Gathering and recording data in the field

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Introduction

The successful use of genetic resources conserved *ex situ* depends to a large extent on the availability and quality of data – both conventional 'scientific' data and indigenous knowledge – on the sample and on the physical, biotic and human environment at the collecting site recorded by the collector in the field. It is at least partly on the basis of such data that samples in different collections can be recognized as duplicates, that appropriate conditions for regeneration, characterization and evaluation can be identified, that material now extinct in the field can be reintroduced to the area where it was originally collected, and that users of conserved germplasm are able to make an initial decision regarding the suitability of the material for inclusion in breeding, introduction or screening programmes. These so-called passport data are also important in studying the phenology of material and the distribution of variation with respect to ecological and socioeconomic factors, which will help in the planning of future collecting. In addition, it will be useful in making an assessment of the threat of genetic erosion.

Germplasm lacking passport data is still usable, of course, but much less valuable to the user than material that is better documented. This is because resources will need to be directed to identifying its general adaptation, for example, which could be spent on detailed evaluation if something of the origin of the material were already known. The more data a germplasm sample has associated with it, the more valuable it is to users. However, there is often a trade-off between collecting germplasm and collecting data. Time in the field is usually limited, and collecting more data may therefore mean collecting less germplasm, either fewer or smaller samples. Typically, in most wild species collecting, putting together a germplasm sample of reasonable size is more time-consuming than filling in a collecting form. Especially if more than one species is being collected at the site, time spent at the site will most certainly not be limited by form-filling. This will emphatically not be the case with crops: documenting indigenous knowledge (i.e. identifying, locating and consulting donor/informants), an essential part of crop collecting, may take considerable time (Chapter 18).

A balance will therefore need to be struck between exhaustively documenting a population and site and moving on to the next. Deciding on this is up to the collector, and will depend to some extent on the immediate purposes of the collecting. For example, an initial survey of a previously unexplored area may tend to concentrate more on data gathering. Emergency rescue collecting may leave little time for anything but the most basic documentation. Whatever the reasons for collecting may be, however, it should be remembered that the collector is also working for unknown potential end-users with unknown requirements in a possibly remote future, when the environments and cultures from which the material was collected and which helped to shape it may no longer exist, along with the germplasm. Though there will always be complaints of too few data (or the wrong data!) having been collected in the field, no user of conserved germplasm has ever accused a collector of recording too much data.

Passport descriptor lists

Many organizations which carry out germplasm collecting have developed and use their own individual, more or less specialized, collecting forms. This has led to difficulties in data exchange and to some mutual incomprehension. To promote standardization, the International Plant Genetic Resources Institute (IPGRI), in cooperation with crop experts, produces crop-specific (sometimes gene-pool-specific) descriptor lists covering passport data as well as characterization, preliminary evaluation and, in some cases, further evaluation data. A full catalogue of such lists is given in Chapter 8. IPGRI has also produced a basic generalized list of collecting data, arranged in a collecting form, and supporting database software, the Collecting Form Management System (Chapter 28). The descriptors and their codings in these lists should not be regarded as definitive, but they do provide a format for data exchange that is internationally understood. Data need not actually be recorded in the field according to these lists, but they may then have to be converted to fit the recommended format for exchange purposes.

Despite the multiplicity of collecting data lists and forms, there are a number of basic passport descriptors which are generally regarded as essential, the absolute bare minimum. The descriptors that must appear on any collecting form and that must be filled in are listed in Box 19.1.

Media for data recording

The descriptors for which data are to be recorded in the field are normally laid out on paper forms, which should be as easy as possible

Box 19.1
List of essential collecting data descriptors

Sample labelling
- Expedition identifier (or collecting organization).
- Name(s) of collector(s).
- Collecting number (or collector's number).
- Collecting date.
- Type of material.

Sample identification
- Genus, species, subspecies, botanical variety.
- Vernacular name (and language).
- Herbarium voucher number.
- Identification numbers of other associated specimens.
- Status of sample.

Sampling information
- Number of plants sampled.
- Sampling method.
- Collecting source.

Collecting site localization
- Country.
- Primary administrative unit.
- Precise locality.
- Latitude of collecting site.
- Longitude of collecting site.
- Altitude of collecting site.

to fill in, update and correct. They should be preprinted and designed to fit on a single sheet of paper (front and back, if necessary), with clear captions and enough space for text. Using more than one sheet for a single sample may result in data becoming separated and lost. *It is best to have one data sheet per germplasm sample.*

Some organizations bind their collecting sheets in a book, which means that sheets cannot go astray. Others use loose sheets. One way of handling these in the field is to keep them in a hard-backed double folder which has a clipboard on one side, where all the unused sheets can be kept, and a pocket on the other side for keeping the completed forms. Another way is to file them in a ring-binder.

Alternatives to filling in paper forms include using dictaphones or tape recorders, data loggers and small portable computers (laptops and notebooks). All have the problem that power is needed to run them. Dictaphones are very convenient in the field but a fully written-out list of descriptors will in any case be necessary to make sure that none is overlooked, and transcription of spoken notes can be difficult and time-consuming. Despite these technical problems, tape recorders may be extremely useful in some situations, for example when documenting indigenous knowledge in consultations with local users. As data will eventually have to be entered into some sort of computer database if any serious organization, analysis and searching is to be done, data loggers and computers would seem to be ideal options, especially when data are numerous. However, these also have their problems. Data loggers are entirely solid-state and thus sturdy, but many have no capability for the inputting of free text. Computers are more flexible in this respect, but also more vulnerable, although they are now becoming available with solid-state storage, increasing reliability in field conditions. Data loggers and computers are of course expensive relative to paper, and taking them across some international borders may be difficult. Whatever system is used for data recording, it is a good idea to keep a paper backup.

It is useful to keep a field notebook in addition to the collecting forms, in the form of a daily log or diary. Along with an account of the day's happenings, including general observations and sketch maps of the region through which one is travelling, some basic information can be recorded on each collecting site, in particular how it was reached. A list of the collecting numbers of all the samples collected at each site should be kept, along with taxonomic identification, local name and any unusual or interesting features of the sample. At the end of every day, this information should be checked against the date, site number, collecting number, etc. recorded on each collecting form filled in during the day. Numbering mistakes are best corrected as soon as possible. Further information which it may be useful to record in the field notebook is pointed out in the discussion of individual passport data descriptors. Bernard (1988) suggests that each day in the field can be represented by two facing pages in the log, with the page on the left showing what was planned for the day and the page on the right what actually happened.

A field notebook is a quick, easy reference to what was collected, when and where. It will be far easier to refer to in the field than a large pile of collecting sheets and is a useful backup in case collecting forms go astray. Field notebooks should be small (but not too small: A5 size is ideal) and hardbound, and should always be kept in the collecting bag, perhaps wrapped in clear plastic. The paper of the field notebook and the collecting forms should be acid-free, long-lasting and marked in permanent ink. Notes should be written in pencil or indelible pen. All writing should be clearly legible.

Collecting passport data

In order to ensure the continuing usefulness of a germplasm sample, more descriptors than just the minimal set listed in Box 19.1 will be required, covering a wide range of factors relating both to the collecting site and its surroundings and to the population from which the sample was taken. The essential descriptors and some of these additional ones are described in detail in this section, along with their importance to both user and collector. Recommendations on the most efficient ways of obtaining the required data are also made. More general guidelines on documenting indigenous knowledge are given separately in Chapter 18, though details of some relevant participatory methods are presented here. The aim in deciding which descriptors to include here has been to develop a list with general applicability. Some species may require specific descriptors in addition to the ones presented here, or very particular descriptor states. This may be ascertained by consulting more specialized descriptor lists.

Certain basic principles underlie the design of lists of descriptors to be recorded in the field. Such lists should be kept as simple as possible, but not to the point where flexibility is lost and the inclusion of important additional data made difficult by the rigidity of the format. Multiple choice and binary descriptors are preferable to ones requiring text to be written out, though there should always be room for comments, and in some cases free text is necessary, for example in the case of ethnobotanical observations. In multiple choice descriptors, it is better for states to be mutually exclusive, but, if they are not, it should be possible to record more than one choice. An option (perhaps labelled 'Other') which allows space for free text is often useful, included within the relevant data field rather than left until the end of the form. Some collecting forms list all the states of each descriptor, and the collector ticks or circles one or more as appropriate. To save space, other collecting forms simply have the descriptor name followed by a blank space, and the collector fills in the appropriate choice for each descriptor by consulting a separate master form on which all states allowed are fully spelled out.

The descriptors have been grouped below into convenient classes for ease of discussion, arranged in logical order, though the order in which descriptors are laid out on the collecting form within each class need not rigidly follow the sequence adopted here. Descriptors marked with a '►' are on the list of essential descriptors in Box 19.1. The classes are:

1. Sample labelling.
2. Sample identification.
3. Sampling information.
4. Collecting site localization.
5. Collecting site context and description.
   (a) Physiography.
   (b) Soil.
   (c) Biotic factors.
   (d) Other.
6. Population information.

The definitions of sample, site and population are given in Chapter 3. The descriptors in classes 1–5 are common to both wild and cultivated material, though some biotic site descriptors, in 5c, are perhaps of more relevance in one case than in the other. Many of the descriptors in 6, however, are specific to either wild species or crops. *It is common practice to have separate collecting forms for wild and cultivated material.*

Note that the descriptors in classes 1–3 and 6 are sample-specific and need to be filled in for each sample, whereas descriptors in classes 4 and 5 are site-specific and will have the same value for all samples collected at a given site. *It is a good idea to arrange sample-specific and site-specific descriptors in separate sections on the collecting form, for example on the two sides of a sheet.*

Data should be recorded immediately, at the collecting site, pooling information from all the collectors involved. Leaving the filling of collecting forms until 'later', whenever that might be, usually results in forgotten detail and missing data. Collecting trips can be unpredictable, and there may not be a chance to catch up on missed notes for many days. A few descriptors, however, can be left until the end of the day or the end of the mission, for example latitude and longitude and other data which can be read off a map on which the location of the site was marked in the field. Descriptors such as these, which can and will eventually be filled in, must be distinguished from descriptors for which data were not collected in the field, for whatever reason, and which it will not be possible to fill in later. The best way is to tick off or otherwise flag descriptors as they are being completed in the field, to make sure that a blank means that data are genuinely not available and not that the descriptor was overlooked. When an interdisciplinary team is collecting, it will often be a good idea to hold meetings at the end of each day to summarize and discuss each other's data.

Recording information supplied by farmers and other local people needs to be approached with tact. In some situations, it may be best to start taking down notes or filling in forms immediately after a meeting, or some way into it, when confidence has been established, rather than right from the beginning (a suitable methodology is described in Chapter 18). Still and video cameras and audio recorders can greatly facilitate the collecting of some kinds of ethnobotanical data, but permission should always be asked before these are used. A demonstration may also be useful. There may be difficulties about taking photographs and making video recordings of people and their activities in some cultures. There may also be legal restrictions on the subsequent use of such material. Curtin (1968) provides some useful practical guidelines on the use of tape recorders for collecting oral data in the field, and then archiving and analysing them. Collier and Collier (1986) review the use of photography as a research method in anthropology. FAO (1991) gives technical guidelines on the use of video in the field.

A list of the basic equipment that will be necessary for data recording (using paper collecting forms) is given in Box 19.2. Some have already been mentioned; the rest are described and discussed more fully below under the appropriate headings, along with some additional pieces of equipment which may be desirable but not essential.

