

GEOG696C -Physical Geography Seminar - Fall 2008
The Geography of Phenology: Synchronies and Trajectories of Natural and Human Systems



Lead Instructor: Dr. Wim van Leeuwen
Format: Guest speakers, Discussions, Presentations, Research, Review
Course Credits: 3 credit hours
When & where: Th; 5-7³⁰ PM, Harvill 452

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There is a d2l site set up for this course that you will use to access and submit course announcements, materials, turn-in assignments, and check your grade. To get to it, go to: <http://d2l.arizona.edu> and enter your UA NetID and password (what you use to check your UA email account).

Course Theme Description and Objectives:

Phenology is the study of regularly occurring biological phenomena interacting with climate and environmental factors. Phenology science explores the effects of seasonal cycles on life cycles. Phenologists map and examine the spatio-temporal patterns and distributions of plant and animal life cycles and study how current climate change and variability impacts synchronies and trajectories of natural and human systems. They also conduct research on how phenology impacts or changes earth surface processes like carbon exchange, water use, agricultural production, and health issues. Knowledge of phenology is pertinent to understanding the processes and interactions between biosphere, atmosphere, hydrosphere and lithosphere. Examples of phenological phenomena include the timing of flowering and leafing and dates of insect appearance and bird migration patterns.

This course is designed to critically explore the field of phenology. Phenology research and coordination efforts related to species and environmental observations, remotely sensed land surface phenology, education and outreach, and regional, continental and (USA-NPN) and global phenology networks will be examined.

The goals of the course are to combine human and ecological perspectives in the field of phenology and demonstrate how historical and current environments impact ecological processes that have shaped species dependencies and nearly all species and land surface patterns. Foci will be placed mostly on terrestrial ecosystem phenology. Not only will you be gaining insight and

experiences that should be useful in your future career, this course will also provide opportunities to work as individuals and as teams.

The objectives of the course are to (a) examine the field of phenology, (b) examine how geographically-linked processes influence phenology of biota in time and space; (c) provide an overview of the analytical techniques and applications for studying the interplay between phenology, geographic ranges, environment and seasonality; (d) discuss and develop a phenology calendar/protocol/curriculum.

The seminar will cover several themes that will be covered throughout the semester:

Theme 1. Introduction to the science and history of phenology

Theme 2. The USA National Phenology Network (USA-NPN)

Theme 3. Phenological observations and protocols

Theme 4. Phenological modeling (data and ecosystem)

Theme 5. Phenological applications (natural resource monitoring and management)

Theme 6. New frontiers in phenology (adaptation, scale, networks, outreach and education)

Required Text:

Haggerty, Brian P. and Susan J. Mazer, 2008. *The Phenology Handbook-A guide to phenological monitoring for students, teachers, families, and nature enthusiasts*. University of California, Santa Barbara. Pp43.

http://www.ucsbphenology.christophercosner.com/The_Phenology_Handbook-Haggerty_Mazer_2008_v1.pdf

IPCC 4th assessment, Climate Change 2007: Synthesis Report.

http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

Recommended Reading: (preliminary list of *Articles* from the primary literature).

(MacDowall 1903, Clark 1923, 1926, Caprio 1957, Stiles 1975, Justice et al. 1985, Kochmer and Handel 1986, Vanschaik et al. 1993, Bever 1994, Reed et al. 1994, Loveland et al. 1995, Sellers et al. 1996, Myneni et al. 1997, White et al. 1997, Post and Stenseth 1999, Potter and Klooster 1999, Hughes 2000, Stevenson and Bryant 2000, Both and Visser 2001, Falge et al. 2001, Penuelas and Filella 2001, Stenseth and Mysterud 2002, Walther et al. 2002, Cotton 2003, Parmesan and Yohe 2003, Sitch et al. 2003, Zhang et al. 2003, Chuine et al. 2004, de Beurs and Henebry 2004, Cautín and Agustí 2005, Elmore et al. 2005, Frankl et al. 2005, Orr et al. 2005, Cleland et al. 2006, Herfindal et al. 2006, Huete et al. 2006, Morton et al. 2006, Sparks et al. 2006, Betancourt et al. 2007, Myneni et al. 2007, Rainio et al. 2007, Sherry et al. 2007, Wittemyer et al. 2007, Crimmins and Crimmins 2008, Crimmins et al. 2008, Huete et al. 2008, Inouye 2008, Montague et al. 2008, Post et al. 2008a, Post et al. 2008b, Rich et al. 2008, Rosenzweig et al. 2008, van Leeuwen 2008)

