Managing the populations – some general considerations

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Abstract

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The management of the wild relatives of crop plants can only be undertaken in a limited number of cases. Clear objectives therefore have to be set when identifying priority species or conservation action. Numbers, sizes and proportions of populations to be conserved and their gerographic distribution are key questions when preparing management plans. Also important is an analysis of the threats to which the species are subjected. Conservation options include both *in situ* and *ex situ* and an integrated multidisciplinary approach is recommended.

Introduction

Conservation biology has been described as a mission-oriented crisis discipline (Soulé 1985). It is concerned with providing a framework for making decisions about what activities to undertake in order to ensure that particular ecosystems or species continue to survive. Conservation work is essentially practical – the objective is to ensure that target species or ecosystems are conserved; that they continue to exist, adapt and evolve and, where appropriate, are available for direct or indirect use by people.

The conservation of wild relatives of crop species is a largely neglected field. While its importance is generally recognized (e.g. Hoyt 1988), both the traditional crop genetic resources sector and those concerned with habitat conservation have tended to consider the specific issues raised by the conservation of crop relatives as peripheral to their main interests. The workshops on which this volume is based which have had as their focus the conservation of the wild relatives of European cultivated plants are therefore very important initiatives.

Decision making in conservation is necessarily multidisciplinary. Information from a wide variety of biological disciplines is needed and must be combined with sociological, economic and cultural information and an appreciation of legal aspects and current political realities. All aspects which will affect the long term survival of particular species or ecosystems need to be considered in developing possible conservation strategies. Many of these have been specifically considered in a wide variety of publications and their direct relevance for wild relatives of European crop plants are referred elsewhere in this volume. In this presentation some of the more important of these aspects will be described in the context of the conservation decisions that will need to be made for individual populations of the target taxa of the wild relatives of concern.

Objectives in managing populations

The large numbers of wild relatives of European crop plants that have been identified (Heywood & Zohary 1995) makes it unlikely significant conservation initiatives can be undertaken on any scale for more than a small proportion of the species of concern. A primary level of decision-making will therefore involve setting criteria which will allow species that require positive intervention to be identified. Most species will not receive much attention (and may not need any) but we need to be sure that we have ways of identifying those that do need positive intervention of some kind. Where conservation action is required the consensus has been that, for wild relatives, *in situ* conservation is preferred. However, *ex situ* conservation is an essential element in developing conservation strategies. It is not a question of alternatives but of using the different approaches available in complementary ways that maximize conservation capacity.

The functional units of any conservation strategy for wild relatives are likely to be individual populations of the target species. Their place within ecosystems will of course be important and will necessitate consideration of conservation at the ecosystem level but the primary target of concern will be the species of interest and practical concern will be with individual populations of these species. There is debate about what constitutes a population. It may be analysed at the level of metapopulations, patch populations or population networks and a considerable body of theory and discussion has developed around this area. However, a functional description of the populations of an individual species is usually possible (even if rather arbitrary) and provides the necessary framework for planning conservation activities.

Central questions affecting the development of management plans concern the numbers, sizes and proportions of the populations that are to be conserved and their geographic distribution. Estimates have been made of minimum viable population sizes which have varied widely depending on the objectives identified. Thus, Franklin (1980) suggested that simply to maintain short term fitness required population sizes of about 50 while, to maintain sufficient variation for adaptation to changing environment, populations of about 500 individuals were required. Much higher estimates of population numbers have been produced by subsequent workers with different objectives and much of the recent discussion in this areas has tended to emphasise the importance of environmental, demographic and other non-genetic factors in determining population survival. However, genetic properties of the target populations are important in developing management plans and, for the wild relatives of crops, an additional dimension which needs to be considered is the potential use of the species for crop improvement programmes. This may affect decisions not only on how much diversity it is desired to conserve but also on the nature of the diversity that should be included in any conservation programme and the use to be made of *ex situ* conservation.

While the analysis of population vulnerability and minimum viable population sizes will continue and provide new insights on population sizes for effective conservation, the desirable general objective of management plans are bound to involve securing the potential for continued evolution and adaptation of the species and ensuring that the variation which is potentially useful can be made available.

Threats to plant diversity

Given that only limited resources are available and that large numbers of species are involved, decisions to take positive conservation action in respect of particular species will need to be based on the perception that some kind of threat exists to particular populations of the species (or, indeed, to the whole species). However it should be noted that such threats can be very diverse and the effect that they have on the species of interest is almost equally variable (Falk 1992).

