Elevation and Latitudinal Gradient Sites: Detecting Phenology Controls and Climate Change

Taking the Pulse of Our Planet

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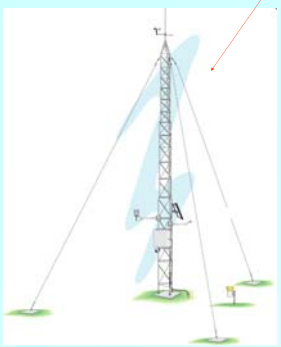
INTRODUCTION

Phenology is the study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic forces, the interrelation among phases of the same or different species, and a critical tool for enabling adaptive responses to climate change. With sufficient observations and understanding, phenology can be used as a predictor for other processes and variables of importance at local to global scales, and could drive a variety of ecological forecast models with both scientific and practical applications.

To fully utilize the value of phenology, not only are more observations at more locations needed, but also linkages between climatic factors and phenology must be more firmly established. Establishing networks of phenology observations over elevation gradients over a range of latitudes provides an excellent way to begin to investigate these linkages.

Elevation gradients offer the spatial efficiency of compressed ecosystem transitions, plus the potential for climatic matching of sites at different latitudes. These enable expanded research opportunities to evaluate abiotic factors such as day length, seasonal variability, storm track, and atmospheric chemistry, on biological species and whole biomes. Gradient sites also provide excellent platforms to evaluate new and existing remote sensing of phenology methods.

ELEVATION-LATITUDINAL GRADIENT NETWORK COMPONENTS



Co-located at each site:

•Standardized surface phenology observations using NPN protocols; www.usanpn.org

•Meteorological/hydrological instrumentation with cloned plant garden

•Near surface remote sensing instrumentation; (enables scaling from surface observations to space)

Coordination, standardized protocols, and data services are key; www.usanpn.org

VALUE

Immediate

Track current and ongoing climate change

Develop earth surface-to-space scaling tools and procedures

Enhance synergistic and comparative research value at all sites

Long-term

Meld existing data bases, including paleo-climatic reconstructions, with ongoing observations and data collection to enhance the value of these measurements at all sites

Create synthetic, cross-disciplinary, and comparative research opportunities

Provide a climatic contextual perspective for empirical biological studies

Provide a field site network structure for all to test and evaluate future climate scenarios at scales from species to biome

Inform model development and effective adaptation strategies to ongoing and future climate change

PHENOCAMS OFFER LOW-COST, NEAR REMOTE SENSING CAPABILITY TO LINK SURFACE CONDITIONS TO SATELITE BASED PRODUCTS

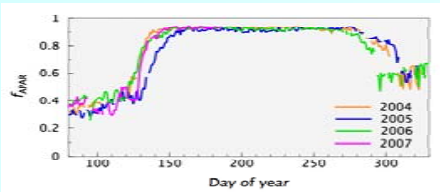
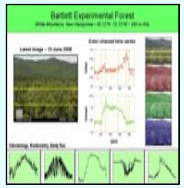


Figure 1. Seasonal trajectory of canopy phenology as derived from webcam images from Bartlett, New Hamshire. Shown is relative brightness (%) of the red, green and blue color channels. Green% begins a rising trend around day 120 (early May), corresponding to leaf out, and levels off around day 160 (mid June), when the canopy is fully developed. The onset of autumn coloration begins by day 220 (mid August). By day 270 (late September), green% has reached the dormant season minimum—although at this point in time, leaves have not yet fallen. The spike in red% at day 270 corresponds to peak autumn coloration. The decrease in red % over the next 30 days (through day 300) occurs as senescence progresses and the deciduous canopy is shed.



Courtesy Andrew D. Richardson

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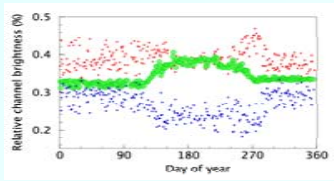


Figure 3. Seasonal and interannual variation in *f*APAR, the fraction of incident photosynthetically active radiation absorbed by the canopy. Data from the Bartlett Experimental Forest, indicate a rapid spring increase in the *f*APAR as the developmental trajectory progresses from a leafless (day 121 in Figure 1A) to a fully-foliated (day 165). This figure also shows the late arrival of both spring and autumn senescence in 2005, compared to other year. These patterns are in agreement with what is observed from both satellite and observer-based phenology records.

