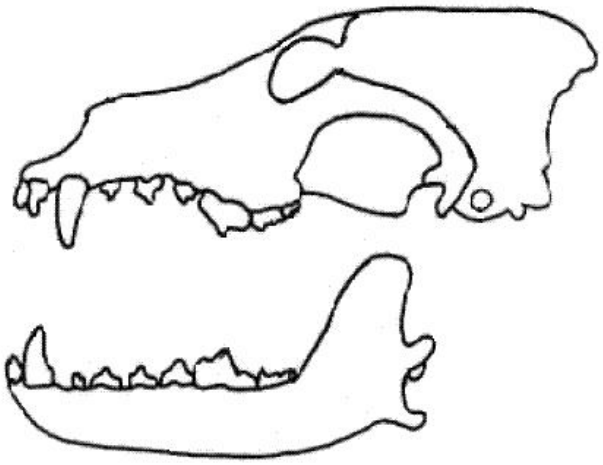


Background Info

This section is designed to provide important information about mammal biology. Detailed descriptions of important features of skulls and tracks are included. You will learn how to use skull characteristics to identify what an animal might eat and where it might live. In addition, since wildlife can be difficult to find in the outdoors, you will learn how to identify animals by the most readily available signs: the tracks they leave behind.

The Bone Box Resource Trunk contains replica skulls for 11 common Arizona mammals. Use the knowledge from this section to help you improve the learning experience for your students. The skulls are intended to be a tactile resource. Feel free to allow your students to handle them, to feel the difference between slashing incisors and grinding molars. If a skull does break, simply inform us when you return the box. This will ensure that we can make the necessary repairs or replacements to provide a quality experience for the teachers and students who will use the box when you are finished.

The Resource Trunk also contains a sheet with the tracks of a number of different animals painted on it. This track sheet is a valuable resource to guide inquiry learning and critical thinking. After identifying the animals that made the tracks, students can attempt to figure out what happened. Were all the animals there at the same time? What were they doing? How do they know?

As you read through the material, you will notice that some of the words appear in a **bold font**. These are vocabulary words that may be new to either you or your students. Definitions can be found in the glossary found later in this teacher's guide.

Tracks and skulls are examples of animal signs – clues that animals leave behind. They indicate the presence of wildlife even when the animals aren't directly seen. The Department's website provides some additional information to get you started on finding animal signs and increasing your chances to see wildlife. Please visit the following links to learn more:

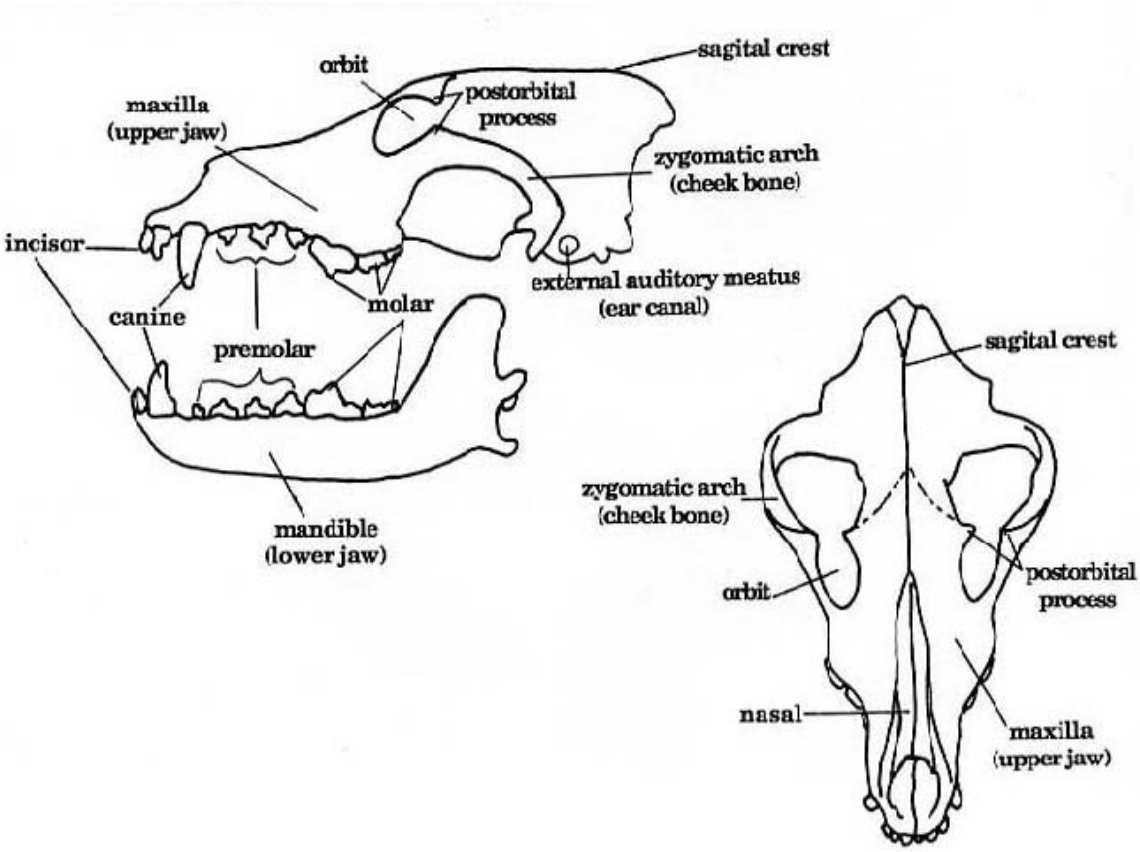
- Arizona wildlife viewing - **http://www.azgfd.gov/outdoor_recreation/watchable_wildlife.shtml**

