

CRITICAL GROUNDWATER HYDROPERIODS FOR MAINTAINING RIPARIAN
PLANT SPECIES

by
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Field data from montane meadows in Wyoming suggest that Kentucky bluegrass (*Poa pratensis* L., var. *park*), tufted hairgrass (*Deschampsia cespitosa* [L.] Beauv.), and Nebraska sedge (*Carex nebrascensis* Dewey) have different optimum hydroperiods. The objective of this study was to compare the results observed in the field with the results obtained from controlled tests in the Tall Column Plant Growth Facility at the University of Wyoming for these three species.

Plants were tested in 3 m tall columns filled with commercial grade coarse silica sand to minimize the capillary fringe, and watered with a 50% Hoaglands solution by reverse column irrigation to minimize the available water above the water table. Above and below ground biomass, and percent live leaves were utilized to evaluate plant response.

Results from this study suggest all three species cannot survive for more than 20 days if the water table drops below 40 cm during the growing season. Since the water table alone was unable to maintain these species, other hydrologic and soil factors must be involved in the maintenance of riparian plant communities. These other sources, such as precipitation, should be considered when water allocations are considered for riparian habitat improvement.

INTRODUCTION

The importance of riparian areas can be illustrated by literature generated in recent years. For example, riparian areas are important for forage resources, wildlife, fisheries, recreation, flood control, and water quality (Burgess et al. 1965, Johnson and McCormick 1978, Kauffman and Krueger 1984, Johnson et al. 1985, Gresswell et al. 1989, Murphy and Meehan 1991, Anderson 1994, Catling et al. 1994), and the presence of a water table near the ground surface (shallow water table) is generally accepted as a requirement for delineating riparian-wetlands (U.S. Army Corps of Engineers 1987, Federal Interagency Committee for Wetland Delineation 1989, General Services Administration 1991).

Stromberg and Tiller (1996), Allen-Diaz (1991), Auble et al. (1994), and Henszey et al. (1994) data suggest that the shallow water table must, in part, be responsible for maintaining riparian plant communities because plant roots can access soil moisture from this supply. Although the presence of a shallow water table is generally accepted as the most important water source for riparian plants, other hydrologic factors may be equally important during parts of the growing season when the water table decline rates, soil texture, or a combination of both causes a decline in the supply of soil moisture within plant root zones. Examples of hydrologic factors that may interact and complicate efforts to illustrate how important a water table is for maintenance of riparian plants are shown in Figure 1.

Researchers recognize components of the hydrologic cycle interact and are inherent to the presentation of their results (Bryan 1928, Henszey et al. 1994, Allen-Diaz

