

## C. Agriculture and Land Use

Agriculture is directly tied to the land. The type of agriculture a society is able to develop correlates with the way a society utilizes its land. The following section examines the forces and processes that are used by governments and societies to determine rural land use.



Bid Rent Theory. The way a piece of land use is determined by financial and perceived value. The Bid Rent Theory proposes that at the heart of every civilization is a high density population center known as the central business district (CBD) or market place. This serves as the heartbeat of society, where farmers, craftsmen and merchants agglomerate to barter, exchange and trade what they have for what they need. Because the CBD is the location of the greatest wealth, the greatest number of people wish to be there. The demand for the land and its resources is high. But how does demand impact the price of something? Examine the following scenarios.

**Scenario 1:** You are at the grocery store making your weekly shopping trip. Having been thirsty, you got a drink from the drinking fountain, then went into the bathroom to wash your hands. Upon returning to your cart, your friend Joe greets you. After a couple minutes of conversation, Joe pulls out his bottle of water and takes a drink. You look at the half-consumed bottle of water and see particles of who-knows-what floating in the bottle from Joe's repeated backwashing. Then, Joe asks you if you want to purchase THAT bottle of water (technically half bottle) from him? "Most vending machines have bottle of water for a dollar..." he suggests. What would be your response?



Most people would be disgusted and would say no to Joe's offer. They would not pay him anything for his half-bottle of debris filled water. But why? Because at a grocery store, there is a large supply of water. There is the free water fountain. There is the bathroom sink. There is an entire row with multiple shelves of bottled water for sale. The demand (1 person) is smaller than the supply (urban water system, thousands of bottles of water), so the price/cost will be very small - if any price at all.

**Scenario 2:** You are at the grocery store. You are walking through the aisles, but they are all empty. No food. No drinks. Nothing but the crumbs a few insects are fighting over. Major global events have transpired resulting in no clean water on the entire continent. Not a single lake, water-table, well, river, stream or creek is potable any more. Even the rain has turned against you with high acidic levels. People are scrambling through the aisles, looking for anything they can find. You are thirsty. You run into Joe. Joe greets you. After a couple minutes of conversation, Joe pulls out his bottle of water and takes a drink. You look at the half-consumed bottle of water and see particles of who-knows-what floating in the bottle from Joe's repeated backwashing. Then, Joe asks you if you want to purchase THAT bottle of water (technically half bottle) from him? What would be your response?

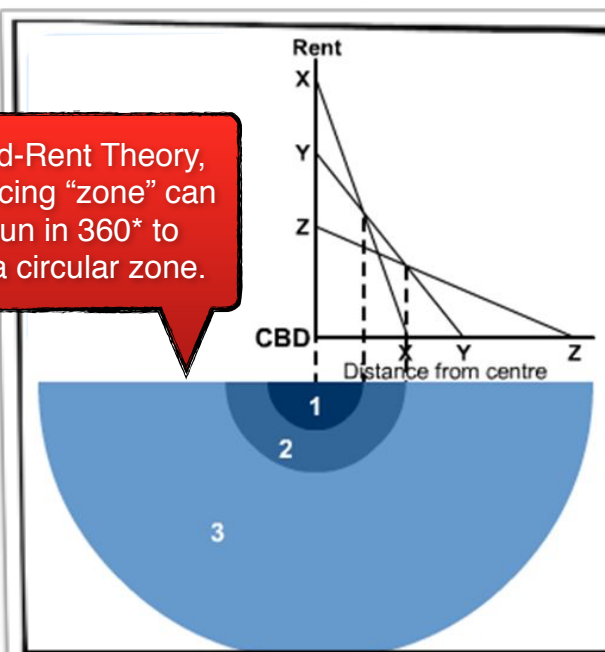


The scenario has changed significantly. Now, the supply (1/2 bottle of drinkable water) is now lower than the demand (a thirsty continent's worth of people). Everyone in the aisle has now stopped, because they see Joe with the bottle of water, too. How much would you pay? \$10? \$50? \$1,000? What happens when everyone in the store finds out about the bottle? How much would they offer to pay? As more thirsty people find out, the price for the bottle continues to increase higher and higher. Soon, the price becomes more expensive than most people could pay for it. Desperate, those who have been outbid tackle Joe and try to rip the bottle from him. A riot breaks out as people scramble for the life-giving resource.

**Conclusion:** Did the bottle of water change? No. Same bottle. Same Joe. Same backwash. What DID change is the supply and demand. When the supply was higher than the demand, Joe couldn't give away his water. When demand was higher than supply, the price soared exponentially. Because the resource was a means of survival, high demand led to riots and violence.

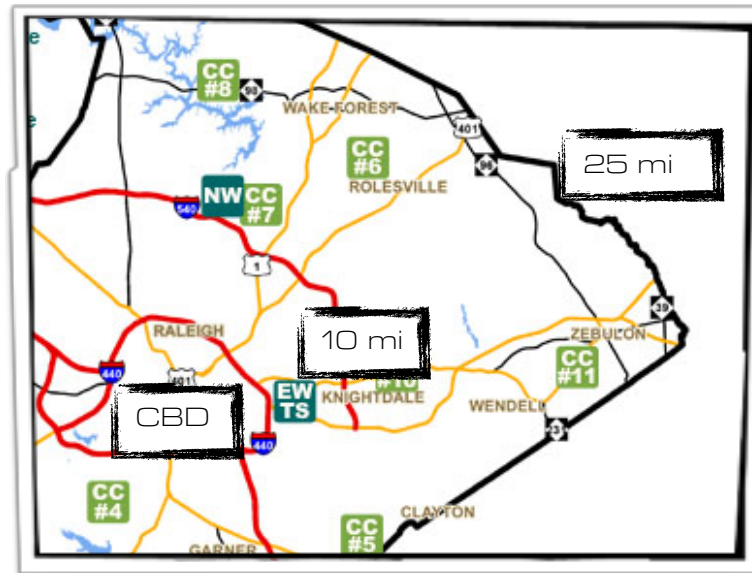
Connecting back to the land conversation and the Bid Rent Theory: Is there an unlimited amount of land at the Central Business District? No. It is typically a specifically zoned area (wealthier cities have larger CBDs, less wealthier areas have smaller CBDs). More people want to be where the wealth and economic activity are located then there is land/space to house them. As a result, the more people that will BID to use a piece of land, the greater the RENT will be to use the land. The greater the demand to live and work at the CBD, the higher the land value rises. Conversely, the farther the land is from the CBD, the greater the distance decay and the lower the value of the land.

With Bid-Rent Theory, each pricing "zone" can be spun in 360° to create a circular zone.



