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CHAPTER 11

BOTANICAL COLLECTING

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11.1 INTRODUCTION[1]

Since plants are a very important part of the material and cultural heritage of all communities, those who are interested in studying the culture of a people require an understanding of the plants associated with them (Fosberg 1960). To understand plants and their association with the people, it is important to know the identity of the plant species used by them. Knowing the vernacular name of a plant used by a community assists with communication within that community but fails to provide information to a broader group. Furthermore, the information on how this plant is used by other communities remains inaccessible to most researchers. Therefore, it is important to link local plants to their scientific names so that all the information about these plants is available to everyone (Conn 1994). However, the identification of plants is often quite difficult and requires careful examination of the features of the plant and comparison with other previously identified species. Therefore, carefully prepared botanical collections are always required to identify plants

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with certainty. Furthermore, our scientific understanding of the relationship between plants is constantly being revised, particularly as new techniques and data, such as molecular data, are becoming available; the names of many species have been changed to reflect these changes. Therefore, the lodging of botanical collections in scientific herbaria and museums is important for acquiring the currently correct scientific name for a plant. Since each collection will be available for further study at a later stage, the scientific name can be corrected based on modern knowledge, thus ensuring that vernacular names always remained linked to the correct scientific literature.

This chapter provides a brief introduction to the techniques used for collecting botanical specimens that will enable fieldworkers to provide specimens of plants that are adequate for identification and valuable for scientific study.

11.1.1 Botanical identification

Many different types of publications provide information about the diversity of the flora of a region. These publications include:

1. Checklists: a simple list of plants of a specific area. Sometimes these lists are annotated with brief descriptive notes, such as Charters (2003–) and Press, Shrestha, and Sutton (2000–). Local authorities, especially environmental agencies, frequently have unpublished checklists that are often more current than the published lists. These checklists can also be very useful for identifying plants from a specific area. However, a high level of botanical taxonomic knowledge is usually required to use these lists effectively to assist in identification.
2. Field guides: usually provide readily observable features that can be used in the field for distinguishing plants of a specific area, usually with brief descriptions, often with illustrations, of the most common plants of an area (e.g. Balgooy 1997; 1998; 2001; Court 2000). Sometimes field guides are only a list of botanical names and photographs and/or illustrations. However, many popular field guides are excellent (e.g. Harden, McDonald, and Williams 2006; Hutton 2008; Steenis 1949–) and these publications are usually adequate for identifying the plants of a specific region.
3. Floras: descriptions, identification tools (keys), illustrations, and images of plants of a specific area, for example Nee (2004, 2008), Stannard (1995), Steenis (1949–). Recently, more of these floras are readily available via the internet, such as Conn and Damas (2006–), Conn et al. (2004–), Flora of Guianas (1885–), Flora of North America (1993–), Hoch (2000–), Western Australian Herbarium (1998–). eFloras (2009) is an excellent on-line resource that provides a comprehensive listing of electronic floras (e.g. Flora of China 1994; Ulloa Ulloa and Jørgensen 2004) and checklists, as well as other information.
4. Scientific revisions: these are more technical scientific publications than the previous examples and are published in peer-reviewed scientific journals and

books. These publications often deal with larger taxonomic groups, such as a family or genus, frequently dealing with a specific geographic area. They provide the same information as a 'Flora' but usually in more detail and with more precise technical terminology than used in the other forms of publications. However, early scientific publications are often very brief, being little more than a listing with a brief descriptive diagnosis in Latin. All forms of scientific revisions usually require a specialized level of knowledge to use effectively.

There are too many useful publications available to provide a generalized simple list here. However, Frodin (2001) provides an extensive and yet selective annotated bibliography of the principal floras and related works of inventory for vascular plants. The book lists principally specialist publications such as floras, checklists, distribution atlases, systematic iconographies, and enumerations or catalogues. A few popularly oriented books are included. Increasingly, publications that are useful for botanical identification and general information about botanical diversity are becoming available in electronic format, e.g. 'Flora of Australia' (ABRS 1981–), 'Flora of China' (Flora of China 1994–) and 'Flora of Taiwan' (TAI 2003–). Other publications are also available electronically, e.g. the printed version of 'Flora Europaea' (Tutin et al. 1964; 1968; 1972; 1976; 1980; Moore 1993) has been replaced by Walters and Webb (2001). Interactive guides to many plant groups have been specifically developed as CD ROM products (e.g. Agoo et al. 2003; Brooker 2006; Hyland et al. 2003; Jones et al. 2006; Maslin 2001; Schuiteman and Vogel 2001; 2002; 2005; 2006; 2008; Schuiteman et al. 2008; Thiele and Adams 2002).

Since new electronic interactive identification tools are being rapidly developed, regular searching of the internet is strongly encouraged. Specific websites (e.g. Anonymous 2001–) provide current information on their theme. The websites of herbaria are also an excellent resource for links to relevant identification publications (e.g. Missouri Botanic Gardens 2009). Of course, the primary resource should always be the authoritative advice of herbarium staff.

11.1.2 Botanical terminology

The descriptive terminology for plants and their component parts have been developed for the purpose of providing an accurate and complete vocabulary for description, identification, and classification (Radford et al. 1998). The collector requires some knowledge of this terminology so that adequate material and accompanying field notes are provided to assist the identification process and to provide material that is useful for other scientific purposes. For example, a basic understanding of the structure of flower is required if the colour or shape of the parts of a fresh flower are to be described unambiguously for interpretation of the dried material. A glossary of technical terms is usually provided in regional 'Floras' (Conn and Damas 2006–) and in specialized textbooks on plant systematics of taxonomy (Radford et al. 1998–).

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A generalized search of the internet will recover several excellent on-line glossaries of botanical terms (e.g. Lyne n.d.; Flora of China n.d.; Wilmé 2002–). However, it is preferable to use the glossary of terms provided in the publication being used for identification purposes. Some otherwise 'standard' terms may be defined slightly differently in various botanical publications. The terminology used in this chapter has been simplified as much as possible, but reference to a botanical glossary may be required. There are a few specialized glossaries that assist with the translation of a botanical term to other languages (e.g. Rossi-Wilcox n.d.).

11.1.3 Collecting equipment

Botanical collecting, especially in remote areas, requires considerable planning before the fieldwork is undertaken. A summary of what should be done to ensure safe and successful field studies is discussed in §11.6. Before starting to collect botanical specimens, the correct equipment is required. The equipment includes: secateurs, hand lens (10× magnification), jeweler's tags, field book, knife, paper and plastic bags (of various sizes to put plant samples in), small clip-lock plastic bags, silica gel (for drying samples quickly if required for molecular studies), plant press, newspaper, cardboard sheets, tissue paper, GPS (Global Positioning System), maps—topographical, road, and any other maps of the area—pencil (preferable) or waterproof or permanent-ink pen.

11.1.4 Using local knowledge

Local knowledge of the landscape (see Turk et al., Chapter 16 below), other natural features including local climate, and an understanding of modifications to the local environment are always valuable. This information may mean the difference between finding a plant and not locating it. Furthermore, since you may need to visit or traverse private land, it is important to obtain permission and assistance from local landowners before undertaking any field activities.

11.2 The botanical collection

The essential aspects of making an adequate plant collection for identification and further scientific study include collecting botanical material that is of adequate size and has required morphological features, and the provision of adequate supplementary information provided by the collector.

The importance of collecting adequate botanical specimens cannot be overemphasized. Good specimens are always required for accurate identification. The morphological characteristics of good specimens form the basis of continuing scientific research. Although other sources of data are being increasingly utilized, such as molecular data, morphological features remain the primary source of data for communicating species concepts. As our scientific knowledge of taxonomy improves, the identity of good specimens can be re-determined. Since these collections are authenticated vouchers for the original project, the information in that project will remain linked to the most modern taxonomic concepts via these collections.

Although it may be easier to examine an unmounted botanical specimen, normal handling easily damages dried, brittle material. Therefore, herbaria and museums affix these specimens to white mounting cards/sheets. Many of the collections held by these organizations are irreplaceable, and any serious damage would lessen their scientific value. Furthermore, herbaria and museums are custodians of these natural heritage objects on behalf of the citizens of their region. Therefore, it is useful to remember the size of the herbarium sheet that will be used to mount the specimen. Since most herbarium sheets are about 430mm long and 280mm wide (or larger), botanical specimens about 300mm long make suitable specimens of most species.

When possible, collect the entire plant or at least a portion of a plant when it is much large than a typical herbarium sheet. A typical branch or portion of the stem, about 200–300mm long, showing the leaves in position and with flowers and/or fruits (both if possible), should be collected: these are the characteristics that are traditionally used for determining the identity of a plant. If open flowers are not available, then flowers buds should be included. If variation in leaf form is apparent, specimens should include different parts of the same plant to represent this variation. Seeds can be useful in the identification of plants and should be included, if available.

For plants with large leaves or massive fruits, do not limit what makes up the collection because it may be difficult and/or take a great deal of time. It is more important to have a complete, useful specimen than to conform to arbitrary rules (but see below about storage of large specimens).

11.2.1 What to collect

The features most important for identification vary between different plant groups. The major plant groups and some specific requirements for collecting these groups are listed below.

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Figure 11.1. Selecting material from a flowering branch for the botanical specimen using secateurs.

11.2.1.1 *Vascular plants*

Vascular plants (also known as 'higher plants') are plants that have specialized tissues (often woody) for conducting water, minerals, and photosynthetic products through the plant. Vascular plants include the ferns, clubmosses, flowering plants, and conifers. There are many useful publications on the collection of vascular plants (see references cited in Taylor 1990). Additional practical advice for working in tropical regions is provided by Hyland (1972), Kajewski (1933), Mori (1984).

(i) **Ferns.** It is important to make sure that the specimen being collected is fertile (spore-bearing) (Bridson and Forman 1998). The spores are arranged in sporangia which differ in position and appearance in the various groups of ferns. In the majority of ferns the sporangia occur on the margin or on the lower (abaxial) surface of 'leaves' (fronds). Therefore, specimens must include the sporangia (if separate from the fronds), or fertile (spore-bearing) fronds and sterile fronds, as well as part of the rhizome (if present) or base of stem (stipe). For tree ferns, a portion of a fertile frond and the base of the frond stalk bearing scales or hairs must be collected.

(ii) Herbs. When dealing with small herbs the entire plant should be collected. Herbs with underground storage organs should be dug up complete with storage organs. However, if the plant is uncommon, make notes on the characteristics of these basal parts, including measurements and drawings, and leave them to shoot again in the following year. This is especially important in the case of orchids and rare species.

(iii) Grasses. Grasses and other plants of grass-like habit, such as sedges and rushes, should be collected whole so as to show the rootstock. Grass clumps may be broken up into small tufts of leaves and flowering stalks; two or three of these tufts should make a satisfactory specimen. All soil adhering to the roots should be carefully knocked off or washed away. Grasses are best collected after the flowers have opened, but before fruits are ready to drop. If the grass specimen is longer than the herbarium sheet (see measurements above), it should be bent once, twice or more so as to form a V, N, or M (according to its length) and pressed in this position. Attempts to bend it after it is dry will probably cause it to break. In the case of exceptionally tall grasses, the flowering parts and a piece of the basal parts should be collected, and a note made of the height and habit.

(iv) Bamboos. Bamboos are variously woody, temperate, or tropical grasses that have jointed and often hollow stems. They can be identified from sterile material (lacking flowers and fruits); however, reproductive structures have traditionally been used for identification purposes.

The parts of the plant that are essential for identification are discussed in Soderstrom and Young (1983) and Womersley (1969). The features include:

1. Culm sheaths: at least two complete sheaths, from about the fifth node from base of culm ('stem') and several mature sheaths from mid-culm nodes. Attach to each of these sheaths a label that records the node from which they were collected. If too large, then cut or fold as necessary. If a sheath cannot be flattened without fracturing, then roll and do not press. However, it is necessary to protect the fragile apex of the sheath by enclosing the rolled sheath with paper.
2. Leafy twigs: include large and small leaves, both young and old. Since the leaves often begin to 'curl' soon after collecting, it is advisable to press the leaves as quickly as possible.
3. Section of branch: at least one typical section of a branch (15–18cm long) from about half-way along culm.
4. Culm nodes and internodes: a segment of mature-sized culm, including the fourth and fifth nodes above the ground.

5. Rhizome: at least one complete example of the structural unit, preferably two or more units that show the branching habit of the rhizome (the horizontal, usually underground stem that often sends out roots and shoots). Trim off roots.
6. Flowering branches: although rarely present in bamboos, collect enough to show the habit, leaf arrangement and density, and stages of development. Collect fruits if present, making sure they are not lost (during pressing and drying) because they readily detach from the plant.

