Lectures at Kazan Federal University – Tatarstan, Russia

Maxim R. Bayan, PhD, PhD

2013

Maxim R. Bayan is a soil scientist, clay mineralogist, and an environmental geochemist. He has doctorate degrees in both soil and geological sciences. His undergraduate degrees are in agricultural engineering and computer science and information technology. He received his education in the United States from Iowa State University and the University of Kentucky. Shortly after his academic training he started an environmental engineering company named The E-TEC Group, LLC (Environmental Testing, Engineering, and Consulting). In 2010, he joined the faculty of Lincoln University to devote his life to research and teaching of basic agricultural and environmental concepts to socially under-advantaged students. In a short period, since his return to academics, the significance of his research was recognized by the International Biochar Initiative (IBI) and was selected to serve on its advisory board. Dr. Bayan teaches his students not only the principles of agricultural and environmental sciences but also the rules of conducting a business and entrepreneurship. He is also an advocate of the fine arts and music, from Bach to Shostakovich, and the evolution of human thoughts from Socrates to Khayyam of Nishapur, and others.

New Approaches to Soil Management
(Four Lectures)

New Approaches to Soil Management (Four Lectures)

- Soil, Water and Air Conservation Management
  - Soils are managed to protect water- and air-quality
    - Sustainable use of natural resources and soils
    - New approaches to soil management
      - Use of biochar as a soil amendment
        - What is biochar?
        - How is biochar produced?
        - Pyrolysis of biomass
        - Biochar Constitutes
        - Effect of biochar on plant growth
        - Biochar effects on soil quality and productivity (fertility)
        - Other uses of biochar in agriculture
        - Novel uses of biochar
        - Use of biochar in organic farming
        - Effect of biochar on soil enzymes and nutrient cycling
        - Use of biochar to reduce nutrient loss through seepage to protect inland waters.
        - Effect of biochar on nitrogen loss to atmosphere from soil
        - Use of biochar to reduce nutrient loss from feedlots
- Precision Agriculture.
  - Decision Support System (DSS): A computer-based information system for organized decision making which is based on an artificial intelligence or an expert system that is a computer system that emulates the decision-making ability of a human expert.

Why is there a need for "New Approaches to Soil Management"?

The new approaches to soil management are based on a principle indicating that soil (pedosphere), as a medium for food, feed, and fiber production, must be seen within the context of other attributes of human physical environment such as water (hydrosphere) and air (atmosphere). The new approaches to soil management use new technological advances to produce food in a sustainable way. These approaches are employed in what is now termed "Precision Agriculture."

Soil, Water, and Air Conservation

Soil and water are essential resources for the production of food, feed, and fiber. The food and fiber are renewable resources that can be produced again once they are exhausted. The soil that is used to produce food is not renewable. The water is vital for plant growth but the supply of water is limited in many areas of the world. Gradual changes resulting from persistent processes such as soil erosion usually escape attention despite their fundamental importance. Soil conservation focuses on ways to maintain soil productivity while using it to grow plants to produce food. Water conservation techniques are aimed at preserving the usability of water for various needs. The conservation of air concerns itself with ways that the quality of air could be maintained to protect the biota and people from illnesses and loss of optimal functions. Modern techniques of soil management approach see the soil conservation within the context of a broader system that includes water and air conservation.

Sustainable Use of Natural Resources and Soils

New Approaches to Soil Management fall within the realm of sustainable use of all natural resources. Soil quality indices are calculated using mathematical models with the aid of computer software. These indices are being modified and improved with the expansion of knowledge about soils and the inclusion of developments in technology. The difference between soil fertility and soil quality is now clearly explained (O'Neil et al., 2005a; Tȯth, et al., 2007).

Agricultural Sustainability

"Agricultural sustainability is defined by four generally agreed-upon goals:

1. Satisfy human food, feed, and fiber needs, and contribute to biofuel needs.
2. Enhance environmental quality and the resource base.
3. Sustain the economic viability of agriculture.
4. Enhance the quality of life for farmers, farm workers, and society as a whole.

To be sustainable, a farming system needs to be sufficiently productive, robust (a system is robust when it is able to continue to meet the goals in the face of stresses and fluctuating conditions), use resources efficiently, and balance the four goals mentioned above." (National Research Council, 2010). The difference between "Robust Systems" and "Efficient Systems."

New Approaches to Soil Management

As discussed previously, soil management is now seen within the context of the environmental management. The trend in world population dynamics points at even higher growth in the decades to come. Due to advances in medical science and technology, the life expectancy in India went from 38 years in 1952 to 64 today; in China, from 41 to 73. The population in India, china, and sub-Saharan Africa are expected to grow in the next 40 years. The global threats such as poverty, decline in agricultural production, scarcity of water, fertilizer shortage, increasing incidents of cataclysmic climatic events and the overall warming of the troposphere and the hydrosphere are among an increasing number of global threats that should be addressed. To tackle these megatrends, scientists face a daunting task. It is clear that not one single technology can undertake all these issues; what is required is a system of management that is powerful enough to educate the citizens and to pressure the decision makers (politicians) to come together to accept scientific findings and recommendations over the pressure from the special groups such as the fossil fuel cartels and advocates of combustion. These pressure groups mislead the public by making them believe that systems based on combustion (and all other carbon positive systems) are the only means to produce the needed energy for the burgeoning population. It has been proposed by Lehmann (2009) that a system that includes biochar can be one of the promising approaches that can mitigate some of the human-generated threats to the environment. Biochar is a valuable soil amendment that enhances soil quality and promotes better plant growth and higher yield. Additionally, a system that involves biochar has the ability to sequester the atmospheric carbon dioxide; such a system is carbon negative.

