SYLLABUS – INAF 180

Course	Science of Sustainable Food Systems	**Number**	INAF 180
Semester/Year	Summer, 2021	**Schedule**	MTWRF, 8:30am-10:40pm
Instructor	William Hahn	**Office Hours**	By appointment
Room	TBA	**E-mail**	wjh22@georgetown.edu

Course Description

The production and processing of food along with disposal of food waste have some of the most profound global environmental effects of all human activities. Modern agriculture accounts worldwide for 11% of land use, 80% of tropical deforestation, 70% of freshwater use, 13% of carbon emissions, well over half of nitrogen emissions, and contributes to soil erosion, water and air pollution, and loss of biodiversity. A more sustainable food system is clearly needed if we are to feed the 9 billion human mouths expected on Earth by 2050. In this course we will examine the scientific underpinnings of a range of environmental issues that pertain to agriculture since its invention roughly 12,000 years ago with particular focus on how different scientific methods are employed to both improve agriculture as well as understand and minimize the environmental impact of food systems. We will look at topics such as the biological origins of crop plants and domesticated animals, patterns of land conversion and use, soil creation and loss, the use and contamination of water, fertilizer and its impact on nutrient cycling, pesticides and other novel chemicals employed in agriculture, the use of fossil fuels for food transport and processing, food packaging, and the processing of food waste. Some potential solutions to the challenge of global food sustainability will be examined such as the use of GMOs and other biotech approaches, the role of subsidies, energy and water policies, changing diets and food sources, alternate farming practices, and food justice issues.

Course Objectives:

Explore the science behind food production, processing, use, and disposal.

Understand various measures and reporting metrics of sustainability for food systems.

Recognize how science is used at all stages of agriculture and food systems including hypothesis formulation and testing through quantitative and qualitative data acquisition and analysis.

Explore how science is communicated and interpreted in both peer-reviewed journals and in the popular press.

Review international regulatory, financial, and political frameworks where food sustainability is considered.

Consider alternate food production systems and their potential to address food sustainability and security.

Required materials:

As indicated by the instructor. All readings are available electronically.

Student deliverables

In addition to two exams covering the basics of environmental and agricultural science, students are required to: a) analyze and present to the class as a team one food sustainability issue reported in the popular press, b) contribute to case studies and other discussions, and c) participate in a group project exploring food sustainability issues and presenting team findings to the class. Guidelines and grading rubrics for these assignments will be distributed in class. Students are required to contribute to discussions and respond to several short surveys for full participation credit.

Grading Framework:

News analysis & report	20%
Exams (20% each)	40%
Team projects	30%
Class participation & case study discussions	10%

Weekly Summary

The schedule is subject to change due to speaker availability and other factors. Sessions may include lectures, student presentations, case study discussion, guest speakers, or other activities related to the course**.**

Week 1
1. (5/24) Science, Sustainability, Food Systems
2. (5/25) Origins and Extent of Agriculture
3. (5/26) Land and Soils
4. (5/27) Water
5. (5/28) Nutrient Flows and Ecosystem Services

Week 2

6. (5/31) MEMORIAL DAY
7. (6/1) Loss, Waste, and Disposal
8. (6/2) Climate Change
9. (6/3) Case study discussion and exam review
10. (6/4) Exam 1

Week 3
11. (6/7) Pesticides
12. (6/8) Genetics and Breeding
13. (6/9) Fisheries
14. (6/10) Organic and Alternate Agriculture
15. (6/11) Case study discussion

Week 4
16. (6/14) Journalism Presentations
17. (6/15) Journalism Presentations
18. (6/16) Project presentations
19. (6/17) Final Exam

Georgetown University Ethos Statement

Choosing to come to Georgetown University means joining a distinctive community. As a Catholic and Jesuit University, Georgetown places special emphasis on the dignity and worth of every person and the love of truth. Membership in this community carries with it high expectations regarding the ways in which each person will act both within and beyond Healy Gates. In particular, students are expected to honor the following commitments in all their actions:

- A commitment to the highest standards of honesty and personal integrity both inside and outside the classroom.
- A commitment to treat others in a respectful manner, regardless of differences such as race, religion, nationality, ethnicity, gender, or sexual orientation.
- A commitment to open discourse and the free exchange of ideas. A commitment to exercise mutual care and responsibility in all relationships.
- A commitment to an active concern for the safety, security, and well-being of each individual and a respect for individual, communal and university property.