Photographs, sketches, and additional notes complement the botanical specimen and are extremely helpful when identifying the plant.

(v) **Trees and shrubs.** As for all plants that are too large to fit onto the herbarium sheet, additional information about the tree or shrub being gathered must be recorded at the time of collection. When collecting trees, the collector's notes should describe the colour and type of bark (e.g. rough, smooth, stringy, or fibrous) and if rough, how far it extends (e.g. over base of trunk only, also on main branches, and/or on fine twigs); sometimes it may be appropriate to collect a wood and bark sample as an ancillary collection. As for other flowering plants, flowers, including flowering buds and fruits, should all be collected if available. Since there may be differences between the types of leaves present on a plant, the collection of adult and juvenile leaves, and sun and shade leaves should be observed and collected if different, or described if any of these cannot be obtained. Since many plants are deciduous, the flowers and fruits may be present when leaves are absent. This should be recorded in the collector's field notes. Each separate stage of the plant's lifecycle can be collected independently and treated as separate specimens, but from the same plant. The bark features may not be as important for the identification of large shrubs, but it is always good practice to record this information at the time of collection.

(vi) **Succulents.** The tissues of succulents and fleshy plants (e.g. cacti, agaves, aloes, bromeliads) usually contain large amounts of water, and some even tend to retain water during the pressing and drying process. There are several techniques used to overcome this problem (Victor et al. 2004):

1. Remove inner tissue: the specimen can be cut longitudinally or transversely so that the fleshy inner tissues can be removed before pressing. This method is used for *Aloe* species and many species of cacti.
2. Hot water/liquid treatment. Submerge the plant material in very hot water or in methylated spirits, petrol or even vinegar. Prior to submersion, pierce material with a needle to allow ready penetration of liquid.

3. Freezer/microwave: place unpressed material in a freezer for two days and then place in microwave for periods of 5–10 seconds and then check, repeat as necessary until material dried (Leuenberger 1982).

Fleshy flowers can be prepared for pressing and drying by cutting longitudinally, separating the two halves on white card (some prefer moistened gummed paper—Victor et al. 2004), cover with wax paper and enclose in a sheet of newspaper and then press with the remainder of the collection.

There are many excellent references on pressing and drying succulents that should be consulted for detailed information (e.g. De Langhe 1972; Logan 1986; Croat 1985; Griffiths 1907; Jorgensen 1972; MacDougall 1947).

(vii) Plants with large inflorescences or other large parts. When collecting plants such as agaves, palms, pandans (Stone 1983), or bananas, the lengths of the flowering and non-flowering parts of the inflorescences and trunk heights should be noted. For plants such as large-leaved palms, cycads, bananas, and aroids, the smallest complete leaf is often many times larger than the standard sheet. There are two collection and storage methods for such plants. One technique is to cut the leaf into numerous (carefully numbered) portions which are attached to multiple herbarium sheets in the herbarium or museum. This has the advantage of not requiring alternative storage areas. Disadvantages include the need for additional documentation, preferably including photographs, and the difficulty of relating the specimen to the living plant. The alternative technique is to collect the entire leaf and to provide special separate storage for such material. The main disadvantages of this technique are that the material is difficult to handle in the field (to press and dry) and greater storage space is required.

(viii) Bananas. The collection of giant herbaceous plants, like bananas, some aroids, and heliconias, is always difficult. As for all large plants, it is impossible to collect the entire banana (*Musa*) plant as a herbarium specimen. Photographs, sketches, and extensive detailed notes are essential. Record the following features:

- Pseudostem ('stem'): suckering habit, height, colour, degree of waxiness, colour of exudates (sap), height, and diameter.
- Leaves: held erect or spreading, length and width of lamina (size of leaf blade), length of petiole (stalk of leaf), including leaf colour, waxiness, and markings), margin of sheath (lower part of leaf that more or less surrounds the stem).
- Fruit clusters: banana fruit grow in hanging clusters, with fruit arranged in a 'hand', and several hands form a bunch. Record if the bunches are erect, semi-pendulous, or pendulous, number of hands per bunch, whether hands compact or distant from each other, number of 'fingers' (individual fruits per hand), and whether fingers are close together or distant.

- Fingers: curved upwards or downward, length, diameter, cylindrical or angular at maturity, colour of skin when immature and mature, whether skin peels off mature fingers, colour of pulp surrounding seeds.
- Rachis: the axis of the fruiting bunch. Record if rachis is directly pendulous, slightly S-shaped, or markedly so.
- Male bud: occurs at the end of the rachis. Record shape, size, and colour (photograph and make a drawing). Also record whether or not the bracts overlap each other.

To make adequate herbarium specimens from bananas is extremely difficult, but the best method is to store most material, except for leaf samples, in bottles containing solutions of 70 per cent ethanol or methylated spirit. Removing some of the bracts from female and male flowers assists with the penetration of the preserving liquid.

(ix) Palms. When collecting palms it is important to realize that ample time is required to prepare a good herbarium specimen, especially of large tree palms. Since the plant is too large to collect in its entirety, the collection should represent the living plant in such a way that someone else can imagine what the palm looked like from the material that you collected (Dransfield 1986). As for other flowering plants, it is generally not sufficient to collect sterile specimens for the purpose of identification. However, sterile material of rattans (climbing palms) has many useful features for identification purposes in the leaf and leaf sheath (Baker and Dransfield 2006). The features to collect include:

- A section of stem: if stem is slender then take a sample of stem. However, if large, cut off a thin strip of the stem's outer surface.
- Leaf sheath: take an entire sheath and split it down the middle, cut into fragments if very large, representing base and apex (always clearly label all parts).
- Leaf: remove an entire leaf, or if large, then cut into smaller sections representing base of petiole (stalk of leaf), basal part of leaf (often first leaflets) plus apex of petiole, a middle section of leaf with axis (rachis), and then apex. Label all parts carefully. The leaflets from one side of the leaf can be removed if the leaf is very large.
- Inflorescences (arrangement of flowers): if large, then cut inflorescence into sections and provide a basal part, middle, and apical portions.
- Flowers and fruits: good flowers and fruits are required. You may not be able to get both from the same plant. Furthermore, fruits and seeds may be plentiful on the ground. Collect germinating seedlings as these can be useful.
- Rattans (climbing palms): collect the climbing 'tendrils' and record if they arise from the leaf apex or the leaf sheath. Do not attempt to remove the sheath from the stem.

(x) Aquatic plants. Generally the entire plant should be collected, if possible. As for terrestrial plants, aquatic vascular plants usually require flowers and mature fruits for identification; others require the rhizomes (e.g. water lilies) and rootstock; since immature and/or submerged leaves are different from mature and/or emergent or floating leaves, these should be collected as well. Remember that aquatic plants will wilt very quickly once removed from the water. Keep them in a bag or bucket with some water at all times until ready for pressing.

Some very small plants, like the floating duckweed (*Lemna*) and floating fern (*Azolla*), do not make very satisfactory pressed and dried specimens, but these can be placed between paper towelling (very absorbent paper) for pressing and drying, to produce reasonable specimens. Plants which contain a lot of mucilage are better pressed between sheets of greaseproof paper (Leach and Osborne 1985). Many publications that provided useful information on collecting aquatic plants (e.g. Haynes 1984; Ceska and Ceska 1986; Fish 1999).

11.2.1.2 *Non-vascular plants*

Non-vascular plants ('lower plants') are plants that lack specialized vascular tissue. These plants have no true roots, stems, or leaves; however, they often have structures that are superficially similar. Non-vascular plants include two distantly related groups, namely, Bryophytes (Lepp 2008+) and Algae (green algae) (Entwisle and Yee 2000–; Entwisle et al. 1997; Millar 1999–).

(i) Bryophytes (mosses, liverworts, hornworts) and lichens. Bryophytes and lichens should *not be pressed* when collected because the pressing process distorts the form of the plant and destroys some of the critical morphological features.

Detach the specimen from the substrate by hand or by use of a knife blade, taking care to include a narrow layer of soil or bark underneath the plant. Collecting lichens that grow on rocks can be more difficult, and may require some of the rock to be chipped away with a hammer or geological pick.

Place the specimen in a brown paper bag—never use polythene bags. However, remember that some bryophytes, for examples species of peat moss (*Sphagnum*), may contain large amounts of water. Remove as much of the water as possible by gently squeezing prior to placing specimen in paper bag. To make sure that the plants dry quickly, it is usually necessary to open the bags to the air or fan (if available) as much as possible. This is especially true in the wet tropics, where it is often difficult to dry any type of botanical collection. Once the specimen has dried, remove the excess soil and place the specimen back in an envelope and keep in a dry place until ready for despatch to an herbarium for identification.

(ii) Algae.

Freshwater algae Large algae and any attached microalgae can be collected by hand or with a knife, more easily in shallow water than deep. However, the risks associated with tropical waters, such as larvae of parasites, crocodiles, and other predatory animals, strongly indicate the use of various mechanical aids (Fosberg and Sachet 1965). The collection should include at least part of the substrate (e.g. rock, plant, or wood) if possible. When searching for freshwater algae, it is important to search all habitats in the body of water being investigated, including the edge of stones in fast-flowing water, surface of aquatic plants, dam walls, and any floating debris. In running or slightly turbid waters, a simple viewing box made from transparent Perspex enables attached algae to be more easily observed (Entwisle and Yee 2000–). A 10× hand lens is often required to determine if material is fertile. Microscopic floating algae (phytoplankton) can be collected with a mesh net (e.g. with 25–30 μm pores) or, if present in sufficient quantity (i.e. colouring the water), by simply scooping a jar through the water. Water samples can be left overnight allowing the algae to settle and concentrate on bottom of container. Squeezing peat moss (*Sphagnum*) and other mosses, or some aquatic flowering plants is a good way to collect a large number of species (Entwisle and Yee 2000–). Algae growing on soil are difficult to collect and study, many requiring culturing before sufficient materials are available for identification. An understanding of the morphology of freshwater algae is very useful when making collections (e.g. Wehr and Sheath 2003).

In addition to the standard information provided by the collector (see below), the field notes should include information on: whether the water is saline, brackish, or fresh; whether the collection site is terrestrial or a river, stream, or lake; whether the alga is submerged during water level fluctuations or floods; whether the water is muddy or polluted; whether the alga is free-floating or attached, and if the latter, the type of substrate to which it is attached; and the colour, texture, and size of the alga.

Initially, algae can be stored in a container (bucket, jar, bottle, or plastic bag), with some water from the collecting site. The container should be left open or only half filled with liquid; wide, shallow containers are better than narrow, deep jars. For long-term storage, specimens can be preserved in liquid (Entwisle and Yee 2000–; Entwisle et al. 1997), dried, and/or made into a permanent microscope mount. Seek advice from professional phycologists for specific advice and instruction.

Marine algae In general, the collection of marine algae (seaweeds) requires specialist diving skills. However, the collection of littoral algae can be undertaken by most people, with due awareness of the risks inherent within the marine environment. Algae that occur in deeper waters can only be collected by snorkelling and/or scuba diving. Although many collections can be made by hand, tools are generally essential. Collected specimens of different seaweeds should be kept separate while collecting. The specimens need to be fertile (with reproductive structures) because these features are required for identification. These reproductive structures are sometimes visible without a hand lens, because they have different coloration on the seaweeds, either on the surface or on special branches of the thalli (body of the alga) (National Taiwan Museum 2006). In addition, knowing the lifecycle of seaweeds can help with the identification of the species (Millar 1999–) and can assist the collector when selecting appropriate specimens. Hence, it is important to observe and record all details about the form, colours, numbers, substrate, location, and the surrounding environment.

As for freshwater algae, storage and preservation of marine algae require specialized treatment. Therefore, advice from experts should be sought on how to manage the specimens of different algal groups. Freshly collected algae should be kept cool after they are placed in plastic bags or plastic bottles (National Taiwan Museum 2006).

(iii) **Fungi.** When collecting fungi, it is important to place the specimens in a flat-bottomed basket or open box to minimize the amount of damage that may be caused to these delicate specimens. Each collection should be carefully wrapped in newspaper or, especially for the smaller and more delicate species and microfungi, placed in individual containers. Never use polythene bags. For agarics, it is essential to collect the entire 'fruiting body' (what most people think of as a mushroom, puffball, or toadstool), the base of the stipe ('stem'), and the remains (if any) of the cup- or sac-like structure (volva) occurring at the base of the stipe of agarics. A spore-print from at least one specimen of each collection is useful for larger fungi (see Bridson and Forman 1998; Major 1975).

