Hunger and Environmental Nutrition

a dietetic practice group of the
Academy of Nutrition and Dietetics

ORGANIC TALKING POINTS

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According to the United States Department of Agriculture (USDA) Economic Research Service, consumer demand for organically produced food continues to increase. In 2013, 81% of families reported that they are purchasing organic at least sometimes, with 41% of those families being new entrants into the organic market (Organic Trade Association, 2013). The sales of organic products are estimated to produce $35 billion in 2014, with fresh fruits and vegetables outselling other food categories. While the buying habits and demographics of consumers vary, overarching themes for organic purchasing behaviors exist: organically produced goods are preferred due to consumers' interest in health, the environment, and animal welfare (USDA, 2014).

In an effort to empower Registered Dietitian Nutritionists (RDNs) to speak with confidence and competence on the evidence surrounding organic food production, members of the Hunger and Environmental Nutrition Dietetics Practice Group (HEN) have synthesized the most current research into easy-to-use Talking Points. The Organic Talking Points are designed to inform RDNs about key issues surrounding organic food production in the following four areas:

- Food labeling regulations
- Requirements for crops and livestock production
- Demonstrated benefits to human, environmental and community health, as well as food safety
- Gaps and areas of unsettled science where further research is merited

How to Use the Organic Talking Points

Synthesized Talking Points for use with clients and media appear in Section I. The summary benefits and areas requiring further research are based on the exhaustive literature review found in Sections IV through VIII. More nuanced points are divided by concept and listed in the Table beginning in Section III. More detailed explanations of the overarching concepts along with comprehensive citations are presented in Sections IV through VII, following the Table. Terms appearing in bold are included in the Glossary on page 23 followed by the list of references on pages 26-33.

Section I. Synthesized Organic Talking Points

A. Benefits of Organic Farming Practices:

- Organic farming practices outperform conventional practices in years of drought, and are more resilient to environmental stressors, such as temperature extremes and water scarcity.

- Organic farming practices sequester significantly more carbon in the soil, which may help offset emissions from fossil fuel combustion and other carbon-emitting activities, while enhancing soil quality and long-term **agronomic** productivity.

- Organic farming practices increase the biodiversity of soil, flora, and fauna.

- A published meta-analysis (Gibbons et al., 2014) concluded that the systemic pesticides neonicotinoids and fipronil (neonics) are causing damage to a range of beneficial invertebrates such as earthworms and vertebrates including birds, and are a key factor in the decline of bees. Furthermore, evidence suggests organic farming may help to protect and provide essential **pollinator services**.

- Organic farming practices reduce pesticide, fertilizer, and other chemical runoff, protecting local land and waterways.

- A comprehensive literature review (Forman & Silverstein, 2012) reports that organic farming reduces fossil fuel consumption, reduces environmental pesticide contamination, uses less energy, and produces less waste.

- Organic farming practices promote humane farming practices that protect animal welfare.

B. Benefits of Organic Farming in relation to Food Safety, Antibiotic Resistance, & Human Health:

- Organic produce has significantly lower levels of pesticide residues. According to the American Academy of Pediatrics, pregnant and nursing women, infants, and young children are at potentially greater risk from exposure to **organophosphate** pesticides, due to rapidly dividing cells, smaller body weights, and the establishment of critical metabolic, hormonal, and cognitive pathways.

- Organic farming provides health benefits to the farmer, farmer's family members, and farm workers most notably from reduced exposure to toxic synthetic pesticides. Epidemiological evidence demonstrates associations between pesticide exposure in early childhood and pediatric cancers, impaired cognitive function, and behavioral problems.

- Choosing organic animal products reduces consumers' exposure to potentially harmful **antibiotic resistant** bacteria. Antibiotic-resistant bacteria are significantly less prevalent in organically raised poultry and swine.

C. Areas Requiring Further Research:

Nutrient Composition of Organic Compared to Conventional Agriculture

- While scientific conclusions of significant nutrient advantage across all sectors of organic foods are unsettled, evidence does suggest that organic meat, poultry, and dairy products are naturally higher in omega-3 fatty acids than comparable conventional products. This is likely related to fresh forage in the diet of the organically raised animals. Consumption of organic dairy

products is associated with a lower risk of eczema during the first two years of life (Kummeling et al., 2008). These authors hypothesize "a high intake of omega-3 fatty acid and/or conjugated linoleic acids from organic dairy products by the child is protective against eczema (independent of atopy) and that the mother's intake of these fatty acids during pregnancy and lactation contributes to this protection." (Kummeling et al., 2008). More research is needed in this area.

Yield: Can Organic Be as Productive as Conventional Agriculture?

- While some studies have found organic agriculture does not match conventional in the initial years of cultivation, longer-term studies have found yields to be equivalent, with organic farming practices proving superior in extreme temperatures and drought conditions.

Environmental Impact

- Organic farms may leach less nitrogen into waterways, reducing pollution; however, this effect may depend on crop type and on-farm management practices.

Section II. Organic Food Production, Regulations, & Labels

A. Background

According to the International Federation of Organic Agriculture Movements (IFOAM), organic agricultural production systems are founded on principles that sustain the health of soils, ecosystems, and people. Through tradition, innovation, and science, organic agriculture utilizes ecological processes, biodiversity, and local conditions that benefit the environment and promote fairness for all involved (IFOAM). In 1990, the United States Department of Agriculture (USDA) established the Organic Foods Production Act to form a national standard for the marketing and production of organic foods, and to facilitate interstate commerce of organic products. This act also created the National Organic Program (NOP). Labeling standards developed by the NOP have been in effect since October 2002. These standards apply to all raw, fresh, and processed products containing organically raised agricultural ingredients (USDA, 2012).

Organic certification verifies that a farm or handling facility complies with the USDA organic regulations, allowing the producer to sell, label, and represent that product as certified organic, as well as use the USDA organic seal. A USDA-accredited private, foreign, or state entity oversees organic certification. The farmer or producer pays the costs of inspection and certification to the accredited certifying agent (ACA). There are numerous ACAs currently operating worldwide. Examples of certifying agencies include California Certified Organic Farmers (CCOF), Quality Assurance International, and Oregon Tilth Certified Organic (OTCO) (Baier, 2012; USDA, 2012). International organic agriculture definitions, regulations, and guidelines have been discussed elsewhere (McCullum-Gomez and Riddle, 2009).

