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A Brief History of Agriculture and Food Production: The Rise of “Industrial Agriculture”

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Scope of This Section

- Build upon Dr. Wolman's presentation
- Provide historical context
- Set the stage for course topics to follow



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Section A

A Brief History of Agriculture

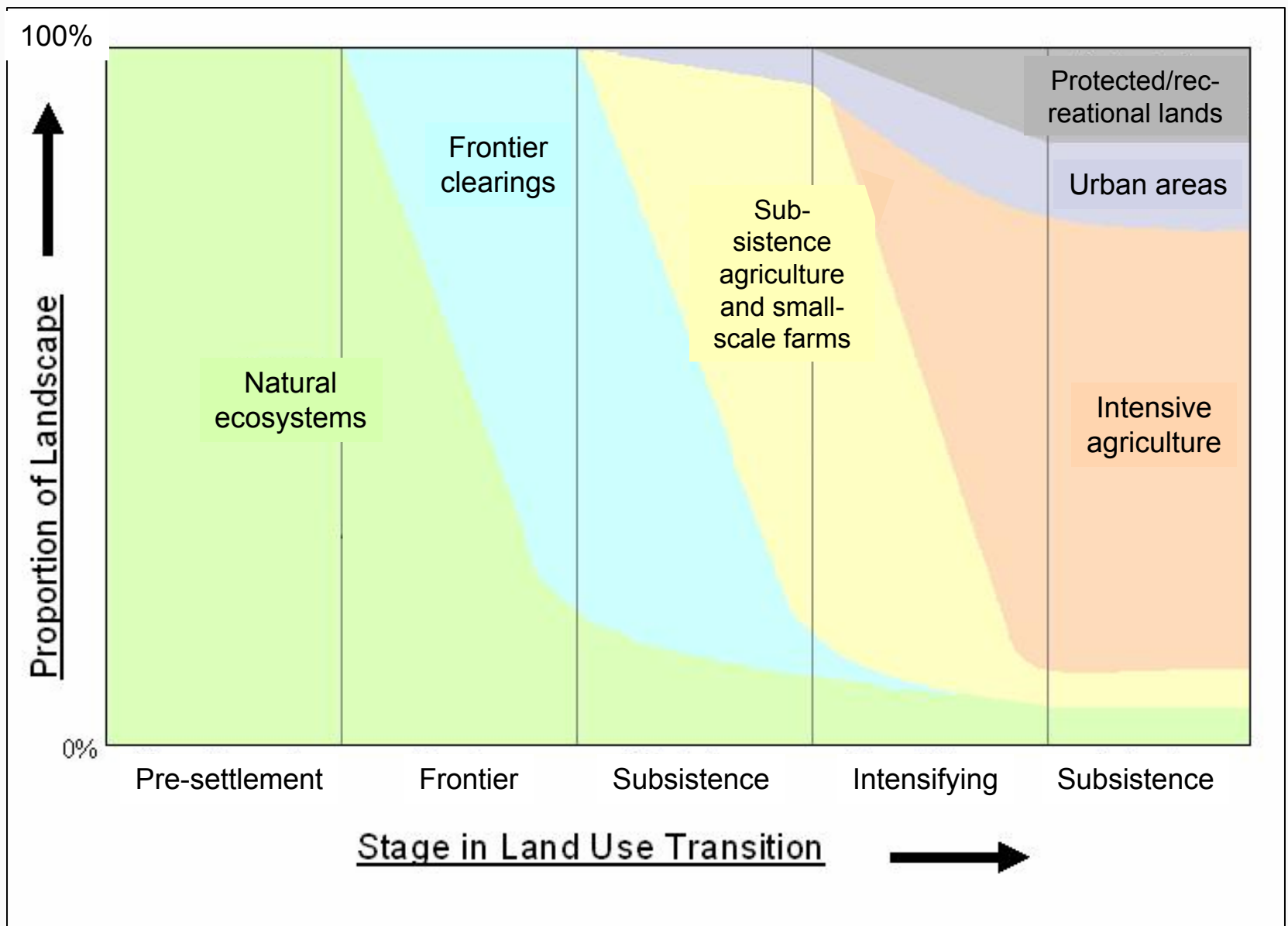
Connected to Agriculture?