11.2.2 Collecting plant disease specimens

When collecting plant material that appears to be affected by diseases, such as rusts, smuts, leaf spot, galls, cankers, and other diseases, these collections can be pressed and dried (see §11.5). It is important to include a collection of the diseased (host) plant that is adequate for identification. Make sure that as many identifiable stages of the disease are represented by the collection. Since it is important to have some understanding of the possible type of disease affecting the plant, further detailed information should be sought (e.g. Schubert et al. 1999 and literature cited therein).

11.2.3 Collecting living material

Living material may be required for cultivation in botanic gardens and gardens of research institutions (Bridson and Forman 1998). Increasingly, these collections are required for conservation purposes by having a readily available source of viable seeds and/or vegetative material for use in habitat restoration (Offord and North

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2009). Cryopreservation of germplasm (seeds, embryos, pollen, and other botanical tissue) at –130 to –196 °C in liquid nitrogen is a method of long-term storage of botanical material for conservation purposes (Hamilton et al. 2009). If requested to collect botanical material for cryopreservation, then detailed instruction would need to be provided prior to making the collection. However, as for collecting herbarium specimens, the collection of living plant material from natural communities represents a potential threat to rare species as well as local populations of more common plants. In general, the collection of living material is not encouraged unless there is an important reason to do so and the person making the collection is adequately proficient in both collecting living material and in maintaining this living material after collection. Note that sale or trade of living material is equally strongly controlled by many regulations. The following are critical points to remember when collecting plants (for further details see §11.6).

- Obtain collecting permits before collecting any material (see §11.6.1) and permission of the landowner before collecting on private land. Report illegal or unauthorized collecting that you encounter to the appropriate authorities.
- If you encounter a plant with which you are not familiar, assume it is rare and refrain from collecting until you have ascertained that it is not rare.
- Collect discriminatingly—even in large populations. Collect only the amount of material you will actually make use of. Care properly for any material you collect—do not let it go to waste.
- Avoid unnecessary damage to sites and their aesthetic values. Avoid frequent visits to the same sites.

If you must collect living plants from natural communities for scientific research, collect in a manner least likely to damage the wild population. Make sure that you understand why the material is required. Although pressed and dried herbarium voucher material can often be prepared with relatively little prior skill, always seek advice and instruction on how to best collect and store the living material.

In order of general preference, collect:

- Seeds, if abundant (see Gunn et al. 2004; Schmidt 2000). For information on how to collect seeds that represent the genetic variation of a species and hence are suitable for long-term storage, see Bridson and Forman (1998), Cochrane et al. (2009), Gunn et al. (2004), Offord and Meagher (2009).
- Cuttings or other plant parts: when plants can be collected and rapidly transported to plant nursery, it is convenient to collect cutting material. Hardwood cuttings of temperate and some tropical shrubs is an inexpensive and simple method for collecting material for propagation. In general, choose shoots with a section of older wood, last season's growth, and a few centimetres long. Softwood cuttings are not as resilient (Bridson and Forman 1998). Both types of cuttings should be dispatched as soon as possible by air, wrapped in moist newspaper and enclosed within a padded envelope.

- Whole plants: this collecting technique is required for plants with recalcitrant seeds and/or herbaceous material that are not readily propagated from cuttings. Seedlings should be carefully packed, with moist shredded paper, preferably enclosed in an ethylene absorption plastic bag; a normal plastic bag can be used but should be opened every evening to allow the ethylene to escape, to reduce or avoid damage to the underground parts (roots, runners, or stolons). It is usually essential that cuttings are dispatched by air freight.
- Collect most material: leave behind some reproductive or regenerative parts such as fruits, roots, or rhizomes (Washington Native Plant Society 2007). This is the least satisfactory type of collecting and should be avoided whenever possible.

11.2.4 How much material to collect?

The herbaria and museums are part of an international network of scientists who share botanical specimens, knowledge, and information about the flora of the world. Since no single organization can hope to have scientists who are specialists on the identification and taxonomy of every botanical group, these organizations donate replicate material of their collections to other organizations so that particular experts can provide expert determinations. Therefore, it is important to always collect more than one sample of each collection so that enough material is available as donations. Three to five replicate collections (all with the same collection number) are usually sufficient unless requested otherwise. Of course, this may not be appropriate when collecting rare and vulnerable species.

11.2.5 Label your collections

Each collection and each separate part of a collection should be labelled with a tag (e.g. a jeweler's tag) on which your name and unique collection number is written (preferably in pencil, never in ink that is not waterproof or resistant to methylated spirits, 70 per cent ethanol, or other solutions that may be used to preserve botanical collections). A personal collection-numbering series is worth beginning, even if you do not intend to collect many organisms. A simple numbering series, starting at one (1), is preferable. Once you have started your own collection-numbering series, continue it for all future collections, in numerical order. Avoid the inclusion of the collection date or some other prefix or suffix: these tend to be confusing for others to refer to and frequent errors are made when referring to these collections. The different parts of single gathering (collection), as for collections of large plants, should all be referred to by your name and the same collection number.

11.3 Field notes and observations

The most important rule to following when deciding on what should be recorded at the time of collection is:

If the feature or information is not present on the specimen or is distorted after it has been pressed and dried, then it should be recorded by the collector.

Botanical features that change and so must be recorded include:

- Colours: these often change during the drying process.
- Shape and sizes of fleshy parts: these change dramatically when dried and pressed.
- Features of delicate flowers may become detached and/or lost, or get changed by the pressing and drying process—for example, the shape of complex irregular or zygomorphic flowers, such as orchids, legumes, and labiates, may become very distorted and so difficult to evaluate once dried. These problems can be at least partly overcome if one or two flowers are carefully opened along one side and flattened so that the inner features are displayed.

11.3.1 What to include in your field notes?

- Collector's name(s) and number: always remember to include the names of any local people who assist you with the collection of the specimen. However, remember that the numbering series belongs to the primary collector; the other people are regarded as secondary collectors.
- Date of collection: if you are aware that the flowers of the plant you are collecting do not last for the full day (e.g. some species of *Xyris* and some aquatics), then record the time of collection as well.
- Locality of collection: the descriptive and spatial coordinates of the locality from where the plant was collected. Include:
  - Country.
  - Province/State/Territory—as formally recognized within the country.
  - Districts/SubDistricts—if formally recognized.
  - Special geographic areas—such as Conservation Parks, National Parks and other special reserves.
  - Description of specific locality—e.g. '5km W of Nauti, on road to Aseki'; '300m S of "Resting Place 2" on walking trail to summit of Mt Wilhelm'. Avoid imprecise descriptions of the locality like, 'near Wanang River', 'between Wail and Goroke', 'N of Ciawi'. Remember that the descriptive locality information is often more useful than anything else for relocating the organism.

- Altitude (m) and how measured, plus degree of precision (also in metres).
- Depth (m) and how measured—for aquatic plants, plus degree of precision (metres).
- Latitude and longitude (or geographical coordinates—eastings and northings): these geocodes should describe the locality as accurately as possible so that the collection site and the plant can be re-visited if necessary. The method used to generate the spatial geocode should be provided (e.g. GPS, Map, Gazetteer), the level of uncertainty of the geocode (in metres), and most importantly, the datum used for generating these spatial geocodes (most commonly, the datum for a GPS should now be set to WGS84). If maps are used to generate the geocode, then the map type, scale, map name, and map number should be provided.
- Habitat—a description of the specific habitat, including vegetation structure and composition (e.g. forest type and two or three of the names of the dominant species), substrate—rock and soil type (including name of host plant for climbers, epiphytes, and parasites).
- Habit notes: a description of the appearance of the plant are important for identification; features that may be distorted in the pressing and drying process or are not represented by the specimen collected should be recorded. Comments on the status of the plant at the collection site should indicate whether or not the plant is thought to be naturally occurring or has been introduced, and whether or not the plant is cultivated.
- Vernacular names and plant uses: vernacular names used by the local people (including the name of the language group). The name of the informant as well as his/her language group should be recorded. An audio recording of the vernacular name is preferable, but is rarely done by botanical collectors. If the plant is used by the local people, then this should be recorded, noting which part of the plant and what its uses are.

11.3.2 How useful are photographs for identification?

Photographs never replace the need for good-quality herbarium collections. Photographs and drawings often assist the person identifying a specimen because the images can better represent features of habit, presentation of plant parts, shape, texture, and colour than is provided by the preserved specimen or the collector's notes. However, the specimen is required as an authoritative voucher of the species. Therefore, photographs and drawings should be regarded as secondary and complementary material to the botanical collection.

Photographs of whole plant or parts of the plant may be used to supplement the information included in the notes (a note in the field notebook 'photo taken' is

Collection Type
- Wood
- Pollinator
- Spirit/Wet
- Seed
- Cutting
- Cytological
- Spore print
- DNA
- Photo

Field det.:..

Locality (and Country, State/Province, Region):

Latitude ° ' " N/S Longitude ° ' " E/W

Datum: .... Alt.: .... m Depth: .... m

Accuracy of Lat/Long ...... m

Frequency:

Habitat (incl. vegetation type, dominant species, substrate)

host (if collecting epiphytes/parasites/fungal diseases):

Habit (incl. bark/wood/leaf features):

Flowers (incl. reproductive features of ferns/non-vascular plants):

Fruits (incl. cones of conifers):

General notes:

Local names: ....

Informant (incl. language group): ....

Local uses: ....

Informant (incl. language group): ....

Collector: .... Collection No.: .... Date: ....

Other Collectors: ....

Figure 11.2. A sample page from a collecting field book showing the usual fields of information recorded when collecting botanical specimens. Other possible types of material associated with collection are listed in textbox.

then useful). If additional material (e.g. photographs, separate seeds, wood, and methylated spirit- or ethanol-preserved collection) is also gathered, it should also be numbered with the same collection number as all other parts of the collection.

11.4 Electronic data

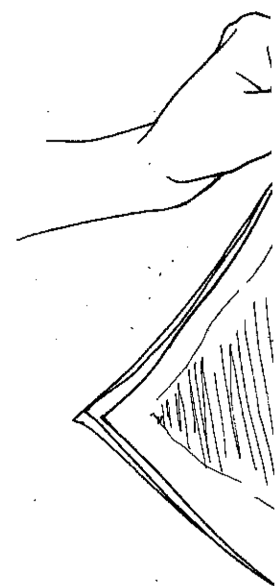
Increasingly, computer systems are being used to store and manage biological data. Develop a data field-based system, such as an electronic database or spreadsheet, to record and store botanical collection data. Personal digital assistant (PDA) hand-held computers are also available for direct data entry. Make sure that you enter the information into the data fields (spreadsheet cells) in a consistent manner, according to the data definition of each field/cell. Always be careful with spelling. For information of data exchange standards refer to Conn (1996) and for more recent versions of this standard, refer to HISPID (2007–). Provide these data to the agency receiving your botanical collections. This avoid data processing errors caused by rekeying information, and will make these data part of a much larger national and/or international biodiversity data network.

11.5 Pressing and drying plants

Once the botanical material has been collected, labelled with the collector's name and collecting number, and the field notes have been completed, the next task is to flatten (press) and dry the material as soon as possible (with exceptions discussed above). The selected specimen is inserted into folded newspaper (Fig. 11.3) or into special drying paper with good absorbing properties. If it is not possible to press specimens in the field because of insufficient time or the inaccessibility of the collecting location, then the collections can be sealed within a plastic bag for a short period of time, usually less than one day, without their deteriorating noticeably. In dry conditions, the collections should be moistened with a small amount of water to minimize dehydration. Individual collections can also be rolled in moistened newspaper and sealed in plastic bags for a short time, mostly for less than twelve hours, and then pressed and dried. Botanical specimens should also be kept cool if they are not pressed and dried immediately. However, it should be noted that many plants, particularly some flowers, are not robust enough to survive any delay in pressing. Every effort must be made to ensure that the separate parts of each collection are kept together until they are pressed.

The reasons for pressing and drying botanical material are:

- to preserve the material for future study;
- to prevent wilting and minimize distortion;
- to not only flatten the material so that less space is required for storage, but to protect delicate features that are generally less likely to be damaged in pressed specimens.