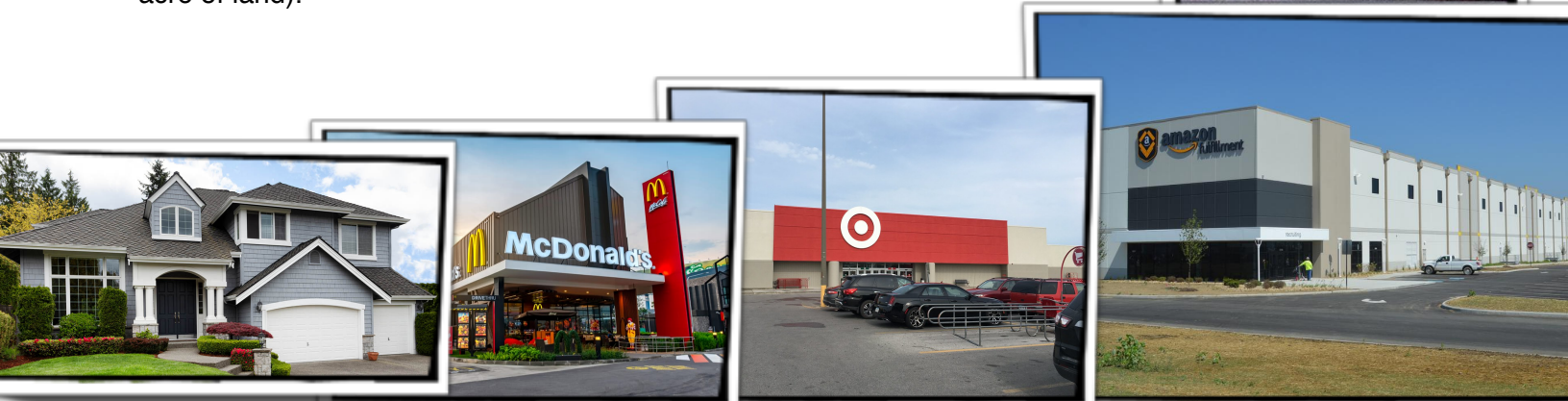


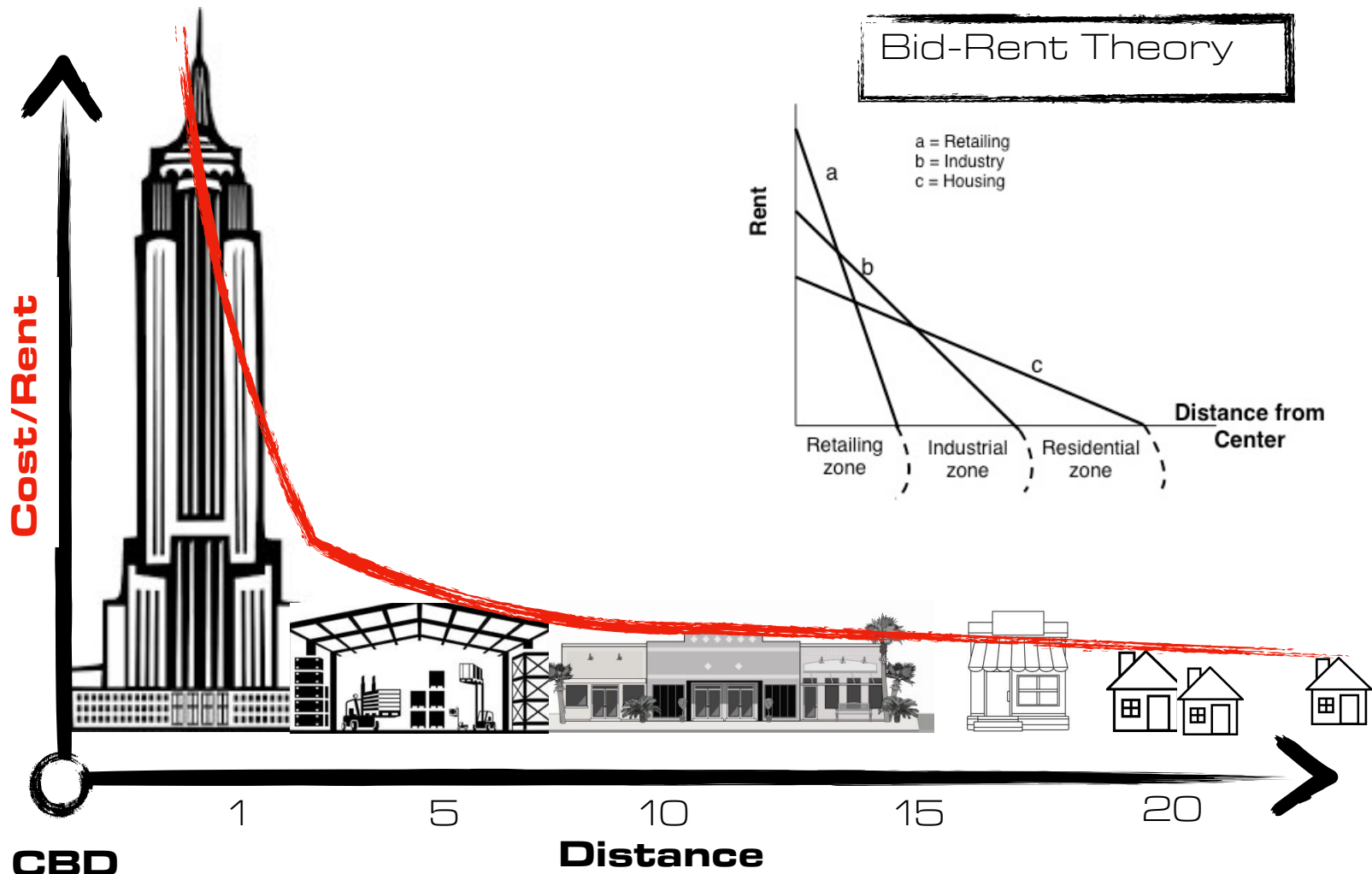
For example: The Research Triangle area (Raleigh, Durham, Chapel Hill) is one of the most prosperous and fastest growing regions in the USA. As more businesses (and their workers) have been agglomerating in the Research Triangle Park (RTP), the demand for land has been increasing. However, the further way from RTP a person moves, the land value decreases. According to Zillow in 2016: a 4 bedroom, 1700 square foot house that is located near downtown Raleigh costs \$300,000. 10 miles away by Highway 540, that same sized house costs \$180,000. 25 miles away in Franklinton, the same house costs \$125,000. The generically similar how changed \$175,000 just based on its location. This concept applies on a regional/national scale as well. Land that is located close to New York City is worth more than the land located by Pittsburgh, PA. The land value continues to diminish when reaching Kentucky, Missouri, and finally Wyoming. That same sized acre of land in the heart of NYC maybe worth over 1000 times as much as that same sized acre of land in Wyoming or South Dakota.



According to bid-rent theory, the demand and value for the land determines/influences HOW the land will be used. In the CBD, banks, lawyers, government services, hotels, stores, restaurants, stadiums, tech companies, and office space are all fighting to use the land. There are also the places for the workers to live, as people like to live near where they work. When the demand for land is high and the value of the land is high. Who is going to pay the most to be on that land: the bank-backed office tower developer, the factory owner, the strip mall, or the home builder?

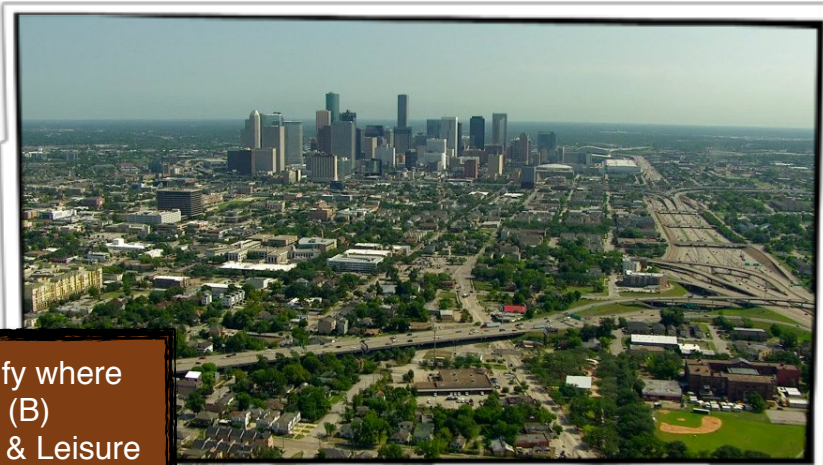
- **High Rise Office Space:** The Willis Towers (formerly known as Sears Tower) cost \$1.3 Billion to build 110 floors of office space (~4.5 million square feet) on ~ 1.5 acres of land. The One World Trade Center in NYC cost \$4 Billion to build 94 floors of office space (~3.5 million square feet) on ~1.5 acres of land.
- **Large Warehouse/Factory:** Amazon paid ~\$200 million for a 2 million square foot warehouse/factory that will exist on 70 acres of land (that averages \$30 million per acre).
- **Strip Mall.** To build a Target/Walmart costs ~\$30 million to build 135,000 square feet on ~1.3 acres of land.
- **Fast Food/Free Standing Business.** To build a Chick-Fil-A or McDonalds costs between \$1-2 million, for a .3-.5 acres - including parking lot.
- **Single Family Home.** The builder of the 3,000 square foot individual home paid \$300 Thousand for .25 acre lot (1.2 million for 4 homes on 1 acre of land).





Who wins the bid for the most prime, high demand land in the CBD? Clearly, the High Rise who is paying over \$1 billion for 1 acre. The land in the CBD will have high density, vertical architecture, and EVERY INCH will be purposefully planned. The more vertical sky scrappers a CBD has in its skyline, the greater the wealth and economic power of they possess. Now, when you move a mile or two away from the center of the CBD, the demand for the land decreases sharply. Will the High Rise office tower still pay \$1 billion for the land 2 miles out? Would they attract high-priced clients to rent that space? Will they get a good return on their investment? No, it would not. Who IS ready to bid the most to be relatively close-but-not-close to the CBD? The Warehouses/Factories and the Strip Malls be interested in the lower-cost opportunity - paying \$30 million per acre. The density will still be fairly high, but the buildings will be only be 2-4 stories tall, but much wider. Finally, 10-15 miles away from the city center, will factories still want to pay \$30 million? No, they will not. Who will? The Free Standing Businesses will buy up the best locations at intersections, and the rest will be sold off to Single Family Homes. After 30 miles away from the CBD...? An occasional single family home separated by undeveloped land and farm land.

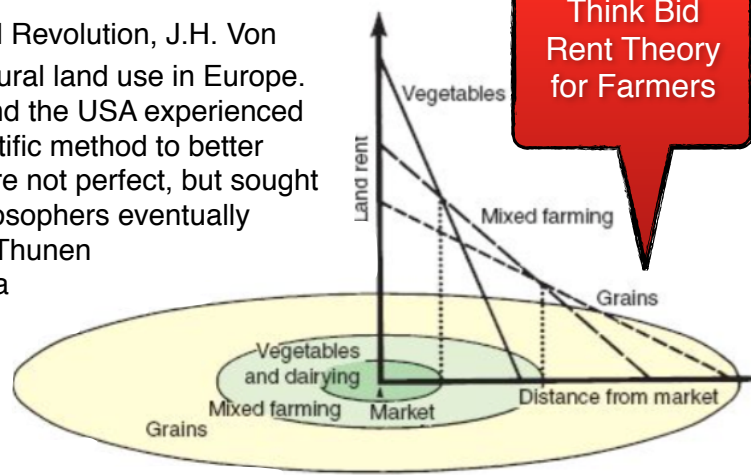
While this model is not perfect (no model is), the Bid-Rent theory provides a framework for understanding how the value of land changes and how the land use changes based on distance from market/CBD. *[Note: Distances and values will vary by location. High demand locations will have high values that decay over long distances. Small demand locations will have lower values that decay over short distance.]*



**Application #1.** This is a picture of Houston. Identify where each of the following zones begin/end (A) the CBD (B) Medium density warehouses/stores (c) Residential & Leisure



Von Thunen. In the early 1800s, just before the Industrial Revolution, J.H. Von Thunen was a German farmer that published his theory on rural land use in Europe. Von Thunen was a part of this 1800s era in which Europe and the USA experienced a surge of “models” and “theories” that tried to use the scientific method to better understand and explain societal patterns. These models were not perfect, but sought to create a base line of understanding the world. These philosophers eventually hoping to manipulate them to produce a better society. Von Thunen studied pockets of agriculturally based areas, searching for a pattern in how agricultural communities utilized their land in this *PRE-INDUSTRIAL ERA*.

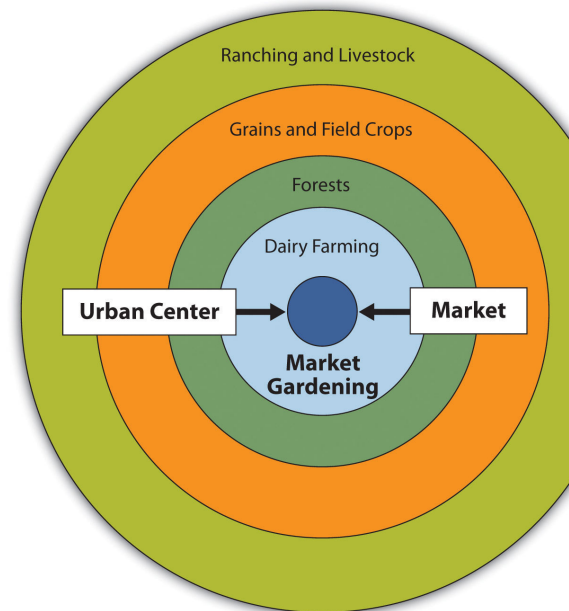


Von Thunen made a number of assumptions in laying out his model.

