

1 Introduction to forensic botany

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Forensic botany is the study of plants and how they can relate to law and legal matters. Botany, while widely known as a science, has few professionally trained botanists. In proportion to the number of students trained in most other scientific disciplines, botanists are but a tiny fraction of the total number of individuals working in the field of botany. Many people who teach botany at two- and four-year colleges have perhaps taken only a course or two, and that is likely only because botanical training is typically included in a basic science curricula at the undergraduate level. Some college courses are combined zoology/botany courses, and as a result many college graduates have only portions of a full botanical course and never an entire course. Often, members of various professional plant societies (native plants, garden clubs, and nature organizations), environmental agency employees, and industry workers do not have any formal botanical education. With this low level of academic exposure it is no wonder that so few individuals understand the importance of plants, especially in criminal investigations.

Law enforcement officers and attorneys are no more informed about the science of botany, on average, than the general population. Therefore, important plant evidence is frequently overlooked. Sometimes this evidence can place a person or object at a crime scene, verify or refute an alibi, help determine time since death, the time of a crime, the place where a crime occurred, cause of death, or reason for an illness.

Botanical evidence in legal investigations

To be of value, plant evidence must first be interpreted by a botanist. Typically, legal investigators should seek a botanist with well-rounded training and experience who possesses knowledge of the various specialties within the botanical field in question (Figure 1.1). Some of the various botanical specialties involve systematics (plant names), anatomy (plant cells), morphology (plant structures), ecology (relationship of organisms within the environment), and physiology, chemistry, and genetics (DNA).



Figure 1.1 Dr David Hall, forensic botanist discusses the collection of plant evidence with students at a North Carolina State University forensic science workshop. (Photograph courtesy of Gary Knight.)

Not all botanists have such training. As in many fields, most professional botanists have specialized in one particular area, and have only scant knowledge concerning the forensic possibilities within others.

Plant systematics is the field that deals with the biological classification of plants. A plant systematist deals with the taxonomic classification of plants and utilizes standard nomenclature techniques to derive the scientific names of plants. Consulting with an expert in plant systematics is usually an excellent place for the legal investigator to start when trying to obtain expert assistance. Some experts work with only a single group of plants, but many, if not most, systematists work with many groups and have a good general knowledge of the entire field of botany. In order to place a name on a previously unknown plant, the existing information about that plant and its relatives must be reviewed. To have the capability to review this wide-ranging data, the plant systematist has taken courses and often conducted research and training in all of the areas of botany. They are by no means an expert in each of these fields, but the systematist usually does have connections with professionals who do have such expertise.

Legal plant definition

According to Webster's *Unabridged Dictionary*, ordinarily a plant is any living thing that cannot move voluntarily, has no sense organs, and generally makes its own food by photosynthesis. It is a vegetable organism, as distinguished from an animal organism, and there are many kinds of plants, exhibiting an extremely wide range of variation (Figure 1.2).

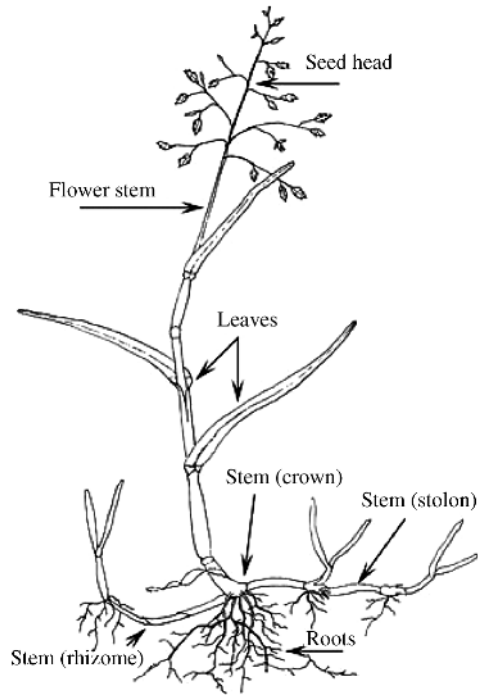


Figure 1.2 Diagram of the major parts of a common plant. (Courtesy of the Center for Turfgrass Science, College of Agricultural Sciences, The Pennsylvania State University.) The Cool-Season Turfgrasses: Basic Structures, Growth and Development.