References

Jenkins, J.P., A.D. Richardson, B.H. Braswell, S.V. Ollinger, D.Y. Hollinger, and M.-L. Smith. 2007. Refining light-use efficiency calculations for a deciduous forest canopy using simultaneous tower-based carbon flux and radiometric measurements. *Agricultural and Forest Meteorology*, 143: 64-79

Richardson, A.D., J.P. Jenkins, B.H. Braswell, D.Y. Hollinger, S.V. Ollinger, and M.-L. Smith. 2007. Use of digital webcam images to track spring green-up in a deciduous broadleaf forest. *Oecologia*, 152: 323-334.

Schwartz, M.D., Ahas, R. and Aasa, A. 2006. Onset of spring starting earlier across the Northern Hemisphere. *Global Change Biology*, 12: 343-351.

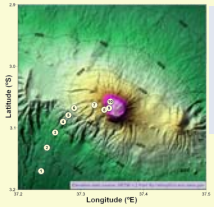
EXAMPLES OF ELEVATION GRADIENT NETWORKS

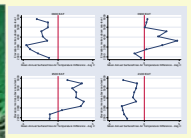
Elevation gradient networks across broad latitudinal gradients offer a powerful field structure to asses ongoing climate change, and evaluate predictions of future species, ecosystem, and biome changes brought about by climate change. Such networks provide the opportunity for broad ranging comparative and synthetic research that informs mitigation and adaptation strategies.

RMBL, Gothic, CO (Funded)

The network of observations and measurements linking phenology, meteorology, climate, and remote sensing will be installed summer 2009.

KILIMANJARO (T/Rh gradient)

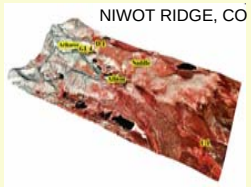




Vertical profiles of the mean surface/free air temperature difference for four limes of day. Pepin, N.C., Duane, W.J. and Hardy, D.R. Towards a Model of the Mountain Thermal Circulation on Kilimanjaro, Tanzania: ompaison of Surface Mountain Climate with Equivalent Free Air Parameters

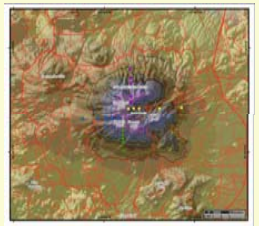
Courtesy of Nick Pepin

NIWOT RIDGE, CO (Instrumented)



Niwot Ridge is an LTER site with extensive long term data bases. Incorporation of an active phenology program and linkage to remote sensing products enables a complete program.

SAN FRANCISCO PEAKS, AZ (Proposed)



Overstory vegetation and proposed climate observation sites in the San Francisco Peaks region (Data source: Forest Ecosystem Restoration Analysis, Northern Arizona University; Map credit: D.Simeral-WRCC)

Courtesy of David Simeral (PI) - Assistant Research Meteorologist, Western Regional Climate Center, Division of Atmospheric Sciences, Desert Research Institute

SUMMARY

- Localized elevation gradient networks + broad latitudinal distribution = Research opportunity

(synthesis, comparative, cross-disciplinary, hypothesis testing and evaluation at climate-equivalent sites)

Co-located instrumentation and phenology observations using standardized protocols facilitate the identification of specific biotic and abiotic parameters that shape our environment. Identification of the mechanistically-linked drivers, and the roles they play, informs predictive models, and advances the quest to develop adaptive strategies for our future.

The National Coordinating Office of the USA-NPN, in collaboration with the Rocky Mountain Biological Lab, is developing and testing a template that standardizes elevation-latitudinal gradient site installation and operation, and is well placed to coordinate an elevational-latitudinal network of sites. Feedback and suggestions are solicited from all.

Simplified: Add phenology to any existing monitoring site.

Value-added vs. cost is extremely high: research relevancy, connection to biological systems, national network linkage via www.usanpn.org

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