Major activities such as dam building or urban development can destroy whole habitats for species or populations and may be direct or insidious (e.g. development of holiday homes and hotels along the Mediterranean coastline). They may have other indirect effects for example by altering patterns of water availability or quality in nearby or more distant areas. As with more general environmental problems such as acid rain these developments may affect species and populations which are in some way already protected (e.g. in National Parks). Falk (1992) also notes the importance of biological factors as threats to rare and endangered species in the USA. These include competition by introduced exotic vegetation and predation by introduced animals (such as the coypu in Eastern England). Even where land is publicly owned, competing interests may threaten particular species as in the case of forestry areas subject to logging or even where different conservation interests compete.

Global warming may well have a significant impact on species distribution and on population survival. This is likely to be particularly so for species in more northem latitudes where the effects of global warming are expected to be greatest. It is also of particular significance for montane species. As temperatures rise such species may be isolated and unable to adapt to warmer climates or to re-establish themselves in alternative habitats.

The significance of a particular threat to a population of a species will depend not only on its nature but on the characteristics of the species itself. One important aspect of this is the biology of the species (see also below) which will determine its adaptiveness to different types of environmental change. Others are the size of the populations that exist of the species, their number and distribution. Small populations are vulnerable to stochastic effects which are essentially random and which can cause a drastic drop in plant numbers in a population from which it may not be able to recover. Rare species are particularly vulnerable to the four types of stochasticitics identified by Shaffer (1981) – genetic, demographic, environmental and catastrophic.

The analysis of threat and its significance in conservation planning is still at an early stage. However, it is clear that the nature of the threats to a species has a significant impact on the conservation strategy chosen and on the management plans for individual populations of the species. At its very simplest, total habitat destruction requires, at least temporally a significant measure of *ex situ* conservation. Other types of threat can probably be met effectively by *in situ* conservation actions involving some degree of management of the populations concerned in still other cases (such as global warming and montane species) an increased level of monitoring may be sufficient until it becomes clear whether the species is adapting to changed environmental conditions.

Species and population characteristics

Individual species characteristics (and specific features of individual populations of a species) are of key significance in developing management plans for conservation. Such characteristics include, not only species and population distribution and numbers, the significant biological features of the species and its ecology, but also interactions with other species in particular ecosystems. Many of these are discussed in other papers in this volume and here the emphasis will be on those identified as of importance at the species level.

The number, sizes and distribution of the various populations of a species are of first importance in the development of any conservation strategy. Many species are reduced to small populations by loss of habitat while others naturally grow as small populations and it is important to distinguish betyween the two. Mapping of distribution is a first requirement for developing conservation strategies and should include studies which assess the ecology vulnerability of the individual populations identified. Assessment of vulnerability is, at present, largely subjective and will involve the development of systems analysis approaches as described by Gilpin & Soulé (1986).

While population survival may depend very much on demographic and environmental factors, the extent and distribution of genetic diversity within individual populations of the target species is also of major importance for conservationists. Population genetic structure varies dramatically among plant species, both with respect to the kinds and amounts of diversity they contain – and in respect of the pattern of distribution of diversity within species (Brown & Schoen 1992). It follows that information on the distribution of diversity within a species is crucial to the development of an effective conservation strategy. Variation seems to be particularly unevenly distributed between populations of inbreeding and apomictic species (Schoen & Brown 1991). For these species, selection of the appropriate populations for conservation is likely to be particularly important.

An important aspect of discussions on the estimation of variation within plant populations has concerned the nature of the characters to be used for such studies. Although isozyme variation has provided many important data on so-called neutral variation, information on adaptive variation is also important and may reveal variation patterns not detected using isozymes. As technologies improve, molecular genetic data may become increasingly available and, already, such data have provided evidence on the importance of variation between populations as compared with that found within populations.

While there have been a number of studies which have provided clear evidence that genetic diversity is structured in space and time and that there may be significant adaptive differences between populations with respect to genetic variation, there have also been situations in which such differences were not detected even when they might have been expected (McNeilly, this volume). In some of these cases phenotypic plasticity appears to be of major significance and McNeilly noted the importance of such plasticity in adaptation by species to environmental heterogeneity – a feature that would have considerable conservation significance.