- Arizona Watchable Wildlife Experience - **http://www.azwatchwildlife.com/**

In addition, a number of additional activities focused on observing animal signs are available as extension activities on the Bone Box Resource DVD provided with this resource trunk.

Skulls

Skulls can indicate many things about the habitat, behavior, and physical attributes of an animal. What did the animal eat? How big was it? Did it live in the forest, grassland, water, or even underground? Clues from a skull can often help us answer these questions. An animal's skull can provide insight into how good the animal's senses of vision and smell were. Was the animal active at night (**nocturnal**), active during the day (**diurnal**), or was it active in the early morning and evening (**crepuscular**)? The teeth in a skull can indicate whether the animal was a plant eater (**herbivore**), meat eater (**carnivore**), or if the animal ate both plants and animals (**omnivore**).



NOSE

The size of the nose is often indicative of the animal's ability to smell. Long nasal bones hint at a good sense of smell. Animals with short noses generally have a poor sense of smell. These animals usually have good hearing or eyesight to compensate. Rabbits have a relatively poor sense of smell, but well developed eyesight and hearing. Coyotes, on the other hand, are well adapted with good eyesight, keen sense of smell, and keen hearing.

ORBIT OR EYE SOCKET

Eye location and the size of the **orbit** can be used to indicate whether the animal was a predator or prey, and if **nocturnal**, **diurnal** or **crepuscular** in activity.

The eyes of most prey species are large and located towards the sides or back of the skull like the turkey, deer, and rabbit. This allows for the detection of predators at a great distance and in many directions, including front and back without turning the head. The beaver has eyes located towards the top of the head for the detection of predators while swimming!

Eyes of most predators are "forward looking" as in mountain lions, hawks, owls and humans. Forward facing eyes provide **binocular vision**, enabling predators to judge distance – a critical adaptation for predators hunting moving prey!

The size of the orbit will indicate the size of the eye and thus the quality of eyesight of the animal. Small eyes often indicate diurnal activity. Animals with small eyes relative to the size of their skull, such as bears and javelina, have poor eyesight. Animals such as bobcats and coyotes have large orbits, thus good eyesight. These animals often tend to be either nocturnal or crepuscular. The large eyes help them see in low light conditions.

It is sometimes difficult for students (and adults) to distinguish the orbit from the space defined by the **zygomatic arch.** In many cases, these two spaces are continuous. The space formed by the zygomatic arch provides sites for the large lower jaw muscles to attach, and forms the surface upon which the lower jaw hinges. The arch also protects the eye. To differentiate the two spaces, look for the postorbital (post = after) process on both the frontal bone and zygomatic arch. These processes define the **posterior** borders of the orbit. On some skulls, the postorbital process of the zygomatic arch is poorly defined or absent. And in the weasel family, all four processes are greatly reduced or absent. In these cases, the orbit can be considered to be the front half, and the zygomatic arch space the back half.

TEETH

Most mammals have **heterodont** (hetero = different, -dont = teeth) teeth consisting of incisors, canines, premolars, and molars. The shape of teeth is one of the most important characteristics used to determine the general types of food a mammal can eat efficiently. Check the cheek teeth first. **Cheek teeth** are the premolars and molars.