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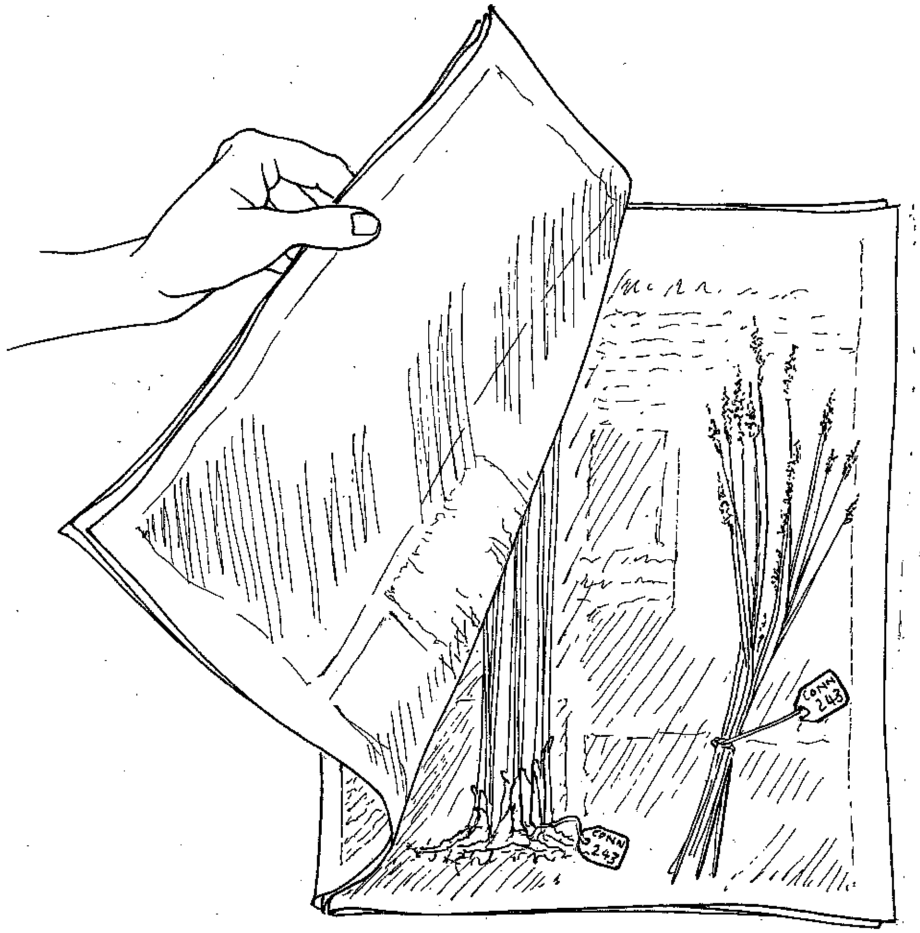


Figure 11.3. Plant specimen inserted into folded newspaper or special drying paper with good absorbing properties. All specimens of the collections must be labelled with the collector's name and collection number.

Remember: the drying papers must be inspected and changed regularly, particularly during the first few days of pressing. This is very important in humid environments and for specimens that have a high moisture content.

11.5.1 The plant press

A plant press consists of two strong, rigid lattice frames, made either of wood or of metal that is slightly larger than a standard herbarium sheet (Fig. 11.4). The botanical specimens are enclosed in drying paper. Newspaper is usually used because it is inexpensive, normally plentiful, and has adequate absorptive properties. Place the specimen in one folded sheet of newspaper and then enclose this in another folded sheet of newspaper that covers the opening of the first (Fig. 11.4). In this way, the specimen is more or less held within the two sheets. Corrugated cardboard or metal sheets (Nichols and St John 1918; Stevens 1926) are often used as ventilators to allow airflow across and between the specimens to assist the drying process. The press is usually held together and tightened by two expandable straps or by small ropes (Fig. 11.4). Polyurethane foam is also useful to maintain more or less even pressure on bulky specimens (Chmielewski and Ringius 1986).

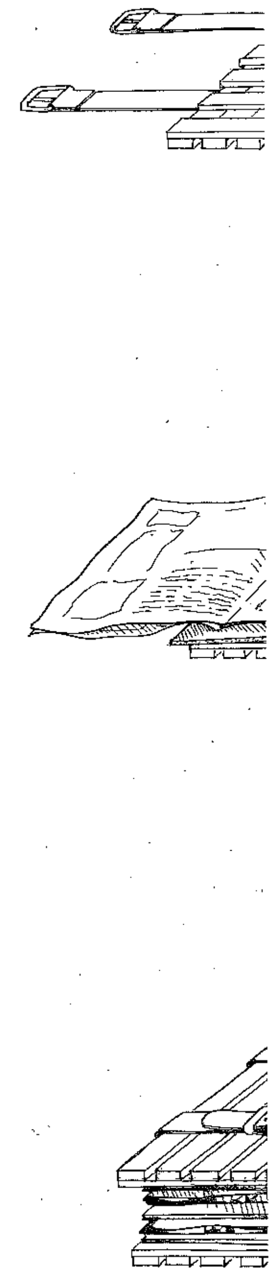
Attention should be given to the pressing process: once a specimen is pressed and dried, its overall shape cannot be readily altered without damaging the material. Therefore, position specimens in such a manner so that the different features are clearly visible. Leaves should show both surfaces, so make sure that some leaves have their upper (adaxial) surface showing while the lower (abaxial) surface of other leaves face the opposite way. Likewise, turn some flowers so that both sides are visible when pressed. Spread the lobes of leaves, flowering and fruiting structures, and flower parts so as to show the shape and arrangement of these features more clearly. Arrange each specimen within the press so as to minimize any damage to other collections. Reduce the bulk of specimens with large fruits, thick stems, or underground parts by splitting or cutting away sections. The number of leaves, flowers, and fruits can be reduced if they obscure important features—but always leave sufficient material to make it clear that something has been removed.

A lightweight, temporary alternative to a field press is an A4-size notebook. A more robust temporary press can also be made from interwoven strips of bamboo.

Remember: after twelve to twenty-four hours the specimens in the press should be examined and rearranged if necessary to improve the presentation of the botanical material.

11.5.2 Drying botanical specimens

In dry climates, drying the specimens is usually relatively easy. Artificial heat is usually not required. However, there must be sufficient airflow between the specimens in the press to ensure that the samples dry quickly, otherwise the specimens may become mouldy. Therefore, even in dry environments, the collections should be checked daily and any damp sheets/newspaper should be replaced by dry sheets (Victor et al. 2004). This method is not suitable in the wet humid tropics, where the drying of collections and keeping them dry can be very challenging. Several useful publications suggest excellent solutions to drying specimens in the wet tropics (e.g. Beard 1968; De Wit 1980; Fuller and Barbe 1981). In all instances, the best policy is to



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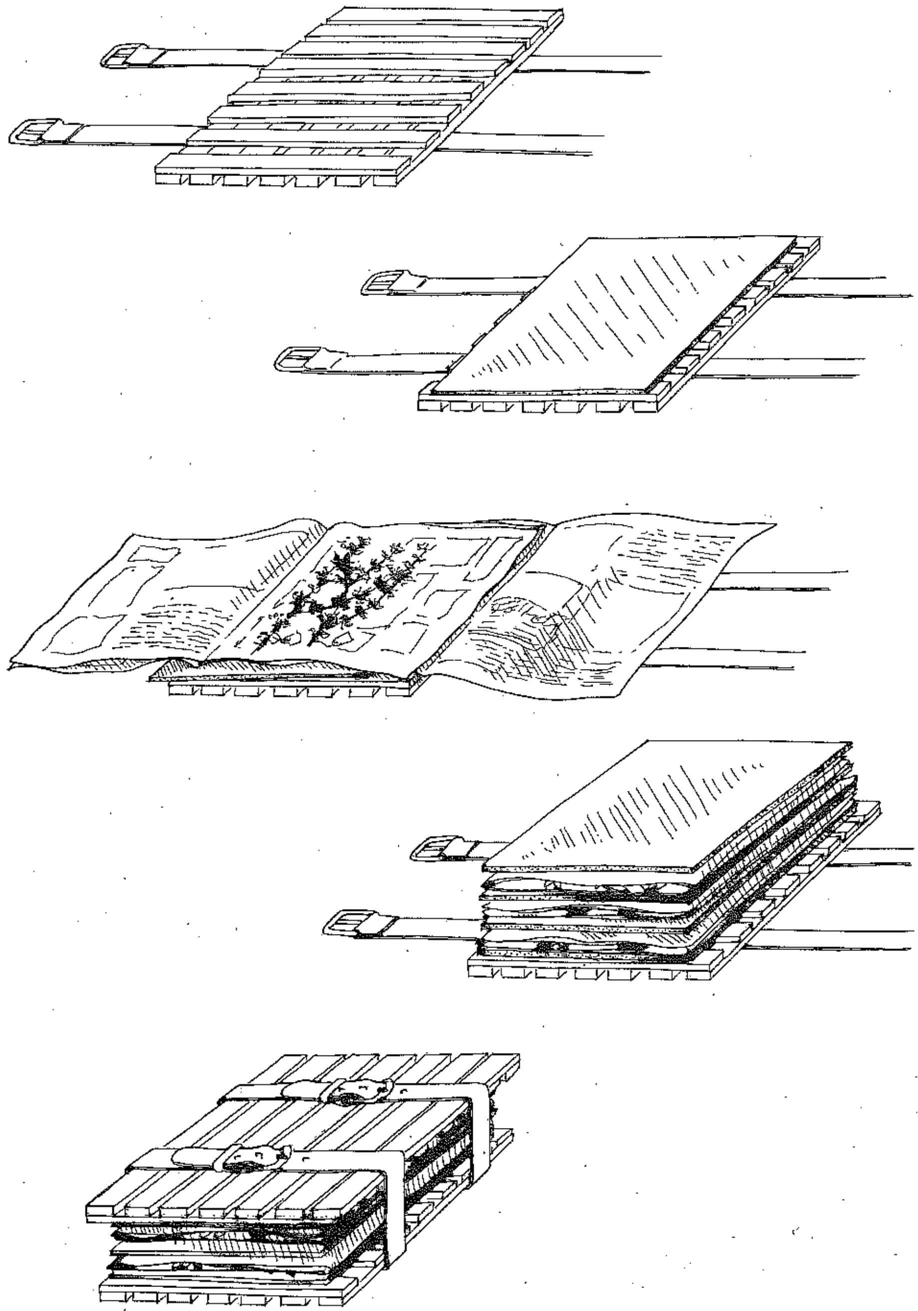

Figure 11.4. Plant specimens being placed in a plant press for drying and pressing. The correct pressing of specimens is very important. The shorter the time between collecting of a specimen and pressing, the better the resulting herbarium specimen. Note: place a cardboard sheet next to the frame of the plant press. Cardboard between the drying sheets surrounding each collection, or between separate specimens of a collection, gives the best results.

get material to a herbarium or museum as quickly as possible, because they have the appropriate facilities and resources to deal with these materials.

11.5.3 Field drying

The drying of material while in the field is often difficult unless the appropriate techniques and equipment is used. Field driers that consist of a source of heat and a frame to enclose the heater and to support the collecting press of specimens are required. Pressurized lamps (kerosene or gas lamps) are very effective and have the benefit of providing light in the camp (Fig. 11.5). If electricity is available, then a hot plate, heating fan (Jenne 1968), or set of light globes makes an effective plant drier (Gates 1950; Hale 1976; Van der Merwe and Grobler 1969; Womersley 1969). Heat can be provided from naked flames produced by gas rings (Halle 1961; Croat 1979) or hot coals (Victor et al. 2004), but are not recommended, because dried pieces of plant material may fall into the heat source and result in a devastating fire. However, it must be remembered that whatever the source of heat, the risk of fire is always a possibility. Care must be taken at all times. If the field trip involves travelling by motor vehicle, then in dry environments, plant presses containing the botanical specimens can be attached to the roof-rack of a moving vehicle. The airflow through the ends of the press will effectively dry the specimens. However, the presses must be secure and frequently checked to make sure that they do not become loose. The consequences of an unsecured press on a travelling vehicle are usually disastrous for the specimens!

11.5.4 Field preservatives

Botanical specimens frequently begin to deteriorate in a plant press if they are not dried promptly. This is particularly a problem with specimens from the wet humid tropics where the leaves frequently fall off and/or the specimens become mouldy. This may happen within a couple of days of collecting. If it is not possible to dry botanical specimens in the field, then there are two preservative liquids that are available which can prevent mould developing in freshly collected botanical specimens, namely methylated spirits (readily available) and 70 per cent ethyl alcohol (with restricted availability). Previously a solution of formaldehyde (known as formalin) was also used, but the previous two liquids are safer to use.

