during the wet season. Heavy thunderstorms occur every day during the first sampling week, but no rain falls during the second week. During the dry-season surveys, week I is approximately 10° C warmer than week 2. In the wet-season inventories, 18 species are recorded in forest A and 25 species in forest B. During the dry season, 13 species are found in forest A and 22 in forest B. Based on the number of species found, one concludes that the mammalian assemblage in forest B is considerably larger than that in forest A during both seasons. Actually, the assemblages may be equal, or the assemblage in A may be larger. The data may not reflect the true species richness because of uncontrolled weather variables: many mammals, particularly bats, are more difficult to sample in wet than in dry periods, and temperature differences may affect activity patterns. If the weather data are not recorded, it may be difficult to evaluate the mammal data obtained.

The effect of weather can be minimized in several ways, depending on time and personnel constraints. In the previous example, a better design would have been to have five persons work in forest A at the same time that five persons surveyed forest B. If personnel had been limited (e.g., a field crew of three persons), another option would have been to carry out half-day inventories using all personnel, thus surveying both sites each day (alternating sampling times for each site) for two weeks. If the sites were too far apart to reach within one day and still have time to survey both areas, inventories in two sites could have been done on alternate days. (This design does not solve the problem entirely, but alternating days is preferable to surveying for 7 days at one site followed by 7 days at the other.) If time were not a constraint (i.e., if the survey could have been done over several months each season), it might have been better to carry out many replicate inventories in the two sites; increased samples should minimize effects caused by differences in weather. Potential confounding effects of weather would have been minimized if the investigator had used a method for estimating species richness (see Chapter 10), rather than simply obtaining counts with no means of estimating detection probabilities.

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Data standards

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The many individual mammals encountered during the course of an inventory or monitoring project will have to be identified to species. Depending on the goals and sampling method(s) used, some individuals will be identified from a distance by sight or by their calls; others will be captured. At the same time, some will be marked for reobservation or recapture, and others will be sampled as vouchers. For each individual, certain minimum data should be recorded. In this section we consider data pertaining to locality and sampling methodology. Information on microhabitats and specimen vouchers is covered in sections that follow. The data outlined here should be the *minimum* for any project. Investigators with specific goals may require additional types of data as well.

Standardized, printed sheets containing the required data categories provide a convenient, inexpensive, and effective way to ensure that all the desired information is recorded in a consistent format. Data sheets should be well organized, be printed on good-quality paper (75%–100% cotton content), and include extra space (e.g., backside of sheet) for notes that do not fit preestablished categories.

Data should be recorded in the field with permanent (waterproof) ink as simply and directly as possible. The use of numerical codes in the field should be avoided; it is easy to forget codes or to enter the wrong code, and subsequent users may be unfamiliar with the codes used. Original data sheets can be photocopied for security, but they should not be copied by hand. If data are to be coded for computer analysis, the original or photocopied sheets should be used for data entry to minimize transcription errors. Some workers prefer recording information on small tape recorders; this also works well if a list of the standard data categories is checked during taping to ensure that all required information is recorded. Information recorded on tapes should be transcribed to data sheets or into a computer within 24 hours of taking the sample.

Geographic Characterization

Specific information about a locality should include a geopolitical characterization of the study site and a description of the habitats sampled. The geographic and political descriptions of the locality minimally should include the following information:

1. *Country or island group.* The country name is normally equivalent to the political unit, but substituting island names for country may be of value in some instances.
2. *State or province.* A secondary political unit should be part of every locality record.
3. *County, district, or other tertiary division.* For specimens collected in the United States and certain other countries, a tertiary political unit should be included. In countries in which tertiary divisions exist but are infrequently used or rarely mapped, this category may not be useful.
4. *Mountain range and other geographic data.* Some reference to the closest mountain range is important, especially in remote areas for which detailed maps are not readily available. Inclusion of other geographic information may also be extremely helpful (e.g., drainage system, savanna, zoogeographic region).
5. *Specific locality.* The locality should be as detailed and specific as possible. Distances and compass directions from easily located places (e.g., towns, mouths of rivers, mountain peaks) are essential. Whether the distances are by road or straight-line on a map should be specified. Inclusion of a map or gazetteer reference is helpful.
6. *Latitude and longitude.* This geographic attribute is independent of political units. It is the only generally recognized locator that allows for universal retrieval of data from any geographic area and for electronic mapping. Workers should include coordinates for each locality as specifically as possible. However, approximate coordinates, clearly identified as such, are also of value if specific coordinates cannot be obtained. Latitude and longitude are reported with the standard notation of degree, minute, and second, rather than with a decimal. Portable global positioning devices that provide accurate measures of latitude and longitude are available for field use (about U.S. $1,000; see Appendix 9). Such devices record seconds as a decimal; such measures can be converted to the standard notation.
7. *Elevation.* Elevation should be noted. Approximate elevation, clearly indicated as such, is better than none. Elevations and distances should be given in standard metric units.