Teeth used by herbivores for grinding vegetation tend to be discolored (remember grass stains on your knees?) and flattened either horizontally or at an angle. The flattened surface is used to crush and grind vegetation. The teeth that are flattened at an angle tend to have "sharp" top and bottom edges. These "sharp" edges are due to the sliding-grinding action of the upper and lower jaws against one another and should not be confused for "sharp" carnivorous teeth.

Cheek teeth of carnivores tend to be narrow and shaped into sharp cutting edges. The cheek teeth of the lower jaw slide against their counterparts in the upper jaw much like a pair of scissors. These teeth are used for ripping and tearing flesh. No grinding takes place due to the absence of sideways movement between the upper and lower jaws. Carnivores also tend to have fewer cheek teeth than herbivores, possibly because a large surface area for grinding food is not required.

Omnivores have a combination of both flat grinding teeth for vegetation and sharp cutting teeth for flesh. As you can guess, omnivores that tend to eat more meat will usually have more sharp than flat teeth, and those that tend to eat more vegetation will have more flat than sharp teeth.

Not only do some animals have different types of teeth, they also have different numbers of teeth. For

example, white-tailed deer have 32 teeth while a black bear has 42. A beaver only has 20 teeth!
Biologists have developed an easy method to show the number and type of teeth that all mammals have. It is called a dental formula. The dental formula for a white-tailed deer is shown below:

$$\text{White-tailed deer: } \frac{0\text{-}0\text{-}3\text{-}3}{3\text{-}1\text{-}3\text{-}3} = 32$$

To understand the dental formula, we need to know some simple rules about what the numbers mean and where they come from:

1. Mouths are symmetrical, with the same number and type of teeth, from the left side of the mouth to the right. So, a dental formula only shows the teeth on one side of the mouth. To get the total number of teeth, the numbers in the formula must be multiplied by 2.
2. Some animals have different numbers and types of teeth on the top and bottom of their mouth. For example, a deer has three incisors on their bottom jaw but none on the top. To show this difference, the top teeth are represented above the line in the dental formula. The bottom teeth are below.
3. The different types of teeth always appear in the same order and location in the mouth. Incisors are always at the front. These are followed by the canines. The premolars and molars are found at the back. The numbers in the dental formula occur in the same order. So, the first number represents the number of incisors, the second is the number of canines, etc.

So, looking at the white-tailed deer's formula above, we know a number of facts about the animal, even if we have never seen its skull. As mentioned, it has a total of 32 teeth. Of these, 12 are on top and 20 on the bottom. (Remember: the dental formula only shows the number of teeth on one side! We have to multiple those numbers by two in order to get the totals.) Next, we know that the deer has no incisors or canines on top, and only two canines (one on each side) on the bottom. So, what does this tooth configuration tell us about the animal? Well, the deer lacks many of the teeth necessary for tearing meat and has many premolars and molars used for grinding. So, it is most likely an herbivore.

The table on the next page summarizes all of the features just discussed. It allows for a quick reference to compare the 11 skulls included in the Bone Box Resource Trunk.

Additional skulls can be found in some of the other resource trunks available from the Arizona Game and Fish Department. This includes a Bat Box and an Elk Box. Not all of the trunks are available at all Department offices. For more information about the other resource trunks, visit our website at **http://www.azgfd.gov/bonebox**.

Bone Box Skulls at a Glance

This is a quick reference to some of the characteristics of the skulls included in the bone box.

ANIMAL	NOSE	ORBIT	TEETH	DENTAL FORMULA
Beaver	Short	Large; toward top	Flat	1-0-1-3 = 20 1-0-1-3
Black bear	Long	Small; toward front	Flat; few sharp	3-1-4-2 = 42 3-1-4-3
Bobcat	Short	Large; toward front	Sharp	3-1-2-1 = 28 3-1-2-1
Coyote	Long	Large; toward front	Flat and sharp	3-1-4-2 = 42 3-1-4-3
Deer	Long	Large; toward side	Flat	0-0-3-3 = 32 3-1-3-3
Gray fox	Long	Large; toward front	Flat and sharp	3-1-4-2 = 42 3-1-4-3
Jackrabbit	Long	Large; toward side	Flat	2-0-3-3 = 28 1-0-2-3
Javelina	Long	Small; toward side	Flat	2-1-3-3 = 38 3-1-3-3
Mountain lion	Short	Large; toward front	Sharp	3-1-3-1 = 30 3-1-2-1
Raccoon	Short	Large; toward front	Flat and sharp	3-1-4-2 = 40 3-1-4-2
Ringtail	Short	Large; toward front	Flat and sharp	3-1-4-2 = 40 3-1-4-2

Dichotomous Key to Bone Box Skulls

A common and useful tool for identifying living organisms is a **dichotomous key**. From the Greek *dicho* meaning "in two parts" or "in pairs," dichotomous keys consist of a series of couplet statements. Each couplet contains two descriptions of a specific characteristic. The unknown organism is compared to each of the two statements to see which is a better description. Once a decision is made, directions are provided to the next appropriate couplet. This process continues until the identification of the unknown organism is made. Dichotomous keys are sometimes referred to as decision trees.

