

SIGN AND
HABITAT ANALYSIS

Because most mammals are secretive and/or nocturnal, many times they are seldom seen by the casual observer. Their presence, however, is often revealed by tracks, burrows, nests, runways, evidence of feeding, and other **sign** (Fig. 28.1). This sign is often useful in determining the distribution of mammals and learning something of their habits. Learning to recognize and interpret mammal sign is essential to efficient collecting and other field investigation. Techniques to identify sign are covered in the section "Identifying Mammal Sign."

Mammals live in both aquatic and terrestrial habitats. In the terrestrial environment, mammal ecologists use qualitative and quantitative techniques to help define the nature of the habitat that mammals occupy. This information can be useful in understanding how species can coexist in ecological communities. The section "Habitat Analysis" will show techniques that can be used by mammalogists and wildlife professionals to characterize terrestrial habitats.

IDENTIFYING MAMMAL SIGN

Footprints and tail markings can be found in mud along streams and lakes or in any other suitable substrate such as dust, soft soil, sand, or snow. Such tracks can usually be identified and, with experience, are a reliable means for verifying the presence of a particular species in a given locality. The tracks of most larger mammals can be readily identified by their characteristic shapes and arrangements (Fig. 28.2), but it is sometimes difficult to distinguish closely related species. The tracks of small mammals are difficult to distin-

guish unless one knows which species can be expected in a particular area. Even then, evidence other than tracks is often necessary for positive identification. Olaus Murie (1954), in his *A Field Guide to Animal Tracks*, described and illustrated footprints and other



Figure 28.1 Nest of the hazel dormouse, *Muscardinus avelanarius*, Myoxidae.
(Ognev 1947:542)

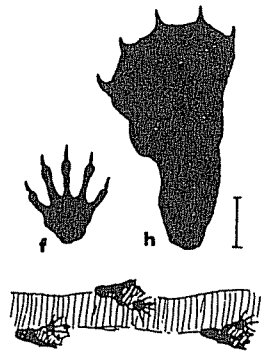


Figure 28.2 Tracks of the American beaver, *Castor canadensis*, Castoridae. Forefoot, f; hindfoot, h. Bottom figure shows footprints and tail drag.
(Henderson 1960:54)

sign of many North American mammals. This book and several other books, by Perkins (1954) and by Seton (1958) for U.S. species, and by Lawrence and Brown (1967) and by Twigg (1975a) for British species, may be used to identify tracks in the field or casts or photographs of them in the laboratory.

28-A Use Murie (1954), Stains (1962), or another book on mammal tracks to answer the following questions. Use casts when available.

- How do the footprints of *Felis* and *Canis* differ? What is the reason for this difference?
- How, other than by size, can you differentiate between the tracks of a deer and a cow? Between those of a deer and a wild sheep?
- What similarities do you note between the footprints of an opossum and a raccoon? How are these two distinguished?
- Why does a hog walking on a relatively hard surface leave the impression of two digits per foot whereas on softer ground it registers four digits per foot?

Scats

A mammal's fecal material or **scat** is also frequently species-distinctive and can yield important information on feeding habits, occurrence, and activity. Scats of small mammals can usually be identified only to the generic level, whereas scats of carnivores and ungulates are often species-distinctive (Fig. 28.3). However, the