Over 30% of angiosperm species are of polyploid origin (Stebbins 1971). In comparison with diploids, polyploids can possess (and often do possess) significantly higher levels of diversity and may be less susceptible to problems following inbreeding, a characteristic which rnay affect decisions on population sizes in the development of conservation plans.

The reproductive biology of a species has both direct and indirect consequences for conservation management. Breeding system affects the distribution of genetic diversity in a species and the way in which a population may be managed whether *in situ* or *ex situ*. As noted above diversity is more unevenly distribute in self-pollinated species where the identification of 'hot spots' of variation may become highly significant. By comparison variation in out-pollinated species is much more evenly distributed and the specific characteristics of different populations may be relatively more important.

As well as affecting the choice of populations, breeding system can affect the maintenance of populations. Major problems may be encountered in maintaining very small populations of obligate outbreeders with a self-incompatibility system *in situ*. *Ex situ* collections also need to take account of breeding system when planning maintenance or regeneration of accessions. Where outbreeders are conserved there is also a need to take account of the pollinating mechanism involved especially when specific pollinating agents are essential for effective cross pollination.

Breeding system is only one relevant aspect of reproductive biology. Of equal importance in developing a conservation plan for a target species will be its fecundity, the mechanisms that exist for seed dispersal germination capacity and the importance of seed or seedling banks in the natural survival of a species. Species which do not normally produce seed or which produce recalcitrant seed, which cannot be stored, must be maintained *ex situ* in field gene banks or *in vitro*. The former requires considerable labour and land inputs while the latter may require research and development before appropriate tissue culture methods become available for the species in question.

Species longevity will also play a significant part in planning conservation activities. Substantial changes in the environment may have particularly deleterious effects for long-lived perennials and lead to situations in which recruitment of new individuals virtually ceases, giving the population an unbalanced age structure. Perennials with a long generation time can also present problems for those concerned with their *ex situ* conservation in terms of maintenance and regeneration.

To these specific features of individual species, those concemed with *in situ* conservation will need to add the characters of the particular ecosystems in which the species occurs. Species interactions, competitive ability and the general nature and status of the ecosystems will all be crucial in making decisions on how to ensure survival of the target taxa.

Many of the species with which we are concerned grow in successional/subseral habitats (e.g. grassland species) that have to be maintained in that state by specific intervention. There may be conflicts between the requirements of the target taxa and those of the habitat as a whole and species which occur in inaccessible habitats may be difficult to monitor even when management intervention is unnecessary.

Conservation options

The different ways in which conservation may be carried out for a species of interest constitute a further component of a conservation plan. These may be broadly classified as *in situ* or *ex situ* and, as noted above, the former has been described as the method of choice for the wild relatives of crop plants. However, *in situ* and *ex situ* conservation are not mutually exclusive alternatives. They may be used in ways that complement each other and maximize the effectiveness of the overall conservation plan for a species.

Much of the work undertaken to conserve *in situ* has been focussed on ecosystem conservation rather than being targeted on specific species and there is a need to integrate a species oriented approach into such work. The first need is to locate and monitor the target populations and quick, economic and reliable ways of obtaining the desired information need to be described and tested. In many cases this may be sufficient but there will be species for which more active management is required to ensure survival of the required populations. This may involve successional management, the introduction of practices such as occasional burning or avoidance of others such as dune stabilization which can affect survival of particular species. It may go further and require recruitment by plants or seed from the original population, or even by material from other unrelated populations. *In situ* conservation is not necessarily more economic or simpler than *ex situ* conservation. It is desirable for other reasons and, for wild relatives of crop plants, it is likely to be a more efficient way of conserving the variability of the genepool. However, it may well require considerable research, monitoring and management work to be fully effective.

While *in situ* conservation may be the most desirable option for many species, it will need to be supported by some measure of *ex situ* conservation for most species of concern. *Ex situ* conservation has been extensively practiced over the last 20-30 years for many crop species and a variety of methods and procedures have been developed to ensure that the diversity originally collected is maintained to the greatest extent possible. Where possible seed storage still remains the procedure of choice and can provide for extremely long term conservation (of the order of hundreds of years) of large amounts of material in a relatively cost effective manner. Field gene banks have to be used for asexually propagated material or species with recalcitrant seeds. However, field gene banks (including Botanic Gardens) involve considerable space and are associated with problems of loss through disease and many abiotic stresses. For this reason *in vitro* techniques involving tissue culture can offer a viable altemative in many cases and procedures have been developed for a number of crops and their wild relatives. Cryogenic methods will offer a significant methodological advance for *in vitro* conserved material since they would permit long-term conservation at reduced cost. Other *ex situ* alternatives (such as pollen or DNA storage) have yet to be fully developed but are likely to find specific roles in the development of an overall conservation strategy for a species.