Some general rules of thumb to follow when you are using a dichotomous key:

- Always start at the first couplet. This is usually indicated by the number 1 or the letter A.
- Read both statements in the couplet carefully before making a choice. You do not want to jump at the first option just because it sounds like it might fit.
- Follow the directions at the end of the statement exactly. Often, people forget to skip to the appropriate couplet and simply move to the next consecutive one in the key.
- Take notes. It is easy to get lost or distracted as you move through the key, especially long ones.
- When you have identified the organism, go back and check your work. If possible, have someone else check to see if they come to the same conclusion.

There are dichotomous keys for just about all living things including insects, trees, wildflowers, and fish. The key on the next page can be used to help you or your students identify the skulls found in the Bone Box Resource Trunk*. In addition, the Arizona Game and Fish Department provides an excellent interactive key to help people identify common captive turtles. This web-based key is found at **http://www.azgfd.gov/w_c/turtleID_chart.shtml**.

** Please note: The skunk is not actually included in the Bone Box Resource Trunk. It is listed in the dichotomous key to provide a little more challenge to students and to show the similarities between animals.*

Key to Common Arizona Mammal Skulls

1a	Canines absent	Go to 2
1b	Canines present	Go to 4
2a	Upper incisors present	Go to 3
2b	Upper incisors absent; orbits fully enclosed by bone	DEER
3a	Large orange incisors; 8 molars on either the upper or lower jaw	BEAVER
3b	Incisors white; second set of peg-like incisors behind the top front pair; fenestration (lots of openings on maxilla	RABBIT
4a	Cheek teeth flat with rounded cusps (similar to human teeth)	JAVELINA
4b	Cheek teeth a mixture of both sharp and flat teeth	5
5a	Short nasal bones: 3 lower cheek teeth on each side of jaw; cheek teeth narrow with pointed centers	6
5b	More than 3 lower cheek teeth on each side of the jaw	7
6a	4 upper cheek teeth per side of jaw (first and last cheek teeth are smaller than the others)	MOUNTAIN LION
6b	3 upper cheek teeth per side of jaw (last greatly reduced)	BOBCAT
7a	No or poorly developed postorbital process	8
7b	Postorbital process developed	9
8a	3 to 5 cheek teeth on side of upper jaw; no nasal sutures visible	SKUNK
8b	6 cheek teeth on each side of upper jaw; nasal sutures visible	RACCOON
9a	Molars with rounded cusps; some premolars absent (large gap between premolar and canine)	BLACK BEAR
9b	Cheek teeth sharp and evenly distributed	10
10a	U-shaped ridge on top of skull	GRAY FOX
10b	Single ridge on top of skull; upper incisors lobed in front	COYOTE

Animal Tracks

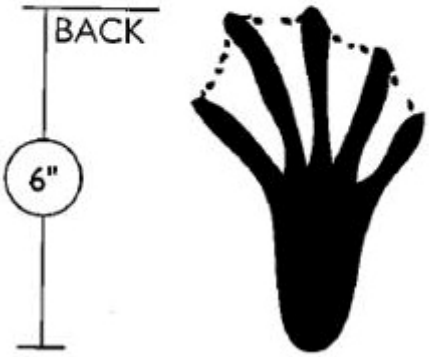
Many times we never see the animal, but we know it was there because it left some sign of its presence. The sign is usually a footprint or track in the snow, mud, dust or sand. There is a story behind every set of tracks; it just takes time to interpret the story.

Interpreting tracks is not an easy task, and takes some detective work. There are a few broad principles to use (number of toes, overall shape of foot, claw marks, etc.), but none of these principles are hard and fast. There will always be a track that breaks every rule. The **substrate** in which the track is made can also alter your interpretation. Tracks made in mud or snow tend to be larger than actual size; dust tracks tend to be incomplete; and, windswept sand tracks are obscured or altered. But the substrate can also help identify the track-maker. Those tracks found in desert sand exclude many animals that are not found far from water. Tracks in snow generally exclude desert dwellers (the exception being the rare snow fall in the Sonoran Desert). Even lighting can affect the appearance. A track can look remarkably different in the morning and the afternoon! Shadows can both highlight and hide certain identifying features.

