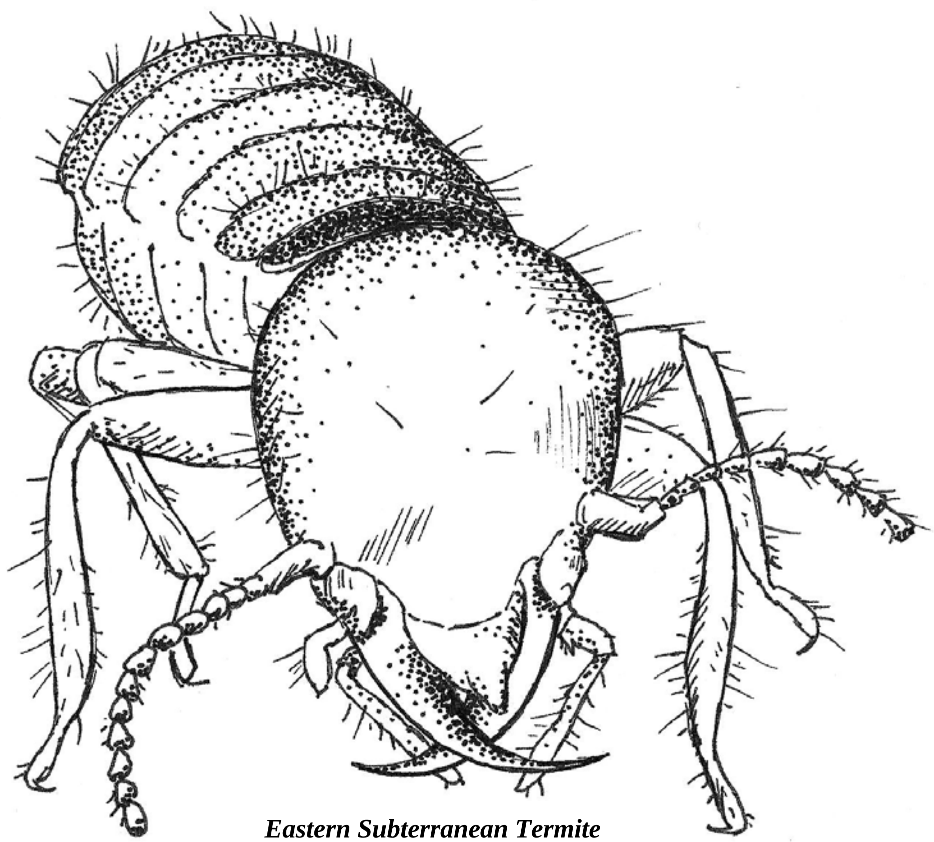
WOOD DESTROYING PEST MANAGEMENT

Study Guide for Pesticide Application and Safety
Category 15



Eastern Subterranean Termite

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STUDY GUIDE FOR WOOD-DESTROYING ORGANISM PEST CONTROL

The educational material in this study guide is practical information to prepare you to meet the written test requirements. It doesn't include all the things you need to know about this pest-control subject or your pest-control profession. It will, however, help you prepare for your examinations.

Contributors include the Utah Department of Agriculture and Utah State University Extension Service. This study guide is based on a similar one published by the Colorado Department of Agriculture. Materials for that guide were prepared by Colorado State University Extension Service. Other contributors include: University Extension Service personnel of California, Kansas, New York, Oregon, Pacific Northwest, Pennsylvania, and Wyoming, The U.S. Department of Agriculture -- Forest Service, the U.S. Environmental Protection Agency (Region VIII Office), and the Department of Interior -- Bureau of Reclamation, and Metro Pest Management.

Other topics that may be covered in your tests include First Aid, Personal Protective Equipment (PPE), Protecting the Environment, Pesticide Movement, Groundwater, Endangered Species, Application Methods and Equipment, Equipment Calibration, Insecticide Use, Application, Area Measurements, and Weights and Measures. Information on these topics can be found in the following books:

1. National Pesticide Applicator Certification Core Manual, Published by the National Association of State Departments of Agriculture Research Foundation.
2. The Workers Protection Standard for Agricultural Pesticides – How to Comply: What Employers Need to Know. U.S. EPA, Revised September 2005, Publication EPA/735-B-05-002.

These books can be obtained from the Utah Department of Agriculture or Utah State University Extension Service. Please contact your local Utah Department of Agriculture Compliance Specialist or Utah State University extension agent.

The following individuals at Utah State University Extension contributed to the revision of this manual: E.W. Hodgson, F.R. Beard. and H.M. Deer.

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I. INTRODUCTION

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STUDY GUIDE

The wood destroying organism study guide provides basic information that applicators of restricted use pesticides (RUPs) need to meet the minimum federal and state standards for certification and recertification. The standards are set by the U.S. Environmental Protection Agency (EPA) and the Utah Department of Agriculture and Food (UDAF) in line with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended and the Utah Pesticide Control Act.

Pesticide handlers who are licensed in the wood destroying category includes applicators using pesticides to control termites, carpenter ants, wood boring or tunneling insects, bees, wasps, wood decaying fungi, and any other pests destroying wood products. Licensed pesticide applications working to control wood destroying organisms should be aware of the following exception to the general rule for pesticide applications. It is unlawful for a commercial pesticide applicator to apply a termiticide at less than the minimum rate indicated by the termiticide label. Most pesticides can be applied at less than label rate, but not a termiticide. The Utah Department of Agriculture and Food strictly enforces this legal requirement because inadequate termiticide applications may not control termites and over time a structure can be substantially damaged by termites.

PESTICIDE PERSPECTIVE

Humans depend on living things to provide the essentials for survival. Destructive pests make the efficient production of these necessities very difficult. Other pest organisms constitute a threat to the health and comfort of people. Such pests must be managed to protect desirable plants and animals.

Plants or animals may be identified as a pest if they appear in unwanted places or their numbers are too great. For example, a weed is a plant growing where it is not wanted. In this context, a corn plant in a lawn is a weed and a rose in a cornfield is a weed. Some animals have been domesticated and provide humans with food and fiber. Other animals provide recreation through human interaction, but if these animals are destructive or carry diseases then they are pests.

