CAN FUTURE POPULATION TRENDS BE PREDICTED FROM CURRENT POPULATION BEHAVIOUR? EVIDENCE FROM A LONG-TERM STUDY ON A RARE ORCHID SPECIES.

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In holding this workshop on Non Detriment Findings it is implicit (i) that it is possible to make accurate predictions about the future behaviour of populations, (ii) that when populations are subject to exploitation, reliable judgements can be made about levels of harvesting that can be adopted that will not endanger their future survival. In this case study, I will challenge the safety of these assumptions, using data from a very long-term study on an orchid species that is not subject to exploitation. I will pose the question whether scientists, conservationists and managers yet have the data, and the practical and analytical techniques, to judge whether exploitation will be benign or risk the future of species that fall within the remit of the present working group. I will also ask whether the answer to this question for the Geophytes and Epiphytes working group is equally valid for species that fall under the remit of other working groups.

The study that will be used to illustrate this presentation is on an orchid species (*Ophrys sphegodes*, early spider orchid) that has suffered a dramatic range decline (about 80%) in the UK over the last fifty years. For species in the Geophytes and Epiphytes working group this project is possibly unprecedented in length – it has been conducted over 30 years (1975-2006) – and scale – the individual life histories of several thousand plants have been recorded through the accurate mapping of every emergent plant in every year of the study. In most years there have been several hundred emergent plants.

A key feature of the data is that rather than simple counts being made of the plants in the population, every plant that has emerged every year has been individually censused (i.e. its location has been recorded, and details of its performance have been collected in each year that it has appeared). Counts allow for little to be learnt apart from whether the emergent population increases, decreases or remains stable through time. Moreover, for orchids, and species in other families in which dormancy and post-germination subterranean phases can occur, counts can be of very doubtful value as a record of population size (although in the case of orchid species they are more likely to cause under- rather than overestimation of true population size). Although it is far more demanding to collect, both in terms of time and labour involved, information from censuses increases the analytical and predictive possibilities of the data several-fold. Among the information that can be extracted from censuses, and the uses to which census data can be put, are the following:

- Individual life histories can be analysed
- Life spans of individual organisms can be determined
- Age/state structures of populations can be determined and compared between years and localities
- Survivorship data and data about reproductive output can be amassed
- Information can be obtained about the spatial structure of the population, and about microsites in which recruitment of new individuals and mortality of established individuals is occurring
- Population flux, i.e. the number of births and deaths, and whether there has been a net increase or decrease in population size, can be determined from one year to the next, and over longer periods of time.
- The behaviour displayed by individual plants in different age and state classes from one year to the next can be determined. The probability of plants making transitions between states can be calculated from year to year.
- If data are collected from different populations, or from populations subjected to contrasting management regimes (including harvesting regimes) all of the above can be compared, allowing insight into conditions that afford the greatest chances of populations growing, persisting or declining to extinction
- Data on transitions between years can be used in transition matrix modelling to try to predict future population performance
- These data can also be used to carry out non-interventionist “thought-experiments” in which future population behaviour is modelled. This approach avoids the risks attached to conducting real experiments with different management or harvesting regimes, by undertaking modelling exercises to predict what could happen under different management regimes.

It is important to note the emphasis on collecting data through time. Static data (i.e. a snapshot of the condition of the population, collected at one point in time) may easily reflect the population in an uncharacteristic state, and will almost certainly fail to expose important facets of the population's structure or behaviour. For example, the size of a population may be large, suggesting a healthy condition, but if its age structure is dominated by old, senescent plants, that are likely to give rise to very few descendants, extinction of the population may be imminent. If its age structure is dominated by juvenile plants, this may suggest a greater chance of population persistence – but not if the juveniles are very susceptible to adverse weather conditions or to competition from larger plants, perhaps of different species. Data will be shown illustrating strong variation in population structure between years in the orchid population.

It has already been stressed that population counts scarcely illuminate the way in which population behaviour is changing through time. This will be demonstrated using data collected from years in which the orchid population was subject to different management regimes. Counts may not be capable of giving timely warnings of imminent population crashes or explosions, and provide no way of interpreting population responses to the imposition of different management regimes. Although such responses may be very swift, it may take years before their effects are visible in counts.

Population biologists have been making rapid advances in developing predictive methods for modelling population behaviour, especially involving different types of matrix modelling. A life history diagram for the orchid is shown in Fig. 1. This can be used for predicting future trends in the population, using matrix models, for which the probabilities of plants making transitions between different states are calculated. Several requirements must be satisfied, however, before models based on diagrams such as Fig. 1, and the transition probabilities calculated from population censuses, can be relied on for accuracy. The orchid study will be used to illustrate that awareness of these basic modelling requirements creates serious doubt that even the largest, longest census studies can reduce the predictive uncertainty inherent in these techniques to an acceptable level (see also Bierzychudek 1999). This creates significant risks in estimating NDFs, especially for populations with relatively small size, or for species that occur in few populations. Among the problems are the following:

- That many studies record the life histories of too few plants to provide reliable estimations of the probability of transitions between life states. This is especially true when the plants recorded must be

divided between several age or state classes in each year t of the study, and when the plants in each of these classes can make any one of several transitions in year t+1.
- That many studies are continued for too few years to sample the full range of year-to-year variability in environmental conditions that the species may experience, and the full range of behaviour that the study species may display
- That it is often forgotten that density-dependence is likely to influence important aspects of plant behaviour

Despite the large number of plants recorded in this study, a long, uninterrupted period of the same management regime, and no apparent change in the conditions or appearance at the study site, there have been substantial between-year variations in individual transition probabilities. This will be illustrated, together with strikingly unstable values for the mean probability of transitions between different state classes when the number of observations on plants in different life states is low.