In the United States, the legal definition of a plant can have sentencing ramifications. For instance, by legal definition a plant must have a connected stem and root. If the stem and root are separated, each becomes a plant fragment. Of course, not all plants have roots, but most do. It is illegal to possess plants or plant fragments of marijuana (*Cannabis sativa* L.), a plant with psychological and euphoric qualities (Figure 1.3). The US government measures the marijuana by either weight or the number of plants. Marijuana plant samples without roots are considered to be plant fragments and are weighed with other pieces, and a plant with a root can be counted as an entire plant regardless of size. Federal guidelines recommend sentences based on either the number of entire plants or various amounts by weight. If entire plants are found along with loose fragments that have been harvested for use or sale, the number of plants can result in longer sentences than the loose fragments, even if the plants are tiny and the weight is insignificant.

Botanical evidence in legal investigations

Not all legal matters are concerned with crimes against persons. Local and national ordinances can prohibit growing, selling, or importation of certain plants, such as



Figure 1.3 Marijuana leaf (*Cannabis sativa* L.), a plant which the United States government considers to be a controlled substance. Penalties for possession can be imposed based on total weight or number of plants. (Photograph courtesy of the United States Fish and Wildlife Service.)

marijuana. Identification of these plants is crucial for law enforcement. Examples of plants needing biological identification are plants listed as illegal drugs, dangerous agricultural weeds, and exotic species known to invade and destroy native habitats. A very large responsibility at all points of entrance to countries is that of illegal plant identification. All imported goods should be inspected for the many types of illegal plants and their parts. Suspected importation of harmful drugs, prohibited medicines, invasive weeds, including the seeds of prohibited plants (Figure 1.4), all need to be verified before interdiction can occur. Illegal plants are often found as fragments or as seeds or seedlings in shipments of other products such as grain or ornamental plants. Almost no-one can absolutely identify all the various plants that travel around the world with humans, and the identification of the various parts of those plants is even more difficult. Often such identifications go beyond the scope of law enforcement and border protection, and specialists are often needed.

While technically not plants, fungi have historically been studied by botanists. In many areas, naturally occurring plants, such as certain mushrooms (species of *Psilocybe*, the magic mushrooms), Peyote cactus (species of *Lophophora*), even marijuana when grown for fiber, are not illegal unless collected and prepared for use of their hallucinogenic properties. In fact, the cultivated form of marijuana used for fiber has very little hallucinogenic effect. However, unknowing individuals attempting to collect these plants often trespass on private property. Additionally, the mere transportation of plants used for



Figure 1.4 Marijuana seeds (*Cannabis sativa* L.) are often not recognized by law enforcement personnel due to their similar appearance to many other plant seeds. (Courtesy of Dr D. W. Hall.)

their hallucinogenic effects can be illegal. While rare plants are not protected from destruction on private property, transportation of them without proper permits is a violation of international, federal, state, and local laws. The rationale for the regulation of the transportation but lack of penalties for the destruction of any protected plants naturally occurring on your property stems from old English law. In essence, if it grows on your property, you own it, but transportation on public roads can be regulated.

Alibis

In many criminal events, an alibi can prove to be very useful. Fortunately, very few individuals who are not botanists can successfully lie about plant evidence. Although a particular plant can grow in a wide range of areas, linking a plant to a particular spot or area can support or refute an alibi by showing that the person is, or is not, telling the truth. Because plants grow in specific areas, an object or person can often be linked to that location by plant evidence. Plant pieces found underneath a vehicle or on clothing can be linked to the location of the crime (Figure 1.5). Plant evidence can also show where the person or vehicle had previously been. Several locations can be combined to show movement relevant to the crime, and as a result victims and suspects can easily be connected to a crime scene.