Academic Integrity

All students are responsible for adhering to the guidelines outlined in the University's academic integrity policies. Additional information may be found on the Library's website.

All work submitted must be your own work with the exceptions of assistance from librarians and minor editing or proofreading of papers and presentations. Proper citation of sources is particularly important. Please note that your submissions may be subject to plagiarism detection review, typically using Turnitin.

Instructional Continuity

In the event class cannot be held at the normal time and venue, please refer to the course Canvas site for updates. Remote delivery of lectures via Zoom may be employed.

Sexual Harassment and Misconduct

As faculty members, we are obliged to report any disclosures about sexual misconduct to the Title IX Coordinator. Additionally, the University offers confidential professional resources to help support survivors of sexual assault and other forms of sexual misconduct. More information may be found at https://sexualassault.georgetown.edu

Teaching philosophy

This course is based on a reasonable amount of factual and conceptual material presented in lecture form, analyses of cases that exemplify real world environmental issues, and class discussion of cases and other examples of sustainability in practice. Each class session will be roughly half lecture and half discussion, invited speaker, or other exercise. I believe that learning is based on a combination of inputs (lectures, readings, videos, etc.), analyses (reflections, discussions, calculations, reviews, etc.), and outputs (presentations, discussions, reports, tests, etc.). These are meant to allow time to receive, evaluate, and present your findings and understanding. This process permits you, as a student, to demonstrate your knowledge and depth of comprehension and for me, as an instructor, to gauge your progress and accomplishment as well as provide feedback. Your participation in each aspect of the class is therefore expected and assumed.

Attendance policy

Students are expected to attend all class sessions and deliver course materials on time. Outside forces may intervene and necessitate incomplete attendance or absences. In such cases, the student should contact the instructor as soon as possible and to make arrangements to receive class notes and other materials from other students as appropriate. Most materials will be available from web resources (e.g., Canvas, other sites, etc.) but there will be no make up sessions. Lectures will not be recorded. Nonetheless, presentation files should be reviewed as they will be a primary source for content.

Electronic device policy

Laptops, cell phones, tablets, and other electronic devices are permitted in the classroom to the extent that they do not interfere with classroom dynamic. In some cases we will be doing online research in class so devices will actually be required (usually in a small team setting). However, if I see any giggling while looking at a screen, particularly if more than one person is involved, I will take that as *prima facie* evidence that you are not using the device for appropriate classroom purposes.

Readings

I have listed and will post a good number of readings for each session. You are primarily responsible for the content on the presentation files and many of the sources for my presentation content are posted on the course Canvas site and/or listed in the readings below. The Primary readings are general overviews for the given topic while the Secondary readings are more targeted sources. These are all recommended and not required readings. Treat them as background for your further inquiry and curiosity. My suggestion is to glance at the table of contents or abstract for the Primary readings, then follow up as you see fit. For the Secondary readings, use them as your interest dictates. In a few cases I will specifically call out a reference that you should examine, either for the lecture or for an exam or discussion.

CLASS MEETINGS & ASSIGNMENTS

Day 1 – May 24 – SCIENCE, SUSTAINABILITY, FOOD SYSTEMS

We will define the elements of the (1) Science of (2) Sustainable (3) Food Systems. That is: What is science? What is sustainability? What are food systems? Following establishment of this foundation we will explore the scope of environmental impacts that agriculture has wrought as well as some possible solutions to these problems.