Use of biochar as a soil amendment

Biochar plays a beneficial effect in all types of soil but its effects are more pronounced in soils that most benefit from the application of an amendment. Biochar enhances soil physical properties. It lowers the bulk density and improves the available water capacity. It promotes earthwork growth and improves the hydraulic conductivity of soil.

Biochar improves soil chemical properties. It increases the soil pH and makes nutrients more available when applied to acid soils. Biochar also carries mineral matter that is water soluble and has a positive effect on nutrient availability and plant growth. The sorption properties of biochar help retaining some nutrients such as P and N and slowly releases these nutrients to plant roots. The cation exchange capacity of biochar helps with adsorption and exchange of cations such as K, Mg, and Ca. Biochar also enhances the favorable chemical properties of soils through its effect on microbial biomass particularly in the rhizosphere. Biochar is not a fertilizer but a carrier of nutrients to plant roots.

Biochar has an effect on the makeup of the microorganisms in the soil. There are reports that biochar enhances the microbial population in the soil and promotes biochemical reactions that would help plant growth. Optimal use of biochar does not inhibit soil enzyme activities (Bayan, 2013b) and imparts a positive effect on nutrient cycling in the soil environment.

Biochar is recalcitrant in the soil and for the most part remains active in the pedosphere for centuries. Without the recalcitrant nature of biochar in the soil environment, the biochar system of soil and environmental management will be meaningless. It is this longevity of biochar in the soil that renders the system as a viable tool to sequester atmospheric CO_2.

What Is Biochar?

Biochar is the solid byproduct of biofuel production from the biomass in an oxygen deprived environment. The other products are the combustible gases (syngas) and a liquid phase (biofuel). Biochar is produced through a process named pyrolysis in which the biomass components namely the cellulose, hemicellulose and lignin are converted into a solid components whose structures approache that of graphite as the thermal energy is increased. Biochar structure includes functional groups that are responsible for the sorption properties of biochar. A biochar that is produced at higher temperature has more sorption capacity.

How Is Biochar Produced?

There are different techniques to produce biochar. These techniques are all based on exposing the biomass to thermal energy in an oxygen deprived environment. Traditionally charcoal is produced using large pit kiln, mound kiln, brick kiln (FAO, 1983), transportable metal kiln (Paddon and Harker, 1980), Missouri-type charcoal kiln (Maxwell, 1976), and the continuous multiple hearth kiln for charcoal production (Maxwell, 1976; Brown, 2009). There are more advanced techniques for the production of biochar including, screw pyrolyzer with heat carrier, fluidized-bed fast pyrolysis reactor, gasifiers suitable for co-production of producer gas (low calorific value gas consisting of CO and N) and biochar, and wood gas stoves. These techniques are described in Brown (2009). The two main techniques are fast pyrolysis that generates 10-12% biochar and the slow pyrolysis that result in 24-31% biochar (Bayan, unpublished data).

Types of Pyrolysis

Fast: Moderate Temp ~500˚ C. Short vapor residence time ~ 1 sec; Liquid (75%); Char (12%); Gas (13%)
Moderate: Moderate temperature ~500˚ C. Moderate vapor residence time ~10-20sec; Liquid (50%); Char (20%); Gas (30%)
Slow: Moderate temperature ~500˚ C. Very long vapor residence time ~5-30min; Liquid (30%); Char (35%); Gas (35%)
Gasification: High temperature >750˚ C. Moderate vapor residence time ~10-20sec; Liquid (10%); Char (20%); Gas (85%) (Brown, 2009).

