Current Climate Studies 10:

CLIMATE CHANGE IMPACTS ON U.S.: AGRICULTURE AND ECOSYSTEMS

1. Print this file. Also answer the "Concept of the Week" questions in the *Weekly Climate News* File. (Check for additional *News* updates during the week.)

2. Complete the Investigation by responding to the *Chapter Progress Questions* (*Study Guide*) and the Investigations 10A and 10B from the *Climate Studies Investigations Manual,* and this *Current Climate Study*.

Introduction

The third *U.S. National Climate Assessment* (*NCA3*) includes analyses of impacts of climate change on seven sectors (human health, water, energy, transportation, agriculture, forests and ecosystems) and the interactions among sectors at the national level. Several of these have already been addressed in Current Climate Studies segments. Here, we focus on agriculture and ecosystems.

Agriculture

NCA3 builds on previous assessments which merit examination because of their foundational content and previous findings that have stood the test of time. Go to the second *U.S. National Climate Assessment (NCA2)* published in 2009, and available at http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf. In the *NCA2* report, turn to page 72 in the section focusing on agriculture. There it is indicated that crop production is impacted by the interplay of changes in three factors: temperature, water resources, and carbon dioxide. Variations in these factors due to climate change can have both positive and negative consequences.

1. The leading statement on page 72 indicates many crops show positive responses to a combination of atmospheric carbon dioxide concentration being _____.

   [ ] reduced in combination with low levels of warming
   [ ] elevated in combination with low levels of warming
   [ ] elevated in combination with higher levels of warming

2. According to information on page 72, cereal crops are particularly sensitive to temperature changes. Analysis of crop responses suggests that even moderate _____ in temperature will decrease yields of grains including corn, wheat, beans and rice.

   [ ] increase
   [ ] decrease

3. The sensitivity of crops to changes in mean daily temperature can be seen in the figure on page 72. Note that the optimal temperatures for vegetative growth are different than those for seed (corn kernels and soybeans) production. Both crops exhibit about the same temperature range for vegetative growth (50 ºF to slightly above 100 ºF). However, the purple reproductive response curves indicate that, if subjected to the same increasing temperatures, _____ crops would be the first to fail to produce seed.

   [ ] corn
   [ ] soybean

4. As seen in the pie chart on page 71 of the report, livestock account for slightly more than half of agricultural production (52% in 2002). On page 78, it is indicated that livestock will be impacted by the anticipated changes in winter and summer temperatures. Generally, the negative effects of higher summer temperatures _____ outweigh the positive impacts of warmer winters on livestock productivity.

   [ ] will
   [ ] will not

Now access NCA3 *Highlights* by going to your bookmarked *Highlights* address, to the course website and click on "National Climate Assessment Highlights", or directly to http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf. There, on page 46, *NCA3*'s Finding 8 Agriculture, states, "Climate disruptions to agriculture have been increasing and are projected to become more severe over this century." Appearing on the same page are Key Messages concerning the impact of climate change on agriculture.

5. The first Key Message states that climate disruptions to agricultural production have been happening and will continue to happen. From the mid-century and onward, these impacts are projected to be increasingly _____.

   [ ] positive
   [ ] negative

6. The second Key Message indicates many agricultural regions will experience declines in crop and livestock production due to elevated stress due to _____.

   [ ] weeds
   [ ] diseases
   [ ] insect pests
   [ ] all these plus other climate change induced stresses

7. Another Key Message states that the increasing frequency of weather extremes will result in increasingly negative impacts on agricultural productivity because critical thresholds _____ exceeded.

[ ] will eventually be
[ ] are already being

8. Another Key Message points out that climate change will have consequences for food security in the U.S. and globally through changes in crop yields, food prices, and effects on food processing, storage, transportation and retailing. The message ends with the statement, "Adaptation measures _____ help delay and reduce some of these impacts.

   [ ] can
   [ ] cannot

9. On page 47 a figure describes three key climate variables affecting agricultural productivity. According to the captions accompanying the maps, the change in_____ has an explicitly stated adaptation potential leading to greater agricultural productivity.

   [ ] frost-free season length
   [ ] number of consecutive dry days
   [ ] number of hot nights

Visiting the *Climate Resilience Toolkit*: As stated earlier, the *U.S. Climate Resilience Toolkit* builds on NCAs by providing "resources and a framework for understanding and addressing the climate issues that impact people and their communities." Agriculture is treated in the *Toolbox* primarily under the heading of Food. Go to https://toolkit.climate.gov/topics/food-resilience.

10. The key points appearing on the Food web page and the information following them project that extreme weather, climate variability, and climate change will generally cause crop and livestock production to _____ by 2050 and beyond.

    [ ] increase
    [ ] remain steady
    [ ] decrease

11. The Food web page includes brief descriptions of the food sub-topics the *toolkit* addresses. The sub-topics reveal that food resilience goes beyond meeting the impacts of extreme weather, climate variability, and climate change on food production. Other food issues that also must be addressed are _____.

    [ ] food distribution
    [ ] food safety and nutrition
    [ ] international food security
    [ ] all of these

A food case study already incorporated in the *Toolkit* can be viewed at AgroClimate.org. Go to: https://toolkit.climate.gov/tool/agroclimate%E2%80%94tools-managing-climate-risk-agriculture. Read the introduction and view the related video about AgroClimate.

12. AgroClimate is a web resource dealing with risk in agriculture in the_____ U.S.

    [ ] Northeastern
    [ ] Southeastern
    [ ] Southwestern
    [ ] Northwestern

13. AgroClimate draws on interactive tools and climate information to improve crop management decisions and to reduce production risks associated with _____.

    [ ] climate variability
    [ ] climate change
    [ ] extreme weather events
    [ ] all of these

AgroClimate exemplifies the kinds of interactive tools and information accessible via the *U.S. Climate Resilience Toolkit* on a broad array of weather and climate related issues of value to many sectors of society.

Ecosystems

An ***ecosystem*** is an interactive community consisting of all living organisms and their physical and chemical environment within a specific geographical area.

Return to *NCA2* at: http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf. Go to page 79, where a Key Message states "Ecosystem processes, such as those that control growth and decomposition, have been affected by climate change."

The *NCA2* further states that, "The natural functioning of the environment provides both goods – such as food and other products that are bought and sold – and services, which our society depends upon. For example, ecosystems store large amounts of carbon in plants and soils; they regulate water flow and water quality; and they stabilize local climates. These services are not assigned a financial value, but society nonetheless depends on them. Ecosystem processes are the underpinning of these services: photosynthesis, the process by which plants capture carbon dioxide from the atmosphere and create new growth; the plant and soil processes that recycle nutrients from decomposing matter and maintain soil fertility; and the processes by which plants draw water from soils and return water to the atmosphere. These ecosystem processes are affected by climate and by the concentration of carbon dioxide in the atmosphere."

NCA2 continues, "The diversity of living things (biodiversity) in ecosystems is itself an important resource that maintains the ability of these systems to provide the services upon which society depends. Many factors affect biodiversity including: climatic conditions; the influences of competitors, predators, parasites, and diseases; disturbances such as fire; and other physical factors. Human-induced climate change in conjunction with other stresses, is

exerting major influences on natural environments and biodiversity, and these influences are generally expected to grow with increased warming."

14. The *NCA2* assessment of climate change impacting U.S. ecosystems includes many examples, with most being negative. The complexity of impacts is exemplified on page 81 concerning the breaking up of existing ecosystems. Such breakup will result in the formation of new ecosystems, but with unknown consequences. This is because entire communities of species do not shift intact in response to changing patterns of temperature and/or precipitation. The range and timing of each species shifts in response to_____.

    [ ] its sensitivity to climate change
    [ ] its mobility
    [ ] its lifespan
    [ ] the availability of the resources it needs
    [ ] all of these

Return to the *NCA3 Highlights* report and go to page 50. Finding 10 Ecosystems specifically states, "Ecosystems and the benefits they provide to society are being affected by climate change. The capacity of ecosystems to buffer the impacts of extreme events like fires, floods, and severe storms is being overwhelmed."

15. Biodiversity refers to the variety of life in an environment. The introductory paragraph on page 50 indicates biodiversity is being impacted by _____.

    [ ] alteration of critical biological events
    [ ] substantial range shifts of many species
    [ ] both of these

16. Examine the Key Messages: Ecosystems and Biodiversity. The first Key Message states, "Climate change impacts on ecosystems _____ their ability to improve water quality and regulate water flows."

    [ ] have no effect on
    [ ] increase
    [ ] reduce

17. One of the Key Messages indicates _____ system management is often more effective, and can help reduce the harm climate disruption might cause.

    [ ] "one species at a time"
    [ ] "whole**"**

18. The upper figure on page 51 compares the major North American CO_2 sources and sinks. It shows that fossil fuels are the primary sources of human-caused CO_2 emissions into the atmosphere while forestland and cropland are the primary places or "sinks" where carbon

is stored over the short or long term. According to text on page 51, CO_2 emissions from human activities in the U.S. exceeds the ecosystem uptake of carbon dioxide by more than _____ times.