Most of the work on *ex situ* conservation has involved crop species and may need adaptation for use with their wild relatives. They are, after all, wild species and often have quite different characteristics with respect to breeding system, seed production, seed longevity under storage and seed germination. Seed production is frequently much reduced by comparison with their crop relatives; it is produced over longer periods of time and released as soon as it is mature. *Ex situ* genebanks have found the maintenance and regeneration of such material difficult.

While technical factors will be important in determining what conservation system is to be developed for a species, they will not be the only factors involved. *In situ* conservation will depend upon the availability of the land on which the species occurs and will be subject to land ownership issues and land use considerations. Resources will need to be available for monitoring and management over long time periods. For *ex situ* conservation there must be centres prepared to make the commitment to maintain such material and to make it available and they must have the resources that enable them to do this effectively. In many cases this will depend very much on the political will to direct resources to the objectives of conservation.

Towards a useable strategy

The successful conservation of the wild relatives of European crops will depend on the integration of information on threats to the target taxa, their biological and demographic characteristics and the methods and resources available for their conservation. Although these are highly variable and each species will require individual consideration, it is possible to identify some general approaches that will permit effective initiatives for managing populations to be undertaken.

The need for information is a first requirement. Information on species characteristics, on demography, the distribution of genetic variation and on the many other aspects described above will be required and will need to be continuously extended and refined. The need forthis information does not preclude action from being taken whenever possible. In fact the development of specific initiatives can clarify the information needed and act as the necessary spur to its collection. The papers on the 9 chromosome *Brassica* complex and *Dactylis glomerata* have already shown how information that exists already can be used to develop an effective conservation strategy for a taxa or group of taxa (Gustafsson & Lannér-Herrera 1997, this volume; Lumaret 1997, this volume).

The development of complementary conservation strategies that take account of the different contribution that different conservation methods can make is a second requirement. *In situ* conservation of particular populations can be complemented by the use of different *ex situ* methods to provide an integrated approach. Such *ex situ* methods can include maintenance in field genebanks or as seed and may also include the use of tissue culture, pollen storage and even DNA storage. The precise mix of methods will depend on the species and its current conservation status and will take account of interests of different potential users of the conserved material.

By developing conservation plans for specific taxa the work necessary to define effective monitoring and management strategies çan be initiated. This is an area in which there is still very little information and where we will need to be prepared to continually review procedures on the basis of field experience. A guiding principle will be one of risk avoidance. The actions taken should be those that minimize the risk of loss of the population and its diversity. One approach to this has been developed by Gregorius (1990) and describes ways in which an adequate genetic load may be maintained through selction of populations from diverse environments. It may well be desirable to include expertise in risk assessment and on methods of minimizing risks in planning work on conservation.

Gilpin & Soulé (1986) advocate a systems approach to the management of conservation and this approach is likely to become increasingly relevant in conservation planning. It provides the necessary framework for integrating information from a wide variety of sources in the development of action plans. It also enables the consequences of different kinds of conservation to be considered and will enable integrated conservation strategies involving both *in situ* and *ex situ* elements to be developed. Again it is an action-oriented approach allowing population conservation plans to proceed while providing a way of modifying them to take account of the experience gained.

The approaches outlined above are likely to be most effective if tackled on a European level for a group of carefully selected high priority taxa. The taxa should be selected with due regard to their importance as wild relatives, their status and the degree of threat to which they are subjected. The availability of information that would enable effective decisions to be made may also be an important criterion, as might the extent to which conservation initiatives are already in progress. Depending on the distribution of the selected taxa and the interests of European conservationists, research workers and potential users, collaborative conservation projects could be developed. These might include the development of networks or links to existing networks to ensure that the potential for integrated multidisciplinary work is not lost. Such initiatives will provide evidence of successful conservation of important species, will demonstrate the effective use of *in situ* and *ex situ* conservation in a complementary manner and will provide planners with an increasing body of information on conservation needs for a wider range of species.

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