- “If you eat, you are involved in agriculture.”
 - League of Women Voters
- “How we eat determines to a considerable extent how the world is used.”
 - Wendell Berry
- “The whole problem of health in soil, plant, animal and man is one great subject.”
 - Sir Albert Howard

Defining Agriculture

- The process of producing food, feed, fiber, and other desired products by cultivation of certain plants and the raising of domesticated animals (livestock)
- Food, land, people
- History and cultures
- Commodities and crops; consumer choice; politics; waste management; land use; climate change, policy; international development; ethics; population growth; rural families and communities; science; public health; and distance education...

Land Use Transitions



Adapted from: Foley et al. (July 22, 2005). *Science*, volume 309.

Origins of Agriculture

- Until 8,000 BC, nomadic hunter-gatherers
- Then people began to grow food, domesticate animals, live in settlements
- Why did humans move to agriculture?
 - Population pressures?



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The Fertile Crescent



Population Growth and Agriculture

- The art of tillage, plant selection, harvesting, and processing
- Populations thrived
- Agricultural production kept pace with the logarithmic rate of human population growth
- By 1500 BC, 500 million people on earth



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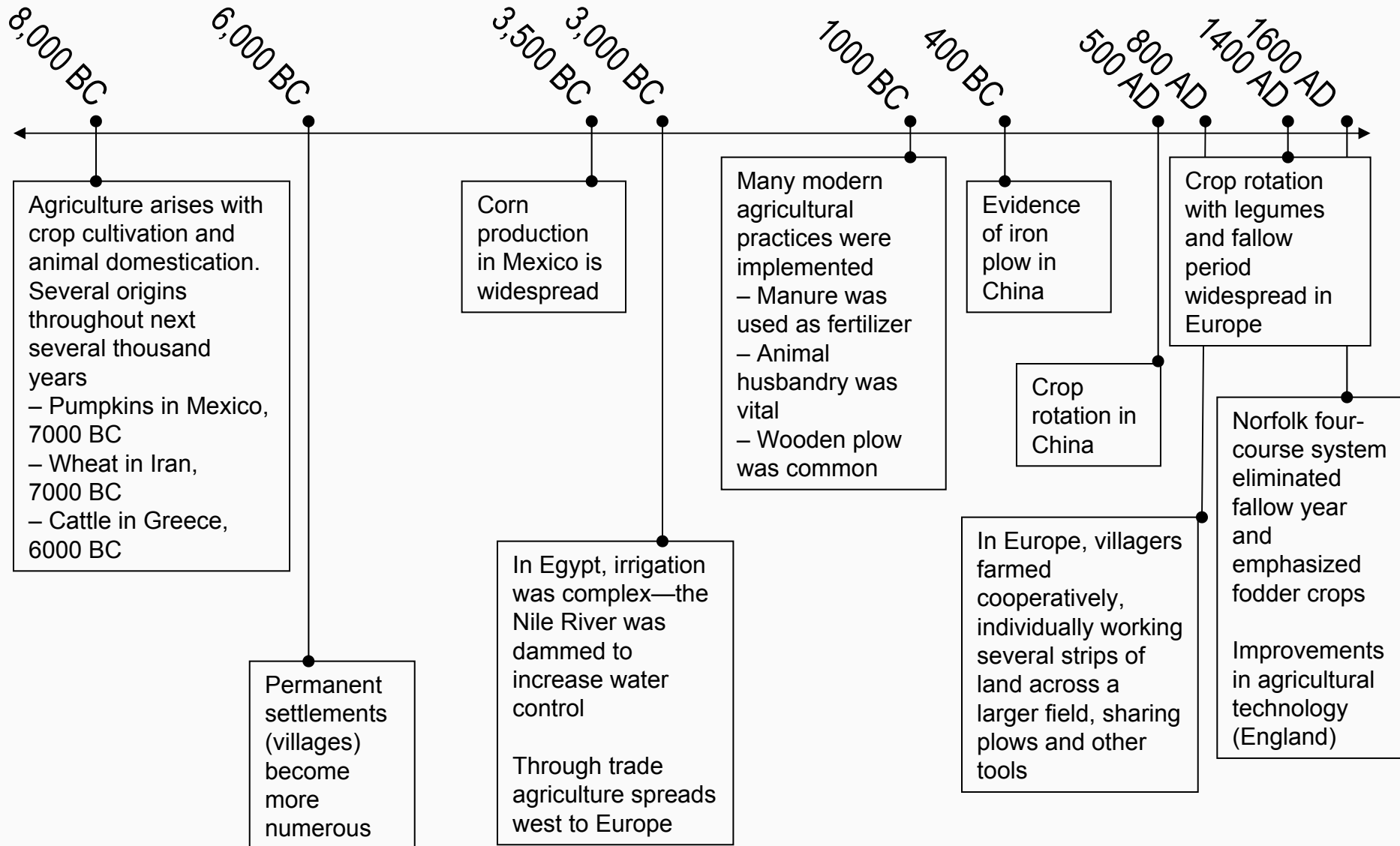
Land Availability and Population