Timing

Plants can give an indication of when an event occurred. Many plants are annuals, such as warm season crops like corn and soybeans. Some annuals are quite short-lived,

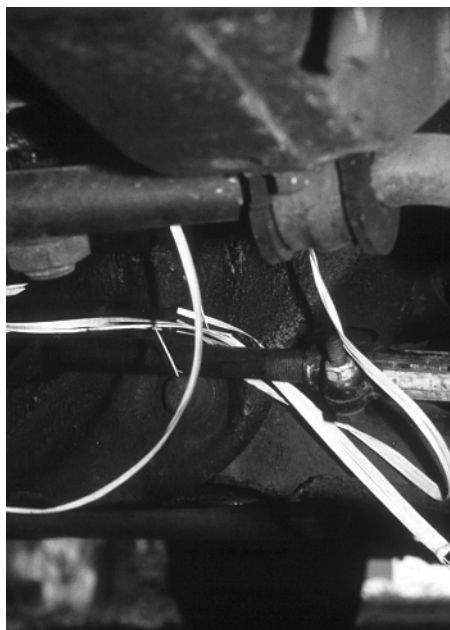


Figure 1.5 Vegetation found on suspension under suspect vehicle. (Courtesy of Dr J. H. Byrd.)

completing their life cycles in a matter of days or weeks, especially those in areas where the growing season is very short. These short-lived annuals may germinate as soon as the ground is warm enough and die when the weather becomes hot. Annual plants at high altitudes commonly are quite short-lived due to the very short periods of warm temperatures. Thus if a short-lived plant is present, the person or object would have been where that plant grew during its growing season.

Other characteristics also indicate seasonality and therefore can be of help. Plants that lose their leaves for the winter or in dry seasons will then regain leaves in warmer or wetter times. If a branch with no leaves attached is potential evidence, the branch could represent a time period during the winter or dry season. Leaves, flowers, and fruits that have fallen, sometimes in masses, can be of great use if the time when they fell or the amount of time it takes them to disintegrate can be determined. Thus, a single flower, fruit, or leaf may indicate something entirely different than a mass of them.

In areas of regular leaf fall the layers of leaves can indicate periods of time (Figure 1.6). Colder climates and very dry climates will normally accumulate several layers of leaves because the leaves take several years to decompose. In warm to hot climates leaves decompose very rapidly and may represent time intervals of only a few weeks or months. Leaves falling into standing water or buried in certain soil types are very slow to deteriorate due to the lack of oxygen, although they may be colonized by organisms that can speed up the process.



Figure 1.6 Layers of leaf fall can help to indicate the time period that has elapsed since the deposition of evidence (Courtesy of Dr D. W. Hall.)

Time of death (time since death, post-mortem interval) can be estimated by the use of plants. Tree rings are one type of plant evidence being used for time of death estimation (Figure 1.7). If a woody plant with seasonal growth producing annual tree rings is found growing on a grave or growing through a skeleton, the annual rings can be counted. The number of rings, corresponding to a year per ring, can show that the grave or skeleton was at this location for at least that many years.



Figure 1.7 Tree rings are one type of plant evidence used for time of death estimation. (Courtesy of Dr J. H. Byrd.)



Figure 1.8 The amount of wilt present on broken or damaged leaves and branches can help to establish a time frame. (Courtesy of Dr James L. Castner.) (Please refer to the colour plate section.)

The time of an event can be determined using other plant characteristics. A broken branch usually will wilt. The amount of wilt can be determined experimentally if the evidence is photographed and collected correctly (Figure 1.8). The time for sap to dry after a branch is broken or bark is nicked can also be determined by experimentation. Leaf wilt can also occur when plants are uprooted or the root systems are severely disturbed. Determining the approximate time the sap has been accumulating or the leaf wilting depends on having a botanist at the scene quickly. As with most types of physical evidence, proper photography is essential. The botanist will need to determine the identification of the vegetation and conduct an experiment by breaking similar branches. By examination at regular intervals a botanist will be able to determine the relative time it takes the sap and/or wilt to match that shown in the photographs. For best results, several replications are necessary to get an average time period. The investigator should keep in mind that if conditions change between the time of discovery and when the experiment is started, the results may not be applicable. If parts of plants that are green (have photosynthesis) become buried, they will gradually lose their green color as the chlorophyll breaks down from the lack of sunlight. The color will gradually become yellow and eventually brown (Figure 1.9).

