



## CLIMATE CHANGE AND ARBORETUM WETLANDS

Curtis Prairie, Photo by Claudia Lipke

*The maintenance of representative Wisconsin communities  
is the Arboretum's purpose  
(Anon. 1993).*

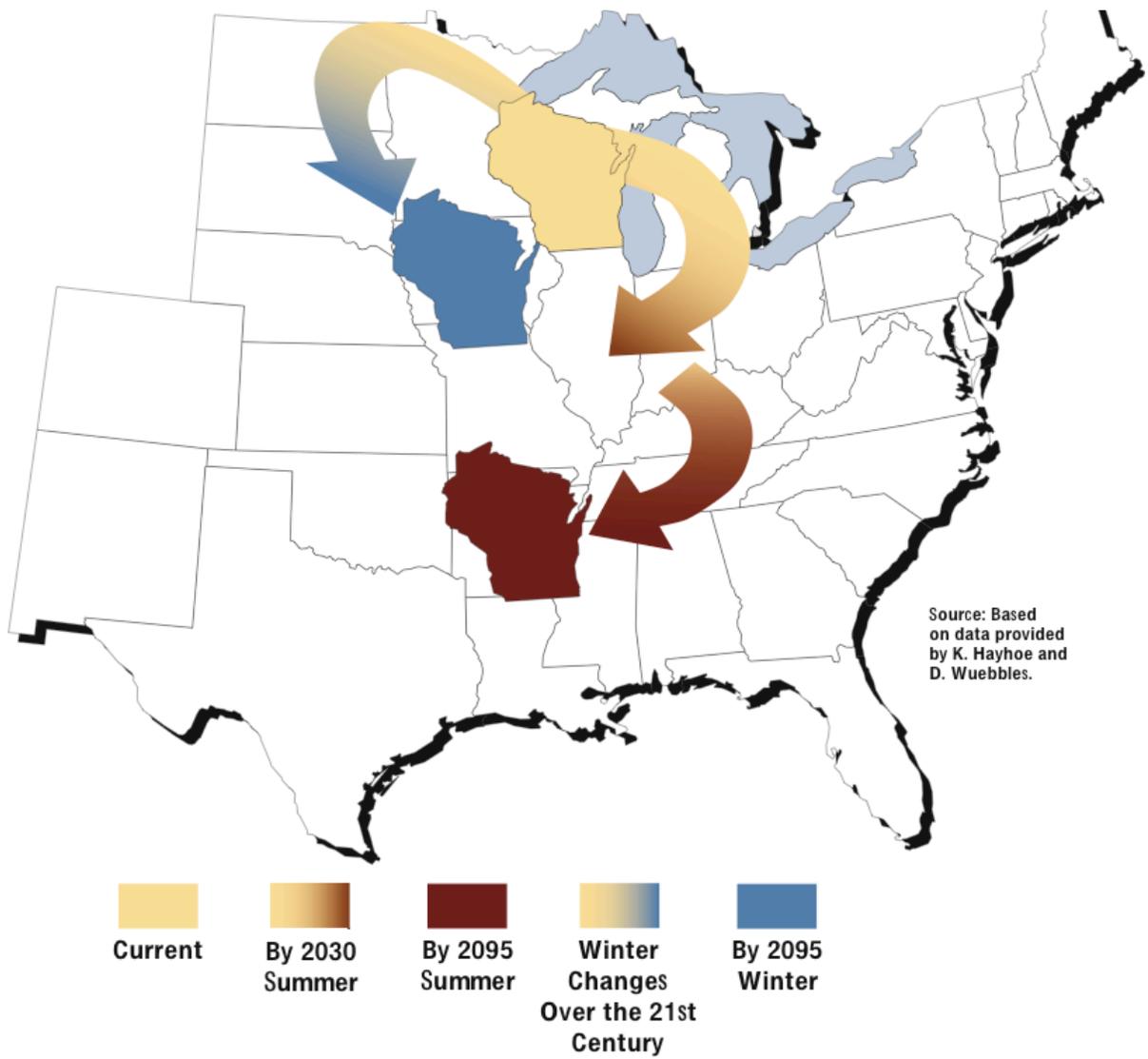
**W**hat effects will Earth's changing climate have on our wet prairies and sedge meadows? Already plagued with stormwater inflows and aggressive weeds, will more and more native vegetation yield to invaders? To predict long-term outcomes, we consider how environmental conditions are changing and examine new data comparing invasive and native plants in Curtis Prairie.

