The USA National Phenology Network:
A national science and monitoring program for understanding climate change

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www.usanpn.org
Outline

• Definitions
• Implications for natural ecological systems
• The National Phenology Network
• Plant, animal, & landscape monitoring programs
Phenology

Study of the cause and the consequence of the timing of recurring biological phases
Phenology and the biosphere

Climate
Temperature, Precipitation, Radiation, Humidity, Wind

Chemistry
$\text{CO}_2$, $\text{CH}_4$, $\text{N}_2\text{O}$, ozone, aerosols

Heat

Moisture

Momentum

Biogeophysics

Energy

Water

Aerodynamics

Biogeochemistry
Carbon Assimilation
Decomposition
Mineralization

Microclimate

Canopy Physiology

Species Composition

Ecosystem Structure

Nutrient Availability

Water

GPP, Plant & Microbial Respiration
Nutrient Availability

Evaporation

Transpiration

Snow Melt

Infiltration

Runoff

Disturbance
Fires
Hurricanes
Ice Storms
Windthrows

Betancourt 2006, modified from Bonan (2002)
“Phenology…is perhaps the simplest process in which to track changes in the ecology of species in response to climate change.” (IPCC 2007)
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Changes in spring timing for many organisms

Parmesan and Yohe

- Meta-analysis
- 677 species examined
- 16-132 years (med = 45)
- 62% advanced in timing

Parmesan and Yohe 2003 Nature
Differential response across species groups

Changes in spring timing (days/decade)

N = 203

Parmesan 2007 - GCB
A three-way mismatch

English Oak

Winter Moth

Pied Flycatcher

EARLIER

SAME TIME EACH YEAR

Both et al. 2006 Nature
Differential responses generate mismatches

Miller-Rushing et al. 2007 AJB
Differential responses generate mismatches

Miller-Rushing et al. 2007 AJB
Thoreau on Walden Pond

- Henry David Thoreau, Walden Pond, Concord, MA
  - 600 plant species, first flowering, 8 years, 1850s

- Richard Primack & Abe Miller-Rushing, Concord, MA
  - 43 plant species, first flowering, 4 years, 2004-2007
  - Average flowering date: 7 days earlier
  - Common plant flowering date: 21 days earlier
  - Culprit: rising winter and spring temperatures
Local extinctions in Concord, MA

What's declining?

- asters
- bladderworts
- buttercups
- dogwoods
- lilies
- mints
- orchids
- violets

Willis et al. 2008 PNAS
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A new data resource—a national network of integrated phenological observations across space and time

• Understand how plants, animals and landscapes respond to environmental variation

• Develop tools and techniques for human adaptation to climate change
• Cooperate with agencies, NGOs, academia, public

• Standardize collection of phenology observations

• Incorporate historical data

• Provide online data entry, downloading, visualization

• Educate public

• Incorporate new technologies – e.g., remote sensing
Decreasing Spatial Coverage
Increasing Process Knowledge

USA-NPN Conceptual Structure

Intensive science sites
Extensive management sites
Volunteer & education networks
Remote sensing

Adapted from CENR-OSTP
Intensive science networks

Natl Ecol Obs Ntwk (NEON)

USFWS NWR system

Remote sensing

2005 Start of Season (SOS)

Volunteers
Education, outreach and citizen science

- Engage public in GC data collection and analysis
- Education programs and modules (K - gray)
- Live for 2008 on Feb 15
- Enormous interest (AP, Science, NPR, Sunset: 200+ news articles)
- Source of legacy datasets
- Portal to detailed data collection protocols
The NPN partnership model

NCO Core Programs
- Plant phenology
- Animal phenology
- Land surface phenology

Regional phenology networks (NE-RPN, MAP, SE-RPN)

Agency programs (NWR, NPS, Heritage, CEN, NCCWSC)

Ecological Observatory Networks (NEON, LTER, AmeriFlux)

Phenology Gardens/Canopy-Cam Network

Specialized networks (Monarch Watch, Hummingbird Network, ARMI, BBS)

Education, Outreach, Citizen Science (Project BudBurst, Phenology 101)

Science (Conservation, species interactions, climate change impacts, modeling)
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Plant Phenology Program

- 220 plant species
  - Useful for applications in research, health, agriculture, recreation, conservation, invasive species…

- Sampling protocols
  - Tiered levels of involvement
  - Consistent with international standards
  - Accommodate issues of scaling, taxonomic differences, historical data
Wildlife Phenology Program

• Build partnerships
  - government, academic, conservation, and education organizations

• Develop and vet list of species and monitoring protocols

• Incorporate historical datasets

• Integrate observations of plants, animals & landscapes

• ID opportunities for early success
Bartlett Expt’l Forest, NH

Latest image - 15 June 2007

Green index predicts GPP

Richardson in prep.

Remote Sensing Working Group

Pieter Beck, Jess Brown, Kirsten de Beurs, Geoff Henebry, John Kimball, Liang Liang, Jeff Morisette, Wim van Leeuwen, Xiaoyang Zhang, others

• Governance: Geoff Henebry, Chair; Wim van Leeuwen, Vice-Chair
• Phenology Special Session at 2008 AGU Fall Meeting
• Develop LSP workshop for ESA 2009
• Land Surface Phenology Variable Intercomparison Project
• Submitted: NASA Terrestrial Ecology Proposal

“Assessing the Impacts and Consequences of Global Change on Shifts in Phenology: A scoping study to design a NASA campaign”
USA-NPN RSWG progress, cont.

• Update Friedl et al. (2006) ESDR white paper
• Review/revise LSP content on USA-NPN website
• Prepare LSP articles for Encyclopedia of Earth
• Develop gallery of LSP “eye-candy” for public and media
• Produce suite of “standard” products for naïve technical users (e.g., NEON, NPS, BLM, USFWS)
• Develop teaching modules/outreach products and funding possibilities
• Develop guide to LSP terminology
• Develop National LSP Coordinator position description
Data Management Plan

Observational data

Legacy datasets

Network datasets

Data entry/contribution web interface

NPN Data Store

DC-Bio

FGDC

Data retrieval/visualization web interface

Queried Data

Visualization tools

External datasets (e.g., NCDC)

Visual Data

USER END
A National Phenology Network

Phenology is the study of periodic plant and animal life cycle events and how these are influenced by seasonal and interannual variations in climate. Examples include the timing of leafing and flowering, agricultural crop stages, insect emergence, and animal migration. All of these events are sensitive measures of climatic variation and change, are relatively simple to record and understand, and are vital to both the scientific and public interest.

Phenology can be used as a predictor for a variety of processes and variables of importance at local to global scales. Phenology modulates the abundance and diversity of organisms, their inter-specific interactions, their ecological functions, and their effects on fluxes in water, energy, and chemical elements at various scales. Phenological data and models are useful in agriculture, drought monitoring, and wildfire risk assessment, as well as management of invasive species, pests, and infectious diseases. Integration of spatially-extensive phenological data and models with both short and long-term climatic forecasts offer a powerful agent for human adaptation to ongoing and future climate change. To fully utilize the value in phenological data, however, a new data resource is required – a large-scale network of integrated phenological observations, linked with other relevant data sources, and the tools to analyze these data at multiple scales.