There are beneficial birds that eat destructive insects and many provide aesthetic enjoyment. Other birds because of their population numbers and/or excessive noise are regarded as public nuisances. Some insects destroy crops or transmit diseases, while others pollinate plants or serve as parasites or predators of undesirable insects. In general, those plants or animals that conflict with the immediate or long term needs and desires of humans are regarded as pests.

Chemical pesticides are commonly used to control pests. The goal of a pesticide application is to effectively manage the pest without threatening the safety of humans and the environment. Instances of inappropriate use or over application have resulted in the banning or limited availability of some pesticides. In some instances past mistakes have resulted in the development of better pesticides that are safer to use.

Using pesticides often means the difference between profit and loss. The use of pesticides has become almost indispensable to modern agriculture and to the consumer of agricultural products who expects agricultural products to be readily available at the market.

There is no indication that pesticides will be eliminated and they continue to be the most effective defense against pests. It is important that researchers continue to investigate the effects of pesticides on humans and the environment. There are numerous well funded groups concerned about environmental protection that will continue to publicly resist the use and misuse of pesticides.

Where safety concerns occur relative to the use of a pesticide, the advantages must outweigh the disadvantages for a pesticide's continued use. Such decisions require objective evaluation. At present, the safest way to use a pesticide is to assure that applicators and handlers carefully adhere to label instructions and apply pesticides only when appropriate.

Concern about the environment has added considerable stimulus to the development of pest management techniques that reduce the need for pesticides. The challenge is to accomplish pesticide use reduction without lowering yields or quality. This goal has been accomplished in a few instances and there is reason to believe that further progress will be made.

PESTICIDES AND THE ENVIRONMENT

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Both the beneficial and harmful effects of pesticides are determined by how pesticides and the environment react to each other. To be effective a pesticide must normally penetrate the pest, move or be transported to the site of action, and there disrupt or alter a vital function of the pest. The manner in which the pesticide affects the vital function is called its mode of action. Penetration, transport, and mode of action involve interactions between the pesticide and the pest.

Interactions are also involved in the metabolism, accumulation, and elimination of pesticides by the pest, as well as in the biodegradation and biological magnification of pesticides. In addition, the ability of pesticides to kill or otherwise alter one pest, while not affecting another, and/or the pest's ability to develop a resistance to pesticides are dependent on differences in the interaction between pesticides and pests.

***D**ichloro-**d**iphenyl-**t**richloroethane* or DDT as it is better known is one example of how pesticide perceptions have changed throughout the history of their use. DDT and other persistent chlorinated hydrocarbons formed the basis for much of today's public awareness and the legislative action that controls current pesticide use.

DDT was the most well known organic insecticide and most widely used chemical for the control mosquitoes responsible for malaria, typhus, and other insect borne diseases. Today it is banned from use in the US. It is still manufactured and continues to be used to battle mosquitoes in other parts of the world.

Rachel Carson published the book *Silent Spring* in 1962. In her writings it was alleged that DDT harmed bird reproduction by thinning egg shells and caused cancer in humans. *Silent Spring* caused a huge public outcry which eventually resulted in DDT being banned for use in the US. This event was one of the most important events that led to the environmental movement.

DDT was subsequently banned from agricultural use in many countries by the 1970s. DDT, perhaps, more than any other pesticide in history, is responsible for saving hundreds of thousands of lives, but is perceived to be too hazardous for use in the environment. The controversy surrounding DDT continues as tissue analysis has found this pesticide to be present in humans from all parts of the world.

PESTICIDE MONITORING

Pesticides are monitored in the environment by the EPA, FDA, and USDA. The monitoring program includes fish, shellfish, wildlife, water, soil, food, and humans. In addition to the federal program, considerable monitoring is also done by state agencies, scientists from universities, and the chemical industry.

Extensive monitoring indicates that only a limited number of pesticides are generally found in environmental samples such as soil, water, air, and wildlife. However, articles written about pesticides in the environment often generalize about their occurrence, giving the false impression that all pesticides are involved.

Careful reading of these articles will usually reveal that they are based on studies involving DDT or another of the more persistent chlorinated hydrocarbon insecticides. The only samples that commonly contain pesticides are food crops that have been treated with these materials. These generally occur at levels below tolerance limits set by EPA. Pesticide monitoring studies must be interpreted carefully, especially when dealing with amounts in parts per billion or parts per trillion.

The use of gas liquid chromatography and mass spectrometry has made possible the detection of extremely small amounts of some chemicals. However, identification of these chemicals is by no means certain unless confirmatory techniques are employed. This may be very hard and perhaps impossible at such low levels unless large samples are used. Also, at these levels it may not be possible to rule out accidental contamination of the sample, either at the time of collection, during storage, or in the analytical process.

The importance of confirming the identity of pesticides was illustrated recently when two chlorinated hydrocarbon insecticides, dieldrin and heptachlor, were apparently discovered in soil that had been collected and sealed in jars between 1909 and 1911, long before these chemicals had even been synthesized. Efforts to confirm the identity of these chemicals proved they were not pesticides but apparently naturally occurring constituents of the soil.

There is also evidence that polychlorinated biphenyls (PCBs) have been erroneously reported as DDT in environmental samples. Apparently PCBs, which were used in a variety of products ranging from plastics to industrial coolants, are widespread in the environment and can easily be mistaken for DDT if proper analytical procedures are not followed.

PESTICIDES IN WATER

Pesticides may enter water in several ways, including fallout from the atmosphere, drift from nearby applications, and movement from treated land by means of soil particles or runoff water. They may also be applied directly to water, either purposely or accidentally. Although quantitative information on the importance of these sources of contamination is limited, it seems likely that treated soil is the principal factor involved.

Most pesticides found in the environment are often bound tightly to soil particles or organic matter in the soil and are not readily soluble in water. These particles can move long distances by wind and water, so it is not surprising that pesticides are sometimes found far removed from the site of application. Although agricultural lands contribute to pesticide contamination of water, some of this pollution originates from urban areas where pesticides are used in the home and garden.