- The “city” is isolated and self-sufficient; no external influences or trade relations.
- All space surrounding this city was unoccupied wilderness.
- The land is flat, with no distinguishing or disrupting features like rivers, mountains or lakes.
- Soil quality and climate were consistent and equal in all parts of the region.
- These pre-industrial Farmers had to transport their own goods to market by animal or human power. The further the distance to market, the higher the friction of distance - increasing the cost and effort with every mile.
- Due to escalating transportation costs, being located close to the central market was of high importance.
- Being pre-industrial, there is no refrigeration. Food perishability was a big concern.
- The farmers will make decisions to maximize their profits, minimize costs, and only use the “highest and best” financial use for their land.

Based on these assumptions, Von Thunen came to the following conclusions about rural land use in the pre-industrial era. Following with bid-rent theory, there were five general zones, that explained most pre-industrial societies:

- **Center - City/Market.** The economic heart of the city is the central business district; where the market, housing, financial institutions, religious and government buildings are located. The high demand and profitability for this land causes the cost of land to be extremely high. The buildings tend to be clustered and high density, with vertical architecture being used to maximize the space.
- **First Ring - Market Gardening & Milk Shed.** Fruits, vegetables and milk spoil quickly, requiring the products to reach the market before they go bad. The “milkshed” is the farthest point a dairy farm can exist away from the city center, without the product spoiling. The problem for farmers is that the land located close to the city center is very expensive. The increased expense of the land caused an increase in the price of the products - making milk, fruit, and vegetables very expensive products. As a result, farmers use this land for intensive agricultural practices to ensure each plant and inch of the expensive ground is maximized for its profit potential.
- **Second Ring - Forest.** In a pre-industrial society, wood was extremely critical to a families success. Wood was used daily for heating, being a critical component of cooking, bathing, etc. Wood was also the key component for construction. The problem was that wood was difficult and expensive to transport. Thus, the ring outside of the intensive agricultural zone was typically reserved for wooded lots. The wooded lot also helps protect the soil against erosion; serving as both a wind barrier and helping to give root to the top soil.



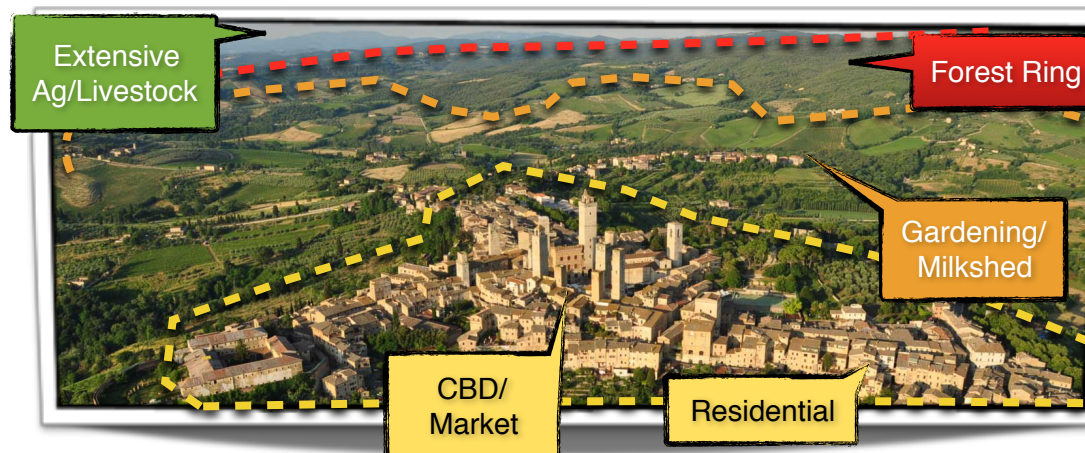
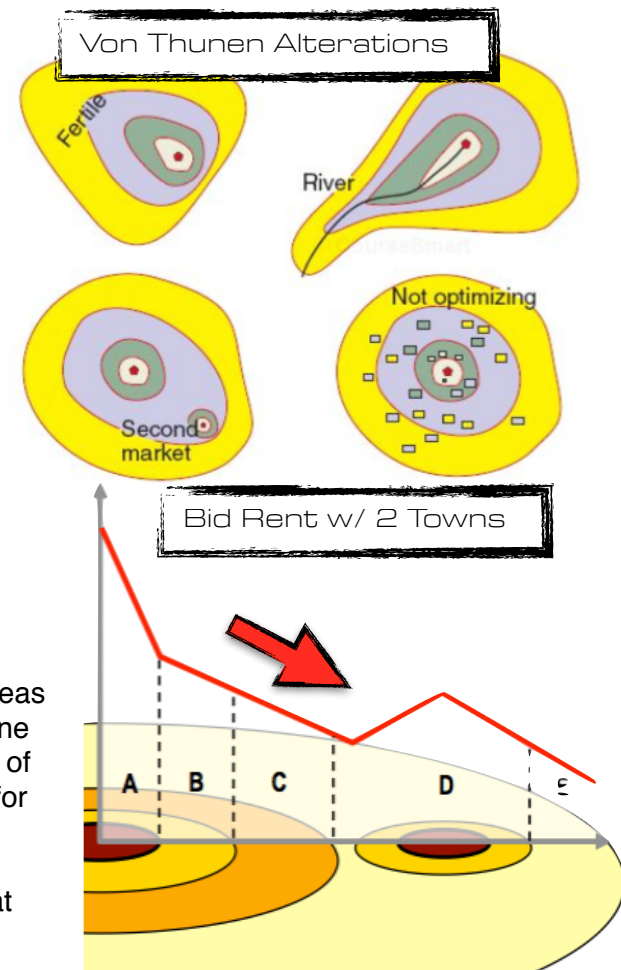
- **Third Ring - Field Crops.** This ring is for the extensive crops, like grains and cereal crops. Grains and cereal crops need large fields to be able to grow a bountiful harvest. At first, this location would be a concern because the land is farther from the city center, making the products from this ring less accessible to market. However, the cereal crops and grains create seeds that can be easily stored for months, allowing them to be transported long distances without spoiling. The benefit of this ring is that the distance from market **DECREASES** the demand for the land which **DECREASES** the land cost. As a result, farmers can buy large swaths of land and grow large fields of grain. The harvested grain is sold for a lower cost compared to the fruit/vegetable/milk products grown in the first ring. Also, the storability of the seeds allows them to be stored to make breads and pastas all year long.
- **Fourth Ring - Animal Grazing.** Similarly to the extensive crops, the last ring is for the extensive animal grazing. The livestock can be moved from location to location for food, with comparatively little effort needed by the ranchers. When it is time for the cattle to be brought into market, the cattle are able to walk on their own efforts to the city center; needed no extra transportation or cost. The area on the edge of ring 3 & 4 is where “Mixed Farming” transpires. Mixed farming has both extensive grain cultivation **AND** raises cattle. It is the intersection of both worlds.

However, there are flaws in Von Thunen’s assumptions that has caused his theory to face a number of criticism. One force that alters Von Thunen is if the society is located along a river. Rivers reduce the friction of distance and cost of transportation, allowing people to move goods further, faster, and more affordably. As a result, the “rings” shift to being elongated ovals upstream of the market (because the goods flow easily down the river).

A second force of change is the presence of a second town/city center within close range. The presence of a second market causes **ANOTHER** moderate increase in land value, altering how the agricultural land will be utilized. It creates a second market zone, a second garden/dairy zone, and a second forest zone. The purpose of these zones is to serve the food needs of the second, smaller residential community that is too far away to effectively utilize the first market/dairy/forest zones. Because of the distance to the second market and the lack of preservations, the milk/fruit/eggs would spoil or damage before reaching the second market.

A third force is the uneven distribution of natural resources. Certain areas have the natural elements needed for agriculture and others do not. One part of the area may have fertile soil and the other has a solid bedrock of granite... or any myriad of combinations that makes one part suitable for raising crops and the other... not.

The fourth force is the irrationality of people. Von Thunen assumed that people would act in their rational best interest, for what would be most profitable. Unfortunately, not everyone thinks in terms of their best interest, nor do they see or understand all of the components, to be able to make the most profitable choice. This leads to a situation where the farms are placed in less-than-ideal locations and an ineffective mixture of agricultural styles.