Caution will be urged before sanctioning harvesting regimes to exploit populations that may be based on predictive models that themselves are founded on inadequate datasets, especially if populations are small or few in number. Two of the largest datasets available for plant projection matrix modelling (the *O. sphegodes* study that will be used as the case study here, and Bierzychudek 1999) suggest that forward projections of population behaviour based on transition matrices will rapidly lose any dependability they may initially have. The models are rarely to blame – although their output can be beguiling. Instead, the data on which the models are based is usually insufficient in scope and insufficiently reliable. For exploited populations there will be a need for initial caution and conservatism in setting harvesting targets, to avoid unsustainable use being permitted and populations being driven to extinction. Continual re-calibration of permissible harvesting regimes will also be essential as further data accumulates.

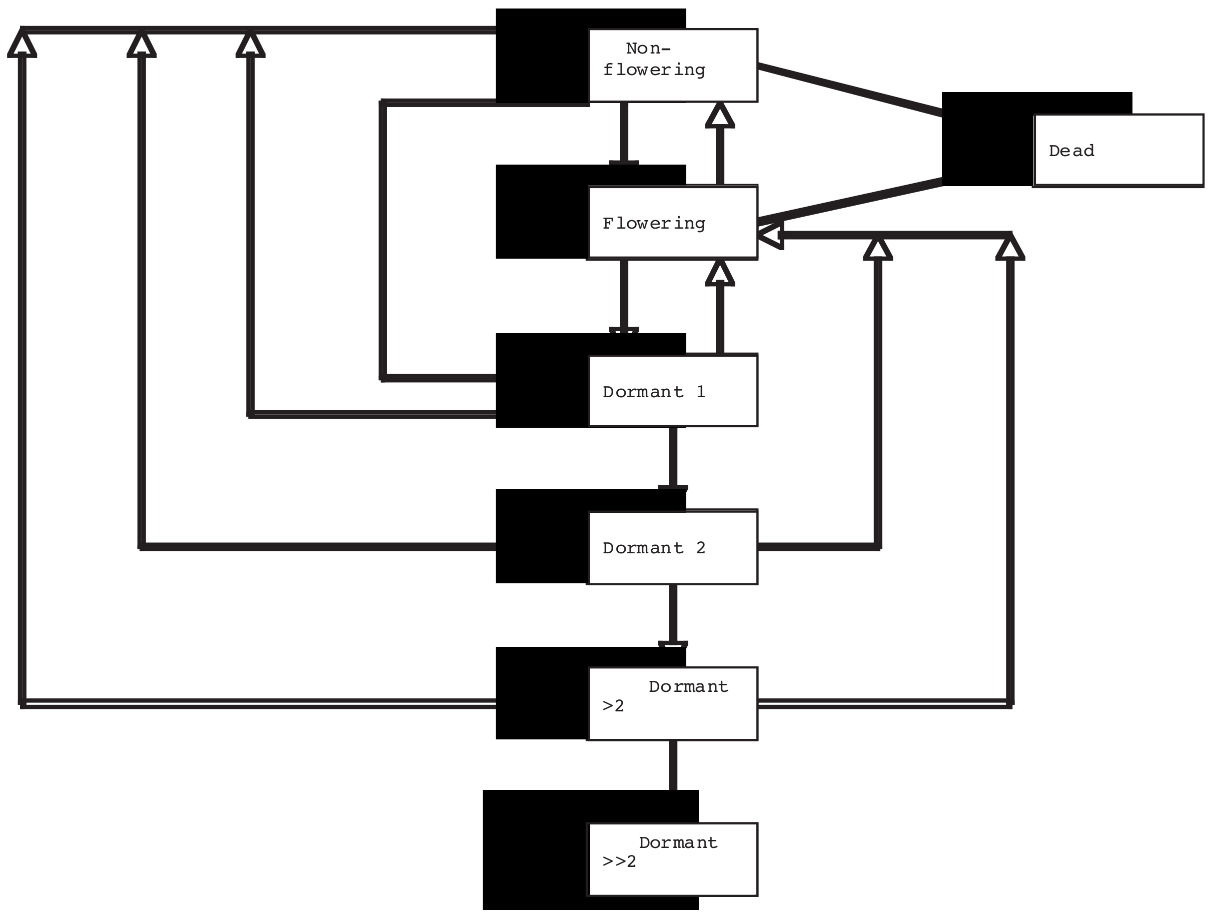

Fig. 1. Life history diagram for *Ophrys sphegodes*.