Some of the contamination of the Great Lakes with DDT has been traced to city sewers. Pesticide contamination in the Red Cedar River in Michigan is reported to have come mostly from waste water treatment plants, even though the river runs through areas of extensive agricultural development.

The pesticides most often found in water were some of the chlorinated hydrocarbon insecticides including dieldrin, endrin, heptachlor, lindane, BHC, and chlordane. Herbicides such as atrazine, alachlor, prometon, and simazine are now the most common pesticides found in water.

PESTICIDES IN SOIL

Soils are important in determining what happens to a pesticide after application. Even though some pesticide volatilizes before reaching the soil or is intercepted by plants, a large portion eventually reaches the soil. As previously discussed, soil can serve as a reservoir from which pesticides may move to other areas by water or wind erosion.

Pesticides may also escape by evaporation from the soil surface into the atmosphere. Soil organisms may serve to transport pesticides from one area to another, usually because they serve as a food source for animals or birds.

The fact that soils and organisms in soils are largely responsible for the breakdown or inactivation of pesticides is of great importance. This neutralization of pesticides varies with soil type and climate and this is one of the determining factors as to whether a particular pesticide should be used in a given area. Aside from purely environmental concerns, if a pesticide persists too long in soil, it may also damage future crops.

Most pesticides do not move readily in soil because they are bound to soil particles, especially clay and organic matter. Consequently, they are usually found in the top few inches of soil. In rare instances some have been found at depths of several feet.

PESTICIDES IN WILDLIFE

It is not surprising to learn that pesticides found in wildlife are generally the same ones found in soil and water. Wildlife consume the food derived directly or indirectly from soil and water, and in some instances, pesticides will accumulate in wildlife at concentrations ranging up to thousands of times more than in soil and water. This process is referred to as bio-magnification and is known to occur with persistent chemicals that are readily soluble in fat. One of the best examples is DDT.

Dieldrin and heptachlor have also been implicated in bio-magnification as have some other chlorinated hydrocarbon insecticides. Some of the highest residues of the chlorinated hydrocarbon insecticides have been found in birds of prey such as hawks and eagles. Fish eating birds are especially likely to contain residues of these insecticides. As might be expected, the insecticides most commonly found are DDT and dieldrin. These chemicals have been associated with lowered reproduction in several species of these birds. In fact, this is the principal reason that the use of DDT and dieldrin were severely restricted in the United States and other countries of the world.

The presence of pesticides in seed eating birds is generally much less than in birds of prey and there is little reason to believe there has been any effect on their reproduction. Seed eating birds have been killed by direct application of pesticides and by eating food contaminated with pesticides. This is not a general occurrence and, so far as is known, has not caused population declines that would threaten the existence of any species of seed eating bird.

PESTICIDES IN FOOD

Pesticides in food are monitored and controlled by three federal agencies, EPA, FDA, and USDA. State agencies are also involved in these activities. EPA has the responsibility of establishing tolerances for pesticides in food. FDA monitors pesticides in foods that are prepared for the table. This is commonly referred to as a "market basket" or "total diet” studies.

FDA determines the amount of pesticides present in foods shipped in interstate commerce. It has authority to seize shipments that contain pesticide residues above tolerance levels and to initiate legal proceedings against the shipper.
FDA examines foods for contaminants other than pesticides, including such things as rodent hair, fecal pellets, and insect parts. Tolerances are established for these contaminants in food as well as pesticides. While consumers might be surprised to learn that a certain number of fecal pellets or insect legs are permitted in foods, perhaps they can take some comfort in knowing that current standards are much stricter than they were 20 or 30 years ago.

Pesticides have been largely responsible for these strict standards, and ironically, these standards are now a serious obstacle to the reduction of pesticide usage in certain situations. To the farmer, the use of pesticides may mean much more than simply increasing yield. If the quality of his crop is lowered by pest damage, he may not be able to market it at any price.

Every year, FDA determines the amount of pesticide chemicals in processed and raw agricultural products that are shipped interstate. This is a surveillance and regulatory program designed for the enforcement of tolerances set by EPA. Samples are collected throughout the year at producing, shipping, and destination points.

ENVIRONMENTAL CONCERNS

As more is learned about the behavior of pesticides in the environment, it is necessary to devise more sensitive and discerning techniques to determine what will be the total impact of pesticides. Human innovations are normally advanced without a complete understanding of their consequences and pesticides are no exception. The best that can be done is to use all available knowledge, make allowances for unknown factors, and carefully estimate benefits and risks.

The concern about the effects of pesticides on the environment is an extremely controversial issue debated by scientists, politicians, and the general public. One of the main reasons for this is that it is very hard to prove that a chemical is or is not harmful, especially when it is present in small amounts and its effects cannot be clearly demonstrated outside the laboratory.

WOOD DESTROYING ORGANISMS

The classification of an insect as a pest is often dependent upon its relationship with humans. Problem insects are often difficult to control because of their close proximity to structures, homes, food storage facilities, and humans. Wood destroying insects are controlled much like other structural pests. The basic strategies for the control of such pests include inspection of the site, diagnosis of the problem, prescription for control, application or treatment, and evaluation of the control measures.

Effective pest management requires that the pest must be properly identified and that any factors contributing to the infestation be remedied. Incorrect identification of a pest can result in a costly, ineffective selection of pesticide treatments. Inspectors should carefully determine what pest is causing the problem and implement a pest management strategy that is timely and appropriate.

Termites are the most economically important structural pests, but other wood destroying insects also cause problems. There are several other groups of wood destroying insects in Utah such as beetles, bees, ants, and wasps.

PESTICIDES AND PESTS

Pesticides include a variety of chemical products designed for the management of pests. The term pesticide refers to products such as herbicides and insecticides that are used to kill or control harmful organisms such as insects, weeds, or microorganisms. The following list includes numerous pesticides and the pests controlled.

