SYNECOLOGY OF WEEDS

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Weed scientists try to understand enough about the performance of weeds in various ecosystems to develop useful methods of controlling the weeds while improving the growth and production of the more desirable plants. There is an increasing realization that an ecological approach based on the integration of several control methods has more possibility of long-term success than reliance on a single method of control. Detailed information is, therefore, needed for each ecosystem on the interaction between the weeds, the climatic and soil conditions, other plants present and on biotic factors (including man). This is the topic that the Organizing Committee selected for this session - the examination of weedy plants as members of particular plant communities or ecosystems.

Synecology could be defined as the study of communities as components of ecosystems. It is concerned with how communities originate and maintain themselves and how they may be classified. Unfortunately few papers in the Conference fit neatly into this definition although there is some overlap between this and previous sessions.

Since the last Australian Weeds Conference more emphasis has been placed on the biology of weeds. Most studies have been on the autecology of species rather than on the complex interactions that occur within and between plant communities.

In view of the complexity of the subject and the young state of weed science, particularly in Australia where our limited resources are thinly spread, it is not surprising that there are huge gaps in our knowledge. Our aim today should be to expose some of these gaps as well as sharing a little of what we do know.

WEEDS AND PLANT SUCCESSION

The main stages of ecological succession in plant communities are nudation, migration of species to the area, growth and reproduction of colonizing plants, competition, reaction of plants on the physical environment, and final stabilization of the community as the climax vegetation. A dis-climax (disturbance climax) vegetation is generally considered to be one which persists under a fairly stable influence, e.g. grazing of pastures prevents their degeneration to forest.

In Australia we are indebted to Dr R.M. Moore for his extensive studies on succession in woodland and pastures as summarized in the book "Australian Grasslands" and to Mr N. Johnson for his reviews, in the proceedings of the first two Victorian weed conferences, of the place of weeds in successions in cereal crops and in industrial situations.

The species involved and the rates of change vary with the environment. For example, Mears considers that wet sclerophyll forests cleared for dairying in Gippsland, Victoria, revert to forests in about 80 years while those on the far north coast of New South Wales do so in 40-50 years. The weeds are initially a bramble, bracken and a Composite. These are followed by native shrubs and then trees. In part of the Western Division of New South Wales, thick scrub regeneration has been associated with the removal of rabbits (as has been documented in England following the advent of myxomatosis) and the lack of bush fires.

Mears points out that the length of the weed phase depends also on the level of management. Although weeds are inevitable in man-made communities, their density and relative abundance can be manipulated by man. How well this can be achieved depends, to a large extent, on our knowledge of the autecology of each species. Autecological information also helps to explain the occurrence of new weeds when management systems are changed. A good example of this is given in the paper by Monaghan, Brownlee and Mears. Because of a recent change in land use from grazing to irrigated cropping, a native plant, *Solanum karsensis*, has emerged as a weed apparently because of the increased germination of the seed. Management tools frequently used to manipulate or manage weed populations are cultivation, sowing competitive plants, adjusting stocking rates, controlling animal and plant pests, applying fertilizer and using herbicides, and there is an increasing interest in the use of introduced biological control agents.

Table 1 shows possible changes in the nature of weed problems in crops. Australian crops, but probably not pastures, seem to be reaching the last two stages of these changes. Would delegates agree that papers in this and other sessions refer mainly to weed-crop interactions in these two stages? If this is so then we at least know the general framework in which much of our crop weed research and extension effort will be placed in the foreseeable future.

TABLE 1

Possible changes in the nature of weed problems in crops†

1. PIONEERING STAGE	Residue of original vegetation and some alien weeds.
2. MORE DEVELOPED AGRICULTURE	Rich and variable flora of alien weeds.
3. INTENSIVE CROPPING SYSTEMS	Weeds adapted to crop rotations and high fertilizer use. Weeds suppressed by high labour input.
4. PERIOD OF LABOUR SHORTAGES	Fewer cultivations, simpler rotations, more weeds.
5. INCREASED USE OF HERBICIDES	Replacement of some cultivations by herbicides, fewer weeds.
6. INCREASE IN WEEDS RESISTANT TO HERBICIDES	e.g. Grass weeds in cereals.
7. COMMUNITY REACTION AGAINST PESTICIDES BECAUSE OF COST AND SUPPOSED EFFECT ON ENVIRONMENT	Search for better integration of control methods and less damage to non-target species.

† The early stages in this table are based on information in van der Zweep, W. (1968) Past, present and future of weed research in Europe. *Meded. Rijksfakult. Landb. wetensch. Gent.* 33: 537-553.

Many alien plants have found an ecological niche in Australia and will remain indefinitely unless persistent control measures are carried out. For example in Queensland Harrisia cactus has spread into large areas of brigalow forests and woodlands, and persists in infested areas that have been cleared for grazing. Harvey considers that the soil and climatic conditions in much of Queensland are suitable for the growth of this cactus. He suggests that its success as a colonizer is related to the following factors:

1. In its country of origin it is suppressed by the combined effects of fungi, bacteria and insects but this does not occur in Australia.

2. The crassulacean acid metabolism typical of cacti gives it a competitive advantage, particularly under low light intensities.

3. The seed is spread extensively by birds and feral pigs and the plant also propagates vegetatively.

It would be interesting to know why this species has not colonized the native grasslands.

Discussion showed that few formal studies of succession have been carried out by weed scientists in Australia. However, considerable practical experience is available on the relationship between weeds and succession in agricultural and non-agricultural situations. It was considered to be unfortunate that so little of this information has been reported.

'ENVIRONMENTAL WEEDS'

Although most weeds discussed at this Conference have been those of man's crops or pastures, there is an increasing awareness of 'environmental weeds' or 'community pest plants' in non-agricultural land. For a variety of reasons, plants such as blackberry, lantana, groundsel bush, privet, boneseed, St. John's wort, African daisy and tutsan growing in non-agricultural land concern many people. These plants have a common ability to thrive in forest edges, which may be thought of as tension zones between forest and agricultural communities. A characteristic of forest edges is the variable light regime. Often these plants invade bushland that has been subject to a minor disturbance such as grazing by rabbits. Why are such plants successful invaders? Can we predict what their long-term effect in bushland will be? Is it really necessary to devise methods for their selective control in bushland? To what extent is it possible to do so? In my opinion, weed scientists have a duty to find answers to these questions and to adequately inform the public, and particularly those who often become very emotional about a particular weed in a particular plant community.

There was considerable discussion on unwanted plants in National Parks (described by one delegate as unweeded gardens). It was considered that few alien plants were able to colonize really undisturbed areas. Where colonization has occurred in bushland, control measures are not always necessary because the alien plant may be replaced or suppressed by later stages in the succession. It was suggested that it would be useful to place alien plants in National Parks in two categories depending on whether or not control measures were necessary. Based on the discussion it was apparent that there was a lack of factual information on weeds and weed control in bushland and on dispersal of weeds by feral animals, man and vehicles.

Lane considers that South African boneseed is successful at colonizing bushland because of the high production of large seeds, a high level of seed dormancy, and the extensive dispersal of the seeds by birds and animals. In south eastern Australia boneseed is colonizing coastal areas and parklands. It is interesting that in South Africa boneseed occurs as an early plant in the succession to forest and is not regarded as a weed problem whereas introduced Australian hakeas and wattles are. In addition to reassuring us that justice will prevail, this point raises the perplexing issue of whether it is possible to predict which species will become weeds if introduced into other countries or regions.

Selective control of small infestations of boneseed is possible but the more difficult problem is to know what to do with large infestations. One approach, which would not be popular with conservationists, would be to do nothing in the hope that boneseed will eventually be replaced by trees. Lane considers it unlikely that this approach would be successful. Two of his suggested methods of control, which could apply to other community pest plants, warrant general discussion. Firstly to what extent should fire be used in bushland to remove a weed, and to stimulate germination of the remaining seeds, before other control treatments are carried out? Secondly, the more gentle art of biological control is suggested. Clearly biological control is the only possible method of suppressing large infestations of weeds in inaccessible country. However at the present level of Commonwealth and State funding for research on biological control, suppression of environmental weeds by this method will probably remain a pipe dream for a long time to come.

During the discussion it was established that fire has a role to play as a management tool to be used in conjunction with other methods of weed control. The key variables are the intensity and frequency of the fire and the time of the year in which the burn is carried out. Consideration should be given to the information that is available on the effect of fire on Australian plants and mammals. From the discussion there was an indication that biological control of weeds would receive increased attention in the future.

Australian weed scientists are only just starting to critically look at what vegetation exists on roadsides. Clearly, we need to know more about the various zones of vegetation that occur near the road pavement, in the easement, at the fenceline and in the adjacent fields. More information is required before we can satisfactorily state to what extent alien plants are a problem on roadsides and, if they are a problem, what should be done about them.

The papers in this session also raise several questions concerning plant competition.

1. <u>To what extent do weeds compete for moisture, nutrients and light in Australian crops, pastures and forest plantations?</u>

At this Conference several generalizations, but few facts, have been presented on the competition between weeds and crops for moisture, nutrients and light. The reason for this is easy to see when one tries to find examples of relevant research on this subject in the index of weed research projects listed in the March 1975 Australian Weeds Research Newsletter. Without basic information it is difficult (or impossible) to explain the short-term and long-term results of many trials involving weeds in crops or to make realistic predictions. We need to ask ourselves whether our current research on competition between weeds and crops has sufficient depth.

In the discussion it was pointed out that the nature of competition depended on the stage of the crop. Generally, competition for nutrients is most important in the early stages, after which competition for light is of increasing importance and in the later stages there is often intense competition for moisture. Various modifications of this general statement to cover certain crops, pastures and forests were discussed.

2. <u>What density of a weed (or weeds) can be tolerated?</u>

This key question is rarely adequately answered because the decision may be influenced by biological, economic, aesthetic and political factors. Clearly, there should be a nil tolerance on drug plants but what level of 'environmental weeds' can be tolerated? In crops, the decision is usually made on economic grounds. Boardman, Boomsma and Zed consider that in forestry practice the aim is to maximize individual tree growth in the first few years and to provide sufficient nutrients in later years so that closed-forest conditions are reached as soon as possible. Consequently, herbicides such as atrazine and aminotriazole are now used extensively to control herbaceous weeds, the densities of which Boardman *et al.* did not specify.

Carteledge *et al.* studied the economic threshold level of wild oats over a 7-year period (in which grain yield was measured for 4 years) and concluded that even after this period the practical application of the data was not easy. They point out how difficult it is to predict the effects of weeds because of the influences of crop density and vigour and the relative times of emergence of the weed and the crop. What should our approach be? We could sow various densities of the weed and measure the effect on grain yield and other parameters, supported by measurements of the climatic and soil conditions in order to construct predictive models. But how general would the practical conclusion be? Holland and McNamara found that, in the north west of New South Wales, sorghum yields are linearly reduced by increasing dry matter yields of weeds and that the yield reduction is greatest in years of severe moisture stress. Is this as much definition as we can give the problem or should we do better? Reeves has been able to develop two equations which describe the average effect of ryegrass on wheat yield and which make allowance for the time of sowing. Another paper by Reeves reminds us of the continuing need to measure the competitive ability of new crop cultivars such as the dwarf wheats.

In the discussion it was stressed that the residual effect of weed control on weed densities in subsequent years must be considered when deciding the level of weeds that could be tolerated.

3. <u>To what extent are some weeds more competitive than others?</u>

The paper by Wells in Section 2(a) is of interest because an attempt is being made to determine the comparative effects of different weed species in a crop. Differences in the competitive ability of annual weeds in wheat were shown but the need for several years' results were emphasized. Also Allen showed that at one location, ryegrass, but not capeweed, caused considerable reductions in the grain yield of lupins. What other information do we have, or need to collect, on the competitive ability of different weed species? As weeds often occur in mixed stands, how can we design experiments that will provide a general, but sound, basis for statements on the effect of weeds on crops?

4. How reproducible are the effects of weeds in different localities?

It is to be expected that because of weed-crop-environment interactions, the degree of competition provided by the same weed species could differ in each ecosystem. But how often is the range of variation measured? The papers by Allen on lupins and McKenzie on oxalis suggest that large differences in the effects of weeds at different locations do exist. How often do we have the quantitative data needed to adequately explain the differences? Paterson's query on the extent of genotypic variation in weeds is relevant here.

5. At what stages in the development of the crop is competition most important?

It is generally assumed that weed competition is most severe in the early stages of a crop and the use of pre-emergence herbicides is one approach to solve this problem. Boardman *et al.* have stressed the value of suppressing weeds in the first few years of pine plantations. But how extensively has the assumption of early competition been investigated in each of our weed-crop situations?

Felton found that pre-emergence herbicides were unsatisfactory for the control of *Datura* spp. in irrigated soybeans. By removing weeds at various times after sowing he was able to show that the onset of competition did not occur until at least 8 weeks after sowing. Because of this, post-emergence herbicides and cultivation are now being investigated. This is a useful example of how a weed problem is being analysed and practical solutions to the problem will no doubt be developed.

6. Do we have adequate experimental and analytical techniques for studying the effects of weeds in plant communities?

The paper by Hateley describes a technique for recording and analysing the components of plant communities and that by O'Neill and Martin outlines a statistical procedure which can be used to distinguish the main components of interactions between species. These papers raise the question "to what extent are Australian weed scientists restricted by their experimental or analytical techniques in studies of weeds in plant communities?" I suspect that the answer may be that there are deficiencies in the available techniques but even larger gaps in familiarity with the techniques by Australian weed scientists.

Measurement of vegetation is a large topic which has occupied the minds of plant ecologists for many years. Most of us would be familiar with the traditional methods for obtaining plant density, cover or dry matter production. The method described by Hateley involves the use of vertical and oblique photographs from a camera mounted on a hand-held boom. The sample is viewed as a group of occupied and vacant spatial niches in which growth, decline and death of each species occurs. This method would considerably reduce the time required for field work and be of particular benefit when working in difficult terrain. Successive sampling should enable future trends in the vegetation to be predicted.

Information on the interaction between weeds and crops can be obtained by:

1. surveys of the effects of a weed in crops at many sites;
2. experiments using 'additive designs' in which various densities of the weed species are added to a fixed density of the crop;
3. experiments using 'substitutive designs' in which monocultures and mixtures are sown at the same overall density;
4. the development of mathematical models in which hypotheses of possible field interactions can be tested.

An increasing number of relevant statistical methods are becoming available. O'Neill and Martin have pointed out that when several variables are measured in an experiment, univariate analyses are usually prepared for each variable and the inferences are based on a combination of the effects of each variable. However the combination and interpretation of univariate analyses is often difficult because the measured variables are correlated. The authors suggest that principal component analysis (PCA) is a more suitable method for analysing data collected on plant communities because it reduces the data and simplifies the interpretation of the results.

ALLELOPATHY

It has been known for some time that some plants produce allelopathic substances, i.e. chemicals that may give the plants a competitive advantage over others. No Conference papers have referred to this but there is increasing evidence that such substances may be widespread. Interest in the extent to which allelopathic substances are influencing the interaction between weeds and other plants in Australia has been raised by the recent work of Bendall on Californian thistle in Tasmania.