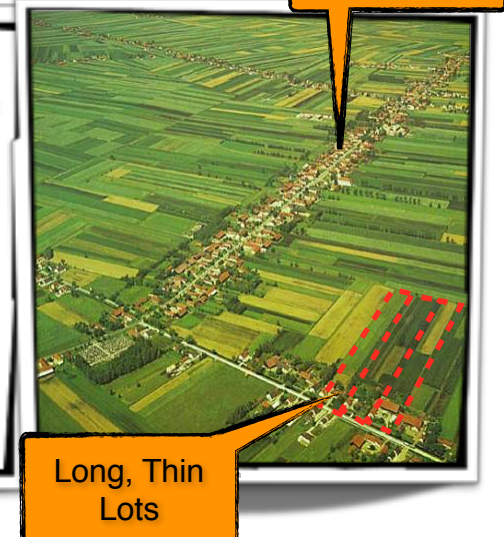
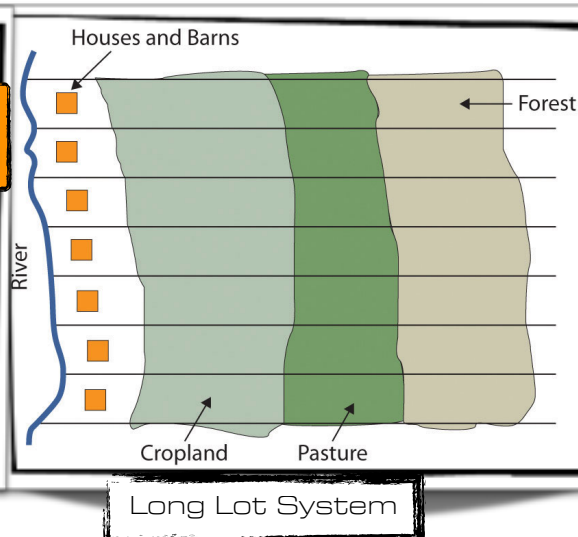
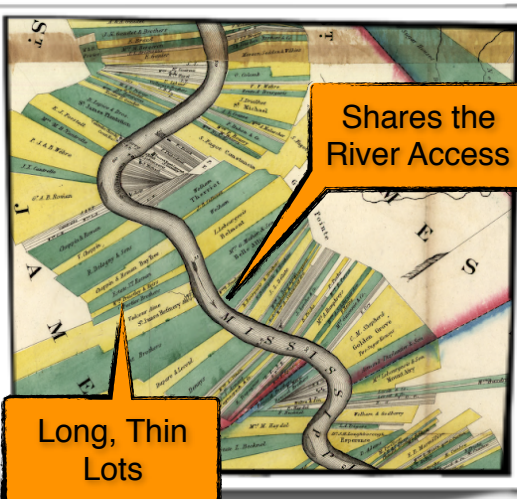
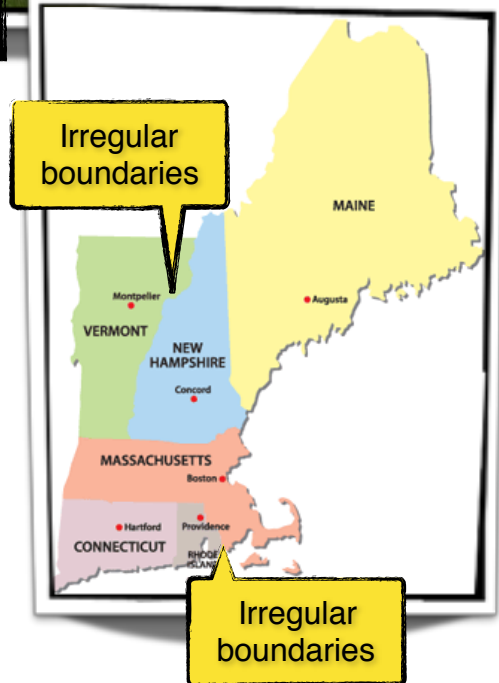
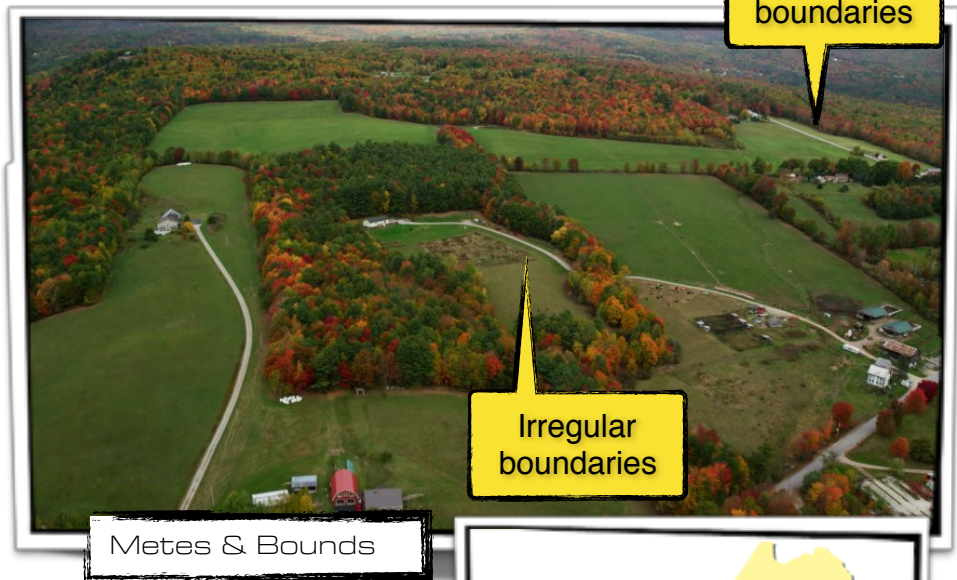
## Surveying the Land.

While all the citizens agree the government controls the land, western societies have promoted the establishment of private property laws for the organizing, selling and distributing of the land to private citizens and corporations. Private citizens have the right to live on the land and utilize its resources to profit from the land. The government is not allowed to seize the land. It will also provide protection (i.e. Police and Fire Fighters) to keep other people and elemental forces from harming the land.

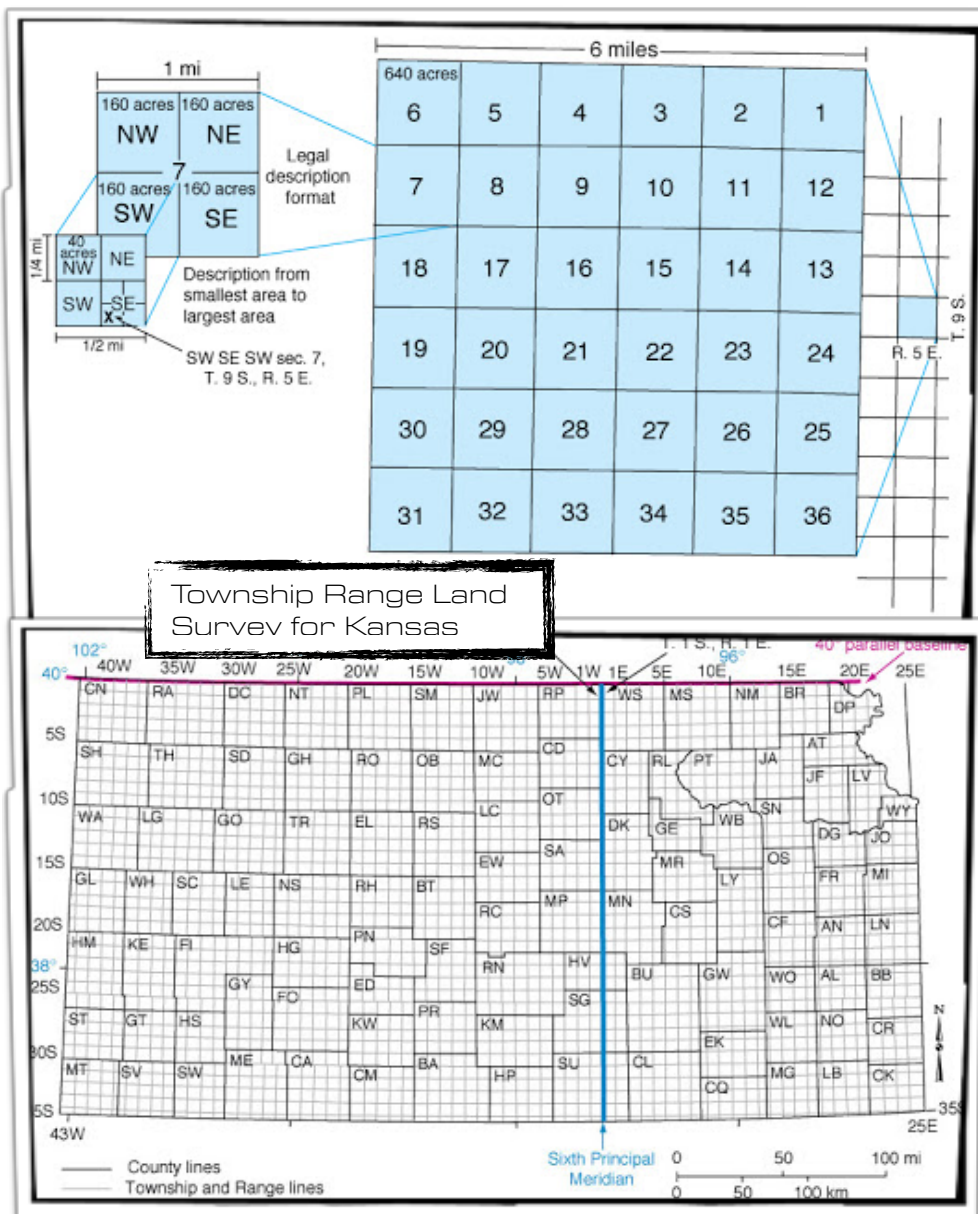
Governments have utilized three main systems for surveying and distributing agricultural land:

- **Metes and Bounds.** This system dates back to old England, using natural features and low stone walls to mark the boundaries of property. Boundaries follow the physical landscape and are often jagged or very messy. An example would be: "Beginning with a corner at the intersection of two stone walls near an apple tree on the north side of Muddy Creek road one mile above the junction of Muddy and Indian Creeks..." Metes and Bounds is still used in the large estates in England, as well as in the New England/ Northeastern USA.
- **Long Lot.** This system was created by the pre-colonial French, creating long, narrow lots of land that settlers/citizens could own. The French were concerned that the rich would dominate the roads and the rivers. By using long, thin lots, it divides this access to everyone. The lots are ~350-600 feet wide, and 6000 feet deep. The land is divided between homes, crops, pastures, and forests. The homes create a linear distribution along the road.

The French installed the Long Lot system in their colonial empire - especially Eastern Canada (especially Quebec), in settlements along the Mississippi River, and in New Orleans.