The botanical collections are pressed for up to twelve hours. After this, the specimens are removed from the press, with any damp enclosing newspapers replaced with dry sheets of newspaper. The collections are inserted into a polythene bag or tube (Fig. 11.6). When all the specimens are in the bag or tube (with one end of tube enclosed and sealed with alcohol-resistant tape), add about three average-

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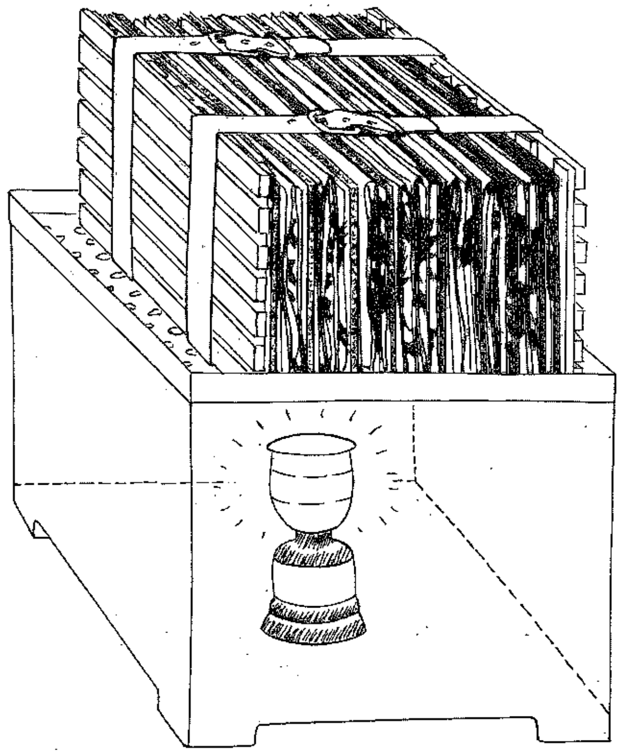

Figure 11.5. A simple plant drier using a pressurized lamp, with plant pressed firmly strapped and placed on one side to allow maximum airflow between the specimens. If the sides of the box/stand enclosing the lamp are of clear plastic, then light is available for other camp activities.

sized cups of methylated spirit or ethyl alcohol solution (Fig. 11.6). Spread the preservative evenly across the open end of specimens, ensuring that sufficient liquid has soaked throughout the material. Since the preservation is effected by the vapor of methylated spirit or ethyl alcohol, it is not necessary that any free liquid be present. Close the open end of tube/bag thoroughly and tie the bundle with a simple crossed string (Figure 11.6) (Womersley 1969).

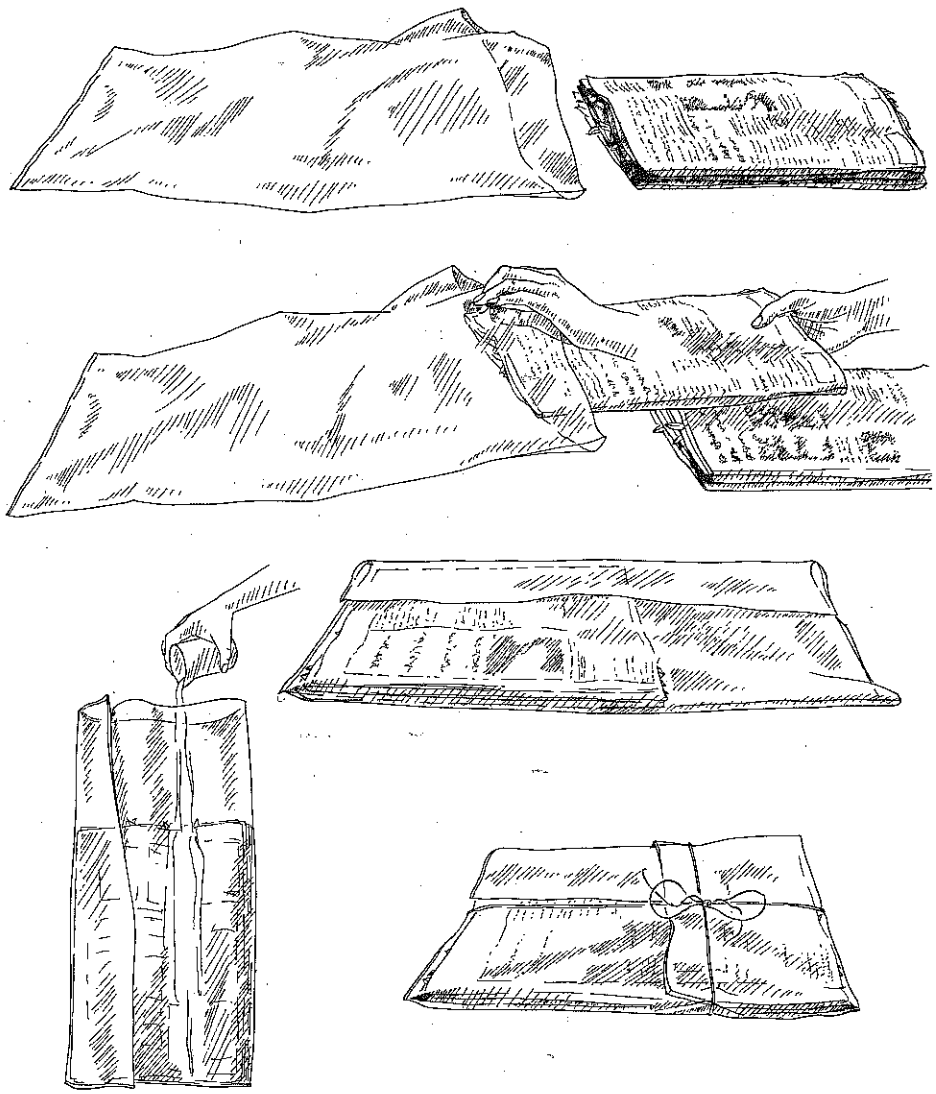

Figure 11.6. Partially pressed specimens can be preserved for later drying by sealing specimens and drying papers in a plastic bag after saturating the papers with methylated spirit or ethyl alcohol. These sealed bags of specimens can usually be kept for two or three months without deterioration. However, the specimens should be sent to a herbarium as soon as possible so that the drying process can be completed.

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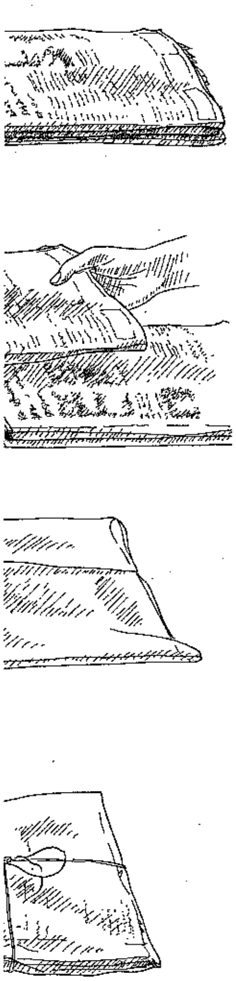

11.6 What you need for plant collecting: pre-fieldwork planning

Botanical collecting in foreign countries, especially in remote areas, requires considerable pre-fieldwork planning to ensure that all the necessary collecting permits and other legal documents have been obtained, appropriate equipment is available, all the personnel have been fully briefed on the social and civil status of the area being visited, and the physical and health risks have been thoroughly assessed. Although some aspects of this planning may not be as necessary when undertaking field studies within the collector's own country, the following points should be considered carefully prior to undertaking any field studies. Cochrane et al. (2009) provide a 'collection checklist' that summarizes important issues to be considered when undertaking botanical collecting.

11.6.1 Plant collecting permit

Most countries are signatories to the International Convention on Biological Diversity (CBD 1993–). Therefore, it is advisable to be fully aware of the laws applicable to the area from which you wish to collect and to obtain the necessary approval and permits. You can usually obtain collecting permits from government departments that are responsible for environment management within the area to be visited. Contact the nearest major herbarium or museum (see Thiers 1997– for contact information) and seek their advice prior to making the collection. Remember, in many countries, separate permits are required for different States or Provinces as well as separate permits for different types of management areas (e.g. conservation parks, national parks, and nature reserves). Finally, remember to obtain permission from local landowners or custodians so that you can undertake field studies on their land.

11.6.1.1 Special permits

Phytosanitary permits will probably be needed when transporting plants across borders of different countries. These permits must be obtained from the country of origin.

The Convention on International Trade in Endangered Species (CITES) legislation regulates and controls the international trade in material obtained from plants considered to be endangered. Remember: scientific material is not exempt from CITES regulations. Therefore, CITES-listed plants require a *CITES export permit* from the country of origin as well as a *CITES import permit* from the authority

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(herbarium or museum) receiving the material. Since not all botanical authorities are registered as an agency approved to receive CITES material, it is important to verify that your collections are being sent to a herbarium or museum that is legally allowed to receive these specimens.

11.6.2 Pre-planning meeting: field hazard assessment

Possibly the most important aspect of field studies is the recognition, by all members of the field team, of the possible hazards that they are likely to encounter in the field. Careful planning and preparation can avoid many of the potential difficulties of working in remote areas. It is recommended that a 'Field Hazard Assessment' document be completed prior to any fieldwork. A copy of the completed document must be held by the principal organization involved with the work. This document should form the basis of a post-fieldwork evaluation of all aspects of the field study.

The topics and issues that should be covered by this document should include the names of participants, including Team Leader; description of project and area to be visited; dates when field team expected to be at specified localities; and insurance arrangements, especially for non-staff.

11.6.3 Emergency aids and contact schedule

Mobile/cell telephone numbers of all team members must be listed and held by all members of the team. However, since the work is in remote areas, a review of any expected areas of non-coverage is essential. If satellite telephones are to be used (and this is strongly recommended for remote areas), all members of the team need to be trained in their use. Likewise, if a two-way radio is to be used, then all members must be familiar with its operation.

Each member of the team must carry matches (in a water-proof container) or a fire lighting flint, a watch (for estimating time) and/or compass for estimating direction, a small reliable light (head-lamps are usually more convenient), survival blanket (especially recommended in alpine zones or high latitudes), and a whistle (for attracting attention).

11.6.3.1 Personal Locating Beacons (PLB) and Emergency Position-Indicating Radio Beacons (EPIRBS)

Emergency or radio beacons are tracking transmitters which aid in the detection and location of boats, aircraft, and people in distress. The basic purpose of the distress emergency beacon is to get people rescued within the first twenty-four hours following a traumatic event, when the majority of survivors can still be saved. Every botanical collecting trip, especially to remote areas, should carry an emergency beacon.

11.6.3.2 Contact arrangements

It is essential that a regular and frequent contact schedule is developed so that emergency rescue authorities can be informed of potential problems if the team fails to make contact at a designated time. The most important safety action is to ensure that people know where you are planning to be and where you actually are so that they can monitor the progress of the fieldwork. Therefore, make sure that there is a reliable contact person that the field team can contact regularly. The primary organization requires agreed emergency procedures and protocols that will be activated when there has been no contact with the field team after a set amount of time.

11.6.3.3 Global positioning systems and maps

A Global Positioning System (GPS) is an instrument that provides spatial coordinates and should be used in conjunction with good maps. A GPS is an excellent way of obtaining accurate coordinates for a locality, but they should not be viewed as a replacement for detailed maps. Always select the best map, at the best scale, for the area that you are visiting. In the event of an emergency, an accurate geocode reference of the team's locality will help rescue agencies to provide rapid assistance.

11.6.3.4 Vehicles to be used, vehicle recovery, and safety equipment

For motor vehicles it is important to list personnel with recovery training or substantive experience; assess physical strain risks for potential recovery tasks; list recovery equipment items being taken, such as gloves, snatch strap, tree strap, chain, shackles, spare tyres.

Other considerations include:

- Boat: record boat registration and ownership; review boat operator licences, radio skills, radio schedules, motor service status, navigational skills and equipment, safety gear, general equipment status—including mandatory certifications.
- Dive equipment and skill (review Divemaster and SCUBA certifications, equipment status—including mandatory certifications, and dive schedules with regard to personnel experience and capabilities.
- On foot: although most of the fieldwork requires considerable amount of time and often involves a considerable distance to be walked, frequently whilst carrying heavy equipment and supplies, there is a tendency not to consider the

risks and hazards associated with this aspect of the work. Review on-track and off-track work expected, with regard to personnel experience, capabilities, and navigational skills/equipment, tree- and rock-fall hazards, and likelihood of danger from animals and poisonous plants).

When working in developing countries and remote communities, the available vehicles (including boats) may not be of a standard that will provide the maximum safety. However, it is still important to ensure that the vehicle, the driver, and the recovery equipment are as good as possible. It is also an excellent opportunity to increase the awareness of general safety issues for within-country agencies if that is required. Well-maintained vehicles are more reliable. It is important to minimize the chances of serious breakdowns, especially in remote areas, as these can seriously impact on the safety of all participants.

