Open access • Journal Article • DOI:10.1111/J.1399-3054.1983.TB04205.X

The effects of ultraviolet-B radiation on plant competition in terrestrial ecosystems

Warren G. Gold, Martyn M. Caldwell

Institutions: Utah State University

Published on: 01 Jul 1983 - Physiologia Plantarum (Blackwell Publishing Ltd)

Topics: Avena fatua and Plant ecology

1983

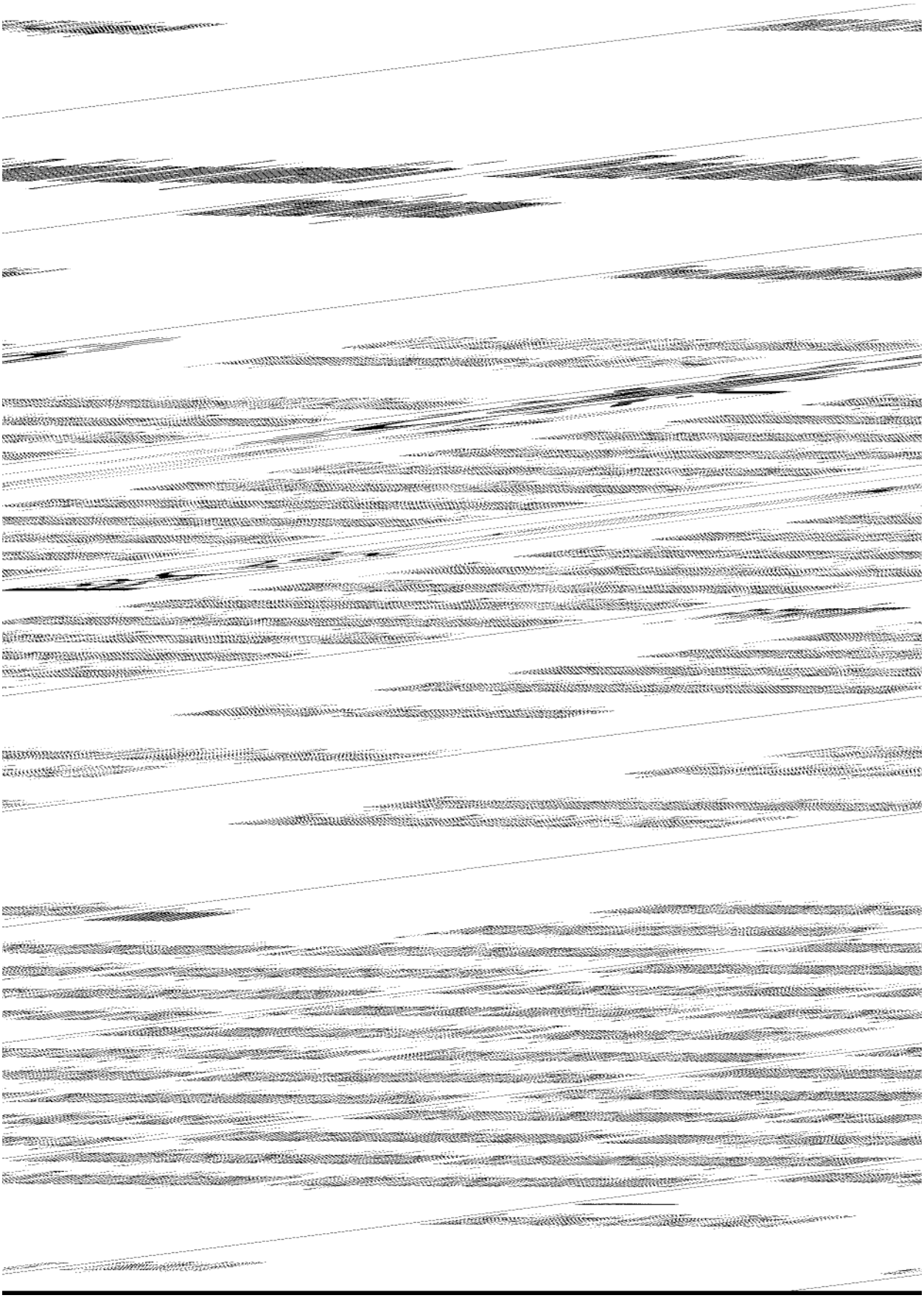
The Effects of Ultraviolet-B Radiation on Plant Competition in Terrestrial Ecosystems