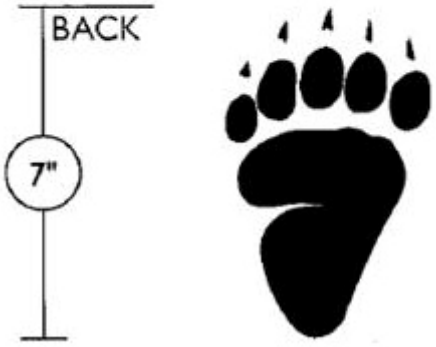
When interpreting the story behind tracks, look forward and back from your initial starting point. You may discover a day bed of a jackrabbit, or clipped vegetation. Looking further ahead, the distance between tracks may suddenly lengthen and then be joined by a different set of tracks (possibly a coyote). Still further you may find that the coyote ate the jackrabbit or the jackrabbit escaped under a brush. Following tracks for some distance may also help you identify, with some degree of certainty, the true identity of the track maker - you may come across "the perfect" track, making identification more positive.

On the next few pages are animal tracks and some track features that may help identify the track-maker. In general, only a few of these features will be seen in any given single track. The examples below are of "perfect" tracks. Tracking an animal using footprints alone can be time and labor intensive. Today wildlife specialists use technology to track animals from remote locations. This technology allows them to track birds as they fly, mammals as they migrate and even fish as they swim. More information about tracking techniques is available in our Tracking Resource Trunk. Like the bone box, this trunk can be checked out for free from the Arizona Game and Fish Department. For more information about the Tracking Trunk or other resource boxes, visit **http://www.azgfd.gov/bonebox**. Currently, this trunk is only available from our main headquarters office in Phoenix. As additional locations are added, they will be included on the website.