11.6.3.5 First aid training and kits

Since botanical specimens are often gathered from relatively remote areas, it is important that all members of the field team have training in basic first aid techniques, and that each member always carry a first aid kit that they are familiar with. Knowledge of cardiopulmonary resuscitation and other basic remote area first aid is important. Contact an organization that presents first aid courses in your area for training and more information.

Although you may visit a remote area alone, it is never safe to do so. The field team should consist of a minimum of three people. The skills and limitations of each person should be known to all members of the team to ensure that the fieldwork can be done efficiently and safely.

11.6.3.6 Medical conditions and personal capabilities

Within the limits of privacy and with due regard for confidentiality, the field leader must be aware of any medical conditions or physical limitation of all members of the team that may affect the safety of fieldwork. The leader is responsible for providing advice to personnel should a member require medication during fieldwork. All team members must ensure that they have all of their required personal medications.

It is the leader's responsibility to make adjustments to schedules and tasks to ensure minimal stress on all personnel. Furthermore, the leader should consider the interpersonal dynamics of the team under field conditions and monitor the level of activities and rest periods accordingly.

Medical advice should be sought prior to obtaining antiseptic solutions and medicines for pain management, antihistamines, anti-emetic medicine for nausea, antispasmodic medicine for diarrhoea, and treatment for other medical conditions.

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11.6.3.7 Climatic hazards

An assessment of the climatic conditions of the area being visited is important. The precautions for dealing with excessive heat, humidity, aridity, cold, and/or wet weather should include having water, protective clothing, sunscreen, amongst other aids. Drinking-quality water should be available, together with water-purifying tablets when relying on local water supplies of unsatisfactory quality.

11.6.4 Working with local communities

The above points have been provided to assist researchers to work in a safe environment, according to the various regulations. However, it is equally important to ensure a respectful, equitable, and mutually beneficial relationship with local community where the field studies are being undertaken. The following suggestions are offered:

1. Plan on a medium- to long-term relationship—although one-off visits are often all that is possible, longer-term collaborations are usually more beneficial to both the researcher and the community.
2. Learn the language—being fluent in a language that allows for communication between yourself and the community is extremely beneficial to essential. Plan ahead—start learning the language at least six months in advance.
3. Obtain at least one extra bilingual dictionary to share with your field research associates if the local language is not fluently spoken by team members.
4. Introduce yourself and your team—it is important to take the time to introduce yourself and your associate researchers to the community so that everyone has some understanding of who is involved with the research program. A introductory photographic album that includes topics of interest, such as photographs of your family, friends, home, garden, and workplace, can be useful.
5. Have copies of your research proposal in the local language—as well as organizing meetings with the local people to explain what you are intending to do while in their area, written proposals allow for people to consider your proposal further after the meeting.
6. Develop a bilingual cooperative agreement/Memorandum of Understanding between yourself and your national counterparts. As part of this process, explain the project at a meeting with local community members. Ensure that women are also informed, either at these meeting or at separate ones, if that is culturally preferable.
7. Purchase additional sets of national and/or local maps to share with the community.
8. Donations and gifts—discuss with the community their needs to ascertain whether or not you can assist. It may be possible to assist a community obtain

funding for a community-based activity. Present any donations in an informal ceremony to institutional representatives, along with an inventoried list of the donations which is signed by the recipients. Do not present donations to individuals. In developing communities, donations of medical supplies for local health clinics or educational supplies for local schools may be welcomed. However, be cautious about providing medical supplies that require greater skills to use than is available within the community.

9. Recruit local community members as field assistants—without discrimination on basis of gender, age, marital status, religion, profession, level of formal education, political affiliation, or sexual orientation.
10. Take photos of community members and distribute them as soon as possible.
11. Translate research results into the local language—make photocopies and distribute widely within the community, inviting comment, and deposit a set of the data with the community.
12. Joint publication with local field assistants: the individuals who provide field assistance and knowledge are rarely included as co-authors of scientific publications. It is always important to consider the significance of their contribution, and to determine if they should be joint authors—or at least fully acknowledged within publications.

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CHAPTER 12

ETHNOBIOLOGY

BASIC METHODS FOR DOCUMENTING BIOLOGICAL KNOWLEDGE REPRESENTED IN LANGUAGES

WILL McCLATCHEY

12.1 Introduction[1]

Ethnobiology methods are undergoing a certain degree of standardization following Martin's (2004) very influential ethnobotany methods book outlining many of the basic field techniques. Translation into Chinese, Spanish, Bahasa Malaysia, and French is evidence of acceptance of this book and its role as a basic tool for learning fundamental techniques. Among its many useful chapters is one on linguistic methods. The descriptions provided in this chapter are intended to build on Martin's procedures, but add recent trends that reflect recent important changes in ethnobiological research. I begin with a discussion of some of the sorts of research ethnobiologists are doing around the globe (which

[1] Thanks to Bruce Hoffman for help with literature sourcing and Kim Bridges, Piet Lincoln, David Reedy, Nat Bletter, Al Chock, and Valerie McClatchey for reading drafts. Thank you to three anonymous reviewers for providing many detailed and helpful comments.

takes place everywhere from modern cities to remote rural forests). This is followed by discussion of some key aspects of the discipline, in order to set the stage for the presentation of five basic field methods that may be applied to collect integrated ethnobiological and linguistic data. The primary purposes of this chapter are to provide encouragement to field linguists considering working with biological materials, and to promote collaboration among scholars, particularly linguists and ethnobiologists.

Ethnobiology is the scientific study of dynamic relationships among peoples, biota, and environments (Salick et al. 2003). This discipline has departed from being descriptive and now attempts to use the full spectrum of scientific methodologies and tools to understand and explain cultural differences and similarities in the knowledge and use of biota and environments (Balée 1994). This methodological shift has taken the discipline well beyond its original inventorying activities (Fox 1953; Diamond 1966; Conklin 1967; Bulmer and Tyler 1968) into an era of the analysis of processes. For example, recent studies have focused on:

- acquisition, distribution, and control of biological knowledge (Berkes and Folke 2001; Zent 2001; 2005; Torre-cuadros and Ross 2003; Zent and López-Zent 2004);
- ongoing management of wild and domesticated natural resources (Posey and Balée 1989; Berkes 1999; Cunningham 2001; Anderson 2005; Ticktin et al. 2006);
- management and conservation of landscapes and biocultural diversity (Sillitoe 1998; Saemane 1999; Maffi 2005; Stepp et al. 2004; Shepard et al. 2004; Lampman 2007; Hoffman 2009); and
- indigenous responses to global climate change (Bridges and McClatchey 2009; Salick et al. 2007; Turner 2009).

In addition, much attention has been paid to intellectual property rights of traditional knowledge holders, and researcher ethics and responsibilities (see Laird 2002). Ethnobiologists are examining topics that cut across the biological and social science disciplines. These have been summarized as: 'knowledge systems [including cognitive research]; medicine, health, and nutrition; ecology, evolution, and systematics; landscapes and global trends; and biocomplexity' (Salick et al. 2003: [3]). Linguistics can benefit not only from recent developments in ethnobiological techniques, but also from the advances in scientific theory being generated in the above research. Obviously this has reciprocal importance: good linguistics research not only aids an ethnobiologist or local people, it may often be a critical contribution in developing scientific and cross-cultural understanding.

An area of past and future research cooperation between linguists and ethnobiologists is a focus on cognitive research. The next section outlines a general understanding of this area by ethnobiologists, and is presented here as a starting point for further discussion and research. This is followed by a section that focuses on basic methodological aspects of ethnobiological research, particularly as they relate to (and may be used by) linguistic researchers. Another view of this research area is seen in the analysis of thirty-four recently conducted ethnobiological studies by Reyes-García et al. (2007). They concluded that there is a 'lack of conceptual consistency and comparable data [that] limit the inferences that can be drawn from empirical analyses of ethnobotanical knowledge' (p. 182). They recommend: 'Future research should 1) validate the consistency of measures of individual ethnobotanical knowledge; 2) analyse the reliability of data generated by the different methods developed so far; and 3) address the relationship between the various dimensions of ethnobotanical knowledge' (p. 182) Their recommendations clearly point to our need to be better aware of methods used by other researchers, and to adopt these when possible in order to generate comparable data sets.

12.1.1 Cognitive research

One of the core areas of research within ethnobiology is the study of human cognition (alternative areas of emphasis include economic, social, legal, and nutritional aspects). While there are many interesting areas within this core, the study of folk or ethnobiological classifications is most germane to this chapter. Berlin (1992) has outlined the essential characteristics of ethnobiological classification systems that most ethnobiological researchers agree are universals. The heart of Berlin's classification consists of nine major 'principles' (Berlin, Breedlove, and Raven 1973) that are cross-cultural and for the most-part comparable (see Dwyer 2005 for an alternative perspective). These are:

1. Nomenclature: In all languages it is possible to isolate linguistically recognized groupings of organisms (taxa) of varying degrees of inclusiveness that have names.
   - Examples at different taxonomic levels are: *animal, bird, raptor, owl, barn owl.*
2. Taxa are further grouped into a small number of classes referred to as taxonomic ethnobiological categories similar in many respects to the taxonomic ranks of globalized science.
   - These categories number no more than six: *unique beginner, life form, intermediate, generic, specific,* and *varietal.*
3. The six ethnobiological categories are arranged hierarchically (as ranks) and taxa assigned to each rank are mutually exclusive.
   - Consider what example we might choose as the archetype for 'plants' or 'animals'? Although we can all identify these, there is not a 'unique' type that is *the* plant or *the* animal that is the 'unique beginner'.
4. Taxa of the same ethnobiological rank usually are at the same taxonomic level in any particular cultural (linguistic) taxonomy.
5. In any system of ethnobotanical or ethnozoological classification, the taxon that occurs as a member of the rank 'unique beginner' (*plant* or *animal*) is not (normally) named with a single, habitual label. This means that people speaking

a particular language often recognize inclusive ranks such as *animals* and can sort a group of things into the that rank, but won't necessarily have a name for the grouping that they have made.

6. There are usually but a handful of taxa that occur as members of the category 'life form', ranging from five to ten, and they include the majority of all named taxa of lesser rank.
   - These life-form taxa are named by linguistic expressions that are lexically analysed as primary lexemes, e.g. *bush, liana, palm, reptile, fern,* and *bird.*
7. The number of generic taxa ranges around 500 in typical folk taxonomies, and most are usually included in one of the life-form taxa.
   - A number of generic taxa may be aberrant, however, and are conceptually seen as unaffiliated (i.e. are not included in any of the life forms). Aberrance may be due to morphological uniqueness and/or economic importance. Examples vary widely between cultures: baobab trees and camels are morphologically unique for many cultures in tropical Africa, while grasses/grain and cattle raised for food are economically important in many Eurasian cultures. Each of these may be generic taxa that are unaffiliated with other generic taxa because of their outstanding or unusual roles in society.
   - Generic taxa are the basic building blocks of any folk taxonomy, are the most salient psychologically, and are likely to be among the first taxa learned by the child, e.g. *dog, taro, oak, banana, ant, clay.*
8. Specific and varietal taxa are less numerous than generic taxa, and occur in small contrast sets typically of two to three members. Varietal taxa are rare in most folk biological taxonomies.
   - Both specific and varietal forms are distinguished from one another in terms of a few, often verbalized characters.
   - Taxa of the specific and varietal rank are commonly labelled by secondary (vs. primary) lexemes, e.g. *three-needle pine, Mexican evening primrose, blue heron.*
9. Intermediate taxa occur as implied members of the category 'intermediate' and usually include taxa of generic rank that have residual characteristics. Residual characteristics are unusual features that distinguish either a monotypic taxon (a weird/unusual sort of thing) or a group that is placed together because of a single (unusual) characteristic. These are not often named but are implied in cultural conversations. However, some can be mentioned.
   - Examples that are named: *spiders, root crops,* and *pigeons.*

The nine principles above are slightly enhanced from the Berlin et al. (1973) outline. For more clarity, see the longer explanation in Martin (2004).

Ralph Bulmer (1974) independently verified and proposed very similar concepts, although Berlin's (1992) theoretical structure is cited by most ethnobiologists. Holman (2005) has verified the generalized, cross-cultural ethnobiological

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hierarchical folk classification systems for plants and animals showing evidence that they are different from other domains. Holman (2005: 71) states that 'cross-cultural regularities suggest that taxonomic judgements are not entirely determined by culture'.