Habitat

Mammals occupy both terrestrial and aquatic habitats. Habitat descriptions should include the following information.

TERRESTRIAL HABITATS

1. Moderately detailed description of the kind(s) of vegetation (e.g., lowland tropical evergreen forest, temperate deciduous forest, thorn scrub, savanna-woodland) at each site. For forests, some mention of percent canopy cover and stratification, as well as abundance of ground and shrub cover. Height of canopy, abundance of vines and epiphytes, and average size of leaf can also be highly informative about habitat type. For savanna-woodland habitats, designation as natural, agricultural, or fire-maintained; indication of extent and regularity of seasonal flooding. For other terrestrial sites, plant type and cover. If plant species are known, a list of some of the dominant forms is useful. Published references to vegetation at the site should be noted.

   Descriptive lists of vegetation types exist for most regions of the world (e.g., Walter 1973) and can be used as a foundation for specific site descriptions. Representative vegetation types for tropical and subtropical forests in Southeast Asia might include the following: primary rain forest, hilly; primary rain forest, flat; evergreen oak/chestnut montane forest; mossy montane forest; coniferous forest; deciduous forest; gallery forest; selectively logged forest; rubber plantation; secondary growth; large clearing; camp.
2. Description of the climate at each site, including details of weather, with distribution and abundance of rainfall and annual and diel variations in temperature.
3. Some indication of the degree of disturbance. For forests, designation as primary, secondary, or plantation may be adequate. For grasslands, some mention of the influence of grazing, agricultural use, or frequency of fire or flooding may be important. Sampling done near or through a forest edge should be indicated.
4. Brief mention of other habitat factors (e.g., substrate type, soil type, soil compaction, type and abundance of litter layer, presence of rock piles and outcroppings, general topography, elevation, and other features) potentially important to mammals is helpful.

FRESHWATER HABITATS

Details of surrounding vegetation (see item 1 under "Terrestrial Habitats," above), climate and weather (item 2 above), water temperature, water clarity, and information for the type of water body sampled.

LENTIC—PONDS, LAKES, AND WETLANDS

1. Habitat type (e.g., lake, pond, swamp), size (surface areas in hectares or length × width), and depth (minimum, maximum, and average); percentages of the water surface that are open or occupied by emergent or surface vegetation; notation of whether the site is open above or covered by forest canopy.
2. Some indication of the relative duration of the habitat (e.g., is permanent, has water most years, results from flooding).
3. Nature of any shoreline or emergent aquatic vegetation; species or types of vegetation (e.g., reeds, water lilies), if known.
4. Bottom type (e.g., silt, sand, leaf pack).
5. Evidence of habitat disturbance from natural causes or human activities.

LOTIC—STREAMS AND RIVERS

1. Habitat type (e.g., river, stream, spring, creek), width, and depth (e.g., pools and shallows, riffles); some indication of the flow rate (e.g., cascades and falls, white water–high gradient, moderate current, slow and meandering, meters per second).
2. Some indication of the relative duration (life) of the habitat (e.g., flows all year, only in the wet season).
3. Nature of any bordering vegetation (e.g., trees, shrubs); plant types and species, if available.

4. Substrate type (e.g., rocks, boulders, gravel, sand, mud, leaf pack).
5. Evidence of habitat disturbance from natural causes or human activities.

TRANSITION HABITATS

ESTUARIES

1. Habitat type (e.g., coastal plain, bar-built, fjord), size (surface area), and depth (minimum, maximum, and average).
2. Some indication of the physical characteristics of the habitat (e.g., salinity patterns, wave action, tidal currents, turbidity, temperature, and oxygen profiles).
3. Nature of any shoreline vegetation or subtidal algal communities; types of vegetation or species, if known.
4. Bottom type (e.g., mud, sand, gravel, organic material).
5. Evidence of habitat disturbance from natural causes or human activities.