Pyrolysis of Biomass

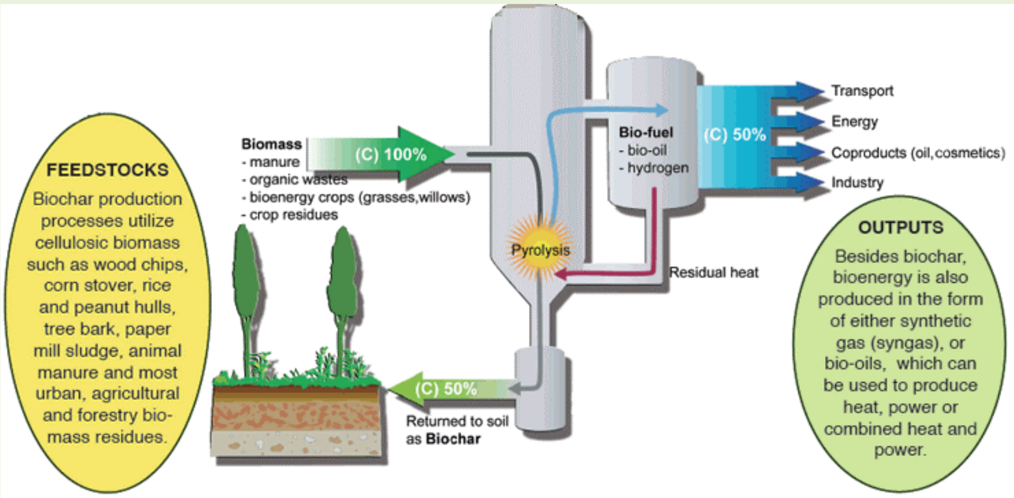

Figure 1. Pyrolysis
Source: http://www.biochar-international.org/technology

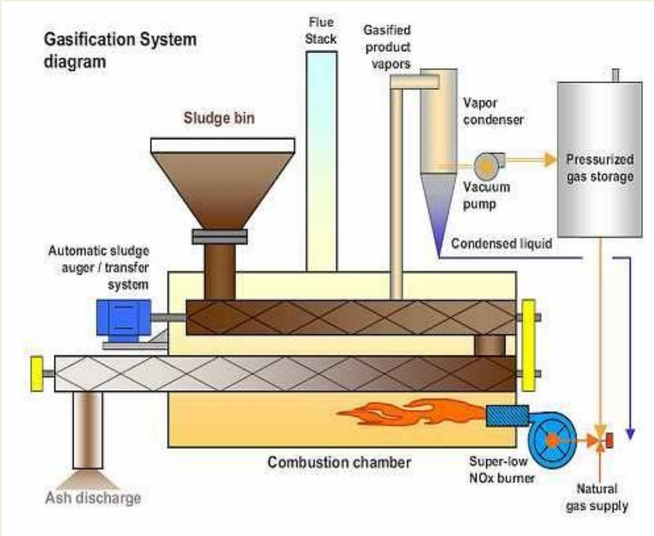

Figure 2. Schematic of a pyrolyzer
Source: http://terrapreta.bioenergylists.org/node/1377

Figure 3. A pyrolyzer
Source: http://eefcenergy.com/technology/

Biochar Constituents

The carbon bearing products of photosynthesis consist of aromatic polymers and polysaccharides such as hemicelluloses, cellulose, and lignin. At thermal values above 120 °C, organic constituents of wood begin to undergo thermal decomposition mostly by losing their structurally held water. Hemicelluloses break down between 220-315 °C, while cellulose goes through degradation at 315 °C to 400 °C. And the lignin constituents of wood start degrading at 160 °C and the process continues beyond 600 °C (Sjöström, 1993; Yang et al., 2007). The significant loss of volatiles leaves behind a solid amorphous carbon matrix

(Downie et al., 2009; Yang et al., 2007). The proportion of the aromatic carbon in biochar increases as the temperature in the pyrolyzer is raised. The volatiles leave the feedstock beginning with water, followed by: hydrocarbons, vapors containing compounds with heavy molecular structure (tarry), hydrogen, carbon monoxide and carbon dioxide. And, the alkyl and O-alkyl carbon convert to aryl carbon (Baldock and Smernik, 2002). At higher thermal value (~330 °C) the sheets of conjugated polyaromatic carbon start to grow laterally and eventually coalesce. At thermal values above 600 °C, carbonization becomes the dominant process and the structure becomes graphitic with order in the third dimension (Verheijen et al., 2010). Therefore, carbonization involves removal of most non-carbon atoms yielding biochar that could consist of 90% carbon from woody feedstock (Antal and Grønli, 2003; Demirbas, 2004). A biochar particle comprises of a stacked crystalline graphene sheet and a randomly ordered amorphous aromatic structure (Bourke et al., 2007; Downie et al., 2009). The disordered amorphous aromatic structure can hold hydrogen, oxygen, nitrogen, phosphorus, and sulfur as heteroatoms giving rise to highly heterogeneous surface chemistry and reactivity of biochar (Verheijen et al., 2010).

Biochar Effects on Plant Growth

In a greenhouse experiment 2% application of biochar to an Entisol (young soil without horizonation – American Soil Classification System, Soil Taxonomy) increased yield of soybean plant significantly. Although biochars have different effects, application of biochar increased root length, root dry weight, stem height, leaf surface area, and the developed pods significantly (Bayan, 2013a).

Other Uses of biochar in Agriculture

Biochar has been used as a carbon feed after mixing with wheat bran resulting in reduced methane emission from animal waste (study from Vietnam and another study by Hans-Peter Schmidt, Delinat-Institute for Ecology and Climate Farming in Valais (Switzerland)). Biochar has been used as bedding for animals on the feedlot. It has been used as a manure additive. When it was mixed with chicken feed, it reduced the mortality rate of chicken. When biochar is fed to animals, they produce more milk and better quality milk and get sick less. It reduces emission of greenhouse gases such as NH_3 and CH_4 from feedlots and the manure that is good for the ecosystem. Biochar can also be combined with minerals to produce different complexes that could be used in agriculture for consumer uses such cosmetics.

Novel Uses of Biochar

Biochar is a big player in the bioeconomy and so many other things. It can be used to more efficiently produce bioenergy. It can be used for the treatment of drinking water. In exhaust filters, industrial materials like carbon fibers and plastic semiconductors, in cosmetics, in medicine, in textile, building materials such as biochar plaster (mixture of biochar with clays); use in indoor rooms, for insulation, humidity control, and to absorb toxins. With the use of biochar in the building material we can finally speak of a building material that is sustainable. One can produce biochar bricks when biochar is added to cement. There are more than thirty patents in China and Japan involving use of biochar as a building material. One can build a biochar house and explain to the future generation that hundreds of years from now the house can be recycled as a soil amendment. Hans-Peter Schmidt has made biochar pillows for himself and his family! Biochar absorbs the IR radiation from cellphones. It also absorbs any body odor. There are also other uses for biochar...