Box 19.2
Basic equipment for data gathering and recording

- Collecting forms.
- Field notebook.
- Pencils, pens, markers.
- Maps.
- Checklists and identification aids.
- Binoculars.
- Hand lens.
- Altimeter.
- Compass.
- Clinorule or clinometer.
- Tape-measure.
- pH kit.
- Colour chart.
- Single lens reflex (SLR) camera, tripod, flash and film.

Sample labelling

► *Expedition identifier (or collecting organization)*

Collecting expeditions normally have a name and/or code decided on in advance. This makes keeping track of samples much easier. The name or code can be stamped or printed on the collecting forms before departure, and will include a reference to the organization(s) involved in the mission, as well as the country in which the collecting is taking place.

► *Name(s) of collector(s)*

This is a very important field, which together with the collecting number gives a unique identity to each sample. The collector's name and the collecting number should stay with the sample and any subsamples wherever they go. Although new accession numbers may be issued on entering successive gene banks, they will always be cross-referenced to the original collector's name and collecting number, and it is this which will remain the unique identifier essential for tracing duplicates held in different collections around the world. There will frequently be more than one collector, in which case the surnames of each should be used, or a general team designation (e.g. the expedition identifier). Half a line of space is usually adequate for this field, or the collectors' names can be printed on the forms before departure if the composition of the team is unlikely to change during the course of the mission.

► *Collecting number (or collector's number)*

As detailed above, this descriptor, together with the collector's name, forms the sample's unique identifier. Collectors sometimes start a new number series for each different collecting mission, prefixed by different codes for new countries, areas, sites or even species. These codes may sometimes be dropped or lost at a later stage, leaving several identical number series. Since in practice it often happens that the collecting number is the only piece of information accompanying a sample as it moves between institutes (at least initially), this numbering practice may result in serious confusion and hence effective loss of samples.

A better, more reliable, numbering procedure is for the collector to give the number 1 to the first sample collected on his or her first collecting mission, and to continue numbering samples from mission to mission in a consecutive sequence which, although it may be broken, is never repeated. When a new trip is begun, the sequence commences with the number following the last collecting number of the last mission. If the last number has been forgotten, then a margin of safety should be left to avoid unintentional duplication, and the series commenced at the next hundred, for instance. Gaps of this nature in a collector's series are of no consequence, but duplications cause serious complications.

If it has been decided to collect both seeds and vegetative material of a vegetatively propagated species, numbering of samples should be according to the following guidelines (Hawkes, 1980): give the same collecting number if seeds are taken from the same plant from which a vegetative sample has also been taken; give a separate collecting number if seeds are taken from more than one morphotype and bulked. In the former case, an alternative is to give separate numbers, but cross-reference the two samples. Random and selective samples from the same population should be given separate collecting numbers. Again, it will be useful to cross-reference 'related' samples. This can be done in a separate descriptor, which could be labelled 'Other samples collected from the same population'. The different components of stratified random sampling procedures (i.e. samples from different microsites) should also be given separate collecting numbers.

Any other material that is collected as an adjunct to a germplasm sample, for instance pest specimens (Chapter 17), *Rhizobium* samples (Chapter 26) or herbarium specimens (Chapter 27), is best given the same number as the germplasm. Trying to reconcile several different numbering series for different types of specimens is time-consuming, tedious and frequently problematic.

If several collectors are involved in a single mission, each with their own interests and numbering system, it should be agreed in advance whose system will be followed. Separate numbering systems for the different members of a team should be avoided. An alternative is to use the expedition identifier or a similar general team designation instead of individually listing the names of all team members.

The collecting number should be written in indelible ink on whatever container is being used to hold each sample, e.g. cotton or paper bags, glass vial etc. It should also be written in pencil on a paper or plastic tag and placed inside the container. Cuttings, tubers and other vegetative samples can be labelled with tie-on plastic tags. Labelling should be done immediately.

► *Collecting date*

Recording the date on which a sample was collected is useful to the collector in keeping track of his or her activities. It allows the receiving gene bank to calculate the time that has elapsed between collecting and registration and hence estimate what deterioration there may have been in the quality of the material. Also, if the sample was collected very early or very late in the season, it may indicate unusual or biased genetic make-up. If it was collected in a year of unusual environmental conditions such as drought or flood, the population may have become biased in the direction of individuals possessing particular tolerances or traits of interest. Date of collecting can also help in deciding the timing of future collecting of the same species and in monitoring genetic changes in populations. It should be recorded in full using the format day/month/year (the format should always be specified).

► *Type of material*

This descriptor is important because the type of material collected will determine where a sample is to be sent and how it will be treated on arrival. Also, more than one type of material may be collected for a given population, and in some cases the same number may be given. An example of this might be collecting both seeds and tubers from the same plants in a wild population. It will be important in subsequent work to know what form the original sample took. Germplasm may be sampled as:

☐ seed
☐ vegetative material (e.g. herbaceous cuttings, budwood cuttings, storage roots, tubers, seedlings, etc.)
☐ *in vitro* material
☐ pollen

Sample identification

► *Genus, species, subspecies, botanical variety*

This information is usually best accommodated in separate data fields, each with a line of space, which allows for a provisional identification in the field and subsequent changes or confirmation. Before setting out, annotated checklists (of species and/or landraces, either already published or compiled by the collector during planning), relevant Flora accounts, botanical drawings and photographs of plants, botanical keys to the target taxa and other identification aids will have been gathered together to take on the expedition (Chapters 10 and 11). Hand lenses (×10 and ×20) are often necessary for the field determination of material. However, collectors may not have the time to fully verify all scientific names in the field, particularly on multi-species collecting missions. Indeed, in some cases a field determination may not be possible, for example if microscopic examination is necessary. A provisional name should then be entered on the collecting form (e.g. *Acacia* cf. *sarcophylla*), or different taxa may simply be given arbitrary labels (e.g. A, B and C, or *Vigna* X, Y and Z), so that the collector can at least keep track of how many samples of each taxon, whether actually named or not, have been collected. This can be done in the collecting notebook, where a checklist of species collected can be kept. Alternatively, a previously prepared checklist can be annotated with collecting numbers.

If there is any doubt about identifications, this should be noted, perhaps in a separate yes/no field indicating whether confirmation is required. It is the responsibility of the collector to ensure that all germplasm samples eventually have confirmed names, hence the need for herbarium voucher specimens. Seed samples suspected to be mixtures of species should be labelled as such on the collecting form. It may be possible to sort out the components back at base.

► *Vernacular name (with name of language and dialect)*

The importance of local names to collectors and users of germplasm is discussed in Chapter 12, along with some of the problems associated with collecting and using them. As with all ethnobotanical data, the source of a local name needs to be recorded, though this perhaps belongs more in the field notebook than on the collecting form. A translation of the name should be provided on the form, however, if the word or phrase has a meaning. A recognized standard system should be adopted for rendering local sounds, and words should also be written out in the local script, if one exists. A standard system of transliteration will usually be set out in dictionaries and, if such works exist for the languages likely to be encountered during collecting, it will be worthwhile taking them along. Much confusion has been caused in the past by different people rendering the same local word in different ways. If no recognized system exists, phonetic renderings and transliterations should at least be internally consistent. The language and dialect (and/or name of the ethnic group) should always be specified in a separate field. The degree of corroboration should be noted, perhaps in the field notebook. It should be made clear to which level of the taxonomic hierarchy the local name refers. In particular, when collecting cultivated material, both the local name for the crop and that of the landrace should be recorded. A line or so of free text will be necessary.

A running list of the local names collected can be kept in an alphabetically indexed notebook. This can be annotated with morphological information and observations on genetic erosion, for example. An initial checklist may be derived from research at the planning stage, and this can be added to as the collecting proceeds.

► *Herbarium voucher number*

Though it is recommended that herbarium vouchers be collected for all germplasm of wild species, this is essential if there is any doubt over determinations (Chapter 27). Accessions which cannot be named for lack of a herbarium voucher will tend to remain unused longer than material for which a confirmed name is available. The herbarium voucher for a particular germplasm sample should bear the same number as the germplasm, but whether this is the case or not the voucher number should be written on the collecting form, along with the destinations of all duplicates of each specimen. This last piece of information could be added at the end of the mission.

► *Identification numbers of other associated specimens*

Pest specimens and *Rhizobium* samples are also occasional adjuncts to germplasm samples. The number identifying the material, which again should be the same as the collecting number for the germplasm, and the destination of the material need to be recorded on the collecting form in the same way as for herbarium vouchers. Half a line of free text is usually adequate for each kind of associated material.

Photograph number(s) and subject(s)

Note should be taken in the field notebook of all photographs taken (whether of people, landscapes, collecting sites, plants, etc.), giving the roll number (all film cartridges should be labelled), frame number, subject and location (site number). The identifying numbers (roll and frame) of all photographs relevant to the site or the material collected should then be recorded on the collecting form.

► *Status of sample*

This descriptor refers to whether the plant population sampled is wild, weedy or cultivated. It is usually broken down into the following choices, though in most cases only the first three will be relevant:

- ☐ wild
- ☐ weedy
- ☐ landrace
- ☐ obsolete improved variety
- ☐ advanced improved variety
- ☐ breeding/research material
- ☐ interspecific derivative
- ☐ other

'Weedy' species in this context are those species related to crops but not actually cultivated themselves, which require the disturbance often caused by human activity for establishment and reproduction and which are therefore found on the edges of cultivation, often in close proximity to their cultivated relatives. A 'landrace' may be defined as a set of populations or clones of a crop species originally developed by farmers, maintained by them over a long period and recognized by them as belonging to a single entity. The term is used here as synonymous with 'traditional variety' (the terms 'primitive variety' and 'farmer's variety' are also occasionally used). 'Improved varieties', in contrast, are the products of scientific plant breeding, though of course this is not to imply that landraces have not also been 'improved' by farmers. Crop collectors will almost exclusively be interested in landraces and wild relatives, but will occasionally also collect older improved varieties ('obsolete') if these have been grown in the area for a considerable period and farmers have been maintaining seeds from year to year, rather than obtaining new stocks regularly from private or public seed suppliers.

'Other' could include recent farmers' selections and crosses, off-types, material descendent from the small seed samples brought back by travellers, grain saved from food aid etc. Details can be recorded under 'History of sample and landrace' (see below). Information on the status of crop samples will normally come from discussions with farmers.

Sampling information

► *Size estimates of population and of sample*

It is important for users to know the approximate size of the sample in relation to the size of the original source population (measured in numbers of individuals). If, for instance, the population was large but only a very small sample was taken, then the implication is that there may be more genetic diversity available in the population than is present in the sample. If the original population consisted of only a few plants, all of which were sampled, then the population will probably not be worth re-collecting in the hope of finding new genetic diversity, but the information will clearly be important in assessing the danger of the plant disappearing at the site. The size of the sample is also important to gene-bank curators. Some collectors, particularly foresters, record the total number of seeds collected and/or the weight of their seed samples in the field. Though this is not usually necessary, it can be useful to flag in some way small samples that will require multiplication prior to entering a gene bank.

In some cases, it may be useful to also indicate the proportion of the population sampled in area terms. Such estimates may be given in square metres or hectares. Though they are often necessarily very approximate, they can give the user an indication that there may be more diversity available, for example if only a small area of an extensive population was sampled. An effective method of calculating the area of an irregularly shaped field is to divide it notionally into squares and right triangles.

