	10.9%	3,678.2	89.1%	4,127.8
	2: Resilient Eating	A: Current Land	339.9	9.1%	3,390.4	90.9%	3,730.3
	2: Resilient Eating	B: Reach 30% RSR	572.3	15.3%	3,158.0	84.7%	3,730.3
VEGETABLES	Reference		327.7	41.0%	472.1	59.0%	799.7
	1: Unchanged Eating	A: Current Land	404.8	49.5%	413.8	50.5%	818.5
	1: Unchanged Eating	B: Reach 30% RSR	411.6	50.3%	406.9	49.7%	818.5
	2: Resilient Eating	A: Current Land	460.9	40.7%	671.1	59.3%	1,132.0
	2: Resilient Eating	B: Reach 30% RSR	508.0	44.9%	624.0	55.1%	1,132.0
FRUIT	Reference		35.6	6.9%	477.4	93.1%	513.0
	1: Unchanged Eating	A: Current Land	94.5	18.0%	430.5	82.0%	525.0
	1: Unchanged Eating	B: Reach 30% RSR	106.8	20.3%	418.2	79.7%	525.0
	2: Resilient Eating	A: Current Land	153.6	12.2%	1,108.0	87.8%	1,261.7
	2: Resilient Eating	B: Reach 30% RSR	246.5	19.5%	1,015.2	80.5%	1,261.7
DAIRY	Reference		643.0	47.4%	713.7	52.6%	1,356.6
	1: Unchanged Eating	A: Current Land	700.2	51.3%	664.1	48.7%	1,364.4
	1: Unchanged Eating	B: Reach 30% RSR	795.3	57.3%	593.2	42.7%	1,388.5
	2: Resilient Eating	A: Current Land	700.3	50.0%	699.1	50.0%	1,399.5
	2: Resilient Eating	B: Reach 30% RSR	782.6	55.9%	616.9	44.1%	1,399.5
PROTEIN-RICH FOODS	Reference		86.5	2.6%	3,293.5	97.4%	3,380.1
	1: Unchanged Eating	A: Current Land	167.9	4.9%	3,291.7	95.1%	3,459.5
	1: Unchanged Eating	B: Reach 30% RSR	179.6	5.2%	3,279.9	94.8%	3,459.5
	2: Resilient Eating	A: Current Land	180.1	7.1%	2,345.4	92.9%	2,525.6
	2: Resilient Eating	B: Reach 30% RSR	220.0	8.7%	2,305.6	91.3%	2,525.6

TABLE 10: FOOD ENERGY (Calories) Supplied From Within New England and From Outside the Region, by Scenario

Food Group	Diet Scenario	Land Use Pathway	Supplied From Within New England	% From Within New England	Supplied From Outside the Region	% From Outside the Region	Total Supply of Food Energy
FATS AND OILS	Reference		79.5	2.6%	3,007.2	97.4%	3,086.7
	1: Unchanged Eating	A: Current Land	272.1	8.6%	2,887.2	91.4%	3,159.3
	1: Unchanged Eating	B: Reach 30% RSR	284.2	9.0%	2,875.1	91.0%	3,159.3
	2: Resilient Eating	A: Current Land	233.2	17.0%	1,137.5	83.0%	1,370.7
	2: Resilient Eating	B: Reach 30% RSR	253.9	18.5%	1,116.8	81.5%	1,370.7
SWEETENERS	Reference		19.9	1.0%	1,952.7	99.0%	1,972.6
	1: Unchanged Eating	A: Current Land	20.3	1.0%	1,997.8	99.0%	2,018.1
	1: Unchanged Eating	B: Reach 30% RSR	20.3	1.0%	1,997.8	99.0%	2,018.1
	2: Resilient Eating	A: Current Land	20.3	2.0%	1,015.8	98.0%	1,036.1
	2: Resilient Eating	B: Reach 30% RSR	20.3	2.0%	1,015.8	98.0%	1,036.1

– food groups with low RSR levels. Second, the calories-based estimate gives greater weight to calorically-dense food groups, and the calorically-dense food groups (grains, protein-rich foods, oils, and sweeteners) have low RSR levels.

The results show that significant improvements in self-reliance can be made. Scenario 1, Pathway A increases RSR by nearly 45% over the Reference on a servings-basis, and Scenario 2, Pathway A nearly doubles RSR relative to the Reference on a calorie-basis. However, neither scenario met the 30% goal when limited to the current footprint of agricultural land. In all cases, the limits on available land prevented the 30% target from being achieved.

Land Requirements for Increased Self-Reliance

Achieving the RSR levels attained in either scenario under either pathway would require substantial changes in the allocation of land to different crop and pasture categories (Table 11). The land area required to increase RSR increases land use for every use category except cropland used for pasture and idle land. The increases are particularly pronounced for grains, vegetables, fruits, and, in some cases, feed grains and oilseeds. The change in perennial forages is less dramatic, but use of land for grazing doubles.

Taken together, the land requirement estimates show that land use intensity (the proportion of cropland put to productive use and the amount of tillage and management associated with that use) must increase to meet the RSR levels attained both production pathways for both scenarios. This occurs through shifting of land from lower intensity crops to higher ones and by more complete utilization of land that currently lies in pasture cover.

To meet the goal of supplying 30% of regional food needs, additional land must be brought into production. Scenario 1 (Unchanged Eating) requires about 290,000 acres, whereas Scenario 2 (Resilient Eating) requires an additional 590,000 acres. Both scenarios increase RSR by reducing reliance on virtual land imports in the form of feed grains and oilseeds and by increasing regional grains. In addition, Scenario 2, Pathway B substantially increases land use for vegetables, fruits, and forages for grass-based meats.

Photo credit: Ink + Cabot

Food and beverage product manufacturing, like cheesemaking by Cabot in Vermont, has a high multiplier effect, generally pays higher wages, and it is a way to increase regional ingredients available to consumers.

One important caveat to this analysis is that we were unable to model the impact of *food and beverage product manufacturing* on regional self-reliance. No data is available that quantifies the amount of local, regional, or imported food ingredients in our manufactured food and beverage products. If we were to include food and beverage products—made from any amount of local or regional ingredients—in our analysis, then our regional self-reliance would be higher.

TABLE 11: Land Required to Supply Food From New England Sources According to the Regional Self-Reliance Targets of Each Scenario (Acres)

Land Use Category	Specific Use	2017 Reference (Census of Agriculture)	Current Land: Unchanged Eating	Current Land: Resilient Eating	Reach 30%: Unchanged Eating	Reach 30%: Resilient Eating
Cultivated Cropland	Grains for food	30,426	89,442	71,792	96,167	126,011
	Vegetables	97,511	158,776	158,077	170,655	235,258
	Fruits	72,985	100,512	121,303	108,567	185,770
	Feed Grains + Oilseeds	191,275	240,182	204,316	335,429	338,416
	SUBTOTAL	**392,197**	**588,912**	**555,488**	**710,818**	**885,455**
Cropland - Perennial Forages	Hay + Other Perennial Forages	705,207	784,640	801,505	841,364	881,473
	Used for Pasture	53,973	-	-	-	-
	SUBTOTAL	**759,180**	**784,640**	**801,505**	**841,364**	**881,473**
Cropland - Non-Food or Non-productive Use*	Idle Cropland	160,954	96,281	95,120	108,802	123,855
	Summer Fallow	22,820	27,301	26,972	30,852	35,120
	Land on Which Crops Failed	18,885	22,594	22,321	25,532	29,064
	Non-Food Crops	35,851	42,891	42,374	48,469	55,175
	Seed Uses of Grains	1,774	2,638	2,210	3,454	3,717
	SUBTOTAL	**240,284**	**191,705**	**188,997**	**217,109**	**246,931**
Permanent Pasture	Used for Pasture	287,500	513,837	533,441	599,517	654,232
	Pasture Cover, Ungrazed	400,500	n/a	n/a	n/a	n/a
	SUBTOTAL	**688,000**	**513,837**	**533,441**	**599,517**	**654,232**
	TOTAL	**2,079,661**	**2,079,094**	**2,079,432**	**2,368,808**	**2,668,092**
	ADDITIONAL CLEARED LAND	**n/a**	**(567)**	**(230)**	**289,147**	**588,430**
	VIRTUAL LAND IMPORTS**	**n/a**	**95,248**	**101,422**	**-**	**19,057**

* Our model assumes that (a) future production would reduce the percentage of cropland that is idle, and (b) the percentage of land in summer fallow, failed crops, non-food crops, and seed uses of grains increases as cropland increases.
** The equivalent area of New England cropland needed to grow imported feed grains.