Discussion prompts

What are basic elements of science? What is sustainability at different levels? What is the scope of a food system? How can science inform a sustainable food system, especially on environmental terms? How have we met global food needs so far? What are some of the limits of food production?

Assignment

Conduct a food footprint analysis of yourself using Foodprint.org. Submit your results by Tuesday, Feb 2, 5pm.

Readings

Primary

Steffen, S., et al., 2015 Planetary Boundaries: Guiding human development on a changing planet. Science. Vol. 347, Issue 6223.

EAT - Lancet Commission. 2019 Food Planet Health. Summary Report of the EAT Lancet Commission.

FAO. 2020. World Food and Agriculture - Statistical Yearbook 2020. Rome.

Gerten, D. et al. 2020. Feeding ten billion people is possible within four terrestrial planetary boundaries. Nature Sustainability 3: 200-208.

The Economics of Ecosystems and Biodiversity (TEEB). 2018. Measuring what matters in agriculture and food systems: a synthesis of the results and recommendations of TEEB for Agriculture and Food's Scientific and Economic report. Geneva. UN Environment.

Quantis. 2020. Dig In. A Landscape of Business Actions to Cultivate a Sustainable + Resilient Food System. Lausanne, Switzerland.

Rockström, J. et al. 2020. Planet-proofing the Global Food System. Nature Food 1: 3-5.

Springman, M. et al. 2018. Options for Keeping the Food System within Environmental Limits. Nature 562: 519-525.

WBSCD. 2019. CEO Guide to Food System Transformation

World Resources Report. Creating a Sustainable Food Future. A Menu of Solutions to Feed Nearly 10 Billion People by 2050 Synthesis Report. December, 2018

Secondary

Alexandratos, N. and J. Bruinsma. 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working paper No. 12-03. Rome, FAO.

Bentham, J. et al. 2020. Multidimensional characterization of global food supply from 1961 to 2013. Nature Food 1: 70–75

Ellis, E. C., et al. 2013. Used planet: A global history. PNAS 110:7978–7985.

Foley, J. A. et al. 2011 Solutions for a cultivated planet. Nature 478: 337-342.

Godfray, H. C. J., et al. 2010. The future of the global food system Phil. Trans. R. Soc. B 365: 2769–2777

Hayo, M.G. et al. 2002 Evaluation of the environmental impact of agriculture at the farm level: a comparison and analysis of 12 indicator-based methods. Agriculture, Ecosystems and Environment 93:131–145

Heller, M. C and G. A. Keoleian. 2000. Life Cycle-Based Sustainability Indicators For Assessment Of The U.S. Food System. The Center for Sustainable Systems, Report no. CSS00-04, Ann Arbor, Michigan,

Hellerstein, D. et al (editors). 2019 Agricultural Resources and Environmental Indicators, 2019. EIB-208, U.S. Department of Agriculture, Economic Research Service

National Research Council 2015. A Framework for Assessing Effects of the Food System. Washington, DC: The National Academies Press.

National Research Council 2019. Science Breakthroughs to Advance Food and Agricultural Research by 2030. Washington, DC: The National Academies Press.

Tilman, D. 1999. Global environmental impacts of agricultural expansion: The need for sustainable and efficient practices. Proc. Natl. Acad. Sci. USA Vol. 96: 5995–6000

Tilman, D. et al. 2011 Global food demand and the sustainable intensification of agriculture. PNAS 108:20260–20264

USDA. 2020. Agricultural Projections to 2029. Office of the Chief Economist, World Agricultural Outlook Board, U.S. Department of Agriculture. Prepared by the Interagency Agricultural Projections Committee. Long-term Projections Report OCE-2020-1, 114 pp.

There are various other Earth System frameworks for tracking environmental degradation such as The Great Acceleration but we will focus on Planetary Boundaries. Here is a good blog post about pros and cons of these frameworks.

Also, note the UN's Millennium Assessment program that sets sustainability goals

Day 2 – May 25 – ORIGINS AND EXTENT OF AGRICULTURE

We will define agriculture and trace its origins and development from small-scale steps of early plant and animal domestication to large scale modern industrial agriculture. We will look at archeological evidence, mechanisms for dating archeological remains, examine various elements of genetic change during the process of domesticating agricultural plants and animals, and begin our discussion of the environmental impacts of agriculture. Techniques and concepts such as carbon dating, cultural artifact correlation, measuring biodiversity, and basic processes of domestication will be explored.

Discussion prompts

How do we know when and how agriculture originated? What is the evidence to support interpretations of the plant and animal domestication process? What are cultural, economic, health, and societal implications of agriculture across its history?

Assignment

None.

Readings

Primary

Larson, G., et al. 2014. Current perspectives and the future of domestication studies. PNAS 111: 6139–6146

Price, T. D. and O. Bar-Yosef. 2011. The Origins of Agriculture: New Data, New Ideas: An Introduction to Supplement 4. Current Anthropology 52 S4:S163-S174

Secondary

Fuller, D. Q and T. Denhamb. 2014. Convergent evolution and parallelism in plant domestication revealed by an expanding archaeological record. PNAS 111: 6147–6152

Gerbault, P., et al. 2014. Storytelling and story testing in domestication. PNAS 111: 6159–6164

Gremillion, K. J., et al., 2014. Particularism and the retreat from theory in the archaeology of agricultural origins PNAS 111: 6171–6177

Larson, G. and D. Q. Fuller. 2010, The Evolution of Animal Domestication Annual Review of Ecology, Evolution, and Systematics. 45: 115-136

Meyer, R. S., et al. 2012. Patterns and processes in crop domestication: an historical review and quantitative analysis of 203 global food crops. The New Phytologist 196: 29-48

Piperno, D. R. 2017. Assessing elements of an extended evolutionary synthesis for plant domestication and agricultural origin research www.pnas.org/cgi/doi/10.1073/pnas.1703658114

Smith, B. D. 2001. Documenting plant domestication: The consilience of biological and archaeological approaches. PNAS 98: 1324–1326

Weiss, E. and D. Zohary. 2011. The Neolithic Southwest Asian Founder Crops: Their Biology and Archaeobotany. Current Anthropology 52. S4, The Origins of Agriculture: New Data, New Ideas. S237-S254

Day 3 – May 26 – LAND AND SOILS

Land types are often defined based on vegetation cover which is, in turn, a function of factors such as climate, hydrology, and soil. Different vegetation types have different ecosystem dynamics (carbon fixation, nutrient cycling, water retention, patterns of biodiversity, etc.) and influence what type of agriculture is possible on that land. Conversely, the nature of agriculture practiced has an impact on the vegetation and surrounding landscape (an agricultural "footprint"). Soil is one of the pillars of traditional agricultural productivity (recognizing hydroponics and other soil-less approaches as more recent innovations). The origin and development of soil is based on both local geologic factors as well as climate and the vegetation history of the land. Underlying ecosystem processes are critical to soil formation and agriculture is both dependent upon and has an an impact on soil ecosystems. Carbon is a central element of soil structure and composition forming a critical role in the "living" aspects of soil. In this section we will discuss vegetation patterns, land use, soil formation, degradation, and loss, and introduce ecosystem services as they pertain to agriculture. Special focus will be on soil carbon dynamics.

Discussion prompts

What are global patterns of land types and use, both currently and historically? What are ecosystem services? How does agriculture modify or appropriate ecosystem services? How do we classify soils? How do natural processes create and deplete soil? How does agriculture modify soils? What are alternate approaches to agriculture that use other media besides soil? What role does carbon play in soil dynamics?

Assignment

None

Readings

Primary

Soil Overview. 2019. Soil Science Society of America.

United Nations Environment Foresight. 2019. Putting Carbon back where it belongs - the potential of carbon sequestration in the soil.

UNEP (2014) Assessing Global Land Use: Balancing Consumption with Sustainable Supply. A Report of the Working Group on Land and Soils of the International Resource Panel. Bringezu S., et al.

Secondary

Bünemanna, E. K. 2018. Soil quality – A critical review. Soil Biology and Biochemistry 120: 105–125

Paustian, K., et al. 2016. Climate-smart soils, Nature 532: 49-57

Smith, P., et al. 2010. Competition for land. Phil. Trans. R. Soc. B 365, 2941–2957

Day 4 – May 27 – WATER

Agriculture is the largest single use of water among human activities. While much of this water comes in the form of precipitation, irrigation has greatly expanded the extent of agriculture but also changed local environments. In this session we explore water as a critical component of agriculture, its sources and limits,

Discussion prompts

What is a water cycle? What are the major bodies and sources of water? How is water tapped and used for agriculture? What are competing demands for water? What are global patterns of water availability, use, and quality? What are some measures of water quality? What is embedded water? What is a water footprint? What are green, blue, and grey water? What is a cost curve?

Readings

Primary

Gleick, P. H. and M. Palaniappan. 2010. Peak water limits to freshwater withdrawal and use PNAS 107: 11155-11162

Hoekstra, A. Y. 2008. The water footprint of food. in J Förare (ed.), Water for food. The Swedish Research Council for Environment, Stockholm.

Mekonnen, M. M. and A. Y. Hoekstra 2011. The green, blue and grey water footprint of crops and derived crop Products. Hydrol. Earth Syst. Sci., 15, 1577–1600

Mekonnen, M.M. and Hoekstra, A.Y. 2011. National water footprint accounts: the green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands.

Strzepek, K and B. Boehlert. 2010. Competition for water for the food system Phil. Trans. R. Soc. B 365: 2927–2940.

Secondary:

Addams, L. 2009. Charting our Water Future 2030. Water Resources Group. McKinsey and Co.

FAO. 2015. Towards A Water and Food Secure Future. Critical Perspectives for Policy-makers. Rome.

Marston, L., et al. 2018. High-resolution water footprints of production of the United States. Water Resources Research, 54, 2288–2316.

Renault, D. 2002. Value of Virtual Water In Food: Principles And Virtues UNESCO-IHE Workshop on Virtual Water Trade. Delft, the Netherlands

Other water footprint calculators:

Water Footprint Calculator, National Geographic.

Water Footprint Calculator, Water Footprint Network

Day 5 – May 28 – NUTRIENT FLOWS AND ECOSYSTEM SERVICES.

In this session we will review nutrient requirements of agricultural systems and how natural and synthetic fertilizers improve crop yield but exact an environmental toll. The role of nutrients in plant and animal growth will be examined as well as the use of both natural and artificial sources of fertilizers. We will consider the consequences of excess nutrients in the environment, the ecosystem consequences, and how to monetize disruption of ecosystem services.

Discussion prompts

What is the role of nutrients in plant growth and in agricultural expansion? What are natural nutrient cycles? What are some basic chemical reactions involved in nutrient cycles? How does agriculture modify nutrient cycles? What are the differences between "natural" and synthetic fertilizers? How are synthetic fertilizers acquired? How does an excess of nutrients influence ecosystems? What are "dead zones"? What are ecosystem services? How can we monetize ecosystem services?

Assignment

None

Readings

Primary

Fagodiya, R.K., et al. 2017. Global temperature change potential of nitrogen use in agriculture: A 50-year assessment Scientific Reports. 7:44928

Power, A.G. 2010. Ecosystem services and agriculture: tradeoffs and synergies. Phil. Trans. R. Soc. B 365: 2959–2971

Secondary

Costanza, R., et al. 2014. Changes in the global value of ecosystem services. Global Environmental Change 26:152-158.