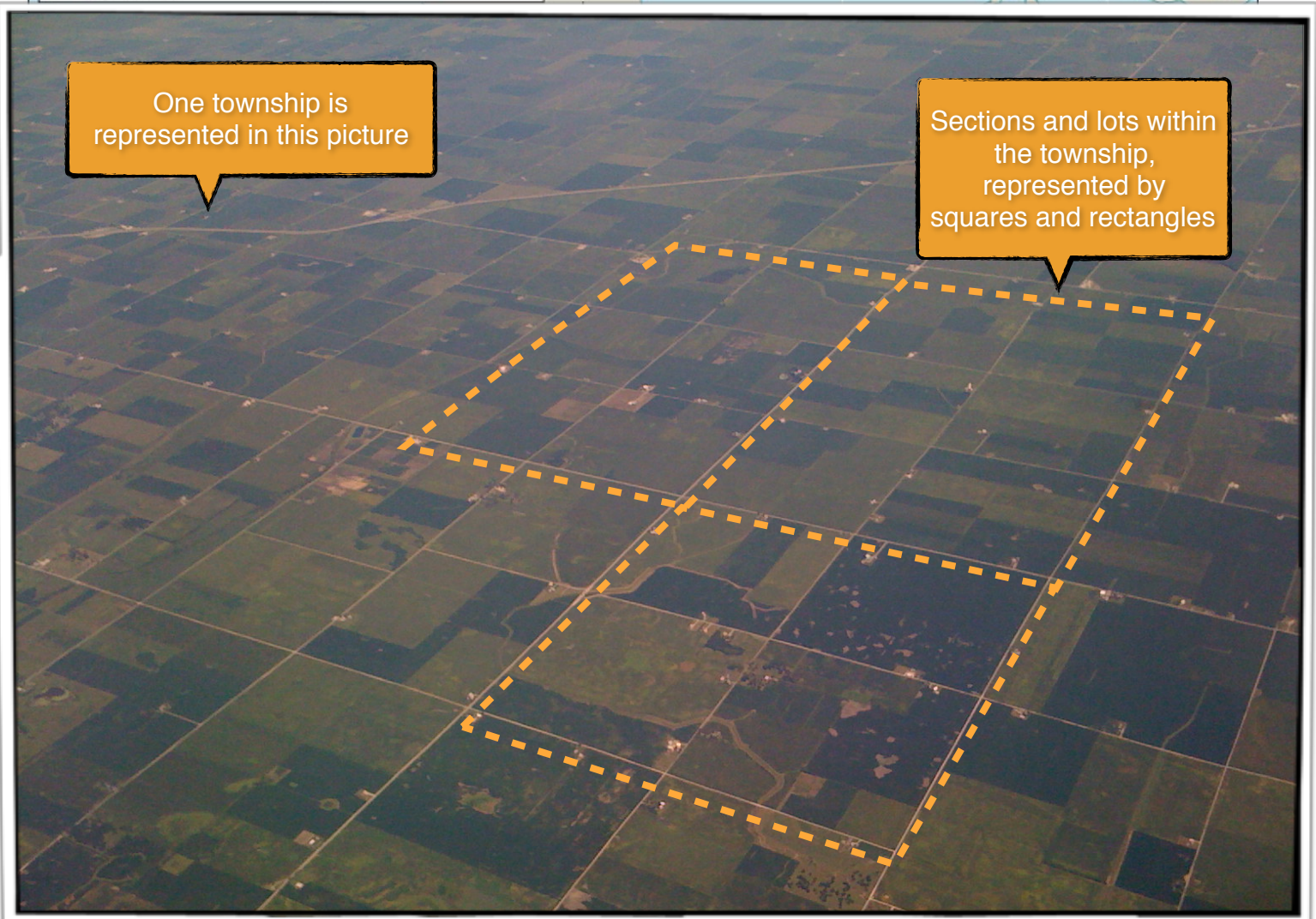
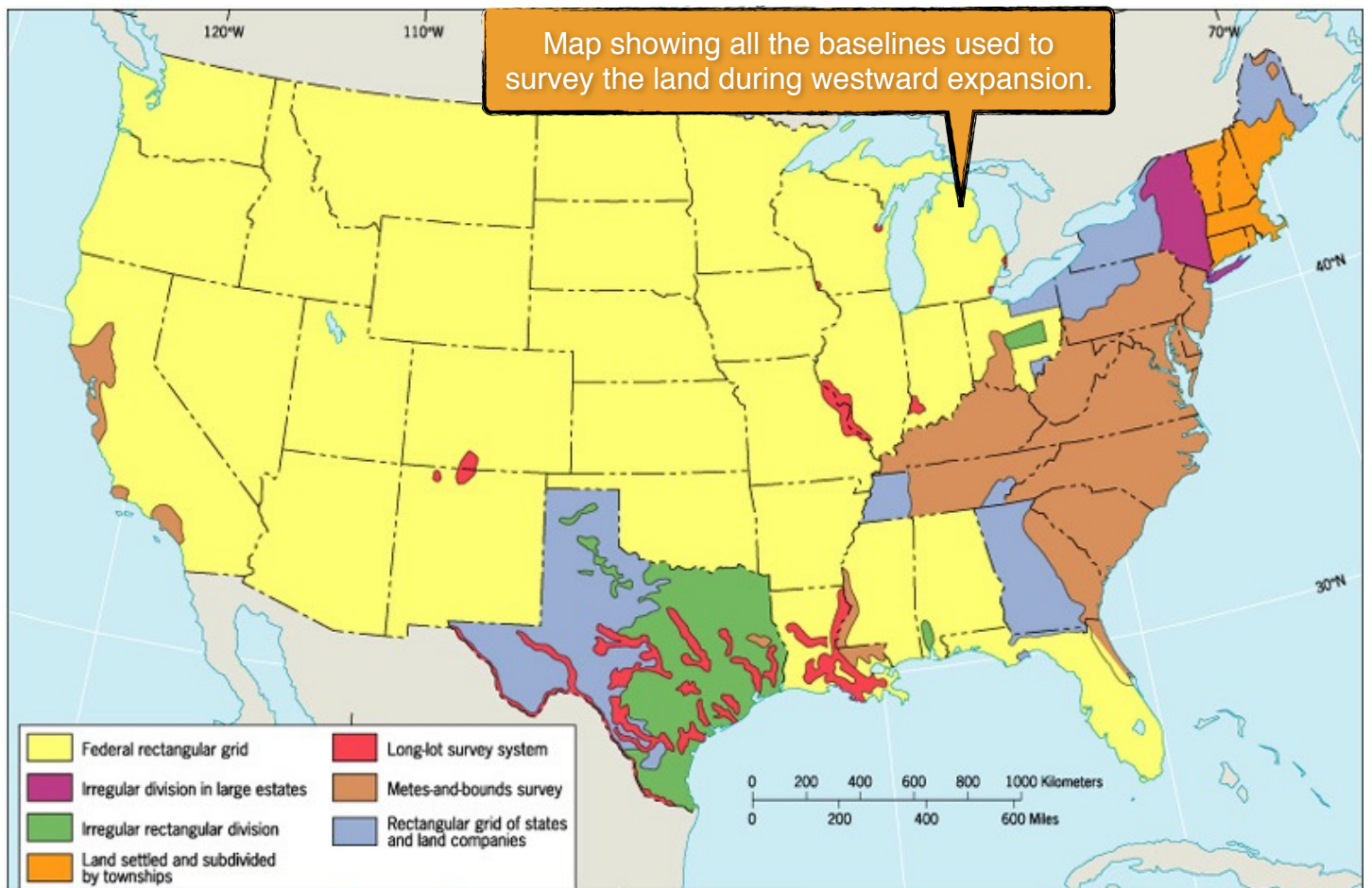


- Township and Range.** This system divides the land using latitude and longitude lines, create square or rectangular shapes. This is also referred to as the Public Land Survey System (PLSS) or the Rectangular Survey System. Created with the Land Ordinance of 1785, Township Range served as a means of organizing, selling and governing land in the new world. It was first utilized in Ohio, and became the primary means of arranging and distributing land into the West. The system works by establishing baseline, or starting line, with a line of longitude. Land is measured into parcels typically six miles in length and six miles in width. Each 6 mile x 6 mile section is called a Township, creating a rectilinear grid of squares (and some rectangles). Each township is subdivided into 36 parcels of land that were 1 mile by 1 mile. Finally, the 1x1 squares were subdivided into 160 acre parcels of land that were sold to the settlers. Those each township and range was numbered, and given directional coordinates. This system of organization is meant to help make the land easier to sell, govern, and tax.



This system was used in the USA, as the settlers expanded westward. As a result of the Township and Range system, the houses as isolated and dispersed across the agricultural landscape. One reason for the dispersed settlements is when people build their homes/barnes in the middle of their squared settlement, it creates disperses the buildings across the landscape. This dispersed isolation has increased as small family farms have been bought out and consolidated by the megafarm-agribusinesses. The second reason for the dispersal is how Americans expanded westward. Many people came to America in small family units, not as large family clusters or clans. Also, people migrated to America from a multitude of unrelated origin points. Thus, as America expanded west, people migrated as small, isolated family units that were ecstatic about become the landowning elite of the new frontier. They built their homes and barnes to accommodate one, isolated family; as opposed to clusters and communes to support many families.







## D. History of Agriculture

Hunting and Gathering. For 200,000 years, Human history was a transhumance existence. Humans lived in bands that survived on extensive activities, such as hunting, fishing and gathering wild edible vegetation. Most groups traveled similar routes and routines, staying near freshwater sources and areas with a rich diversity of edible food - typically areas with very fertile soil. The diets of hunting and gathering groups were highly nutritious, with a wide variety of foods. 60-70% of their diet consisted of plants and nuts gathered by the women, with 30-40% of the food coming from animal meat. Hunting and Gathering bands used relatively small amounts of energy to acquire food, giving them significant amounts of leisure and social time.



Pastoralism. Akin to hunting and gathering was the birth of pastoralism - the breeding and managing of domesticated grazing animals. Pastoralists centered their lives around their herds, typically goats, sheep, cattle, llamas or camels. The herders extensively manage the animals, guiding them to places where they can graze; moving when the land can no longer support the herd. These animals tend to exist in highland areas that are dry, cold, or mountainous regions like the Arabian Desert, the Ethiopian Highlands, the Plateau of Iran, and the Steppes of Turkmenistan and Mongolia.





Agricultural Revolution. Around 10,000 BC, humanity underwent its most radical revolution, the Agricultural Revolution (also referred to as the Neolithic or New Stone Age Revolution). Humans had been accidentally laying the foundations for agriculture of centuries. As hunting and gathering bands roamed, certain areas were the native hearths to domesticable plants. Unbeknownst to the early humans, they would eat the delicious fruit or nuts and then defecate the seeds that survived being digested. Since domesticable foods have to exist in regions with fresh water, and the since the seeds were surrounded by a natural fertilizer, domesticable plants gradually began to diffuse along the routes the bands would travel. The more domesticable food that was consumed, the more that would reproduce and diffuse.

Unfortunately, there are no written or oral accounts of how humans made the next transition step to settled agriculture. The best hypotheses consist of people realizing the more edible food grew by sources of water, thus deciding to alter the landscape to irrigate the wild edible crops. The growth of domesticable crops due to increased access to fresh water eventually evolved into the discovery of purposefully putting seeds into the ground instead of eating the seeds, in order to create a new harvest. This was an action of unquestionable courage, giving up a guaranteed meal now in hopes that the delayed gratification would pay off in a larger harvest later. Eventually the fields of harvest became bountiful enough that the hunting and gathering band took the next great leap of courage, settling down and making permanent residence amongst their domesticated crops.

The decision to focus almost exclusively on agriculture had a complex set of costs and benefits.