SALT OR TIDAL MARSHES

1. Habitat type (e.g., associated with an estuary or along sheltered, open coast), size (surface area and percentage of the surface that is covered by tidal creeks and streams or shallow pools).
2. Some indication of the relative degree and duration of flooding at high tide, topographic patterns within the marsh, and runoff from adjacent terrestrial habitats.
3. Nature and zonation of marsh vegetation, presence of algal mats, type of shoreline vegetation; species or types of vegetation, if known.
4. Substrate type (e.g., mud, sand, litter pack).
5. Evidence of habitat disturbance from natural causes or human activities.

MANGROVE FORESTS

1. Type (e.g., dominant tree species), size of forest (area: length × width).
2. Some indication of the relative duration and stability of the habitat (e.g., degree of tidal flooding, evidence of terrestrial runoff).
3. Nature of zonation, including species, if known; canopy stratification and cover.
4. Bottom type (e.g., mud, litter pack).
5. Evidence of habitat disturbance from natural causes or human activities.

MARINE HABITATS

NEAR-SHORE SUBTIDAL

1. Habitat type (e.g., seagrass, kelp forest, oyster reef) and size (surface area).
2. Some indication of physical characteristics (e.g., tidal range, depth, currents, salinity patterns, turbidity, distance from shore, evidence of terrestrial runoff).
3. Nature of the community (e.g., zonation and stratification of community components, density).
4. Bottom type (e.g., sand, gravel, rock).
5. Evidence of habitat disturbance from natural causes or human activities.

COASTAL AND CONTINENTAL SHELF

1. Location, slope, and depth (minimum, maximum, and average) of the habitat.
2. Some indication of important physical characteristics (e.g., depth, turbulence, temperature, oxygen, salinity profiles, light penetration, distance from shore, evidence of freshwater runoff).
3. Nature of phytoplankton, zooplankton, nekton, and benthic communities, if known.
4. Bottom type (e.g., mud, sand, gravel, ledge).
5. Evidence of habitat disturbance from natural causes or human activities.

DEEP WATER

1. Location relative to continents.
2. Some indication of relevant physical characteristics (e.g., salinity, temperature, depth, currents, light penetration).
3. Nature of phytoplankton, zooplankton, and nekton communities, if known.
4. Bottom type (e.g., topographic relief, presence of ridges and mountains, if known).

5. Evidence of habitat disturbance from natural causes or human activities.

Sampling Methodology

Information pertinent to sampling procedures should be recorded, with reference to the specific method(s) used. In addition, the following information should be taken for each specimen encountered during an inventory or monitoring project (see also "Microhabitat Description" and "Voucher Specimens," below):

1. Date and time of encounter.
2. Identification of specimen (e.g., *Cryptotis mexicana, Neotomys* sp., brown rat of type A).
3. Size of specimen. Standard measurements for mammals include total length, tail length, hindfoot length, ear length, and weight. Adult, subadult, and juvenile may be convenient size categories for use in monitoring studies of well-known species, but the use of these terms can present problems (e.g., adult-size mammals are not necessarily mature nor are juvenile-size mammals necessarily immature, as the names imply).
4. Sex. Recorded only if the determination is confirmed. If in doubt, a voucher should be collected.
5. Position in environment. The horizontal and vertical position of each individual, in as much detail as possible.

Microhabitat description

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Mammals typically are irregularly, often patchily, distributed in a habitat, particularly in complex habitats. Individual species occur in microhabitats, which are limited subsets of habitats at each site. Microhabitats, as used here, are the precise places where individual mammals occur within the general environment. Although simple species richness at a site can be determined without knowing the microhabitats used by the mammals living there, recording microhabitat data for each individual mammal observed will result in data that are scientifically richer. For example, differential microhabitat use by the same species at different sites can be determined, as can seasonal differences of microhabitat use at a given site. Knowing that certain mammal species are restricted to given microhabitats might have profound conservation implications.

Recording microhabitat data requires advance planning, especially in the design of an appropriate checklist for registering microhabitat features. Taking such data can be time-consuming and may result in a decrease in the number of specimens captured and preserved. However, the general utility of specimen records that include microhabitat data is so superior to the utility of those without them that the trade-off in reduced numbers of specimens preserved overwhelmingly favors collection of the data. Microhabitat information is useful for determining ecological distributions in a manner that is repeatable from site to site. By combining all data from a microhabitat classification scheme, it should be possible to describe the ecological distribution of each species at a site and to compare distributions across sites.

Each major biome type has its unique environmental features and will, therefore, require a distinct descriptive checklist, with two important caveats. First, no paper scheme can duplicate the actual complexity of the real world; consequently, one must expect to amplify certain records with supplementary notes. Second, the use of a microhabitat checklist does not obviate the need to record gross aspects of the environment, such as vegetation type, elevation, general to-