Use of Biochar in Organic Farming

Biochar regulates the nitrogen and other nutrients in compost when mixed with it. Normally compost does not last in the soil environment more than a few years but biochar extends the effectiveness of the compost. It increases the soil humus over time and it interacts with it and stabilizes it. Biochar and compost increase the CEC of the soil significantly. Biochar can be saturated with organic-based insecticides before application to plants. Some of the pesticides will last longer when delivered by biochar.

Effect of Biochar on Soil Enzymes and Nutrient Cycling in the Pedosphere

Soil enzymes are protein catalysts that play a significant role in nutrient availability and cycling in the soil environment. In a greenhouse study Bayan (2013b) concluded:

Effect of time: The overall activities of enzymes studied in this greenhouse experiment generally increased throughout the course of this study.

Effect of Biochar type and rates:

1. Biochar type and its application rate affected the activity of acid phosphatase. At 5% miscanthus biochar lowered the activity of this enzyme significantly. At 2% application rate, however, this effect was not significant.

2. The pine biochar reduced alkaline phosphatase activities significantly

3. The activity of arylamidase increased significantly by the presence of miscanthus biochar regardless of the application rate. The pine biochar, on the other hand, did not affect the activities of this enzyme

4. The activity of β-glucosidase was significantly lowered by miscanthus biochar. The inhibition was exacerbated at the higher rate of application but the pine biochar did not affect the activity of this enzyme

Effect of biochar on nitrogen loss to atmosphere from soil

A large fraction of the N applied to soils is lost as nitrogen oxides to the atmosphere and large portion is lost as NO_3 from the soil column. These losses seriously impact the environment and affect public health. Biochar is capable to adsorb nutrients and prevent nitrogen losses through leachate or nitrous oxide emissions. "Preliminary results show that biochar has the potential to prevent N losses at lower fertility levels but no interaction effects on plant production were observed. Large spatial variability was observed within studied plots, especially for (N_2O) fluxes. However, decreases in N_2O emissions in biochar amended plots for some of irrigation or precipitation events were observed. These data also suggest that biochar can improve soil properties such as pH, aggregation and soil microorganisms." (Pereira et al., 2012).

Use of biochar to reduce nutrient loss from feedlots

Biochar adsorbs the nitrogen in urea. In a study Widowati et al. (2011) reported that a soil treated with biochar adsorbed nitrogen. They reported that the nitrogen loss due to leaching from biochar treated soil column was 470 – 510 mg as compared to 641 mg in the untreated soil. Biochar has been shown to act as an absorber of NH_3 and water-soluble NH_4^+. Steiner et al. (2010) reported that ammonia concentrations in the emissions of pine biochar treated poultry litter were lower by up to 64% and total N losses were reduced by up to 52%. They concluded that biochar might be an ideal bulking agent for composting N-rich materials.

Precision Agriculture

The following are needed:
1. A positioning system (including the Global Positioning System)
2. A system to monitor the yield and map it out
3. Means to sample soils for analysis
4. Remote sensing technology from an aircraft or via satellites
5. Variable rate technology that allows application of different rates of fertilizer at locations across the field.
6. Decision Support System (DSS): A computer-based information system for organized decision making which is based on an artificial intelligence or an expert system that is either fully computerized or operated entirely by humans or a combination of both.

According to McBratney et al. (2005) the development of proper DSSs for implementing precision decisions remains a major issue and a stumbling block to adoption of precision farming. Other critical issues include insufficient recognition of temporal variations (variants that are a function of time), lack of whole-farm focus, crop quality assessment methods, et cetera (McBratney et al., 2005). Remote sensing plays a significant role in making precision agriculture a reality (Figure 4).

Precision agriculture aims to optimize field-level management with regard to:

- Crop production: by matching farming practices more closely to crop needs (e.g. fertilizer inputs);
- Environmental stewardship: by reducing agrichemicals through more efficient use of nutrients or reduction of nutrient loss from agricultural land;
- Economics: by enhancing competitiveness through more efficient practices (e.g. through application of biochar mixed with compost or residue from the feedlots).

"Precision agriculture also provides farmers with information to:

- Establish a database of their farm and farming issues;
- Improve decision-making on issues of soil amendments, plant growth and economic issues
- Foster greater traceability
- Improve marketing of farm products
- Improve the quality of farm products such as oil content in soybean et cetera" (Wikipedea, 2013).

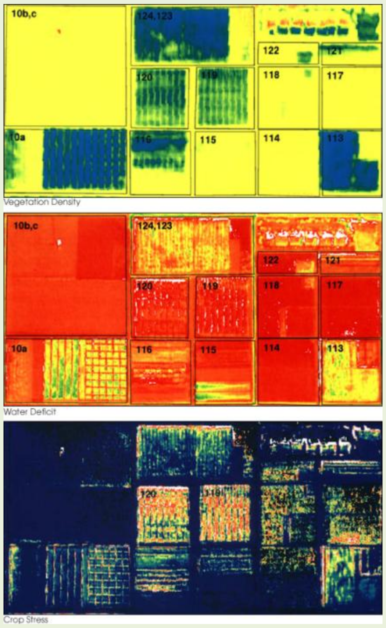

Figure 4. Remote sensing technology is used in Precision Agriculture (NASA Earth Conservatory)

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The Geographic Information System (GIS)
(One Lecture)

The Geographic Information System (GIS) (One Lecture)

-Use of GIS in Agriculture and Environmental Sciences

-What is GIS? Merging of Cartography, Statistical Analysis, and Computer Science

“Soil chemical and physical properties vary spatially, sometimes dramatically so, within a single field. Spatial tools such as the global positioning system (GPS) and geographic information systems (GIS) for storing and analyzing spatial data can help us make better decisions in agriculture, land development, and environmental protection and restoration. In precision agriculture, farmers use GPS, GIS, yield monitors, and variable rate technology (VRT) to apply appropriate quantities of inputs in different parts of a field. Land use planners and developers use GPS and GIS to assess soil spatial variability as it affects position of homes and on-site waste (septic) systems and protection of ground and surface waters and wetlands. Optimal soil management and environmental protection require agricultural and natural resource managers equipped to characterize and manage soil spatial variability.”