Websites

- [USA-National Phenology Network](#) (USA)
- [Project Budburst](#) (USA)
- [Nature calendar](#) (België; in dutch)
- [European Phenology Network](#) (Europa)
- [Nature's Calendar](#) (Engeland)
- [Nature's Calendar](#) (Netherlands)
- [Naturdetektive](#) (Germany; in german)
- [Naturewatch](#) (Canada)
- [Plantwatch Program](#) (Canada)
- [GLOBE Phenology Investigation](#) (USA)
- [Wisconsin Phenological Society](#) (USA)
- [Journey North - engaging students in a global study of wildlife migration](#) (North America)
- [Phenological observations in Finland](#) (Finland)
- [Bloom Times for Wildflowers of the Southern Appalachians](#) (USA)
- [Wolf Ridge Phenology project in Minnesota, Wisconsin, and North Dakota](#) (USA)

"Leisure" reading:

There are several books that deal directly and indirectly with phenology that make for interesting reading:

- The Weather Makers: How Man Is Changing the Climate and What It Means for Life on Earth by Tim Flannery
- Schwartz M.D., Editor, 2003. *Phenology: An Integrative Environmental Science (Tasks for Vegetation Science)* 592 pages; Kluwer Academic Publishers

Activities:

The seminar will entertain a series of guest speakers, as well as lectures, assigned readings, student presentations and several in class activities. Individual students or teams of 2 students will choose a phenological topic (topics will be chosen upon approval by the instructors) for additional research, literature study and presentation to the class. Grade assessment will be based on your preparations for scheduled class activities, formulation of questions, and participation in discussion based on the lectures, assigned readings and other activities.

Student Activities:

- Participate in SWASPRS/NPN conference October 10, 2008
- AAG Abstract deadline October 16, 2008
- Invite guest speakers
- Analyze/review literature
- Write a part of your dissertation related to phenology
- Lead discussions, suggest readings about phenology research and applications
- Present your perspective on a phenological topic
- Assess your work and the work of your peers

"Field Trips":

Visits to NPN, SWASPRS-NPN conference, UA colloquia, Desert Museum and Catalina Mountains etc. are encouraged.

Grading:

This is **not** a correspondence course! All students are expected to **attend every class period**, and, **have completed the assignments for each meeting**, read the appropriate book chapters and articles, and perhaps some of the suggested additional readings. All students are expected to be active participants.

- **Assignments/jobs:** There will be several assignments that emphasize interdisciplinary research aspects of phenology science. Assignments will account for **25%** of the students overall grade in the course. Further information on format expectations for these assignments will be provided as assigned. Assigned work will involve several jobs or exercises to be completed individually or in small groups.
- **Presentation:** All graduate students will present their research or topic of interest (~20min). Your powerpoint will be shared with the class and your presentation skills will be evaluated by your peers (a rubric will be provided). Topics need to be approved by the instructor. A PowerPoint presentation will need to be submitted before the lecture. **25%**
- **PhD Graduate students** will write up a report that designs a phenology curriculum, protocol, or calendar. Another option to be discussed in class is to write a research paper based on your common interest. They will present this report or paper at the end of the semester. A summary and outline are essential before full submission of the report or paper. More information on this component will be discussed in class. **25%**
- **Master's students start with 25%.**
- **Participation & Attendance (PA):** Class meetings will be a mixture of lectures, guest presentations, student presentations and discussions. Students will be evaluated on their participation in class discussions. The instructor and your peers will assess **25%** of your grade in this area. Questions and comments are greatly encouraged.
- If you miss a class you are responsible for obtaining notes, handouts and assignments that you may have missed.

Grading Scale: Grades for the course will be on a percentage basis. 89-100% = A, 79-88% = B, 69-78% = C, 59-68% = D, 58% and below = E.

Policies:

Code of Conduct and Academic Integrity. "Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student's submitted work must be the student's own. This principle is furthered by the student Code of Conduct and disciplinary procedures established by ABOR Policies 5-308 - 5-403, all provisions of which apply to all University of Arizona students. This Code of Academic Integrity (hereinafter "the Code") is intended to fulfill the requirement imposed by ABOR Policy 5-403.A.4 and otherwise

to supplement the student Code of Conduct as permitted by ABOR Policy 5-308.C.1." For the complete Code of Academic Integrity, go to:

<http://dos.web.arizona.edu/uapolicies/UACAIpolicies.pdf>

Turn of your cell phones and pagers!