Acaricide: mites and ticks
Adulticide: adult pests
Algicide: algae
Aphicide: aphids
Attractant: insects and vertebrates
Avicide: birds
Bactericide: bacteria
Defoliant: foliage removal
Desiccant: water removal from plant foliage
Disinfectant: microorganisms
Fumigant: insects, rodents, and weeds
Fungicide: fungi and other plant pathogens
Germicide: germs
Growth regulator: insects and plants
Herbicide: weeds
Hormone: insects and plants
Insecticide: insects
Larvicide: larval pests
Miticide: mites
Molluscicide: snails and slugs
Nematicide: nematodes
Ovicide: eggs

Pediculicide: lice
Pheromone: insects
Piscicide: fish
Predacide: predators
Repellent: insects and vertebrates
Rodenticide: rodents
Sanitizer: microorganisms
Silvicide: trees and woody vegetation
Slimicide: slime molds
Sterilant: microorganisms
Termiticide: termites
Wood preservative: fungi and insects

PRECAUTIONARY STATEMENT

Pesticides offer both benefits and risks. Benefits can be maximized and risks minimized by reading and following the labeling. Pay close attention to the directions for use and the precautionary statements. The information on pesticide labels contains both instructions and limitations. Pesticide labels are legal documents and it is a violation of both federal and state laws to use a pesticide inconsistent with its labeling. The pesticide applicator is legally responsible for proper use. Read and follow the label instructions.

II. TERMITE PEST MANAGEMENT

TOPIC **PAGE**

INTRODUCTION TO TERMITES

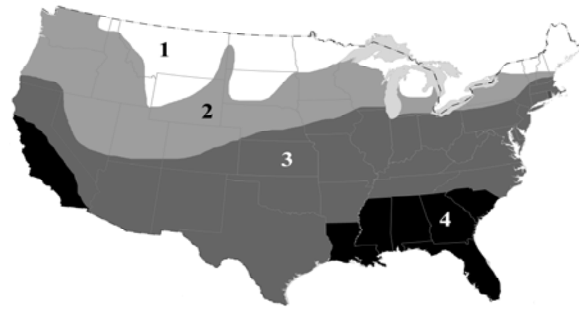
Termites belong to the insect order Isoptera which means equal winged and refers to the similar size and shape of the forewings and hind-wings. Termites are most closely related to wood eating cockroaches and are some of the oldest insects in existence. There is evidence that termites existed about 100 million years ago and they are the oldest known group of social insects.

There are over 2,800 different termite species grouped into seven different families found throughout the world. Rarely are termites found above 9,800 feet or beyond the 45 to 50 degrees north/south latitude regions. Figure 1 shows the level of termite infestation in the continental United States. Termites are most abundant in tropical rainforests, but they are also capable of living in the Himalayas and the Rocky Mountains. In the United States, termites are found in every state but Alaska, and are considered to have slight to heavy activity in Utah. Historically, southwestern Utah has more termite activity than locations along the Wasatch Front, but termites can be found anywhere in the state.

Figure 1. U.S. Termite Infestation Risk: 1 Slight; 2 Slight to Moderate; 3 Moderate to Heavy; and 4 Heavy

In nature, termites are considered beneficial because they accelerate the breakdown of dead and decaying wood. In addition, termites contribute to nutrient recycling and improve soil quality. Abandoned termite nests provide habitat for birds and other animals. There are some negative aspects to termites as well. Termites produce methane as a byproduct of feeding on wood, and contribute three to four percent of world gas emissions annually. Also, termites can become serious pests when they infest and damage wooden structures.

Termites are generally grouped by their



feeding location and behavior such as soil feeding, drywood, dampwood, subterranean, and grass eating. Around the world, about 150 species are known to cause damage to wooden structures; however, only 50 species are known to be serious pests. In Utah, there are two subterranean termite species and one drywood species with the potential to cause serious structural damage. Dampwood and other termites are rare in Utah and are not discussed in this study guide.

Insects are the most abundant animals in the world, with more than one million different species known. Insects are most closely related to arachnids which include spiders, ticks, mites, and scorpions, and are often referred to as bugs. Insects have certain adult body characteristics that differentiate them from other animals. These include:

- Hardened exoskeleton to provide strength and prevent dehydration, and the exoskeleton is periodically shed or molted during metamorphosis;
- Bilateral symmetry where the left side is a mirror image of the right side;
- Segmented body with the three major regions of head, thorax, and abdomen; and segmented appendages, such as legs and antennae that allow for flexibility;
- One pair of antennae attached to the head, three pairs of legs attached to the thorax; and
- There are typically two pairs of wings for flight attached to the thorax, but there are exceptions to this for primitive and advanced groups of insects.

TERMITE DESCRIPTION

Termites are similar to other insects, but distinguished from other insects by the following combination of features:

- The forewings and hind-wings, if present, are similar in size and shape; the wings are transparent and extend past the abdomen;
- Small, bead like antennae that come out straight from the head;
- Broad waisted between the thorax and abdomen;
- Tarsi (feet) have four segments on all legs.

Termites are soft bodied insects that tend to dehydrate quickly because they lack a thick, waxy cuticle in the exoskeleton. The majority of termites are wingless, creamy white or transparent, and are blind or have very poor vision. Sometimes termites are incorrectly called white ants. True ants, in the insect order Hymenoptera**,** have a hard exoskeleton compared to most insects, elbowed antennae, and a constricted waist between the abdomen and thorax. Figure 2 shows the comparison of termite to ant. Winged ants have clear wings of unequal size and the hindwings are smaller than the forewings.

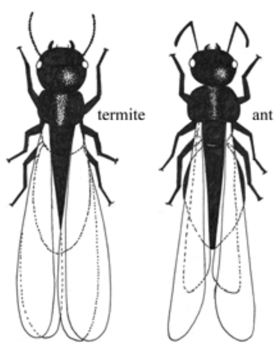


Figure 2. Termite and Ant Comparison

LIFE CYCLE

Termites are the only social insects with simple metamorphosis that includes egg, nymphs, and adult. All other social insects go through complete metamorphosis that includes egg, larva, pupa, and adult. Although termites go through simple metamorphosis, they have an extremely complicated development.