These descriptors could be set out as follows, and either completed with exact numbers or with a choice from among those set out below:

Number of plants in population is ______, covering ____ m^2
Number of plants sampled is ______, covering ____ m^2

Area	*Number*
☐ <1 m^2	☐ 1 plant
☐ 1–10 m^2	☐ 2–10 plants
☐ 10–100 m^2	☐ 11–100 plants
☐ 100 m^2–0.1 ha	☐ 100–1000 plants
☐ 0.1–1 ha	☐ 1000–10,000 plants
☐ 1–10 ha	☐ >10,000 plants
☐ 10–100 ha	
☐ >100 ha	

Estimating the number of plants in a population and the area it covers is relatively easy when the unit of collecting is a well-defined agricultural field, with plant density fairly uniform and individual plants clearly visible. It is straightforward in these situations to count plants in a number of small areas of known size within the field (located at random or along a transect, for example) and extrapolate up to the number of plants in the whole field.

For many wild species, this procedure will be neither so easy to apply nor so accurate, because populations may cover large areas that are not clearly delineated, density may be very low, individuals may be difficult to define and plants may not be particularly obvious. There are various plotless methods of density estimation that may be useful in these cases. The closest-individual method is probably the easiest to use. Sampling points are chosen at random and the distance to the nearest individual of the target species recorded. If the mean of these distances is d, $4d^2$ is the mean area occupied by each individual, and its reciprocal will be the density. Cottam and Curtis (1956) describe more complicated plotless methods. Techniques particularly suitable for forestry species are discussed by Freese (1962).

If estimating total population is problematic, one option is to simply record the number of plants sampled as a proportion of the number encountered in searching a given area. In the case of plants that reproduce solely by vegetative means, there is no easily definable population structure to sample. Only the number of clones sampled, which could be just one, need be recorded. Population size estimates are not applicable if the source of the sample was a farmer's store or market. This is another reason why recording the source of a sample is important.

For perennial wild species (and some perennial crops) it is useful and instructive to note not only the size of the population, but also its age structure, for example in terms of the proportion of the population in different size classes. In forestry, diameter at breast height (DBH) is often used to define size classes. In particular, knowing whether recruitment to a population is taking place will affect any assessment of the threat of genetic erosion. This will be impossible to ascertain during a single visit, but the presence of seedlings may give a clue.

Frequency of populations in the area

The frequency of populations of the target taxon (wild species, crop and/or landrace) in the area around the collecting site, together with estimates of the size of these populations, can be used to assess the threat of genetic erosion. It is also useful to know what proportion of populations found have actually been sampled. It will obviously make a difference to the amount of genetic diversity recovered whether the population sampled was the only one found in an area or, in contrast, whether it was only one of several, chosen at random or for a particular reason.

The frequency of a taxon in an area can be recorded in a number of ways. The simplest is perhaps to use an arbitrary scale of 1–5 (sporadic to common, say) to record the relative number of sightings of the species: (i) during a given period of travelling through the area (for crops); or (ii) as a proportion of the number of stops made to look for it (for wild species). Local people can also be asked about the rarity or otherwise of plants, and about any changes in the frequency of occurrence of landraces, crops and wild species (see 'History of sample and landrace').

There are more complicated schemes. Rabinowitz (1981) discusses an eight-category system based on geographic distribution, habitat specificity and local population size which can be used to compare species. The World Conservation Union (IUCN) has a system of categories of species conservation status (extinct, critical, endangered, vulnerable, susceptible, etc.), which, though aimed at comparing species globally, could also be used for a given species in different areas

(Mace *et al.*, 1992; IUCN, 1994). The Taxonomic Databases Working Group (TDWG, also known as the International Union of Biological Sciences Commission on Taxonomic Databases) is preparing a standard scheme for recording the state of a plant in an area.

Sampling method

Whether the plants from which a sample was collected were chosen at random, systematically or in a selective or biased manner from the population can have a profound effect on the amount and type of genetic diversity present in the sample. The number of seeds collected from each individual sampled will also be significant, and whether this was in fact the same for all individuals (Chapter 5). Such information will be necessary if comparisons are to be carried out, for example of the diversity at a site on two sampling occasions, or of the diversity at two separate sites. Some collecting forms simply have the random/selective choice, but this is unduly restricting. Note must be made of the details of the procedure used. For example, if sampling is along transects, the technique might be described as:

> 5 transects across the field, starting at random points along the S edge and proceeding in different, randomly chosen directions, sampling 10 seeds from a single plant every 5 m

In stratified random sampling at a site, note must be taken of the basis of the stratification, e.g. the nature of the different microsites sampled (this could be recorded under 'Specific habitat'). If selective sampling is carried out, then a note must be made of the characters on which selection was based, e.g. a few disease-resistant plants in an otherwise heavily infected field, locally recognized phenotypes in a mixture, etc. This data field is probably best left for free text, allowing one line of writing.

It is also worthwhile noting whether there was any bias in the collecting apart from that imposed by conscious sampling strategy at the site. Was the sample collected at the very end of the season? In the case of forages, this would indicate sampling biased in favour of genotypes which remain green after the rest of the population has died back. Was it collected in a period of drought? This might mean a bias in the sample in favour of drought tolerant genotypes.

Though this descriptor deals mainly with the sampling procedure employed at a given site to choose individuals for inclusion in the sample, it could also be used to record how the population itself was chosen. It could be that stops are being made at regular intervals of a given number of kilometres. On the other hand, particular microenvironments may be being targeted, for example areas of standing water to collect waterlogging-resistant genotypes of a particular species.

► *Collecting source*

Collecting wild species from habitats undisturbed by man and crops from fields and home gardens just at harvesting time are ideals that it may not always be possible to realize. Farm stores may have to be visited, if all the crops in a rotation are of interest or if the material has already been threshed or not yet sown. Local markets are good sources of information on the diversity available in the area they serve. Occasionally, they are the only sources of germplasm. However, markets often contain a biased sample of the agricultural diversity available in an area, farmers growing some crops and landraces exclusively for home consumption.

It is important to note the source of a sample because this conveys important information about the possible genetic structure of the material. For instance, the genetic structure of a disturbed population along a roadside, say, is likely to be different from that of a population of the same species growing in a relatively undisturbed natural habitat. A sample collected in a market may come from an area agroecologically quite different from the collecting site. When collecting from piles of threshed material, from farm stores and from markets, it will be impossible to record many morphological details, some postharvest selection by the farmer may already have occurred, and the material may consist of mechanical mixtures. Compared with freshly harvested material, material collected in farm stores and markets may have low viability.

This data field can have the following choices:

☐ undisturbed natural habitat
☐ disturbed natural habitat
☐ weedy habitat (roadside, field margin)
☐ farmer's field, plot or orchard
☐ backyard, kitchen or home garden (urban, periurban or rural)
☐ threshing floor
☐ farm store
☐ market or shop
☐ seed company (family or large-scale)
☐ institute, experimental station
☐ other

If the collecting site is not the place where the material was grown, as might be the case for material collected in markets, separate note should be taken of the actual source of the germplasm, if this can be ascertained. This may be recorded in a separate descriptor (see 'History of sample and landrace').

Collecting site localization

Detailed and thorough notes on the geographic origin of a sample are an essential part of germplasm collecting. Such information allows re-location of populations for future collecting. Researchers may wish to sample certain areas or even specific populations again more thoroughly on the basis of initial characterization and evaluation trials or screenings. Information on the geographic origin of material can also provide clues to the requirements and adaptation of the material, which is important at all stages from multiplication to use. Locality data are best dealt with in a number of separate descriptors.

► *Country*

The name of the country in which collecting is to take place can be stamped or printed on to the collecting forms before the trip. The official name should be used, or a standard abbreviation.

► *Primary administrative unit*

This field specifies an official first-level administrative division of the country. These can be obtained from cadastral and other maps, or from local people. Whether the administrative unit is called a province, a state, a 'wilayat', or whatever, should also be recorded, ideally in the local language. If secondary and even tertiary subdivisions exist and are known, they should be recorded after the primary, separated by a '/' or similar delimiter, or even in a separate descriptor. An example, taken from Kenya, might be as follows:

Province: Rift Valley / *District*: Kericho / *Division*: Belgut / *Location*: Soin

► *Precise locality*

Some collecting forms use the following format to record the exact locality of collecting:

____ km from ________ (village name or other landmark) in a ____ direction

When collecting at a village, say, the first and third blanks would be filled in with a dash. They should not be left empty, as this could suggest that the field had been overlooked. In writing down the names of places given by local people, the observations made earlier with regard to local plant names also apply. Whenever possible, the same orthography used on the map being marked and annotated in the field should be adopted when entering names on the collecting form.

This format only allows for the broadest description of locality, however. In many instances, particularly in wild species collecting, there may be no village or precise landmark in the vicinity. An alternative is to allow free text for recording how the site was reached. A good general procedure for recording locality data might then be as follows:

1. Describe in the field notebook in detail how the site was reached and its setting in the surroundings, with sketch-maps of the area (showing major natural features and infrastucture) as necessary. The description

should be accurate enough for the site to be located easily by another collector on a later occasion. This will clearly be necessary if the mission is an exploratory one for wild species, carried out at flowering time, during which the site will be marked, to be revisited at the end of the season. However, if the material collected proves interesting, or if it is wanted to monitor genetic erosion at the site, repeat visits may well also be warranted. For distances, vehicle odometer readings can be used. The odometer should be reset at the beginning of each day at a fixed point clearly identifiable on a map (e.g. intersections).

The following is an actual example, from the Moroccan Atlas, of a detailed description of how a wild species collecting site previously targeted from herbarium labels was reached:

> On the main road RS501 from Marrakech to Tizi-n-Test, proceeded SW until 5 km SW of Talat-n-Yakoub. Turned right on the track to Tafreghoust and proceeded for 3 km to the village. Continued north for about 8 km (about 2 hrs by mule) up the valley to the third summer village (azib), at 2100 masl. Continued uphill on foot towards Djebel Gourza in a N direction; it is possible to reach 2800 m in about 3 hrs.

2. Locate and mark the position on a large-scale map, labelling with the site number (see below). The position of sites should be marked with an '×': dots tend to get lost as the map gets crumpled and dirty with use. If sites are close together, to avoid crowding of markings on the map, site numbers should be written at some distance from the '×' and enclosed in a circle, with an arrow going from the circle to the location of the site.
3. Record the precise locality on the collecting form as free text summarizing the information in the notebook or coded as suggested above. If the coding method is used, the landmark quoted should be easily identifiable on the map (i.e. its name should be printed on the map). In the Moroccan example given above, since the village was marked on the 1 : 250,000 map that was being used, the following was appropriate to record the location of the site on the collecting form:

> 10 km from Tafreghoust in a N direction

4. Read off latitude and longitude from the map (this can be done later if necessary) and altitude from the map or an altimeter, and record them on the collecting form, as detailed below.

► *Latitude, longitude and altitude*

These descriptors greatly facilitate mapping distributions and will be essential if a geographic information system (GIS) is to be used in analysing the results of the collecting. They are also frequently used in computer searches for appropriate accessions, for example when looking for holdings likely to have a particular day-length sensitivity, which would come from particular latitudes. Latitude and longitude should be recorded in degrees, minutes, seconds and a hemisphere (N, S, E or W). Altitude should be in metres above sea level (masl).

Latitude, longitude and altitude can all be read off maps if locality is reasonably accurately known. Ideally, only maps of scale 1 : 250,000 or larger should be used for this, which would give accuracies of better than 1 km. It is good practice to take to the field one or two original copies of large-scale topographic maps of the specific target area or areas (rolled up and kept safe in a cardboard tube) and two or three reproductions of these on A4 sheets (perhaps in a ring-binder or in a plastic folder) for marking sites, plus one or two original copies of smaller-scale road maps of the whole region to be covered. Reproduction of published maps may require the publisher's permission.