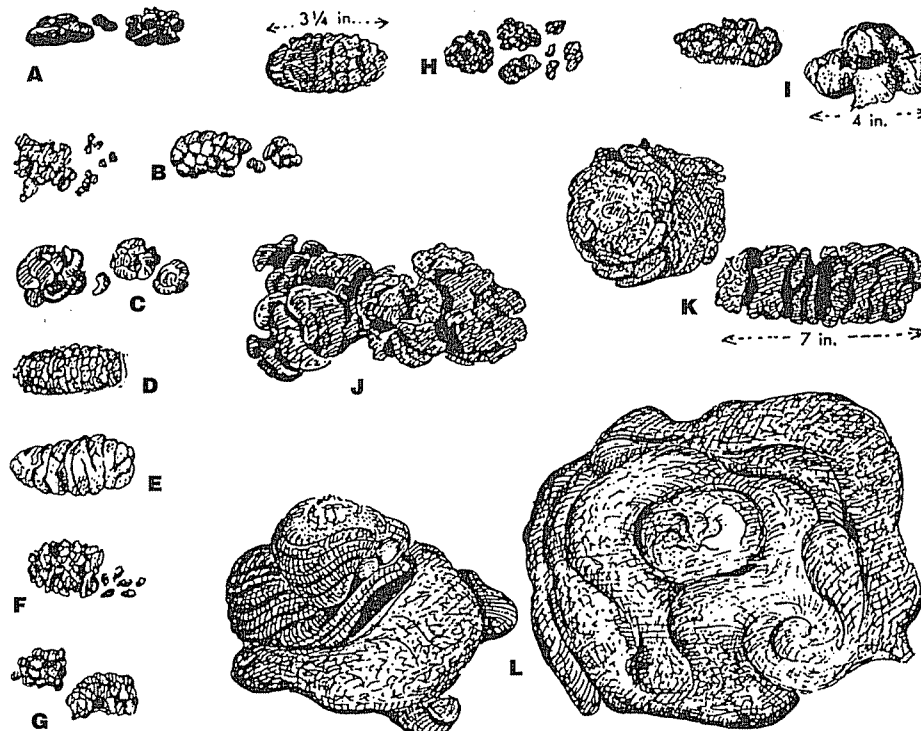


Figure 28.3 Scats of some North American artiodactyls. (A) Collared peccary, *Pecari tajacu*; (B) mule deer, two examples, *Odocoileus hemionus*; (C) white-tailed deer, *Odocoileus virginianus*; (D) Bighorn sheep, *Ovis canadensis*; (E) domestic sheep, *Ovis aries*; (F) mountain goat, *Oreamnos americanus*; (G) domestic goat, *Capra hircus*; (H) caribou, two examples, *Rangifer tarandus*; (I) pronghorn, two examples, *Antilocapra americana*; (J) moose, *Alces alces*; (K) American elk or wapiti, two examples, *Cervus elephus*; (L) American bison, *Bison bison*, two examples.

(Murie, O. 1954. A field guide to animal tracks. Houghton Mifflin Co., Boston, 374 pp., fig. 132. With permission of the publisher.)

shape and appearance of scats vary with the diet and age of the animal.

Examinations of scats can help determine the dietary habits of a species. Relative amounts of different vegetable and animal matter can be determined by indigestible portions, such as hair, feathers, seed coats, and chitin of insect exoskeletons. Microscopic analyses of fecal material (and stomach contents) are usually necessary, however, for quantitative determinations of food habits (see Chapter 34).

- 28-B Use the illustrations in Murie (1954) or collections of preserved (dried) scats to answer the following questions.
- How do you differentiate between the droppings of a deer and of a sheep?
 - Between those of a deer and of a rabbit?
 - Between those of a *Peromyscus* and of a *Microtus*?

Trails, Runways, and Burrows

Terrestrial mammals of all sizes may form conspicuous trails in their travels to and from feeding sites, water holes, or other areas within their home ranges. Many small rodents and insectivores establish definite **runways** that may be completely open above (e.g., those of ground squirrels, *Spermophilus*), partly covered (e.g., of cotton rats, *Sigmodon*), or entirely roofed over by surrounding vegetation (e.g., of voles, *Microtus*). Some kinds of mammals that usually do not form distinct runways themselves (e.g., deer mice, *Peromyscus*) will frequently use runways formed by others, but other species (e.g., harvest mice, *Reithrodontomys spp.*) apparently disregard runways completely.

The excavations made by individuals of different species of terrestrial mammals are highly variable. Many mammals, such as the hares, *Lepus*, use only shallow depressions, termed **forms**, to rest in. Some species, such as sewellels, *Aplodontia rufa*, and northern pocket gophers, *Thomomys talpoides*, dig elaborate networks of tunnels and nests and storage chambers. Several burrows, each with one or more entrances, may be located within an individual's home range.

The location and shape of the burrow entrance, coupled with a knowledge of the species that potentially inhabit an area, can be used to ascertain the animal responsible. The diameter of the hole places a limit on the size of animal occupying it. Some species leave excavated soil in large mounds at the burrow entrance, whereas others scatter the soil. Individuals of some species dig burrows that enter the ground at slight angles, whereas others dig nearly vertical entrances. Members of some species normally locate burrow entrances at the base of a rock or of vegetation; others select open areas. Many species leave their burrows open, but some place a