Guo, M. et al. 2017. How China's nitrogen footprint of food has changed from 1961 to 2010. Environ. Res. Lett. 12: 104006

Makowski, D. 2019. N2O increasing faster than expected. Nature Climate Change. 9: 907–910 |

DAY 6 – May 31 – MEMORIAL DAY, NO CLASS

Day 7 – June 1 – AGRICULTURAL LOSS, WASTE, AND DISPOSAL

Post-harvest losses and wasted food constitutes upwards of a third to half of all food grown in the field. Due to produce rotting on the vine, crops lost due to weather-related delays, transportation and storage spoilage, processing losses, and food on the table not eaten but left for the disposal, we manage to waste a very large portion of food produced. The decomposition of organic matter has a role in regenerating soil quality as well as adding to greenhouse gas emissions. Reducing these losses is one of the most important mechanisms for improving our food sustainability and the environmental impact of food production. In this session we will look at the impact of reducing food loss along the production and processing pipeline and examine uses for food that would otherwise be tossed in a land fill.

Discussion prompts

What is the difference between food loss and food waste? Describe the life cycle, start to finish, of your favorite food item. What are some trends among crops, regions, diets, and agricultural systems with regard to food loss and waste.

Assignment

None

Readings

Primary

FAO. 2011. Global food losses and food waste – Extent, causes and prevention. Food and Agriculture Organization. Rome

FAO, 2014. Food Wastage Footprint (FWF). Full-Cost Accounting. Food and Agriculture Organization. Rome.

National Academies of Sciences, Engineering, and Medicine 2019. Reducing Impacts of Food Loss and Waste: Proceedings of a Workshop. The National Academies Press. Washington, DC

Secondary

Birney, C. I., et al. 2017. An assessment of individual foodprints attributed to diets and food waste in the United States Environ. Res. Lett. 12: 105008

Buzby, J. C., et al. 2014. The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States, *EIB-121*, U.S. Department of Agriculture, Economic Research Service

Parfitt, J. et al. 2010. Food waste within food supply chains: quantification and potential for change to 2050 Phil. Trans. R. Soc. B 365, 3065–3081.

Verma, M., et al. 2020 Consumers discard a lot more food than widely believed: Estimates of global food waste using an energy gap approach and affluence elasticity of food waste. PLoS ONE 15(2): e0228369

Day 8 – June 2 – CLIMATE CHANGE

Global climate change is one of the largest challenges to the future of agriculture. Apart from a general warming of the Earth, changes in precipitation, seasonality, and the intensity and frequency of storms will require significant modifications of our agricultural practices. In this session we will explore the evidence for climate change, reach an understanding of how long-term processes such as Milankovich cycles and greenhouse gas dynamics influence climate, examine the mechanisms of global warming induced by human activities, and discuss the role of agriculture in causing climate change. We will also discuss the need to adapt agriculture to meet future climate change.

Discussion prompts

What are long-term global patterns of climate change and what factors influence global climate? How do various activities related to agriculture such as forest clearing and land use, soil management, water use, nutrient flows, add to climate change? What forms of energy are used on farms and in the life cycle of food production, processing, and disposal? How do we calculate carbon equivalents?

Assignment

None

Readings

Primary

Challinor, A. J., et al. 2014. A meta-analysis of crop yield under climate change and adaptation. Nature Climate Change. 4:287-291

Rosenzweig, C., et al. 2020. Climate change responses benefit from a global food system approach Nature Food 1: 94–97

Tomich, T. P. et al. 2011. Agroecology: A Review from a Global-Change Perspective. Annu. Rev. Environ. Resour. 36:193–222

Vermeulen, S. J. et al. 2012. Climate Change and Food Systems. Annu. Rev. Environ. Resour. 37:195–222

Secondary

Davidson, E. 2016. Projections of the soil-carbon deficit. Nature. 540: 47-48.

FAO. 2018. Climate-Smart Agriculture Case Studies 2018. Successful approaches from different regions. Rome. 44 pp. Licence: CC BY-NC-SA 3.0 IGO.