University Policy on Threatening Behavior. "The University seeks to promote a safe environment where students and employees may participate in the educational process without compromising their health, safety or welfare. The Arizona Board of Regents' Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one's self. Threatening behavior can harm and disrupt the University, its community and its families." For the complete policy, go to:

<http://policy.web.arizona.edu/%7Epolicy/threatening.pdf>

Students with Disabilities: Students with physical, psychological or learning disabilities are encouraged to contact the Disability Resource Center (DRC). Students who are registered with the Disability Resource Center must submit appropriate documentation to the instructor if they are requesting reasonable accommodations. For more information:

<http://drc.arizona.edu/teach/index.html>. If you have a documented disability and anticipate needing accommodations in this course, please make arrangements with me immediately. For more information about the program and services available, including testing accommodations for students with disabilities, contact the DRC at 621-3268.

Tentative Semester Schedule: The following is a course outline covering the major lecture topics and reading assignments. This is a tentative schedule which may be adjusted as the term progresses. Note that additional outside readings may be assigned. These readings will be available through d2l.arizona.edu. Materials covered are subject to change and dependent upon the pace of the class. You will receive ample advance notice and the maximum amount of preparation you should need to succeed.

Example assignments and discussion topics:

- Bring in a photo and tell your pheno story!
- What is your favorite research article/author related to phenology science? Summarize why (+ citation)
- Discuss how results from IPCC could impact your research or use your own example of how IPCC results could affect phenology.
- Discuss how a plant (indicator species) that growth in the region of where you were born can be use to study the pulse of the planet.
- How does the phenology of certain natural systems impact your health?
- How are the different trophic levels affected by climate change and variability?
- Will certain food chains be disrupted as different species respond in different ways to temperature or precipitation change?

- Discuss scales of phenological phenomena: Data acquisition protocols at different scales, intensive monitoring sites, weather station network, citizen science, synoptic remote sensing, phenology camera systems.
- What are or will be the socio-economic impacts of changes in phenology be on health (allergies, diseases, pests), desert flora and fauna (tourism), wine industry?

Course schedule:

Invited speaker schedule		5-6 pm Tentative topics/titles	6:15- 7:30pm 2nd tentative topic/ Dr Wim van Leeuwen and/or student topic
Thursdays 5- 7:30 pm			
8/28/2008	Dr. Willem van Leeuwen	Introduction phenology - history - overview	reading assignments
9/4/2008	Dr. Jake Weltzin (Director National Phenology Network)	USA - National Phenology Network	Phenology Networks - You and phenology - photo contest
9/11/2008	Dr. Willem van Leeuwen	Phenological modeling	News (video clip) on phenology - an integrated assessment
9/18/2008 NPN meeting no class			
9/25/2008	Dr. Barron Orr (Assoc. Prof. - UA - Geospatial Extension Specialist)	Community outreach - Project Budburst	Designing a phenology calendar a la McGinnies
10/2/2008	Dr. Dave Breshears (Prof. - UA - Ecohydrologist)	Phenology of Ecosystem Gradients and Extreme Disturbance Events	Species phenology - protocol development
10/9/2008	SW ASPRS phenology conference on Friday 10/10/08	Characterizing the Phenology of Southwest Landscapes	Characterizing the Phenology of Southwest Landscapes
10/16/2008	Dr. Julio Betancourt (USGS - Senior physical scientist - Phenologist)	Climate Change and Phenology in the West	IPCC and phenology
10/23/2008	Dr. Kamel Didan (Research Scientist - UA - NASA PI)	Land Surface Phenology with Remote Sensing: Methods and Applications	Scales of observations
10/30/2008	Dr. Alfredo Huete (Prof. - UA - Phenology of tropical forests)	Phenology of tropical forests: links to disturbance, fire, and climate	Phenology of bioclimatic zones
11/6/2008	Dr. Theresa M. Crimmins (National Phenology Network Coordinator)	Flowering range changes across an elevation gradient in response to warming summer temperatures: Patterns in the Catalina Mountains	Phenology of exotics
11/13/2008	TBD	e.g. Bird phenology	Southwest phenology network
11/20/2008	Dr. Mike Crimmins (Assis. Prof. - UA - Climate Extension Specialist)	Climate and phenology research - repeat digital photography	Phenology observations - tools, technologies and protocols
11/27/2008 Thanksgiving no class			
12/4/2008	Student presentations throughout the semester	Choose your topic or from provided class topics	Phenology curriculum/ protocol / calendar

Reading list:

Betancourt, J. L., M. D. Schwartz, D. D. Breshears, C. A. Brewer, G. Frazer, J. E. Gross, S. J. Mazer, B. C. Reed, and B. E. Wilson. 2007. Evolving plans for the USA National Phenology Network. *Eos Trans. AGU* **88**:211.