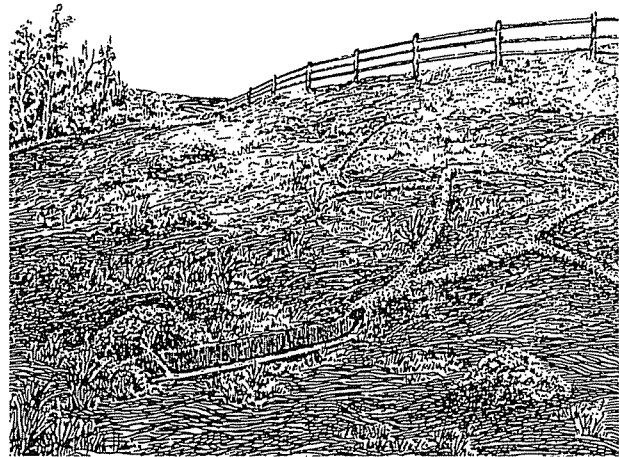


Figure 28.4 Ridges and mounds made by a mole (*Talpidae*) with sectional view of some tunnels in lower left of figure. (Silver and Moore 1941:4)

soil plug in the entrance. Many terrestrial species do not usually dig their own burrows but inhabit those abandoned by other species.

Certain fully fossorial mammals such as moles, pocket gophers, and “mole”-rats have elaborate tunnel systems that may be barely subsurface or very deep. Some moles, *Talpidae*, usually dig tunnels just below the surface, pushing up serpentine ridges visible above ground, and leaving radially symmetrical eruptions of excavated soil at intervals along the ridges (Fig. 28.4).

Pocket gophers (*Geomyidae*) and some other burrowing rodents (e.g., *Spalax*, *Ellobius*, *Heterocephalus*) excavate tunnels that are several inches underground. The tunnels themselves are not visible at the surface, but mounds of excavated soil indicate their presence. A short tunnel connecting these mounds with the main underground runway system is generally opened to permit removal of excavated soil, to air-condition the burrow system, or to allow the animal to exit and forage above-ground (Fig. 28.5).

- 28-C Compare illustrations of mole and pocket gopher tunnel systems. What similarities do you see? What differences?

Nests and Dens

Burrowing species usually include nest chambers in their network of tunnels. Frequently, these chambers are lined with dry grass, leaves, or some other cushioning and insulating material. Nonburrowing small mammals may construct nests for retreat, for resting, and/or for the rearing of young. These may be located in small depressions in the ground, in tangled vegetation, in cracks in rocks, or in hollows in trees. Some woodrats or pack rats,

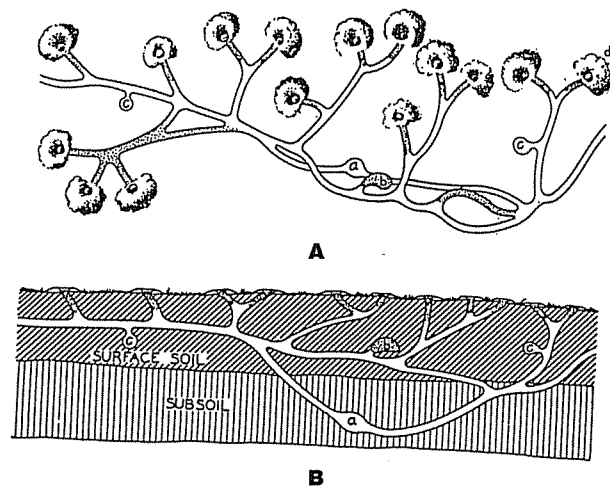


Figure 28.5 Burrow system of pocket gopher (*Geomyidae*) viewed from above (A) and in diagrammatic section (B). Nest in use (a), old nest filled with dirt (b), chambers (c) for storage of roots and other materials, and (d) one of 15 mounds shown. (Crouch 1933:8)

Neotoma, use twigs, rocks, dried dung, and any other handy material to construct elaborate domed lodges, or dens (Fig. 28.6). Grass-lined and/or fur-lined nests are constructed in chambers within these dens. Beavers, *Castor* (Fig. 28.7) build elaborate houses when appropriate habitat and sufficient construction materials (sticks, limbs, etc.) are available. When these are lacking, they burrow into the side of a pond or into a stream bank.

Arboreal species frequently construct leaf and twig platforms or use cavities in tree trunks. Many tree squirrels inhabit leaf nests during the warm months and move to hollow trees during the winter. Gorillas, orangutans, and chimpanzees (*Hominidae*) build sleeping platforms in trees for overnight occupancy. The red tree vole, *Arborimus longicaudus*, normally constructs an arboreal nest out of Douglas-fir twigs and resin ducts from the needles. Such a nest may grow to 3 feet in diameter through generations of use.

Hollow trees, caves, protected areas under fallen logs, and other similarly protected spots may be used by mammals as dens for a temporary rest or for hibernation.