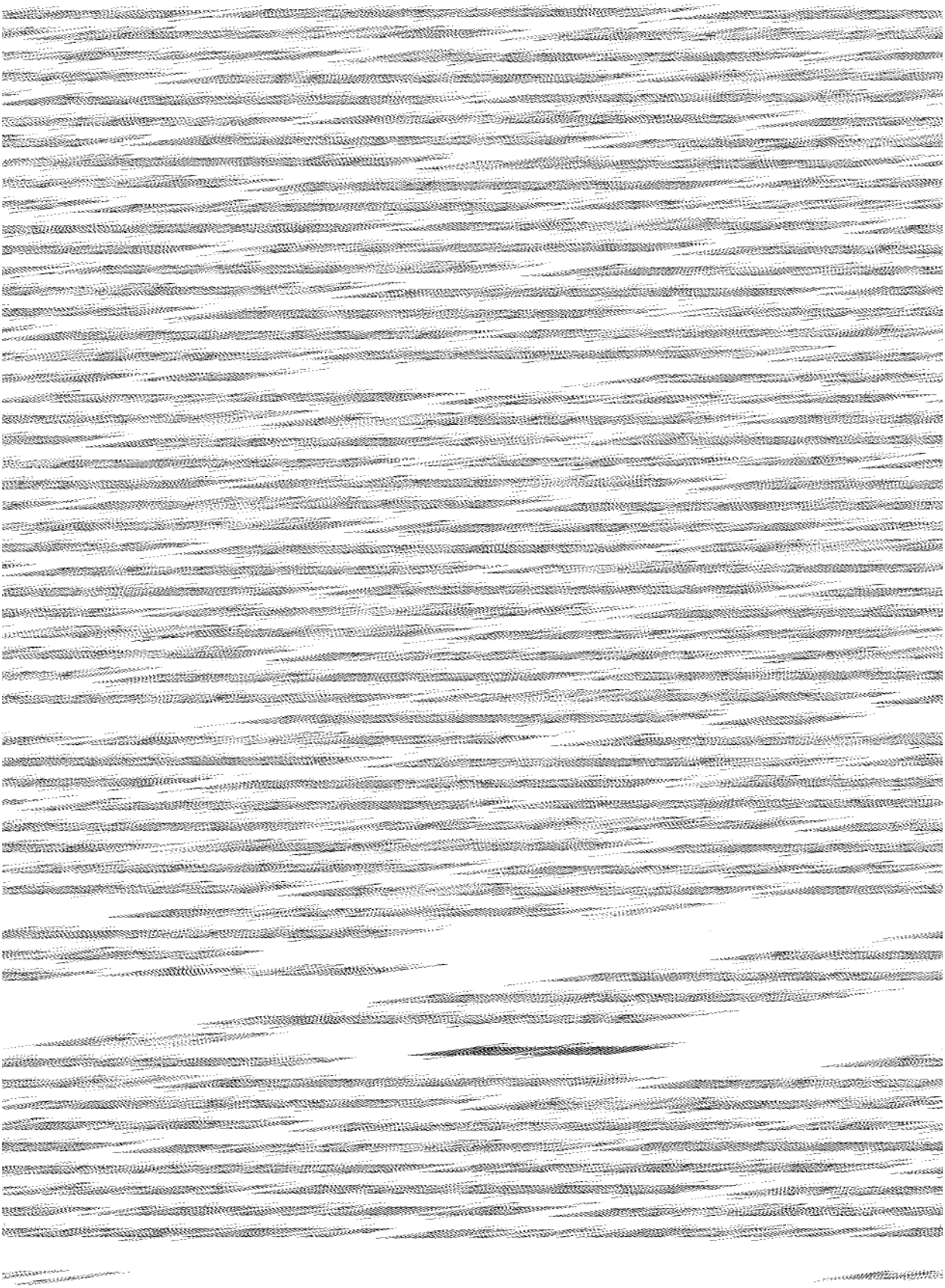
Warren G. Gold

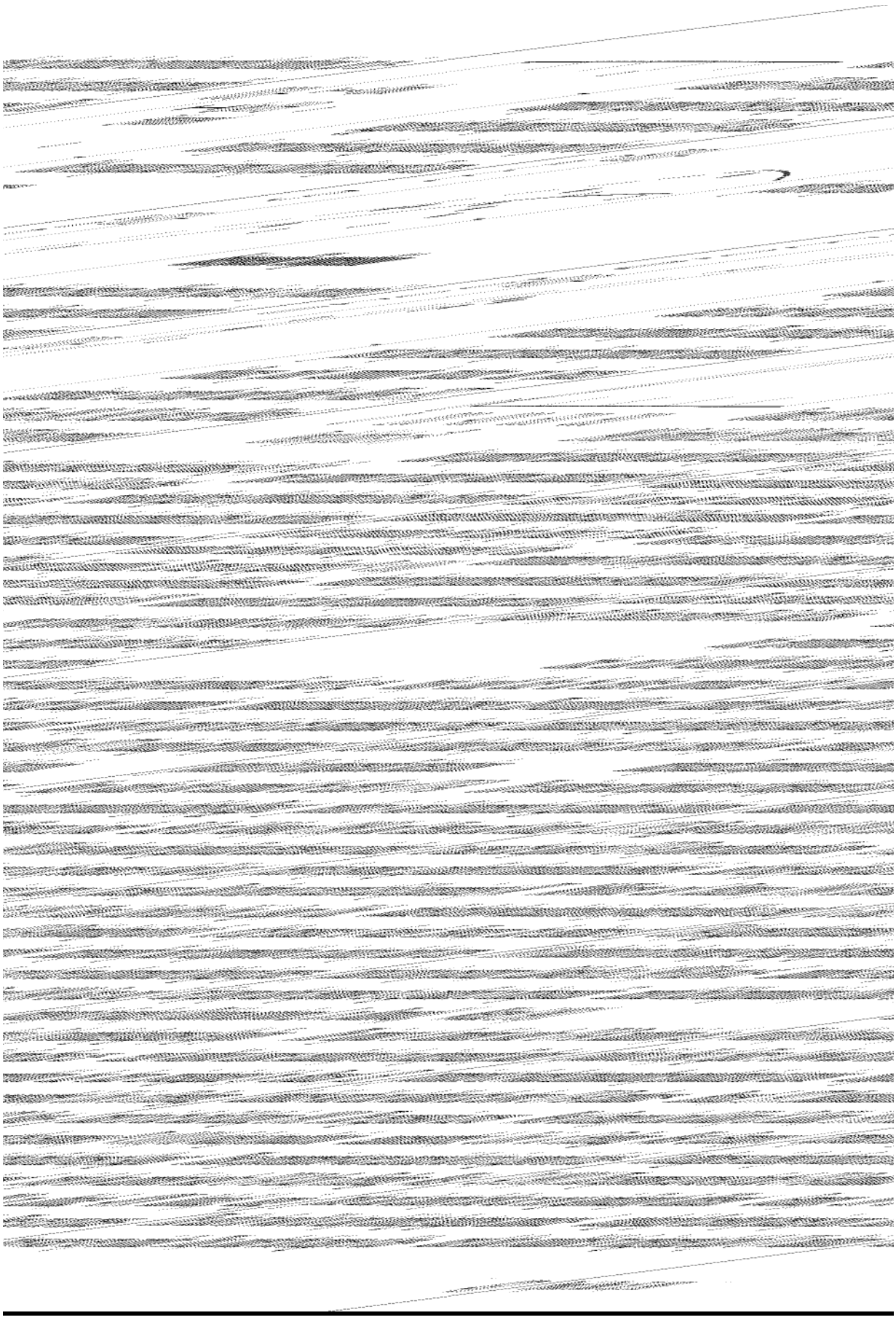
Martyn M. Caldwell

