CC/NUMBER 34
AUGUST 21, 1989

This Week's Citation Classic®

Werner P A. Predictions of fate from rosette size in teasel (*Dipsacus fullonum* L.). *Oecologia* 20:197-201, 1975.
[Department of Botany and Plant Pathology and Kellogg Biological Station, Michigan State University, East Lansing, MI]

In field populations of a biennial plant species, the probability that an individual either died, remained vegetative, or flowered in any growing season was highly correlated with the size of its vegetative rosette the preceding year. Rosettes produced flowering stalks only after attaining a critical size. Size provided better predictions of plant fate than did age. [The *SCI®* indicates that this paper has been cited in over 125 publications.]

Plant Critical Sizes for Survival and Flowering

Patricia A. Werner
Division of Wildlife and Ecology
Tropical Ecosystems Research Centre
Commonwealth Scientific and Industrial Research Organisation
Darwin, Northern Territory 0821
Australia

January 10, 1989

Neither the research nor publication of this paper was a straightforward matter. In fact, the research began as a study not about teasel or biennial plants, but about old-field succession. I was working on doctoral research in the late 1960s testing several notions of the day about secondary succession, including my favourite: that particular combinations of life-forms were responsible for the patterns of diversity and productivity observed in successional seres. I was working at the Kellogg Biological Station of Michigan State University in an experimental set of old-fields set up by Dr. John Cantlon. Teasel was a perfect experimental tool—it was not in the fields although it could grow there, it had large seeds, no seed bank to speak of, large leafy rosettes in one year, and (I expected) very tall single flower stalks the second year. My main interest was what teasel would do to the plant communities when added in known quantities.

In hindsight, it was fortunate that I also had taken time to mark, measure, and monitor individually the introduced teasel seedlings, some 1,785 of which were still alive by the end of the first year. In the second year the rosettes seemed healthy enough, but 85 percent did not produce flowers; a disaster, I thought! In my nightmares, smug green rosette faces mocked my wish to finish a PhD in normal time. Nevertheless, I duly measured the little beasts. By the third year about 60 percent flowered, and I wrote my thesis about communities and life-form "combinability." I continued to monitor the teasels for the next two years, as the stragglers also flowered. I found out that the probability of various fates depended on how large it had become by the end of the growing season, regardless of age. As it turned out, growth rates were slowed to different degrees, depending upon the type of surrounding neighbours.[1]

The paper was rejected outright by the first journal whose reviewer did not understand that the results went beyond the trivial point that a biennial might take longer than two years to produce flowers. One of the reviewers of the second journal wanted me to cite "previous work" on this species by a well-known plant ecologist who, in fact, was actually referring to my own unpublished results! When this was pointed out, the paper was quickly accepted.

The paper carried implications for two major lines of inquiry, which seems to account for the majority of the citations. First, it pointed out a major, easily measured quality of plants that was tied to vital attributes; it followed that if size was at a premium, then growth rate must be also. Both size and growth rate received increased attention by physiologists, geneticists, and evolutionary and community ecologists.[2-4] Second, the paper carried a key concept important for modelling plant population growth. Plant ecologists working on field populations could go beyond phenomenological studies of various stages of life history to predictions of population behaviour.[5,6] Also, theoretical work advanced in the form of general formulae that applied to organisms with variable growth rates.[7] Finally, it seems that the phenomenon of critical size for flowering was inherent in many scientists' data sets; several of these were published as notes soon after 1975.

Today, the concepts demonstrated in this paper are well entrenched in our thinking. This was not the case in the 1970s, just at the height of the growth phase of the field of plant population ecology.

1. **Werner P A.** Colonization success of a "biennial" plant species: experimental field studies of species cohabitation and replacement. *Ecology* 58:840-9, 1977. (Cited 40 times.)
2. **Solbrig O T, Jain S, Johnson G B & Raven P H,** eds. *Topics in plant population biology*. New York: Columbia University Press, 1979. 589 p.
3. **DeJong T J, Klinkhamer P G L & Metz J A J.** Selection for biennial life histories in plants. *Vegetatio* 70:149-56, 1987.
4. **Grace J B & Tilman G D,** eds. *Perspectives on plant competition*. Orlando, FL: Academic Press. (In press.)
5. **Werner P A & Caswell H.** Population growth rates and age *vs*. stage-distribution models for teasel (*Dipsacus sylvestris* Huds.). *Ecology* 58:1103-11, 1977. (Cited 100 times.)
6. **Bierzychudek P.** The demography of jack-in-the-pulpit, a forest perennial that changes sex. *Ecol. Monogr.* 52:335-51, 1982. (Cited 50 times.)
7. **Caswell H.** Matrix population models and the analysis of complex plant life cycles. (Levin S, ed.) *Lectures on mathematics in the life sciences*. Providence, RI: American Mathematical Society, 1980. p. 1-63.

P B-2