Bats may roost in caves, buildings, or hollow trees. Some species select crevices in rocks or spaces under tree bark. Some tropical bats conceal themselves among the leaves of palm trees, and some (e.g., *Artibeus cinereus*, *Uroderma bilobatum*) modify leaves to construct shelters.

Feeding Residues

Mammals leave many signs of their feeding activities. Species that browse on woody vegetation break twigs and branches and leave conspicuously nipped-off twigs. Rodents of all sizes chew nuts and large seeds and discard the shells. Shrews and rodents eat the soft bodies of

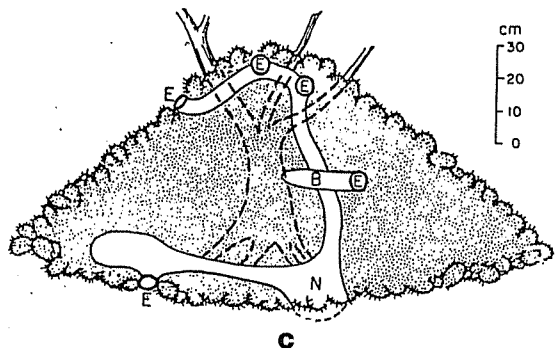
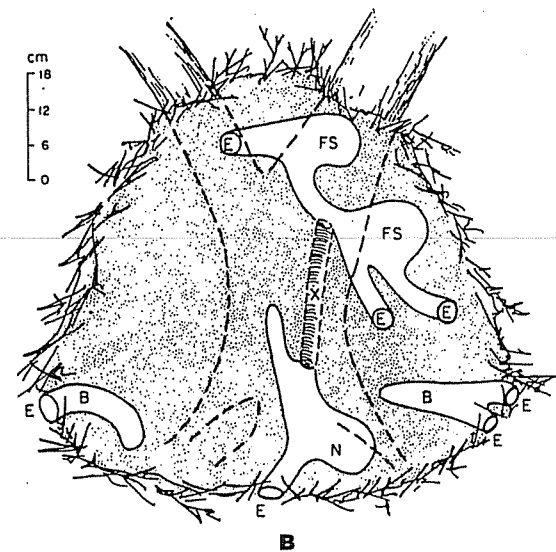
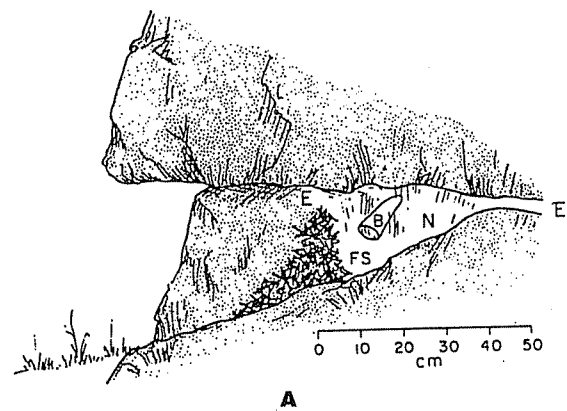


Figure 28.6 Diagrammatic side views of rock (A), stick (B), and cactus (C) houses (dens) made by the desert woodrat, *Neotoma lepida*, Muridae, Sigmodontinae. Blind passageway, B; entrance, E; food cache, FS; nest, N; tree hollow used as passageway, X. Houses may also be made of combinations of these and other materials.

(Cameron and Rainey 1972:256, 258, 261)

snails and leave the opened shells. Many species strip bark from trees, and beavers cut down trees for food and construction materials (Fig. 28.7). Hogs, skunks, armadillos, and many other mammals dig and root in the ground for their food and leave evidence of this activity.

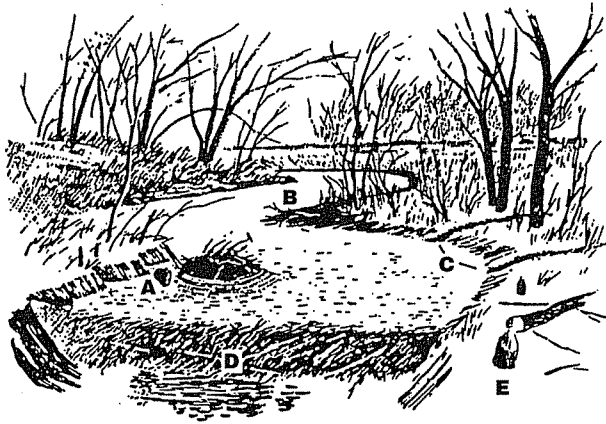


Figure 28.7 View of American beaver (*Castor canadensis*, Castoridae) pond and associated sign. (A) Den; (B) feeding sign near shore; (C) trails leading to logging areas; (D) dam; (E) downed tree.