Please Note that a hands-on GIS project (learning experience) requires access to a GIS laboratory that is equipped with GIS software. (If a hands-on project is scheduled, number of lectures should increase to several).

Environmental Systems Research Institute (ESRI)

The company was founded in 1969 by Jack Dangermond. “ESRI is an international supplier of Geographic Information System software, web GIS and geodatabase management applications.” The main software that is used in GIS is called ArcGIS.

GIS uses spatial data to carry out interesting analyses. The GIS software (ArcMap) captures the information it needs from tables with certain format such as dBase IV, dBase V, PRN, and CSV. The GIS software cannot capture information from file format such as the MS Excel (*.xls).

Therefore, to utilize the GIS software there is a need for the following data structures: Points, lines, and polygons.

Points such as: A sampling location that is defined by latitude and longitude, power poles.

Lines such as: Roads, power lines.

Polygons such as: A block of land where samples are taken from or a subdivision in the city

Point can sit inside a polygon. Note! Data quality matters.

Spatial features consist of points, lines, and polygons. Each geographic feature has a corresponding data record; in GIS the user works with features and their data records (Gorr and Kurland, 2008).

ArcGIS

ArcGIS is a Desktop software from ESRI. The ArcGIS (v. 10) consists of ArcMap, ArcCatalog, ArcScene, and ArcGlobe. After learning the basics of the GIS software (ArcGIS), one can work on spatial analysis and finally design the basic framework for a complex geodatabase. All these steps are explained by GIS specialists such as Allen (2009) and Allen and Coffey (2011).

Application of GIS in Precision Agriculture

GIS technology has been used extensively in agricultural and environmental science. For example, "fertilizer recommendations based on the average soil condition in the field will likely be either too high or too low for almost any particular spot in that field. Using the GIS computer technology, fertilizer rates can be much more precisely tailored to account for soil variations within a field. For this, soil samples should be collected in a grid pattern within the field. Since each sample is geo-referenced as to its specific location (using a satellite-based global positioning system (GPS), computer software can generate maps showing management zones with defined soil properties and fertilizer needs. Special computer-controlled fertilizer-spreading equipment can be automatically adjusted zone. High technology used to facilitate site-specific nutrient-management systems. The global positioning system (GIS) can plot the location of many soil sampling and plant production sites on a grid basis within a field. A soil sample (composite of 20 cores) is taken from each cell (about 1 ha) and is analyzed. With soil analysis and other data from these cells, computers can help create maps (Figure 5). The top map combines data from the other layers to define "fertilizer rate zones." Satellite/computer systems can then be used to control variable-rate fertilizer applicators that apply only the amounts of nutrients that the soil tests and past soil management suggest are needed. At harvest time, similar satellite/computer connections make possible the monitoring of crop yields on the same grid basis when the harvest machine traverses the field. The yield data are used to create yield maps, which can then be used to further refine the nutrient-management system." (Modified from Brady and Weil, 2010).

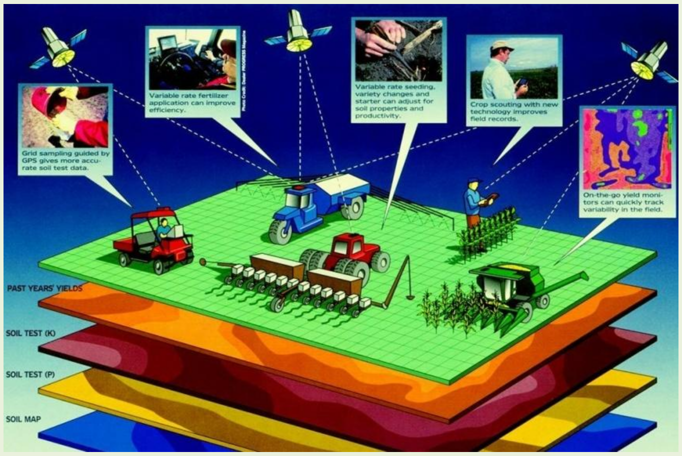

Figure 5. Global positioning and geographic information systems help create a 21st Century farm. Source: http://www.gps4us.com/news/post/Global-positioning-and-geographic-information-systems-help-create-an-environmentally-friendly-farm-20111228.aspx

For a case study of use of GIS for organization and manipulation of soil information one could look at the soil organic carbon stocks in the US (Figures 6-8).