- As populations increased, people extended agriculture to more land, new areas
- For centuries, amount of arable land adequate to support growing populations
- Environmental impact scarcely apparent because natural resources were so abundant
- Cycles of increase and reduction of populations common
- Natural phenomenon changed fortunes



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Agricultural Timeline (8,000 BC to AD 1600)



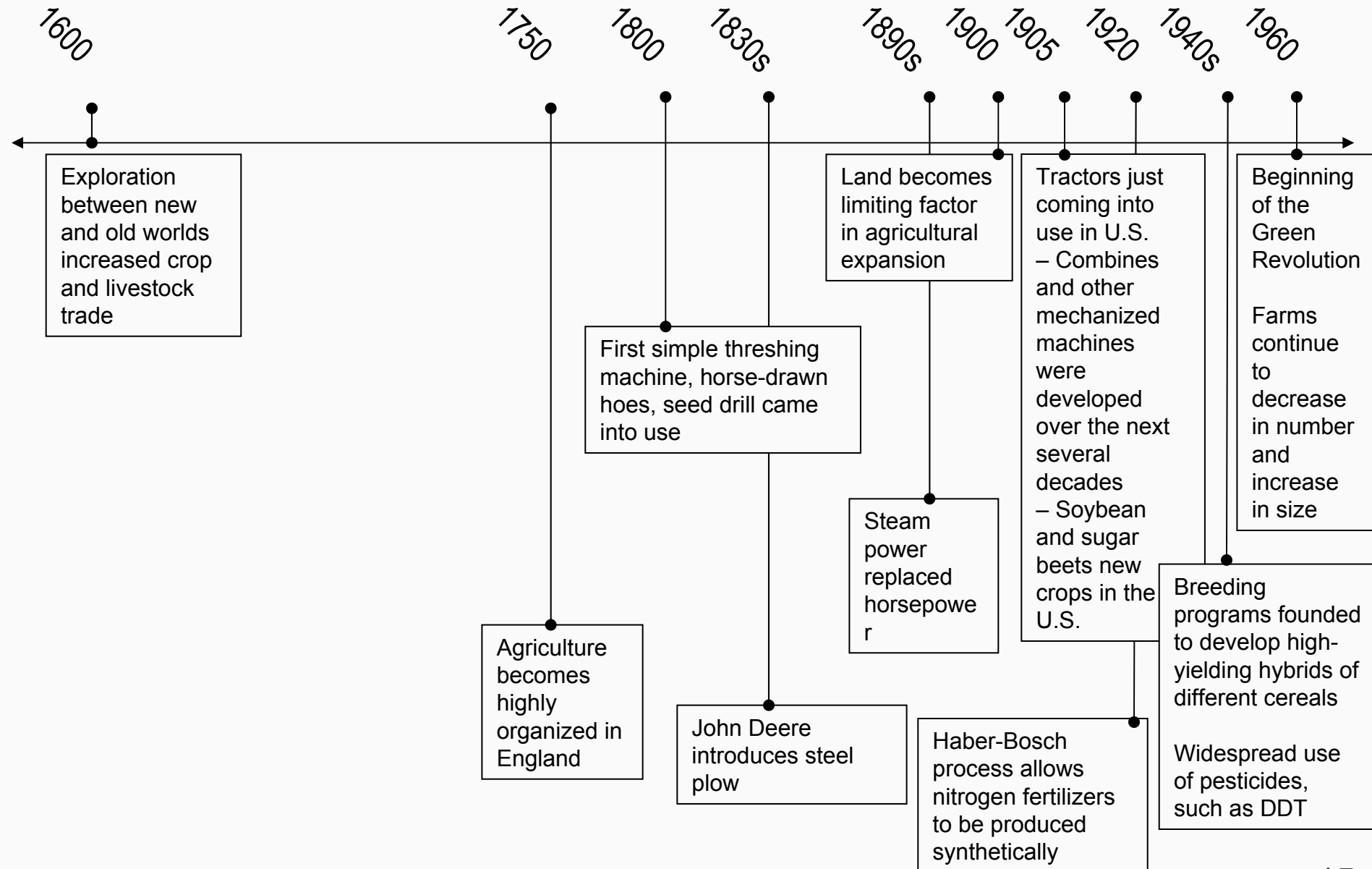
The 11th Century

- Draft horse and plow came into use, greatly increasing farmers' ability to cultivate larger fields
- Farmers learned how to maintain soil fertility, but cereal yields reached a plateau
- Increased concentration and larger amounts of land under cultivation
 - Food surpluses enabled peasants to more easily move to cities



Fig. 18.—Ploughmen.—Fac-simile of a Miniature in a very ancient Anglo-Saxon Manuscript published by Shaw, with legend "God Spede ye Plough, and send us Korne enow."

Agricultural Timeline (1600 to 1960)



The 1700s

- An important period
- 1750s—agriculture in England became highly organized
- Late 1700s—European societies saw stagnant/falling yields; high prices and widespread concern about food availability
- 1798—Thomas Malthus published his series of essays (still controversial)
 - Population increases exponentially, food supplies increase arithmetically = famine



The 1800s

- Period of profound change
- 1825—world population reaches one billion people
- Crop yields sufficient to provide exports
- Mechanized farm equipment, expansion of farm size, and the decline in the number of farms
- Agricultural science gained prominence; enough food to “feed the world”
(Evans, 1998)
- 1850–1900—population of industrialized nations grows from 500 to 800 million