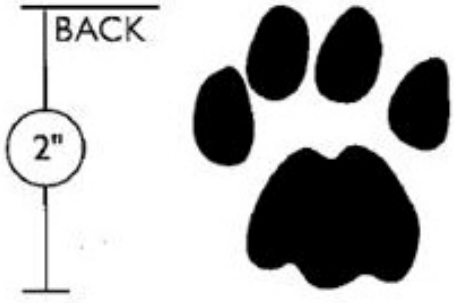
BEAVER



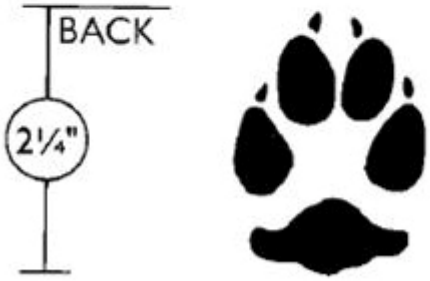
BLACK BEAR



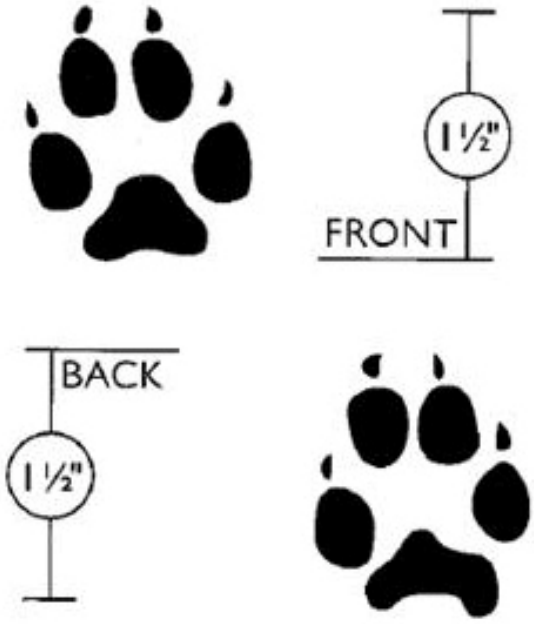
BOBCAT



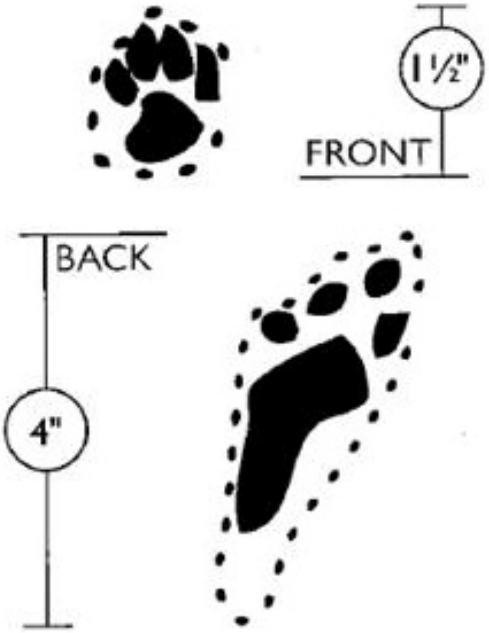
COYOTE



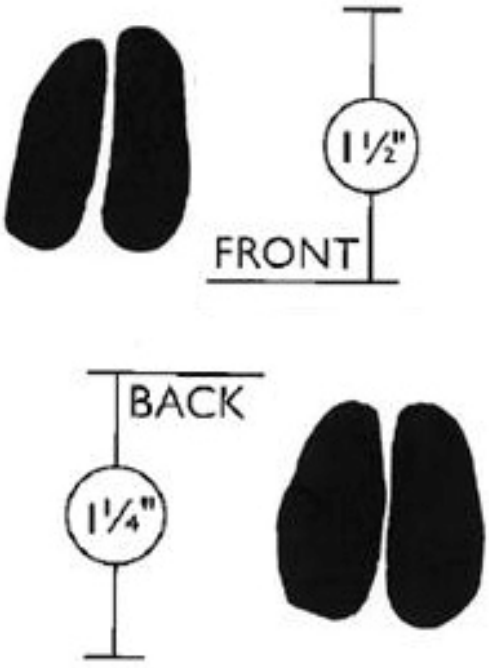
GRAY FOX



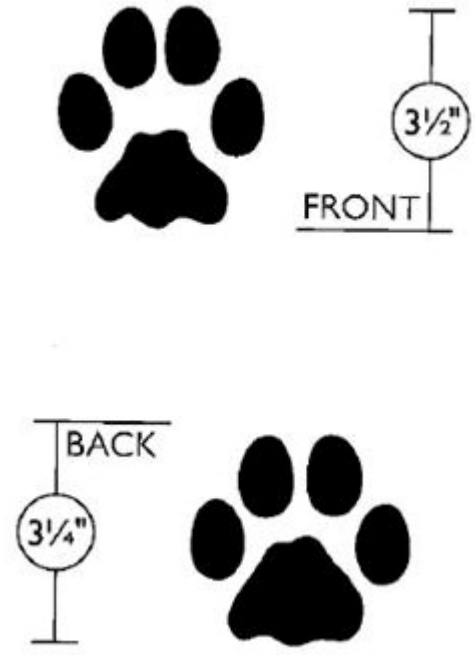
JACKRABBIT



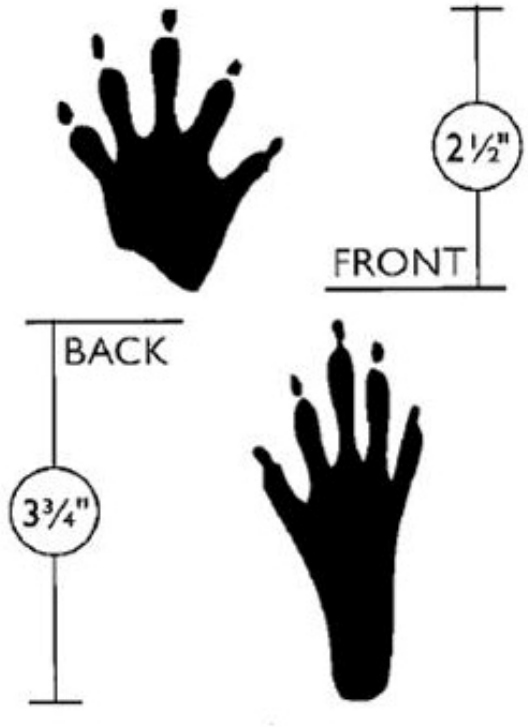
JAVELINA



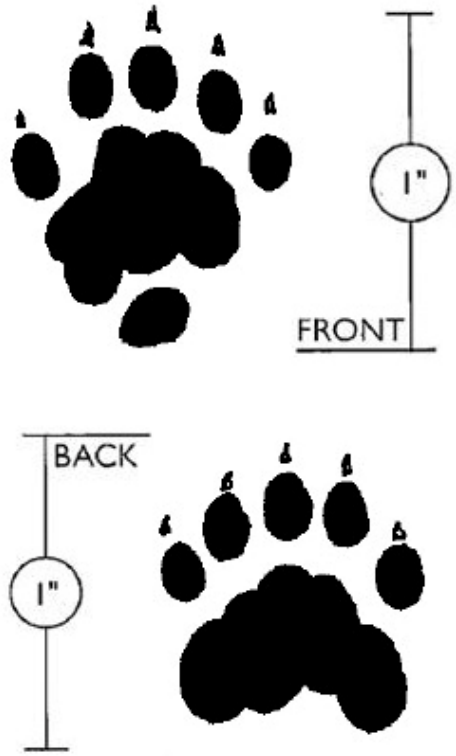
MOUNTAIN LION



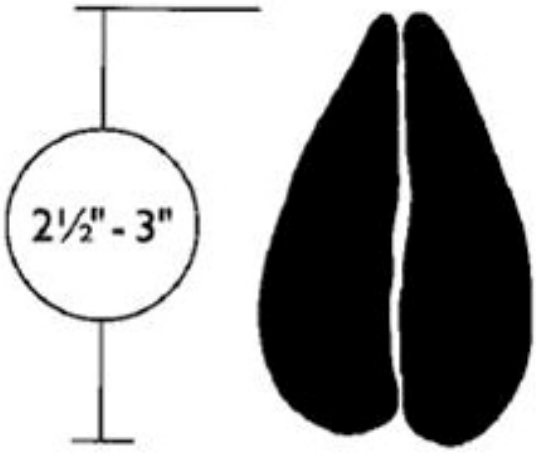
RACCOON



RINGTAIL



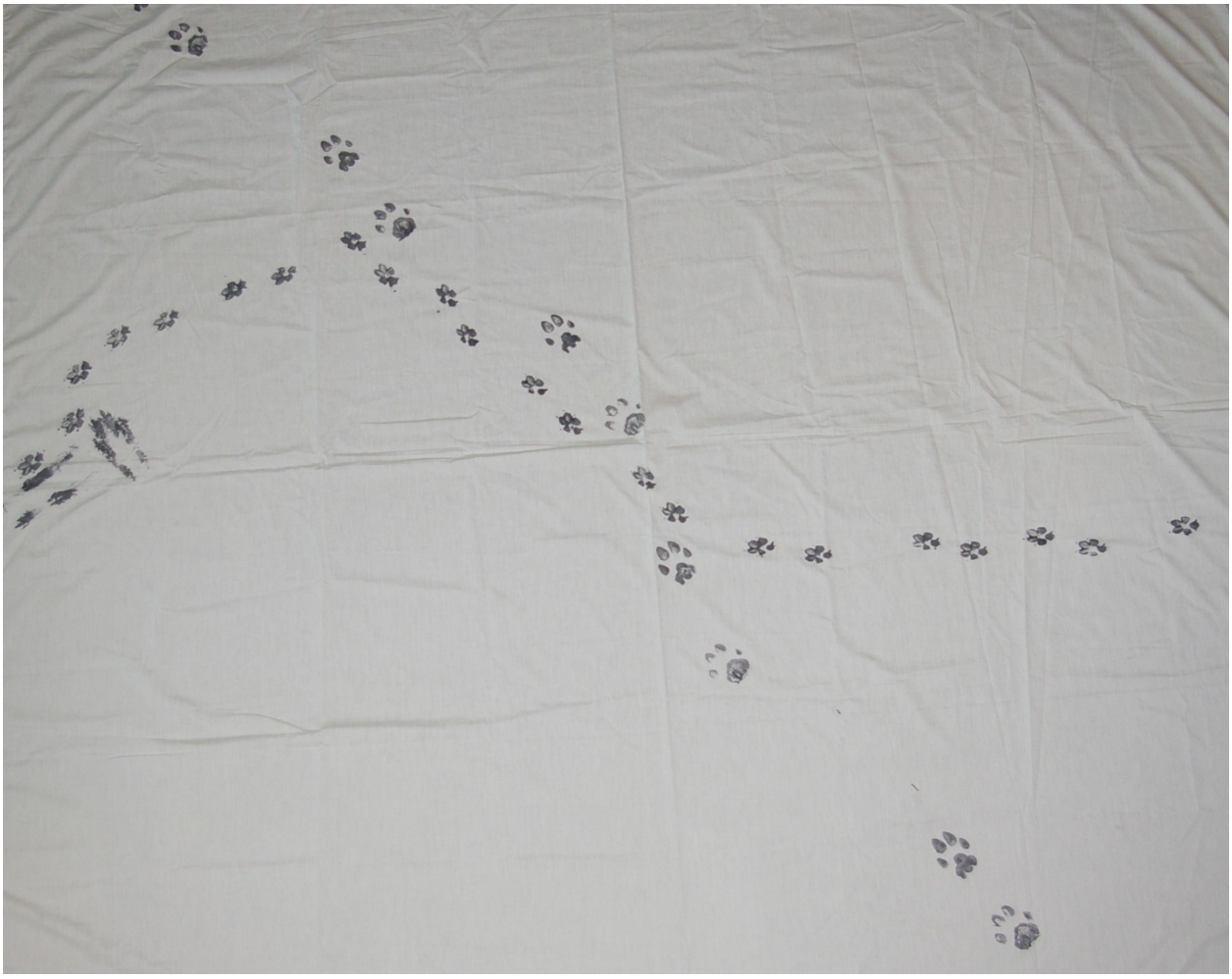
WHITE-TAILED DEER



Tracking Sheet at a Glance

This is a quick reference to the tracking sheet included in the bone box. It will give you some basic information about the animals represented and some helpful clues.

TRACKING SHEET IMAGE
Below is a representative image of the tracking sheet.



DESCRIPTION
This sheet was developed with a basic storyline in mind. The animals were "caught in the act" and the tracks help us determine what they were doing. In this case:

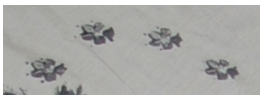
A mountain lion was walking along (tracks moving from the lower right to the upper left). Later, a coyote was walking through (tracks in the middle right side) and smelled the former presence of the lion. The coyote followed the tracks for a little while before noticing a jackrabbit (tracks in the middle left side). The coyote then chases the jackrabbit and the rabbit jumped away.

Students should be able to look at the sheet, identify the animals, find clues and come up with a similar story.

CLUES AND HINTS

It may be necessary to ask some guiding questions to help move students to the correct interpretation. Here are some questions and answers that can help facilitate discussion:

- How many animals are represented on the sheet? How do you know? *Answer: There are a total of three animals. They are the mountain lion, coyote and jackrabbit. There are multiple tracks for each animal. For each different animal, the tracks appear in a repeating pattern which seems to indicate they belong to a single animal as opposed to multiple animals. Students should notice that even though the tracks may be from the same animal, not all of the prints are the same. This is the case in nature. Rarely do we find a "perfect" track. Sometimes, depending on the surface substrate, you only get partial tracks. Sometimes the tracks become more pronounced during different behaviors. For example, when an animal runs, it tends to push down harder. Therefore, these tracks may appear bigger and clearer.*
- Did all of the animals appear at the same time or did some pass through before others? How do you know? *Answer: The location and placement of the tracks hints at the behavior of each of the animals. They seem to indicate that the animals were not all present at the same time. When we look at the mountain lion, its tracks are consistent across the sheet. There is no change in stride length or walking pattern. This particular set of tracks indicates that the lion was not in a hurry, most likely walking through this area. It probably came through first. Later, a coyote entered the scene. In the beginning it was walking. Once it reached the location of the lion tracks, however, it changed direction. It appears to follow the lion. Like other canines (including domestic dogs), it likely picked up the scent of the lion (which had gone through this area earlier) and decided to follow it. In both of these cases, the coyote continues to walk. We can tell this by the similar gait observed in the tracks. Notice how the right and left feet alternate steps (see the picture to the right). A little while later, the coyote picks up the scent of another animal – the jackrabbit.*



In this case, the jackrabbit is actually there, most likely feeding on some grass. The coyote takes off running. Notice how the track pattern has changed (see the picture to the left). Now, the coyote places two left feet down and then two right feet down. This is indicative of a run. Once the coyote starts running, the jackrabbit takes off as well. We cannot tell from the information on the sheet whether or not the coyote successfully caught the rabbit. If a kill took place, it occurred off the confines of the sheet.

There are many ways to tell the difference between the tracks of canines (represented by the coyote) and felines (represented by the mountain lion). On the left is a relatively standard mountain lion track. On the right is a coyote. The tracking sheet is able to highlight a few main differences:

- Most felines have **retractable claws** and, therefore, do not leave toenail marks. Since cats rely on their claws to help them take down prey, they need them to be sharp at all times. If they ran with their claws exposed, they would have a better chance of breaking.
- The overall shape of the tracks is slightly different as well. If you were to draw a circle around each of the tracks, you would notice that the canine track tends to be more elliptical. It is longer than it is wide. The feline track is much more round.
- Another difference between the tracks is the amount of space between the main pad and the toes. Notice that the coyote track is much more compact. There is very little space. The lion, however, has a large amount of empty space between the toes and the main pad.