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A Comparison of Environmental Substrate Gradients and Calcium Selectivity in Plant Species of Calcareous Fens in Massachusetts

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Abstract
The distribution and occurrence of plant species within a given region provides insight into the many environmental properties of that region. Although much research has been conducted on plant communities and associated environmental properties, few studies have been conducted on the characteristics of individual plants within those communities. Calcareous fens are wetlands formed by the upwelling of mineral-rich groundwater and often are associated with many unique plant communities and rare species of flora and fauna. Although many studies have documented the vegetation patterns and associated environmental gradients of these fens, none have isolated the specific hydrogeochemical conditions associated with individual species, nor have any studies attempted to document and compare the individual physiological response of species to elevated environmental calcium levels. This research was conducted to estimate environmental calcium requirements for rare as well as common indicator species of calcareous fens of Massachusetts and to examine the relationship between the accumulation of calcium in the tissues of these species to calcium availability in their environment. These factors will be important when determining required conditions for fen restoration and will further the understanding of why these species often only occur in calcareous fens.

Eight calcareous fen study sites at three different locations were established where calciphiles occur in western Massachusetts. In each site, data were collected on the vegetation patterns and associated soil chemistry, water chemistry, and hydrology. In addition, plant tissues were collected and analyzed for calcium. Species distributions were evaluated as to whether they increased in abundance as environmental calcium did or whether they appeared to occur only once a specific calcium threshold was met. In addition, the concentrations of calcium in the tissues were used to determine the extent to which those plants accumulated calcium and how those levels related to levels of calcium in the substrate environment and to their overall distributions.

It was found that certain calciphiles are calcium specialists, i.e. they are more abundant when environmental calcium levels are elevated, absorb greater quantities of calcium and those quantities correlate to the available environmental supply. These species include *Parnassia glauca*, *Packera aurea*, *Geum rivale* and *Carex granularis*. Of these, *Geum rivale* and *Carex granularis*, as well as *Carex sterilis*, did not occur below calcium concentrations of 48 $mg \cdot L^{-1}$. However, other calciphiles are calcium generalists, i.e. they are tolerant of elevated calcium levels but show no other relationship with respect to growth or accumulation. These species include *Carex flava*, *Carex hystericina*, *Juncus nodosus*, *Solidago patula*, *Solidago uliginosa*, and *Symphyotrichum puniceum*. In addition, some wetland generalists maintain elevated calcium levels (*Symplocarpus foetidus* and *Mentha arvensis*) whereas most others do not (*Thelypteris palustris* and *Fragaria vesca*). Of the calciphile and wetland generalist species, some appear to increase in abundance in calcareous fens in relation to increases in accessory benefits (*Dasiphora fruticosa* and *Juncus brachycephalus* with pH; *Thelypteris palustris* and *Carex flava* with magnesium and possibly *Equisetum fluviatile* with iron). Combined, these findings characterize the growth habits and calcium accumulation of species that grow in calcareous fens and indicate that calciphiles have varying degrees of dependence on calcium.

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