- Per capita calorie consumption increased, consumption of animal proteins increased, and cereal consumption decreased



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The 1900s

- 1927—world population reached 2 billion
- Land available for cropping became a limiting factor
- Increased crop yields prioritized
- Nitrogen fertilizers
- First use of pesticides in the early 1900s
- Traction power contributed to the expansion of farm size and decline in farm numbers



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“Industrial” Agriculture

- 1960—world population reached 3 billion
- Industrial methods in agriculture well established in U.S. and other Western nations
- Chemical inputs for agriculture greatly increased
- Mechanized methods of farming and food production became the norm
- Animal agriculture industry begins raising large numbers of animals confined in crowded indoor facilities
- Dramatic increases in yields—with significant hidden costs



The Green Revolution

- Planned international effort to eliminate hunger by improving crop performance
 - Increase yields—new crops, irrigation, fertilizers, pesticides, mechanization
 - Increasing technological knowledge
 - Supplying materials to farmers
- Norman Borlaug considered the father of the Green Revolution
 - Won the Nobel Peace Prize in 1970



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Was the Green Revolution a Success?

- Increased food production more than 1000% in some places
- Didn't work the same in all settings
- Helped keep hunger at bay, but did not eliminate famine
- Led to increased costs of production and negative environmental impacts
- Technology approach does not guarantee a secure food supply and is often not ecologically sustainable
- Did not address people's lack of resources—or distribution of economic power, purchasing power, etc.