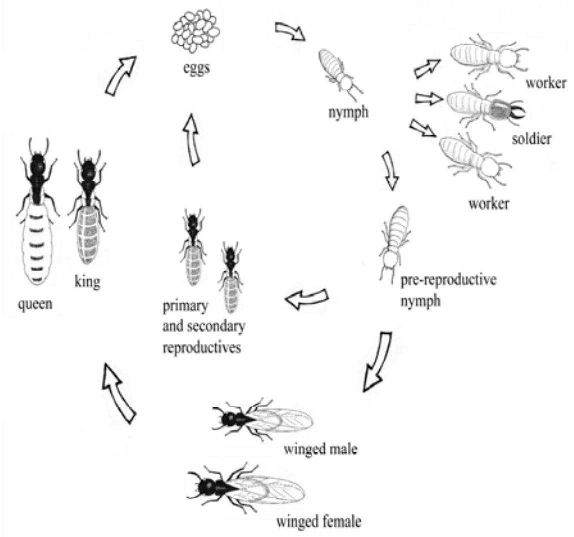
The termite life cycle begins with the flushing or ejecting of winged adults from an existing termite colony. These winged adults are sexually reproductive and immediately begin looking for a mate. Winged termites will settle in a prospective area and break off their wings. After digging a small nest within the soil or wood, termites will mate and begin egg production and nest formation.

Termites are the only social insects with a king that remains active in the colony after mating. At first, the queen and king have to forage, construct the nest, and take care of the young. Even with adequate food and moisture, colony formation can be very slow during the first three to seven years. As the colony size increases and workers take over responsibilities of food gathering and rearing nymphs, the queen can focus solely on egg production for the remainder of her life. Termite queens may live for more than 10 years. The basic stages of the termite life cycle are depicted in Figure 3.

Figure 3. Generalized Termite Life Cycle

Termite eggs are small and clear. Eggs are transported by workers to the brood chamber and monitored until hatching. The queen can produce male and female offspring to work in the colony, which is unlike other social insects such as ants and bees that only have female workers.

After the eggs hatch, nymphs are fed by adults until they are old enough to leave the brood chamber. Nymphs look like adult termites except are smaller in size. Nymphs will molt, or shed their exoskeleton, numerous times before becoming adults. Some termite entomologists divide the immature stages into larvae (young instars), workers (no wing pads), and nymphs (with wing pads). In this study guide, the term "nymph" is used to describe all immature



termite stages. The estimated life span for non-queen termites is one to four years.

DIET OF TERMITES

Animals, including insects, cannot typically digest the cellulose in wood, paper, and cloth. Termites have evolved to take advantage of this widely available food resource. In order to digest wood termites use symbiotic protozoa and bacteria to produce digestive enzymes that break down cellulose. Although essential for digestion, termites are not born with the beneficial symbionts. As a result, termites use trophallaxis which is the exchange of food and body secretions to pass on beneficial gut symbionts to other colony members. Trophallaxis can be via mouth to mouth or anus to mouth. As the nymphs shed their exoskeleton they lose all their gut protozoa and therefore must regain the symbionts from older termites between molts. Workers also exchange food and symbionts with the king, queen, and soldiers.

SOCIAL ORGANIZATION

Termites are successful social insects and they avoid exposure to unfavorable conditions. Nest placement is dependent on temperature and humidity conditions. In warmer climates, the nests require ventilation and may be built above ground. In Utah, termites live below ground in wood or soil and occasionally live in or use structural wood. Termites have an efficient division of labor that enhances colony expansion. The castes of a termite colony are shown in Figure 4.

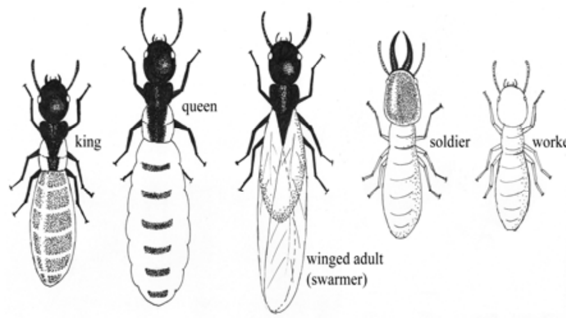


Figure 4. Termite Caste System

Although living closely together can promote disease outbreaks and encourage predation, there are several advantages to forming a social insect colony, including:

- Division of labor with a caste system, where members of the same colony can look radically different and have distinct working roles;
- Division of reproductive capabilities where only a few members are sexual while the majority of the colony is sterile;
- Parental care of young to increase the likelihood of survival; and
- Overlapping generations.

Primary Reproductives: Queen and King

The primary sexually reproductive caste of termites includes the king and the queen of the colony. Swarmers that find mates and start a colony become the queen and king of a new colony. They break off their wings and begin to construct the parent nest. The queen and king grow larger than other termites. The king has a large abdomen and will continue to mate with the queen throughout his life. The queen has a distended abdomen that restricts her movement from the parent nest. Her swollen abdomen known as the physogastric has extra ovaries to increase her egg lying potential. The queen of some species of termites can lay an egg every few seconds over many years.

Winged Reproductives

This sexually reproductive winged caste makes up a small portion of the colony. This caste is less than one percent of the colony population and is not produced until the colony is well developed. Winged termites are also known as swarmers or alates that will eventually become the king and queen of a new colony. Immature swarmers look like workers except they have two pairs of wing pads. As adults their wings are smoky or transparent and extend past the abdomen. Winged termites are dark brown or black, and have fair vision.

Termite swarms are most commonly seen after a period of rain and can occur during the day or night. Swarmers have a thicker cuticle layer in the exoskeleton than other castes to prevent dehydration, but they are still susceptible to hot and dry conditions. Winged termites are weak, clumsy fliers and are easy targets for predators. Consequently, a termite queen will produce a swarmer flush to increase the chances of starting a new colony.

Termite Workers

This sterile caste makes up the largest proportion in the colony with 75 to 95 percent of the population being workers. Workers are creamy white or transparent and are especially sensitive to dehydration because of the thin cuticle layer in their exoskeleton. They have chewing mouthparts, they are blind, wingless, and responsible for maintaining the colony. They clean, repair, and construct the nest, build and expand foraging tunnels, gather food, and feed other caste members. Older workers take eggs from the queen and rear them in a brood chamber.