Organic farming and organic certification are not synonymous. Farming is a practice, whereas organic labels are legal descriptions. A 2008 report, *Factors Associated with Deregistration among Organic Farmers in California*, identified barriers to maintaining organic certification. Regulatory issues, such as paperwork and record keeping, as well as certification costs, were among the most common barriers reported by organic growers (Sierra et al., 2008). Despite these barriers, the organic industry continues to flourish, both domestically and internationally. In a 2014 press release, the USDA reported that there are 18,513 organic farms and businesses in the US, representing a 245% increase since 2002 (USDA, 2014). Additionally, the Agricultural Act of 2014, commonly referred to as the Farm Bill, adopted numerous provisions that support organic farming practices and address the aforementioned barriers:

- $20 million annually for dedicated organic research, agricultural extension programs, and education.
- $5 million to fund data collection on organic agriculture that will give policymakers, organic farmers, and organic businesses data needed to make sound policy, business, and marketing decisions.
- Expanded options for organic crop insurance to protect farmers.
- Expanded exemptions for organic producers who are paying into commodity “check off” programs, and authority for USDA to consider an

application for the organic sector to establish its own check off.

- Improved enforcement authority for the National Organic Program to conduct investigations.

- $5 million for a technology upgrade of the National Organic Program to provide up-to-date information about certified organic operations across the supply chain.

- $11.5 million annually for certification cost-share assistance, which reimburses the costs of annual certification for organic farmers and livestock producers by covering 75% of certification costs, up to $750 per year (USDA, 2014).

B. Food Label Definitions

The following list defines organic labels common in the US:

- **100% organic:** a USDA agent has certified that all ingredients are organic, including any processing agents. This label may display a USDA Organic Seal.

- **Organic:** all ingredients are certified as organic, with the exception of up to 5% non-organic ingredients, which must appear on the **National List**. The National List includes ingredients like celery powder, chia, and turmeric extract color, and is reviewed every five years to ensure that all listed items meet the allowable standard for organically labeled foods (U.S. Government Printing Office). This label may display a USDA Organic Seal.

- **Made with organic ingredients:** at least 70% of the ingredients in a product are certified organic. The remaining ingredients do not have to come from the National List, but they cannot be produced using prohibited methods (e.g. genetic engineering, sewage sludge, or ionizing radiation).

- **Specific organic ingredients:** the word "organic" is included by producers in the ingredients list to identify an individual ingredient as organic; however, the producer may not place an organic seal or the word "organic," on any main display area of the food package.

- **Transitional:** appears on products that have been grown under conditions that meet organic growing standards, but lack the required length of time for the land to be free of chemical usage (36 months) or the organic certification process has not yet been completed.

The USDA Certified Organic Seal:

Agricultural Marketing Service
National Organic Program

C. 2014 USDA Requirements for Organic Crops & Livestock

Certified Organic Crops

In order to grow certified organic crops, the land must be managed according to a set of defined organic methods. According to the regulations, the farmer must maintain or improve the physical, chemical, and biological condition of the soil and minimize erosion. Crop rotation, cover crops, composting, use of animal manure or green manure, and minimization of tillage are all methods that can be used by organic farmers as part of their soil improvement plan, which must be approved by the certifying agency. Specific requirements include:

- Land cannot be treated with synthetic pesticides, fertilizers, or herbicides for the three years prior to certification.
- Allowable pest and weed management practices include physical, mechanical, and biological methods. Pesticides, herbicides, and fertilizers must be from natural origin. Usually farmers purchase products that have been certified as acceptable for use in organic agriculture by one of two different agencies, the Organic Materials Review Institute (OMRI) or the Washington State Department of Agriculture (WSDA) to assure compliance. Examples of organically approved sprays are insecticidal soaps, oil sprays, and compounds made from various plant extracts. Mechanical and physical methods may include the trapping of insects and the hoeing or burning of weeds. Producers cannot use excluded methods, such as genetic engineering, ionizing radiation, and sewage sludge.

- If desired, the farmer may use allowable synthetic substances, as listed in section 205.601 of Title 7 in the Electronic Code of Federal Regulations (e.g. copper sulfate, boric acid, and hydrogen peroxide). Approved synthetic methods may be used, as regulated by the National List.

- Use of organic seeds is required, when available. The farmer must prove that no organic alternative was available, prior to using non-organic seed, by contacting a minimum of three organic seed suppliers and assessing organic seed availability. The grower is required to document these contacts. Use of **genetically engineered (GMO)** seed is prohibited.

Certified Organic Livestock

Organic certification verifies that livestock are raised according to the USDA organic regulations throughout their lives (USDA, 2013).

- Organic animals for slaughter must be raised under organic methods from the last third of gestation.

- Poultry must be raised under organic methods by the second day of life.

- Livestock must be fed 100% organic feed.

- Cows and other ruminant animals must receive at least 30% feed from dry matter intake, and ruminants must be out to pasture for at least 120 days.

- Producers may use vitamin and mineral supplements, as allowed by the National List.

- Conventionally raised dairy cows may become certified organic when they are provided feed that is at least 80% organic for 9 months, followed by 3 months of 100% organic feed.

- Growth hormones and antibiotics are prohibited from use in organic slaughter-stock animals; however, vaccines are allowed.

- In order to be labeled organic, dairy products must come from animals that have been managed organically for at least 12 months.

- According to the NOP, a producer may not withhold treatment from an organic animal simply in order to keep that animal organic. If an organically approved medical intervention fails, the animal must be given all appropriate treatments; however, if an animal receives a prohibited substance (e.g. antibiotics), the animal, and/or its products must not be sold as organic post-treatment.

- All animals must have access to outdoors year round (with the exception of temporary confinement due to mitigating documentable health or environmental considerations).

For more information on USDA Organic Regulations, visit http://www.ams.usda.gov/AMSv1.0/nop.