Altitude can also be measured using an altimeter, which should have a range of 0–5000 m. The altimeter should be reset whenever possible, at sea level or when altitude is known from reliable sources.

As a result of recent advances in satellite technology, it is now possible to accurately locate one's position on the surface of the earth by means of small hand-held devices called Global Positioning System (GPS) receivers. These are rapidly becoming less expensive, and are already in use at several institutes involved in germplasm collecting. Prendergast (1993) reviews one of the models currently on the market. Latitude and longitude are commonly fixed by these instruments to a precision of about 100 m root mean square (RMS) (meaning that 63% of fixes will be within 100 m of the true position) in less than a minute. A reading of altitude can also be provided, though this will take somewhat longer and is of considerably poorer accuracy; in general, altimeters are preferable.

Transferring a GPS reading to a map requires knowledge of the 'map datum', essentially a mathematical description of the earth or part of the earth. The latitude and longitude coordinates of a given position differ from one datum to another. The datum that was used in making the map will usually be specified in the map legend, and should be entered into the GPS receiver if the locations of sites are to be accurately shown.

A limitation on the use of GPS receivers is their battery requirement, but some models come with a device which can be used to obtain power from a car cigarette lighter. GPS receivers require unimpeded sight of three of a constellation of 21 satellites, so their usefulness may be limited in heavily wooded and/or deeply dissected terrain.

Map reference

It is essential, in the case of map-derived positions, to fully identify the map used, in particular its scale. One line of free text is adequate for this. The information to be recorded includes map series number, sheet number, edition, scale and map grid reference (Lazier, 1985).

Site number

The site number is not a necessary piece of information for sample identification, collector's name and number being sufficient. However, it can assist in data handling and management. It is common to collect more than one sample per site. In such cases, all the site data will apply to all samples collected there. If each site is given a unique number, these site data need only be recorded once, and the site number cross-referenced with the appropriate collecting numbers. In compiling databases of collecting information, site number is a convenient linking field between a file containing sample-specific data and one containing site-specific data. It is also much easier to label collecting localities on a map with a single site number instead of enumerating the collecting number of every sample collected at that locality. Microsites are sometimes distinguished on collecting forms by appending different letters to the site number (as in 12a, 12b, 12c, etc.), though some collectors give entirely new site numbers.

This field is most conveniently located on the collecting form next to the collecting number and is a short numerical field. There are no strict rules about site numbering systems, but a common practice which works well is to begin at 1 on each new collecting mission. Unlike the collecting number, the site number is not used in sample identification and repetition is not a problem. It is useful to keep in the field notebook a listing of all the samples collected at each site, as a cross-check to the collecting forms should any of the latter go astray.

Some collectors write the site number on each sample container, circled or differentiated in some other way to prevent confusion with the collecting number.

Farmer's name (or owner's name)

In the case of crops, recording the name of the farmer or market stall-holder from whom the material was collected can help in finding material again, quite apart from acknowledging the part played by the farmer in the development, maintenance and conservation of the germplasm. However, any wish for anonymity should be respected. When collecting wild species, a note should be made of the person(s) and/or organization which gave permission to collect at the specific site (e.g. a national park administration, private landowner or village council). Cultural anthropologists and other social scientists often keep a separate, alphabetized file of short profiles of informants and other people met, noting ethnicity, caste, gender, age, occupation etc. (Bernard, 1988).

Collecting site context and description

The unit of collecting (the population) may be defined pragmatically as those conspecifics inhabiting a restricted area under relatively homogeneous ecological conditions (the collecting site). It is important to document these conditions because they will help to deduce the adaptation of the material, and the collecting form is the place for such site data. However, the surroundings of the site – its setting or context – will also need to be noted, in particular whether soil, vegetation, etc. are markedly different at the site compared with the surrounding area and with the region as a whole (Bunting and Kuckuck, 1970). Notes on the area and region may be made in the field notebook while travelling through it, and any differences between site and surroundings recorded on the collecting form. A pair of binoculars will be useful not only in locating potential collecting sites, but also in documenting their surroundings.

Describing collecting sites and their context, no less than their precise locality, may be facilitated by making reference to different kinds of thematic maps in the field. The kinds of maps that it may be useful to take to the field are discussed in Chapter 9.

Physiography

The natural form of the land surface around the collecting site – the physiography of the area – affects both soil and microclimate at the site itself. The general topography of the region should be given, followed by a more detailed description of the setting of the collecting site. Photographs are often used to supplement any written description; 35–50 mm lenses are the most appropriate for this application. Sketch maps and profiles are also useful. These should always include an indication of scale and orientation. Maps, diagrams and profiles drawn by farmers and other local people, or at any rate in participation with them, are increasingly being recognized as important ways of arriving at descriptions of the environment which are relevant to local needs (Conway, 1989).

Topography of region

Topography refers to the variation in elevation of the land surface on a broad scale. It commonly takes the following states (FAO, 1990):

☐	flat or almost flat	slopes <2%
☐	undulating	steepest slopes 2–10%
☐	rolling	steepest slopes 10–15%
☐	hilly	steepest slopes 15–30%, range of elevation moderate
☐	steeply dissected	steepest slopes >30%, range of elevation moderate
☐	mountainous	steepest slopes >30%, range of elevation >300 m

Landform at the site

It is necessary to detail the exact location of the site within the overall topography or landscape. FAO (1990) suggests that the position of the site within a land element of a landform be recorded. The major landforms are:

- ☐ mountain
- ☐ hill
- ☐ upland
- ☐ plain
- ☐ plateau
- ☐ basin
- ☐ valley

Land elements are subdivisions of landforms, though 'depending on magnitude, the same geomorphological feature may be described as a landform or as a land element' (FAO, 1990). It is not possible to give an exhaustive list of land elements here. Examples are flood plain, lagoon, interdunal depression, valley floor, etc. If a land system study of the target region has been carried out, it may be possible to use it to develop a more manageable list of land elements for inclusion on collecting forms.

Position of site in topography

Position within a landform or land element may be recorded as follows (FAO, 1990):

In undulating to mountainous terrain

- ☐ crest
- ☐ upper slope
- ☐ middle slope
- ☐ lower slope
- ☐ bottom (flat)

In flat or almost flat terrain

- ☐ higher part
- ☐ intermediate part
- ☐ lower part
- ☐ bottom (drainage line)

TDWG is developing sets of standards that can be used to record the landscape where a plant is growing and its habitat.

Description of site

Describing the topography of the region and locating the site in the landscape may not give a full picture of environmental conditions at the site. In an arid plain, one might be collecting wild species along a seasonal stream, for example. In a valley bottom, the cultivated field being sampled may be adjacent to the river or some distance from it, or in the type of restricted, specialized microenvironment described by Chambers (1990). It is clearly important to record the details of such collecting sites or misleading conclusions may be reached about the likely tolerances and requirements of the material collected there.

Though to some extent the problem of describing the site of collecting is dealt with in the land element description, it is nevertheless a good idea to also characterize the site in detail with free text. In the arid plain example, the kind of information recorded in this field might be 'seasonal watercourse in gravelly plain' (a more detailed description than this may be possible, and necessary, in the case of microsites: see 'Specific habitat'). Often, local words exist which describe a site quite precisely, for example 'wadi in hamada' in the Middle East in this case. Riverine strips and seasonally flooded areas, crucial to subsistence agriculture in Zambia and Zimbabwe, are called 'dambos' locally. Such terms can be used to save time in filling in forms in the field, but may not be understood by users, so translations or explanations should be substituted before the forms are sent for distribution. One line of text is normally enough for this field, though it could be supplemented by sketch-maps and profiles. In crop collecting, transect profiles through the village area and farm sketches, to which the farmers themselves should contribute, can be particularly useful in describing collecting sites.

The description of a site should include an indication of its size. This will be different from the area covered by the sampled population, another important descriptor which is discussed below, because more than one species may be sampled at a site and because a larger area may be searched than actually contained target species. In wild species collecting, it is useful to compare the size of a site with the 'minimal area' of the vegetation at the site. This is the smallest area that provides enough environmental space for a particular community type or stand to develop a full and characteristic species complement and structure. It can be measured empirically by counting species in progressively larger quadrants, but is generally 1–25 m^2 for herbaceous vegetation, 25–100 m^2 in short woody vegetation and 200–500 m^2 for the tree layer in forest (Goldsmith *et al.*, 1986).

Slope: magnitude, form and aspect

An estimate of the slope on which the site is located is often included as part of the physical description of a site, as it affects drainage, soil stability and microclimate. Slope is measured up from the horizontal by means of a clinorule or a clinometer. A clinorule is a simple piece of equipment that looks like a ruler with a joint in the middle. One segment of the ruler is held horizontal with the assistance of a built-in spirit level, and the second section is rotated to an angle parallel to that of the slope to be measured. The slope may then be read off. A clinometer is often built into a compass, and allows slope angles to be measured by the free movement of a suspended arm along a degree-graduated scale. Both instruments give measurements in degrees. Slope may be measured as a ratio, degrees or percentage; the units of measurement should always be specified. If clinometer readings are not possible, field visual estimates of slope gradient should be matched against calculated gradients from contour maps. Field estimates are perhaps most easily done by estimating the vertical distance between objects (two people, for example) located at a known distance apart along the slope. In addition to the extent of slope, some indication of its form may be given, as follows (FAO, 1990):

- ☐ straight
- ☐ concave
- ☐ convex
- ☐ terraced
- ☐ complex (irregular)

The aspect of a slope is the direction in which the slope faces. This is often a key factor determining absence or presence of a species. At high latitudes, the difference of insolation between south- and north-facing slopes may be considerable, for example. There may also be differences in the rainfall received by mountain slopes facing into and away from the prevailing winds. Aspect is usually measured with a compass but may also be estimated from maps.

The overall aspect and slope of the site should be recorded, disregarding irregularities. Thus, the aspect and slope of a site consisting of a terraced field on a mountainside are those of the mountainside, not the level field.

Soil

The soil is an important feature of a plant's environment and should ideally be described in detail. All of the soil descriptors listed below can be recorded directly in the field with a minimum of effort and without specialist knowledge. Some collectors gather more detailed soil data using specially designed soil testing kits and/or take samples for laboratory analysis. This is not often part of the collecting routine, but will be of value in some cases, for example if adaptation to specific edaphic conditions is being sought. See Ball (1986) and EUROCONSULT (1989) for useful introductions to the field description of soils.

Parent material

The composition of rocks directly affects soil type and soil chemistry, so the collector needs to consider the origin of the material from which the soil at the collecting site is derived. This field should include information both on the origin (aeolian, alluvial, colluvial, *in situ* rock) and nature of the material from which the soil at the site is derived. An example might be 'colluvial material derived from granite'. There are clearly a large number of possible states. If information on the general geology of the target area is available, this can be used to cut the list down to manageable size for inclusion on preprinted collecting forms. Otherwise, a line or so of free text will be needed. If parent material is simply read off a geological map, this should be noted, and the map name and scale specified.