Termite Soldiers

This sterile caste is the next largest proportion in the colony making up 5 to 10 percent. In general, they are creamy white or transparent, but often have a darkened head. Most soldiers are blind and wingless, but have enlarged and hardened mandibles. They have large mandibles and rely on workers for food exchange. The termite soldier's only responsibility is to defend the colony. Ants are the primary enemies of termites because they use the same habitat for building nests. Other insects, birds, and small mammals also attack termites.

Secondary Reproductive

Some species of termites have additional sexually reproductive castes to supplement egg production. The secondary reproductive castes make up less than one percent of the colony. Unlike the queen and king these males and females have never left a colony and do not develop true wings as adults. Secondary reproductive castes may be found in the parent nest or in satellite nests and enhance the overall egg laying capabilities of the colony.

TERMITE BEHAVIOR AND COMMUNICATION

Some termite species can have over one million members in a colony. A strong network of communication is needed for any colony to expand and thrive with the division of labor. This is particularly true for termites because they are blind or have poor vision and live in soil or wood.

The termite queen determines which caste each termite will ultimately become a part of as an adult. The fate of each termite is not known when the egg is produced, as with other insects. Instead, the termite queen will use pheromones as chemical communication to delegate caste differentiation as the nymphs develop. Most termites are workers and will remain workers for their entire life. More soldiers or winged adults may be needed at certain times of the year. The queen will pass on pheromone cues throughout the colony and the nymphs will then respond with body modifications and specialized responsibilities. This dynamic division of labor is a defining characteristic of termites and contributes to their success throughout the world.

In addition to termite caste determination other pheromones can be produced within the colony. Pheromones that relay information about foraging, defense and alarm, and nest construction can trigger various behaviors in the colony. If a foraging worker finds a new food source it will leave a pheromone trail for other workers in the colony. If a soldier detects a predator in the parent colony an alarm pheromone will be released for the other soldiers to protect the queen. Although most termite behavior is instinctive, every member depends extensively on pheromones to stay in touch with the colony.

Pheromones are passed on throughout the colony through grooming. Mutual grooming ensures every member from all castes is cared for by transferring food and pheromones on a regular basis. Grooming also helps clean and remove fungal and bacterial pathogens that can infect and destroy a social colony. The queen is constantly groomed and her pheromones are passed on throughout the colony. As workers and soldiers come into contact with the pheromones they receive chemical instructions from the queen. If a colony is in decline the queen can literally be licked to death by surrounding workers as they attempt to gain instructional cues.

Besides using pheromones to communicate termites have various sensory organs on the mouth and antennae. Termites also have sensory hairs on their body, legs, and antennae. Most termites are blind and because of this they use their sensory organs and hairs to detect obstacles, and monitor temperature and humidity. In general, termites prefer tight spaces so they can stay in constant contact with their surroundings.

SUBTERRANEAN TERMITE CHARACTERISTICS

There are over 200 species of subterranean termites, of the family Rhinotermitdae, in the world, including nine species in the United States. Although considered beneficial in non-urban areas, these termites can seriously damage structures. Subterranean termites are the most destructive insects in the world. They cause over $2 billion in damage each year in the United States. They inflict more property damage than the damage caused by both fire and windstorm. Subterranean termites are destructive for the following reasons:

- Large colonies are able to survive many years in a relatively small spatial area;
- Colonies are self-perpetuating because their food supply is virtually unlimited;
- Winged forms are produced to migrate to new nesting areas with adequate food; and
- Members require wood to soil contact and live underground protected from natural enemies and harsh environmental conditions.

Subterranean Termite Biology

A new subterranean termite queen will produce one to two eggs a day; however, a queen can produce 2,000 eggs a day during her prime. Subterranean termite queens are particularly long lived and can produce eggs for over 25 years. Mating swarms are produced from well developed colonies. Winged adults are flushed from existing colonies on spring mornings after a rain with soil temperatures over 70 degrees Fahrenheit. In Utah, the two subterranean termite species that cause structural damage are the Eastern Subterranean termite and the Rocky Mountain Subterranean termite. Termite swarming flights are variable depending on the location in Utah and are depicted in Figure 5.

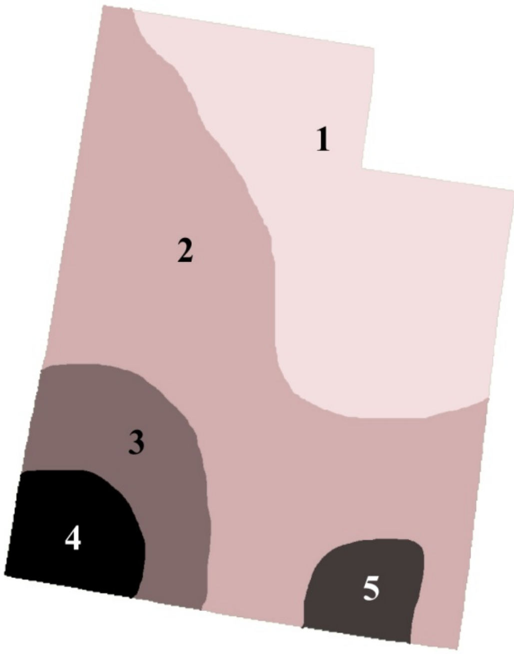


Figure 5. Utah Subterranean Termite Swarming Dates: one is April 4 to 18; two is March 19 to April 3; three is March 3 to 18; four is February 1 to 15; and five is May 5 to 19

Eastern Subterranean Termite

This species (*Reticulitermes flavipes*) is the most widely distributed termite in North America and the most common species in Utah. The workers are about 1/8˝ (3 mm) long, and are generally smaller compared to drywood termite workers. The soldiers have orange with rectangular shaped heads that do not taper or narrow. The Eastern Subterranean termites are about 1.5 times longer than they are wide. Their darkened mandibles are curved inward at an angle of about 70 to 90 degrees.