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Section B

The Rise of Industrial Agriculture

Scope of This Section

- Build upon *A Brief History of Agriculture*
- Provide some insight into what we refer to as *industrial agriculture*
- Public health and ecological implications

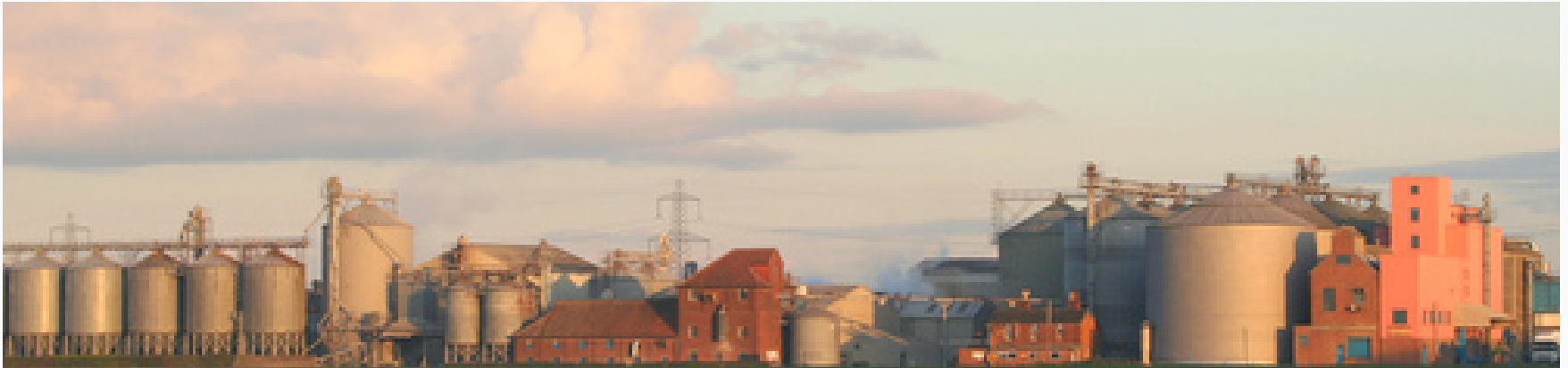


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What Is Industrial Agriculture?

■ UCS

- ...that industrial agriculture views the farm as a factory with "inputs" (such as pesticides, feed, fertilizer, and fuel) and "outputs" (corn, chickens, and so forth). The goal is to increase yield (such as bushels per acre) and decrease costs of production, usually by exploiting economies of scale.

■ Industrial agriculture

- Modern farming methods that depend on synthetic fertilizers and pesticides, large amounts of irrigation water, major transportation systems, factory-style practices for raising livestock, and machine technology.

▶ <http://www.ecohealth101.org/glossary.html>

Industrial Agriculture

- A new phenomenon
- *Heavily* dependent on synthetic inputs
- Concentration of production
- Vertical integration of producing and marketing food
- Spectacular increases in productivity



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- Industrial agriculture
 - Depends on expensive inputs from off the farm (e.g., pesticides and fertilizer), many of which generate wastes that harm the environment
 - Uses large quantities of nonrenewable fossil fuels
 - Tends toward concentration of production, vertical integration
 - Is associated with many environmental and public health concerns