Soil taxonomic class

This field refers to the name of the soil according to a recognized local or international system such as that of the Food and Agriculture Organization and the United Nations Educational, Scientific and Cultural Organization (FAO–Unesco) (FAO–Unesco–ISRIC, 1988), the US Department of Agriculture (USDA) (USDA, 1975) or the Commission de Pédologie et de Cartographie des Sols (CPCS, 1977) (Young, 1987). Soil classification can be complex and requires a knowledge of the entire soil profile. FAO has published guidelines on soil profile description (FAO, 1990). Collectors may not have the training to be able to apply these systems, and attempting to classify each soil would in any case be too time-consuming to warrant the effort in most cases. If classification is attempted, however, the system used should be specified. Young (1976) provides a useful simplified key to tropical soil classes in the FAO–Unesco system. Soil type may be read off soil maps, but, if this is done, it should be noted, and the map name, scale etc. specified. Note that TDWG is developing standards that can be used worldwide to characterize the soil type in which a plant occurs.

Local knowledge of soils is often systematized by farmers and others into indigenous classifications. These distinguish between soils on the basis of those characteristics which are most important to the everyday user of the land, in particular suitability for different crops, and can be an important complement to scientific taxonomies (Tabor *et al.*, 1990).

Soil texture

In the field, soil texture, the relative amounts of primary particles of different size classes in the fine earth fraction of the soil, is normally assessed by sight and feel. Texture is one of the more important characteristics of soil, usually giving a good indication of the edaphic preferences of a species. Particle size classes making up the fine earth fraction are: clay (diameter <0.002 mm), silt (0.002–0.05 mm) and sand (0.05–2.0 mm). Soils with an approximately equal contribution of all three classes are called loams. The percentage contribution of each fraction can be measured in the laboratory and plotted in a triangular diagram. EUROCONSULT (1989) describes a simple manual texture test for use in the field. A small heap of about 2–3 cm diameter is formed from about one tablespoon of soil. Water is then slowly dripped on to the soil until the material just starts to stick to the hand. The extent to which the moist soil may be shaped by hand is used to describe its texture, as follows (intermediate classes, such as 'sandy clay loam', are also possible):

- ☐ sand — soil remains loose and can only be heaped into a pyramid
- ☐ loamy sand — soil can be shaped into a ball that easily falls apart
- ☐ silty loam — soil can be shaped by rolling into a short, thick cylinder
- ☐ loam — soil can be rolled into a cylinder about 15 cm long that breaks when bent

☐ clay loam — soil cylinder can be bent into a U, but no further, without breaking
☐ clay — soil cylinder can be bent into a circle

Stoniness

The total extent and size (average or maximum) of coarse surface fragments in the soil and of rocky outcrops is sometimes recorded, usually separately. Extent can be recorded as none, low, medium or high; or as percentage cover. Size fractions for surface fragments are: fine gravel (2–6 mm), medium gravel (6–20 mm), coarse gravel (20–60 mm), stones (60–200 mm), boulders (200–600 mm) and large boulders (>60 cm). When describing crop collecting sites, stoniness is sometimes recorded in terms of the effects it has on cultivation: tillage may be unaffected, affected, difficult or impossible.

Soil colour

Soil colour can give indications as to leaching and fertility. It is, however, difficult to record accurately. Soil colour changes according to whether the soil is wet or dry, and it also appears different at different times of day, with the sun at different angles. The most accurate way to record this parameter is to compare moist unrubbed soil with the small squares of standard colours provided in colour charts. The colour chart used should always be specified. These are reviewed by Tucker *et al.* (1991). For many purposes, simply recording whether the soil is black, brown, grey, orange, yellow or white may be sufficient. The main matrix colour should be noted, plus the intensity and extent of mottling and of other secondary colours, if present. Bingham and Ciolkosz (1993) discuss the significance, causation and measurement of soil colour in detail.

Soil depth

This is a factor which can be difficult and time-consuming to determine, often requiring a soil pit to be excavated. Shallow soils or superficial bedrock are usually easy to detect, but for deep soils the only way to get data is often from fortuitous profiles, such as might be found along stream sides or road cuttings. When collecting crops, soil depth is sometimes given relative to plough depth.

Soil pH

Most soil pH values fall within the range 3.5 to 12, with 3 being very acidic, 7 neutral and 12 strongly alkaline. Tolerance of highly acid or alkaline soils can be an important agronomic trait, and plant introduction teams are continuously searching for genotypes with these tolerances.

Soil pH may be measured in the field by means of a dual glass-calomel electrode. This is usually the most accurate method, but the instrument is delicate and requires calibration with buffers. There are also methods which rely on the change of colour of reagents, though these tend to be less precise. It is important to choose a light, compact and durable soil testing kit for use in the field. Samples for pH measurements are usually taken from the top 20 cm of soil, but deeper samples are sometimes also taken.

Salinity

Salinity can be an important determinant of plant performance, and tolerance of high soil salt concentrations is being sought in many crops (often among the wild relatives) and forages. Salinity is measured in the field or laboratory by means of a conductivity meter. It can also be recognized visually, however, by a whitish crusting on the soil surface (the cover and/or thickness of which may be recorded) or by the degree of inhibition of salt-sensitive crops.

Drainage

Drainage covers a subjective estimate of the balance between water arriving at the soil surface and leaving it by run-off and infiltration. It depends on site relief, ground surface conditions and soil permeability. It may be divided into site drainage and profile drainage (Lazier, 1985). The former refers to the movement of water horizontally along the surface of the soil, the latter to vertical movement down the profile. Agronomists frequently seek plants with high tolerance to permanent or seasonal waterlogging in crops and forages, and poor drainage at the collecting site can give a good indication of this. Soils are most often simply described as poorly to well drained on an arbitrary scale. Such features as the frequency, duration and depth of flooding can also be recorded here, and the depth of the water table. If the site is on crop land, such information will be available from the farmer.

Identification number(s) of soil sample(s)

Isbell and Burt (1980), León *et al.* (1979) and Ball (1986) describe soil sampling methods. Soil samples are most efficiently taken with a screw auger, but a small digging implement such as a graduated planting trowel can also be used, and these are perhaps better in loose soils. Implements should be of stainless steel to avoid contamination. A screw auger is composed of a wood-boring large-diameter bit with a screw thread (2.5 × 20 cm long), welded to a T-shaped steel handle about 1 m long. The auger is screwed into the soil and then withdrawn by a strong upward pull. The top 20 cm or so of soil from 5–10 points should be sampled, bulked and mixed, taking care to discard loose plant litter and other debris. Samples are usually taken from the immediate vicinity of the plants being collected, but samples from adjacent areas may also be collected for comparison. About 500 g per sample is sufficient for most purposes. Soil samples should be kept in strong polythene bags, and are usually labelled with the site number both on the outside of the bag and inside. The number of the soil sample should be written on the collecting form. Soil samples should be air-dried, avoiding contamination from fertilizers and the like, and then the containers sealed.

Additional notes on soil

Other features of soils that may be important to germplasm collectors are (FAO, 1990):

- extent of bare ground;
- extent and type of soil erosion;
- size and frequency of surface cracking;
- thickness and consistency of surface sealing;
- soil fertility;
- organic matter content;
- groundwater quality;
- differences between the soil at the site and in the surrounding area.

If information on these is not recorded in separate predetermined descriptors, comments may be made in a general field for soil notes. Two lines of free text will usually be adequate.

Biotic factors

Vegetation type

Vegetation is the assemblage of plant species growing at a site. It may be described in terms of its component species i.e. floristically) or in terms of its appearance (i.e. physiognomically). Often, a combination of the two methods is used.

Species may have very precise associations with particular vegetation types. Recording vegetation type at the collecting site will thus assist future collectors in deciding where to look for more material. Being the result of the interaction of many climatic and soil factors, vegetation can also help in characterizing the general adaptation of material. Though it is usually only considered in wild species collecting, it is useful to record the dominant natural vegetation in the region even when collecting crops, as it can provide useful indications as to climate and soil in the absence of more direct information.

Terms such as 'forest' and 'grassland' are physiognomic descriptions of the size and spacing of the main components of the vegetation, which may be qualified and subdivided at various levels, for example by a statement of periodicity or phenology, as in 'evergreen forest', and/or climatic requirement, as in 'tropical rain forest'. Unfortunately, terms such as these, which are in general use, may be interpreted in various different ways, and precise definitions are therefore necessary. One way around the problem is to record the percentage cover of various life-forms, plus bare ground. Life-form categories could just be trees, shrubs, broad-leaved herbs and grasses, possibly subdivided into size classes, or Raunkiaer's categories based on the position of perennating buds relative to ground level could be used (e.g. Goldsmith *et al.*, 1986).

However, various widely used and widely applicable descriptive systems based on physiognomy do exist which actually name and define different vegetation types. These include Fosberg's (1961) classification using spacing and vertical stratification, Unesco's (1973) authoritative attempt to produce a generally applicable system (see also Ellenberg and Mueller-Dombois, 1967), the not wholly standardized classification system used by the Institut de la Carte Internationale du Tapis Végétal (ICITV) and White's (1983) system used for the AETFAT/Unesco/United Nations Sudano-Sahelian Office (UNSO) map of the vegetation of Africa. There is a standard classification system for wetlands, adopted as part of the *Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (also known as the *Ramsar Convention*). A synopsis of the Unesco system is provided in Box 19.3, mainly giving only the first level of the classification, the formation class: each level is considerably subdivided in the full classification. A project is under way to develop a global classification scheme for vegetation (UNEP/GEMS, 1993).

Such a broad physiognomic classification at the formation class level is a useful first step in describing vegetation on collecting forms. There could be an additional vegetation type to the ones listed above, labelled 'arable land' or similar, to represent man-made landscapes. A broad physiognomic description may be augmented or qualified by floristic information, usually on the dominant or most abundant species, as in '*Acacia–Commiphora* woodland' or '*Themeda* grassland with scattered *Acacia* shrubs'. Alternatively, the more detailed levels of the full classification system may be used. However, as with the physiographic description of the site, listing all possible choices on a collecting form at this level of detail will only be feasible when dealing with a relatively restricted target area. It will then be possible to compile a full but still manageable listing of the vegetation types in the area with reference to published vegetation surveys and maps. Otherwise, a line or so of free text will be needed. In the case of Africa, for example, vegetation could be recorded at a first level according to the main vegetation types of White (1983), and it would be possible to produce lists of his mapping units for a given target area, among which a choice could be made for a more detailed vegetation description.

Vegetation type may be read off maps, but, as in the case of soil and geology, the name and scale of the map used will need to be specified. The vegetation classification system that is used should always be noted by reference to a publication. It is useful to record whether the vegetation at the collecting site is markedly different from that in the surrounding landscape, as observed during travelling or recorded on maps.

Vegetation types may have local vernacular names, some of which have actually entered into general botanical usage, such as 'fynbos', 'kefkalla', 'chaparral' or 'caatinga'. Such words or phrases may be used to save time in the field, but will need to be defined or substituted for more widely recognized terms when the forms are circulated to

Box 19.3
Unesco vegetation classification formation classes (Unesco, 1973)

I. Closed forest	stand of trees >5 m tall, with interlocking crowns
II. Woodland	stand of trees >5 m tall, with crowns not interlocking but tree cover >40%
III. Scrub (fourrés)	stand of caespitose woody perennials $\frac{1}{2}$–5 m tall
• shrubland	scrub with crowns not interlocking
• thicket	scrub with crowns interlocking
IV. Dwarf scrub	stand of caespitose woody perennials ~$\frac{1}{2}$ m tall
• dwarf shrubland	dwarf scrub with woody perennials isolated or in clumps
• dwarf shrub thicket	dwarf scrub with woody perennials with interlocking crowns
V. Herbaceous communities	
• tall graminoid	stand of grasses or graminoids >2 m tall
• medium tall grassland	stand of grasses $\frac{1}{2}$–2 m tall
• short grassland	stand of grasses <$\frac{1}{2}$ m tall
• forb vegetation	stand of broad-leaved herbaceous species
VI. Deserts and other sparsely vegetated areas	
VII. Aquatic plant formations	

Each vegetation type in I–IV may be further qualified as
- evergreen
- semideciduous
- deciduous
- xeromorphic

Each vegetation type in III–V may be further qualified as having
- trees (>5 m tall) contributing to 10–40% of cover
- trees contributing to <10% of cover
- shrubs
- tuft plants
- no woody plants

collaborating organizations. Indigenous vegetation classifications are a useful complement to scientific systems, often highlighting features that, though highly significant to local people who know and use the vegetation daily, have not been considered in more formal treatments.