Eastern Subterranean termite soldiers are slightly bigger than workers, ranging from 3/16 to 1/5˝ (4 to 5 mm) in length. The winged adults are about 3/8˝ (9 mm) long including the wings. The body is dark brown to almost black, and the tarsi (feet) are pale compared to the legs. The wings have few veins and hairs, and are transparent or smoky.

Rocky Mountain Subterranean Termites

The Rocky Mountain Subterranean termite, species *Reticulitermes tibialis*, is not as common as the Eastern subterranean termite. These species are widespread in desert regions where they feed on creosote and greasewood bushes. The winged adults are 1/5˝ (5 mm) long including the wings. The body is brown or black, the wings are whitish, and the tarsi (feet) are black. Soldiers are 1/4˝ (6 mm) long and have straight mandibles. Swarms occur in March below 4,000 feet of elevation, but can be delayed until June or July in areas above 4,000 feet of elevation.

Termite Nest And Tunnel Formation

The workers of soil dwelling termites build underground nests and tunnels near wood. Subterranean termites can build tunnels more than 30 feet underground. This is significant because colonies can form under basements and other belowground structures. Workers in a large colony will search for food in an area extending to a radius of 125 feet from the colony.

Workers attack the softer springwood along the grain and leave the summerwood behind. A heavily damaged piece of lumber will have a honeycomb appearance as seen in Figure 6. A mature subterranean termite colony can include more than one million members, consuming 3.3 ounces (83 grams) of cellulose per day. That is equivalent to about 39 feet of 2-inch by 4-inch lumber annually.

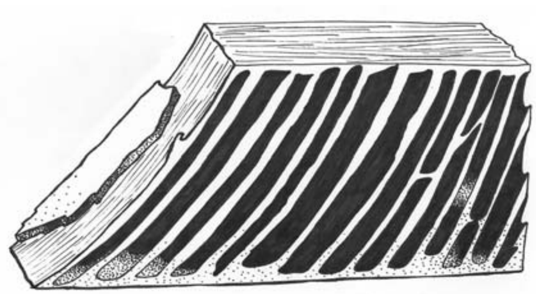


Figure 6. Termite Damage Along Wood Grain

Termites can obtain moisture from the soil and wood. Workers will tunnel deep into the soil, sometimes below the frost line, to sustain adequate moisture levels. Colony members can extract cellulose from almost any wood or wood byproduct. If there is abundant food nearby they prefer seasoned wood with a high moisture content.

In general, subterranean termites are very sensitive to dehydration and exposure to the environment, and workers will go to extreme measures to maintain favorable temperature and moisture conditions for the colony. Depending on the surroundings, workers may make compact or diffuse colonies. Typically, there is a parent colony with the king and queen plus additional satellite colonies for supplemental egg production as shown in Figure 7. Subterranean termites often have a parent colony and supplemental satellite colonies that can randomly come in contact with a wooden structure.

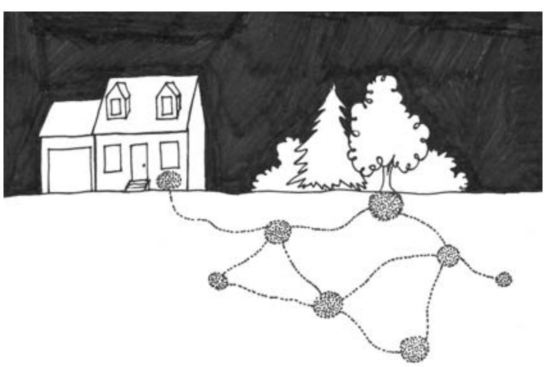


Figure 7. Subterranean Termite Parent and Supplemental Satellite Colonies

When subterranean termites bridge non-wood gaps such as metal or concrete they build mud tubes to avoid desiccation or dehydration. Mud tubes are made of moist soil and liquid frass or excrement. Soil and frass are taken into the mouth and molded into pellets with the mandibles and saliva. The pellets are placed together in the construction area creating pillars that join at the top to form arches. Mud arches can range from 1/2 to 2″ (12 to 50 mm) in diameter. Workers can build vertically or horizontally depending on the non-wood structure they are trying to bridge.

Old mud tubes are dry and crumble easily. They leave an etching on solid surfaces for years. Etching is an indication of a subterranean termite infestation in the past. It is not possible to determine when the infestation occurred from the old tubes. Subterranean termites can construct three different kinds of mud tubes as shown in Figure 8. Subterranean termite working tubes are large in diameter and provide a soil tunnel around concrete, metal, and masonry. Exploratory tubes and drop tubes are fragile and are often abandoned by the colony if a connection to wood or the ground is not achieved.

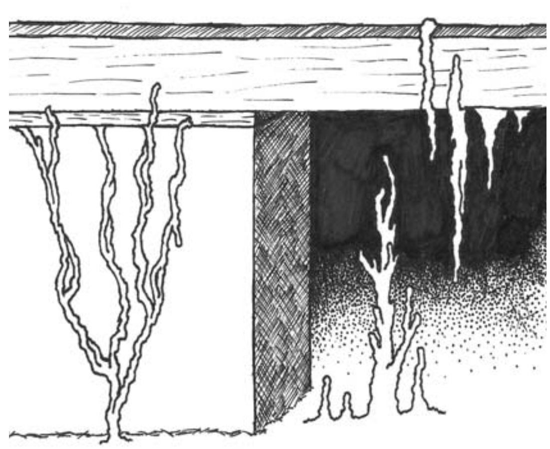


Figure 8. Left: Termite Working Tubes; Center: Exploratory Tubes; Right: Drop Tubes

Drop tubes are built in an attempt to join a tunnel down to the soil. Like exploratory tubes, these tunnels are thin and fragile and often abandoned. Commonly, they may be found hanging from ceiling support beams and appliances.

Exploratory tubes are constructed by workers in an attempt to probe for new food sources. Often these tubes are thin and fragile until a food source is identified by foraging workers. Damage to exploratory tubes may not be repaired if the pathway is abandoned.