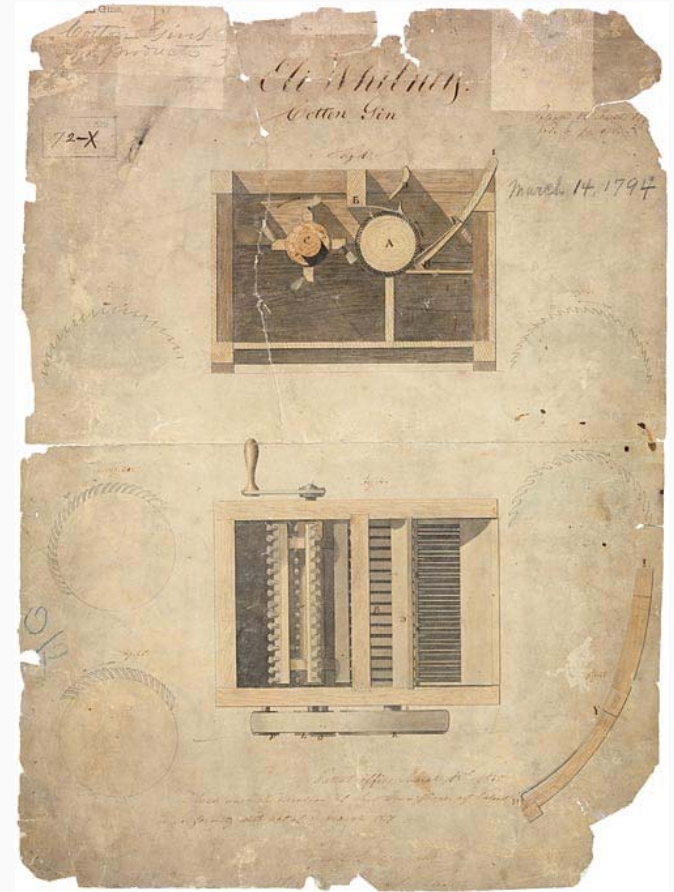
The Roots of Industrialization

- The industrial revolution changed the ways the world produced its goods
- Changed society from having an agriculture base to having one of industry and manufacturing
- 1850s—more than half the U.S. population were either farmers or lived in rural communities



Pursuing Potential Gains

- Late 1800s, U.S. pursued its potential to
 - “Free” people from farm labor
 - Free-up income
 - Enable people to buy the products
- America’s challenge: make agriculture more efficient
- “We bent nature to serve our needs. We achieved the economies of large-scale, specialized production as we applied the principles, strategies, and technologies of industrialization to farming.”
 - John Ikerd



Eli Whitney's cotton gin patent.
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Key Innovations

- Development of new energy sources
- Use of fossil energies and electricity to extract and synthesize fertilizers and pesticides
 - Synthetic fertilizers first used in the 1930s
 - Haber-Bosch process, nitrogen fertilizers had great impact
- Develop and diffuse new crop varieties

Key Innovations

- Innovations improved yields, replaced draft animals, reduced labor needs
- U.S. rural labor 60% of the total workforce in 1850, reduced to less than 40% in 1900, 15% in 1950, and 2% since 1975
 - Smil (U.S. Bureau of the Census)



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Benefits of Industrial Agriculture

- Increased yields—much more efficient production
- “Cheap” food
- Large, profitable agricultural industries have thrived
- Increased export markets



Image Source: USDA

Increased Yields

- Remarkable increases in productivity
 - For example, U.S. farmers produced 30 bushels of corn per acre in 1920
 - 1999 yields averaged about 134 bushels per acre (350% increase)
- Last 50 years—increase in agricultural production outpacing population growth; helped reduce hunger and improve diets
- High-yield varieties and fertilizers—foundation of the Green Revolution
 - Pakistan produced 8.4 million tons grain in 1970, up from 4.6 million in 1965
 - India produced 20 million tons in 1970, up from 12.3 million 1965
 - Credited with saving over 1 billion people from starvation

“Cheap” Food

- “Real” cost of food
- Affordability
- U.S. families and individuals currently spend 10 percent of their disposable income on food
 - USDA’s Economic Research Service (ERS)



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Agricultural Operations

- Large, corporate-controlled, industrialized operations dominate
- Large, commercial farms account for most farm sales
 - For example, Tyson, ConAgra, and Cargill
- Common model
 - Corporations control genetics, manufacture and distribution of seed, fertilizers, pesticides and machinery; manage through contracts; control the processing, distribution, and, increasingly, marketing and retail



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Export Markets

- Production levels which enable exports
- Major profits, contribute to GDP
 - Brazil agribusiness controls one-third GDP (Bussey)
 - Mexico imported 50% of its wheat in 1944, reached self-sufficiency by 1956 and, by 1964, exported a half-million tons (Grohol)