- Farmers claimed land as their own for their family/tribe. This was a distinct change from their hunter-gatherer roots, which felt the land was something that could not be possessed. As the most fertile land was claimed and controlled, the land had to be protected from animals and other humans. Hungry and over populated groups fought over the most fertile land. Once the crop came in, the crops had to be harvested and stored; being protected from anyone wishing to make a quick meal. Nomadic tribes treated the farms like they were a fast-food drive throughs; swoop in, grab and go.
- Agriculture required considerable amounts of time and effort. The new farmers had to discover tilling, sowing, and weeding the ground for the crops to grow. While this path resulted in considerably larger harvests and stores of food, the extra work led to the farmers consuming larger amounts of food.
- As the intensive subsistent farms needed more workers, women's fertility rates increased dramatically, further increasing the demand for more food. The role of women became tied to farm work and fertility, especially sons.
- The larger populations were vulnerable, as food security and questions about carrying capacity were a chief concern. A drought, flood, famine, locust/pestilence, or poor decision could ruin an entire harvest; leading to starvation and conflict.
- The variety of foods on the early farms was dramatically smaller than the pallet of foods consumed by hunters and gatherers. There are thousands of edible plants, but only dozens of domesticable plants. This reduced the amount of nutrition led to malnutrition, stunted growth and shorter lives.
- While domesticated animals were able to provide a critical source of labor along with an extra source of food through lactation, blood and meat; they also posed a serious health risk due to disease. As the farmers lived in close quarters with their domesticated animals, animal born diseases mutated to humans, creating the most deadly pestilences on the planet: small pox, measles, tuberculosis, influenza, and malaria to name a few.



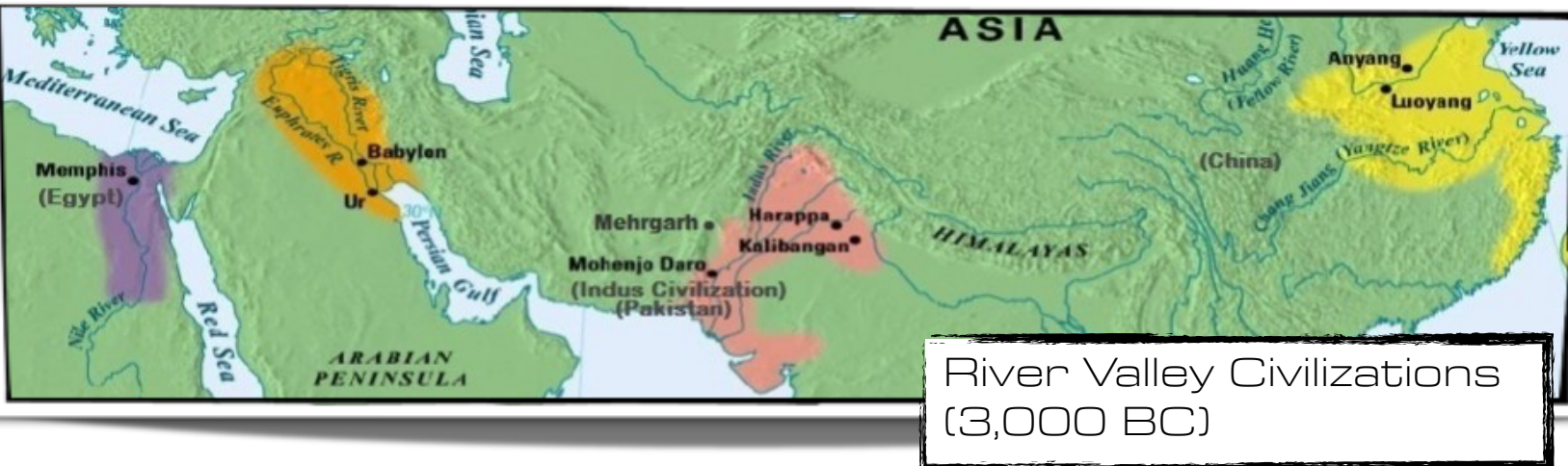
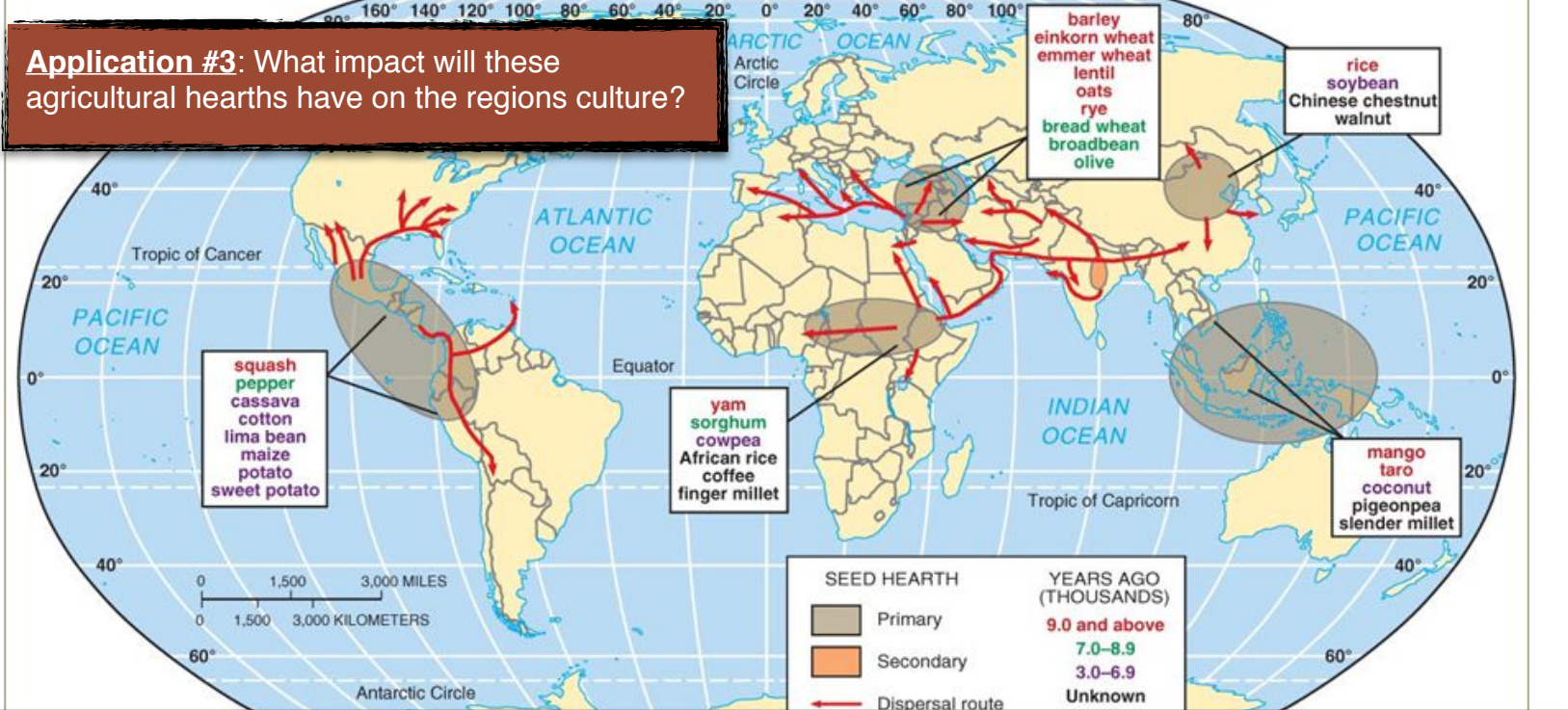
A History of Plant and Animal Domestication									
Region	13,000 BC	7,000 BC	6,000 BC	5,000 BC	4,000 BC	3,000 BC	2,000BC	1,000 BC	1 AD
Europe							- Horse		
S. America		- Squash	- Manioc	- Gourds - Lima Beans - Tobacco - Llamas - Alpacas			- Potato - Sweet Potato - Guinea Pig -Peanut		
Meso America		- Gourds - Squash		- Maize/ Corn		- Manioc - Turkey - Avocado - Cotton	- Sunflower		-Cocoa
N. Africa			- Cattle	- Millet - Cotton	-Sorghum	- Cats - Groundnut Watermelon - Yam			-Coffee
SE Asia			- Rice - Bananas - Sugarcane - Taro - Yam	- Plantain - Coconut					-Tea
E. Asia	-Dog	- Rice - Beans - Hemp	- Pig - Silkworm	- Millet - Fowl - Water Buffalo					
S. Asia				- Cattle - Cotton	-Chicken				
Middle East	- Dog	- Pig - Goat - Sheep - Barley - Rye - Wheat	- Flax - Lentils - Cattle			- Grapes	- Camel		
C. Asia	-Dog		- Horses				- Camel	-Donkey	

**Application #2.** Assuming you only could eat food from one region, which region would most like to have lived in based off the available food (plants/animals)?

Despite the difficulties presented by agriculture, fertile lands experienced a drastic growth in human population. Overtime agriculture evolved. Farmers improved their practices, determining ways to increase yields and giving birth to intensive subsistent agriculture. Eventually large mammals were domesticated and harnessed for animal power. They provided human settlements with an external source of labor as well as fertilizer, at the cost of needing to be fed... a lot. Eventually harvest grew large enough to support people who could complete jobs that were not directly involved with crops and animals. More effort was put into improving tools, which produced greater yields. New innovations led to the discovery of metals and the ability to craft metals into different shapes. Increased yields led to larger populations and the development of advanced society: social structures, government systems, property rights, market places, written language, legal codes, education, advanced architecture, inequality gaps, slavery, culture, etc.



**Application #3:** What impact will these agricultural hearths have on the regions culture?



River Valley Civilizations (3,000 BC)

As human societies expanded, “food packages” were diffused horizontally/latitudinally to similar areas that could support/grow those crops. These first agricultural hearths were directly associated with river valleys. The rivers provided ample water for irrigation and annual flooding brought fresh layers of fertile alluvial soil. The result were sites there were ideal for agriculture. People gathered in high densities around these rivers, due to migration and high fertility rates. These packages diffused by farmers relocating or contagiously through trade amongst the farming communities across the region.

