US Food System, 1995 (millions of pounds)

1.67 trillion lbs = 0.8 billion tons

Crop production 921,590
- Stored grains & soybeans 153,000
- Fruit 64,450
- Sugar beets 56,130
- Soybeans 30,460
- Grains 611,340

Animal products 239,470
- Red meat 43,680
- Poultry 30,742
- Eggs 9,760
- Milk & milkfat 155,290

Feed to livestock & poultry 964,000
- Feed grains to animals 307,800
- Concentrated feeds 436,000
- Harvested roughage 158,000
- Pasture 370,000

Exports* 355,560
- Stored grains & soybeans 68,080
- Processing & water losses (36,770) by difference

Imports* 41,390
- Dry beans, lentils, nuts 4,120
- Grain products 45,600
- Fruit (46% fresh) 48,340
- Vegetables (59% fresh) 63,080
- Caloric sweeteners 33,830
- Fats & oils 20,250
- Meat & poultry 51,470
- Dairy products 76,280

Edible food supply 355,880
- Consumed 259,610
- Losses 96,270
- Retail losses 5450
- Foodservice & consumer losses 47,180

Feed grain imports 13,870
- Other byproduct feeds 19,900

Processed foods
- Wheat & flour 73,020
- Oil seeds (inc. soy) 52,020
- Feeds & fodders 29,400
- Protein meal 24,120
- Fruits, nuts & preparations 8340
- Vegetables & preparations 6910
- Rice 7220
- Other 16,630

*Exports
- Feed grains 147,260
- Wheat & flour 73,020
- Oil seeds (inc. soy) 52,020
- Feeds & fodders 29,400
- Protein meal 24,120
- Fruits, nuts & preparations 8340
- Vegetables & preparations 6910
- Rice 7220
- Other 16,630

*Imports
- Bananas & plantains 8530
- Fruits, nuts & preparations 5860
- Sugar & related 4370
- Veg. oils 3440
- Other 11,360

Figure from University of Michigan Center for Sustainable Systems (css.snre.umich.edu)
MyPyramid (2005)
My Plate (2011)

Choose MyPlate.gov
MyPlate vs. Actual US Diet

- USDA recommends
  - Twice as much fruit and dairy as typical
  - 50% more vegetables
  - One-quarter to one-third of oil, fat, sugar
  - 20% fewer calories

Meet or exceed USDA’s daily recommendation (%)

Kids, 2-17
- Grains: 72%
- Meat/Fish/Nuts/Eggs: 32%
- Vegetables: 8%
- Fruit: 11%
- Dairy: 25%

Adults, 18+
- Grains: 59%
- Meat/Fish/Nuts/Eggs: 35%
- Vegetables: 6%
- Fruit: 6%
- Dairy: 6%

NPD Group, 2011
Vegetables

• Botanical definition
  – Edible leaf, stem, or root of a plant (vegetative structure)
  – Not seed or seed-bearing structure (grains, nuts, fruits, berries)

• Culinary, cultural, or common definition
  – Any savory, edible plant part
  – Eaten fresh, frozen or canned, not dried
Vegetables

• Major dietary source of
  – Minerals (essential elements for life)
  – Vitamins
  – Fiber
  – Phytochemicals

• Some are major energy (calorie) source; most are not
Minerals

- Essential elements for life

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<th>Elements</th>
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The four organic basic elements: C, H, O, N.

Quantity elements: Mg, Ca, Fe.