### HOW CLIMATE AND WEATHER ARE CHANGING

Scientists agree that carbon dioxide concentrations and mean temperatures are rising at the global scale. The Great Lakes Regional Assessment (GLRA 2006) predicts that our region will be wetter and warmer through this century (Figure 1), but that doesn't guarantee that the Arboretum will experience warmer weather. Existing models of global change are not yet able to predict what will happen in specific sites. Some predict greater swings in weather and greater extremes in rainfall and/or temperature. GLRA (2006) predicts that minimum summer temperatures will increase 1–2°C and maximum temperatures

will increase 0–1°C, with 15–25% more summer precipitation than normal. Higher maxima or minima could be more important to plants than small shifts in average conditions.

Some climate models predict increased storminess, which would likely mean more rainfall, more frequent rains, altered timing of peak precipitation, and potentially more violent weather. I experienced such changes near San Diego, beginning in 1978 with Tijuana Estuary's first flood in 35 years. The next 28 years saw 10 floods, and, due to increased streamflows, the highest sedimentation rates ever recorded in my salt marsh study sites (Zedler and West, in press). Furthermore, storms interacted with increasingly intensive land use, such that urban hillsides and cultivated soils discharged more sediment per storm than previously seen. Will this be the case in Madison? GLRA (2006) predicts more frequent and intense precipitation events and increased streamflow variability. The Arboretum needs an ambitious monitoring program to characterize current conditions (water quantity and quality). We also need to document biotic responses. For example, are plants growing earlier and senescing later?



**Figure 1** • By the end of the century, Wisconsin summers may feel like those of current-day Arkansas.  
 Reprinted with permission of Union of Concerned Scientists (2003)



Big Bluestem



Tussock Sedge



Reed Canary Grass

## How might the growing season be changing?

Recently, UW's John Magnuson and colleagues (2000) documented longer periods between thaw and freeze for 26 lakes in the northern hemisphere. In Magnuson's study, Lake Mendota thawed 7.5 days earlier than normal and ice covered it 6.0 days later, for an extension of 13.5 days. These data relate to global warming and suggest that growing seasons are lengthening.

Do plants and animals notice such changes? They do, according to long-term observations on the phenology (timing of events) in Wisconsin. Nina Leopold Bradley and colleagues (1999) recorded earlier migration of birds and earlier blooming of plants in Sauk County, with an average response of 12.2 days earlier per century. Eleven plant species bloomed earlier over the 61-year record, implying an earlier start to the growing season.

For Arboretum wetlands, growing seasons will likely lengthen even more than in uplands, because there is an additional warming effect of upstream hardscapes on urban runoff. Spring meltwater flowing from roofs, sidewalks and streets into the Arboretum is warmer than non-urban inflows. With warmer runoff, wetlands downstream from urban areas could support plant growth before upland soils thaw.

## Summary of existing and potential climate changes

The potential effects of climate change are warming, increased storminess, greater extremes of rainfall and temperature, and longer growing seasons (especially in wetlands receiving meltwater from heat-absorbing roofs and streets). Because all our Arboretum wetlands receive urban runoff, wetland vegetation will likely experience the greatest impacts of climate change due to the interaction of earlier thawing, in turn due to warmer air temperatures and warmer hardscapes (roofs, sidewalks, streets) that elevate the temperature of meltwater in spring and melt the early snowfalls. Monitoring of urban inflows and phonological events in the path of stormwater is thus a priority.

## Which species will respond to longer growing conditions and how?

Given that the weather is hard to predict beyond the next week, we can't expect to predict specific events over the next several years. Biotic responses are even more elusive, because organisms have compensating mechanisms, complicated life cycles, complex interactions among species, and far more unknown cause-effect relationships than do physical processes. Flowering, for example, can be queued by either daylength (which is unaffected by climate change) or temperature (Bradley et al. 1999). Forecasting the weather is a snap compared to forecasting the effects of climate change on plants, because we lack computer models to map each species' response to critical environmental factors. Nevertheless, experiments and observations can move us closer to accurate predictions.

In 2006, two Botany undergraduates (Kate Legner and Vanessa Kolberg) monitored the phenology of three plant species in Curtis Prairie: big bluestem (*Andropogon gerardii*) in the wet prairie, tussock sedge (*Carex stricta*) in the sedge meadow and reed canary grass (*Phalaris arundinacea*), which has invaded both of those plant communities. Every week from March through early November, they visited replicate plots and recorded growth and flowering (Table 1).