Land use and farming system

If the climax vegetation actually or potentially present at a site is an integrated, synoptic expression of the natural environment, land use in an area is an integrated expression not just of the climatic and edaphic situation, but also of cultural and socioeconomic conditions (Oram, 1987). FAO (1990) lists the following main categories of land use:

- ☐ settlement, industry
- ☐ crop agriculture
- ☐ animal husbandry

- ☐ forestry
- ☐ mixed farming
- ☐ extraction and collection
- ☐ nature protection
- ☐ not used and not managed

A general impression of the extent of each category in the area surrounding the collecting site, and land use at the collecting site itself, should be recorded.

To further characterize protected areas, the system recently adopted by the IUCN Commission on National Parks and Protected Areas, a modification of that of IUCN (1978), is useful:

- ☐ strict nature reserve/wilderness area
- ☐ national park
- ☐ natural monument/natural landmark
- ☐ habitat and species management area
- ☐ protected landscape/seascape
- ☐ managed resource protected area

In crop collecting, the 'crop agriculture' and 'mixed farming' categories will also have to be further characterized, to the level of farming system, in the same way that vegetation type will further characterize some of the other categories in the list. A farming system may be defined as 'a reasonably stable arrangement of farming enterprises that the farm household manages according to well-defined practices in response to the physical, biological and socioeconomic environments and in accordance with the household's goals, preferences and resources' (Shaner *et al.*, 1982).

The FAO scheme provides for further description of farming systems (by noting whether crops are annual or perennial, rainfed or irrigated etc.), but more detailed classification frameworks are possible. That of Boserup (1965), for example, essentially ranks farming systems on a scale of increasing intensity of land use, from shifting cultivation to irrigated multicropping by way of fallow systems of decreasing duration. A similar scheme is followed by Okigbo and Greenland (1976). Altieri (1987) recognizes seven main types of agricultural systems in tropical environments:

- ☐ shifting cultivation
- ☐ semipermanent rain-fed farming
- ☐ permanent rain-fed farming
- ☐ arable irrigation
- ☐ perennial crop farming
- ☐ grazing systems
- ☐ systems with regulated ley farming

Going into a little more detail, Beets (1990) defines and describes seven major crop-based smallholder farming systems in the tropics:

- ☐ shifting cultivation
- ☐ lowland rice-based farming
- ☐ cereal-based farming
- ☐ smallholder mixed farming
- ☐ irrigated smallholder farming
- ☐ smallholder farming with plantation (perennial) crops
- ☐ agroforestry

Each of these can be detailed further and subdivided. One way is in terms of the dominant crop. Middle Eastern cereal farming may be based predominantly on barley, bread wheat or durum wheat, for example. A further way is in terms of crop growing environment. For example, IRRI (1984) provides a comprehensive review of classification systems for rice growing environments and suggests a generally applicable terminology based on a combination of factors, including water regime, drainage, temperature, soils and topography. Carter (1987) is a similar study on cassava. Nair (1985) describes the International Centre for Research in Agroforestry (ICRAF)'s classification of agroforestry (i.e. home-garden) systems (the descriptions are in a database; see Oduol *et al.*, 1988), though his definition of the term is not exactly the same as Beets' (1990). More information on farming systems worldwide is available in Grigg (1974) and Ruthenberg (1980).

Of course, the situation is more complex than such classifications may imply. Farming system classifications often overlook Chambers' (1990) microenvironments, the sort of restricted, specialized, hard-to-find sites where much subsistence agriculture takes place. A single household (let alone a single village) may practise more than one of the farming systems in a classification, for example a permanent, home-garden-type 'infield' and a shifting 'outfield', perhaps with different people responsible for each. The character of the individual subsystems and the linkages among them need to be documented. In Francophone studies, the village level and the farm (or household) level are often distinguished as 'système agraire' and 'système de production', respectively (Beets, 1990). When the unit of analysis is the field or plot, one may speak of the cropping system used on that piece of land, or the 'système de culture'. This will be documented under 'Cultural methods'.

Many countries use their own standard national nomenclature and classification system for land use and farming systems, for example in producing land use maps. These systems may be very specific to the country. For example, the *Land-use Map of China* has a 'cultivated land' category divided into 'paddy', 'irrigated field' and 'non-irrigated field' (all are further subdivided on the basis of whether they are terraced or not) and a 'garden' category divided into 'orchard', 'tea garden', 'mulberry field', 'tropical crops' and 'diked pond' (Editorial Committee of Land-use Map of China, 1990). The *Atlas de la Nouvelle Calédonie et Dépendances* has such land use categories as 'coconut grove' and 'small-scale food crop garden', but also 'alluvial meadow with traces of old yam ridges' and 'former irrigated taro garden' (ORSTOM, 1981). Such maps, agricultural censuses, household surveys and ethnographic studies may be used to develop manageable lists of the land use types and farming systems occurring in a particular target area for inclusion on the collecting form. The source(s) used should always be specified.

Otherwise (or in addition, if secondary sources are deemed not sufficiently precise and time permits) the farming system at the household level will need to be described on the basis of observation and consultations with the members of the household. This can be done in many different ways. Conway (1985) describes a framework for farming systems description based on the analysis of spatial and temporal patterns, flows (e.g. of energy, materials, information, etc.) and decision-making. The annotated checklist of survey questions provided in an appendix by Richards (1985) 'to assist agricultural extension workers assess local skills and R&D priorities, and open up the possibility of participatory approaches to agricultural development' is a good model for farming system description. Another is the Worksheets for Land Use System Description used by ICRAF (Raintree, 1987). See Fernandes and Nair (1986) for the checklist used to describe and characterize home-gardens by ICRAF. Shaner *et al.* (1982) present a system for documenting farming systems based on the description of: (i) household structure and decision-making; (ii) household resources (land, labour, capital and management); and (iii) farming enterprises. An exhaustive farming system description would need to include information on at least the following:

- farm access, the size and fragmentation of the holding and the size and composition of the household which works it;
- the character of land tenure for the home compound, off-compound gardens, crop land, grazing land, woodlands, etc. (freehold, tenancy, communal control, state ownership); see Raintree (1987) for a full list of land tenure types;
- the main cultivated and semicultivated species, their relative importance and their spatial (horizontal and vertical) and temporal relationship to each other (intercropping, relay cropping, rotation, etc.);
- the main wild species used;
- the associated livestock species, their management (free-ranging, herding, paddocking, stall-feeding), source of feed and contribution to the system (milk, meat, manure, draught);
- the disposal of plant and animal produce and residues (home consumption, sale, barter, social uses);
- the seasonal calendar of temperature and rainfall, cropping activities for each species, collecting of different materials from the wild, agricultural labour demand, crop and livestock pest and diseases, diet, livestock feed availability, etc. (Box 19.4);
- the sharing out in space and time of farming responsibilities within

Box 19.4
Participatory preparation of seasonal calendars (after Theis and Grady, 1991)

- Draw an 18-month calendar either on a large piece of squared paper or on the ground, labelled with local names for months and seasons (how these are defined, i.e. by the moon, stars, etc., should be specified).
- Ask community members to use seeds, stones, twigs of different sizes or other small counters to indicate the relative magnitudes of different variables (e.g. rainfall, labour demand) at different times of the year.
- Ask community members to indicate planting, harvesting, etc. dates for different crops, e.g. using seeds of the different species. The ranges of dates should be shown, and reasons for differences between years investigated.
- Combine all seasonal patterns into one diagram to bring out correlations and discuss these with the group.

the household, i.e. the particular roles of men, women, children, paid hired labour;

- the method of land management (microcatchments, mounding, ridging, terracing) and soil fertility management (burning, manuring, mulching, fallowing); see Raintree (1987);
- the method of water management (rain-fed cropping, residual soil moisture cropping, flood-recession cropping, tidal irrigation, groundwater pumping, etc.); see Underhill (1984) and Adams and Carter (1987) for useful lists and classifications of water management practices;
- the character and extent of modern inputs (pesticides, fertilizers, mechanization, improved varieties, extension advice);
- the most significant constraints and bottlenecks in the system and changes in this and any of the above over the years.

To what extent the collector will be able to – and need to – collect information on all these aspects will vary. Ideally, in a preliminary or reconnaissance survey of an area, a number of households, reflecting the range of socioeconomic variation, should be documented fairly fully, whether or not germplasm is actually collected at each household. One could then specify whether many, some or only a few households within the village fall into a given class. Such data may be useful in formulating a sampling strategy and in identifying key informants for future collecting. On other occasions, the main crops and rotations and the most common land management practice and water management method in the village may be recorded (in a sentence or two, or using a broad classification category), in addition to more details on the particular household from which material is being collected.

For the non-cropping land use categories, any regular, artificial treatment of the environment or plants at the collecting site should be described. This could be grazing, burning, thinning, mowing or some other management practice. The frequency, intensity, extent and history of management are all important factors to note. In pastoral areas, a description of the system of land tenure obtaining at the collecting site will largely define the management the vegetation has received. Useful (though confined to Africa) reviews of traditional vegetation management systems - and frameworks for their description - are provided by Niamir (1990) and Shepherd (1992). Bruce (1990) describes rapid rural appraisal (RRA) methodologies for the assessment of tenure systems in a forestry context. Different species at a site in natural or seminatural vegetation may be managed in specific ways. This could be documented in this section, but, if some of these species are being collected, data pertaining to them should be included in a separate 'Population management' descriptor in the 'Population information' section.

Local people often have their own indigenous nomenclature for land use and farming systems (and perhaps a taxonomy). For example, systems of shifting cultivation are referred to as 'jhum' in the north-eastern hill region of India and as 'podu' in Andhra Pradesh. Similar systems are called 'rosa' by some native communities in Mexico. However, as in the case of local names for landscape, soil and vegetation types, such appellations will need to be translated into generally understood phrases, carefully defined, or at least a reference given to an explanatory source, before wider distribution of the data.

Three-dimensional models, farm and village sketches and diagrammatic profiles through the village and surrounding areas drawn with farmers' participation can be used to relate particular ways of using the land - and, indeed, the distribution of particular crops or landraces - to specific features of the environment. Constraints and opportunities can be quite effectively pin-pointed in space in this way. Any changes that may have occurred in the pattern of land use over time can also be documented by inviting local people to draw a series of profiles through the village and surrounding areas showing the situation as it was at different times in the past (historical transects). Again, this is information for the notebook rather than the collecting form.

If there has been agroecological characterization of the target area, note could also be taken here of where the collecting site fits in the system, though this will not always be entirely possible in the field. Johnson (1974) gives an example of an indigenous system of ecological characterization. Describing a collecting site according to such multi-dimensional classifications (scientific or indigenous) can be an efficient way of defining the overall adaptation of the germplasm.