Essential trace elements: Zn, Cu, Mn, Co.
Vitamins

• Essential organic compounds, not synthesized sufficiently by organism

• Vitamins A, B1, B2, B3, B5, B6, B7, B9, B12, C, D, E, K

Chemical structure of vitamin B12
<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Name</th>
<th>Deficiency</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>Retinol, retinal</td>
<td>Night-blindness, Hyperkeratosis, and Keratomalacia</td>
<td>Orange, ripe yellow fruits, leafy vegetables, carrots, pumpkin, squash, spinach, liver</td>
</tr>
<tr>
<td>Vitamin B1</td>
<td>Thiamine</td>
<td>Beriberi, Wernicke-Korsakoff syndrome</td>
<td>Pork, oatmeal, brown rice, vegetables, potatoes, liver, eggs</td>
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<tr>
<td>Vitamin B2</td>
<td>Riboflavin</td>
<td>Ariboflavinosis</td>
<td>Dairy products, bananas, popcorn, green beans, asparagus</td>
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<tr>
<td>Vitamin B3</td>
<td>Niacin, niacinamide</td>
<td>Pellagra</td>
<td>Meat, fish, eggs, many vegetables, mushrooms, tree nuts</td>
</tr>
<tr>
<td>Vitamin B5</td>
<td>Pantothenic acid</td>
<td>Paresthesia</td>
<td>Meat, broccoli, avocados</td>
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<tr>
<td>Vitamin B6</td>
<td>Pyridoxine</td>
<td>Anemia, peripheral neuropathy.</td>
<td>Meat, vegetables, tree nuts, bananas</td>
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<tr>
<td>Vitamin B7</td>
<td>Biotin</td>
<td>Dermatitis, enteritis</td>
<td>Raw egg yolk, liver, peanuts, certain vegetables</td>
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<tr>
<td>Vitamin B9</td>
<td>Folic acid</td>
<td>Megaloblast and Deficiency during pregnancy is associated with birth defects, such as neural tube defects</td>
<td>Leafy vegetables, pasta, bread, cereal, liver</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>Cyanocobalamin</td>
<td>Megaloblastic anemia,</td>
<td>Meat and other animal products</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Ascorbic acid</td>
<td>Scurvy</td>
<td>Many fruits and vegetables, liver</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Cholecalciferol</td>
<td>Rickets and Osteomalacia</td>
<td>Fish, eggs, liver, mushrooms</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Tocopherols</td>
<td>Deficiency is very rare; mild hemolytic anemia in newborn infants.[30]</td>
<td>Many fruits and vegetables</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Phylloquinone, menaquinones</td>
<td>Bleeding diathesis</td>
<td>Leafy green vegetables such as spinach, egg yolks, liver</td>
</tr>
</tbody>
</table>
Fiber

• Indigestible portion of plant-based food
  – Reduces appetite and risk of colorectal cancer

• Soluble
  – Readily fermented in colon to make gasses and physiologically active products
  – Reduces variation in blood sugar levels and risk of heart disease

• Insoluble
  – Add bulk, absorb water, promote regularity
  – Reduces blood sugar levels and lowers risk of diabetes
Photochemicals

- Biologically significant (but not essential) chemicals produced by plants
  - Antioxidants
  - Anti-inflamatories
  - Anti-carcinogens
  - Hormones
  - Immune system boosters
  - Psychoactive compounds

- Some help prevent or cure disease

Bright colors are often associated with antioxidant content
US Vegetable Use, 1980-2009

Farm weight (annual lbs per person)

- Total
- Processed
- Fresh

US Census Bureau, 2012
Vegetable Production Scales

• Garden
  – Containers on porch
  – Small and large backyard gardens
  – Community gardens
  – Market gardens

• Small, medium, and large farms
  – An acre or two up to hundreds of acres
  – Vegetable farms usually smaller than grain farms or ranches (500 acres is huge for veg.)

• Greenhouses
Home and Community Gardens

• Food (mostly vegetables)
  – Potential savings
• Exercise
• Education
• Recreation
• Community-building
• Resource cycling
Commercial Vegetable Production

US Census, 2010
Presidential Election, 2012
Major Vegetable Growing Areas

• Mild climate
  – Ocean moderates temperature

• Near urban centers
  – Perishable product
  – Mostly water

• Available labor
  – Often migrant labor
Vegetable Farms: Managed Ecosystems

• Open Fields
  – Vast majority of vegetable acreage
  – Often irrigated
  – Lowest yield

• High Tunnels
  – Simple, cheap
  – Soil-based
  – Passive solar heat
  – Passive ventilation
  – Higher yield

• Greenhouses
  – Complex, expensive
  – Often hydroponic
  – Furnace for heat
  – Often use supplemental light
  – Computer-controlled
  – Highest yield
Maddocks’ Farm

- Iceberg & Romaine
- Transplanted at 9 plants / m²
- 6-12 weeks, transplant to harvest
- 2 crops per summer
- Soil-based system
- Overhead irrigation
- Heavy fertilizer & insecticide use
Western Lettuce

- Bibb lettuce
- 12-18 plants / m²
- 12 weeks, seed to harvest
- 8 crops / year
- Hydroponic, tabletop
- Biocontrol for insects
- Steel frame
- Single pane of glass
- Natural gas boiler heat
Au Naturel Farm