Legner and Kolberg's (2006) results suggest that reed canary grass will benefit from an extended growing season, especially later frosts. This invader seems to initiate growth when soils thaw, and it grows long after native plants have senesced (Figure 2). Because tussock sedge initiates growth just as early, this native graminoid might remain competitive in spring, but a later frost would likely benefit only reed canary grass. Again, the effects of urban runoff will be relevant, because increased runoff would warm the wetland and import more nutrients, which enhance reed canary grass growth more than that of sedges (Kercher and Zedler 2004, Woo and Zedler 2002).

**Table 1**  
Growth and flowering dates for three species in Curtis Prairie  
(2006 data of Legner and Kolberg [2006] from Curtis Prairie)

	Tussock Sedge	Big Bluestem	Reed Canary Grass
Growing days	157	143	207
Start	12 April	26 April	12 April
End	16 September	16 September	5 November
Flowering days	26	22	30
Beginning of flowering	18 May	20 July	13 June
End of flowering	13 June	11 August	13 July
Growing days after flowering	95	36	115



Figure 2 • Comparative **growing** and **flowering** times (approximate; from Legner and Kolberg 2006)

## Will the competitive advantage tip further toward the invader?

Reed canary grass will likely gain further advantage over natives with both direct and indirect effects of global warming. Reed canary grass exhibits high plasticity in its canopy architecture (Herr-Turoff and Zedler in press) in response to flooding and nutrients; hence, it is reasonable to predict positive reactions to greater rainfall and runoff, as well as longer growing seasons. The worst-case scenario is that climate change will act in synergy with urbanization, increasing volumes of runoff, elevating temperatures of runoff, causing earlier thaw and later frost, and exacerbating the effects of climate change on growing seasons, with reed canary grass elongating its growing season while tussock sedge, big bluestem and other natives retain their shorter growing periods. We can test this prediction by monitoring phenological events of these and other species over the next several decades.

## Given climate change, how can we sustain native species?

Conservation ecologists employ many tools to sustain native species, including tending collections in arboreta, botanical gardens, and greenhouses or storing seed- and DNA-banks. Such measures are last resorts. The first choice is controlling invaders and managing for native species in situ. This is easier for wetlands if preserves are located high in the watershed (e.g., fens and small streams that occur upstream from urban or agricultural runoff). The Arboretum wetlands form a landscape sink, however, so runoff must be reduced at the watershed-scale or captured, purified and infiltrated upstream of valued wetlands. New facilities (Leaflet 12) are intended to find ways to treat inflowing stormwater at the Arboretum.

When species cannot be sustained in situ, conservationists consider ex situ measures. For example, southern sedge meadow species might be planted north of their current distributions, perhaps using Arboretum outlying properties as test gardens. Such approaches, however, presuppose greater understanding of climate change and species responses than exists to date. Learning how best to restore and sustain regional vegetation types in the Arboretum seems preferable to risky modifications to outlying properties.

## References

- Anonymous. 1993. Arboretum Manual. University of Wisconsin-Madison.
- Bradley, N. L., A. C. Leopold, J. Ross and W. Huffaker. 1999. Phenological changes reflect climate change in Wisconsin. Proceedings of the National Academy of Science 96:9701-9704.
- GLRA (Great Lakes Regional Assessment). 2006. Preparing for a Changing Climate: The potential consequences of climate variability and change. Environmental Protection Agency and University of Michigan Cooperative Agreement No. CR 827236-01-0. <http://www.geo.msu.edu/glra/assessment/assessment.html#chapters>
- Herr-Turoff, A., and J. B. Zedler. In press. Does morphological plasticity of the *Phalaris arundinacea* canopy increase invasiveness? Plant Ecology.
- Kercher, S. M., and J. B. Zedler. 2004. Flood tolerance in wetland angiosperms: a comparison of invasive and noninvasive species. Aquatic Botany 80:89-102.
- Legner, K., and V. Kolberg. 2006. Comparative phenology of invasive *Phalaris arundinacea* and wetland natives *Andropogon gerardi* and *Carex stricta*. Botany Senior Thesis. University of Wisconsin, Madison.
- Woo, I. and Zedler, J. B. 2002. Can nutrients alone shift a sedge meadow towards the invasive *Typha x glauca*? Wetlands 22:509-521.
- Zedler, J. B. and J. M. West. In press. Declining diversity in natural and restored salt marshes: A 30-year study of Tijuana Estuary. Restoration Ecology.

This leaflet was compiled by J. Zedler. Layout by Kandis Elliot. This and other leaflets can be found at [www.botany.wisc.edu/zedler/leaflets.html](http://www.botany.wisc.edu/zedler/leaflets.html) and the Arboretum website: [www.uwarboretum.org](http://www.uwarboretum.org).



THE UNIVERSITY  
OF  
**WISCONSIN**  
MADISON