Bever, J. D. 1994. FEEDBACK BETWEEN PLANTS AND THEIR SOIL COMMUNITIES IN AN OLD FIELD COMMUNITY. *Ecology* **75**:1965-1977.

Both, C., and M. E. Visser. 2001. Adjustment to climate change is constrained by arrival date in a long-distance migrant bird. *Nature* **411**:296-298.

Caprio, J. M. 1957. PHENOLOGY OF LILAC BLOOM IN MONTANA. *Science* **126**:1344-1345.

Cautín, R., and M. Agustí. 2005. Phenological growth stages of the cherimoya tree (*Annona cherimola* Mill.). *Scientia Horticulturae* **105**:491-497.

Chuine, I., P. Yiou, N. Viovy, B. Seguin, V. Daux, and E. L. Ladurie. 2004. Historical phenology: Grape ripening as a past climate indicator. *Nature* **432**:289-290.

Clark, J. E. 1923. Nature study and phenology. *Nature* **111**:49-49.

Clark, J. E. 1926. International phenology. *Nature* **117**:413-414.

- Cleland, E. E., N. R. Chiariello, S. R. Loarie, H. A. Mooney, and C. B. Field. 2006. Diverse responses of phenology to global changes in a grassland ecosystem. *Proceedings of the National Academy of Sciences of the United States of America* **103**:13740-13744.
- Cotton, P. A. 2003. Avian migration phenology and global climate change. *Proceedings of the National Academy of Sciences of the United States of America* **100**:12219-12222.
- Crimmins, M. A., and T. M. Crimmins. 2008. Monitoring plant phenology using digital repeat photography. *Environmental Management* **41**:949-958.
- Crimmins, T. M., M. A. Crimmins, D. Bertelsen, and J. Balmat. 2008. Relationships between alpha diversity of plant species in bloom and climatic variables across an elevation gradient. *International Journal of Biometeorology* **52**:353-366.
- de Beurs, K. M., and G. M. Henebry. 2004. Land surface phenology, climatic variation, and institutional change: Analyzing agricultural land cover change in Kazakhstan. *Remote Sensing of Environment* **89**:497-509.
- Elmore, A. J., G. P. Asner, and R. F. Hughes. 2005. Satellite monitoring of vegetation phenology and fire fuel conditions in Hawaiian drylands. *Earth Interactions* **9**.
- Falge, E., D. Baldocchi, R. Olson, P. Anthoni, M. Aubinet, C. Bernhofer, G. Burba, R. Ceulemans, R. Clement, H. Dolman, A. Granier, P. Gross, T. Grunwald, D. Hollinger, N. O. Jensen, G. Katul, P. Keronen, A. Kowalski, C. T. Lai, B. E. Law, T. Meyers, H. Moncrieff, E. Moors, J. W. Munger, K. Pilegaard, U. Rannik, C. Rebmann, A. Suyker, J. Tenhunen, K. Tu, S. Verma, T. Vesala, K. Wilson, and S. Wofsy. 2001. Gap filling strategies for defensible annual sums of net ecosystem exchange. *Agricultural and Forest Meteorology* **107**:43-69.
- Frankl, R., S. Wanning, and R. Braun. 2005. Quantitative floral phenology at the landscape scale: Is a comparative spatio-temporal description of "flowering landscapes" possible? *Journal for Nature Conservation* **13**:219-229.
- Herfindal, I., E. J. Solberg, B. E. Saether, K. A. Hogda, and R. Andersen. 2006. Environmental phenology and geographical gradients in moose body mass. *Oecologia* **150**:213-224.
- Huete, A. R., K. Didan, Y. E. Shimabukuro, P. Ratana, S. R. Saleska, L. R. Hutyrá, W. Z. Yang, R. R. Nemani, and R. Myneni. 2006. Amazon rainforests green-up with sunlight in dry season. *Geophysical Research Letters* **33**.
- Huete, A. R., N. Restrepo-Coupe, P. Ratana, K. Didan, S. R. Saleska, K. Ichii, S. Panuthai, and M. Gamo. 2008. Multiple site tower flux and remote sensing comparisons of tropical forest dynamics in Monsoon Asia. *Agricultural and Forest Meteorology* **148**:748-760.
- Hughes, L. 2000. Biological consequences of global warming: is the signal already apparent? *Trends in Ecology & Evolution* **15**:56-61.
- Inouye, D. W. 2008. Effects of climate change on phenology, frost damage, and floral abundance of montane wildflowers. *Ecology* **89**:353-362.
- Justice, C. O., J. R. G. Townshend, B. N. Holben, and C. J. Tucker. 1985. ANALYSIS OF THE PHENOLOGY OF GLOBAL VEGETATION USING METEOROLOGICAL SATELLITE DATA. *International Journal of Remote Sensing* **6**:1271-1318.
- Kochmer, J. P., and S. N. Handel. 1986. CONSTRAINTS AND COMPETITION IN THE EVOLUTION OF FLOWERING PHENOLOGY. *Ecological Monographs* **56**:303-325.
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- MacDowall, A. B. 1903. Sun spots and phenology. *Nature* **68**:389-390.
- Montague, J. L., S. C. H. Barrett, and C. G. Eckert. 2008. Re-establishment of clinal variation in flowering time among introduced populations of purple loosestrife (*Lythrum salicaria*, Lythraceae). *Journal of Evolutionary Biology* **21**:234-245.
- Morton, D. C., R. S. DeFries, Y. E. Shimabukuro, L. O. Anderson, E. Arai, F. D. Espirito-Santo, R. Freitas, and J. Morisette. 2006. Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon. *Proceedings of the National Academy of Sciences of the United States of America* **103**:14637-14641.

