important that we produce citizens that appreciate those species, and view them, if not each as gems, then as potential gems. The value of anything in the world depends on its rarity and its usefulness but also on our awareness of those features. May this book help to educate another generation of students to think of a diversity of species as a kind of richness. The alternatives leave us all impoverished.

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Phenology and ecosystem processes


Key words: ecosystem productivity; land surface phenology; modeling; remote sensing phenology; respiration.

Phenology (derived from the Greek phainesthai, to appear) is a relatively recent (dating only to about 1850), albeit somewhat arcane, term for a field of study that evolved in agrarian societies where understanding the timing of plant and animal activity was critically important to the human endeavor. This edited volume extends the traditional organismal focus of phenology to include ecosystem-level processes, including biogeochemical fluxes, which meet Helmut Leith’s (1974, Phenology and seasonality modeling. Springer, New York) definition of phenology as adopted in this volume, “...the study of the timing of recurrent biological events, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species.” Ecosystem processes, such as the exchange of carbon or water between the biosphere and the atmosphere, are important considerations in phenology because they are both a cause and a consequence of organismal activity. For example, intraannual variations in concentrations of carbon dioxide in the global atmosphere exhibit a seasonal periodicity driven by the balance of photosynthesis and respiration in temperate forests.

This volume is most appropriate for scientists interested in understanding and tracking temporal (diel, seasonal, interannual) dynamics of carbon across a variety of spatial scales (intracellular space to atmosphere) using a variety of techniques and approaches (eddy covariance flux, stable isotopes, process models). This matches the intended and relatively broad audience: those “new to the field to get an overview of its scope ... a reference to people active in the field ... and an educational aid for courses on climate change and ecosystem ecology.” The interesting and unique cover illustration, which portrays seasonal variation in a deciduous forest ecosystem both literally and figuratively, cleverly illustrates the relationship between structure and function over time, with standard acronyms serving as codes to more experienced scientists. Indeed, several of the chapters contain content, detail, and analyses that would be most appropriate for the advanced undergraduate student and beyond.

The book is organized into three broad sections: “Phenological phenomena,” “Biological feedbacks,” and “Upscaling and global view.” All but one of the six chapters in “Phenological phenomena” focus on spatial and temporal dynamics of carbon (and to a lesser extent energy and water), and most of these are comparative across subregions, biomes, or communities. As such, the single chapter in this section (and in fact volume) that examines patterns of population and community variation in organismal phenology—with essentially no discussion of ecosystem processes or linkages thereto—seems out of place. However, this chapter also includes an important evaluation and comparison of spring phenology models; the growing global emphasis on participatory monitoring of organismal phenology will require a similar and ever more concerted effort to develop and evaluate such organismal and predictive models.

Two of the three chapters in the section “Biological feedbacks” focus on temporal relationships between photosynthesis and respiration, whereas the third chapter provides a broad (and somewhat out of place) overview of intraannual physiological and phenological development of trees with a description of process-based scaling from tree to stand. The final section “Upscaling and global view” includes two chapters that provide broad overviews of land surface phenology—seasonal patterns of variation in vegetated surfaces determined typically by remote sensing—and its relationship to ecosystem processes. Broader application of land surface phenology will require extensive multi-tier validation across a range of scales using a variety of approaches, and will depend in part on standardization of terminology and further development of models.

Interestingly, relationships between phenology and ecosystem-level processes other than carbon (and to a lesser extent energy and water) are not addressed well. For example, relationships between and among phenology and fire, pests and disease, biological invasions, water and nutrient cycling, and land use/land cover change or other anthropogenic disturbance are not described. That said, a thorough investigation of these processes (at the level at which carbon is examined in this book) would require several more volumes. Moreover, because control of carbon is also likely controlled by these other ecosystem processes, the next volume could investigate their complex and potentially non-intuitive interactions with pheno- nology and biogeochemistry.

Also interestingly, despite the subtitle, there is little or no emphasis on anthropogenic or directional climate change. Rather, the focus here is on contemporary drivers, rates, and patterns of spatial and temporal environmental variation. This is likely constrained by the availability of historic data for developing predictive relationships (though climate models could be incorporated). Rather, the focus is clearly on ecosystem processes and their relationship with phenology on relatively short time scales. Subsequent volumes could also

Phenology and seasonality modeling; remote sensing phenology; respiration.
place much of this work within the context of climate change, and or provide projections as to how phenology may constrain, exacerbate, or otherwise control the response of ecosystems to climate change or other ecosystem drivers.

The preface concludes with the hope that “...the reader will develop his or her own vision of the seasonality of ecosystem processes ...” However, personal or scientific curiosity and the wonder of the natural world notwithstanding, such individually based definitions create issues for integrated and comprehensive understanding of phenology (from organisms to ecosystems to landscapes), and suggest why a book such as this is necessary: the field of phenology needs integrated definitions and standards for monitoring and understanding temporal patterns in processes from organisms to ecosystems. The continuation and development of national phenology networks, with the ever-present potential for international cooperation, should contribute greatly to the development of phenology as a tool to better understand how plants, animals, and ecosystems respond to environmental variation, and the causes and consequences of this variation for the human endeavor.

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