[ ] 3
[ ] 5
[ ] 7

NCA3 completes its treatment of the impact of climate change on ecosystems by focusing on Forests, Land Use and Land Cover Change, Biogeochemical Cycles, and Species Responses.

Forests: On pages 51 and 52, *NCA3* points out that forests are the largest component of the U.S. carbon sink by providing the significant ecosystem service of absorbing carbon dioxide from the atmosphere and storing it.

19. The figure on page 52 shows the forest growth rates across the contiguous U.S., which directly correlates with forest CO_2 uptake. The forest growth rates vary considerably across the country, with the greatest rates occurring in the forests of the _____ states.

[ ] Northeastern
[ ] Great Plains
[ ] Pacific Coastal
[ ] Midwest

20. According to the one of the Key Messages: Forests on the same page, the equivalent of about _____% of the CO_2 emitted by the burning of fossil fuels is currently absorbed and stored by the U.S. forests and associated wood products.

[ ] 16
[ ] 24
[ ] 35
[ ] 52

21. Another Key Messages: Forests points out that climate change is increasing the susceptibility of forests to ecosystem changes and tree mortality through _____.

[ ] fire
[ ] insect infestations
[ ] drought
[ ] disease outbreaks
[ ] all of these

Land Use and Land Cover Change: On page 54, a Key Message indicates that "Land-use and land-cover changes affect local, regional, and global climate processes." Changing how the land is used (e.g., growing food or building cities) or land cover (e.g., physical

characteristics such as vegetation or concrete) ranks second to emissions of heat-trapping greenhouse gases in bring about human-caused climate change.

22. As stated on page 54, "Decisions about land use and land cover can therefore affect _____ how much our climate will change, and what kind of vulnerabilities humans and natural systems will face as a result."

    [ ] positively
    [ ] negatively
    [ ] positively or negatively

Biogeochemical Cycles: Biogeochemical cycles describe the pathways along which solids, liquids, and gases move among the various reservoirs on Earth, often involving physical or chemical changes to these substances. On page 55, Key Messages: Biogeochemical Cycles indicate many biogeochemical cycles have been altered by human activity.

23. According to one Key Message, human activities increased atmospheric CO_2 by 40%, and more than _____ the amount of nitrogen available to ecosystems, with similar trends for phosphorus and other elements compared to pre-industrial levels. The Key Message ends, "these changes have major consequences for biogeochemical cycles and climate change."

    [ ] doubled
    [ ] tripled
    [ ] quadrupled

Species Responses: *NCA3* ends its Ecosystems sector by describing changes experienced by numerous species on pages 56 and 57 that are consistent with climate change. While some of the species responses would be considered as positive, most are negative.

Visiting the *Climate Resilience Toolkit*: Go to the *Toolkit*'s Ecosystem Vulnerability topic at https://toolkit.climate.gov/topics/ecosystems. Following the Key points adapted from NCA3, the Value of Ecosystems is discussed. It points out that climate change "will influence the distribution, extent, and composition of ecosystems, and hence affect the spectrum of services and economic value they provide."

24. The impacts of climate change, along with multiple other environmental stresses such as habitat loss and pollution, on ecosystems are expected to disrupt ecosystem processes and _____ the risk of species extinctions.

    [ ] increase
    [ ] decrease

To treat the impacts of climate change and variability on ecosystem vulnerability, the *Toolkit* explores subtopics. While at the Ecosystem web page, click on the subtopic links to the right and read the introductions to each of these subtopics. Focus on one of the subtopics of

greatest interest to you to learn details. Read one of the Taking Action case studies to learn how one group or community approached an ecosystem vulnerability.

Summary

Assessing possible climate-change impacts from a sector perspective offers the potential to confront climate change risks and explore solutions across a range of climate change concerns. These can lead to informed mitigation of global warming and adaptation to the effects of climate change at local, regional, national, and global levels.

Instructions for Communications with Mentor:

Transmit this week's work to your LIT mentor by Monday, 14 November 2016, or as coordinated with your mentor. Include:

- **Chapter Progress Response Form** from the *Study Guide* or the *RealTime Climate Portal* course website.
- **Investigations Answer Form** for 10A and 10B from the *Study Guide* or *RealTime Climate Portal* website.
- **Current Climate Studies Answer Form** from *RealTime Climate Portal* website.