- Myneni, R. B., C. D. Keeling, C. J. Tucker, G. Asrar, and R. R. Nemani. 1997. Increased plant growth in the northern high latitudes from 1981 to 1991. *Nature* **386**:698-702.
- Myneni, R. B., W. Z. Yang, R. R. Nemani, A. R. Huete, R. E. Dickinson, Y. Knyazikhin, K. Didan, R. Fu, R. I. N. Juarez, S. S. Saatchi, H. Hashimoto, K. Ichii, N. V. Shabanov, B. Tan, P. Ratana, J. L. Privette, J. T. Morisette, E. F. Vermote, D. P. Roy, R. E. Wolfe, M. A. Friedl, S. W. Running, P. Votava, N. El-Saleous, S. Devadiga, Y. Su, and V. V. Salomonson. 2007. Large seasonal swings in leaf area of Amazon rainforests. *Proceedings of the National Academy of Sciences of the United States of America* **104**:4820-4823.
- Orr, B. J., G. M. Casady, D. G. Tuttle, W. J. D. van Leeuwen, L. E. Baker, C. I. McDonald, and S. E. Marsh. 2005. Phenology and trend indicators derived from spatially dynamic bi-weekly satellite imagery to support ecosystem monitoring *in* Connecting mountain islands and desert seas: biodiversity and management of the Madrean Archipelago II, Proc. RMRS-P-36. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 206-211.
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- Penuelas, J., and I. Filella. 2001. Phenology - Responses to a warming world. *Science* **294**:793-+.
- Post, E., C. Pedersen, C. C. Wilmers, and M. C. Forchhammer. 2008a. Warming, plant phenology and the spatial dimension of trophic mismatch for large herbivores. *Proceedings of the Royal Society B-Biological Sciences* **275**:2005-2013.
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- Potter, C. S., and S. A. Klooster. 1999. Dynamic global vegetation modelling for prediction of plant functional types and biogenic trace gas fluxes. *Global Ecology and Biogeography* **8**:473-488.
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- Rosenzweig, C., D. Karoly, M. Vicarelli, P. Neofotis, Q. G. Wu, G. Casassa, A. Menzel, T. L. Root, N. Estrella, B. Seguin, P. Tryjanowski, C. Z. Liu, S. Rawlins, and A. Imeson. 2008. Attributing physical and biological impacts to anthropogenic climate change. *Nature* **453**:353-U320.
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- Stevenson, I. R., and D. M. Bryant. 2000. Avian phenology - Climate change and constraints on breeding. *Nature* **406**:366-367.
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- van Leeuwen, W. J. D. 2008. Monitoring the effects of forest restoration treatments on post-fire vegetation recovery with MODIS multitemporal data. *Sensors* **8**:2017-2042.
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- White, M. A., P. E. Thornton, and S. W. Running. 1997. A continental phenology model for monitoring vegetation responses to interannual climatic variability. *Global Biogeochemical Cycles* **11**:217-234.
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- Zhang, X. Y., M. A. Friedl, C. B. Schaaf, A. H. Strahler, J. C. F. Hodges, F. Gao, B. C. Reed, and A. Huete. 2003. Monitoring vegetation phenology using MODIS. *Remote Sensing of Environment* **84**:471-475.