

BOOK REVIEW 2010 - #2

Gibson, David J. Grasses and Grassland Ecology. 2009. viii + 305 pages; tables; figures; colored photographic plates; references; plant index; animal index; subject index. Oxford University Press Inc., New York, New York. ISBN13: 978-019-852918-7 (hard cover) and ISBN13: 978-019-852919-4 (soft cover). Price: \$140.00 and \$70.00, respectively. Available from Oxford University Press, Inc., 198 Madison Avenue, New York, NY 10016.

This marvelous book is a comprehensive account of evolutionary biology of grasses, particularly in relation to modern systematics, and grassland ecology encompassing a global perspective with an emphasis on North American prairies. The chapters are expanded versions of lectures from a course the author developed and teaches at Southern Illinois University at Carbondale. Eloquenty written in concise and clear language and style, a result of extensive personal knowledge and experience with the subject matter, Gibson offers the reader a remarkable balance between details of essential topics while limiting citations often to a single reference for each referenced material. Nevertheless, 44 pages of bibliography attest to the comprehensiveness of the review of applicable literature.

The introduction (Chp.1) provides an excellent review for any biologist working with, or interested in, grasslands including insightful information on a broad range of topics that are covered more thoroughly in subsequent chapters. Of particular interest is a short discussion of two prominent early ecologists, J. W. Bews of South Africa and J. E. Weaver. I had the privilege 30 years ago of taking grassland ecology from Gibson's predecessor, the late John Voigt, a student of J. E. Weaver. This book, with its historical perspective combined with modern synthesis of population, community, and ecosystem ecology and systematics, could not have been written as effectively three decades ago. Grasses and Grassland Ecology provides a timely and fitting treatment of grasslands with unparalleled detail, in a single volume, on the biology of grasses and grassland habitats.

The author takes a broad view of grasslands in an introductory summary of critically endangered ecoregions, including shrublands and savannas and such varied habitats as the *Protea* and *Erica*-dominated fynbos of the Cape Floristic Region of South Africa characterized not by grasses but by the related Restionaceae. Also included are Mediterranean woodlands and scrublands where grassy patches are characteristic. Ignoring these areas underestimates total world grassland area, while including them amplifies estimates. However, this broad perspective of grasslands was not always followed. For example, reported remaining grassland in Illinois included only estimates for high-quality prairie (0.01% of the extent present at the time of Euro-American settlement) without the inclusion of remaining savanna habitats.

In the chapter on Systematics and Evolution (Chp. 2), botanists who learned the former supra-generic tribal classifications of grasses based on morphological attributes will be interested in reading the revised approach, based on phylogenetic order, that recognizes 12 subfamilies. The subfamilies are described briefly and proposed phylogenetic relations of the 12 subfamilies and their precursor groups are graphically illustrated.

Chapter three presents an ecological perspective on grass morphology and anatomy beginning with growth and development. The detailed description of leaf, culm, and spikelet morphology provides insights helpful in understanding and interpreting ontogenetic development. Grass spikelets also are addressed with a phylogenetic view that puts into perspective structural specialization and reduction. The closing section of chapter two describes many of the distinctive anatomical features of grasses and provides helpful background information towards understanding grass physiology discussed in the following chapter.

Chapter four begins with a detailed introduction to C3 and C4 photosynthetic pathways and further characterizes the physiological ecology of the three types of C4 photosynthesis found among warm-season grasses. These basic physiological differences among grasses are put into a very useful ecological context providing a framework for understanding distribution patterns among genera and species. In addition, the author includes an outline of the trade-offs likely to occur in abiotic and biotic interactions, and clearly notes how predictions of responses for pools of grassland species to global climate change are a very complex challenge. A map (Fig. 4.3) illustrates projected changes in C4 grass abundance in South America, that correspond to a doubling of atmospheric CO₂ concentrations according to three general atmospheric circulation models. Unfortunately, the map is difficult to interpret because it relies on four fairly indistinct shades of grey.