Fargione et al., 2018 Natural climate solutions for the United States. Sci. Adv. 2018; 4: eaat1869

Gornall, J. 2010. Implications of climate change for agricultural productivity in the early twenty-first century. Phil. Trans. R. Soc. B. 365, 2973–2989

IPCC. 2019. Climate Change and Land. An IPCC Special Report. Intergovernmental Panel on Climate Change.

Poore, J. and T. Nemecek. 2018. Reducing food's environmental impacts through producers and consumers. Science 360: 987–992.

Smith. P. et al. 2008. Greenhouse gas mitigation in agriculture Phil. Trans. R. Soc. B 363, 789–813

Day 9 – June 3 – Case study discussion and exam review

Day 10 – June 4 – Exam 1

Day 11 – June 7 – PESTICIDES

The history of agriculture has been, in part, competition between humans and a range of pests and parasites for the bounty that agriculture produces. Numerous measures to control these maladies have been developed over the years ranging from physical removal, development of resistant strains, and the use of chemicals (both "natural" and synthetic) that reduce or eliminate the pests of concern. Pesticides (including insecticides, fungicides, herbicides, and others) have greatly improved crop survivorship and yield but often at the cost of environmental degradation or contamination. Here we will explore the history of pesticide use, the physical, chemical, or biological mode of action of various pesticides, and the nature and extent of their environmental impact. We will cover concepts such as mechanisms of pesticide action, measures of toxicity (e.g., LD_{50}), and the evolution of pesticide resistance.

Discussion prompts

What are the mechanisms or mode of action for various classes of pesticides? How can pesticides have negative impacts on non-target species including humans? What are some trends in pesticide use in the US and globally? What are some trade offs with pesticide use?

Assignment

None

Readings

Primary

Fernandez-Cornejo, J. et al., 2014. Pesticide Use in U.S. Agriculture: 21 Selected Crops, 1960-2008, EIB-124, U.S. Department of Agriculture, Economic Research Service.

Field to Market: The Alliance for Sustainable Agriculture. 2020. Trends in Pest Management in U.S. Agriculture: Identifying Barriers to Progress and Solutions Through Collective Action. 68 pp.

Spees, C. and D. Fugere. 2019. Pesticides in the Pantry: Transparency & Risk in Food Supply Chains. As You Sow. Oakland, CA.

Secondary

Fenner, K., et al. 2013. Evaluating Pesticide Degradation in the Environment: Blind Spots and Emerging Opportunities. Science 341: 252-258.

Tranel, P. and T. Wright. 2002. Resistance of weeds to ALS-inhibiting herbicides: what have we learned? Weed Science¨ 50:700-712

Day 12 – June 8 – GENETICS AND BREEDING

Traditional crop and animal improvement is based on the relatively slow process of selecting desirable traits and removing undesirable traits from a breeding pool. The advent of molecular biology in the latter half of the 1900's allowed for much more rapid and directed modification of organisms at the genomic level with both advances in agricultural yield but also occasional unintended consequences. In this section we will explore the basis of traditional breeding (quantitative genetics) and the underpinnings of genetically modified organisms (GMOs). Some concepts that we will cover include the role of mutations, specific traits that are transferred from one organism to the other, role of GMOs in US and global agriculture, the evidence for negative health effects of GMO foods, and gene transfer from GMOs to wild species of plants and animals.

Discussion prompts

How are domesticated plants and animals traditionally selected and bred for improvement? What are the mechanisms for creating "genetically modified organisms" (GMOs)? What are some positive and negative attributes of each of these two broad classes of organisms?

Assignment

None

Readings

Primary

Ahmad, S.. et al. 2020. CRISPR/Cas9 for development of disease resistance in plants: recent progress, limitations and future prospects. Briefings in Functional Genomics, 00(00) 1–14

Bailey-Serres, J., et al. 2019. Genetic strategies for improving crop yields Nature 575: 109-118.

Oliver, M. J. 2014. Why We Need GMO Crops in Agriculture Missouri Medicine 111 (6): 492-507

National Academies of Sciences, Engineering, and Medicine 2016. Genetically Engineered Crops: Experiences and Prospects. Washington, DC: The National Academies Press.