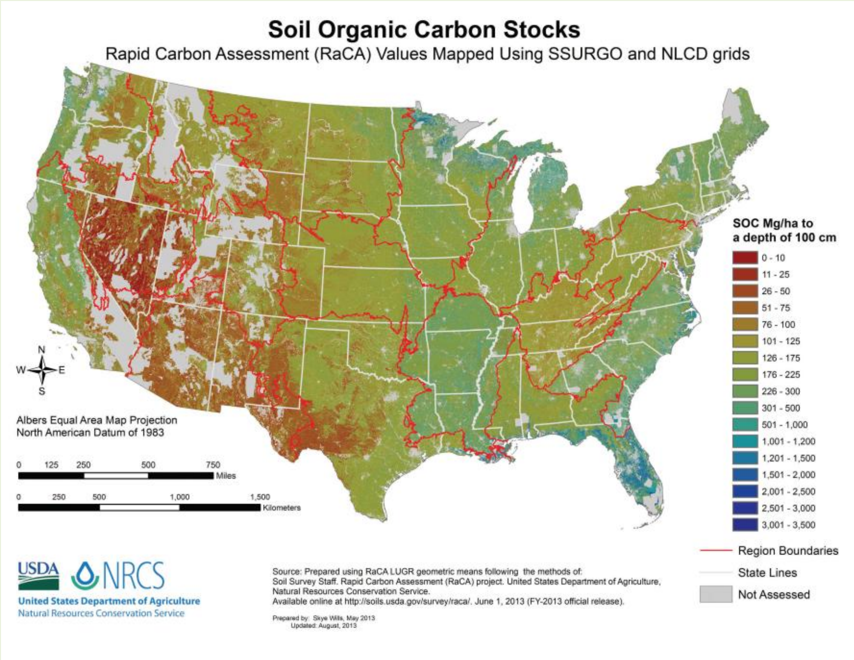

Figure 6. Rapid Soil Carbon Assessment
Source: http://soils.usda.gov/survey/raca/index.html

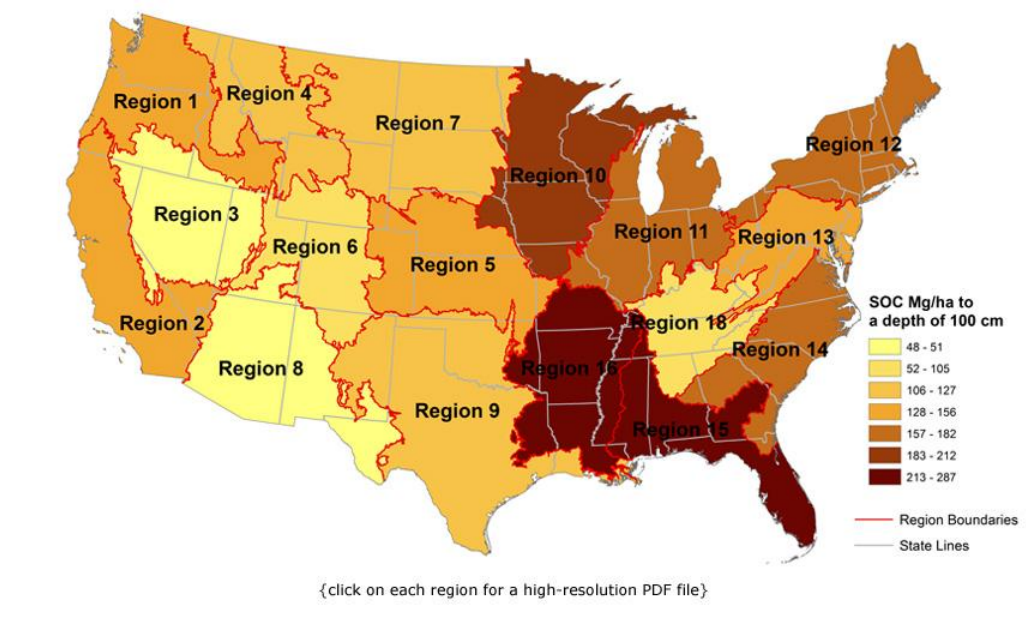

Figure 7. Rapid Soil Organic Carbon Assessment in Mg/ha to a depth of 100 cm
Source: http://soils.usda.gov/survey/raca/index.html#methodology