There is a key assumption implicit in the above that we will accept for the purposes of the balance of this chapter: that cultures are similar enough to be comparable, and that naming and classification systems have not primarily emerged as individual or culture-specific practices but are rather part of generalized human traits. Furthermore, from a biological perspective, we will accept the assumption that taxonomic diversity in the world is discontinuous in its spectrum of characteristic distributions, and that humans are able to recognize discontinuities (see also Turk et al., Chapter 16 below). The result is that humans group like things together in categories as described above using the discontinuities as indicators of domain circumscription. If these assumptions are correct (and some argue that they are not: see Ellen 1996; 2003a; 2003b; 2006; 2007), then comparisons may be made by information learned between individuals and/or groups of people at differing scales (e.g. families, communities, 'cultures', 'languages'). Further, the results then inform us about variations in the human condition and human responses to differing cultural, psychological, physical, and biological environments.

Note that this type of research emphasizes comparisons. Although it is possible to use a non-comparativist approach to research, even non-comparativists must be aware that the results of their work, once published, will be used by comparativists. The danger is that if the research is not framed within a standardized structure, the research will be forced into one, and likely misrepresented. With that in mind, it is probably best to conduct research assuming that the data will be used for comparisons even if that is not the immediate intention.

Modern research in the sister biological discipline of systematics (the study of diversification and relationships of life on earth) provides a clear lesson that relates to the long-term value of these sorts of studies. Systematists are returning to stored biological specimens in herbaria and museums to verify species identities with genetic, anatomical, chemical, and other physical analyses. Studies which generate lists of names/terms must be supported by the deposition of appropriate physical evidence in a secure storage facility. This physical evidence is now a requirement of publication within ethnobiological journals (e.g. Verpoorte 2009). Therefore, modern ethnobiological research increasingly relies upon an evidence-based system that blends quantitative and qualitative data collection (Cook and Prendergast 1995; Alexiades 1996) and analysis in the testing of one or more hypotheses about dynamic relationships between peoples, biota, and environments.

12.1.2 Evidence-based research

Ethnobiological studies, including research on languages, requires evidence. This evidence may be primary/physical, secondary/documentary, or tertiary/observational. While all three of these are important, the first is the most critical. Unfortunately, primary/physical evidence is most often neglected by non-biologists who are doing ethnobiologically-related, ethnographic research.

Primary or physical evidence of language is a sample of the things that people are talking about such as specific birds, plants, insects, rocks, soil, water, or diseases (when samples are collected). These samples are typically stored as catalogued, labelled vouchers in a museum, archive, or other repository designed to maintain them for long periods of time. These facilities also provide appropriate access to scholars and the public so that research results may be verified by others once work has been published.

It is completely understandable that many scholars feel overwhelmed when faced with the need to collect physical samples of evidence from a wide spectrum of things. However, without such evidence, the results of the research are merely hearsay (Bye 1986). Modern science requires verifiability, and this means that other researchers must have a way to check the results by examination of the samples returned from the field site (see Conn, Chapter 11 above, on the collection of samples). In addition, the Biodiversity Assessment of Tropical Island Ecosystems manual (Mueller-Dombois, Bridges, and Daehler 2008) is available in print or for free on-line and includes detailed instructions for non-biologists on how and why to collect a wide range of biological samples. An excellent resource for collection of plants is Womersley (1976), which was specifically prepared for anthropologists and geographers.

Secondary or documentary evidence of language includes photographs and video and audio recordings. These are critical tools for modern ethnobiological researchers, but in most cases they are insufficient for the positive scientific or cultural identification of the items that people are talking about. This is because they cannot record the genetic or other biochemical, morphological, anatomical, viscosity, or the many other physical characteristics that cultural and scientific experts need to assess in order to identify and distinguish samples. However, documentary evidence supplements primary evidence, as it often provides important information about a sample that is lost because of changes that occur due to sampling, decay, or removal from the natural environment.

Tertiary data or observations about a sample are important for establishing the context in which the sample normally resides. The best observations include a combination of etic[2] and emic perspectives and multiple scales from the most immediate/local to the landscape in which the sample resides. For example, a

[2] See the introduction to Dousset, Ch. 9 above, for a definition of 'etic' and 'emic'.

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collected lizard sample would include observations that note where the lizard was found, such as on a particular named sort of rock outcropping (also sampled), that the collector (scientist or local expert) has said that local experts report that this type of lizard is known to frequent particular forest patches (indicator species sampled), that this type of forest patch is found across a named vegetation zone (indicator species sampled), and that the name of the lizard carries a meaning associated with its use as a food to be consumed in a particular place and time (timing determined within local reckoning). Important types of observational data that have long been recorded by biologists and ethnobiologists that need the help of linguists are the vernacular names and their associations (including metaphorical allusions) and other cultural data recorded on specimen labels associated with primary evidence. Far too many scientists rely too much on the primary evidence to speak for itself, and miss the opportunity to provide critical observations, particularly from emic perspectives.

12.1.3 Comparative ethnobiology

While ethnobiologists consider it desirable to produce data sets that can eventually be comparable in multi-site analyses (Reyes-García et al. 2005), some researchers have conducted comparisons within their data collection and analysis efforts. For example, Nguyen (2006) studied food plant assemblages used by Vietnamese in Vietnam and Hawaii, analysing patterns of evolutionary change in plant constituents as people migrated to new environments. Furthermore, she discussed interconnected roles of botanical and linguistic evidence in understanding human interactions with complex environments (e.g. natural and artificial ecosystems, and other multi-species interactive systems).

12.1.4 Ethnobiology ethics and legal issues

The collection of ethnobiological data, whether it is primary, secondary, or tertiary, has increasingly become the focus of ethical and legal discussions (Laird 2002; see also Rice and Newman, Chapters 18 and 19 below). The most extreme concerns have been fear of bio-piracy, commercialization of traditional knowledge, or the misuse/mismanagement of information that is shared with researchers. Ethical and legal matters are tightly intertwined.

The International Society of Ethnobiology Code of Ethics (2006) is used as a minimal 'framework for decision-making and conduct of ethnobiological research and related activities. The goals are to facilitate ethical conduct and equitable relationships, and foster a commitment to meaningful collaboration and reciprocal responsibility by all parties.' Anyone planning to engage in ethnobiological research should first take the time to read and understand this document (it is published in a number of languages). Among the many concepts of the code of ethics is that of working with people in communities rather than treating them as the subjects of research. Therefore, ethnobiologists, like many linguists, often work and publish with community participants in collaborations, and do not think of or refer to anyone as informants.

12.2 Data collection

Ethnobiological research design (Alexiades 1996; Höft, Barik, and Lykke 1999; Martin 2004) typically follows a hypothesis-driven scientific method of evaluation. Five common methods (see below) used by ethnobiologists for the documentation of traditional biological knowledge are likely to be of use in basic linguistic field research settings. These are used to obtain information that is associated with physical evidence. A critical aspect of these methods is that none of them requires that the researcher have more than passing knowledge about the organisms being examined (i.e. they need not be a biologist, although there is a caveat in the final paragraph of this chapter). In each case the actual organisms are the focal point and also serve as the evidence at the conclusion of the study. Local participants and their specifically local perspectives and knowledge are critical to understanding these organisms. These methods are commonly conducted as ethnographic interview surveys either within the environment (*in situ*) using biological materials or using fresh, or preserved biological materials away from the environment (*ex situ*) (Thomas et al. 2007).

12.2.1 Free-listing

A common initial approach when working with a participant is to inquire about a category of information (e.g. animals: Nolan et al. 2006; desert plants: Khasbagan and Soyolt 2008; edible mushrooms: Garibay-Orijel et al. 2007; one tree genus: McClatchey et al. 2006; wild foods: Ali-Shtayeh et al. 2008). The result is a list of details, usually names and descriptions. Free-listing may be embedded within a survey that is highly structured (Brosi et al. 2007). Although this may appear to be simple, there are many possible errors to be made in asking poorly considered questions (see Alexiades 1996; McClatchey et al. 2008) that can easily produce useless or misleading results. While it may be desirable when building a dictionary, vocabulary list, etc. to learn 'everything', people seem to sort information into categories, and it is easier to learn from them by beginning with a question such as 'Can we talk about the sorts of birds that you know?' rather than 'Can we discuss everything you know?'

a. Decide upon a set of initial categorical 'free-list' questions, keeping them as simple as possible. These should be broad and simple but not leading questions. (Leading questions provide information that might be desired in possible answers.) The questions should be specific for the desired information and not waste the participant's time with other issues. Appropriate examples are: 'Please list the names of any fish that you catch in lakes but not in streams.' 'Please name as many kinds of fruit (you eat/people eat/animals eat) as you can think of.' 'When you were a child and went to the zoo, what sorts of animals did you see there?' 'What kinds of ingredients does your family use in treatments for coughs and colds?'
b. Each participant (or group of participants) is asked to list his or her answers to one question and their responses are recorded. For some kinds of research the order of the responses is important since what is recalled earlier may be of more importance than what is remembered later. If multiple questions are being asked, it is important that each participant or group be asked the same questions in the same order without other information being provided that would make comparison between participants difficult (in contrast to a free-flow text method, where participants can lead the discussion).
c. After a participant (or group) has finished with the questions, the researcher needs to ask the participant to help to locate and collect evidential examples of each of the responses that were provided. (Note that there is a natural tendency to skip this step if terms have already been identified in the past and recorded in a word list or dictionary. However, it is exceedingly rare that these are supported by physical evidence, it is not unusual for these to be scientifically incorrect, and it is fairly common for names of organisms to refer to more than one scientific taxon and the researcher needs to know which one this participant is talking about. Therefore, collection of physical samples is required to overcome assumptions.)

Since this process is time-consuming, it may require one or more additional interview sessions and take much longer than the free-listing exercise itself. An alternative approach is to complete a set of free-listing exercises with different individuals or groups, compile the composite results, and then, working with a few of the participants, collect the evidence samples. Although this would seem to be more time-efficient, it will still be necessary to take these samples to each of the participants for them to verify their answers; and since some time will have passed, and they were not involved in the collection of the samples, they may not be able to confirm or deny if the samples are representatives of their responses. This presumes that there is little synonymy or taxonomic overlap between individuals/groups, which is the most conservative option. It provides independent confirmation of terms when they are the same across the responses of the sample group, as well as evidence of differences when there is a spectrum of differences within a community of knowledge holders. The choice of using either individual or composite collections largely depends on the ease with which participants are likely to be able to identify the samples that are collected.

12.2.2 Inventory interview

A physical collection of one or more categories of organisms/environmental samples—for instance bees (Mendes dos Santos and Antonini 2008), birds (Boster 1987), crustaceans (Ferreira et al. 2009), fish (Johannes 1981), fungi (Lampman 2007), algae (Ostraff 2006), trees (Jernigan (2006)—is first compiled from a location where the researcher is working. This is then numbered and used as a standardized set of visual (and sometimes olfactory etc.) stimuli for eliciting responses from multiple individuals or groups of participants. Photographs are sometimes used (see Diamond 1991; Nguyen 2003), but there are so many drawbacks that their use is strongly discouraged, particularly because voucher specimens of actual materials will need to be collected as evidence eventually. Cases where photos are actually justified are when organisms are rare, endangered, extinct, or locally unavailable. Photos should not be used as a means to avoid work.

a. A participant (or group of participants) is shown specimens in a specific sequence and asked a set of questions about each one. The questions could be similar to those used in a free list but are often more specific to the details of the specimen being shown. For example, while being shown a specific soil sample (#1) a participant could be asked, 'Does this look familiar? If so, does it have a name? If so, where is this particular substance usually seen? Is it considered useful? If so, what would those uses happen to be?' After recording the responses to the questions, the participant would be shown the next sample (#2) and asked the same questions. Phillips and Gentry (1993a; 1993b) recommend that the minimum data required for inventory interviews are: 'Do you know this . . . ?', 'Do you know a name for this . . . (and if so, what is it?)', and 'Do you use this . . . (and if so, how do you use it)?'
b. The process is repeated with multiple participants (or groups) to produce comparable data sets.
c. With each repetition, additional activities may be conducted using the specimens. For example, specimens may be used in pile sorting exercises to identify Berlin's (1992) hierarchical classifications (Lampman 2007; Mekbib 2007) and, in group or individual follow-up discussions, to determine cryptic classifications (Souza and Begossi 2007). Sorting systems often represent ways in which information is perceived about the world. One way to see more clearly how this

information is perceived is to go beyond the classification by mapping indigenous world views (Davidson-Hunt et al. 2005).

