Assessing the threat of genetic erosion

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The causes of genetic erosion

Agenda 21 states that 'the current decline in biodiversity is largely the result of human activity and represents a serious threat to human development'. But exactly what kinds of human activity are to blame, and what are the other factors involved? Collectors need to answer such questions so that they can target for priority collecting regions and species that are particularly at risk.

Many attempts have been made to list the threats faced by plant diversity, both wild and cultivated. WRI *et al.* (1992a) provide a detailed analysis of the indirect or underlying causes of biodiversity loss. WCMC (1992) quotes the following factors as currently endangering biodiversity:

- habitat loss or modification, often associated with habitat fragmentation
- over-exploitation for commercial or subsistence reasons
- introduction of exotic species which may compete with, prey on or hybridize with native species
- disturbance and uprooting
- incidental take
- disease
- limited distribution.

Muchiru (1985) lists essentially the same agents – habitat loss, overexploitation, introduced species and indirect effects – but includes agricultural development as a separate factor. Of course, habitat loss or disturbance may in turn be due to a variety of causes, and agricultural development can take many forms. Such lists can therefore be made quite detailed. Gomez-Campo *et al.* (1992), for example, present a very

comprehensive checklist of specific factors potentially affecting the persistence and genetic diversity of individual populations of wild plants (Box 4.1). Dahl and Nabhan (1992) discuss the threats endangering the genetic diversity of cultivated plants, from global environmental change and international economic pressures to crop-specific problems. They provide a list of the threats perceived by grass-roots organizations, arranged in decreasing order of importance, and suggest that this 'can be used as an evaluation tool for any local community wishing to impede genetic erosion' (Box 4.2). Clearly, it can also be used to assess the danger of such erosion taking place.

Looking at the problem from the other side, Brush (1993) lists four factors which are important in preserving crop diversity, i.e. in limiting the rate of genetic erosion: (i) fragmentation of farm holdings, allowing farmers to maintain landraces in at least one field; (ii) increasing cultivation of marginal land, where landraces tend to have an advantage over modern varieties; (iii) economic isolation, creating market distortions which give landraces a competitive advantage; and (iv) cultural values and preferences for diversity. The contention is that in many cases adoption of modern varieties does not result in the complete replacement of landraces, but reaches an asymptote.

Box 4.1

- Drainage works that destroy humid habitats and lower the water-table in adjacent areas.
- Dam building and the resultant flooding.
- Clearing of land for agriculture.
- Change in agricultural techniques, particularly increasing use of chemicals and heavy machinery.
- Forestry plantation.
- Decrease in pollinator populations due to increasing insecticide use.
- Overgrazing by domestic livestock or wild herbivores.
- Scrub regeneration as a result of lessened grazing pressure on pasture.
- Increased or decreased frequency of forest fires.
- Water pollution.
- Air pollution.
- Contamination of the soil.
- Industrialization and urbanization.
- Tourism and touristic development.
- Road construction.
- Mining and quarrying.
- Intensification of traditional exploitation.
- Horticultural collecting.
- Competition with introduced plants.
- Genetic contamination by hybridization with other species.
- Introduced pests and diseases.
- Small population size.

Box 4.2

- Introduction of modern varieties and exotic crops.
- Loss of seed-saving and vegetative propagation skills.
- Acculturation of traditional caretakers (or their death).
- Change in economic base.
- Land conversion to industrial agriculture.
- Destruction (urbanization) of habitat and farmland.
- Herbicide and pesticide impact.
- Environmental contamination.
- Introduction of exotic pests.
- Loss of seeds to pests.
- Net reduction in the number of farmers.
- Inadvertent crossing of varieties.

One of the most comprehensive attempts to catalogue the threats to biodiversity is presented by UNEP (1993). Article 7 of the *Convention on Biological Diversity* enjoins countries to identify and monitor 'the components of biodiversity important for its conservation and sustainable use' and the processes and activities which threaten them. Country studies on biodiversity are being prepared by many countries to meet this objective. International coordination for their preparation is being provided by the United Nations Environment Programme (UNEP). UNEP (1993) presents a set of guidelines for country studies. It includes a section on defining the threats to biodiversity. Threats are classified into four main generic categories, as follows:

- external socioeconomic factors
- direct human threats: local impact
- direct human threats: regional/global impact
- natural hazards

Under each rubric are listed a number of specific factors, as well as the kinds of information that are required in order to be able to determine an appropriate response.

Measuring the risk of genetic erosion

Each factor on the kind of checklist discussed in the previous section could be scored as present or absent for any given area, wild population or local community, giving an assessment of overall risk of genetic erosion. At a more sophisticated level, each risk could be scored as to temporal and spatial remoteness from the site, area or population under consideration, duration, severity, reversibility, to what extent action has already been taken on the species in other areas, quality of information available, etc. (IBPGR, 1986; UNEP, 1993).

Goodrich (1987) takes such a quantitative approach in developing a model that can be used to estimate the threat of genetic erosion that a particular taxon (wild or cultivated) faces in a defined area. The model is based on scoring a variety of factors – biological, environmental and socioeconomic – and summing the factor scores to give a total which increases in magnitude with increasing threat of genetic erosion. It can be used to compare the threat of genetic erosion that a given taxon is facing in different equivalent areas, or the relative threat to different taxa in an area. Comparisons should be made using only those parameters for which data are available for all areas or taxa being compared. A somewhat modified version of the model is presented at the end of this chapter in Appendix 4.1.