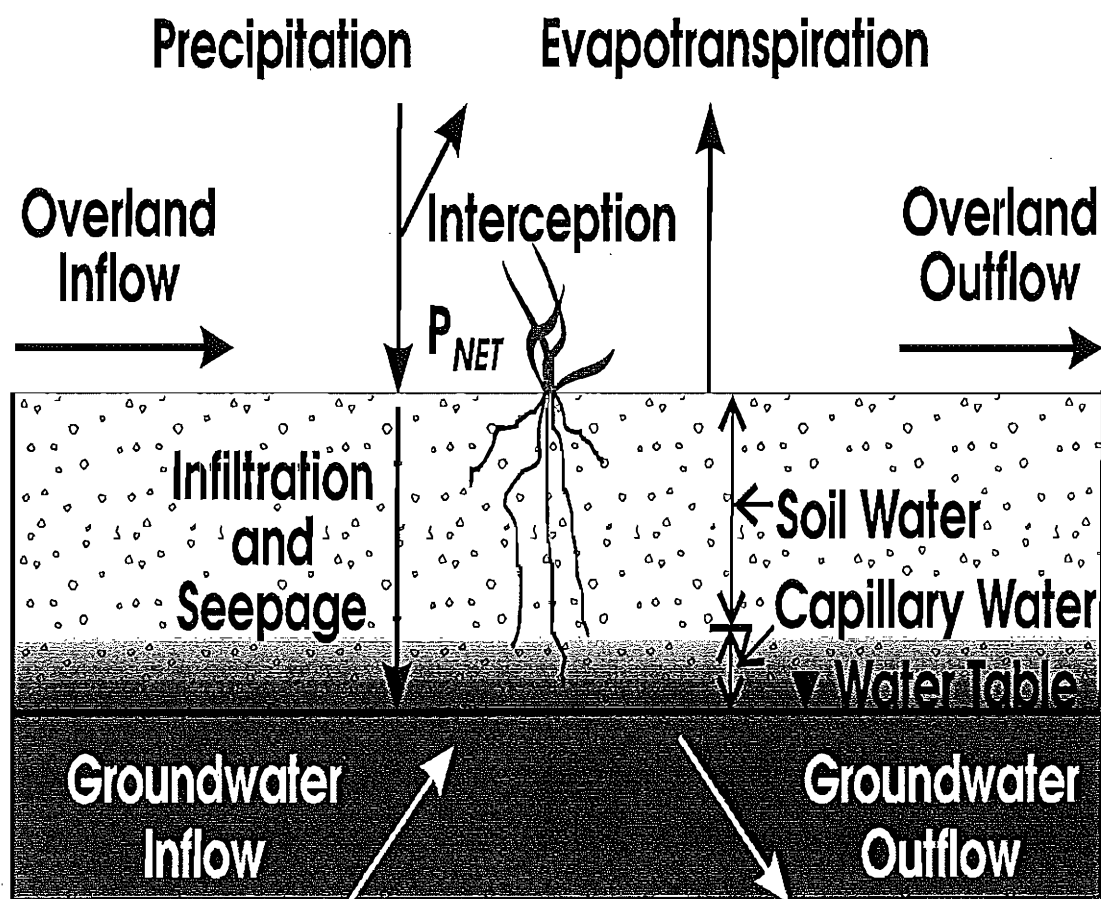


Figure 1. Major factors affecting subsurface water availability to plants.

1991, and Stromberg and Tiller 1996), but these field studies make it difficult to isolate the effect specific hydrologic factors have on plant response and distribution. Stromberg (1993) and Auble et al. (1994) suggest that stream discharge may be an important environmental factor which maintains riparian plant communities, where as, Décamps et al. (1995) implied inner-annual hydrologic variation was controlling the distribution of riparian plant species. The limitation of utilizing their prediction variables is that their results appear to be site specific. Henszey et al. (1994) related the water table directly to plant species' response, but his results were affected by interspecies competition within individual plant communities and his study did not address other soil and hydrologic factors that may affect the subsurface water available to plants (Figure 1).

Consequently, field studies by Bernard (1986), Allen-Diaz (1991), Stromberg (1993), Auble et al. (1994), Or and Groeneveld (1994), Stromberg and Tiller (1996), and Henszey et al. (1994) emphasize additional research is needed quantifies the specific effect water table fluctuations have on survival and response of various riparian plant species. Collection of these data could provide a better understanding of how water table information can be used in the design of restoration programs of riparian areas and serve to evaluate where other hydrologic and soil factors are important for sustaining the distribution of the riparian vegetation (Henszey 1994). In combination, knowing the specific importance of the different hydrologic and soil factors to riparian community health supports Allen-Diaz (1991) emphases that land managers will require models with sufficient sensitivity to predict how species composition changes in riparian wetlands regardless of how water tables fluctuate.

To help answer the questions presented above we have developed a standardized laboratory testing protocol that we believed will be sensitive to evaluating how change in water table levels affect growth of individual riparian plant species. This strategy follows the physiological and ecological optimum theory presented by Walter (1985) and will quantify individual plant species response curves to water table gradients. Walter (1985) recognized that plant response to environmental gradients may be different when measured under field conditions where plant species are in competition with each other and a variety of environmental gradients interact to provide an overall plant response curve (Ecological Optimum), than when one species is tested alone (Physiological Optimum). Figure 2 illustrates Walter (1985) theory and possible differences that may occur in plant response curves when growth is measured along any given environmental gradient.

Henszey 1994 developed ecological optimum plant response curves for plants and groundwater levels for field sites in Wyoming. Our strategy was to: a) follow his research and quantify physiological optimum plant response curves for important plants growing in his study areas, b) compare our physiological optimum plant response curves to those developed from Henszey 1994 field sites, and c) develop a standardized testing procedure which quantifies physiological and ecological optimum plant response curves under controlled laboratory conditions. Results from this research strategy are planned to be used as a predictive tool for planning and evaluation criteria associated with riparian zone management.