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Industrialization: Achieved

- U.S., perhaps the most efficient agriculture in the world
- 10 percent of disposable income for farm-produced food
- Farmers receive 1 cent out every dime
- Other 9 cents for marketing and input firms
- Industrial agriculture has achieved what it can for us
- Costs to the environment and public health



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Achievements, with Costs

- Short-sighted view of success
- Large, complex effects on our environment, health, economy, and society
- Reliance on inputs
- Unintended consequences—society and the environment bear the cost in the form of environmental and public health impacts (Keeney and Kemp, 2003)



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Externalities

- Not included in retail price or in analyses of productivity
- Externalities include
 - Depletion of resources—e.g., fossil fuel, water, soil and biodiversity
 - Pollution of resources by the products of fuel combustion, pesticides and fertilizers
 - Economic and social costs to communities—e.g., lost property values

Environmental Impacts

- Water consumed at unsustainable rates
- Synthetic chemical pesticides and fertilizers pollute soil, water, and air
- Soil is eroding much faster than it can be replenished
- Monocultures erode biodiversity among both plants and animals



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Water Use

- Approximately two-thirds of water use worldwide is devoted to irrigation
- Worldwide, aquifers being depleted for irrigation faster than they can be replenished (e.g., Ogallala Aquifer in the U.S. Midwest, the northern plain of China, etc.)
- The Stockholm International Water Institute 2004 Report

Use of Chemicals

- Heavy reliance on chemical fertilizers, pesticides and herbicides
- 137 million metric tons of chemical fertilizers used worldwide in 1998 (U.S. agriculture—20 million tons)
- Crops absorb only one-third to one-half of the nitrogen applied to farmland
 - Tilman



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Use of Chemicals

- Over 1,600 chemicals used in the manufacture of pesticide—most have not been tested
- Worldwide, **3 million tons** of pesticides per year
- Human health
 - Poisonings; long-term effects on the immune, reproductive, and nervous systems; increased cancer risk



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Soil and Agricultural Runoff

- Agricultural runoff pollutes ground and surface waters
- Nitrogen and phosphorous from fertilizers, pesticides, and agricultural waste
- EPA in congressional testimony
 - “...agriculture generates pollutants that degrade aquatic life or interfere with public use of 173,629 river miles (i.e., 25% of all river miles surveyed) and contributes to 70% of all water quality problems identified in rivers and streams.”
- Remote effects—nitrogen compounds from Midwestern agriculture impact coastal fisheries in the Gulf of Mexico

Biodiversity and Monoculture

- Agriculture accounts for 28–40% of all land use worldwide
 - Of this
 - ▶ 31% crop production
 - ▶ 69% managed pasture
- Biodiversity is inevitably affected by both the scope and methods of agriculture
- Monoculture—the growing of a single plant species in one area, usually the same type of plant year after year
 - Monoculture affects biodiversity among both plants and animals
 - Industrial agriculture is based on the maximum yield of a few types of crops grown in monocultures

Social Costs

- Deterioration of rural communities
- Larger agriculture has driven out small producers, impacts communities
- Fewer farm families to support local schools, churches, public institutions, and retail businesses, etc.
- Bypass local communities in purchasing production inputs/marketing products
- Quality of life issues, e.g., air quality and odors



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How Much Does It Cost?

- Difficult to say exactly
 - Several contributing factors
 - Potential harms?
- Leopold Center study by Tegtmeier and Duffy
 - Negative impacts may cost society between \$5.7 billion and \$16.9 billion each year
 - “. . . the partial estimate of damage costs promotes responsible, creative policy actions to acknowledge and internalize the externalities of production practices that are generally accepted and widespread.”
 - ▶ Tegtmeier and Duffy, 2005

How Much Does It Cost?

- Pimentel (2005) estimates environmental and health-care costs of pesticide use at recommended levels in the U.S. run about \$12 billion every year
- Reminder with regard to context
 - \$1.9 billion additional annual expenditure on water systems to provide potable water for everyone
 - About \$9 billion additional annual expenditure to provide sanitation worldwide (UNDP)

Closing

- Cheap food?
- Low prices provide a false sense of what the real costs are
- Moving toward a more sustainable form of agriculture



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