The chapter on grass population ecology (Chp. 5) is highly recommended reading for biologists working in grasslands for its insightful discussion of pollen incompatibility and other issues related to breeding systems of grasses. The treatment of cleistogamous and combined cleistogamous and chasmogamous breeding systems among some grass species is particularly interesting. A mixed cleistogamous and chasmogamous breeding system is found with *Triplasis purpurea* (Purple Sandgrass), a species of limited distribution in Illinois to inland deep sand deposits. Knowledge of this mixed breeding system provides a renewed appreciation for selected reproductive strategies, particularly in the unpredictable and often harsh sand prairie environment. Perhaps other species in Illinois habitats demonstrate this type of ecological bet hedging, as described by the author, of producing some seeds in secured locations within the sheath for later dispersal upon senescence. Some grasses demonstrate an extreme form of cleistogamy with production of underground spikelets, a strategy that may allow for greater seed survival in fire-prone landscapes. The chapter section on seed bank ecology is particularly relevant to grassland restoration efforts, providing insights for planting designs and implementations based on relevant ecological principles.

The role of fungal pathogens in controlling community organization in grasslands is noted to be significant (Chp. 5), something I had not considered despite the well-known diseases of turf grasses. How these pathogens interact with fire effects in the community assemblage is an area of needed research. Chapter five concludes with an extended section characterizing aspects of the genetic structure of grasslands put into an ecological context. Recent investigations have found greater genetic diversity within populations of *Andropogon gerardii* (Big Bluestem), compared to diversity among different populations, bringing particular importance to protecting prairie remnants. In addition, high levels of ecotypic variation have been reported for grassland species. As noted in a memorable quote from McMillan (1959), "Through natural selection, each stand of true prairie may

be fundamentally different from any other stand”, placing due importance on the protection and conservation of each individual remnant. Furthermore, a summary of recent findings documenting the spatial patterns of genetic diversity, by noting the occurrence of high levels of local genetic variation, also provides key insights to the design of prairie plantings.

Chapters six through ten address grasslands primarily at the community and ecosystem levels of organization. Chapter six addresses the central principles of community ecology, including plant-environmental relations, succession, the array of species interactions including competition, allelopathy, parasitism, facilitation, and mutualisms; and these topics are presented with useful, relevant examples. The debates concerning the chief models of community assembly and structure (e.g., Clements’ community-unit hypothesis and the continuum ideas that emerged from Gleason, and the subsequent mechanistic models presented by Tilman’s resource ratio model and Grime’s CSR model) receive fair and balanced treatment highlighting the insights and limitations of the competing theories. Chapter six concludes with a review of Hanski’s core-satellite species hypothesis developed as an explanation of meta-population and meta-community patterns and Hubbell’s unified neutral theory of biodiversity and biogeography. This chapter is essential reading, especially for graduate students in the plant sciences, because it provides an introduction to the central theories developed to explain biotic and abiotic interactions in natural communities.

Ecosystem-level processes related to grasslands are characterized in chapter seven. Here Gibson examines components of the major factors of productivity, nutrient cycling, and decomposition, including historic perspective as to the development and testing of ideas and the role of simulation modeling in gaining insights. The first third of chapter seven concisely summarizes the ample literature on interactions between productivity and resource gradients, and how these interact at the community level across a range of environmental conditions, grazing history, and fire frequency. The key questions of how species diversity is related to stability of grassland ecosystems is discussed under the heading: ‘Productivity relationships with diversity, invasibility, and stability’.

The transfer and fluxes of nutrients among soil, plant, and animal components are characterized in a section of chapter seven on nutrient cycling leading to a concluding section on grassland soils. The key role of nitrogen among soil nutrients is made particularly clear. Fertilization experiments involving nitrogen additions consistently result in changes in grassland community structure and declines in species diversity. The alarming link between industrial sources of nitrogen in soils (exceeding inputs by natural sources of biological nitrogen fixation) and associated patterns of species losses in European grasslands begs for similar studies in Illinois grasslands.

The types of grasslands found worldwide are described in chapter eight. First with a general summary of vegetation classification systems at various spatial scales, from those with a local focus on species associations to ecoregional-scale classifications based more on physiognomy. Climate is a major factor in grassland development, and grasslands of the world are characterized based on six global climatic regions (for example, Moist subtropical mid-latitude climates [Pampas], Moist continental mid-latitude climates [incl. true prairie], and Highland climates [montane grasslands]). Regional classification sys-

tems are described including examples from the US National Classification System (Grossman et al., 1998). Examples of how grasslands are classified in Europe and China also are included. Plates 5-14 present colorful images of some of the types of grasslands found worldwide.