(Henderson 1960:55)

Some bats (e.g., pallid bats, *Antrozous pallidus*) feed upon large insects and/or vertebrates and leave piles of uneaten feathers, wings, and legs under their roosts.

Many mammals, such as squirrels, Sciuridae, woodrats, *Neotoma*, and kangaroo rats, *Dipodomys*, cache quantities of food in or around their nests or dens. Pikas, *Ochotona*, and some mice cut vegetation and allow it to dry. Carnivores may cache their kills by hanging them in trees (e.g., leopard) or by covering them with brush (e.g., tiger) and return to them several times to feed.

28-D Examine some nuts that have been gnawed by various rodents. How can you tell which were chewed by squirrels and which by mice?

Miscellaneous Sign

Many indications of an animal's presence do not fit into any of the above categories.

Antlers and other bones are frequently well-gnawed by rodents, leaving tooth marks as sign of their presence. Apparently, the animals secure minerals and salts from these objects.

During the fall, male deer in temperate climates lose velvet from their antlers as they rub the antlers against rocks, trees, or brush. Shreds of discarded skin and/or worn spots on the rubbing posts indicate this activity—one that may be partially related to sign-posting. Some carnivores, such as bears and felids, scrape trees with their claws, leaving identifiable marks (Fig. 28.8).

Miscellaneous strands and tufts of hair may be found clinging to brush, barbed-wire fences, or to rocks along a trail where a mammal has brushed against something sharp or rubbed to scratch irritated areas of the body.

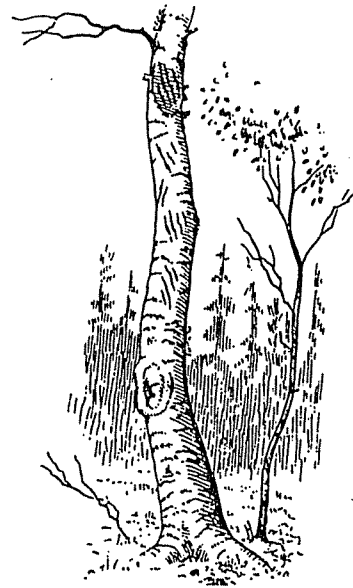


Figure 28.8 Tree that has been clawed by a brown bear, *Ursus arctos*, Ursidae.

(Novikov 1956)

Many mammals mark areas within their home range or territory. Zebras and African buffaloes may rub a termite nest until the ground around the nest is bare. European bison may select a particular tree and remove portions of the bark by rubbing it with their horns. Dung heaps and other signposts usually have a territorial function.

28-E Field exercise: Choose an area with at least two distinct "habitats" (such as an open field and an adjacent wooded area). Mark off two parallel lines 100 meters long and 2 meters apart. These transects should extend into both "habitats." Carefully examine the area between the lines for mammal sign. Plot the location and nature of all sign on a map or piece of graph paper. Using Murie (1954) or a similar reference, identify the sign as precisely as you can. How many kinds of mammals can you now say inhabit the area? Does there seem to be a higher concentration of mammals in any one part of the transect? Where would you set traps to catch the mammals that produced the sign that you have identified?

HABITAT ANALYSIS

The **habitat** of a mammal, i.e., where it lives, is defined by geographic, physical, chemical, and biotic characteristics (Brower et al. 1990). Brower and Zar considered the **macrohabitat** to represent the overall habitat of a community of organisms and the **microhabitat** to represent the specific habitat occupied by a population of a given species. In ecological studies, we are most interested in

techniques for characterizing microhabitats, but attributes of macrohabitat may also be important in helping to identify areas suitable for reserves, refuges, and parks.

Selection of Samples

The investigator should carefully consider how many samples are needed to characterize the habitat of a particular species. Replicated samples or observations taken at a site allow one to conduct statistical analyses of data. Your instructor or statistical consultant will advise you on the number of samples needed for characterizing a particular habitat. As a rough guideline, plant ecologists recommend that samples include about 10% of a study area to get a reasonable estimate of the vegetation in the area. In the following sections, we describe techniques for analyzing soil samples and for measuring vegetation using line transects and quadrats.