Dominant species/crop/landrace

Recording the dominant wild species at a site is only necessary if a non-floristic vegetation description is used. In crop collecting, the most important crop (and variety, whether local or modern) or rotation used by the household can be specified in this descriptor. Half a line of free text is probably adequate, especially if a code is used to record species in the field, such as the first two or three letters of genus and species. If such a code is used, it is essential to keep a key, so that collecting forms can be decoded prior to distribution.

Associated species/crops/landraces

A knowledge of associated species is often important in wild species collecting. For example, forage grasses and legumes which grow well together may be sought. Species may also be listed here that are not dominant or even common but nevertheless significant in characterizing the site. Examples would be forest emergents, endemics and ecological indicators. Target species which it was not possible to collect, for example because of incorrect timing or overgrazing, should be mentioned. If a representative inventory of the flora at a site is needed, an area at least equal to the minimal area of the vegetation should be surveyed.

Comprehensive lists of crops and varieties (both landraces and modern material) for the village (and, indeed, the surrounding area) may be compiled from visits to markets as well as in consultations with several farmers and other local users, who will also be able to say if any crops and landraces are no longer being grown or are being grown less than in the past, to what extent, and why. Not being tied to a particular germplasm sample, this information is perhaps better recorded in the collecting notebook and report. A list for the household under consideration can be recorded here. Information on the actual changes in the crops and landraces being grown by the household, and on probable future changes, can find a place under this descriptor and/or under a separate 'Genetic erosion' descriptor.

Additional notes on biotic factors

Notes on the degree of shading at the site can be made in a separate descriptor or in a comments field. Information on the extent and character of differences in vegetation or land use between the site and the surrounding area can also be recorded here.

Other

Site disturbance

A record of the degree (intensity and frequency) to which a site has been disturbed, and the type of disturbance, can give very valuable information on the genetic structure of the population. If a wild population is growing in a disturbed environment it is likely that the surviving individuals will represent only a proportion of the original genetic diversity of the population. This does not imply that the population should not be sampled, but could serve to suggest that there may be further diversity available elsewhere in the area. Information on disturbance could also indicate possible threats to the site or the population, and impending genetic erosion, although many species are adapted to regular disturbance and may actually require it for regeneration.

Fires, floods, landslides, high winds and drought may be termed 'natural' disturbance factors in that they can occur without human help. So are grazing and trampling by wild herbivores. Purely 'artificial' disturbance ranges from management to complete destruction of the habitat, for example for mineral exploitation or construction or by pollution. Artificial disturbance is perhaps best noted under 'Land use'. Some assessment of the extent of this threat may be recorded in a separate 'Genetic erosion' descriptor, added to this section (Chapter 4). Information on both natural and artificial disturbance can come from direct observation and secondary sources, but local people will usually be the main source.

Population information

Attributes of the population from which the sample is taken need to be described just as much as the ecological conditions at the site which the population inhabits. Attributes such as phenology, pest resistance and morphology will have some kind of genetic basis, and can be seen as preliminary characterization. As such, they will provide an important guide to users.

Information on some of the subjects in this section can only really be obtained from consultations with local people, especially in the case of crops. Some general guidelines on the methodology for documenting indigenous knowledge are given in Chapter 18. Checklists of descriptors such as collecting forms may be ideal for recording sample archival data and site ecological data in the field, but they can be somewhat restricting in the recording of indigenous knowledge. Nevertheless, some structure will still need to be imposed at some stage on the mass of data coming out of such procedures as semistructured interviews, life-history elicitation, ranking tests, cognitive mapping (of landraces and of the environment) and audio/visual recordings if useful information is to emerge. What are enumerated here are perhaps better thought of as general topics around which consultations with farmers and other local people and observation can take place, rather than as a set of rigid questions to be asked and answered or blanks to be filled in.

Inevitably, it will not be possible to find a place on the collecting form for all the information gathered in the course of an ethnobotanical investigation. Indeed, some information will not be directly referable to a particular germplasm sample or collecting site. Such general information should be recorded in the field notebook and included in the mission report.

Phenology

A knowledge of the proportions of the population at different stages in the phenological cycle when collecting took place will be important to breeders looking for genes for early maturation date in a crop, for instance, or for forage material suitable for seed production which produces seeds in a short period rather than throughout the season. It will also help in timing future collecting.

Estimates of this information are normally presented as the percentage of the population which is in the following states:

- vegetative
- flowering
- fruiting
- finished fruiting
- with sterile seed

Note that 'vegetative' refers to plants which did not flower or seed at all, while 'with sterile seed' refers to plants which flowered but produced no seed, as can be seen in empty heads or hollow seeds. The latter is a frequent and very deceptive occurrence in certain grasses and care must be taken not to collect such material. Godron and Poissonet (1970) provide much more detailed subdivisions of the phenological cycle for annuals, biennials and perennials. There are also more specific systems, for example for cereals.

Pests and diseases

Chapter 17 deals with collecting data on the plant damage caused by pests. It also discusses collecting specimens of pests and of the damage they have caused. Local people are often extremely important sources of information on the susceptibility of landraces to different pests and on what pests pose problems in an area, and to what extent. They can also describe the plant protection measures that they adopt.

Uses

The importance of information on the particular uses made by local people of landraces or wild species is discussed in Chapter 12. In addition to data from consultations with local people, this descriptor will also include information from other sources, for example field observations of grazing of forage species or of visits by bees for honey species. It is usually possible to decide from observation whether a species is being grazed or browsed, and a note should be made of what the herbivore is likely to be. It is sometimes possible to tell if a species is particularly palatable, for example if it is only found surviving within thorny bushes. One or two lines of free text should be adequate for this field. Alternatively, a list of non-mutually exclusive options may be provided on the collecting form, for example as follows, based on the main categories developed by the Survey of Economic Plants of the Arid and Semi-arid Lands (SEPASAL) (e.g. see Aronson, 1989):

☐ food and drink
☐ domestic products

- ☐ timber (including fuelwood)
- ☐ forage
- ☐ land use (e.g. shade, soil improvement and stabilization, ornamentals)
- ☐ fibres
- ☐ toxins
- ☐ medicinal
- ☐ chemicals (e.g. gums, resins, dyes)
- ☐ ritual and religious uses
- ☐ other

If such a list of broad groupings is used, it is important to allow space for details, in particular specifying what part of the plant is used for each purpose (including the use of crop residues), the method of preparation, etc. Alternatively, the full classification may be used, in which each of the above categories is subdivided at two or three levels, though the full SEPASAL list runs to several pages. Medicinal plants are often particularly difficult to categorize, as traditional views of health and sickness may be radically different from those of modern medicine. TDWG is developing standards for recording the economic uses of plants.

A plant or plant part may be used in different ways by different sections of a community, e.g. men and women. Gender-disaggregated benefits analysis is a useful tool for documenting this (Thomas-Slayter *et al.*, 1993).

The documentation of methods of preparation can be supplemented with photographs and audio/video recordings. Collier and Collier (1986) provide a scheme for the documentation of technology that may be useful in this context (Box 19.5); 35–50 mm lenses will again be most suitable.

Morphological description

A brief morphological description of the material collected can be very valuable to future users of conserved material. Much time and effort can be saved by being able to make an initial selection of what material to evaluate in field trials on the basis of a search through brief descriptions of the morphology of a number of holdings, if the characters are highly heritable.

There are different, complementary approaches to recording morphological data in the field. One is to provide several lines for free text on the collecting form, where unusual features and those of particular agronomic significance can be noted. Another approach is to use characterization descriptors specific to a taxon or gene pool, such as are provided in IPGRI descriptor lists (Chapter 8). Such lists are often very long, and some selection will be required. Characters identified in previous characterization work as best differentiating among landraces

Box 19.5
Documenting technology by photography

- Environmental location of the technology.
- Raw materials.
- Tools of the trade.
- How tools are used.
- How the craft proceeds.
- End result.
- The function of the technology.
- Social context of the technology.

or that have been used in infraspecific classifications (Chapter 7) will be favoured. The characters most frequently cited by farmers themselves in their description of landraces or in discriminating among landraces might also be a good starting point. It should be remembered, however, that farmers do not necessarily use only morphological features in differentiating among landraces: gastronomic, life habit, familiarity and functional criteria may be just as important (Nazarea-Sandoval, 1992).

When collecting wild plants, each species should be described as to life-form, size, life span and habit, either in a brief phrase, or by going through a list such as the one below, an abbreviated form of that quoted in Chapter 27 in the context of the notes required to document herbarium specimens.

- plant type: tree, shrub, herb or vine (or Raunkiaer categories)
- free-living, epiphytic or parasitic
- plant height
- life span: annual, biennial or perennial
- dry-season deciduous, wet season deciduous or evergreen
- direction of stem growth: climbing, erect, geniculate, decumbent, prostrate, creeping, etc.
- stem structural type: pachycaulous, succulent, bulb, corm, stolon, rhizome, etc.
- perennating organs
- thorns and spines

The models of Hallé *et al.* (1978) can be used to describe the growth form of trees. Forestry workers often record DBH and bole and/or total height of the trees they collect. Height can be measured directly or estimated visually, but the former method is laborious and the latter can be inaccurate. Using a clinometer and trigonometric conversion is probably the most convenient compromise for tall trees. TDWG is in the process of developing standard life-form descriptors.

Taking photographs of the material can be a useful additional method of data collecting in the field. Close-ups of flowers and fruits taken with a macrolens can complement herbarium specimens by recording details that will be lost or distorted on drying. The general habit of plants can also be shown, which will be particularly important for trees. For crops, Marchenay (1987) recommends three views:

- a general view of the field;
- a general view of the entire plant;
- a close-up of the part consumed.

For fruits and tubers, the following views will be needed:

- the entire organ from the side;
- the entire organ from the top;
- an equatorial section;
- a vertical section.

These can of course be arranged in a single frame, against a neutral background (a piece of grey card or cloth), taking care not to include shadows. It is important to include a scale at all times (a 10 cm ruler or a pencil is suitable). Colour transparency film is recommended, of speeds ASA 64, 100, 200 or 400. A flash and a tripod may be necessary in some situations, for example when collecting in forests.

An important reason for recording easily visible morphological information on collecting forms is that it can help keep track of phenotypic duplicates in the field. However, there are other ways of monitoring the material that is being collected that may be easier than comparing piles of paper forms. One possibility is to take Polaroid photographs, for example of the wheat ears, *Phaseolus* beans, apple fruits or sweet potato tubers (in section and whole) found in a field or village. This will be quite expensive, however, and a cheaper alternative is to make drawings on pieces of card. A farmer's drawing or description of a landrace, emphasizing the salient features of the material from the everyday user's point of view, may make it easier for the collector to remember it. If such cognitive mapping of landraces has been carried out, the results should be recorded here (Chapter 18). Another approach is to retain representative subsamples of each seed sample collected. These can be stored glued to pieces of card, in small transparent plastic bags or the pockets of slide holders (Debouck, 1988), labelled with the collecting number and the site number. In this way, they can be quickly referred to and compared with newly encountered material.

It is useful to keep a running count in the field notebook of the different kinds of material collected. Alphabetically arranged running checklists of local and scientific names (and some essential distinguishing features) have already been mentioned. In addition, two- or three-way tables can be constructed using the most important field characterization descriptors and collecting numbers added to the appropriate cell in the table as each sample is collected. For example, wheat landraces could be described in the field in terms of spike density, awnedness and glume colour, as in the example in Table 19.1. Local names for each sample could also be recorded in the table. Instead of the characters themselves, the categories used in an infraspecific classification of the crop could be used (Chapter 7).