- Mixed varieties
- 9 plants / m²
- 10 weeks, seed to harvest
- 3 crops per winter
- Soil-based system
- Organic practices
- Steel, wood frame
- Double layer plastic
- Solar heat only
Three Commercial Lettuce Farms, to Scale

Maddocks’ Farm
Cloverdale, BC
400 acres

Western Lettuce
Milner, BC
14 acres under glass

Au Naturel Farm
High Tunnels
Smiths Grove, KY
¼ acre under plastic
Greenhouse: 2129 MJ/m²/yr

High tunnel: 95 MJ/m²/yr

- Natural gas: 1750
- Electricity: 341
- Plastic: 23
- Steel: 56
- Aluminum: 7.6
- Wood: 23
- Glass: 56
- Concrete: 1750
Yield /100 m$^2$

Embodied energy (MJ/plant)

Energy extracted from a large head of lettuce by human digestion: 0.3 MJ (76 cal)
Production Types

• Conventional
  – Most production
  – May include synthetic fertilizers and pesticides, GMOs

• Organic
  – “Ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity.”
  – Requires certification, record keeping
  – Prohibits most synthetic fertilizers, pesticides, GMOs
  – Higher prices, growing demand

• Sustainable
  – May include elements of organic and conventional
  – Financial, social and environmental dimensions
  – Guiding principle: Not regulated or clearly defined
US Organic Sales

$ Billion

- 1991: $2 billion
- 1994: $3 billion
- 1997: $4 billion
- 2000: $5 billion
- 2003: $6 billion
- 2006: $7 billion
- 2009: $23 billion
- 2012: $34 billion
ORGANIC.
CONSUMER DRIVEN. FARMER POWERED.

ORGANIC FOOD AND FARMING FUELS JOBS, RURAL ECONOMIES, AND CONSUMER CHOICE.

78% OF U.S. FAMILIES ARE BUYING ORGANIC

94% OF ORGANIC OPERATIONS NATIONWIDE ARE PLANNING TO MAINTAIN OR INCREASE EMPLOYMENT IN 2012

40% OF THE ORGANIC MARKET IS FRUITS AND VEGETABLES

MORE THAN HALF OF PARENTS HAVE A HIGH LEVEL OF TRUST FOR ORGANIC PRODUCTS

THE ORGANIC INDUSTRY GENERATES OVER $31 BILLION PER YEAR

17,600 CERTIFIED ORGANIC FARMS, RANCHES AND BUSINESSES NATIONWIDE

4.6 MILLION ACRES OF ORGANIC FARMLAND ACROSS THE U.S.

ORGANIC FARMS ARE 35% MORE PROFITABLE THAN THE AVERAGE FARM

ORGANIC IS NOT JUST FOOD. OVER $2 BILLION WORTH OF ORGANIC FIBER, COSMETIC, AND HOUSEHOLD PRODUCTS WERE SOLD LAST YEAR

OREGON IS THE NATIONAL AVERAGE

THE ORGANIC INDUSTRY IS CREATING JOBS AT 4 TIMES THE NATIONAL AVERAGE

IN 2011, THE ORGANIC INDUSTRY, GREW BY OVER 9% OF ALL DAIRY PRODUCTS SOLD TO U.S. CONSUMERS ARE ORGANIC

ORGANIC IS AN IMPORTANT PART OF THE DIVERSE U.S. AGRICULTURAL LANDSCAPE. THE ORGANIC TRADE ASSOCIATION REPRESENTS OVER 6,500 FARMERS, RANCHERS, HANDLERS, PROCESSORS, DISTRIBUTORS, AND RETAILERS ACROSS THE ORGANIC SUPPLY CHAIN.

LEARN MORE AT WWW.OTA.COM
Vegetable Markets

• Fresh
  – Often sorted, trimmed, washed, cooled, packaged
  – Farmers’ markets, CSAs, restaurants, food services, wholesalers

• Processed
  – Processors are often large plants, owned by multinationals
  – Growers contract with processor before harvest (low price, guaranteed sales)
  – Canned, frozen, pre-cooked, dehydrated
  – Prepared soups, sauces, frozen meals
  – Potato chips, French fries…
Site Selection

• Climate
  – Warm season crops need long hot summer (e.g. sweetpotato, sweet corn)
  – Cool season crops do not tolerate heat (e.g. lettuce, spinach, carrot, potato)

• Resource availability
  – Cost of land
  – Soil quality
  – Water
  – Proximity to labor pool, processors, markets
Site Preparation

• Drainage?

• Weed/pest management
  – Cultivation
  – Fumigation
    • Toxic gas injected into soil under plastic to kill weeds, nematodes, insects, pathogens
  – Solarization
    • Clear plastic placed over wet soil in heat of summer to heat soil and kill weeds, nematodes, insects, pathogens
METHYL BROMIDE TRENDS

Reported production and consumption*
Thousand ODP tonnes

* Consumption: 170 reporting countries; production: 6 (on average).

Planting

- **Direct seeding**
  - Treated or untreated seed
  - Resistant varieties

- **Transplanting**
  - Transplants, slips must be purchased or grown on-farm
  - Head start, but more expensive
  - Works with mulch
Management

• Vegetables often more labor intensive than other crops
  – Irrigation
  – Fertilization
  – Pruning
  – Scouting
  – Weed management
  – Pest management
Harvest

- Timing important
  - Ripe, but not over-ripe
  - Refractometer useful to measure sugar content
- Hand harvest
  - Labor intensive
- Mechanical harvest
  - Specialized machinery (often expensive)
Post Harvest

• Rapid removal of field heat extends shelf life
  – Early morning harvest
  – Vacuum cooling
  – Into cooler quickly

• Sorting, trimming & washing on site adds value
Brar Bros. Farms

The Roots Organic Farm

Our farm has a long history of farming in the South Surrey, B.C. area. Before specialization in herbs, baby vegetables, and edible flowers, our farm used to produce the more traditional crops of onions, carrots, head lettuce, romaine, and green leaf lettuces. However, with the dramatic drop in demand for these staples, a new direction was sought.

Beginning in 1996, we introduced small scale herb production into our greenhouses at Evergreen House Ltd. Through aggressive marketing including food shows, convention activity, across Canada, frequent seminars and personalized service, we expanded business over the next three years. Today, we are one of the largest distributors in Canada.

Roots Organic Inc.
3518 148th Street, Surrey
BC, Canada, V3W 0L9
Tel: 604-576-5667
Fax: 604-576-5668

Naturally Yours.
The less obvious skills...

• Record keeping
  – Often computer-based
  – Required for organic certification and many other gov’t. programs
  – Best farmers are good record keepers

• Maintenance
  – Mechanical skills needed
  – Best farmers are comfortable with their tools

• Continuing education
  – Keep abreast of changing markets, tools, consumer demand
  – Best farmers are always learning
Vegetable Crops: Fruits and Seeds

- Bean, Pea
- Eggplant
- Cucumber
- Okra
- Pepper
- Squash
- Sweet Corn
- Tomato
- Watermelon

- All but pea are frost sensitive, warm-season crops. Staples of ‘southern’ diet.
- Tomato, pepper, & cucumber commonly grown in greenhouses. Excessive heat inhibits fruit set.
- Three sisters – corn, beans & squash – were foundation of many native American farming systems.
Vegetable Crops: Flowers, Leaves, Stems

- Artichoke
- Asparagus
- Cole crops
  - Broccoli
  - Brussels sprouts
  - Cabbage
  - Cauliflower
  - Collards/Kale
- Celery
- Chive
- Endive
- Leek
- Lettuce
- Parsley
- Rhubarb
- Spinach
- Swiss Chard

- Mostly frost tolerant, cool-season crops.
- Excessive heat causes bolting, bitter flavor.
- Common ‘winter vegetables.’
- Lettuce is major crop, often grown in greenhouses.
Vegetable Crops: Roots, Bulbs, Tubers

- Beet
- Carrot
- Horseradish
- Onion
- Parsnip
- Potato

- Radish
- Rutabaga
- Salsify
- Sweet potato
- Turnip

- All but sweet potato are cool-season crops.
- Sweet potato associated with southern diet. (Often incorrectly called ‘yam.’)
- Store well, so often consumed in winter. Ship easily.
- Potato, carrot, and onion among biggest vegetable crops.
Biggest Vegetable States & Crops, 2012
(Total Sales = $11 Billion)

Biggest Vegetable Producing States
- California
- Florida
- Arizona
- Georgia
- New York
- Other

Most Valuable Vegetable Crops
- Lettuce
- Tomato
- Onion
- Sweet corn
- Broccoli
- Carrot
- Other

USDA-NASS, 2012