12.2.3 Environmental transect

This has sometimes been called a 'walk in the woods' (Phillips and Gentry 1993a). It can be a formal survey of a specific area involving repeated examination of a specific set of organisms in their natural habitat by a group of participants in order to learn their responses to specific questions (e.g. What are these things called?, Do they have uses, and if so, what?, Are there things that are usually seen here that are not here now?, What is this environment called?) There are two variations on this—formal and informal; often these variations are combined. A formal transect is a specific pathway that is set out (see below) along which repeated participants may be taken to collect different perspectives on the same set of environmental stimuli. Informally, a participant may, for example, lead a researcher on a hike through the forest, a walk through their garden, market, or grocery store, or snorkeling through a reef pointing out specific biological resources and their names and uses. For informal transects to be systematically useful and reproducible they may need to be circumscribed as area inventories (see §12.4 below).

a. Working with one or more community participants, select a location that meets the needs of the project. A suitable site should have the ecological or taxonomic diversity that is needed to ask the questions that are planned, or it could be a trail/path through a location that needs to be better understood. For example, in order to learn about mangrove swamp organisms a boardwalk built for tourists might be selected because it allows easy, regular access for elderly participants to be able to follow along the same path and see the same locations along the way. As another example, a nylon rope could be tied between two poles fixed at points in a reef and the reef along the rope used as the transect that is to be followed and discussed.
b. Questions are formulated about organisms, ecosystems, contexts, and other features that are encountered along the transect. Questions are associated with specific points along the transect, although sometimes general questions about frequently encountered taxa may be asked at any point along the path.
c. Individual (or groups of) participants are led from a starting point on the transect to the finish point and asked questions at a set of points along the way. This process is repeated with each participant, recording his or her responses.
d. Samples of the taxa being discussed need to be collected, usually after the last interview, since the objective is to collect the sample of the same individual that was being observed throughout the process. However, for taxa that are large, such as trees, or numerous, such as some insects, it is possible to collect samples in advance.

12.2.4 Area inventory

One or more discrete areas—home gardens (Vogl-Lukasser and Vogl 2004), or markets (Nguyen, Wieting, and Doherty 2008), political regions (Pardo-de-Santayana et al. 2007)—or samples of an area—forests (Castaneda and Stepp 2007), or mangrove swamps (Steele 2006)—are inventoried for either a specific category (insects, plants, soil types, ecosystems) or for all categories of knowledge possessed by the participant community managing or interacting with the area. Area inventories are done as rapid assessments (Gavin and Anderson 2005) or as more thorough longer-term analyses (Etkin 1993; Reyes-García et al. 2005).

a. A location is selected, either randomly from within an area type or one that is typical of a particular area type. This is done with someone from the participant community who knows the area categories well. For example, if the objective is to conduct inventories of Puerto Rican markets in New York City, then a Puerto Rican community resident expert in New York City would help to identify a selection of markets that are frequented by members of the Puerto Rican community. A sample of these markets could then be selected at random.
b. The locations are then scouted out and the area boundaries demarcated if they are not already naturally or artificially discrete. Questions are formulated for the area much as they are for an environmental transect, except that the questions may not always be asked in the same order nor at the same location.
c. Participants (individually or in groups) are taken through the area and asked specific questions about the resources within it. It is not unusual for only a small number of participants to be exposed to a single location or (for example) for the location to be explained only by the location owner or manager.
d. Specimens are collected based upon the results of the questions asked. Usually this is done at the time of the interview with the participant directing the process so that the correct samples are collected.
e. At the conclusion the participants are shown the specimens and asked to verify the information associated with them.

12.2.5 Artefact interview

One or more cultural artefacts (e.g. tools, art, clothing, houses) are used as the focus of questions posed to participants usually to learn about such things as the components, history, uses, meanings (Banack 1991; and Lemonnier, Chapter 13 below). Since it is easy for participants to focus on the details of a specific artefact and fail to discuss the general category of the artefact, it is a good idea to have a spectrum of different examples of the same sort of thing present. If a disease complex can be considered as a cultural artefact (albeit an interpreted mental construct rather than a physical articulation), then artefact interviews would also include some kinds of disease-culture-centred research (of disease and its interpretations) that leads to the material basis of remedies (e.g. Balick et al. 2000).

a. For the purposes of an ethnobiological study, questions developed for an interview usually include focus on the material basis of the artefact. The questions should not lead but should rather be simple, such as 'What are the parts of this made from?' Many artefacts are composed of more than one part that is functional in and of itself. As such, these sub-artefacts should be recognized as separate components with their own questions. Some researchers may wish to ask about materials that are used in the production of an artefact but are not physically present in the final product. For example, a tool handle may be sanded with shark-skin during its production but the skin is not present in the final product. An appropriate question could be formulated to elicit this sort of information if desired.
b. At the time of the interview, the participant (or participants) are presented with the artefact(s) and asked the questions in a particular order. The responses are recorded.
c. Following the questions, any materials identified by the participants need to be located and specimens prepared of them. If this process is done with the same participants, they will have identified the materials; if not, the participants need to be shown the specimens in order to verify that what has been collected is the same as they had mentioned in the interview.
d. A special form of artefact interview is a production or reproduction interview wherein a participant or group of participants produces an artefact with the researcher either assisting as a participant in the process or as an observer (see e.g. Cox 1982; Nickum 2008; Rickard and Cox 1984).

12.2.6 Biological evidence

Naturalistic scientists (Atran 1990; 1998) collect almost any sort of evidence. Although it is best to plan for a project by practising how to collect and preserve plants, insects, mushrooms, fish, birds, and soil samples, it is also important to be creative and collect samples when they are realistically available and not be overly concerned about having a perfect sample. At the end of the day, an imperfect sample is better than no sample at all. Common sense should be a good judge about how to collect many samples and what should be collected. For example, preservation in alcohol or drying is often better than storage in water or at environmental temperature because most organisms will decay in the natural environment if left alone. Therefore, by creating an unnatural environment they may be preserved in some fashion. It is not unusual for people within a community to have methods for preserving materials, such as taxidermy, and these should be used when available.

When collecting samples, it is very valuable to collect them in at least triplicate if at all possible; one set for local national deposit, one set for distribution to different international experts for identification, and one set for deposit in another location, either at a different national location or internationally. Sample sets need to all be cross-numbered and labelled the same, so that data determined in one can be shared with the others. The primary set that is deposited locally is evidence that may be accessed by local collaborators and will eventually be the most useful and likely most accessed, so this should be the best set. The set that is distributed to experts will be broken up into separate units with specific items sent to specific experts who are identified as having particular expertise and being likely to identify a particular sample. For example, a beetle expert might be sent all of the beetles, while a humming bird expert might be sent the humming birds for identification. The experts will not send the samples back but will send back identifications and will incorporate the samples into larger international collections. The third collection is basically an insurance policy. Fires, wars, and other things can happen that can result in the loss of, or damage to, a repository. By being placed in a completely different location, the third collection represents a different set that can be used to replace the first if it should become lost or damaged in future.

12.3 Data analysis

Each of the methods described is incomplete without leading to an analytical method. The hypothesis, data collection method, and data analysis method all combine to make a complete chain of logic. Results may often be analysed for frequency of mentioned items (Bernard 2002), list length (Brewer 1995), or salience (Smith 1993). Hoffman and Gallaher (2007) have reviewed a range of methods developed for analysing the importance placed on uses of plants and vegetation by people who use them. The same methods should apply to almost any things studied that people interact with from the environment.

12.3.1 Biodiversity

Collection of biodiversity information using participants from local communities and relying on their local expertise rather than on one's external university training is sometimes called 'parataxonomy'. Parataxonomy is being used increasingly to survey areas and to learn about the ethno-species or morpho-species diversity recognized within an area (Pfeiffer and Uril 2003; Janzen 2004; Sillitoe 2007) and to estimate local biological species richness (Oliver and Beattie 1993; Basset et al. 2000; Basset et al. 2004; Jinxiu et al. 2004).

For those who are not biologists, some important points need to be made about the relationships between common/vernacular names (in any language) and scientific names. Scientific names are not magical or more factually correct; they are often derived from common names at one point in the past and now serve as a unifying language around the world for comparative discussions in science. All of these names (scientific or common) circumscribe identifiable units or taxa that people can recognize. When comparing the taxa recognized by one group of people with those recognized by another group they may (a) have about the same circumscription (have the same constituents) or (b) include one considered to be grouping several taxa of the other into a single taxon (a 'lumper'), and thus the other is considered relatively to be dividing one taxon of the first into multiple taxa (a 'splitter'). These divisions are analytically relative to each other and are not based upon a standard other than one's point of reference. This is true not only of folk knowledge but also of scientific species concepts.

12.3.2 Gloss assumptions

Muller and Almedom (2008) have noted the dangers of gloss terms describing traditional foods, and how these may easily come to depict aspects of culture in unrealistic terms. They focused their analysis on the concept of 'famine foods', but a similar examination of almost any rapid interpretation applied by a researcher to describe a complex cultural phenomenon of human interaction with one or more biological organisms or environments will have similar pitfalls. There is not an easy recommendation for dealing with this problem other than to suggest that it is best to gather as much data as possible, with primary data being the best and to apply as much local expertise as possible within the interpretation of results to minimize misrepresentations.

Probably the best advice for those who are non-experts on a subject is to be as clearly descriptive as possible, including both etic and emic observations (see Diamond 1991) and minimal interpretations. For example, if a disease with a certain traditional name appears to be 'breast cancer' but the researcher documenting the term and gloss is not a physician seeing a patient and collecting a specimen to verify this, then it is best *not* to give this as the name, but merely to describe the traditional symptoms of the illness and say nothing about the assumption of breast cancer. The very important reason for not making the assumption is that placing information such as this within a dictionary could lead later to misdiagnoses based upon information that may or may not be true. The same is true for less critical cases, such as naming of birds, plants, soil types, and ecosystems.

A clear description, when joined with physical evidence, can be deciphered by a subsequent expert collaborating scholar, while a bad assumption may not be retracted.

12.4 Discussion

Each of the five methods for the collection of information described here may be used alone or in combination, and each has certain advantages and disadvantages. Free-listing is the most simple and common method, but it is problematic in that it is dependent upon human memories and subsequent ability to find samples of what was being discussed/remembered at an earlier time. However, free-listing can be the most creative because it is not constrained by the physical reality around people and therefore they are able to include examples of taxa that are now extinct, rare, out of season, or otherwise not present but still part of their cultural memory. It is not uncommon for free-listing exercises to result in some data points that lack supporting physical evidence; these problematic data must be either set aside as irreproducible or discussed as suspect. An artefact interview is merely a particular sort of free-listing exercise with a tangible object for the participants to focus their thoughts on. As such, it has similar strengths and weaknesses to be considered.

Inventory interviews, on the other hand, have a high level of reproducibility because the specimens are prepared a priori and therefore none are lacking at the completion of the data collection process. In addition, comparisons between interviews are unambiguous because there is little doubt that the participants were exposed to exactly the same physical stimuli to formulate their response. However, inventory interviews include displays of taxa outside their normal environments and often dried or preserved in ways that make them look less like they do in the natural environment. On the other hand, environmental transects allow for participants to observe taxa within their natural settings or within settings where they are normally encountered by people, and so they may be able to elicit a higher response level than results from an inventory interview. The problem with the environmental transect is that environments do change over time: some organisms move, die, or are damaged by weather. What is seen by one participant may not be the same as what is seen by subsequent participants over a series of days, weeks, or longer. Also, when specimens are collected at the end, they may not be present as they were at times during the interview period. An area interview is a much more formal and larger version of an environmental transect, and suffers from the same strengths and weaknesses, but magnified. However, since there are

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usually fewer samples taken with an area interview, there is less chance of change over time if the project does not take too long to complete.

Ethnobiological research in many parts of the world has much to offer linguists in the identification of the vocabularies used by people to describe the world around them. Making these descriptions clear does not have to be difficult and, when done in collaboration with experts from other disciplines, should help linguists to feel more confident about the products of their work. As a concluding thought, consider a story (also mentioned by Evans, Chapter 8 above) told about an experience that Ralph Bulmer had with the Kalam in New Guinea (Diamond 1991: 85).

Bulmer, after years of working with the Kalam recording abundant information on plants and animals, recruited a geologist to come with him into the field. The Kalam opened up to the geologist and provided terminology and observations that Bulmer had expected but found difficult to elicit. When he expressed his disappointment that the Kalam had not had these conversations with him, they explained that when he asked about fauna and flora they realized he knew these topics well and was easy to educate. But they found his questions about rocks revealed that he had so little background knowledge that they foresaw a long and difficult process, which they pragmatically sidestepped by denying their geological lore, revealing a minimum of geology words. Had Bulmer selected a different interview technique, perhaps first making a collection of many different sorts of geological samples and then using an inventory interview, he might have had a different experience. But, in this example, the solution to Bulmer's research problem came about through a successful collaboration with an expert in another discipline. The ethnobiologists and other scientists are waiting for the linguists to call.