Climate Challenges for Food Animals
The Future is Here
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Overview

• The evidence for climate change
• Climate forcings
• Anthropogenic causes
• World Response
• Impacts on food animal
The Evidence

Source: NASA Images of Change
The Evidence-Sea Ice Change

- In 2019 Arctic sea ice remained younger, thinner, and covered less area than in the past.
- The 12 lowest extents in the satellite record have occurred in the last 12 years.

Source: NOAA Arctic Report Card 2019
Differences for January

Temperature

Precipitation

Source: Climate.gov
Differences for August

Temperature

Precipitation

Source: Climate.gov
Average US Temperature in September

Contiguous U.S., Average Temperature, September

Source: NOAA
Drought—Is this normal variability?

September 15, 2015

September 15, 2020

Source Climate.gov
Climate Forcings
What is Climate Forcing?

- Any influence on climate that originates from outside the climate system itself.
The Climate System

- Hydrosphere
  - Oceans
- Lithosphere
  - Land surface
- Cryosphere
  - Glaciers
- Biosphere
  - Ecosystems
- Atmosphere

Melting glacier in Iceland. Photo Credit: Yvette Bordeaux
Earth’s Climate Forcing

- Milankovitch Cycles
- Incoming solar radiation
- Volcanic eruptions
- Surface reflectivity
  - Albedo
- Greenhouse gases

Erupting volcano. Photo: Mann & Kump, 2015.
Human Induced Climate Forcing

- Atmospheric aerosols
  - Industrial output
  - Human Caused Wildfires
- Increase Warming through
  - Greenhouse Effect

Wildfire in California. Photo: Mann & Kump, 2015.
Greenhouse Effect
Greenhouse gases in the Atmosphere

Absorption 25%

Reflection by clouds 19%

Absorption by surface 45%

Scattering by atmosphere 6%

Reflection by ground 5%

CO₂
CH₄
N₂O
CFC
The Greenhouse Gases

F-gases=Fluorinated gases (i.e. hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6))

Source: IPCC (2014)
What is the concentration of CO$_2$ in the Atmosphere?
Greenhouse Gases

- Absorb infrared radiation from Earth
- Mainly H\textsubscript{2}O vapor and CO\textsubscript{2}
- Monthly Average:
  - 1958: 317.45 ppm
  - 2020: 414.7 ppm

Source: NOAA
Sources of Carbon dioxide (CO₂)

- **Natural Sources**
  - Decaying matter
  - Natural wildfires
  - Volcanic eruptions

- **Anthropogenic sources**
  - Fossil Fuel burning
  - Limestone Roasting

The Carbon Cycle. Photo: Mann & Kump, 2015
Energy Related CO₂ emissions

Source: IEA
CO₂ emissions over time

Source: NOAA

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CO₂ in Oceans

- CO₂ highly soluble in seawater
- Excess CO₂ in atmosphere locked up in oceans
  - CaCO₃ biogenic sediments
- Stimulate growth of phytoplankton which consume CO₂
- ≈38,000 BT

Chlorophyll map of the world. Source: SEAWIFS
Other greenhouse gases
Global Warming Potential (GWP)

• The ratio of the warming caused by a substance to the warming caused by a similar mass of carbon dioxide

• Usually based on a residence time of 100 years
Methane (CH$_4$)

- GWP = 28-36 *
- Sources:
  - Agriculture
  - Waste Management
  - Energy Use (natural Gas)
  - Biomass Burning

*over 100 years USEPA

Methane concentration in atmosphere Source: NOAA
**Nitrous Oxide (NO$_2$)**

- **GWP=265-298** *
- **Sources:**
  - Agriculture (especially fertilizer use)
  - Product of incomplete fossil fuel burning

*over 100 years USEPA

Nitrous Oxide concentration in atmosphere Source: NOAA
F-Gases

• Sulfur hexafluoride
  • 22,200
• Chlorofluorocarbon (CFC)-12
  • 8,500
• CFC-11
  • 5,000
• Hydrochlorofluorocarbons and hydrofluorocarbons range from
  • 93 to 12,100

Source: NOAA
World Agreements
A Short History of Worldwide Attempts to Control Emissions

IPC C established
UNFCC established
Kyoto Protocol
An Inconvenient Truth
Paris Climate Agreement

1989
1994
1997
2006
2015
Intergovernmental Panel on Climate Change (IPCC)

• United Nations body for assessing the science related to climate change.
• Created in 1989 to aid policymakers in understanding
  • Regular scientific assessments
  • Potential future risks
  • Recommend adaptation and mitigation options
A Short History of Worldwide Attempts to Control Emissions

- **IPCC established**
  - 1989

- **UNFCC established**
  - 1994

- **Kyoto Protocol**
  - 1997

- **An Inconvenient Truth**
  - Al Gore
  - 2006

- **Paris Climate Agreement**
  - 2015
United Nations Framework Convention on Climate Change (UNFCC)

- 197 Parties to the Convention
- Purpose:
  - “Prevent “dangerous” human interference with the climate system”
- Objective
  - “stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system.”
• Industrialized countries are expected to
  • Lead in reduction of emissions
  • Give financial support to developing countries
  • Submit annual inventories
• Annual conferences to measure progress and reassess goals
  • Conferences of Parties
    • COP
A Short History of Worldwide Attempts to Control Emissions