Section III. Organic Talking Points by Concept[1]

CONCEPT	EVIDENCE-BASED RESEARCH	REQUIRES ADDITIONAL RESEARCH
Benefits of Organic Farming to the Environment	• Organic farming improves soil quality and fertility and increases soil carbon sequestration; the global warming potential can be lower in organic systems. • Organic farming increases **biodiversity** of flora and fauna. • Improvements in biodiversity are achieved because organic farming practices support improved biological pest control and provide **pollinator services** to farmers.	• Management practices that reduce tillage frequency and intensity in organic systems are being developed to reduce soil erosion that may occur in organic systems. • No-till organic systems have been shown to maximize soil components and weed management. More research is needed. • Ongoing research promises to augment **ecosystem services** provided by organic grain cropping systems. • Organic farms may leach less nitrogen into waterways, reducing pollution; however, this effect may depend on crop type. Because of this, more research is needed in this area.

1. The demand for organic food in the US has outstripped supply. Some of the increased demand has been met by increased imports of organic foods from foreign countries (Greene et al., 2009). The identified community, farmer, or environmental benefits associated with imported organic foods would remain in the country of origin.

CONCEPT	EVIDENCE-BASED RESEARCH	REQUIRES ADDITIONAL RESEARCH
Benefits of Organic Farming to the Farmer	• Organic farming provides an economic advantage with an increased profit margin on products, savings on farm inputs, less energy consumption (with exceptions for some crops), and reduced fossil fuel consumption. • Organic farming reduces farm contamination through less waste production. • In developing countries, there is increased market access for organic products and increased "Human Capital" in the form of self-sufficiency. • Organic farming provides health benefits to the farmer, farmer's family members, and farm workers most notably from reduced exposure to toxic synthetic pesticides. • Organic farmers benefit from improved soil quality, which contributes to improved yields of some crops.	• Organically managed soil may increase yields for organic farms in drought years. However, more research is needed.

CONCEPT	EVIDENCE-BASED RESEARCH	REQUIRES ADDITIONAL RESEARCH
Benefits to the Community	• Organic farming practices can assist communities in feeding themselves, especially given the projected growth in the world's population. • Organic technologies are more suited to limited resource populations than hi-tech farming because organic farming requires fewer inputs that must be purchased (e.g., seeds, synthetic chemicals). • Increased labor required on organic farms may be a benefit in developing countries, as farm labor is a source of employment. • Organic or near-organic farming practices may increase **social capital** by improving local partnerships, increasing connectedness with external organizations, and increasing farmers' access to markets. • Due to improved soil quality, organic production is likely to be more resilient against droughts and floods, which may lessen the impact of these events on the community. • Organic production and consumption decreases communities' exposure to neurotoxic pesticides.	• In some cases, yields in organic farming can be lower; however, yields vary by crop type, climate zone, and on-farm management practices.

CONCEPT	EVIDENCE-BASED RESEARCH	REQUIRES ADDITIONAL RESEARCH
Nutritional Benefits of Organic Food	• Organic produce is similar in taste and nutrient content to conventional produce, except with regard to **antioxidant**/ polyphenolics, which have been found to be significantly higher in organically produced food. • Organic meat, poultry, and dairy products are higher in omega-3 fatty acids than comparable conventional products. This is likely related to fresh forage in the diet of the organically raised animals.	• Long-term organic cultivation may increase nutrient content of certain produce varieties. • Organic produce may be lower in **nitrates**. • There are limited data available on the nutritional quality of organic eggs and processed organic foods. • Organic wheat flour was found to be lower in Ca, Mn, Fe, and protein content; however, it exhibited better digestibility and had significantly higher amounts of micronutrients K, Zn, and Mo.

CONCEPT	EVIDENCE-BASED RESEARCH	REQUIRES ADDITIONAL RESEARCH
Food Safety & Health	• Epidemiological evidence demonstrates associations between pesticide exposure in early childhood and pediatric cancers, impaired cognitive function, and behavioral problems. • Organic produce consistently has lower levels of pesticide residues. • A diet consisting of mainly organic foods reduces children's exposure to common pesticides present on food produced through conventional farming methods. • Eating an organic diet for a week resulted in pesticide levels dropping by almost 90% in adults. • Antibiotic-resistant bacteria are less prevalent in organically raised poultry and swine. • Organic grains have lower levels and lower risk for contamination with the **mycotoxin** deoxynivalenol. • Organic flour contains lower levels of the heavy metals arsenic and cadmium. • Organic crops contain significantly lower concentrations of cadmium when compared to conventional crops.	• A pesticide formulation that contains **adjuvants** and active principles is more toxic to human cells than the declared active principle alone. Research solely examining the effect of a pesticide's active principle may not reflect relevant environmental exposures. • Organic production practices may prevent prenatal exposure to **organophosphate pesticides** that damage children's neurocognitive development. • Biological effects of synthetic hormones in humans are unknown. • There are no studies supporting the claim that estrogen found in food derived from animals treated with sex hormones plays a role in early onset of puberty or increases risk of breast cancer.

Section IV. Benefits of Organic Farming to the Environment

Organic farming benefits the environment in a number of ways, including improvements in soil quality and fertility, enhanced top soil carbon stocks, reduced pollution of waterways, and increased biodiversity of plants and animals. Research on **soil erosion** on organic versus conventional farms shows mixed results; however, findings may be affected by confounding variables, including use of organic farming practices by conventional growers. For example, a 2009 survey on organic farming among California producers found that 52% of the initial respondents used organic farming methods without the organic certification (Cantor et al., 2009). This crossover between farming styles is especially relevant to soil and erosion research as the crop rotation, cover crops, and green manure methods of soil building required for organic certification are often utilized in conventional farming. Additionally, depth of soil sampling is not standardized, leading to significant variation in outcomes (Derpsch et al., 2014). Additional research is needed with regard to reduction in greenhouse gases.

Over time, organic farming preserves and improves soil quality, including increased organic matter content, increased microbial biomass, better percolation stability, better water retention, and increased diversity of soil microorganisms (Reganold et al., 2010; Gomiero et al., 2011; Coulter et al., 2013). Results from the Long-Term Agroecological Research (LTAR) Experiment in Iowa demonstrated as much as 40% higher microbial activity in organically managed soil plots (Delate et al., 2013). Studies also show that organic farming practices reduce levels of soil pathogens (Gomiero et al., 2011; Underwood et al., 2011). The extent to which improved soil quality on organic farms results in envi-

ronmental benefits may depend on the use of farming practices like cover cropping and tilling (Cavigelli et al., 2013a).

There are very few studies that directly measure soil erosion from organic versus conventional farms (Cavigelli et al., 2013b). The reduction in soil erosion seen on organic farms is typically attributed to higher soil organic matter content and use of cover crops (Gomiero et al., 2011). In one study, rates of soil erosion with organic farming were three times lower than rates with conventional farming (Gomiero et al., 2011). In contrast, others have reported that soil erosion from manure-based organic systems appears greater than conventional no-till systems; though data are limited (Cavigelli et al., 2013b). However, a controlled plot research study from USDA showed organic farming can build soil organic matter better than conventional no-till farming (USDA Agricultural Research Service, 2007). Scientists have claimed that other studies have not been carried out in a controlled environment for a long enough period to show the benefits of organic farming (USDA, Agricultural Research Service, 2007). The U.S. National Organic Program Final Rule, section 205.205, requires organic farmers to implement soil-building crop rotations, which include sod, cover crops, **green manures**, and **catch crops**, to improve soil quality, break weed, pest and disease cycles, manage nutrients, and prevent erosion. Diversified organic systems with perennial hay crops included in the rotation could maintain a lower weed seedbank and lower weed abundance than simpler grain crop rotations (Teasdale et al., 2004). Using rotations with perennial crops could benefit organic farming systems by reducing weed populations and eliminating the

need for tillage during a significant part of the rotation. Advances in equipment design have also led to improved control of annual weeds by rolling cover crops to form a dense, tight mat of residue in no-tillage organic systems (Teasdale, 2007; McCullum-Gomez and Riddle, 2009). The Rodale Institute is a non-profit organization working in the area of no-till organic agriculture (Rodale Institute, 2014). More research is needed in this area.

While results have been mixed, many studies have found **soil carbon fixation** to be higher on organic farms compared to conventional farms. One 15-year study in the United States estimated that, if organic farming practices were adopted by US corn and soybean farmers, soil carbon sequestration could make up for 1 - 2% of the carbon released each year through fossil fuel combustion (Gomiero et al., 2011). A meta-analysis found that organic farms maintained higher soil organic carbon stocks (by as much as 3.5 metric tons per hectare) and sequestered up to 450 kg more atmospheric carbon per year compared to conventional systems (Gattinger et al., 2012). In contrast, results from an individual 27-year study of multiple crop types in Switzerland showed no difference in soil carbon fixation between organic and conventional farming systems (Leifeld et al., 2009). Mixed results have been reported with respect to nitrogen losses into waterways (Gomiero et al., 2011). A Norwegian study demonstrated that when no protective measures were taken, conventional agricultural practices led to the highest levels of **nitrogen leaching** into waterways (Korsaeth, 2008). However, when protective measures were employed (e.g. catch cropping, split application of fertilizer, and reduced tillage), conventional agricultural systems had lower levels of nitrogen leaching than organic methods (Korsaeth, 2008). Researchers attributed this to the use of unharvested green manure in organic systems. This same study found lower levels of nitrogen leaching from organic dairy farms compared to conventional dairy farms (Korsaeth, 2008).

Regarding gaseous nitrogen losses (which can contribute to greenhouse gases), some studies show no difference between organic and conventional systems, and other studies demonstrate higher losses of nitrous oxide from conventional systems (Korsaeth, 2008; Gomiero et al., 2011). A recent meta-analysis found that organically managed soils emit lower levels of nitrous oxide compared to conventionally managed soils; however, this benefit may disappear when the lower crop yields typically associated with organic farming are taken into account (Skinner et al., 2014). Further research is needed in this area, especially studies comparing farming methods such as tilling, cover cropping, and crop rotating (Cavigelli et al., 2013b; Skinner et al., 2014).

Many studies demonstrate that organic farming supports higher biodiversity of flora and fauna both in terms of **species richness** and **species abundance**. Results for individual groups of flora and fauna show 20% higher plant species richness, 20% higher butterfly species richness, 60% higher butterfly species abundance, and significantly higher species richness and abundance of breeding birds on organic farms compared to conventional farms (Gomiero et al., 2011; Jonason et al., 2011; Winqvist et al., 2011). A recent meta-analysis examining results from 94 different studies demonstrated that, on average, organic farms support 30% higher species richness than conventional systems (Tuck et al., 2014). This same analysis showed that for pollinators such as bees, species richness may be as much as 50% higher on organic farms (Tuck et al., 2014).

While evidence exists that improvements in species diversity are most pronounced in large-scale farming systems, studies demonstrate that these effects are generally independent of **landscape complexity** (Gomiero et al., 2011; Jonason et al., 2011; Winqvist et al., 2011). Results indicate that organic farming can be a benefit to the environment in terms of increasing biodiversity; however, there are mixed results with respect to **biological pest control**. One study demonstrated that an increase in biodiversity only supports biological pest control (ecosystem service to the farmer) in complex farm landscapes (Winqvist et al., 2011). Similarly, increased insect biodiversity appears to translate to increased pollinator services only when organic farms are situated close to native habitat (e.g. mixed-use landscape) (Underwood et al., 2011).

Honeybees are **pollinators** for a wide variety of crops, including almonds and other tree nuts, berries, fruits, and vegetables. In fact, according to the USDA Agricultural Research Service, bee pollination is responsible for more than $15 billion in increased crop value each year (USDA, 2014). In October 2006, beekeepers began reporting losses of 30-90% of their hives. **Colony Collapse Disorder** (CCD) is a phenomenon in which worker bees from a honey bee colony abruptly disappear, causing the colony to stop functioning. Theories on the etiology of CCD suggest multifactorial causes, including pathogen infestation, beekeeping practices, and general pesticide exposure; however, a recent study by Lu et al. (2014) found that sublethal exposure of **neonicotinoids** affected the winterization of healthy colonies, subsequently leading to CCD via

hive abandonment rather than disease (Lu et al., 2014). Likewise, a recently released study in the Netherlands revealed how high concentrations of neonicotinoids, particularly imidacloprid, have negatively affected insectivorous bird populations. Researchers discovered that at imidacloprid concentrations greater than 20 nanograms per liter, bird populations decreased by 3.5% annually (Hallman et al., 2014).

Although still allowed in conventional farming practices in the U.S., the European Commission has restricted the use of three pesticides belonging to the neonicotinoids family for a period of two years, beginning December 1, 2013 (US EPA, 2013). In July 2014, The U.S. National Wildlife Refuge System announced that starting in January 2016 they will no longer use neonicotinoid pesticides in agricultural practices used in the System (US Department of the Interior, 2014).

At the same time, the National Wildlife Refuge System will phase out the use of genetically engineered crops to feed wildlife (US Department of the Interior, 2014). A recently published meta-analysis found that neonicotinoids (imidacloprid and clothianidin) and the insecticide fipronil (neonics) pose a risk to honeybees and other pollinators such as butterflies and to a wide range of other invertebrates such as earthworms and vertebrates including birds (Gibbons et al., 2014).

Section V. Benefits of Organic Farming to the Farmer

Switching from a conventional to an organic farming practice presents advantages and disadvantages to the farmer. Due to organic tilling and cultivation practices, organic farming is more labor intensive than conventional methods. Organic techniques for pest removal, soil additions, and conservation, typically performed manually, include using nitrogen-fixing cover crops and composted manures instead of fertilizers, hand weeding and cultivations to control invasive plant species, and multicrop rotations. Empirical studies dating as far back as 1977 reveal greater labor requirement for organic farms; however, crop choice may affect the amount of labor required (Santos et al., 2012).

Despite increased labor requirements, farmers experience numerous benefits from organic production methods. From lower cost inputs to an improved work environment, the economic, health, and soil improvements experienced by organic farmers are significant.

The United Nations (UN) published case studies of organic farms that demonstrate increased yield, a benefit to natural environment, increased partnerships between groups, increased knowledge, and skill of farmers, better infrastructure, better access to markets, and higher farmer incomes (UNEP-UNCTAD, 2008). However, it should be noted that yields in organic farming vary depending on crop type and climate zones and in some cases organic yields may be lower than conventional yields (Seufert et al., 2012).

In semi-arid central India, organic yields were more stable year-to-year than conventional crop rotations consisting of cotton, soybean, and wheat in a four-year test-cycle (Forster et al., 2013).

Research in southwestern Minnesota found that with diversified rotations, organic farming systems could result in high and profitable crop yields while enhancing soil quality. However, these same researchers concluded that organic input and low external input cropping systems are constrained by greater management and labor requirements and pest management challenges than high external input cropping systems (Coulter et al., 2013).

In the Long-Term Agroecological Research (LTAR) Experiment (Iowa), researchers reported that corn and soybean yields were statistically equivalent in the organic and conventional systems during both the transitional phase (1998-2001) and established phase (2002-2010) of the experiment. Yields for organic oats and alfalfa exceeded county averages (Delate et al., 2013). Based on plot-level data, the economic analysis showed that the organic crops fetched approximately $200 more per acre over the 13 years of the study because of the premium market prices and reduced input costs. On average, labor requirements doubled for the organic systems. There were no significant differences in the number of crop pests (Delate et al., 2013). The organic farmer benefits from biological pest control on landscapes through increased biodiversity (Winqvist et al., 2011).

Researchers found lower yields in organically produced wheat, but producers earned higher returns above operating costs (McBride et al., 2012).

In selecting spring wheat cultivars, organically selected lines produced a significantly higher yield and had a higher kernel weight than conventionally selected lines (Kirk et al., 2012).

While yields were higher in conventional apples than organic, organic apples commanded a price premium throughout the supply chain (Slattery & Livingston, 2011).

Conventionally managed cattle herds had greater rates of ketosis compared to organic herds, and greater milk yield compared to organic herds, which is associated with a greater risk of negative energy balance in early lactation (Richert et al., 2013). Negative energy balance during early lactation in dairy cows leads to an altered metabolic state that may interfere with fertility (Fenwick et al., 2008).

A 2013 synthesis on how transitioning from a conventional to an organic and resource conserving agriculture (ORCA) system affected the livelihoods of African and Latin American farmers revealed improvements in yield, food security, and net income. The farmer's initial agricultural practice (conventional or organic-by-default) and the degree of market orientation strongly influenced the economic improvements experienced upon transitioning to an ORCA system. It is not possible, however, to generalize from these findings, as the synthesis was subject to small sample sizes, selection bias, and inconsistent methods and definitions across the 31 studies examined (Bennett et al., 2013).

A comprehensive literature review reports that organic farming reduces fossil fuel consumption, reduces environmental pesticide contamination, uses less energy, and produces less waste. Additionally, studies show that organically managed soil is of higher quality and has higher water retention, which may increase yields for organic farms in drought years (Forman & Silverstein, 2012).

Costa and colleagues evaluated genetic damage and immunological alterations in conventional and organic farmers. Results indicated an increased presence of DNA damage in conventional farmers who had been exposed to numerous pesticides. The study is limited however by a small sample size and an unequal distribution of individuals in the control, conventional, and organic groups (Costa et al., 2014).

A 2014 systematic review and meta-analysis on the association between non-Hodgkin's lymphoma (NHL) and occupational exposure to the active ingredients and chemical groups in agricultural pesticides in high income countries found positive associations between certain pesticides and NHL. B cell lymphoma was positively associated with phenoxy herbicides and the herbicide glyphosate (Schinasi and Leon, 2014).

Section VI. Benefits to the Community

Once marketed primarily to wealthier consumers, organic products are becoming more readily available to the general public through competitive pricing and a wider selection at major food retailers, as well as the increased prevalence of farmers' markets. Organic foods are typically priced 10-40% higher than conventional foods, though many believe the value of organic food is worth the price differential. However, seasonally available, locally-raised organic produce is usually comparable in price to conventional produce. Consumers and families on a tight budget can also purchase organically produced food through a community supported agriculture (CSA) program. To further contain a family's monthly food costs, seasonally available, locally-produced organic foods can be frozen, dehydrated or preserved for later use (McCullum-Gomez and Scott, 2009). However, even those who choose not to or are unable to purchase organic foods may benefit from their production and consumption, particularly within marginal and poor communities. Reduced pesticide exposure, decreased reliance on external inputs for the local economy, increased environmental stewardship, and improved social capital are all considered community benefits of organic food production.

People living in conventional farming communities and those that eat conventionally grown food are exposed to pesticide residues. Organic production and consumption may decrease American's exposure to neurotoxic pesticides (Forman & Silverstein, 2012).

Exposure to organochlorine pesticides and certain organophosphate pesticides was associated with an increased risk of diabetes among wives of farmers in the Agricultural Health Study (Iowa and North Carolina) (Starling et al., 2014).

Exposure to certain pesticides may increase the risk of developing Parkin-

son's disease by two to six times for people with genetic vulnerability to the pesticides' effect on enzyme function (Fitzmaurice et al., 2014).

Prenatal exposure to organophosphate pesticides has been correlated with lower IQ scores in 7-year-old children. This is true even for children born from women who had elevated pesticide metabolite concentrations in their urines, even when those concentrations were within safe limits (Bouchard et al., 2011).

Fetuses and children can be exposed to pesticides from conventionally grown produce, home-use pest deterrents, and from direct exposure to organophosphate pesticides on farm or through contact with farmers and farm workers (Engel et al., 2011).

Pregnant mothers with a specific genotype who had high prenatal urine measurements of pesticide metabolites (dialkyl- and dimethylphosphate metabolites from organophosphates and paraoxonase) gave birth to children with increased risk for delayed cognitive development. These mothers did not produce as much of the enzyme PON1 to breakdown the pesticide metabolites (Engel et al., 2011). Recently, Shelton et al. examined whether residential proximity to agricultural pesticides during pregnancy was associated with autism spectrum disorders (ASD) or developmental delay (DD). Of the 970 participants in the Childhood Autism Risks from Genetics and Environment (CHARGE) Study, one-third of mothers lived, during pregnancy, within one mile of an agricultural pesticide application. Proximity to organophosphate at some point during gestation was associated with a 60% increased risk for ASD. Mothers living near pyrethroid insecticide applications immediately before conception or during the third trimester had children at greater risk for both ASD and DD. Proximity to carbamate applications also increased risk for DD (Shelton et al., 2014).

Organic agriculture is designed to be a diverse planting system that limited resource communities can rely on for more stability than **monocropping.** Planting variety creates less risk related to weeds, pests, and weather threats (UNEP-UNCTAD, 2008).

There has not been a reduction in food insecurity proportional to the increase in food production over the last 40 years. In other words, increased food supply does not equal increased food security, due to inequity of distribution. However, an International Task Force found that in Africa, organic and near-organic farming practices are well-suited to poor, marginalized smallholder farmers because these practices are less dependent on external inputs and more resistant to environmental stress, such as droughts and floods (UNEP-UNCTAD, 2008).

In Africa, organic production may financially benefit poor families due to the low cost of inputs such as seed, organic soil fortification, and organic pest control practices that are available locally. Organic production also stewards the environment for years of planting to come. Additionally, 93% of participants in these case studies reported improved social capital, including local social organization, new ways of managing collective natural resources, and greater connectedness to external policy institutions (UNEP-UNCTAD, 2008).

All case studies reviewed showed increased yields of food in organic production. Combined with the observed improvements in social capital, infrastructure, and crop resilience, this may improve food access for these communities (UNEP-UNCTAD, 2008).

Organic production is not directly supported by government policy in African countries at this time; with more systematic support, more benefits to rural communities may be achieved (UNEP-UNCTAD, 2008).

Section VII. Nutritional Benefits of Organic Food

Many consumers choose organic foods due to a perception that organics have nutritional or sensory advantages over conventional foods (Zhao & Chambers, 2007). A 2014 systematic review and meta-analysis found that the concentrations of a range of antioxidants/(poly) phenolic acids were substantially higher in organic crops/crop-based foods, including levels of phenolic acids, flavanones, stilbenes, flavones, flavonols, and anthocyanines (Baranski et. al., 2014).

There are a number of factors, independent of production method, which may affect the nutrition and sensory quality of food. These include plant cultivar or animal breed, season, climate, geographic location, soil quality, maturity at time of harvest, and post-harvest handling. Factors that may affect nutrient analysis results include post-harvest storage time and measurement technique (Foreman & Silverstein, 2012; Stracke & Rufer 2009; Palupi & Jayanegara, 2012).

There is currently no standardized definition of "conventional" production, which may also contribute to inconsistent comparative results between organic and conventional foods (Zalecka & Bugel, 2012).

Studies analyzing a wide array of nutrients and phytochemicals found higher concentrations of phosphorus, vitamin C, and phenols in organic produce, and lower concentrations of nitrates (Forman & Silverstein, 2012; Smith-Spangler et al., 2012; Zhao & Chambers, 2007).

Grain studies have yielded similarly mixed results. Organic wheat tends to be lower in protein, but with potentially better protein digestibility than conventional wheat (Vrcek & Cepo, 2014). The specific variety of wheat may drive differences in nutrient composition.

Organically raised poultry contains higher levels of omega-3 fatty acids than conventionally raised poultry (Smith-Spangler et al., 2012). Limited research suggests this may also be true for organically raised pork and lamb compared to conventionally raised pork and lamb (Olson & Pickova, 2005; Angood & Wood, 2008). The availability of fresh forage in the diet appears to be the primary driver of this nutritional benefit.

There is limited research on organically raised beef. Grass-fed beef is higher in omega-3 fatty acids than conventional beef; however, grass-fed is not synonymous with organically raised. While organically raised cows must have access to pasture, and often do consume more fresh forage than their conventionally raised counterparts, they may also be fed organic grain (Daley et al., 2010). Bjorkland and colleagues (2014) found that the fat from grass-fed steers was greater in omega-three fatty acids and lower in monounsaturated and saturated fat. However, consumers rated the grass-fed beef the lowest in

overall liking and flavor. In contrast, Cox et al. (2006) reported that one-third of consumers preferred grass-fed finished beef and were willing to pay a premium for the beef. Similarly, Steinberg et al. (2009) reported that 23% of beef consumers preferred the taste of grass-fed meat and would pay a premium for the meat. Hence, Bjorklund et al. (2014) concluded that, "organic dairy bull calves may represent a potential resource for pasture-raised beef in the United States." (Bjorkland et al., 2014).

Based on the results of a meta-analysis, organic dairy products contain significantly higher quantities of protein, omega-3 fatty acids, and **vaccenic acid**; and significantly lower quantities of oleic acid, linoleic acid, and omega-6 fatty acids. Organically raised dairy cows also have significantly more access to fresh forage, which may explain the differences in fatty acid profiles (Palupi & Jayanegara, 2012). In a U.S.-based study, organic milk contained 62% more omega-3 fatty acids than conventional milk. All individual omega-3 fatty acid concentrations were higher in organic milks, as was the concentration of conjugated linoleic acid (Benbrook et al., 2013). Consumption of organic dairy products was associated with a lower risk of eczema during the first two years of life (Kummeling et al., 2008). These authors hypothesize that "a high intake of omega-3 fatty acid and/or conjugated linoleic acids from organic dairy products by the child is protective against eczema (independent of atopy) and that the mother's intake of these fatty acids during pregnancy and lactation contributes to this protection." (Kummeling et al., 2008). More research is needed in this area.

There is limited research on organic eggs. Organic eggs may be higher in stearic acid and potassium, but also higher in palmitic acid and cholesterol. There do not appear to be consistent differences in overall protein, fat, or vitamin content of organic versus conventional eggs (Matt & Veromann, 2009; Samman et al., 2009).

Section VIII. Food Safety & Health

Organic farming practices reduce the consumer's risk of exposure to pesticides, pathogens, including antibiotic-resistant pathogens, and heavy metals. Exposure to pesticides is of concern due to toxic effects resulting from acute and long-term, low-dose exposures (Forman & Silverstein, 2012). Antibiotic-resistant pathogens pose a significant health concern because the rate at which pathogens develop resistance outpaces the development of new antibiotics. Chronic exposure to heavy metals in food is associated with a variety of negative health concerns, such as gastrointestinal distress, brain, kidney, and neurological damage, and cancer.

Research testing pesticide formulation toxicity, rather than single active principle (AP) toxicity, found that formulations were cytotoxic and far more toxic in general than the AP alone (except for **isoproturon** and its formulated pesticide Matin) even at levels well below agricultural dilutions. Of the formulations tested, fungicides were the most toxic, followed by herbicides and insecticides. It appears that adjuvants, which are generally declared inert, amplify up to 1000 times the toxicity of their APs. Pesticide formulations have been associated with cardiac and central nervous system diseases in humans and developmental disorders and decreased fetal body weight in rodents (Mesnage et al., 2014).

According to the Council on Environmental Health from the American Academy of Pediatrics (2012), research demonstrates associations between pesticide exposure in early childhood and pediatric cancers, impaired cognition, and behavioral problems. The American College of Obstetricians and Gynecologists (ACOG) warns that prenatal exposure to certain pesticides may increase

the risk of childhood cancer; adult male exposure to pesticides may alter semen quality, affect sterility, and increase the risk of prostate cancer; and that postnatal exposure to some pesticides can interfere with all developmental stages of reproductive function in adult females, including puberty, menstruation and ovulation, fertility and fecundity, and menopause (ACOG Committee Opinion, 2013).

Analysis of data from the National Health and Nutrition Examination Survey (NHANES) showed that the odds of children being diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) between the ages of 8-15 increased by 55% with a 10-fold increase in urinary concentrations of the organophosphate metabolite dimethyl alkylphosphate (Forman & Silverstein , 2012).

A systemic review of studies related to nutrient and contamination levels in foods found that children fed organic diets have significantly lower levels of organophosphate pesticide metabolites in their urine. This review found that organic produce has a 30% lower risk for contamination with any detectable pesticide residue as compared to conventional produce (Smith-Spangler et al., 2012). More recently, a systematic review and meta-analysis found that the frequency of occurrence of pesticide residues was four times higher in conventional than organic crops. In this systematic review, organic crops also contained significantly lower concentrations of the toxic metal cadmium than conventional crops (Baranski et. al., 2014).

Several studies demonstrate that children fed an organic diet have reduced exposure to the pesticides prevalent in conventional agriculture (Lu et al. 2006; Forman & Silverstein, 2012).

In adults, eating an organic diet for a week resulted in pesticide levels dropping by almost 90%. Authors concluded that the consumption of organic food provides a precautionary approach to reducing pesticide exposure (Oates et al., 2014).

The concentrations of a range of antioxidants (polyphenolics such as phenolic acids, flavanones, stilbenes, flavones, phenolic and anthocyanin) were found to be substantially higher in organic crops and organic crop-based foods (Baranski et al., 2014).

In a systematic review comparing the presence of pathogens in organically raised poultry and conventionally raised poultry, Young et al. (2009) found higher levels of *Campylobacter* in organically raised poultry at slaughter, and a higher prevalence of *Salmonella* in organically raised poultry at retail. However, Sapoka et al. (2014) reported a lower prevalence of antibiotic-resistant *Salmonella* on large-scale U.S. conventional poultry farms that transitioned to organic practices. According to the authors, "these are the first U.S. data to show immediate, on-farm changes in the prevalence of antibiotic-resistant *Salmonella* when antibiotics are voluntarily withdrawn from large-scale poultry facilities in the United States."

In a study comparing the effects of farming method and processing on bacterial presence in spinach, Moore and Norman (2009) found conventionally grown bagged spinach to have significantly higher concentrations of bacterial colonies when compared to organically grown bagged and loose spinach and locally grown loose spinach.

Ciprofloxacin-resistant *Campylobacter* was more prevalent in conventionally raised poultry compared to organically raised poultry. Eight out of ten studies reviewed found conventionally raised poultry, swine, and beef cattle were significantly more likely to contain bacteria resistant to multiple drugs (Young et al., 2009).

In a systematic review, Smith-Spangler et al. (2012) reported that conventionally raised poultry and swine had a 33% higher risk of carrying bacteria resistant to three or more antibiotics compared organically raised poultry and swine.

In a study comparing the nutritional value and safety of wheat flours produced conventionally and organically, Vreck et al. (2014) found conventionally produced wheat flour was significantly higher in arsenic and cadmium; however, the samples did not exceed the regulatory thresholds.

Forman & Silverstein (2012) found no studies supporting the claim that estrogen found in food derived from animals treated with sex hormones plays a role in early onset of puberty or increases the risk of breast cancer.

Glossary

Adjuvants: pesticide adjuvants are any substance added to the spray tank, separate from the pesticide formulation that will improve the performance of the pesticide.

Agronomy: a science that deals with the methods used by farmers to raise crops and care for the soil.

Antibiotic Resistance: a natural phenomenon in which an antibiotic has lost its ability to effectively manage or eradicate bacterial growth, allowing the bacteria to continue to multiply despite the presence of therapeutic antibiotics; the increase in antibiotic-resistant bacteria is attributed to the overuse and abuse of antibiotics.

Antioxidants: natural or man-made substances, such as beta-carotene, lutein, or lycopene, that may prevent or delay oxidative cellular damage.

Biodiversity: refers to the number of distinct species present in a given area. Biodiversity is widely recognized as beneficial by helping an ecosystem respond/adapt to change.

Biological pest control: a type of ecosystem service wherein the natural population of local insects controls the population of crop pests, either through predation or because population growth is limited.

Catch crop: a crop grown between two crops in ordinary sequence, between the rows of a main crop, or as a substitute for a staple crop that has failed; catch crops protect the soil by reducing nitrate leaching and improve soil productivity.

Colony Collapse Disorder: a phenomenon in which worker bees from a honey bee colony abruptly disappear, causing the colony to stop functioning.

Cytotoxic: toxic to cells.

Ecosystem services: the services that the Earth's ecosystems provide humans, such as food and fiber provision, soil fertility, water purification, disease management, and climate regulation. These services are extensive and diverse and affect the quality of our land, water, food, and health. In agroecosystems, biodiversity performs a myriad of essential ecosystem services beyond the production of food and fiber, including nutrient cycling into food crops; generation and preservation of soils and renewing soil fertility; climate moderation (control); resilience to drought; pest control; and provision of habitat for beneficial insects, such as pollinators, decomposers, and predators.

Genetically Modified Organism (GMO): organisms whose genetic material (DNA) has been altered in a way that does not occur naturally; the technology, sometimes referred to as recombinant DNA technology or genetic engineering, allows selected genes to be transferred from one organism to another, also between non-related species.

Ionizing Radiation: used in food irradiation; the process of exposing food to a source of energy capable of stripping electrons from individual atoms in the targeted material. Ionizing radiation is used to preserve food, reduce the risk of food borne illness, prevent the spread of invasive pests, delay or eliminate sprouting or ripening, increase juice yield, and improve rehydration.

Isoproturon: a selective, systemic herbicide used in the control of annual grasses and broad-leaved weeds in cereals.

Landscape complexity: the presence of different land cover types within an area; typically refers to the inclusion of a variety of native ecosystems (e.g. forest, pond, swamp, grassland) within tact of farmland.

Monocropping: the use of land for growing one type of crop.

Mycotoxin: a toxic secondary metabolite produced by organisms of the fungi kingdom. Mycotoxin typically refers to the toxic chemicals produced by molds (a type of fungi) that readily colonize crops.

National List: The National List of Allowed and Prohibited Substances identifies substances that may and may not be used in organic crop and livestock production. It also lists the substances that may be used in or on processed organic products. In general, synthetic substances are prohibited, unless specifically allowed on the List, and non-synthetic substances are allowed, unless specifically prohibited. As a result, a natural substance does not have to be listed to be allowed. Growers often turn to outside agencies, such as the Organic Materials Review Institute (OMRI), to verify that a natural product not on the list is approved for organic production.

Neonicotinoids: a systemic agricultural insecticide, resembling nicotine, that affects the central nervous system of insects, resulting in paralysis and death; neonicotinoids include *imidacloprid, acetamiprid, clothianidin, dinotefuran, nithiazine, thiacloprid and thiamethoxam*.

Nitrates: inorganic compounds composed of one atom of nitrogen (N) and three atoms of oxygen (O); nitrate is the most common groundwater pollutant in rural areas due to its presence in fertilizers, pesticides, septic systems, and manure storage.

Nitrogen leaching: the movement of nitrogen from agricultural systems (fertilizer is the primary source) into ground water systems, lakes, and streams; a form of pollution.

Organophosphate Pesticides: affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some are very poisonous (they were used in World War II as nerve agents). However, they usually are not persistent in the environment.

Pollinator: an agent, such as an insect or a bird, which moves pollen from the male anthers of a flower to the female stigma of a flower to accomplish fertilization.

Pollinator services: a type of ecosystem service wherein the natural population of local insects pollinates the flowers of a farmer's crop and improves fruit set.

Sewage Sludge: hazardous waste produced daily by industrial processes; sometimes called biosolids.

Social Capital: the institutions, relationships, and norms that shape the quality and quantity of a society's social interactions; refers to the value of a social network.

Soil Carbon Fixation: the process through which agricultural and forestry practices remove carbon dioxide from the atmosphere. Fixation, also called sequestration, activities can help prevent global climate change by enhancing carbon storage in trees and soils, preserving existing tree and soil carbon, and by reducing emissions of carbon dioxide, methane, and nitrouse oxide.

Soil Erosion: detachment and transportation of soil particles caused by rainfall runoff or splash, irrigation runoff, or wind that degrades the soil quality.

Species richness: the number of distinct species present within a given area (e.g. number of different species of butterflies).

Species abundance: the number of individuals of a given species present within an area (e.g. number of individual monarch butterflies).

Unharvested green manure: cover crops, such as clover, grown in between crop cycles and then tilled into the soil in order to increase soil nitrogen content.

Vaccenic Acid: a naturally occurring trans-fatty acid found in the fat of ruminants and in dairy products such as milk, butter, and yogurt. It is also the predominant fatty acid comprising trans fat in human milk.

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