Analysis of Soils

Fossorial species of mammals are specialized for living most of their lives underground. One would expect that different species of fossorial mammals might exhibit preferences for different soil types. Different species of pocket gophers (Geomyidae), for example, are known to live in different microhabitats characterized by soils with extremely small particle sizes (clays) to large particle sizes (sands and small pebbles).

Soil samples can be taken to analyze soils for particle size distribution, organic matter, or nutrients. Soil scientists of the U.S. Department of Agriculture use particle size as one of the factors in determining soil type. Table 28.1 shows the USDA System for classifying soil particle sizes. Soil laboratories most often use hydrometer techniques to estimate soil particle sizes (see procedures described in Cox 1996 and Brower et al. 1990). From these analyses, the USDA System groups soils into eleven basic types: *sand*, *loamy sand*, *sandy loam*, *sandy clay loam*, *loam*, *sandy clay*, *clay loam*, *silt loam*, *silt*, *silty clay loam*, and *clay*.

TABLE 28.1

Size Categories of Soil Particles Based on U.S. Department of Agriculture System

Category	Particle Diameter in	
	mm	µm
Clay	< 0.002	< 2
Silt	0.002–0.05	2–50
Very fine sand	0.05–0.10	50–100
Fine sand	0.10–0.25	100–250
Medium sand	0.25–0.50	250–500
Coarse sand	0.5–1.0	500–1,000
Very coarse sand	1.0–2.0	1,000–2,000

Adapted from Brower et al. (1990:45).

A qualitative technique can also be used to characterize soils based on how well a squeezed lump of soil remains intact in the hand after the grip on the sample is released. Soils with a high sand content (e.g., *sand*, *loamy sand*, and *sandy loam soils*) will quickly fall apart and not remain as a clod. In contrast, a lump of soil with a high clay content (e.g., *clay* and *clay loam soils*) will generally remain as clods after the hand pressure is released.

- 28-F Examine several soil samples on display and make a clod in your hand of each type. What is the feel of these soils? Do the soils break apart when your grip on the clod is released?

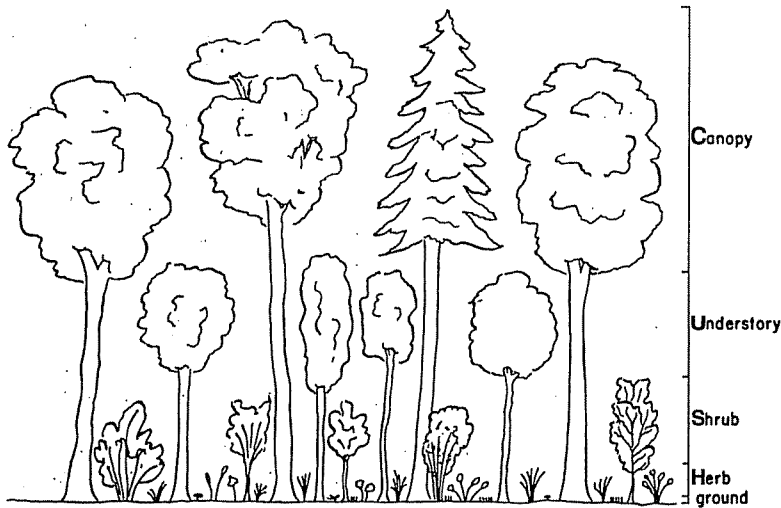
Vegetation Line Transects

Line transects can be used to get quantitative estimates of plant density, of cover area, and frequency and can produce results comparable to those obtained by quadrat sampling techniques (Cox 1996). Line transects are often used in studies of mammals, in which quantitative data are needed to characterize plant resources for diet or resource analyses. In these studies, separate line transects are used for each vegetation stratum (Fig. 28.9) in the community because different species of mammals may occupy different strata in the plant community.