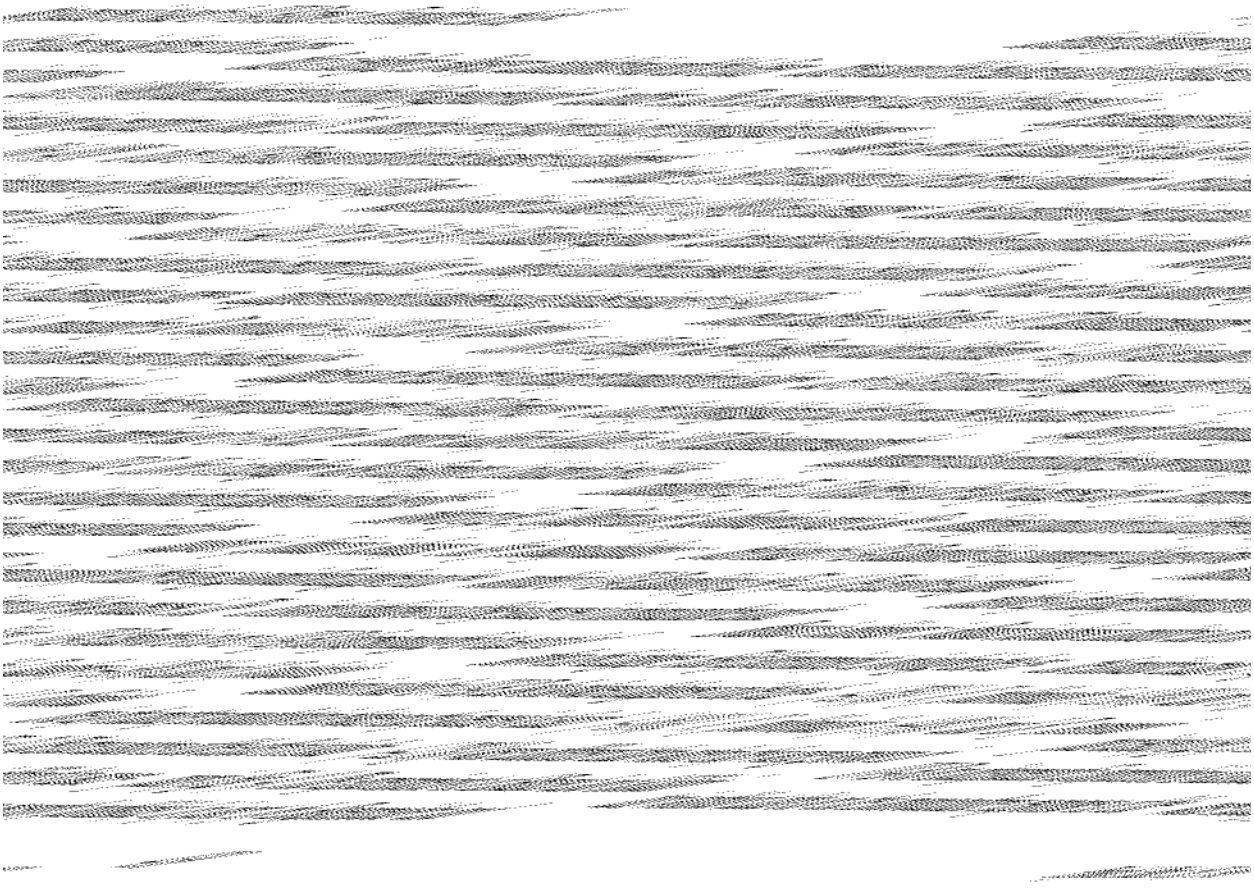
Recommended Citation

Gold, W. and Caldwell, M. (1983). Effects of ultraviolet-B radiation on plant competition in terrestrial ecosystems. Physiologia Plantarum, 58(3): 435-444.