For this and similar models to be used, a substantial amount of information will need to be gathered. Sources will include agriculture, forestry and environment departments and ministries, the local representatives of bilateral and multilateral development agencies, national and international conservation bodies, seed companies, etc. Some information will be available in formal published form. For example, there is a catalogue of seed production projects in the African, Caribbean and Pacific (ACP) countries (Delhove, 1992). Many countries have carried out environmental assessments of various kinds, and the International Environmental and Natural Resource Assessment Information Service (INTERAISE), established in 1991, has published a useful annotated bibliography of such environmental country profiles in the *1993 Directory of Country Environmental Studies* (WRI *et al.*, 1992b). Some sources of relevant information on environmental change are discussed in Chapter 9. Sources of information on conservation activities are discussed in Chapter 10. The international agricultural research centres (IARCs) will also have relevant data, for example on the release and spread of modern crop varieties (e.g. Dalrymple, 1986a, b).

Data from formal sources such as national agricultural surveys and impact assessment studies are only part of the picture, however, and the role of grass-roots organizations such as local non-governmental organizations (NGOs) is particularly important in this context (e.g. Dahl and Nabhan, 1992). As Muchiru (1985) points out, 'NGOs are composed of a wide network of people ... [and] ... are therefore well placed to monitor development projects that may have negative impact on the environment.' Some data will have to be collected first-hand in the field, through interviews with farmers and direct observation, either during the course of collecting or in preliminary surveys. Repeat collecting visits to given areas some years apart are invaluable sources of information on genetic erosion (Chapter 39).

The erosion of biodiversity: global monitoring systems

The data on specific areas, populations and species coming out of the kinds of studies outlined above can be integrated at the national level to estimate the danger to a country's biodiversity as a whole. UNEP (1993) presents a very comprehensive list of key parameters for monitoring biodiversity at the country level. It also suggests, however, that a useful alternative is to monitor a much more restricted number of parameters, a so-called minimum set of indicators of change. It goes on to support the recommendation of the *Global Biodiversity Strategy* (WRI *et al.*, 1992a) that an early-warning network of national centres be set up to monitor potential threats to biodiversity, including crop and livestock diversity, listing the parameters that such a network would need to monitor. The Food and Agriculture Organization (FAO) Commission on Plant Genetic Resources has similarly suggested that an early-warning system be set up for plant genetic resources, to identify gaps and emergency situations.

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Appendix 4.1
A model for quantifying the threat of genetic erosion

FACTOR	SCORE
1. General	
1.1 Taxon distribution	
• Rare	10
• Locally common	5
• Widespread or abundant	0
1.2 Drought	
• Known to have occurred in two or more consecutive years	10
• Occurring on average one or more times every ten years, but not in consecutive years	5
• Occurring less than once every ten years on average	0
1.3 Flooding	
• Area known to be very flood prone	10
• Area not known to be flood prone	0
1.4 Accidental fires	
• Area known to be very prone to fires	10
• Area not known to be prone to fires	0
1.5 Potential risk from global warming	
• Summit areas or low-lying coastal areas	0
2. Crop species	
2.1 Area under the crop	
• Declining rapidly	10
• Increasing or static	0
2.2 Modern cultivars of the crop	
• Available and used by >70% of farmers	15
• Available and used by 50–70% of farmers	10
• Available and used by <50% of farmers	5
• Not yet available, but introduction planned	2
• Not available	0
2.3 Performance of agricultural services	
• Very strong, and biased towards modern varieties	10
• No agricultural services	0
2.4 Mechanization	
• Tractors used by >30% of farmers	10
• Animal traction used by >50% of farmers	5
• Manual labour used by >50% of farmers	0

2.5 Herbicide and fertilizer use
- >50% of farmers 10
- 25% of farmers 5
- None 0

2.6 Farming population
- Declining rapidly 10
- Increasing or static 0

3. Wild species

3.1 Extent of wild habitat of target species within study area
- Very restricted (<5%) 15
- Restricted (5–15%) 10
- 15–50% 5
- Extensive (>50%) 0

3.2 Conservation status of target species
- Species not known to occur in any protected area 10
- Species known to occur within a protected area, but protection status poor or unknown 5
- Species known to occur within a protected area, and protection status good 0

3.3 Extent of use of wild habitat of target species
- Industrial exploitation 15
- Exploitation by surrounding populations (e.g. fuelwood gathering from nearby towns) 10
- Hunting and gathering by small local communities 2
- Completely protected 0

3.4 Extent of use of target species
- Industrial exploitation 15
- Exploitation by surrounding populations 10
- Local exploitation 5
- Protected or not used 0

3.5 Agricultural pressure on wild habitat
- Large-scale cultivation within habitat margins 15
- Subsistence cultivation areas within habitat margins 12
- Land suitable for cultivation, cultivated areas within 3 km of habitat margins 10
- Land suitable for cultivation, cultivated areas within 3–10 km of habitat margins 5
- Land unsuitable for cultivation 0

3.6 Human population growth rate per year
- >3% 10
- 1–3% 5
- <1% 0

3.7 Availability of agricultural land
- >70 ha km^{-2} cultivated 10
- 30–70 ha km^{-2} cultivated 5
- <30 ha km^{-2} cultivated 0

3.8 Species palatability
- High 10
- Medium 5
- Low 0

3.9 Ratio of present livestock density to estimated carrying capacity
- >1.0 10
- 0.5–1.0 5
- <0.5 0

3.10 Average proximity to borehole or other all-year round water supply
- <10 km 10
- 10–20 km 5
- >20 km 0

3.11 Distance to major population centre
- <20 km 10
- 20–50 km 5
- >50 km 0

3.12 Distance to major road
- <10 km 10
- 10–30 km 5
- >30 km 0

3.13 Distance to development projects (irrigation scheme, tourism complex, mining site, hydroelectric power scheme, land reclamation scheme)
- <20 km 10
- 20–50 km 5
- >50 km 0