National Research Council. 2010. The Impact of Genetically Engineered Crops on Farm Sustainability in the United States. Washington, DC: National Academies Press.

Voss-Fels, K. P., et al. 2019. Q&A: modern crop breeding for future food security. BMC Biology 17:18

Secondary

Ahloowalia, B. S., et al. 2004. Global impact of mutation-derived varieties. Euphytica 135: 187–204.

Week 12 – April 14 – FISHERIES

Fish are an important part of our food supply and are managed in a variety of ways. However, human harvest of both wild and farmed fish has numerous environmental impacts. These include overfishing of wild stocks and species loss, disruption of natural habitat and food webs, contamination of waterways, and the transmission of disease and parasites. In this session we will survey these effects and look at topics such as methods used to calculate safe harvest levels for wild fisheries, examine techniques used to minimize by-catch, and examine the evidence for disease transfer between farmed and native salmon.

Discussion prompts

Assignment

None

Readings

Primary

FAO. 2013. Fish To 2030. Prospects for Fisheries and Aquaculture. Agriculture and Environmental Services Discussion Paper 03. World Bank Report Number 83177-GLB

Free, C. M., et al. 2019. Impacts of historical warming on marine fisheries production Science 363, 979–983

Guillen, J. et al. 2019. Global seafood consumption footprint. Ambio 48:111–122

Secondary

Bostock, J., et al. 2010. Aquaculture: global status and trends Phil. Trans. R. Soc. B 365, 2897–2912

Cheung, W. W., et al. 2010. Large-scale redistribution of maximum fisheries catch potential in the lobal ocean under climate change. Global Change Biology 16: 24-35

Day 14 – June 14 –ORGANIC AND ALTERNATIVE AGRICULTURE

Concern over the environmental, societal, health, and other impacts of large scale industrial agriculture has prompted many to consider where their food comes from and how it was grown. The notion of "organic" food is now a major factor in food production and a billion dollar industry worldwide. While the legal definition of "organic" food focuses on it being pesticide free, a variety of other elements of organic farming including low or no till strategies, growing a greater diversity of crop plants, and minimizing the impact of farming on waterways, wildlife, and the environment in general. In this session we will explore production realities of organic food and consider the evidence (or lack thereof) for its health benefits.

Discussion prompts:

Given that organic food is meant to be free of synthetic pesticides, how do organic farmers control pests on their crops? How do "natural" pesticides play a role in organic farming? Could we feed the world with only organic food?

Assignment

None

Readings

Primary

Clark, M and D. Tilman. 2017. Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. Environ. Res. Lett. 12: 064016

Davis, A. S., et al. 2012. Increasing Cropping System Diversity Balances Productivity, Profitability and Environmental Health. PLOS ONE 7(10): e47149

Kastnera, T., et al. 2012. Global changes in diets and the consequences for land requirements for food. PNAS 109 (18): 6868–6872

Muller, A. et al. Strategies for feeding the world more sustainably with organic agriculture. Nature Communications 8: 1290: 1-13

Pretty, J. 2008. Agricultural sustainability: concepts, principles and evidence. Phil. Trans. R. Soc. B. 363, 447–465

Reganold, J. P. and J. M. Wachter. 2016. Organic agriculture in the twenty-first century. Nature Plants 2: 1-8

What is sustainable Agriculture? Sustainable Agriculture Research and Education (SARE)

Secondary

Paull, J. and B. Hennig. 2011. A World Map of Organic Agriculture. European Journal of Social Sciences. 24(3): 360-369

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Day 15 – June 11 – Case study discussion

Day 16 – June 14 – PROJECT PRESENTATIONS AND EXAM REVIEW

Day 17 – June 15 – PROJECT PRESENTATIONS AND EXAM REVIEW

Day 18 – June 16 – PROJECT PRESENTATIONS AND EXAM REVIEW

Day 19 – June 17 – FINAL EXAM