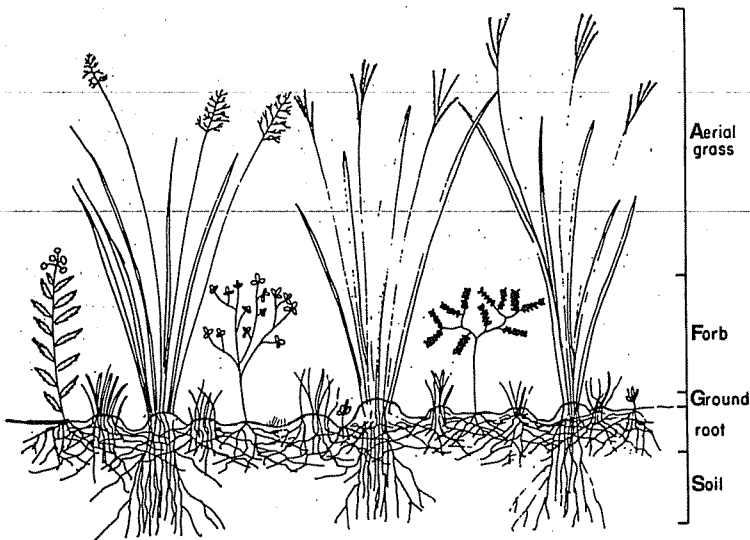
In line-transect sampling, a 30- to 50-meter tape is extended along a line that is determined by a random procedure (e.g., use of a table of random numbers to obtain the compass bearing to orient the line). The tape is secured at one end (using a spike or screwdriver) and then threaded through the habitat in a *straight line*. With a metric tape, the centimeter (cm) marks provide a convenient way to subdivide the tape for recording purposes and make calculations easy. For example, if a plant touches the line, lies above the line, or lies below the line, then that interval is part of the **line intercept** for that individual plant or clump of plants. You should also record the intercept lengths for intervals that have no plant cover, in order to get an estimate of the extent of bare ground.

In Figure 28.10A, four species of plants are depicted. In intervals “b” and “d,” the *crown* of the plant is projected to the tape to determine the line-intercept length. In intervals “a” and “c,” the *basal* area is shown projected to the transect line. You should indicate if you used the “basal” or the “crown” technique to record line-transect lengths.

In Figure 28.10B, three species of plants (labeled a, b, and c) are depicted. In this example, measurements were taken on crown intercepts, with data recorded to the nearest centimeter (cm). Thus, species “a” has an intercept length of 3 cm (25–27 cm), “b” has an intercept length of 4 cm (20–23 cm), and “c” has an intercept length of 1 cm (plant touches line only in the 24-cm interval). On the data sheet (Table 28.2), record the exact



A



B

Figure 28.9 Stratification in plant communities. (A) Mixed deciduous forest; (B) prairie plants. (Brower et al. 1998:37)

interval lengths (e.g., 24–27) for each species [or group of plants (e.g., forbs or grasses)]. With the exact interval lengths recorded, you can look for areas of bare ground. In this example, bare ground between species “a” and “b” would be a 1-cm section in the interval 23–24. The procedure described above can be used to calculate **cover** (or **dominance**) or to calculate **relative dominance** values as a percentage of the ground surface intercepted, using the following formulas:

$$\text{cover} = \frac{\text{total of intercept lengths for a species}}{\text{total transect length}} \times 100$$

$$\text{relative dominance} = \frac{\text{total of intercept lengths for a species}}{\text{total of intercept lengths for all species}} \times 100$$

28-G Use a random procedure to extend a 10-meter tape in a straight line along the ground. Record

the line-intercept lengths for all species of forbs, sedges, and grasses along this line. Compute the cover (dominance) and relative dominance values for at least three species of forbs. Which species of forb was dominant?

To record density and relative density of plants, you must also record the maximum width of the plant on a horizontal line perpendicular to the transect. Cox (1996) and Brower et al. (1990) provided additional formulas and instructions for calculating these other vegetation indices for plant communities.

Vegetation Quadrats

Vegetation **quadrats** are plots of ground defined by rectangular or circular frames, or, when large quadrats must be established, by staking out an area on the ground. The larger quadrats are most often used for shrub and tree

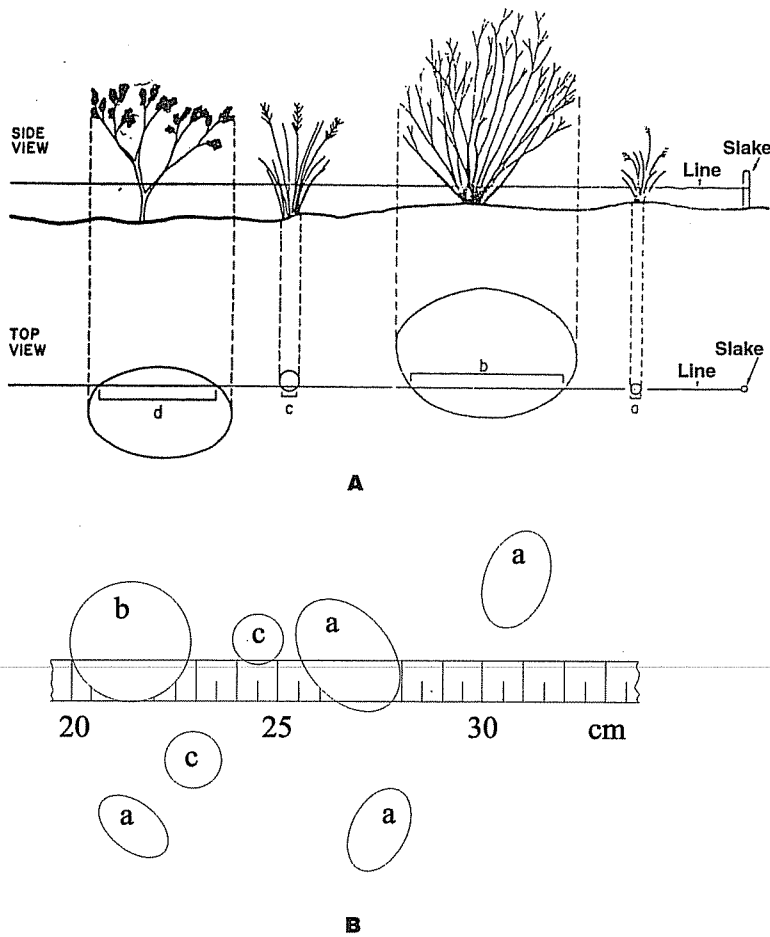


Figure 28.10 Technique for determining vegetation line-intercept lengths. (A) Example of basal area (c and a) and crown area (d and b) intercepts; (B) example of intercept lengths using the crown area method. Note that in (B) the intercept length for species "a" is the interval 25.5–28 cm for a total of 2.5 cm; the area of bare ground between species "b" and "c" is only the interval 23–24 for a total of 1 cm. (A, Brower et al. 1998:98; B, R.E. Martin)

TABLE 28.2 Example of Data Sheet for Recording Vegetation Line-Transect Data*

Line-Transect Data

Locality: _____
 Date: _____ Recorder(s): _____
 Length of Transect: _____ meters Interval Length: _____ Intercept Method (circle): BASAL CROWN
 Stratum (circle): GROUND HERB SHRUB TREE Station/Grid Point: _____

Plant/Clump Number	Species: Intercept Length	Species: Intercept Length	Species: Intercept Length	Species: Intercept Length	Species: Intercept Length

Page ____ of ____

*Data from each sheet are transferred to a summary sheet to get totals for each species.

TABLE 28.3 Example of Data Sheet for Recording Quadrat Vegetation Data
Data from Each Sheet are Transferred to a Summary Sheet to Get Totals for each Species.

Quadrat Data

Locality: _____
 Date: _____ Recorder(s): _____
 Area of Quadrat: _____ Units of Area: _____ Area Method (circle): BASAL CROWN
 Stratum (circle): GROUND HERB SHRUB TREE Station/Grid Point: _____

Plant/Clump Number	Species: Area	Species: Area	Species: Area	Species: Area	Species: Area

Page _____ of _____

species, whereas the frame technique is used when it is possible to position the frame over the plants to be measured (Cox 1996). This technique can be more time-consuming than the line-transect technique because it requires that the area of each individual plant be measured within a quadrat (Table 28.3). For grasses, the measurement of the individuals of each species is often impractical with this technique. Thus, a measurement of the area covered by a class of plants (e.g., all of the forbs, or all of the grasses) might be determined. Alternatively, Cox (1996) described a semiquantitative technique for using cover classes (Table 28.4) to estimate the percent ground cover.

You can calculate several density and dominance values of plants using the following formulas:

$$\text{density} = \text{number of individuals/area sampled}$$

$$\text{relative density} = \frac{\text{density for all species}}{\text{total density for a species}} \times 100$$

$$\text{dominance} = \frac{\text{total area covered by plant}}{\text{area sampled}}$$

$$\text{relative dominance} = \frac{\text{dominance of a species}}{\text{total dominance for all species}} \times 100$$

- 28-H Position a 1-meter square frame over a plot of ground that has been located using a random technique. Count the number of individual forbs in the quadrat and determine the area occupied by each. Use these data to calculate the density and dominance for each species of forb. What are the densities and relative densities of the forbs? What are the dominance and relative dominance values for the different species of forbs?

TABLE 28.4 Method for Ranking Vegetation Using Cover Classes

Cover Class	Range of Percent Cover	Midpoint of Percent Cover
1	0-5	0.5
2	1-5	3.0
3	5-25	15.0
4	25-50	37.5
5	50-75	62.5
6	75-100	87.5

After Cox (1996:90).