Working tubes are the most common type of mud tube. A large number of foraging termites will use these tubes to bridge non-wood gaps. These tubes are sturdy and have a large diameter, acting like a tunnel between wood sources and the nest. Although working tubes are hardened on the outside, they remain moist on the inside to keep members from drying out. Workers will immediately attempt to repair any damage to active working tubes to prevent desiccation.

DRYWOOD TERMITE CHARACTERISTICS

There are about 400 species of drywood termites located throughout the world. These termites are typically restricted to the lower portion of the United States. Drywood termites are the second most destructive insects in wood and can cause significant damage to lumber. Drywood termites are distinctly different from subterranean termites in the following ways:

- Colonies are smaller, ranging from 2,000 to 10,000 members;
- Colonies live and forage in dry sound wood; and
- Wood to ground contact is not essential and workers do not build mud tubes.

Drywood Termite Biology

Drywood termites have low wood moisture requirements and extract water from the nesting wood. Their excrement known as frass is very dry and cylindrical in shape as seen in Figure 8. Drywood termite frass has a seed like shape that is six sided and slightly dimpled on each side. Sometimes drywood termites are called powder-post or furniture termites because of the dry frass pellets they create. Drywood termite frass is black, white, or a mixture of colors. Often workers will clean the inside of the wood by pushing frass out through temporary holes, resulting in saw dust outside the wood. Frass piles are an initial indicator of a termite infestation since the colonies are small and can go unnoticed.

Figure 8. Drywood Termite Frass

In most drywood termite colonies true worker adults are not formed. Instead, workers are nymphs that will never complete adult development. New drywood termite queens produce eggs slowly until workers can assist with foraging and nest formation. Mating swarms are formed at dusk and can occur May through August.

All drywood termites belong to the family Kalotermitidae. In Utah the one species of economic importance is the dark western drywood termite (*Incisitermes minor*). Workers are 1/4 to 3/8″ (6 to 9 mm) long. Soldiers are 5/16 to 1/2″ (8 to 12 mm) long and have orange rectangular heads with white eyespots. The mandibles are enlarged and darkened. Winged adults are 7/16 to 1/2″ (11 to 12 mm) long including the wings and the wings are much longer than the body. The body is dark reddish brown and the wings are dark brown or blackish.

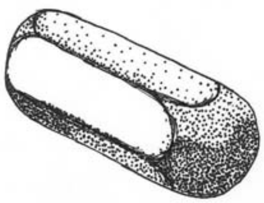
Nest Formation

The workers of wood dwelling termites build the nest and feed completely within sound dead wood. Compared to subterranean termites that eat springwood along the grain, drywood termites feed on springwood or summerwood across the grain. Wood heavily infested with termites will sound hollow.

In non-urban areas, winged drywood termites are attracted to dead wood and will attempt to enter a crack in the wood rather than burrow into it. Winged adults are attracted to lights and will attempt to access crevices of poorly ventilated wooden structures.

TERMITE DETECTION

Thorough and regular termite inspections of structures are important for early detection and damage prevention. Knowledge about situations conducive to termite attack is also essential to preventing structural damage. In addition to protective clothing such as coveralls, gloves, knee pads, and a dust mask, there are several items that will aid in



termite inspections. Items such as a flashlight or head lamp, screwdriver, hammer, knife, and ladder might also be necessary.

Subterranean termites are the most common type of termite in Utah. Termite mud tubes that bridge non-wood gaps indicate infestation. The mud tubes can be broken open to look for workers and determine active or old infestations. Well developed colonies often form satellite colonies that can be difficult to trace. Often drywood termites will have localized infestations. Drywood termites are easily recognized when their frass pellets are pushed out of the infested wood. Knocking on wood throughout the inspection will help pinpoint infestations.

In preparation for the inspection, a scaled drawing of the property is a helpful reference. The four major locations involved in building inspection include exterior, interior, attic, and sub-structural areas. A summary of both old and new termite activity, damaged sites, and locations that termites will potentially infests should be noted throughout the inspection.

Exterior Examination

Termite inspectors should walk around the entire structure and use a measuring wheel to estimate the structure's footprint. Include porches, patios, and other such features in the estimation. Note the soil grade, surrounding vegetation, and any wood to soil contacts. Look for dead or decaying wood around the landscape. Use a screwdriver to tap wooden support beams, stucco, and other potential food sources. Hollow wood or loose stucco is an indicator of termite damage. Also determine the foundation type and note any visible cracks.

Termite inspectors should note any shrinkage or cracks between the foundations and attachments such as porches, masonry, stone facings, and chimneys. Garages can be difficult to inspect if they are cluttered; however, the wooden header above the door and all wood to soil contacts should be examined. This is particularly important if the garage is used for a laundry or moisture accumulation is a problem from leaks or openings.

Most vertical mud tubes attached to the foundation are readily visible. If the property has properly installed termite shields, then mud tubes and other termite activity will be exposed and obvious. Horizontal mud tubes along mudsills, sub-flooring cracks, and floor joists are sometimes more difficult to detect. If possible, the inspector should trace the mud tube back to the point of soil contact.

Interior Examination

Probably the most important features to inspect inside a property are the plumbing fixtures and plumbed appliances. Wet and warm areas are attractive places for termites. Winged adults can be located clustered around areas with excessive moisture. Inspect for leaking dishwashers, water heaters, toilets, and washing machines. Wooden window frames are subject to deterioration and are sometimes infested. Also check around shower stalls and bath tubs where moisture accumulates because these locations are common infestation areas.

Attic Examination

Although uncommon in Utah, termite activity in attics is possible. This is especially true for properties with leaky roofs or in attics directly above soil filled porches. The presence of catch buckets or pans for roof leaks is an indicator the attic might be conducive to termites. Fungal infections on the wood may also indicate poor ventilation.

Crawl Space Examination

The condition of crawl spaces is another important inspection consideration. Inspectors should note any wood deterioration, moisture accumulation, or excessive vegetative growth. In older homes, water lines and plumbing connections are often adjacent to the foundation. Newer homes and larger buildings have more concealed connections which can complicate the inspection process. Pay particular attention to wood debris located near the foundation, exposed plumbing and heating ducts, and other areas directly beneath furnaces and toilets. