National Organic Coalition

July 13, 2009

Barbara Boxer
Chairman
Committee on Environment and Public Works
United States Senate
Washington D.C. 20510

James Inhofe
Ranking Minority Member
Committee on Environment and Public Works
United States Senate
Washington D.C. 20510

RE: THE BENEFIT OF ORGANIC AGRICULTURE FOR REDUCING GREENHOUSE GAS EMISSIONS AND MITIGATING AND ADAPTING TO CLIMATE CHANGE

Dear Chairman Boxer and Ranking Member Inhofe:

On behalf of our organizations and members, we are collectively writing to encourage the Environment and Public Works Committee, as part of its consideration of climate change legislation, to recognize the benefits of organic agriculture practices for reducing greenhouse gas (GHG) emissions and mitigating and adapting to climate change. Within the agricultural sector, increasing peer-reviewed research is demonstrating that organic and other systems that prioritize soil health and carbon addition as well as avoid the use of chemical pesticides, herbicides, and fertilizers, have the greatest potential for reducing GHG emissions and combating and mitigating climate change impacts in the future.

In particular, we recommend, based upon the scientific evidence included in this letter, the following organic practices to be eligible for offset credits within the current legislation for either their ability to reduce emissions or to sequester carbon:

1) Certified organic agriculture for its demonstrated ability to fundamentally reduce GHGs;
2) Cover cropping and abstaining from fallow fields, particularly with leguminous crops which can reduce synthetic fertilizer use and sequester carbon;
3) Abstaining from synthetic pesticide use;
4) Abstaining from synthetic fertilizer use;
5) Addition of compost and/or manures into soils at an appropriate rate determined by a nutrient management plan;
6) Organically managed and rotational pasture, range and paddock lands for meat and dairy production for their demonstrated ability to sequester carbon.

Furthermore, we also encourage the Committee to consider adaptation programs in the current legislation that will benefit all types of agriculture. Additional research is needed to build upon existing research that demonstrates that organic production systems may be better suited for potential climate change impacts. We recommend that the Committee establish adaptation research programs to better investigate these issues.

In the United States, it is estimated that the food system uses nearly 20% of our total energy and fossil fuel requirements in the country.[1] The production, packaging, and application of synthetic fertilizers and pesticides, substances prohibited under the Organic Foods Production Act (OFPA), account for much of this energy use. Each year, the U.S. agricultural system uses nearly forty billion pounds of synthetic fertilizers[2] and more than one billion pounds of synthetic pesticides.[3] Fully 40% of all agriculture production energy goes into making synthetic fertilizers and pesticides.[4] The production of synthetic fertilizers and pesticides contributes more than 480 million tons of GHG emissions to the atmosphere each year.[5]

In addition, the EPA estimates that, once on soils, synthetic fertilizers generate over 304 million pounds of GHG emissions annually.[6] Any serious approach to climate change must address the enormous contributions of conventional, industrial agricultural systems to the production and accumulation of GHGs.

Reducing Greenhouse Gases with Organic Practices and Systems

Fortunately, there are proven ways to reduce emissions from agriculture and, moreover, use agriculture as a tool for climate change mitigation: transition agriculture in the direction of organic and related systems. As stated by the United Nations Food and Agriculture Organization (FAO), "[w]ith lower energy inputs, organic systems contribute less to GHG emissions and have a greater potential to sequester carbon in biomass than conventional systems."[7]

While mitigation of GHGs is important and will be discussed below, it is crucial to begin the discussion with ways to fundamentally reduce GHG emissions in agriculture. Only if the background emissions of agriculture are reduced will the reduction of carbon levels through sequestration make any real difference. Scientific studies are increasingly demonstrating that organic agriculture has an overall lower global warming potential (GWP) and significantly fewer GHGs. Research published last year demonstrated that organic commodity cropping systems required half the energy inputs and have about three-fourths the total GWP of conventional systems.[8]

Additional studies show that organic cropping systems use about thirty percent less fossil-fuel energy than conventional systems.[9] A key reason for the reduced GWP of organic systems is the elimination of synthetic fertilizers and pesticides. And, new evidence shows that such benefits at the production stage are reflected in life cycle analyses of processed products. In a recent study comparing the life cycle emissions of organic and conventional wheat bread, scientists concluded that organic wheat bread has about 30g of CO_2-eq less than that of the conventional loaf.[10]

In addition, organic systems also reduce nitrate leaching from fertilizers in comparison to intensive conventional agriculture systems,[11] and organic compost has the ability to reduce nitrogen and phosphorus leaching five-fold when compared to synthetic fertilizers.[12] By comparison, organic production systems that use cover crops, compost, and intercropping instead of synthetic fertilizer not only avoid the initial GHG emissions from the production of fertilizers, but also prevent fertilizers from leaching into waterways.

Organic and pasture-based animal production

Organic and pasture-based animal production can also play a significant role in reducing GHG emissions. Animal production contributes nearly one fifth of all global GHG emissions, thus making it a significant source of GHG emissions.[13] Many of the synthetic fertilizers and pesticides used in the United States are for feed crops for animal production. It is estimated that about half of the grain and oilseeds grown in the United States are fed to livestock,[14] and conventional grain-fed beef requires twice as many energy inputs as grass-fed beef.[15] Scientists have suggested that reducing feed grains is the single best way to cut GHG emissions in animal agriculture.[16]

A 2006 life cycle assessment of three modes of Irish beef production – conventional, pasture-raised, and organic – found that both pasture-raised and organic systems generate fewer GHGs than the conventional system, with the organic system producing 17 percent less than conventional. The difference would likely be even more dramatic in comparison to U.S. conventional beef production, since Irish beef cattle are primarily finished on grass rather than grain.[17] Other research has drawn similar conclusions, finding that organic animal production systems have more than one-third less GWP of intensive systems as well as reduced impacts on eutrophication and acidification.[18]

Manure management and enteric fermentation are also significant sources of GHG emissions.[19] Part of the reduction in GHGs associated with pasture-based animal agriculture is the result of reduced methane emissions from enteric fermentation. Enteric fermentation is a biological process involving microbial fermentation that occurs during the digestive processes of animals, especially ruminant animals such as cattle, sheep, and goats. A byproduct of this process is methane which is either exhaled or eructated. Enteric fermentation is now the single largest source of methane emissions in the United States.[20]

Diet can play a significant role in reducing methane emissions from enteric fermentation. Scientific studies show that the addition of fats in the diet from natural sources typically found in pasture-based systems including sunflowers, flaxseed and alfalfa can reduce emissions.[21] In general, studies have found that such additions can reduce methane emissions by about 20%.[22] Additional research demonstrates that cattle fed feedlot diets, often rich in corn and soy rather than forage, have higher rates of emissions. One study found that methane production was 20% higher in beef steers from a feedlot where they were fed low forage to grain diet compared to steers on high forage to grain diet.[23] Grazing on high-quality forage reduced methane emissions up to 22% in beef cattle in one study.[24] Authors of another study noted, "The reduction in methane emissions was related to better digestibility of high quality forage, which resulted in better efficiency of utilization, as was observed in higher average daily gain."[25] Recent reports suggest that farmers are beginning to recognize the benefit of changing diets to reduce methane emissions, and that the food industry is encouraging the grazing of cattle on natural forages and grasslands to do so.[26]

In 2007, the EPA reported that livestock manure management is responsible for over 55 million metric tons of GHG emissions,[27] mostly in the form of methane and nitrous oxide. Improper manure storage in large-scale systems typically found in concentrated animal feeding operations (CAFOs) increase GHG emissions because waste is often pooled in large lagoons and holding ponds rather than being directly incorporated into soils.[28] During manure storage and decomposition, gaseous by-products including hydrogen sulfide, carbon dioxide, ammonia, and methane are produced and released into the atmosphere.[29]

The EPA has determined that when manures are stored or treated in systems that promote anaerobic conditions, like liquid storage systems commonly found in CAFOs, the decomposition of manure produces great amounts of methane, unlike when manure is handled as a solid or deposited on pasture, range or paddock lands. Manures spread appropriately on pastures and paddocks produce minimal amounts of methane.[30] Research has also documented that manure stores on conventional farms emitted about twenty-five percent more methane gas than organic farms.[31]

Greenhouse Gas Mitigation through Carbon Sequestration

As mentioned above, organic production systems and practices also have the ability to mitigate GHG emissions through carbon sequestration. FAO has noted that "organic soil management focuses on increasing soil organic matter, which increases carbon sequestered in the soil. Organic practices that do so include addition of manure and plant residue to the fields, mixed cropping, green manuring, legume-based crop rotations, agroforestry and minimum tillage."[32]

While many types of agriculture have the ability to sequester carbon, organic agriculture has demonstrated that it can sequester more carbon and build soil better than conventional systems, including conventional no-till systems.[33] Research performed at the USDA found that after nine years of comparing various no-till systems to organic systems, the organic production system sequestered more carbon. Scientists noted, "Despite the use of tillage, soil combustible carbon and nitrogen concentrations were higher at all depth intervals to 30cm in organic agriculture compared with that in all other systems." Further, the scientists concluded that, "these results suggest that organic agriculture can provide greater long-term soil benefits than conventional no-till, despite the use of tillage in organic agriculture."[34]

Numerous studies have further shown that organic soils can sequester more carbon than conventional soils and that synthetic fertilizer can have a negative impact on carbon sequestration.[35][36][37][38] In one eighteen-year study comparing fields fertilized organically to those synthetically fertilized, scientists found that the organic fields sequestered three to eight more tons of carbon per hectare.[39]

In comparisons of field trials of organic and conventional farming plots, researchers found that while soil carbon levels were initially the same, after more than two decades the organic systems had significantly higher soil carbon levels. The organic systems—one using legume cover crops and the other using manure—retained more carbon in the soil, "resulting in an annual soil carbon increase of 981 and 574 kg per hectare…compared with only 293 kg per hectare in the conventional system."[40] Similar long-term research at the United States Department of Agriculture (USDA) demonstrated that organic agriculture increased overall soil health more than conventional no-till methods and resulted in increased yields over conventional production.[41]

Further, organic grazing systems can sequester more carbon than confined animal systems. In the United States, certified organic animal production has a pasture component that requires livestock producers to utilize organic pasture systems as a significant portion of the animal's diet.[42] One study has shown that pastured animals in rotational intensive grazing could increase soil carbon to offset GHG emission by 15 to 30 percent.[43] Soils and pastures are carbon sinks; pasture-based farming methods could absorb up to 21 million metric tons of carbon dioxide and up to 7.8 million metric tons of nitrous oxide in the organic matter of pasture soils.[44]

Organic Agriculture for Climate Change Adaptation and Food Security
One of the greatest challenges of climate change will be finding ways to adapt to the myriad of potential impacts. Securing and maintaining a food system that can continue to produce, despite unexpected weather and climate events, is crucial for the future. Organic agriculture, which may be more resilient to climate change impacts, will be a necessary component to this challenge. The FAO has taken note of this in a 2006 paper: "As climate change occurs, the ecosystem on a diversified organic farm is more likely to go through natural stages of succession, adapting in ways that prevent whole agroecosystem collapse."[45]

Among the greatest threats of climate change will be the impact on biodiversity and the potential global loss of life. Biodiversity contributes to ecosystem functioning and maintenance; as biodiversity decreases it will be extremely difficult to retrieve and recover.[46] The FAO notes that monoculture practices will also likely decrease biodiversity, a crucial component to health agroecosystems.

> "Simplifying farms by growing monocultures and removing vegetation in the margins further reduces biodiversity in and around farms. Such practices not only cause environmental damage but create agroecosystems that will be less resilient to climate change. Organic farms, on the other hand, are designed with biodiversity in mind, as diverse ecosystems provide a number of important services on the farm."[47]

Considering the loss of biodiversity as a potential climate change threat is vital for species preservation. Endangered and extinct species are already documented throughout the world, but climate change is causing more subtle losses in species and diversity.[48] Many of the species more prevalent in organic farming were known to have declining diversity and numbers as a result of previous agriculture intensification.[49] The biodiversity benefits associated with organic farms likely derive from the management practices absent from or rarely utilized in most conventional systems.[50] Specifically, organic farms have considerably more spiders,[51] birds,[52] butterflies,[53] and other species,[54] in both number and species count. Maintaining biodiversity on farms will be crucial to sustaining food production and ecosystem functions and organic production can perform this task.

Climate change also has the potential to threaten agriculture through changing water and weather patterns increasing both drought and run-off.[55] Soil organic matter and soil carbon content are important for water absorption and retention and can be greatly affected by changes in these elements.[56] Increasing organic matter in soils leads to a direct increase in the ability of soils to retain water[57] and will be an important tool for combating drought and potential flood conditions from increasing snow melt and runoff.[58] Organic soils have higher levels of soil carbon and research has shown that in drought conditions, organic systems produced corn yields twenty-eight to thirty-four percent higher than conventional systems.[59] As weather patterns and precipitation continue to change, existing evidence suggests that organic agriculture will be better able to adapt and continue to produce in uncertain conditions.

In light of the recent food crisis, our society is also reminded of the need to consider agricultural development and food security threats that may result from climate change impacts, particularly in developing countries. Research published this year in *Science* has clearly documented the food security concerns of increasing global temperatures, noting with high probability that growing season temperatures in the tropics and subtropics at the end of the 21st century will exceed even the most extreme temperatures recorded between 1990 and 2006. The conclusions are simple: "Global climate change thus presents widespread risks of food insecurity".[60]

Reports from the United Nations have recognized the vital role of organic agriculture in food security. "Organic farming leads to many improvements in the natural environment, including increased water retention in soils, improvements in the water table (with more drinking water in the dry season), reduced soil erosion combined with improved organic matter in soils, leading to better carbon sequestration, and increased agro-biodiversity. As a result, soils are healthier, are better able to hold water and are more stable, can sustain plant growth better and have a higher nutrient content. All this enables farmers to grow crops for longer periods, with higher yields and in marginal conditions."[61] Further research has clearly shown that organic agriculture can yield equal to or greater than conventional systems, particularly in developing countries that are slated to be most affected by climate change impacts.[62]

As climate change legislation is discussed in Congress, we encourage you to incorporate provisions and appropriate offsets that address the key role of agriculture in climate change. Alternatives like organic production systems offer many benefits for the environment and our nation's many small-to-medium-sized family farms, which have a clear role to play in GHG mitigation. Further, it is clear that organic practices are a viable option for farmers in developing countries and may help increase food security in the face of climate change impacts.

Thank you for your consideration and we look forward to working with you to help enact comprehensive and progressive climate change legislation that will transition our economy to a more sustainable future.

Sincerely,

Lisa Bunin, Center for Food Safety [Lbunin@icta.org]

Steve Etka, Legislative Coordinator, National Organic Coalition [steveetka@gmail.com]

On behalf of The National Organic Coalition, including:

Jay Feldman, **Beyond Pesticides**
Lisa Bunin, **Center for Food Safety**
Keith Olcott, **Equal Exchange**
Patty Lovera, **Food & Water Watch**
Russell Libby, **Maine Organic Farmers and Gardeners Association**
Faye Jones, **Midwest Organic and Sustainable Education Services**
Robynn Shrader, **National Cooperative Grocers Association**
Ed Maltby, **Northeast Organic Dairy Producers Alliance**
Steve Gilman, **Northeast Organic Farming Association -Interstate Council**
Michael Sligh, Rural Advancement Foundation International –USA

National Sustainable Agriculture Coalition, Martha Noble
Organic Farming Research Foundation, Mark Lipson

[1] Pimentel, D., Williamson, S., Alexander, C.E., Gonzalez-Pagan, O., Kontak, C., & Mulkey, S.E. (2008). Reducing Energy Inputs in the US Food System. *Hum Ecol*. *36*, :459-471.

[2] Food and Agriculture Organization., *FertiStat: Fertilizer Use by Crop Statistics*. Retrieved November 12, 2008 from: http://www.fao.org/ag/agl/fertistat/fst_fubc1_en.asp?country=USA&commodity=%25&year=%25&search=Search+%21).

[3] U.S. General Accounting Office. (2001). Agricultural Pesticides: Management Improvements Needed to Further Promote Integrated Pest Management. Retrieved November 18, 2008 from: http://www.gao.gov/new.items/d01815.pdf

[4] Heller, M.C. & Keoleian, G.A. (2000). *Life Cycle-Based Sustainability Indicators for Assessment of the U.S. Food System.* Center for Sustainable Systems, University of Michigan. (Report No. CSS00-04.)

[5] U.S. Environmental Protection Agency. (2009). *U.S. Greenhouse Gas Inventory Report: Inventory of U.S. greenhouse gas emissions and sinks: 1990-2007: Executive Summary*. Pg. ES-6. Retrieved http://www.epa.gov/climatechange/emissions/downloads09/07ES.pdf

[6] U.S. Environmental Protection Agency. (2008)., *Inventory of U.S. Greenhouse Gas Emissions and Sinks: U.S. 1990-2006.* Pg. 6-19. Retrieved from: http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf

[7] Ziesemer, J. (2007). *Energy Use in Organic Food Systems:. Food and Agriculture Organization of the UN.* United Nations Food and Agriculture Organization. Retrieved November 13, 2008 from http://www.fao.org/docs/eims/upload/233069/energy-use-oa.pdf

[8] Pelletier, N., Arsenault, N., & Tyedmers, P. (2008). Scenario Modeling Potential Eco-Efficiency Gains from a Transition to Organic Agriculture: Life Cycle Perspectives on Canadian Canola, Corn, Soy, and Wheat Production. *Environmental Management 42*: 989-1001.

[9] Pimentel, D., Hepperly, P., Hanson, J., Douds, D., & Seidel, R. (2005). Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. *BioScience 55* (7):573-582, p. 573. Retrieved from: http://www.ce.cmu.edu/~gdrg/readings/2007/02/20/Pimental_EnvironmentalEnergeticAndEconomicComparisonsOfOrganicAndConventionalFarmingSystems.pdf

[10] Meisterling, K., Samaras, C., Schweizer, V. (2009). Decisions to reduce greenhouse gases from agriculture and product transport: LCA case study of organic and conventional wheat. *Journal of Cleaner Production. 17*:222-230.

[11] Guido Haas, G., Wetterich, F., Kopke, U. (2001). Comparing Intensive, Extensified and Organic Grassland Farming in Southern Germany by Process Life Cycle Assessment. *Agric. Ecosystems & Env't 83*: 43-53. Retrieved from: http://doi.eng.cmu.ac.th/Thailca/pdf/organic_farming.pdf

[12] Evanylo, G. et al., (2008). Soil and Water Environmental Effects of Fertilizer-, Manure-, and Compost-Based Fertility Practices in an Organic Vegetable Cropping System. *Agric., Ecosystems & Env't 127:* 50-, 56.

[13] Steinfeld H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & de Haan, C. (2008). *Livestock's Long Shadow-Environmental Issues and Options*. Food and Agriculture Organization of the United Nations. Rome, Italy.

[14] *U.S. Could Feed 800 Million People With Grain That Livestock Eat, Cornell Ecologist Advises Animal Scientists* (Aug. 7, 1997). Cornell University Press Release. Retrieved from: http://www.news.cornell.edu/releases/aug97/livestock.hrs.html.). *See also* V. Smil, V. (2000). Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production. The MIT Press. pp. 156-64.

[15] Pimentel, D. & Pimentel, M. (2008). Food, Energy, and Society. CRC Press. pp. 69.

[16] Flessa H. et al., (2002). Integrated Evaluation of Greenhouse Gas Emissions (CO2, CH4, N2O) from Two Farming Systems in Southern Germany. *Agriculture, Ecosystems & Environment 91*: 175.

[17] Casey, J.W. & Holden, N.M. (2006). Greenhouse gas emissions from conventional, agri-environmental scheme, and organic Irish suckler-beef units. *Journal of Environmental Quality 35*:231-239.

[18] Haas, G., Wetterich, F., Kopke, U. (2001). Comparing intensive, extensified and organic grassland farming in southern Germany by process life cycle assessment. *Agriculture, Ecosystems and Environment. 83*:43-53.

[19] Steinfeld (2006).

[20] U.S. EPA (2009). Executive Summary. pp.3.

[21] Kebreab, E., Clark K., Wagner-Riddle, C., & France, J. et al (2006). Methane and nitrous oxide emissions from Canadian animal agriculture: A review. Canadian Journal of Animal Science. *86*: 135-157.), pp. 142.

[22] McGinn, S.M., Beauchemin, K.A., Coates, T. & Colombatt, D. (2004). Methane emissions from beef cattle : effects of monensin, sunflower oil, enzymes, yeast, and fumaric acid. *Journal of Animal Science*. *82*:3346-3356.

[23] Boadi, D.A. et al. (2004). Effect of low and high forage diet on enteric and manure pack greenhouse gas emissions from a feedlot. *Canadian Journal of Animal Science*. *84*: 445-453.

[24] DeRamus, H.A., Clement, T.C., Giampola, D.D. & Dickison, P.C. (2003). Methane emissions of beef cattle on forages: efficiency of grazing management systems. *Journal of Environmental Quality*. *32*:269-277.

[25] Kebreab (2006). pp. 143.

[26] Kaufman, L. (2009, June 4.) Greening the Herds: A New Diet to Cap Gas. *The New York Times.* Retrieved June 9, 2009 from: http://www.nytimes.com/2009/06/05/us/05cows.html?_r=2&ref=science.

[27] U.S. EPA (2008) pp.6-8.

[28] Marvin, D. (2005, February 4). *Factory Farms Cause Pollution Increases*., Johns Hopkins Newsletter. Retrieved from: http://media.www.jhunewsletter.com/media/storage/paper932/news/2005/02/04/Science/Factory.Farms.Cause.Pollution.Increases-2243919.shtml; *See also* Schlosser, E & Wilson, C. (2006). Chew on This: Everything you don't Want to Know About Fast Food. Houghton Mifflin. pp. 166.

[29] Cyr, D.L. Johnson S.B. (2002)., *Barn and Manure Storage Safety Bulletin.* University of Maine Cooperative Extension Service. Retrieved June 9, 2009 from: http://www.umext.maine.edu/onlinepubs/PDFpubs/2304.pdf).

[30] U.S. EPA (2009) Agriculture, pp. 7.

[31] Sneath, R.W., Beline, F., Hilhorst, M.A., Peu, P. (2006). et al., Monitoring GHGs from Manure Stores on Organic and Conventional Dairy Farms. Agriculture,Ecosystems & Environment. 112: 122-128.

[32] Borron, S. (2006). *Building resilience for an unpredictable future: how organic agriculture can help farmers adapt to climate change.* Food and Agriculture Organization. Retrieved ftp://ftp.fao.org/docrep/fao/009/ah617e/ah617e.pdf.

[33] Comis, D. (2007). No Shortcuts in Checking Soil Health. *Agric. Research*, July 2007, p. 4, Retrieved June 9, 2009 from. http://www.ars.usda.gov/is/AR/archive/jul07/soil0707.pdf

[34] Teasdale, J.R., Coffman, C.B., Mangum, R.W. (2007) Potential Long-Term Benefits of No-Tillage and Organic Cropping Systems for Grain Production and Soil Improvement. *Agron. J. 99*:1297-1305.

[35] Marriott, E.E. & Wander, M. M. (2006). Total and Labile Soil Organic Matter in Organic and Conventional Farming Systems. *Soil Sci. Soc. Am. J. 70*: 950-954. Retrieved June 9, 2009 from: http://soil.scijournals.org/cgi/reprint/70/3/950 Available at: http://soil.scijournals.org/cgi/reprint/70/3/950

[36] Fliessbach, A. & Mader, P. (2000). Microbial Biomass and Size-Density Fractions Differ Between Soils of Organic and Conventional Agricultural Systems. *Soil Biology & Biochemistry 32*:757-766. Retrieved June 9, 2009 from: http://www.fibl.org/archiv/pdf/fliessbach-maeder-2000-biomass.pdf

[37] Robertson, G. P. et al., (2000). Greenhouse Gases in Intensive Agriculture: Contributions of Individual Gases to the Radiative Forcing of the Atmosphere. *Science 289:*1922-1924. Retrieved June 9, 2009 from : http://weedeco.msu.montana.edu/Issues/science289_1922_900.pdf

[38] Khan, S.A. et al. (2007). The Myth of Nitrogen Fertilization for Soil Carbon Sequestration, *Journal of Environmental Quality 36*: 1821-1823.

[39] Kotschi, J. & Muller-Samann K. (2004). *The role of organic agriculture in mitigation climate change: a scoping study.* International Federation of Organic Agriculture Movements. Bonn, Germany. pp. 64.

[40] Pimental et al. (2005).

[41] Comis (2007).

[42] § 205.237 National Organic Program Livestock Feed Requirements.

[43] Phetteplace, H.W., Johnson, D.E., & Seidl A.F. (2001). Greenhouse gas emissions from simulated beef and dairy livestock systems in the United States. *Nutrient Cycling in Agroecosystems. 60*: 99-, 102.

[44] Boody, G. et al. (2005). Multifunctional agriculture in the United States. *BioScience 55*(1):27-38.

[45] Borron (2006)

[46] The U.S. Climate Change Science Program (US CCSP). (2008). *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States.* Retrieved http://www.climatescience.gov/Library/sap/sap4-3/final-report/sap4-3-final-exec-summary.pdf pp. 184.

[47] Borron (2006)

[48] US CCSP (2008) pp. 9-10 and pp. 151-181.

[49] A majority of seventy-six studies on conventional and organic farming systems and biodiversity clearly showed that biodiversity is far more prevalent in organic agriculture. Hole, D.G., et al. (2005). Does Organic Farming Benefit Biodiversity? *Biological Conservation 122*: 113-121. Retrieved June 9, 2009 from http://www.englishnature.org.uk/news/news_photo/Organic%20farming%20paper.pdf

[50] Hole, et. al (2005) pp.121-123.

[51] Feber, R.E. et al., (1998). The Effects of Organic Farming on Surface-Active Spider (Araneae) Assemblages in Wheat in Southern England, UK. *J. of Arachnology 26* :190-199. Retrieved June 9, 2009 from http://www.americanarachnology.org/JoA_free/JoA_v26_n2/JoA_v26_p190.pdf

[52] Lokemoen, J.T. & Beiser, J.A. (1997). Bird Use and Nesting in Conventional, Minimum-Tillage, and Organic Cropland. *J. of Wildlife Mgmt. 61*: 644-653. Retrieved June 9, 2009 from http://www.npwrc.usgs.gov/pdf/npwrc1013_birduse.pdf

[53] Feber, R.E. et al., (1997). The Effects of Organic Farming on Pest and Non-Pest Butterfly Abundance. *Agric., Ecosystems & Env't 64*:133-135

[54] Hole, et. al (2005) pp.121-123.

[55] US CCSP (2008) pp.191-92.

[56] Rawls, W.J. et al., (2003). Effect of Soil Organic Carbon on Soil Water Retention. *Geoderma 116*: 61-76.

[57] Rawls et. al (2003) pp. 71.

[58] Pimentel et al (2005) pp. 578.

[59] Pimentel et. al (2005) pp. 575.

[60] Battisti D.S., & Naylor, R.L. (2009). Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat. *Science 323*: 240-244.

[61] *Organic Agriculture and Food Security in Africa.* (2008). United Nations Conference on Trade and Development and United Nations Environment Programme Capacity-building Task Force on Trade, Environment and Development. p. x.

[62] Badgley, C., Moghtader, J., Quintero E., Zakem, E., Chappell, J.M., Aviles-Vazquez, K., Samulon, A., & Perfecto, I. (2007). Organic agriculture and the global food supply. *Renewable Agriculture and Food Systems 22*:86-108.