Disturbances have such a major role contributing to the persistence of grasslands and in patterns of composition and diversity that an entire chapter is devoted to the topic (Chp. 9). Many grasslands persist as a consequence of particular disturbances, and alterations to these disturbance regimes can lead to dramatic changes in grasslands, including conversion to other vegetation types (e.g., savanna, woodland). Gibson first meticulously characterizes the fundamentals of disturbance noting the conundrum when considering the case of grassland fires, because fires can be viewed both as a disturbance when present or absent (i.e., extended absence of fire can lead to equally dramatic changes compared with changes brought by occurrences of fire). There is an extensive literature on fire in grasslands and its effects on vegetation, particularly in tallgrass prairie, and the core portion of chapter nine is a thorough synthesis of this work, noting the dependence on fire for persistence and spread of grasslands worldwide. The conclusion that fire leads to a reduction in species diversity immediately following fire, found in studies in Kansas and elsewhere in the Great Plains, is presented as a general pattern. However, Gibson notes that for all reported fire effects on vegetation, there are counter examples. In Illinois, for instance, diversity has been shown to be greatest in frequently burned sand prairies compared to infrequently burned sites (Bowles et al., 2003). Furthermore, in a dry prairie-like woodland opening, species diversity spiked dramatically following fires but gradually declined between burns in years afterwards (Taft, 2003). Detailed assessments of long-term fire effects on diversity in species-rich mesic tallgrass prairie, however, are lacking in Illinois.

The influences of herbivory and drought on grasslands also receive ample consideration. The significant role of small mammals on community structure and dynamics is particularly interesting since the impacts are largely out of sight when compared to the effects of larger herbivores such as *Bison bison* (American bison) in portions of the original North American prairie. Speaking of hidden effects, the reduction by invertebrate herbivores of 5-15% of above-ground and 6-40% below-ground annual net primary production are particularly startling statistics showing the important role of these species in grassland ecosystems.

The book content on communities, ecosystems, and disturbance (Chp. 6, 7, and 9) is nicely integrated into a concluding chapter (Chp. 10) on grassland management and restoration practices where research and theories are put to the "acid test". Principles of range management applicable to both commercial and subsistence pastoralists are considered in the introductory section of the chapter followed by methods for assessing rangeland habitat condition. Grassland restoration is described for a wide range of methods from restoring degraded remnants, to the complete reconstruction of grassland communities on former grassland sites. The importance of using local ecotypes is stressed to improve successful grassland plantings.

The contrast in grassland management methods employed between those efforts coordinated by local land managers and citizen volunteers and approaches informed by the scientific method is nicely portrayed. Coincidentally, a similar topic is discussed by Ander-

son (2009) in a recent publication on the history of restoration ecology that focuses on tallgrass prairie. Anderson and Gibson use the Curtis Prairie at the University of Wisconsin at Madison as a vital case history given its notoriety as the oldest grassland restoration in the world begun in 1934 by Aldo Leopold and others.

One of the great values of the book is the many ways it serves students of grasses and grassland ecology by providing detailed accounts of the biology of grasses and grasslands. In addition, it should stimulate hypotheses for a myriad of ecological interactions at the population, species, and community levels of organization. I could not be more enthusiastic about this book and its valuable contents. It is well conceived with the organization following a logical transition from historical accounts, to taxonomic, systematic, anatomical, and genetic levels, followed by broader perspectives of communities and ecosystems. All materials are presented from a deeply insightful ecological perspective. It is a unique combination of relevant content, honed from years of lecturing on the topic and research experience. It is a vital, consolidated resource for the research ecologist, graduate students in plant biology, as well as the field biologist working particularly with natural grassland ecosystems and is a highly recommended text that should serve as a guide to grasses and grassland ecology for many years to come. Convenient indices for plant and animal species referenced in the text follow the bibliography.

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Literature Cited

- Anderson, R. C. 2009. History and progress of ecological restoration in tallgrass prairie. Pages 217-228 *in*: Taylor, C., J. B. Taft, and C. Warwick (eds.). *Canaries in the Catbird Seat – The Past, Present, and Future of Biological Resources in a Changing Environment*. Illinois Natural History Survey Special Publication 30. Champaign.
- Bowles, M. L., M. Jones, and J. L. McBride. 2003. Twenty-year changes in burned and unburned sand prairie remnants in northeastern Illinois and implications for management. *American Midland Naturalist* 149: 35-45.
- Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. *International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications*. The Nature Conservancy, Arlington, Virginia, USA.
- McMillan, C. 1959. Nature of the plant community. V. Variation within the true prairie community-type. *American Journal of Botany* 46: 418-424.
- Taft, J. B. 2003. Fire effects on community structure, composition, and diversity in a dry sandstone barrens. *Journal of the Torrey Botanical Society* 130:170-192.