4 Barriers to Increasing Regional Production

Increasing regional self-reliance may be theoretically possible yet difficult to achieve. To ensure that our modeling of future potential was cognizant of the challenges, we organized a series of stakeholder focus groups and reviewed the current literature to better understand opportunities for and barriers to expanding regional production. We organized the themes that emerged along two axes: opportunities and challenges, considering biophysical or social/economic factors (Table 12). We discuss key themes in this section.

Stakeholder Engagement Process

We held 10 focus groups in total, with farmers, fishers, fisheries managers, producers, processors, and other experts, under UVM IRB approval no. 10293. Each session addressed a key product area or common theme, with the goal of speaking with a range of stakeholders across both land-based and sea-based production systems. We hosted virtual, video-based focus groups on ten topics: Annual Crops, Fruit Crops, Beef and Small Livestock, Dairy, Eggs/Poultry, Food Manufacturing, Aquaculture, Wild Capture Fishery Production, Wild Capture Fishery Harvest and Marketing, and BIPOC/Indigenous/Ethnic Food Production.

To identify potential participants, we built invitation lists with input from New England land grant Extension professionals, the New England Food Vision project, and our own networks.

We aimed to have focus groups of approximately 8 members. Groups varied in actual size from 4 to 8 participants. Production team members joined each call as notetakers. Ahead of each group, we distributed information on the NEFNE project, including preliminary findings on potential regional production and consumption of each food category and an information sheet with details on how each group discussion would proceed. During the agricultural focus group sessions, Dr. Peters served as the focus group facilitator, with researchers Donahue, McCarthy, and von Wettberg serving as note takers. During the Aquaculture and Wild Capture Fishery focus group sessions, Dr. Joshua Stoll served as facilitator.

Focus groups had an open format, based on variations of three open-ended questions:

1. If demand for local and regionally produced food were to grow, and assuming your business also grew, how would you increase production on your operation?

2. What barriers, if any, would you foresee in trying to expand production? If possible, explain how this barrier might be reduced or overcome?

3. How do our estimates of New England's self-reliance in food production compare with your expectations of the region's ability to supply its own food?

In some groups we asked further questions based on participant contributions, sometimes to clarify statements or dig deeper into points raised.

TABLE 12: Summary of Focus Group Participant Feedback

	Biophysical	Social and Economic
Opportunities	Crop yield – potential exists for improvement Animal stocking rates – high compared to Western U.S. Soil Carbon - potential exists to increase Integrated production systems (dairy-beef) Carrying capacity – potential to increase (aquaculture)	Compelling stories to tell about regional products Strong consumer base that demands regional products Market the region, not just individual brands Quality of New England products (food manufacturers)
Challenges	Land quality – characteristics that make farming difficult include small parcel size, isolated location, steep topography, and presence of soils that hold too much water or too little water Climate change adaptation (aquaculture and fisheries) Ensuring biosecurity of operation (poultry) Ensuring food safety (food manufacturing) Limited research on biological productivity (aquaculture)	Resource access due to competing or conflicting uses Inequitable access to land and resources for Black, Hispanic, Indigenous, and other New Englanders "Graying" of agriculture and fleets Infrastructure access and availability Logistics of running medium-sized farms Lack of technical assistance Lack of workforce training Negative public perceptions of agriculture/aquaculture Inflexibility of government programs Rising input costs, such as feed and fertilizer Lack of scale appropriate equipment Providing affordable food given higher production costs Sourcing New England grown ingredients (food manufacturers)

Support for Increased Regional Production

A striking theme across many of the focus groups was the enthusiasm and commitment of many of the participants to increasing regional production, and realizing all the social, economic, and environmental co-benefits of thriving regional farms and fisheries. This was often in spite of years of experience of facing the challenges above, often with limited progress to show for it. Many expressed versions of the idea that we need food systems that value things such as soil health, water quality, and wider access to local food. Participants also highlighted the strong consumer support for local food as a key opportunity to increasing self-reliance.

While focus group participants did see greater opportunity to expand production and sales in the region, they provided much greater detail regarding the barriers and constraints that would need to be overcome. Their experience and observations may provide a useful starting place for food system developers interested in working to expand regional food availability.

In order to take advantage of producer willingness to increase production to meet growing demand and achieve the 30% x 2030 goal, a number of barriers and bottlenecks will need to be addressed. While not a complete list, the following represents a compilation of their observations and insight into what needs to be done to strengthen our regional food system.

Access to Land, Waterfront, and Waters

Among the major biophysical opportunities, the region has plenty of good farm soils that are under-utilized, with capacity to store more carbon. However, focus group participants noted difficulty accessing land is a major challenge facing farmers in the region due to land costs and competition with other land uses.

In a region where less than 10% of the land area is in active agricultural use, every single acre counts towards a productive and resilient future in New England. Although the conversion of farmland to non-agricultural uses has waned since the 1980s and 1990s, development and competition from other land uses still threatens the agricultural land base in New England. Between 2001-2016, the American Farmland Trust's analysis estimated that 105,000 acres of agricultural land had been converted to highly developed urban use or was impacted by low-density residential land uses.[23] Roughly half of this converted land was among the region's best in terms of soil quality and suitability for food crop production.

High land prices make it increasingly difficult for farmers to compete with other land uses and prevent farmland loss. New England has some of the highest farm real estate values in the country, especially in Southern New England.[24] Moreover, in the first year of national land value data available since the onset of the COVID-19 pandemic, Massachusetts reported the highest year-over-year change between 2020 and 2021 — a 21.2% increase and Vermont reported the fifth-highest rate at 9.9%.[25] High land costs negatively impact land access for all farmers but are particularly challenging for the region's new and diverse farming population. Focus group participants emphasized that producers of color face steeper challenges accessing land, capital, and credit than white producers and Indigenous producers in particular face complicated land ownership issues. Around New England's more urban areas there are many willing to farm and there is great potential for growing high-value crops on small pieces of land near urban centers, according to focus group participants. However, participants noted that potential urban farmers are often unable to access land due to land costs and soil contamination concerns.

Seafood production is constrained by similar factors. Around the region, working waterfronts face competition and increasing costs because of gentrification, population growth, development, and expansion of the tourism industry.[26] Some wharves and docks need infrastructure improvements and many are highly vulnerable to sea level rise.[27] Pressures are especially acute in small ports and privately held wharves, where dockage is not specifically assigned to commercial vessels and changes in ownership can occur.[28] Publicly owned and managed ports may be more secure in their tenure but are still affected by real estate pressures and debates about the best use of these locations for the public benefit.[29] Working waterfront infrastructure for fisheries and aquaculture not only includes dockage or moorage where boats can be tied when not in use, but also adequate parking, gear storage, cold storage, availability of ice, boat yards, fuel docks, and seafood dealers where harvesters and growers can deliver their catch. Many of these infrastructure assets are disappearing or consolidating in ports around the region and maintaining them will be critical to the future resilience of New England's seafood system.[30]

In wild capture fisheries, state and federal fishing licenses and permits represent another form of access that can be hard to come by. Transferable licenses/permits can be extremely costly, while those that are not transferable are sometimes subject to very long waiting lists, as in the case of Maine lobster licenses.[31] Since federal (and some state) permits are species-specific, these factors can prevent established fishermen from diversifying their businesses to include new fisheries and can act as a barrier to business ownership for new fishermen or for crew attempting to transition to ownership.

While spatial limitations on the water have not historically been a limiting factor for seafood, as they are for terrestrial food, this is beginning to change as human use of the seascape expands and diversifies. The development of expansive offshore wind farms is anticipated to impose new constraints on the spatial distribution of wild capture fishing activities, since some types of fishing gear may not be operable within wind farms and the presence of turbines may potentially affect fishing vessels' ability to transit through wind energy areas.[32] Different usage levels of wind farm areas may be possible in Southern New England, where turbines will utilize fixed foundations, and the Gulf of Maine, where turbines will utilize floating foundations. Meanwhile, aquaculture growers contend with competition from recreational water use and commercial fisheries.