- IPCC established
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- An Inconvenient Truth
- Paris Climate Agreement

- 1989
- 1994
- 1997
- 2006
- 2015
Kyoto Protocol

- Adopted in 1997 and ratified in 2005
- Purpose:
  - Reduce emissions of 6 greenhouse gases in 41 industrialized countries and EU to 5.2% below 1990 levels.
- Target period 2008-2012
- 192 Parties
  - US joined in 1997
  - US dropped out in 2001
Kyoto Protocol Doha Amendment

• Adopted in 2012
• Purpose:
  • Further reduce emissions of 6 greenhouse gases to 18% below 1990 levels.
• Target period 2013-2020
• 37 Industrialized countries and the EU committed
• Did not reach the 144 instruments of acceptance needed to enforce the amendment.
A Short History of Worldwide Attempts to Control Emissions

- IPCC established
- UNFCC established
- Kyoto Protocol
- An Inconvenient Truth
- Paris Climate Agreement

- 1989
- 1994
- 1997
- 2006
- 2015
The Paris Climate Accord

• COP 21 held in Paris
• 195 countries including US signed
• Objective:
  • Prevent a global temperature rise of 2°C above pre-industrial levels
• US dropped out in 2016
The Paris Climate Accord

• Nationally Determined Contributions (NDC)
  • “Each climate plan reflects the country’s ambition for reducing emissions, taking into account its domestic circumstances and capabilities.”
• Plans are to be updated every 5 years
Consequences of a warming planet
Some Consequences of Warming

- Heat Waves
- Wildfires
- Vector-Borne Disease
- Flooding
- Drought
- Increased Storm Intensity
- Sea Level Rise
- Storm Surge

Effects of drought. Photo: Mann & Kump, 2015
Average US Temperature Increasing

• In US, annual average temperature increased by 1.2°F (0.7°C) for the period 1986–2016

Source: Climate.gov

Source: Climate Science Special Report
Heat Stress for Food Animals

- Increases in daily maximum temperatures or heat waves can lead to heat stress for free range food animals
- Result in changes in respiration rate, heart rate, blood chemistry, hormones, and metabolism
- Increased intake of water and reduced feed intake
- Affects reproductive efficiency
- High temperatures adversely affect pasture and range conditions and reduce forage crop and grain production

Source: Fourth National Climate Assessment
Heat Stress for Dairy Cows

• Negative impacts to include:
  • Appetite suppression
  • Rumen fermentation process
  • Lactation yield
• Frequent higher temperatures also lower milk quality
  • Reduced fat, lactose, and protein percentages
• In 2010, heat stress was estimated to have lowered annual U.S. dairy production by $1.2 billion.

Source: Fourth National Climate Assessment
Heat Stress for Beef Cows

• Similar impacts as Dairy
• Higher temperatures result in
  • Reduced appetites
  • Reduced grazing/feeding activity
  • Increase in water intake

Source: Fourth National Climate Assessment
Forage Quality

• Forage quality is expected to be affected by rising CO$_2$ concentrations

• Decrease in dietary iron, zinc, protein, and other macro- and micronutrients

Source: Fourth National Climate Assessment

Drought stricken crops. Photo: Mann & Kump, 2015
Vector-Borne Diseases

- Abundant late-spring and early-summer moisture
- Insect related disease on the rise as a result
- The geographic range of suitable habitats for insect vectors is expected to continue shifting northward into New England in the next several decades

Source: Fourth National Climate Assessment

Mosquitos. Photo: Mann & Kump, 2015
Wildfires

• Wildfires in the west are impacting air quality around the world

Source: NASA

Source: AirNow
Regional Impacts - Northeast

- Heat waves
- Heavy downpours
- Agriculture and ecosystems will be increasingly compromised

Source: NASA

Regions of the US. Source: Fourth National Climate Assessment
Regional Impacts - Northwest

- Reduced water supplies for competing demands
- Erosion of top soil
- Increasing wildfire
- Insect outbreaks
- Tree diseases causing widespread tree die-off

Source: NASA

Regions of the US. Source: Fourth National Climate Assessment
Regional Impacts - Southeast

- Extreme heat
- Decreased water availability

Source: NASA

Regions of the US. Source: Fourth National Climate Assessment
Regional Impacts - Midwest

- Extreme heat
- Heavy downpours
- Flooding
- Air and water quality

Source: NASA

Regions of the US. Source: Fourth National Climate Assessment
Regional Impacts - Southwest

- Increased heat
- Drought
- Insect outbreaks
- Increased wildfire
- Declining water supplies will reduce agricultural yields

Source: NASA

Regions of the US. Source: Fourth National Climate Assessment
References

• AirNow Fires

• Climate Science National Report

• Fourth National Climate Assessment

• Intergovernmental Panel on Climate Change (IPCC)


• NASA Images of Change

• NASA Vital Signs of the Planet

• NOAA Arctic Report Card

• NOAA Global Monitoring Laboratory