The difference between the shades of yellow and the natural shade of green can be determined by burying many replications of the same plant parts at the scene and uncovering them at predetermined intervals. When the experimentally buried plant color matches that collected at the crime scene, it can roughly determine when the plant part was buried. This experimental process can be utilized to determine when the body or object was put in the ground. This time period may, or may not, indicate the time of death. It should be kept in mind that the suspect could have killed the victim some time before the body was buried. Also, at times bodies are moved and this experiment



Figure 1.9 Chlorophyll degradation of plant leaf from a burial site can be used for time interval estimations. (Courtesy of Dr J. H. Byrd.) (Please refer to the colour plate section.)

procedure can be used to show the approximate time of the most recent burial. Likewise, it could show, after the body was moved, when the original burial took place. To be effective this experiment must be done under the same conditions at the scene where the plant material was discovered. The sooner the experiment can be started the more accurate the findings will be. Photographs of the yellowed plant parts must be of very high quality. The botanist must quickly match the vegetation and bury it, and each replication must be photographed at the time of burial and at the time of retrieval. As in any experiment, the more replications per time period, the better the results.

Within the United States several states have legally binding wetland rules that prohibit disturbance of wetlands. Generally, these rules are a civil matter. Wetland boundaries are determined using plants, soils, and hydrology. Disputes frequently arise concerning the boundary locations and prohibited activities in wetlands. The original location of a wetland and the time during which the suspected violation occurred can be an issue solved by plant evidence. Tree rings can provide the year of the original disturbance and other buried plant parts may provide the season, such as finding buried flowers and knowing at what time of year the blooms occurred.

Gravesite growth

A common fallacy is that the vigorous growth of plants on and around a gravesite or body is due to the nutrition provided by the deterioration of the body. In the early post-mortem period this is simply not true. First, a body placed on plants will keep sunlight from reaching the plant, causing most plants to die due to a lack of photosynthesis. An exception would be plants connected by extended stems. The above-ground portion of the plant under the body would die due to the shading, but the extended stem can be



Figure 1.10 Area of decomposition and the resulting lack of vegetation. Over time, plant growth will reoccur. (Courtesy of K. Shaw.)

fed by the part away from the body. Second, fluids left by deterioration are caustic to plants. Most stems and root systems would eventually die because of the caustic fluids and lack of photosynthesis. Also, the fluids will prevent other plants from colonizing the soil (Figure 1.10).



Figure 1.11 Vigorous plant growth over a grave site due to soil disturbance from a burial. (Courtesy of Dr J. H. Byrd.)

The easily observed vigorous plant regrowth over and around a gravesite is due to the disturbance of the soil, not any nutrition provided by the remains (Figure 1.11). The soil disturbance exposes seeds in the soil to environmental factors that will trigger growth. Germination of seeds is often started by changes in temperature, water, or light, all factors that can be kept away by compacted soils or depth of the seeds. Almost all soils contain a seed bank. A seed bank consists of all the seeds that have fallen on or been transported to the area and remain buried. Soil disturbance frequently brings these seeds to the surface. Weedy species are quite common. A simple experiment, often set up in entry level ecology courses, places a square of soil a few inches thick in a pan with a bit of water to await the germination of the seeds. Varying results can be found by subjecting the soil to prescribed differences in temperature, water, and light. If the square of soil is removed in an undisturbed condition the results are quite different from soil that is removed and mixed.

Stomach contents

Plants within stomachs or feces can be identified by means of their anatomy. Bock *et al.*¹ (1988) detail identification of plant food cells in gastric contents. Surprising deductions can occasionally be made on the basis of ingested food. In one case an analysis of the stomach contents of two murdered women led to the assumption that a serial killer was responsible. Sometimes the contents can lead investigators to the place of a last meal. Ingestion and partial digestion of a poisonous plant could also be determined. In some regions of the world plant poisoning is more frequent. Most poisoning must be determined by chemical analysis.

Summary

Very few professionals involved with law enforcement have a background or training in botany. Botanical evidence can be very important as it may be possible to check the validity of an alibi, place someone or something at a particular location, help determine the time since death, or assist with timing of other events. There are many kinds of botanists who can help with the interpretation of plant evidence, such as plant chemists, DNA experts, or those that deal with stomach or feces contents. Plants associated with a crime as well as illegal plants such as those with serious psychological or euphoric effects, or plants that are prohibited because they are dangerous agricultural weeds, or exotic weeds that invade and destroy our native habitats all need classification and diagnosis by a plant identification specialist for proper disposition. Botanists are also essential for certain legal dilemmas regarding environmental rules and regulations.

¹ Boch, J.H., Lane, M.A., and Norris, D.O. (1988) *Identifying plant food cells in gastric contents for use in forensic investigations: a laboratory manual*. US Department of Justice, Washington, DC.