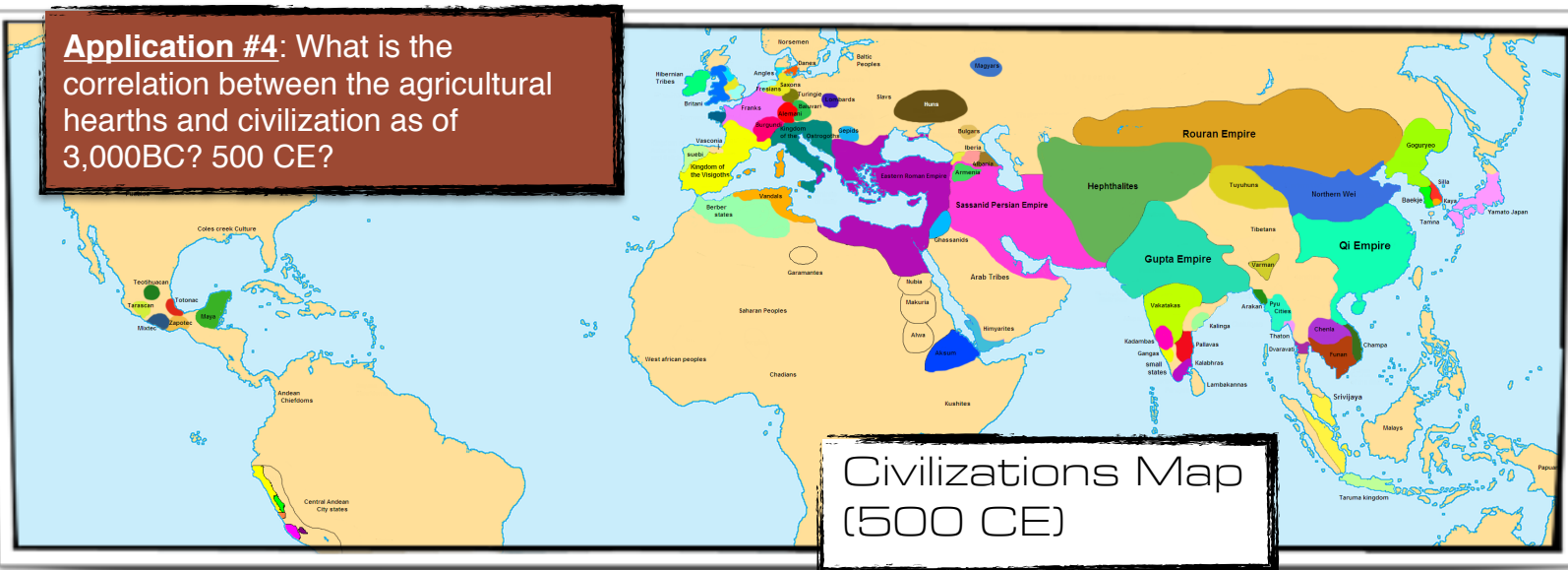
There were five most important agricultural hearths include:

- **Southwest Asia (Middle East):** Referred to as the Fertile Crescent, the region between the Tigris and Euphrates river in modern day Iraq. This region is credited by most historians as being the first place to develop intensive subsistent agriculture. The food package diffused to the Nile River valley. This was the hearth for: cattle, goats, pigs, sheep, wheat, lentils, and oats.
- **East Asia:** Founded along the banks for the Yellow (Huang He) and Yangtze Rivers, this region served as the base of the world’s largest population. This was the hearth for: rice, millet (a cereal crop similar wheat and barley), and soybeans.
- **South Asia:** Founded along the banks of the Indus River in modern day Pakistan and the Ganges River in India. This was the hearth for: chicken and horses.
- **Southeast Asia.** Founded in Indonesia. Was the hearth of rice, bananas, mangos, and coconuts.
- **Latin America:** Founded in Mexico and Peru. Considered the hearth for: corn/maize, beans, squash, cotton, peppers, and sweet potatoes.

The larger populations filled the fertile lands, pushing the smaller and technologically disadvantaged hunters and gatherers, as well as pastoralists, off the fertile lands, and into the regions that were not desirable or were incapable for sustaining agriculture.

By the time the Roman Empire was in full bloom, the agricultural stage was set. All the domesticable plants and large mammals had been domesticated. There has not been a single new domestication in over 2000 years. The basic tool set and process that had been developed, are still used to this day. Until 1800 CE, there were only small changes, such as learning to rotate crops to different fields, but the base of the agricultural system was essentially unchanged.

**Application #4:** What is the correlation between the agricultural hearths and civilization as of 3,000BC? 500 CE?

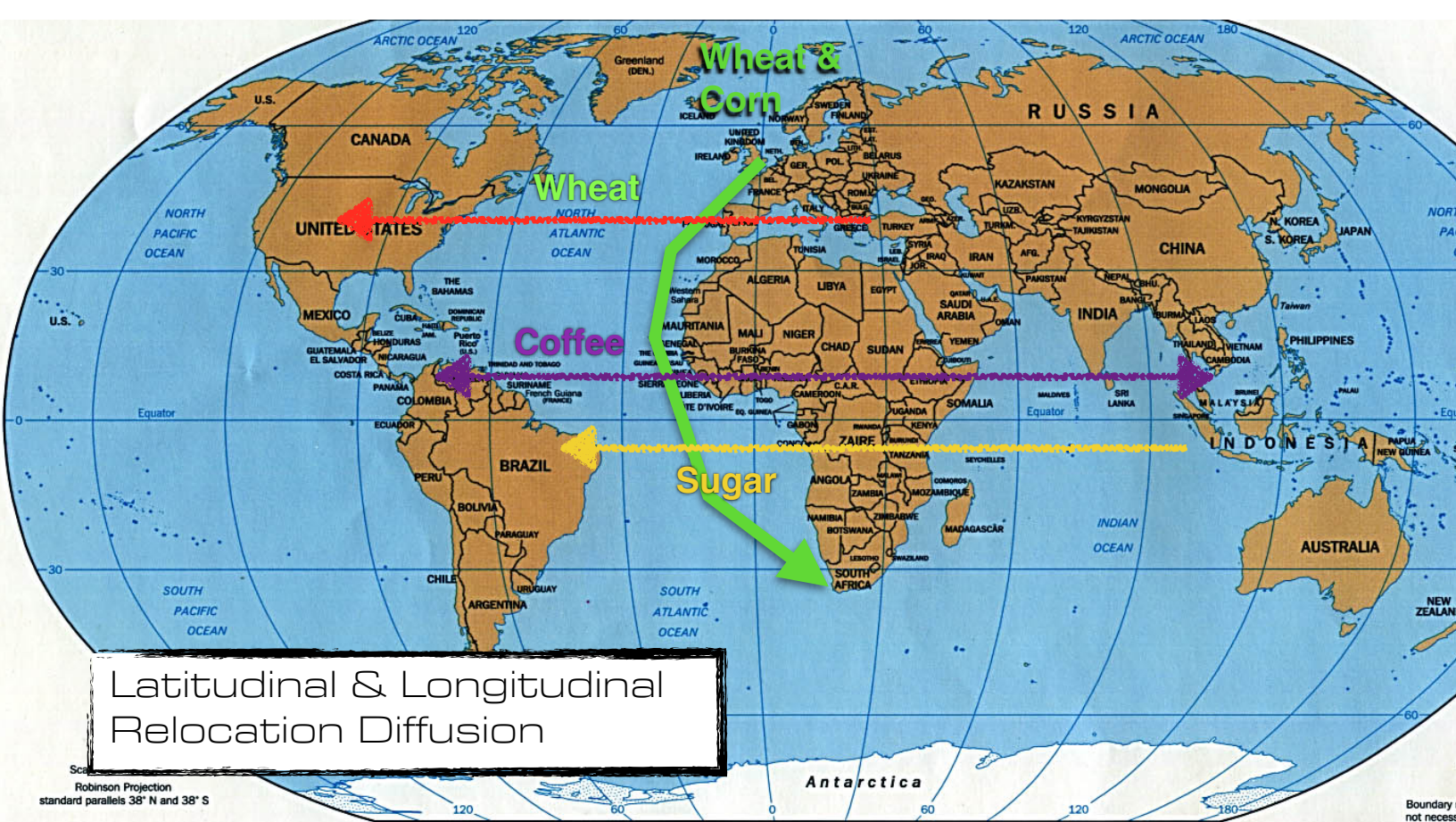


Age of Exploration. As the Europeans began to explore, they made a radical impact on global agriculture: the Columbian Exchange. The Columbian Exchange was massive relocation diffusion of crops and agricultural technology between the “Old World” Europe and the “New World” Americas. Wheat bread/pasta and mozzarella cheese of Europe was finally united with the tomato of North America. Cacao beans of South America were syncretized with the Sugar Cane of Indonesia. Many food combinations that modern Western societies consider key cornerstone foods its culture, were unimaginable before 1500 CE.

The ability for plants to successfully diffuse latitudinally was essential to the success of the Columbian Exchange. Wheat moved from the Middle East and Europe to the largest acreage of farmland in the world in the Great Plains of North America. Coffee diffused through relocation from Eastern Africa to the Caribbean and SE Asia. Sugar diffused from SE Asia to South America. For the first time, food transferred Longitudinally. The European and Middle Eastern food package that succeeded between 20°-40° North found a home between 20°-40° South in South Africa, Australia and Argentina. Unfortunately for the Southern Hemisphere, there is less land available between those latitudes, then the Northern hemisphere.







Industrialization. The innovation of the engine in England started the *second* agriculture revolution. First, the mechanization changed the tools used in the crop production process. The tractor replaced the horse and plow, increasing the speed, quantity and quality of work one farmer could put out. One farmer with a gas-powered tractor could outproduce and outperform 100 people working by hand. Regions that had soil that was too tough to plow were now available to be farmed, increasing agricultural output. Water could be pumped out of deeper wells or through piping for better irrigation. Water could be purified in large quantities. Tractor attachments were developed to improve seeding, manure spreading, and harvesting. By the mid-1800s, tractors were so prevalent and powerful, slavery had become obsolete and too expensive to maintain. Food production increased drastically, decreasing the death rate and infant mortality rates, while improving life expectancy. All combined, Europe experienced a massive population boom from the increased productivity and food stability.



Second, the factory increased demand for agricultural goods. Machines allowed crops like cotton to be processed faster into thread, and increasing the production of textiles. The explosion of textile production created an insatiable demand for cotton. A similar phenomena was experienced with rubber, trees, coffee, cocoa, palm oil, etc. Europeans conquered regions to be able to exploit these resources, establishing plantation farms purely for harvesting and exporting cash crops to processing factories in Europe. This further accelerated European imperialism and globalized trade of resources.

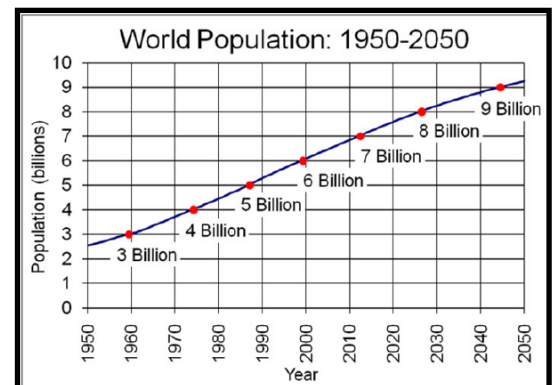


Third, mechanization led to the consolidation of farms. The industrialized economies promoted enclosure, the privatizing all the land for capitalist gain. This resulted in lands once commonly held by the people becoming owned by wealthy land owners. The wealthy were also able to purchase the best farming equipment. This, in turn, allowed the farms with tractors achieve economies of scale: producing more crops in less time, for a cheaper costs. Economies of scale allowed the farms to sell more goods for less than the family farms that did not have tractors; putting the smaller farms out of business. As the smaller farms went out of business, the land was purchased by the rich tractor-run farms. This land consolidation created megafarms. The farmers, farmhands, women and former-slaves were left without a land to call home, being forced to migrate to the growing urban centers to find work in the secondary and tertiary sectors.



Finally, industrialization promoted to the globalization of trade. As the Europeans built global empires, the steamboat allowed goods to cross the oceans in record time. The USA expanded Westward, dividing its newly purchased land from France rectilinearly using the Township & Range land surveying. The government issued the Homestead Act (along with the Indian Removal Act) to sell 160 acres of farm land for just the \$18 processing fee. This pulled migrants and their families into the Great Plains and increased the USA's productivity. Soon after, trains and tractors, dramatically improved these farmer's productivity. As space-time compression was improving, cereal-crop farms (wheat, oats, grains) began to experience economies of scale. It was more profitable to mass produce one crop cheaply to be exported on a global market than to keep food locally. Soon, ship fulls of wheat, corn and soy were being shipped from the USA and Europe to Asia and Africa. The increase in imported grains and other food resources Western farms caused foreign farmland to be used by the imperial Europeans for European crops or speciality cash crops. This led to the extinction of many indigenous foods, and a simplification in the diet of what people would eat.

20th Century. After WWII, science gave birth to the Green Revolution. The world had a population problem. Demographers like Thomas Malthus sounded the alarm in the 1800s that the population was exploding, and would soon outgrow the food supply. The world had 2 billion people in 1927. By 1974, the world's population hit 4 billion - doubling in less than 50 years. With European colonization and imperialism, the entire world had be explored and controlled. All the fertile territories were known and being worked as productive farms. How would the world be able to feed more than 4 billion people?



The Green Revolution was the modern miracle that saved humanity. Utilizing new biotechnologies, scientists changed the qualities of the seeds and soil to be able to get a higher yield from each harvest, using the same amount of land. The soil's nutrients were improved through the use of chemical fertilizers that could be specifically altered to meet the specific nutritional need of each type of plant. More nutrients in the soil meant greater yield from the crops, as well as helping to increase the arability of the land. The seeds were changed, manipulating the genetic code (GMOs) to change the characteristics of the plant. GMOs allowed scientists to increase the yield of each plant while improving the drought/insect/disease resistance. This produced a higher yield on the same amount of land. The maintenance of the crops was improved, with the creation of herbicides and pesticides. These killed the bugs, diseases and weeds the encroached on the crops; helping a higher percentage of the crops make it to harvest, with a more plentiful yield. The Green Revolution was a miracle - more food without increasing the amount of land farmed.

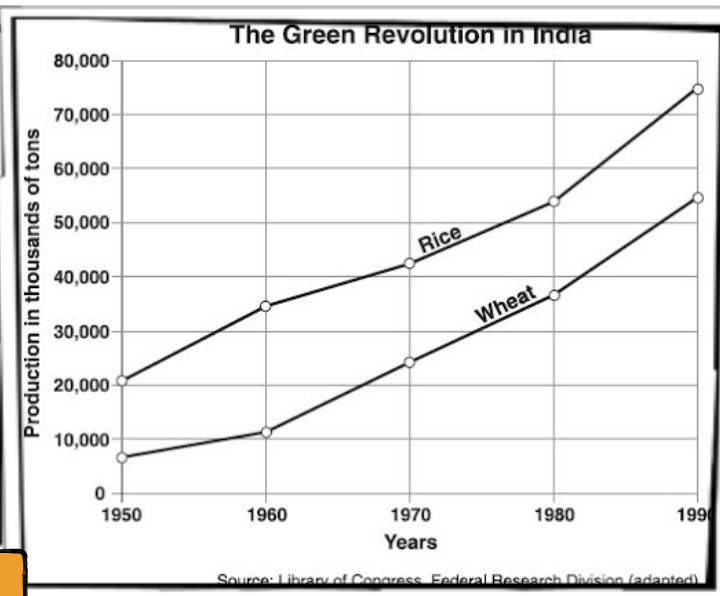
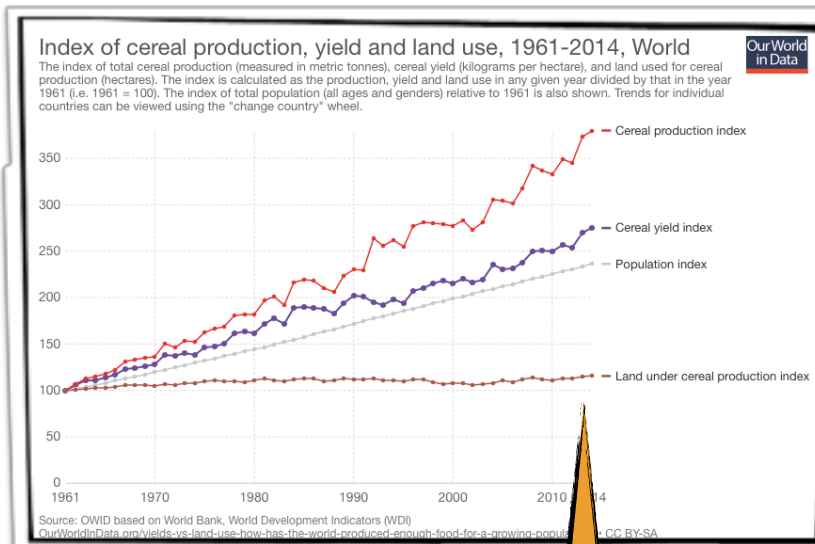




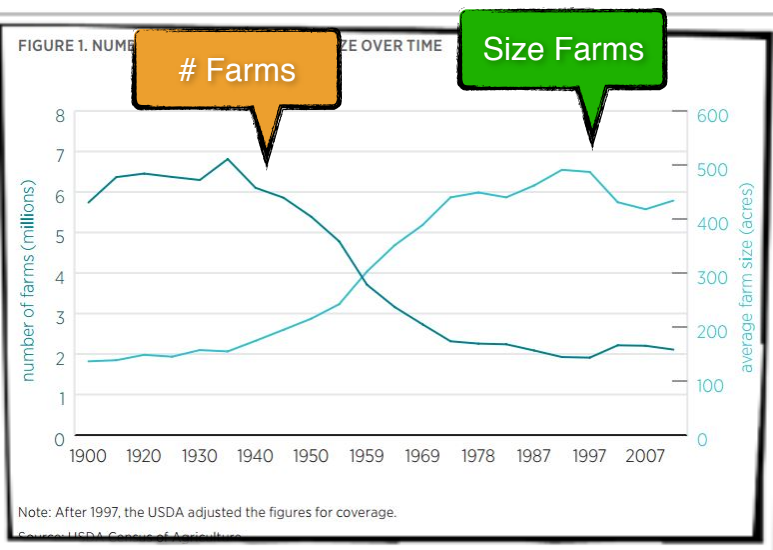


Along with changes to the crop agriculture, animal husbandry underwent critical changes. Feed lots were introduced, bringing industrialized techniques to the raising and processing of animal products. Chemicals such as RBGH were given to animals to increase the size and “meatiness” of the animal. Chickens and pigs soon grew to 4 times their original size in half the growing time. Aquaculture changed with the invention of fish farms. Cages were built to house the fish in lakes. Processed food and growth chemicals were fed to the fish, making them plump, while medicines were given to avoid illness. Feed lots and aqua farms to raise more animals/fish for consumption that had more meat in less time, and on less land.

India, China, Vietnam, Mexico, and Indonesia followed the path of the USA and Europe - transforming their farms with the tools of the green revolution. India tripled its wheat production between 1960-2000. During that same time, China, Indonesia, and Bangladesh quadrupled its rice production. As regions that were moving into Rostow’s Stage 2, the Green Revolution provided food security for their rapidly growing, multi-billion person populations. Malthus’ concerns about overpopulation related to food were put to rest.



Amount of land used



Another result of the Green Revolution was an explosion of food and agribusinesses. One aspect that made the green revolution unique was the hybrid nature of the seeds and the chemicals needed for the soil. These had to be produced by businesses. Agribusinesses grew into multinational companies by designing, producing and distributing these products around the world. Soon, small family farms could not afford to keep up with the cost of the materials, the quantity of food being produced, nor the price at which the Agribusiness could sell it. The family farms were sold and consolidated into mega farms. Agribusinesses soon dominated every part of the supply chain: from selling seed, to producing fertilizer, to tractor equipment, to processing the product after harvest... Each step became separately owned by different corporations, who used machines and transportation to achieve economies of scale. Food products soon flooded the domestic and international markets.

There were advancements in the technology used to process foods. The introduction of refrigeration, flash freezing, vacuum sealed packaging, containerization, and preservatives allowed food to be kept longer without spoiling. This allowed homes to keep food fresher longer, stores to sell more food, and restaurants to offer a greater variety of food than previously possible. Improvements in transportation, married with refrigeration, allowed perishable goods to be shipped across the state and around the world. New machines could make new foods, package them, and ship them around the world. Businesses were no longer bound to their location, but instead to increase their economies of scale to serve a larger global audience. Coca Cola took sugar, water, food coloring and carbonization, and turned it into an international phenomena. Coffee beans could now travel 30,000 miles from coffee plant to Mr. G's coffee cup. Tomatoes travel 2,000-3,000 miles from vine to salad plate. Local farmers markets were soon being replaced or overshadowed by massive grocery stores, packed with food products from all around the world. These megagrocery stores and corporate restaurant chains with their global supply chains allowed people to live and thrive in megacities of 10-15 million people.

The Green Revolution, for its many food benefits, has raised cause for many concerns. Are the GMOs safe to consume? Should our agriculture be based on gasoline consuming machinery and fertilizers derived from oil? What about the chemicals getting into the water and causing pollution? What about the growth hormones, medicines, and the food safety of meat processing factories? What about the loss of biodiversity and deforestation from expanding tropical farms?