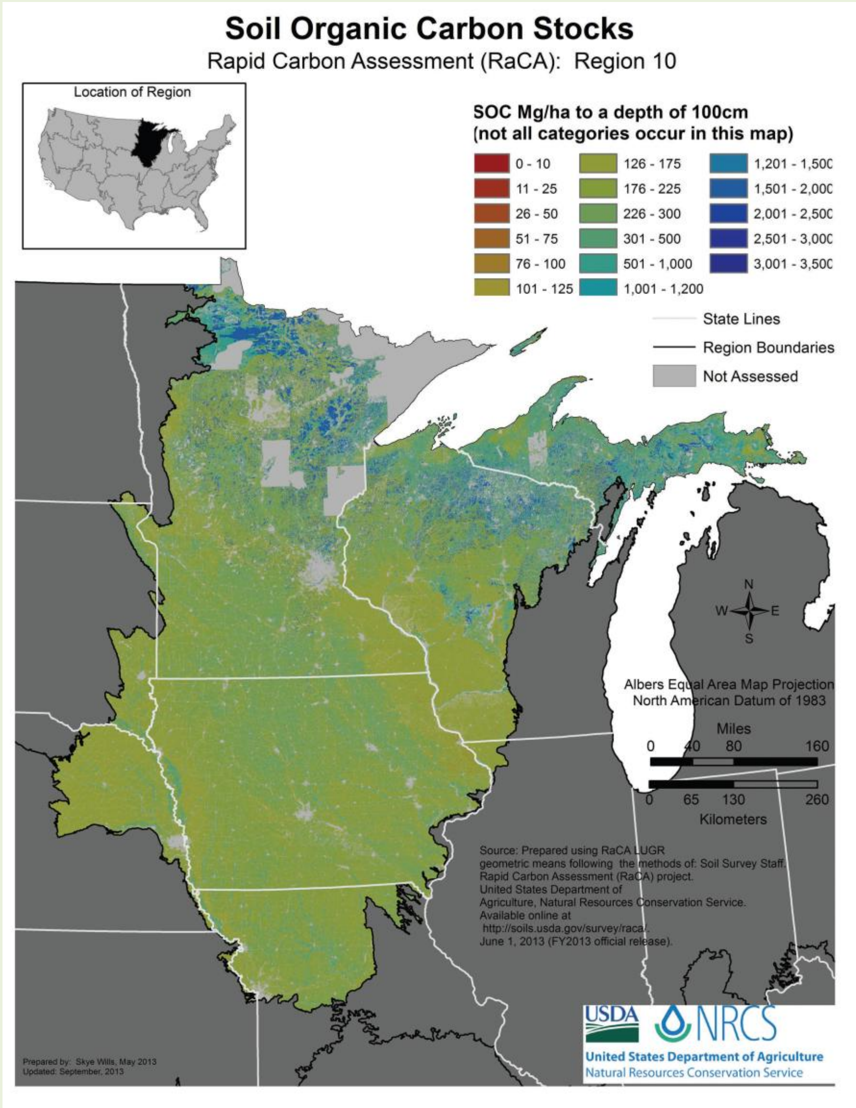

Figure 8. Rapid Soil Organic Carbon Assessment in Region 10 of the US
Source: ftp://ftp-fc.sc.egov.usda.gov/NSSC/raca/RaCA_region10.pdf

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Organic Farming
(Two Lecture)

While they represent a small portion of the total U.S. crop production, organic farmers had more than $3.5 billion organically grown agricultural commodities in 2011, according to the results of the 2011 Certified Organic Production Survey, released by USDA's National Agricultural Statistics Service (NASS). Organic sales totaled more than $3.53 billion in 2010, about 0.9 percent of total U.S. farm receipts, and an increase from 2008 reports. The data from 2008 included farms that were not certified as organic, but produce commodities classified as organic. The 2010 survey collected data only from certified organic operations. The U.S. sales of organic foods and beverages grew from $1 billion in 1990 to $26.7 billion in 2010. The sales in 2010 represented 7.7% growth over 2009 sales. The total U.S. organic sales, including food and non-food products, were $28.682 billion in 2010, up 9.7% from 2009 (Iroquois Valley Farms, 2012).

"The philosopher Paul Thompson (2010) notes that one way to explain why debates over sustainable agriculture are so intense is that there are different perspectives as to what should be the objectives of agriculture and how agriculture should be structured. One view is termed **the industrial philosophy of agriculture**. According to this view, agriculture is just another sector of an industrial society where products are produced at the lowest cost possible and in a manner that provides sufficient food and fiber for society. The trend to fewer and larger commercial farms is not seen as a problem; rather, it is a way to capture economies of scale and lower the costs of food, fiber, and energy production. Indeed, advocates of industrial-scale agriculture view it important to export this structure to other nations to assure worldwide food sufficiency. Essentially, this view sees landscapes in terms of commodities the land can produce; thus, industrial philosophy puts great emphasis on increasing yields per acre or pounds of meat per animal. Although there are concerns within this philosophy about fairness to labor, the vitality of communities, animal welfare, and negative impacts on the environment, it is argued that those issues can be addressed without overhauling the industrial structure of agriculture.

Thompson terms a countervailing viewpoint as an **agrarian philosophy of agriculture** (sometimes called alternative or multifunctional agriculture) that views agriculture as having an important social function above and beyond its ability to produce food, feed, fiber, and biofuel. The social functions include providing positive ecological services and protecting ecological integrity and functioning. Because ecosystems place limits on what kind of farming can be continuously conducted, the agrarian philosophy believes that farming should not be conducted in such a way as to significantly harm ecological functioning; indeed, farming would restore ecosystems by recognizing the complex ecological relationships among plants, soils, and livestock. The agrarian philosophy questions whether the practices of industrial agriculture – with its heavy reliance on purchased inputs, particularly agricultural chemicals – are sustainable. Proponents of this view frequently advocate for reducing or eliminating those practices. Also, the agrarian philosophy frequently focuses on social sustainability: that is, the need for agriculture to support and be a part of rural communities. The large scale of industrial agriculture, and the perceived negative effects of consolidation of farms and ranches or diverse family farms, hence, is not conducive to sustaining rural communities. There is also concern about the effect of industrial agriculture on the welfare of agricultural workers and farm animals. The social sustainability concerns get reflected in calls for "fair trade" or for eating locally grown foods and "humanely produced" animal products.

The two contrary philosophies illustrate the disagreements about agriculture's sustainability have much to do with differing perceptions on outcomes and the desirability of the outcomes produced by various ways to organize agricultural production. That is, there are different philosophical beliefs about what the agrifood system should do for us as a society; sustainability is a social goal (Thompson, 2010).