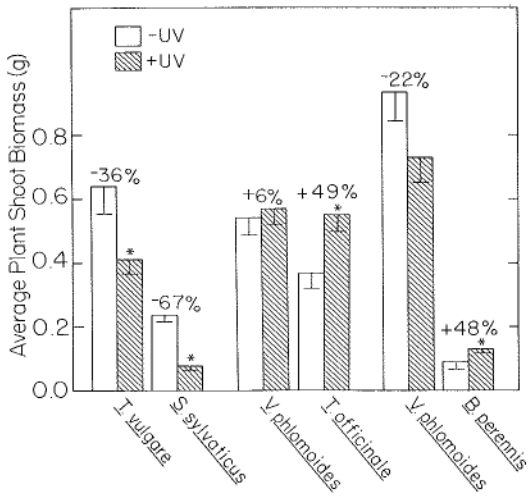


Fig. 4. Average plant shoot biomass (g) produced by species in competition experiments using species pairs without solar UV-B (-UV) and with solar UV-B irradiance (+UV) in the field at Freiburg, West Germany. The error bars indicate one SE. The percentage change in shoot biomass produced under solar UV-B relative to no solar UV-B is given for each species. The asterisks indicate a significant ($P < 0.05$) effect of solar UV-B on shoot biomass production of a species by Student's t-test. The species pairs are: *Tanacetum vulgare : Senecio sylvaticus, Verbascum phlomoides : Taraxacum officinale,* and *Verbascum phlomoides : Bellis perennis.* The data are taken from S. Kiliani, Staatsexamensarbeit.

Klein (1982). The results suggest that ambient solar UV-B (as exists without ozone depletion) has a significant effect upon the competitive interaction of species pairs. The total shoot biomass production of the species pairs was reduced under solar UV-B relative to pairs grown without UV-B in all cases except one (*Verbascum phlomoides : Taraxicum officinale,* Fig. 4).

Caldwell (1977) has hypothesized that an increase in incident UV-B radiation could alter the competitive interactions within plant communities because of the differential resistances of the component species to increases in UV-B. Fox and Caldwell (1978) examined the effect of an artificial increase in UV-B radiation on the competitive interactions of selected species pairs. Solar UV-B radiation was supplemented with sunlamps (Sisson and Caldwell 1975) to approximate the daily dose of weighted UV-B irradiance expected with a 40% reduction in the ozone layer, using the generalized plant action spectrum (Caldwell 1971). Three types of species associations were examined: agricultural crops and associated weeds, montane forage species, and disturbed area weedy associates (Tab. 1). The mixtures were sown in a modified deWit (1960) replacement series design in pots, which were placed in the field for the duration of the experiment.

The deWit (1960) replacement series is a model of plant competition in which plants compete directly for space and limited plant requirements within that space. The experimental design maintains a constant overall plant density while varying the proportion of the two species present within a given area. The competitiveness of a species relative to the other species of a particular pair is evaluated by comparing its performance in the mixtures to its performance in monocultures of the same density.

Relative crowding coefficients (k_{12}) were used to analyze the competitive situations (Harper 1977). The relative crowding coefficient is a relative measure of the competitive ability of one species when it is grown in mixture with a second species. The relative crowding coefficient can be calculated by:

$$k_{12} = \frac{O_1 \cdot M_2 \cdot Z_2}{O_2 \cdot M_1 \cdot Z_1}$$

Tab. 1. Relative crowding coefficients based upon shoot biomass for competing species pairs under ambient solar UV-B irradiance (control) and enhanced UV-B simulating a 40% ozone layer reduction (using the generalized plant action spectrum). The plant associations which the groups of species pairs represent are given. The letter 'a' denotes a significant ($P < 0.05$) difference between treatment and control relative crowding coefficients for a particular species pair. The data are taken from Fox and Caldwell (1978).

Plant association	Competing species pair		Relative crowding coefficient	
	Species 1	Species 2	Control	Enhanced UV-B
Agricultural crops and associated weeds	*Alyssum alyssoides* L.	*Pisum sativum* L.	0.34	0.25
	Amaranthus retroflexus L.	*Medicago sativa* L.	3.56	0.73[a]
	Amaranthus retroflexus L.	*Allium cepa* L.	1.89	2.01
	Setaria glauca (L.) Beauv.	*Trifolium pratense* L.	2.06	18.74
Montane forage species	*Poa pratensis* L.	*Geum macrophyllum* Willd.	0.85	2.28[a]
Disturbed area weedy associates	*Bromus tectorum* L.	*Alyssum alyssoides* L.	6.35	1.63
	Plantago patagonica Jacq.	*Lepidium perfoliatum* L.	0.75	0.68