Table 19.1. Example of description of a wheat landrace. Numbers refer to collecting numbers of different samples.

	Awnless	Awnletted	Awned
Spike lax	1024 – glume white	1025 – black 1032 – white	
Intermediate			1011 – white
Dense		1037 – brown 1056 – brown	

Morphological variation

Obvious variation in highly heritable, especially qualitative, characters within a population should be recorded. On the strength of this information, it may sometimes be decided to selectively collect separate samples of 'unusual' or otherwise interesting individuals. Variation may be recorded for individual characterization descriptors or simply an overall indication or impression given, in which case a line of free text should be adequate. Photographs are sometimes taken showing the range of variation in a sample. For example, it is common to choose an example of each of the various different ear types in a cereal field and photograph them together against a neutral background. Again, a scale should always be included in such photographs.

Proximity of close relatives

When collecting either crops or wild species, the presence of wild, weedy or cultivated relatives in the vicinity could point to the possibility of gene exchange and introgression. This is often encouraged by traditional farming practices, which should be documented. Note should be made of whether there are related forms nearby, and if so what they are and whether it is considered likely that gene exchange is taking place. The presence of intermediate forms would be evidence of this. Specialized collecting forms may ask for the distance from the collecting site to the nearest field of the cultigen or the nearest population of a wild relative. One line of free text is usually adequate for this data field.

Wild species

Specific habitat

It will sometimes be necessary to be very specific about the microsite occupied by a wild plant or crop. Using the seasonal watercourse example quoted above under 'Description of site', for instance, one species (or ecotype, in the case of stratified sampling) might be found 'along the sides of the wadi, among rocks' and another 'in the middle of the wadi bed, on sandy alluvium'. Site context, slope, aspect and vegetation will probably be recorded as identical for the two samples, but strictly speaking the collector is dealing here with two separate collecting microsites, as ecological conditions will in fact be somewhat different. In this case there might be a difference in soil texture, perhaps, which it will be possible to document on the collecting form in the appropriate descriptor, but it is by no means always the case that it will be possible to find a descriptor among the ones included on the form for which a difference can be recorded. Another relevant example might be collecting both in clearings or paths and in the surrounding woodland. Again, these should be treated as separate collecting sites, or at least microsites, though the nature of the ecological difference may not be specifically revealed by any of the site descriptors on the form, unless there is one for trampling or shading. If only one species is being collected, then the full habitat description can be accommodated under 'Description of site'. When more than one species or potential ecotype are being collected, however, it may be easiest to simply describe in this separate descriptor the microenvironmental differences involved. Free text is the most satisfactory way of recording this information, and two lines will usually be adequate.

Abundance

The abundance of a species or phenotype within the plant community may give an indication of such factors as its competitive ability or degree of adaptation in a particular environment. This information can be of interest but is not usually of prime importance, unless the population is small and threatened.

There are a number of ways of measuring the abundance of a species at a site, e.g. biomass, density, frequency, basal cover or crown cover. The simplest and most convenient method for germplasm collecting purposes is to give a rough estimate of crown cover. This entails imagining that the site is being viewed from above. The amount of ground occupied by the vertical projection of the aerial parts of a species is its crown cover. This is normally estimated as a percentage, ranges being grouped together into units. Several cover scales have been developed but the main two are the Domin and the Braun–Blanquet scales (Shimwell, 1971). A slight variant of the latter is given below.

- ☐ a single individual
- ☐ scarce, ⩽5%
- ☐ common, 6–25%
- ☐ moderately common, 26–50%
- ☐ abundant, 51–75%
- ☐ dominant, >75%

General frequency in the region surrounding the collecting site (y) may be combined with abundance at the site itself (x) in some composite index $x|y$ (Isbell and Burt, 1980).

Spatial pattern of population

This descriptor refers to how crown cover of the target species is distributed within the habitat, whether at random, regularly or contagiously (as clumps). Randomness is normally taken as the null hypothesis and departure from randomness (i.e. the existence of pattern) tested. The causes of departure from randomness may be environmental or intrinsic to the plant. Both are interesting to the plant collector. If the cause is environmental, this will help define the adaptation of the material. If intrinsic, it may give information on the distance of seed dispersal in the target species, for example, or the extent of vegetative propagation, which may be relevant to the future user and will in any case affect sampling strategy at the site.

Pattern may be detected by counting the number of individuals in a set of quadrants and comparing the results with the expectation from a Poisson distribution. This will rarely be possible or necessary in the context of germplasm collecting, when a simple visual assessment will usually be sufficient. The extent or scale of any clumping may be described according to a sociability scale such as the following, which also includes an element of abundance (Goldsmith *et al.*, 1986):

- ☐ growing once in a place, singly
- ☐ grouped
- ☐ in troops or small patches
- ☐ in small colonies, extensive patches or forming carpets
- ☐ in great crowds or pure populations

Separation from other populations

The spatial relationship between the population being sampled and other populations of the same species is important because, in the absence of precise information on the distance that pollen and seeds can move, it can assist in inferring the degree of genetic isolation of a particular population. If populations are distinctly separated, there may sometimes be obvious physical reasons for this. An example would be a species that only occurred around the edges of widely separated freshwater pools in an otherwise dry environment.

This field is adequately covered by a straightforward question such as 'Is the population well separated from others of the same species?' If the answer is yes, details of any obvious barriers may be added as free text. The distance to the nearest conspecific population may also be given.

Population management

Individual wild and semicultivated species may be managed by local people quite specifically, independently of the general vegetation at the collecting site. Particular species within the vegetation, for example medicinal plants and fruit trees, may be managed and protected in specific ways. In an area to be cleared for shifting cultivation, for example, selected trees may be spared, some self-propagated trees actively protected and other species actually planted. In some societies, people may have private tenure over individual trees. A particular grass may be selectively harvested as fodder. If it is such species that are being collected, the specific methods of management need to be documented here. A useful framework for describing tree management is provided by Mathias-Mundy *et al.* (1992). Such information will mostly come from consultations with local people.

Crops

Cultural methods

The specific way in which a landrace, crop or semicultivated species is grown and managed can be an important determinant of its success: it will probably have become very closely adapted to particular cultural methods (cropping system, or 'système de culture') within the farming system. It is thus important that detailed information on the cultural methods associated with the population sampled accompanies the sample. The information will come both from consultations with farmers and actual observation (which could be photographed or video-taped). In general, free text will be needed to describe cultural practices, though the field could be broken up into separate topics. Examples include Byerlee *et al.*'s (1980) checklist of crop management practices and Mathias-Mundy *et al.*'s (1992) framework. The techniques, materials and tools used in carrying out each of the activities listed below, and the people involved (men, women, adults, children, etc.), should be described and the terms for them in the local language recorded. Timings and frequencies can be recorded here or in a separate 'Growing season' descriptor.

- site selection and seedbed preparation;
- planting and transplanting (type of planting material, density and spacing, associated crops and landraces, rotations);

- thinning (to achieve desired plant density, but also including roguing, removal of off-types, etc.), pruning, etc.;
- nutrient management;
- plant protection measures, including weed management;
- water management;
- harvesting;
- farmers' selection methods (including special seed production methods);
- threshing, cleaning, drying and other postharvest management;
- storage;
- disposal of major product and of crop residue.

Farmer's selection methods will be a particularly important factor to document. Selection is usually done after harvest, but some farmers mark those plants that are to be used as sources of next year's planting material while they are still in the field. Selection criteria may be for uniformity in particular character(s), or aimed at maintaining a degree of variation. Planting material may be produced in special plots, isolated from the main fields and treated in different ways (Linnemann and Siemonsma, 1989).

Growing season

Information on the timing of agricultural activities relating to the sample, in particular when the field was planted, transplanted and harvested, is important to breeders and other end-users. Characters such as early maturity or short growing season are often keenly sought by breeding programmes. These data also provide information on temperature tolerances, frost sensitivity and day-length sensitivity.

Timings will eventually have to be recorded in terms of months of the year on the collecting form, but will probably be collected in the first instance according to some local system, perhaps involving stars or the moon. Seasons will have specific local names, which may be incorporated into the local names of landraces. A seasonal calendar in which the activities listed under 'Cultural methods' are related to each other and to environmental factors in time is a useful way of presenting such data. Such calendars can be made gender- and age-disaggregated to show how activities are divided up within the community (Thomas-Slayter *et al.*, 1993). Box 19.4 describes a participatory method for obtaining information on the timing of activities through the year. The local system should be used for recording seasonal calendars, and this may mean that the yearly cycle starts not in January but with the rains, say, or the appearance of a particular star. It is often easier to detect seasonal patterns visually in 18-month than conventional 12-month calendars. Even longer calendars have been used.

User evaluation

The reason why a particular landrace is being grown is not always apparent to outsiders. Conventional agronomic factors such as yield can be of secondary importance to the subsistence farmer. A rice variety may be liked despite its relatively low yield because the endosperm does not break when pounded, for example, or for its taste. It is clearly important to know what different categories of local users (e.g. men and women) like and do not like about each landrace collected. Farmers' evaluation tends to be relativistic: this is why triads and sorting/ranking tests are used in this context. In contrast to conventional evaluation, where an absolute value for, say, yield, could be arrived at, in farmer evaluation the properties of a particular landrace will be expressed relative to those of other landraces, and will need to be recorded in such terms. Box 19.6 describes two participatory methods of germplasm evaluation by local users (they are also applicable to evaluation of land, soil, etc.).

History of sample and of landrace to which it belongs

People move crop germplasm around. It is not uncommon to find that in fact the population sampled can be traced back to planting material which was recently introduced from some other, perhaps very distant, place. Perhaps the original introduction was of only a few seeds or a single cutting, which would have consequences for the genetic base of the material. It is important to document this because collectors often work in a particular area in the expectation of finding material adapted to the environmental conditions prevalent there. If material was brought in from outside the area, its actual origin should be noted, as it may not have the required adaptation (though of course it might nevertheless be worth collecting). If produced locally, the method of selection and seed production needs to be documented. Origin is often alluded to in the vernacular name of a landrace. However, farmers will usually know the history of their planting material in detail, often going back many years.

Whether cultivation by the household of the crop or landrace represented by the sample is likely to decline, and why, may also be recorded here (or under 'Genetic erosion'). More general information on trends in the village or surrounding areas may also emerge in the course of consultations with local users, particularly life-history elicitation, and may be recorded (probably in the collecting notebook) as free text or in the form of notes on trends appended to time lines of important events in village history (Chapter 18).

Box 19.6
Participatory ranking (after Theis and Grady, 1991, and Kabutha *et al.*, n.d.)

Direct matrix ranking

- List the landraces or species under consideration (three to eight items), and display examples of each to the interviewee or group.
- Elicit criteria by asking 'What is good about this item? What else?' and 'What is bad about this item? What else?' until there are no more replies.
- List all the criteria, turning negative criteria to positive ones, e.g. 'attacked by pests' into 'resists pests'.
- Draw up a matrix of criteria by items.
- For each criterion, ask which item is best, next best, worst and next worst. Of the remaining, ask which is better. Assign scores, and add up the score for each item. If a group exercise, people could be asked to vote for their preference, and the number of votes added up.
- Ask which criterion is most important.
- Ask which item is best overall: 'If you could have only one, which would you choose?'

Pairwise matrix ranking

- Draw up a matrix with the items in the same order along the side and the bottom.
- Each square represents a paired comparison. Ask the informant(s) which of the items is the better, and why.
- When the matrix is complete, add up the number of items where the item was identified as more important, and arrange them in the appropriate order.

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