Others dispute that there are important differences between the visions of what agriculture should be, but they note that many goals do not result in as many conflicts between the outcomes of various systems as have been portrayed. For example, with respect to yields, systems that move toward increased sustainability are not necessarily small-scale, traditional agriculture, and they can be as productive as conventional and industrial systems. On other hand, small-scale, diversified farms might be better associated with certain types of robust rural communities." [Quoted from (NRC, 2010) with some modifications].

The organic cropping system is of interest as an alternative to the conventional type because its approach is based primarily on using biological processes to achieve high soil quality, control pests, and provide favorable growing environments for productive crops by prohibition of synthetically manufactured agrichemicals. For farm products to meet organic standards, farmers either substitute "organic" inputs or use "biological structuring to achieve a high level of internal ecosystem services in their farming systems to permit high efficiency and productivity. Most productive organic farms are highly integrated and use what is referred to as a holistic approach to manage agricultural operations and their processes and impacts (Vandermeer, 1995; Gliesssman, 1998; Altieri, 2004).

Furthermore, farmers have developed organic cropping systems for most major crop commodities and are located in nearly all major agricultural ecoregions of the United States (USDA-NASS, 2009). The NRCS (Natural Resources Conservation Service) in the U.S. "promotes farming systems that use a combination of conservation practices to protect natural resources (soil, water, air, plant, and animal), encourage long-term sustainability, and help move the farm forward on the "Crosswalk to Organic" farming. Producers can adopt many conservation practices during their "organic transitioning" period to improve soil quality, establish buffer zones, and meet NOP (National Organic Production) Crop Production Standards. Key practices include cover crops to improve soil quality, provide nutrients, and control pests; establishment of beneficial insect habitat; residue management; and composting manure (USDA-NRCS, 2013)."

Principles and Practices of organic Farming

Organic farming started in Europe in the early part of the 20th century and has evolved over the years. The majority of organic farms today are guided by either local or international certification requirements. These requirements are assembled through broad farmer and industry collaboration to regulate the rapidly growing marketplace for organic products. The following principles and practices are based on popular organic literature and represent popular beliefs and values of practitioner-derived systems.

1. Understanding and managing biological processes to regulate balance, flow, and timing of nutrient levels and availability; achieve pest-predator balance; and maintain healthy and productive crops and animals.

2. Avoiding synthetic chemicals. Organic agriculture does not permit the use of synthetic chemical pesticides and fertilizers. An organic management approach needs to go beyond substitution of chemical inputs by approved organic inputs and needs to include the principles and practices explained here.
3. Building healthy soil. Organic farming focuses on building healthy and fertile soil that has high microbial activity, is rich with beneficial and diverse microorganisms, and is well-balanced in organic matter and humus. Good soil health is attained largely through cultural and biological management methods and use of natural organic inputs. Building and maintaining healthy soil is regarded as a key factor in maintaining plant health, which is thought to help avoid pest and disease problems by preventing crop stress or nutrient imbalance. Soil health is understood to be a basis for maintaining healthy balances of soil organisms in the farm (USDA-SARE, 2009). Nutrient cycling and regulation of the flows and temporal availability of nutrients to crops is a key goal of soil management.
4. Managing biota within the system. Soil fauna are seen as critical to a healthy soil. Pest-predator balance within the soil and across the landscape is regarded as important to all systems, but is critical to many fruit and vegetable crops.
5. Cycling nutrients. Organic agriculture aims to foster the cycling of nutrients and energy within and beyond the farming system. The cycling of energy and materials links the living organisms to the nonliving parts of the systems. Microorganisms cycle energy and chemicals from dead organic matter back into food chains (Lindeman, cited in NRC, 2010). Nutrient cycling is fostered in organic farms using various methods, including making and using compost, incorporating cover crops, and integrating crop residues.
6. Conserving biodiversity and working with ecological processes and ecosystem functions. Organic farming aims to enhance biodiversity in and around the farm because it is believed that biodiversity can help maintain a balanced ecosystem. Organic farmers attempt to work with and enhance beneficial ecological processes and to take advantage of ecosystem functions. For example, farmers try to enhance ecosystem functions by planting diverse plants on the farm to attract beneficial insects.
7. Adapting to local conditions to maintain balance. As in all farming systems, no uniform “prescriptions” for organic farming practices work for all farms. The methods are not standardized and have to be adjusted to local conditions. Crops need to be balanced with local growing conditions and ecosystem. Organic growers will likely change their practices over time as they learn innovations and as they adapt their methods to evolving environmental and economic conditions.

Other topics of interest in Organic farming include:

Impact on Productivity and Environmental Sustainability

Impact on yield, nutrient cycling and soil quality, water quality, and weeds.

Economic Impacts

Social Impacts

Impact on labor practices, food adequacy, food quality and nutritional completeness, and community well-being.

“Organic production has been practiced in the United States since the late 1940s. From that time, the industry has grown from experimental garden plots to large farms with surplus products sold under a special organic label. Food manufacturers have developed organic processed products and many retail-marketing chains specialize in the sale of "organic" products. This growth stimulated a need for verification that products are indeed produced according to certain standards. Thus, the organic

certification industry also evolved. By the late 1980s, after an attempt to develop a consensus of production and certification standards, the organic industry petitioned Congress to draft the Organic Foods Production Act (OFPA) defining "organic".
Standards
Certification
Accreditation
International Procedure
Compliance and Enforcement."

And other topics of interest.

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