"Graying" of the Industry and Access to Labor

Land and fisheries access issues are compounded by the graying, or aging, of the workforce. According to the Census of Agriculture, nearly a third of New England's farming population are 65 or older, while just one-fifth are under 45.[33] This demographic balance has shifted dramatically in the last 15 years as producers continue to age. On average, New England counties have increased their proportion of producers over 65 by at least 50%, and some have more than doubled their older farming population since 2002.

This is especially prevalent in the rural regions of New Hampshire, eastern Maine, and eastern Massachusetts. Focus group participants noted that in many families there is not an adult child who plans to continue farming and according to the Census of Agriculture, less than half of farms in New England are involved in any form of estate or succession planning, which raises concerns about farmland transition and preventing farmland loss.

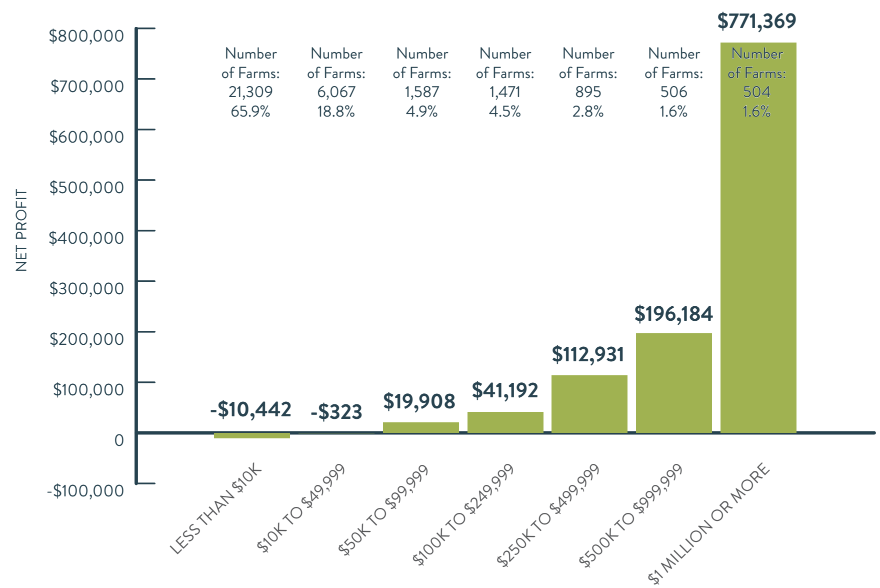
However, focus group participants emphasized that there are plenty of young people who would like to get involved in the agricultural workforce, but face barriers to entry including access to land, capital, and credit and lack of workforce training programs. The inability of the older generation to exit farming and of the next generation to enter farming—the 'farm transition gap'—constitutes one of the greatest challenges for farming in New England.

Similar trends exist in wild capture fisheries, and focus group participants stated that the traditional model for business succession is breaking down in New England fisheries. According to Seara et al. (2016), the average age of Point Judith fishermen increased from 33.9 to 45.2 between 1977 and 2013-14 and average age of New Bedford fishermen increased from 35.1 to 46.1 between 1977 and 2013-14.[34] A recent project by the Northeast Fisheries Science Center suggests that "graying of the fleet" results from a combined trend of fewer people entering the industry and conditions that make it hard for young people to stay in the industry and advance their careers over time. Barriers to entry and advancement include start-up costs, lack of available licenses, and the challenge of learning the skills necessary to be a fisherman, which is particularly acute for entrants who do not come from fishing families. Simultaneously, there is evidence that fewer young people are seeking to enter the industry, possibly because of a discouraging regulatory environment, financial considerations, lack of interest in manual labor, lack of awareness about fishing as a career option, and a societal bias against blue collar work.[35]

Viability of Medium and Small-Scale Operations

Another key challenge to increasing regional self-reliance is the difficulty of competing with the current large-scale, global system that delivers food to the region. Compared to the rest of the country, New England's farm base is small in terms of both the typical acreage operated and revenue earned. For example, data from the 2017 Census of Agriculture indicates that about **85% of farms in New England had sales of less than $50,000, and these farms had *negative* average net profits in 2017. A little more than 3% of New England farms accounted for 69% of total agricultural sales, and these farms had average net profits ranging from $196,000 to $771,000. Scale matters, as net returns are greater, on average, for farms with larger**

FIGURE 7: Average Net Profit Per New England Farm by Economic Class, 2017



Source: USDA Major Land Uses

gross sales. Meanwhile, mid-sized farms have waned in numbers and impact since the beginning of the 21st century.

Across agricultural sectors, focus group participants noted that most small operations have trouble scaling up the size of their operation to become financially viable and provide a decent livelihood. This is due to a number of issues, including access to resources such as land, labor, and capital, difficulty acquiring scale-appropriate machinery, and needing to learn new business skills to meet the needs of wholesale markets. Furthermore, focus group participants noted that for some BIPOC producers, there are unique challenges that result from growing crops with smaller market demand and less extensive distribution networks as well as more limited access to seeds.

In some segments of the wild capture fishery system, there has been a recent trend towards consolidation and out-of-region ownership of fishing vessels and permits. As far as we know, this trend is limited to federal fisheries (i.e., fisheries taking place outside the 3-mile state waters limit), in which permits are assigned to the vessel rather than the individual and the vessel owner need not be on board, enabling business to accumulate multiple vessels and permits and have vessels run by hired captains. Some federal regulations make it increasingly difficult for smaller fishing operations to operate profitability (especially when combined with flat prices for many species) and have driven consolidation around larger fishing operations that can take advantage of economies of scale.[36]

Consolidation in the New England groundfish fishery garnered national attention in 2016 when New Bedford's Carlos Rafael, who at one point had amassed over 40 vessels, 80% of New England's groundfish quota, and a large portion of the region's scallop permits, was imprisoned on charges of conspiring to mislabel fish.[37] Recent years have also seen high-profile purchases of New England-owned vessels and companies by foreign-owned entities.[38]

Limited Manufacturing and Processing Infrastructure

Limited manufacturing and processing infrastructure in the region is another key barrier to expanding production and increasing self-reliance. Based on the focus group responses, processing bottlenecks are particularly critical for beef, pork, poultry, and seafood operations because the region lacks the capacity to slaughter and process all the animals grown or caught in the region, an issue that has been recognized for some time.[39] Similar bottlenecks in processing, storage, and packing impact the potential to increase production of fruits and vegetables that need cold storage or to produce more processed products from regionally grown, fresh agricultural commodities.

These bottlenecks are often due to the seasonal nature of production. For livestock commodities, for example, slaughter and processing is concentrated during certain months of the year, leaving processing facilities operating at less than full capacity for the rest of the year. These bottlenecks manifest as long scheduling times in busy months, like August through December, and shorter scheduling times in quieter months like February through April.[40] On the food manufacturing side, a related challenge in expanding production is that most food processing machinery is not available at sizes that match the scale of New England production. Most off-the-shelf equipment is either geared for small batch production or else very large commodity scale production. This makes it challenging for small scale producers and manufacturers to scale up to be medium sized even when expansion is warranted due to increased consumer demand.

Focus group participants noted processing gaps in the seafood industry as well, especially in smaller ports where aggregation of large volumes is not possible. One acute barrier to expansion of processing infrastructure is the challenge of dealing with large volumes of wastewater in coastal areas with dense populations, high water tables, and limited real estate.[41] Wastewater treatment has been described as the largest barrier to expansion for Rhode Island's squid processors, who land over half of the East Coast's squid catch. Due to these limitations, 80% of Rhode Island squid landings are sent overseas for processing before being reimported.[42]

Processing gaps also exist for new products entering the food system, such as the relatively new sea vegetables industry (e.g., kelp). In the last five years, there has been significant growth in raw supply from harvesters, but current processing infrastructure is limited and requires scaling up to support industry growth. As this industry grows, it will be vital to balance grower capacity with processing capacity that can produce finished end products within the region at scale.[43]

Regional Market Demand and Competition with Imports

In order to enhance the contribution of wild capture seafood to regional self-reliance, focus group participants highlighted a need for consumer education and marketing to help eaters understand differences between local and imported seafood, build demand for under-appreciated local species that could make up a larger share of New Englanders' diets if eaters understood how to utilize and enjoy them, and consumers to be more flexible in their eating choices (a critical need given ecological changes occurring as a result of climate change). Indeed, prior research reveals that processors and distributors feel they would be able to supply much greater quantities of seafood to the region, but are limited by consumer demand.[44]

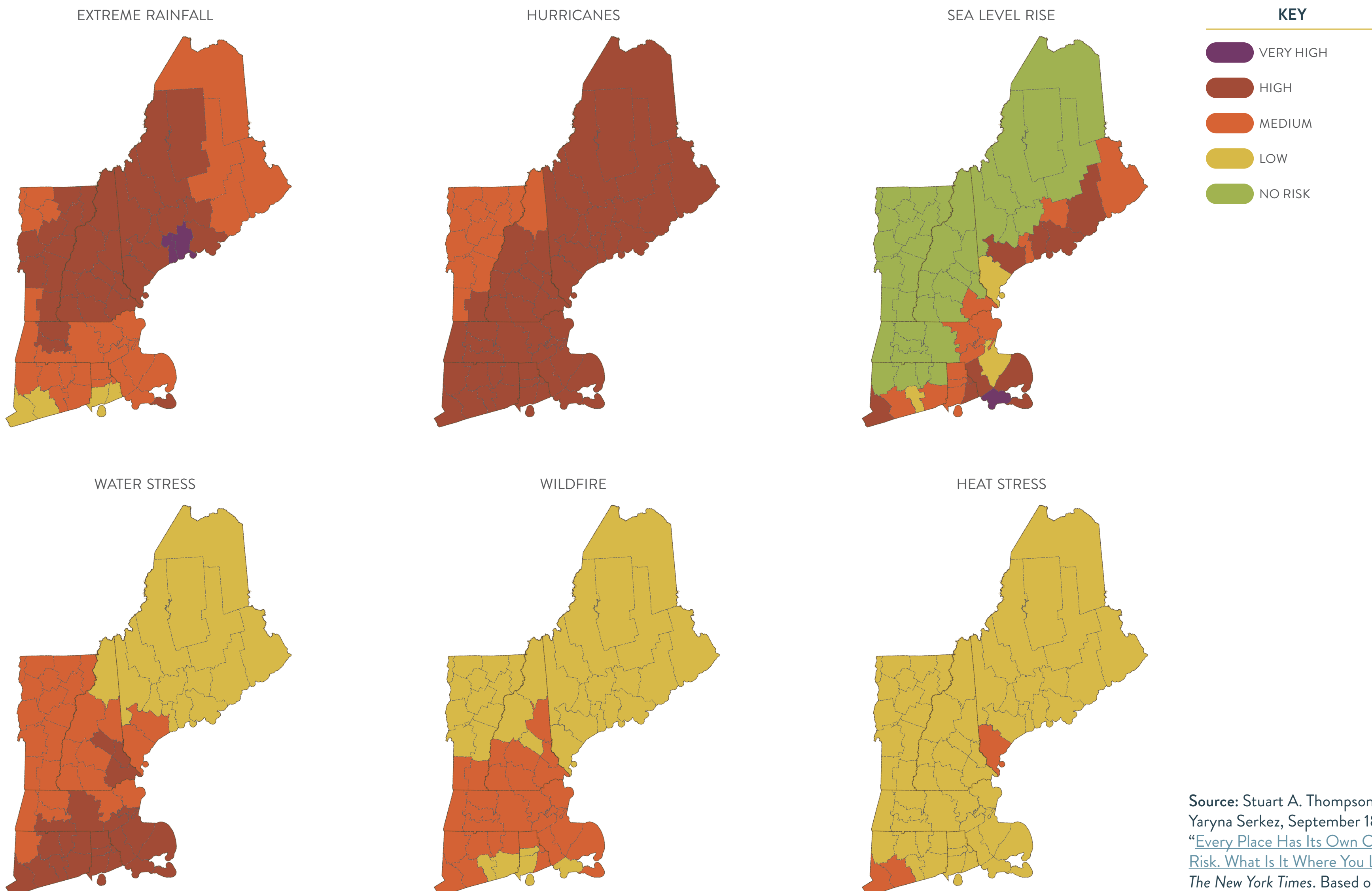
Participants mentioned competition from imports as a key concern, and said that the inconsistent availability and quality of New England-landed seafood contributes to market share takeover by otherwise equivalent imported seafood products. Many recommended freezing fish as a strategy to improve quality, but noted that many New England consumers have a bias against frozen fish, believing it (incorrectly) to be lower quality than fresh seafood (see also Cousart and Leaning, 2019; GMRI, 2018).[45]

Participants highlighted many current efforts to increase consumer awareness and support purchases of New England seafood, meat and vegetables in restaurants, colleges, and schools, and celebrated a recent surge in consumer interest in cooking seafood and local farm products at home and purchasing local, direct-to-consumer seafood, meat and vegetables—a positive side effect of the COVID-19 pandemic and its associated supply chain disruptions.

Climate Change Impacts

Climate change is a biophysical challenge for both agriculture and fisheries due to the expected shifts in seasonal patterns, changes in rainfall patterns (more heavy storms, along with longer periods of drought), warming oceans, and rising sea levels. Northeast agriculture will become more vulnerable to damage from high rainfall events (Figure 7), drought, high temperatures, spring frosts (for perennial fruit crops), and increases in insect, disease, and weed pressures.[46] The climate in the region is generally favorable for a range of crops, especially grasses and other perennial forages, and it is likely to remain so even given climate change, compared to other regions. In New England, vegetable and fruit producers face a range of pathogen and pest challenges due to the wet climate. However, focus group participants also see opportunities for a longer growing season, and greater ability to use season extension technologies as well as increasing indoor and hydroponic production.

FIGURE 8: Projected Climate Change Risks by County



Source: Stuart A. Thompson and Yaryna Serkez, September 18, 2020, "Every Place Has Its Own Climate Risk. What Is It Where You Live?," *The New York Times*. Based on data from Four Twenty Seven.

5 Comparative Results and Limitations of the Approach

Comparison with Earlier Work

There is no standard approach to conducting analyses of local or regional food self-reliance. Reviews of the literature in this area show that analyses of "local" food production capacity use similar, but not identical, methods or data sources, and that the studies are done at different scales and time periods.[47] Comparisons must be made with care.

Our findings on current regional self-reliance can be most directly compared with earlier work on the twelve-state Northeast region.[48] While the results come from different decades, 2001-2009 versus 2010-2019, the study of the Northeast provides the closest point of reference for our analysis of current self-reliance in New England. Like New England, the larger Northeast region has a relatively low total self-reliance. The regional self-reliance across all foods on a weight basis was approximately 30% for the Northeast and 20% for New England. The lower value for New England should not be surprising, as it accounts for just 10% of the land in production in the Northeast but contributes more than 20% of the Northeast's population.

Like New England, self-reliance in the Northeast varies across foods and food groups. Both regions have a relatively high self-reliance for dairy, with lower values for the other food groups. New England's self-reliance values for seafood and vegetables are similar to the larger Northeast region, but the values for fruits, grains, oilseeds, sweeteners, meats, and eggs are lower for New England than the Northeast.

Our estimates of potential future self-reliance are more challenging to compare to previous work because of differences in methodology and spatial scale. Nonetheless, some comparisons can be made. The New England Food Vision, which considers the same region but looks out to 2060, found that the region could supply 50% of its food (on a land basis) by focusing production on fruits, vegetables, dairy products, and grass finished meats, while importing the majority of food grains, feed grains, oilseeds, and sweeteners.[49] Getting to this scenario, however, requires bringing about 4 million acres of land back into agricultural production.

Analyses at other scales generally confirm the challenge of supplying regional food in the Northeast U.S. New York State has sufficient land to supply approximately one-third of its food, were all its agricultural land used to meet in-state needs.[50] The Northeast region has enough land to theoretically feed 13 million people, 20% of the population, a complete diet that is similar to our resilient-eating scenario.[51] A national analysis of potential local foodsheds shows that, even if we used agricultural land in a way that minimized food distance, most metropolitan areas in the Northeast would be unable to supply their food needs from land within an average distance of 300 miles.[52] An analysis of the capacity for current production to supply local food needs shows that, nationally, there is sufficient capacity for most metropolitan areas to supply their dairy and egg needs within 100 miles, but not their fruit and vegetable consumption.[53]

Only one analysis suggests more optimistic potential for food system localization. A national-analysis of the potential for local croplands to meet U.S. food demands found that all metropolitan areas could meet their food needs from croplands within a 200-mile radius.[54] However, this analysis did not restrict the use of cropland to limit the proportion of land devoted to cultivated cropping (i.e., annual crops and perennial fruit crops), which partially accounts for their results. Estimates of the carrying capacity of agricultural lands are highly sensitive to assumptions that restrict the use of land for cultivated crops.[55] Determining the degree to which regional crop rotations and livestock production can be changed to increase self-reliance without resulting in negative environmental outcomes, like soil erosion and nutrient flows, remains an open question in need of further research.

Interpretation of Results and Limitations of the Research

Our estimates of current regional self-reliance compared the weight of food commodities produced to the equivalent weight consumed. This provides a sound benchmark for comparing results to earlier work. Weight-based estimates of regional self-reliance give a clear picture of the region's potential to supply individual food commodities. However, when these data are aggregated into an estimate of total regional self-reliance, water-rich foods, like fruits, vegetables, and fluid milk, have a big impact on the final value relative to their caloric contribution to the diet. Likewise, foods produced in a drier form, like grains and oilseeds, have a smaller impact on the self-reliance estimate, relative to their caloric contribution. **Weight may not be the best measure for understanding the overall ability of the region to feed itself.**

This presents a quandary for which there is no single correct answer. Each metric of regional self-reliance provides its own perspective. Weight may be relevant to the transportation and handling of food, while calories tell you something about the how much of a person's diet can come from regional food. Percentage of food expenditures would give an indication of the importance consumers place on sourcing their food from New England. **For our purposes, we relied on *weight* for the current self-reliance assessment to permit easy comparison with earlier work, and we used *calories* and *servings* to assess capacity for supplying 30% of the food eaten in the region.** Bear in mind, the choice of metric depends on why one cares about regional self-reliance.

To assess future potential for New England to feed itself, we developed a biophysical model of the food system. While expansion of the food system may be constrained by other types of bottlenecks, such as the region's processing capacity or consumer willingness to pay for regional products, it helps to start with a model focused on the region's biological potential. This is particularly true in New England, where the area of active agricultural land (cropland and pasture) declined dramatically over the 20th century. Considering alternative scenarios of land use, agricultural production, and fisheries serves as a starting point for asking questions about whether other logistical barriers can and should be overcome.

Our assessment of biological capacity shows that New England *cannot* supply 30% of its food by 2030 (based on calories or food group servings) with the current footprint of agricultural land even with yield growth. Either more land or a faster increase in productivity would be needed. Meeting the 30% target would require roughly 300,000 acres of new cropland under the current diet (i.e., Unchanged Eating) and approximately 588,000 acres under a Resilient Eating diet broadly consistent with the Dietary Guidelines for Americans.

To put these changes in perspective, consider historical trends. The area of cropland in New England peaked around 1880, at over 13 million acres (about 6.8 million acres were in cropland and pasture)[56] but has hovered just under 2 million acres for the past twenty-five years. Over the 30-year period, 1980-2010, Northeast yields of three major field crops, corn, soybean, and wheat, increased 1.6% to 1.9% each year relative to the 1980 baseline.[57] These are common crops, grown for many decades in this region, with established programs around the country that conduct research to increase yields. **Achieving the goal of 30% regional self-reliance means reversing the trend of land exiting agriculture and a fast rate of yield improvement relative to established crops.**

Bear in mind that in our assessment of biological capacity, we did not consider possible changes to seafood production or consumption. However, regional self-reliance in seafood could increase or decrease by 2030, due to hard-to-predict, yet potentially significant, impacts from climate change and large-scale ocean-based renewable energy development, as well as the potential application of deliberate actions to increase regional consumption of New England seafood species. While modeling of potential future seafood production was beyond the scope of this Volume, a supplemental report, *Increasing Regional Self-Reliance Through Seafood*, explores several external drivers and seven potential actions with potential to increase regional seafood self-reliance.

Conversations with targeted groups of stakeholders suggest that producers see opportunities to increase regional production. These opportunities include possibilities such as increasing crop and grazing yields or intensifying land use, but also include innovations beyond the scope of our models, such as urban agriculture and alternative management of fisheries. In addition, these conversations pointed to a range of economic, social, and logistical challenges to expanding self-reliance. While beyond the scope of this assessment, future work on realizing greater self-reliance would need to address them.

Photo credit: RIFPC

Windmist Farm in Jamestown, Rhode Island, is a small family-farm with grassfed livestock and seasonal vegetables.

6 Next Steps

Can the six New England states provide 30% of their food from regional farms and fisheries by 2030? The New England State Food System Planners Partnership, through its *New England Feeding New England* project, set out to explore this question. Inspired by Food Solution New England's *New England Food Vision* of achieving 50% regional consumption by 2060, our objective was to better understand our current food system environment, and exactly what it will take to grow, raise, produce, harvest, catch and move more food through a complex regional supply chain to our homes and other places we eat.

The 16 NEFNE researchers developed this foundational research so that we can begin to mobilize around a regional food goal, develop strategies, and take action to build a more just, equitable, resilient, and reliable regional food system. A central concept of this approach is the idea of **regional food self-reliance, which is an estimate of how much food we produce compared to how much food we consume.** No single county or state can provide a full menu of food products to meet the needs of its population. For example, within New England, the northern states have *most of the farmland*, while the southern states have *most of the consumers*. Moving toward 30x30 will require, for example, enormous investment in retaining and expanding land in agriculture in the northern states, with most of the people, political power, and potential sources of funding based in southern New England.

A resilient regional food system is both an *investment* in our shared future and an *insurance policy* against future risks.

This dynamic—big population centers in the southern states, and major agricultural production in the northern states—sets the stage for exploring regional food self-reliance.

Volume 2 addresses the current and potential capacity of New England to source its own food. Our analysis measured **regional self-reliance** (RSR), an estimate of the region's production of food commodities compared to its consumption of those same commodities. Our scenarios fell short of the 30% regional food consumption goal utilizing our existing land base and fisheries landings. Following current eating patterns (i.e., Unchanged Eating), the region could provide 27% of major food group servings by maintaining current production of dairy products and increasing production of vegetables, fruits, grains, and grass-based meat production. Following healthier eating patterns (i.e., Resilient Eating), the region could supply just 24% of major food group servings, due to higher consumption of fruits and vegetables. Both scenarios showed increased self-reliance compared to a 2019 baseline of 19% of the major food groups. Reaching 30% of regional food self-reliance will require bringing 400,000 of under-utilized acres *plus* approximately 290,000 acres based on the Unchanged Eating scenario or 590,000 acres based on Resilient Eating scenario of additional land into production.

The Questions We Started With

- » If we ate in a healthier, more resilient way, could more of our food be supplied by regional production?
- » Could the six New England states meet a goal of supplying 30% of the region's food by 2030?
- » Do we have the right mix of industries to ramp up food production? What sectors are growing? What sectors are contracting?
- » What market channels offer the best opportunities for sourcing regional and local products?
- » What might change if we intentionally and regionally plan for our future, making significant investments in strengthening our regional food system and communities?

After a year of intensive exploration by four research teams, we can begin to answer these questions. We have identified key stakeholder groups that we want to engage with over the coming years, because we believe that they have a big role to play in producing and sourcing more regional food and getting into the market channels where most New Englanders access it. We have identified a number of areas where additional investments are most needed to have the greatest impact in order to achieve the 30% regional goal.

The Questions We Now Have

What do we need to do by 2030 to make tangible progress towards this bold vision? What can we do as a region to make our regional food system more equitable and fair, resilient and reliable?

Food Production Questions

- » To reach 30% regional self-reliance by 2030 we need to protect existing farms and farmland, and add an additional ~590,000 acres in farmland production. What will it take to make this happen? Where will it need to happen?
- » How can we support more BIPOC and young farmers in accessing affordable farmland and the working capital to be successful?
- » What public awareness and messaging campaigns are needed to inspire and enable New Englanders to eat more regionally produced foods?
- » How can we focus more effort on expanding production of crops that we eat most?
- » How can we keep more of what we already produce in the region from being exported, so it can be consumed in the region?
- » What strategies and/or policies would enable more of the wild-caught fish and seafood from the region to be consumed here?
- » What strategies/policies/investments need to be made to help farmers and fishermen in New England adapt to climate change?

What Comes Next for the Region?

A regional approach to food system resilience means that we work collectively to adapt, expand, and fortify New England's food production and distribution systems to ensure the availability of adequate, affordable, and culturally appropriate food for all who call New England home. As a collaboration between state-level food system organizations and the region-wide Food Solutions New England network, the New England Feeding New England project provides additional focus for communication, collaboration, and coordination in the region.

It is clear that sustained and collaborative action along with a significant and coordinated investment of resources will be required to meet the 30% by 2030 goal. But we know that the work we intend to do together is by no means the totality of what will be needed. We invite you to consider—and then act upon—how your business, your organization, your community and your choice around the food you consume can contribute towards the regional goal we are inspired to work towards. All of us will need to work together, in alignment, to make progress toward this goal. Each of us—whether we are a farmer, fisher, food entrepreneur, retailer, nonprofit organization, researcher, educator, capital provider, government official, community organizer, or an "eater"—has an important role to play. Each of us has something to contribute, to advance, to accomplish.

System-level change is by its very nature complex, and no one organization, entity or state can change it alone. System-level change requires collaboration, highly networked multi-stakeholder alignment, transparency, continuous communication and strategic action that is properly resourced and built upon trusted relationships.

So let's come together around this goal of 30% by 2030 so that we can build the kind of equitable, resilient, and reliable regional food system that we need to adapt to climate change and ensure that everyone who lives in New England has access to healthy, regionally sourced food from successful food producers and retailers.

We need to do this. We can do this. We invite you to be part of what comes next.

7 Endnotes

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Appendices

A Seafood Harvest and Value by New England State (2010-2020)

TABLE A1: Seafood Harvest in Connecticut by Volume and Value

Year	Pounds Harvested (Public)	Pounds Harvested (All)	Total Live Pounds Harvested (All)	Total Value (Public)	Total Value (All)
2010	6,697,804	6,697,804	16,177,442	$16,094,613	$16,094,613
2011	7,403,330	7,403,330	17,240,454	$20,030,859	$20,030,859
2012	8,940,172	8,940,172	18,165,024	$21,128,116	$21,128,116
2013	7,956,666	7,956,666	12,819,015	$14,628,813	$14,628,813
2014	7,523,025	7,523,085	12,207,681	$14,142,453	$14,142,513
2015	9,389,867	9,389,867	13,791,660	$15,788,937	$15,788,937
2016	12,149,395	12,149,395	16,488,038	$15,013,569	$15,013,569
2017	10,171,969	10,171,969	16,285,231	$13,818,053	$13,818,053
2018	11,473,209	11,473,215	18,863,721	$16,542,575	$16,542,578
2019	9,190,044	9,190,044	15,359,761	$16,603,727	$16,603,727
2020	7,072,222	7,072,222	17,478,606	$20,289,462	$20,289,462

TABLE A2: Seafood Harvest in Maine by Volume and Value

Year	Pounds Harvested (Public)	Pounds Harvested (All)	Total Live Pounds Harvested (All)	Total Value (Public)	Total Value (All)
2010	198,469,357	226,763,224	228,895,513	$380,695,404	$458,447,121
2011	244,852,362	256,584,183	275,733,606	$410,854,690	$434,805,114
2012	259,895,362	289,860,342	289,612,246	$450,968,125	$530,398,190
2013	263,325,159	267,002,775	293,388,054	$474,227,379	$478,880,649
2014	257,874,038	278,048,383	287,537,380	$549,296,169	$595,698,875
2015	230,482,926	252,484,453	259,592,088	$586,761,662	$628,953,892
2016	234,859,544	276,903,113	259,747,621	$622,682,149	$735,141,797
2017	201,565,414	231,221,772	226,450,477	$516,695,288	$577,474,721
2018	227,844,357	252,171,897	253,174,488	$569,039,364	$645,341,617
2019	138,241,519	181,268,024	164,554,660	$553,898,854	$676,635,921
2020	146,086,228	164,020,249	170,495,491	$468,029,224	$515,227,121

TABLE A3: Seafood Harvest in Massachusetts by Volume and Value

Year	Pounds Harvested (Public)	Pounds Harvested (All)	Total Live Pounds Harvested (All)	Total Value (Public)	Total Value (All)
2010	279,408,130	284,078,090	671,867,678	$474,403,496	$478,131,894
2011	247,931,830	264,891,363	555,090,036	$559,378,256	$571,278,191
2012	277,017,870	294,923,359	639,751,768	$602,130,726	$615,122,488
2013	245,124,902	261,450,566	568,445,904	$550,114,148	$562,192,707
2014	269,766,350	273,014,128	629,670,891	$519,562,929	$522,707,323
2015	259,469,653	259,519,777	620,313,158	$523,417,066	$523,482,006
2016	228,530,036	244,355,695	504,353,462	$538,346,312	$550,684,847
2017	241,527,048	242,830,664	687,468,869	$603,730,619	$605,214,845
2018	222,424,917	241,671,118	613,825,917	$630,744,415	$647,645,147
2019	228,420,463	234,129,173	701,273,288	$674,740,141	$680,736,059
2020	221,498,440	227,902,948	588,395,181	$549,358,948	$556,053,520

TABLE A4: Seafood Harvest in New Hampshire by Volume and Value

Year	Pounds Harvested (Public)	Pounds Harvested (All)	Total Live Pounds Harvested (All)	Total Value (Public)	Total Value (All)
2010	11,623,673	11,802,154	11,626,315	$20,521,010	$20,597,214
2011	12,226,267	12,311,389	12,244,973	$23,426,770	$23,481,991
2012	12,068,923	12,145,399	12,158,726	$23,191,171	$23,236,034
2013	8,227,730	8,246,643	8,409,674	$20,127,473	$20,187,640
2014	6,009,857	9,116,773	6,209,178	$23,239,456	$24,288,001
2015	9,923,605	11,093,260	10,150,830	$27,457,835	$27,793,990
2016	7,038,119	7,937,328	7,211,087	$32,980,226	$33,214,356
2017	10,622,045	10,665,421	10,657,910	$34,990,493	$35,038,129
2018	9,131,601	9,939,184	9,217,420	$38,321,136	$38,536,243
2019	7,556,544	10,392,406	7,818,589	$37,880,316	$38,261,681
2020	5,774,671	6,730,163	5,821,626	$26,398,133	$26,769,399

TABLE A5: Seafood Harvest in Rhode Island by Volume and Value

Year	Pounds Harvested (Public)	Pounds Harvested (All)	Total Live Pounds Harvested (All)	Total Value (Public)	Total Value (All)
2010	71,866,309	77,696,395	86,903,146	$60,848,143	$62,724,220
2011	77,094,572	78,749,033	87,216,566	$74,856,179	$75,930,461
2012	73,238,011	85,233,593	87,440,358	$75,105,442	$81,135,941
2013	85,289,934	89,849,566	103,988,636	$84,569,232	$86,062,941
2014	91,744,435	91,773,615	105,047,514	$86,406,191	$86,439,336
2015	75,038,543	75,745,740	86,125,817	$81,837,662	$82,117,098
2016	82,552,925	82,687,958	95,008,626	$94,785,517	$94,905,209
2017	83,731,942	83,795,064	106,474,563	$101,832,065	$101,962,860
2018	81,046,869	81,096,521	105,087,269	$105,051,497	$105,120,249
2019	78,517,748	78,621,440	103,357,092	$108,572,978	$108,624,349
2020	73,443,607	73,492,088	86,375,689	$78,297,724	$78,368,703

B Seafood Species Categories

Categories: Coastal Fish, Diadromous Fish, Elasmobranchs, Pelagic Fish and Cephalopods, Benthic Invertebrates, Groundfish, Seaweed, and Other

Excluding the Seaweed and Other categories, all categories in this analysis are the same as those used in the NOAA Northeast Fish and Shellfish Climate Vulnerability Assessment. The Seaweed category was created by University of Maine research assistant Melissa Britsch for all species of seaweed and kelp landed in New England. The NOAA categories were based on phylogeny and habitat usage by focus species. As explained in Hare et al. (2016), the authors chose common species that were either 1) commercially important, 2) protected, or 3) ecologically important.

Definitions:

For this analysis, we used the following definitions. The definitions were created based on similar attributes identified among the species categorized by NOAA as well as similar definitions for species from the fishbase.de website.

- **Coastal Fish:** Fish that live near the coast and are explicitly mentioned as spending substantial time as adults in estuaries and brackish environments. Freshwater fish like catfish and carp are also included in this group.
- **Diadromous Fish:** Diadromous fish that spend part of their lives in freshwater and part of their lives in saltwater are in this group.
- **Elasmobranchs:** All sharks, skates, and rays are in this group.
- **Pelagic Fish and Cephalopods:** All cephalopods are in this group. Additionally, highly migratory fish, schooling fish not in other categories, and those that do not spend much time on or near the bottom are in this group.
- **Benthic Invertebrates:** All invertebrates except cephalopods are in this group.
- **Groundfish:** Fish that live on or near the bottom but are not generally found in estuaries or rivers. This category also includes reef-associated fish that typically live in the southern U.S. or Caribbean but are occasionally caught in New England.
- **Seaweed:** All species of marine algae.

- **Other:** Species or groups of species present in the Atlantic Coastal Cooperative Statistics Program (ACCSP) landings data for New England that do not fit in any other categories.

Methods:

All fish were searched for in FishBase. If a species was categorized in a specific way by the NOAA analysis, other similar species were also placed in that category. Groups that were not identified to the species level were placed in the same category as species from the same group that had been categorized.

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After the species categories were created, they were merged with the existing ACCSP data in R. The information was merged by "State" and "Common.Name". Some species names were manually corrected so they were consistent and were mergeable (e.g., "sea scallop" and "Scallop, sea" would not merge together).

Seafood Species List

Common Name	Scientific Name	Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*	Clam, ark, blood	*Anadara ovalis*
Amberjacks	*Seriola*	Clam, quahog, false	*Pitar morrhuanus*
Anchovy, bay	*Anchoa mitchilli*	Clam, quahog, northern	*Mercenaria mercenaria*
Barbier, red	*Hemanthias vivanus*	Clam, quahog, ocean	*Arctica islandica*
Barracudas, sphyraenidae (family)	*Sphyraenidae*	Clam, razor, atlantic	*Ensis directus*
Barrelfish	*Hyperoglyphe perciformis*	Clam, soft	*Mya arenaria*
Bass, bank sea	*Centropristis ocyurus*	Clam, stout tagelus (stubby razor/bamboo)	*Tagelus plebeius*
Bass, black sea	*Centropristis striata*	Clam, surf, arctic	*Mactromeris polynyma*
Bass, striped	*Morone saxatilis*	Clam, surf, atlantic	*Spisula solidissima*
Big roughy	*Gephyroberyx darwinii*	Clams	*Bivalvia*
Bluefish	*Pomatomus saltatrix*	Clams, quahog, mercenaria	*Mercenaria*
Boarfishes	*Zeiformes*	Cobia	*Rachycentron canadum*
Bonito, atlantic	*Sarda sarda*	Cod, atlantic	*Gadus morhua*
Brotula, bearded	*Brotula barbata*	Conchs	*Strombidae*
Butterfish	*Peprilus triacanthus*	Conchs, true	*Strombus*
Butterfish, gulf	*Peprilus burti*	Crab, atlantic rock	*Cancer irroratus*
Capelin	*Mallotus villosus*	Crab, blue	*Callinectes sapidus*
Carp, common	*Cyprinus carpio*	Crab, green	*Carcinus maenas*
Catfish, blue	*Ictalurus furcatus*	Crab, horseshoe	*Limulus polyphemus*
Catfish, channel	*Ictalurus punctatus*	Crab, jonah	*Cancer borealis*
Catfish, white	*Ameiurus catus*	Crab, lady	*Ovalipes ocellatus*
Catfishes, bullhead	*Ictaluridae*	Crab, northern stone	*Lithodes maja*

Common Name	Scientific Name	Common Name	Scientific Name
Crab, portly spider	*Libinia emarginata*	Flounder, summer	*Paralichthys dentatus*
Crab, red deepsea	*Chaceon quinquedens*	Flounder, winter	*Pseudopleuronectes americanus*
Crab, snow	*Na*	Flounder, witch	*Glyptocephalus cynoglossus*
Crabs, brachyura	*Brachyura*	Flounder, yellowtail	*Limanda ferruginea*
Crabs, cancer (genus)	*Cancer*	Garfishes	*Lepisosteidae*
Crabs, hemigrapsus	*Hemigrapsus*	Goosefish	*Lophius americanus*
Crabs, hermit, pagurus (genus)	*Pagurus*	Goosefish, blackfin	*Lophius gastrophysus*
Crabs, spider	*Majidae*	Grouper, snowy	*Epinephelus niveatus*
Croaker, atlantic	*Micropogonias undulatus*	Groupers, serranidae (family)	*Serranidae*
Crustaceans	*Crustacea*	Grunts, haemulidae (family)	*Haemulidae*
Cucumber, orange footed sea	*Cucumaria frondosa*	Haddock	*Melanogrammus aeglefinus*
Cucumbers, sea	*Holothuroidea*	Hagfish, atlantic	*Myxine glutinosa*
Cunner	*Tautogolabrus adspersus*	Hagfishes	*Myxinidae*
Cusk	*Brosme brosme*	Hake, offshore	*Merluccius albidus*
Cutlassfish, atlantic	*Trichiurus lepturus*	Hake, red	*Urophycis chuss*
Dolphin	*Na*	Hake, silver	*Merluccius bilinearis*
Dolphinfish	*Coryphaena hippurus*	Hake, spotted	*Urophycis regia*
Dolphinfish **	*Coryphaena spp.*	Hake, white	*Urophycis tenuis*
Dory, buckler	*Zenopsis conchifera*	Hakes, merlucciidae (family)	*Na*
Drum, black	*Pogonias cromis*	Hakes, merluccius (genus)	*Merluccius*
Drum, red	*Sciaenops ocellatus*	Hakes, red and white	*Urophycis*
Drums	*Sciaenidae*	Halibut, atlantic	*Hippoglossus hippoglossus*
Eel, american	*Anguilla rostrata*	Halibut, greenland	*Reinhardtius hippoglossoides*
Eel, conger	*Conger oceanicus*	Harvestfish, northern	*Peprilus paru*
Eels	*Anguilliformes*	Herring, atlantic	*Clupea harengus*
Escolar	*Lepidocybium flavobrunneum*	Herring, atlantic thread	*Opisthonema oglinum*
Fishes, bony	*Na*	Herring, blueback	*Alosa aestivalis*
Flatfishes	*Pleuronectiformes*	Herring, round	*Etrumeus teres*
Flounder, american plaice	*Hippoglossoides platessoides*	Herrings	*Clupeidae*
Flounder, fourspot	*Paralichthys oblongus*	Herrings, river	*Alosa spp.*
Flounder, gulf stream	*Citharichthys arctifrons*	Hogchoker	*Trinectes maculatus*
Flounder, southern	*Paralichthys lethostigma*	Hogfish	*Lachnolaimus maximus*

Common Name	Scientific Name	Common Name	Scientific Name
Jack, bar	*Carangoides ruber*	Perch, sand	*Diplectrum formosum*
Jack, crevalle	*Caranx hippos*	Perch, white	*Morone americana*
Killifishes	*Cyprinodontidae*	Perch, yellow	*Perca flavescens*
Kingfish, northern	*Menticirrhus saxatilis*	Periwinkles, atlantic	*Littorinidae*
Kingfishes	*Menticirrhus*	Permit	*Trachinotus falcatus*
Ladyfish	*Elops saurus*	Pollock	*Pollachius virens*
Lance, american sand	*Ammodytes americanus*	Polychaete, bloodworms	*Glycera dibranchiata*
Little/winter skate mix	*Leucoraja*	Polychaete, sandworms	*Nereis*
Lizardfish, inshore	*Synodus foetens*	Polychaete, sea mouse	*Aphrodita hastata*
Lobster, american	*Homarus americanus*	Pomfrets	*Bramidae*
Lookdown	*Selene vomer*	Pompano, florida	*Trachinotus carolinus*
Mackerel, atlantic	*Scomber scombrus*	Porgies	*Sparidae*
Mackerel, atlantic chub	*Scomber colias*	Porgy, red	*Pagrus pagrus*
Mackerel, bullet	*Auxis rochei*	Pout, ocean	*Zoarces*
Mackerel, chub	*Scomber japonicus*	Propellerclam, northern	*Na*
Mackerel, frigate	*Auxis thazard*	Puffer, northern	*Sphoeroides maculatus*
Mackerel, king	*Scomberomorus cavalla*	Puffers, tetraodontidae (family)	*Tetraodontidae*
Mackerel, spanish	*Scomberomorus maculatus*	Raven, sea	*Hemitripterus americanus*
Marlin, blue	*Makaira nigricans*	Ray, cownose	*Rhinoptera bonasus*
Menhaden, atlantic	*Brevoortia tyrannus*	Redfish, acadian	*Sebastes fasciatus*
Menhadens	*Brevoortia*	Ribbonfishes	*Trachipteridae*
Minnows	*Cyprinidae*	Rosefish, blackbelly	*Helicolenus dactylopterus*
Mollusks	*Mollusca*	Rudderfish, banded	*Seriola zonata*
Mullet, striped	*Mugil cephalus*	Runner, blue	*Caranx crysos*
Mullets	*Mugilidae*	Salmon, atlantic	*Salmo salar*
Mummichog	*Fundulus heteroclitus*	Scad, bigeye	*Selar crumenophthalmus*
Mussel, sea	*Mytilus edulis*	Scad, rough	*Trachurus lathami*
Needlefish, atlantic	*Strongylura marina*	Scad, round	*Decapterus punctatus*
Octopuses	*Octopodidae*	Scallop, bay	*Argopecten irradians*
Opah	*Lampris guttatus*	Scallop, iceland	*Chlamys islandica*
Oyster, eastern	*Crassostrea virginica*	Scallop, sea	*Placopecten magellanicus*
Oyster, edible	*Ostrea edulis*	Scallops	*Pectinidae*

Common Name	Scientific Name	Common Name	Scientific Name
Sculpins	*Cottidae*	Shark, porbeagle	*Lamna nasus*
Scup	*Stenotomus chrysops*	Shark, sand tiger	*Carcharias taurus*
Searobin, armored	*Peristedion miniatum*	Shark, sandbar	*Carcharhinus plumbeus*
Searobin, northern	*Prionotus carolinus*	Shark, sharpnose, atlantic	*Rhizoprionodon terraenovae*
Searobin, striped	*Prionotus evolans*	Shark, thresher	*Alopias vulpinus*
Searobins	*Triglidae*	Shark, tiger	*Galeocerdo cuvier*
Seatrout, spotted	*Cynoscion nebulosus*	Shark, whitetip, oceanic	*Carcharhinus longimanus*
Seatrouts	*Cynoscion*	Sharks	*Squaliformes*
Seaweed	*Phaeophyta*	Sharks, chondrichthyes (class)	*Chondrichthyes*
Seaweed, bladder wrack	*Fucus vesiculosus*	Sharks, dogfish	*Squalidae*
Seaweed, dulse	*Palmaria palmata*	Sharks, mako	*Isurus*
Seaweed, kelp	*Laminaria*	Sheepshead	*Archosargus probatocephalus*
Seaweed, kelp, fingered	*Laminaria digitata*	Shiner, golden	*Notemigonus*
Seaweed, kelp, sugar	*Laminaria saccharina*	Shrimp, northern	*Pandalus borealis*
Seaweed, kelp, winged	*Alaria esculenta*	Shrimp, northern brown	*Farfantepenaeus aztecus*
Seaweed, rockweed	*Ascophyllum nodosum*	Shrimp, royal red	*Pleoticus robustus*
Seaweed, rockweeds	*Fucaceae*	Shrimps	*Caridea*
Seaweed, wormweed	*Ascophyllum nodosum scorpioides*	Shrimps, mantis	*Stomatopoda*
Shad, american	*Alosa sapidissima*	Shrimps, penaeid	*Penaeidae*
Shad, gizzard	*Dorosoma cepedianum*	Shrimps, penaeoid	*Penaeoidea*
Shad, hickory	*Alosa mediocris*	Silverside, atlantic	*Menidia menidia*
Shark, blacktip	*Carcharhinus limbatus*	Silversides, atherinidae (family)	*Atherinidae*
Shark, blue	*Prionace glauca*	Skate, barndoor	*Dipturus laevis*
Shark, bull	*Carcharhinus leucas*	Skate, clearnose	*Raja eglanteria*
Shark, dogfish, black	*Centroscyllium*	Skate, little	*Leucoraja erinacea*
Shark, dogfish, chain	*Scyliorhinus retifer*	Skate, rosette	*Leucoraja garmani*
Shark, dogfish, smooth	*Mustelus canis*	Skate, smooth	*Malacoraja senta*
Shark, dogfish, spiny	*Squalus acanthias*	Skate, thorny	*Amblyraja radiata*
Shark, dusky	*Carcharhinus obscurus*	Skate, winter	*Leucoraja ocellata*
Shark, mako, longfin	*Isurus paucus*	Skates, rajidae (family)	*Rajidae*
Shark, mako, shortfin	*Isurus oxyrinchus*	Smelt, rainbow	*Osmerus mordax*
Shark, night	*Carcharhinus signatus*	Smelts	*Osmeridae*

Common Name	Scientific Name	Common Name	Scientific Name
Snail, slipper limpet	*Crepidula fornicata*	Tunas	*Thunnus*
Snails, moon	*Naticidae*	Unidentified species	*Na*
Snapper, dog	*Lutjanus jocu*	Urchin, green sea, (s. Droebachiensis)	*Strongylocentrotus droebachiensis*
Snapper, red	*Lutjanus campechanus*	Urchins, sea, strongylocentrotus (genus)	*Strongylocentrotus*
Snappers, lutjanidae (family)	*Lutjanidae*	Vertebrates, jawed	*Gnathostomata*
Spadefish	*Ephippidae*	Wahoo	*Acanthocybium solandri*
Spot	*Leiostomus xanthurus*	Weakfish	*Cynoscion regalis*
Squid, longfin loligo	*Loligo pealeii*	Wenchman	*Pristipomoides aquilonaris*
Squid, shortfin illex	*Illex illecebrosus*	Whelk, channeled	*Busycotypus canaliculatus*
Stargazer, northern	*Astroscopus guttatus*	Whelk, knobbed	*Busycon carica*
Stars, other sea	*Asteroidea*	Whelk, lightning	*Busycon sinistrum*
Stickleback, ninespine	*Pungitius pungitius*	Whelk, waved	*Buccinum undatum*
Stingray, atlantic	*Dasyatis sabina*	Windowpane	*Scophthalmus aquosus*
Stingrays, dasyatidae (family)	*Dasyatidae*	Withheld for confidentiality	*Other*
Swordfish	*Xiphias gladius*	Wolffish, atlantic	*Anarhichas lupus*
Tautog	*Tautoga onitis*	Wolffish, northern	*Anarhichas*
Tilefish, blueline	*Caulolatilus microps*	Wolffish, spotted	*Anarhichas minor*
Tilefish, golden	*Lopholatilus chamaeleonticeps*	Wreckfish	*Polyprion americanus*
Tilefish, sand	*Malacanthus plumieri*		
Toadfishes, batrachoididae (family)	*Batrachoididae*		
Torpedo, atlantic	*Torpedo nobiliana*		
Triggerfish, gray	*Balistes capriscus*		
Triggerfishes	*Balistidae*		
Tripletail	*Lobotes surinamensis*		
Trout, rainbow	*Oncorhynchus mykiss*		
Tuna, albacore	*Thunnus alalunga*		
Tuna, bigeye	*Thunnus obesus*		
Tuna, blackfin	*Thunnus atlanticus*		
Tuna, bluefin	*Thunnus thynnus*		
Tuna, little tunny	*Euthynnus alletteratus*		
Tuna, skipjack	*Katsuwonus pelamis*		
Tuna, yellowfin	*Thunnus albacares*		

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