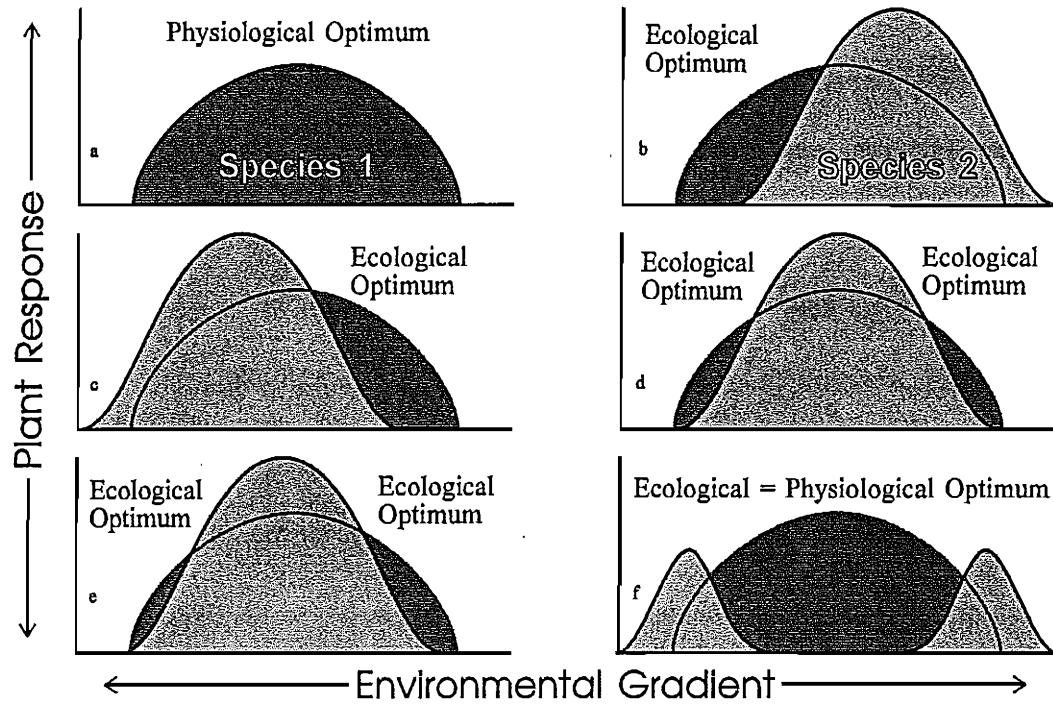


Figure 2. Possible responses to an environmental gradient, showing the physiological optimum for a species without competition, and potential ecological optimums with competition (after Walter 1985).

Having achieved quantifying the ecological optimum plant response curves for water table relationships for Henszey's 1994 field sites, we initiated this study to quantify the physiological optimum plant response curves for important plants growing in his field sites. To do this, a commercial grade course sand was used to minimize the affect capillary rise would have in providing soil moisture to plant roots, and reverse irrigation was used to maintain precise water table levels. This experimental protocol minimizes all other hydrologic factors except water table level (Figure 1). In addition this experimental protocol provides for future testing by being able to maximize capillary rise of water by using a commercial grade fine textured soil. Data provided by these experiments will provide the opportunity for comparing field site results, where interspecies competition occurs, with laboratory results which are plant species specific. Final testing within our protocol will be to test interspecies competition and water table relationships within the large Environmental Simulation Laboratory located in the College of Agriculture, University of Wyoming. Using this facility will allow for simulation of field site conditions under controlled laboratory environments that include testing water table and plant interactions with other hydrologic, soil, and environmental factors.

This study specifically reports on how three important riparian plant species responded to variable water table conditions. The three herbaceous riparian species chosen for this experiment were Nebraska sedge (*Carex nebrascensis* Dewey), tufted hairgrass (*Deschampsia cespitosa* [L.] Beauv.), and Kentucky bluegrass (*Poa pratensis* L., var. *park*). Nebraska sedge and tufted hairgrass were chosen because they occur in wet and moist habitats respectively, and because of their relatively wide geographical

distribution throughout the Intermountain Western United States. Kentucky bluegrass was chosen because it tends to invade degraded riparian areas, and is of concern to some management agencies. The specific objectives of this study were to:

1. Evaluate the response of three important, but morphologically dissimilar, riparian plant species to specific water table decline rates designed to simulate the dewatering of riparian zones; and
2. Develop hydroperiod suitability curves and design hydroperiod duration curves for each riparian plant species and then compare these curves to curves developed from field data.

To accomplish these objectives the following theoretical hypothesis was evaluated: There is no difference between the rate of water-table decline or maximum water-table depth on the growth response of three important riparian plant species.

MATERIALS AND METHODS

Study Facility. The Tall Column Plant-Growth Facility at the University of Wyoming was constructed for this experiment. The Tall Column Plant-Growth Facility has three, 2.4 m-long grow lights that provided 570-600 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ of light intensity within 15-30 cm of the light fixture. The light fixtures used a combination of very high output fluorescence lights and 60-watt incandescent bulbs attached to automatic timers to control light intensity and duration. The timers were set to provide 14 hours of light at four intensities to simulate dawn, full daylight, and dusk. Air circulation was provided to reduce the effect of a vapor boundary layer occurring on the leaves (Salisbury and Ross, 1992).

Plants were tested in 3.0 m tall columns constructed from black acrylic (Figure 3). A removable clear acrylic front allowed for the nondestructive observation and the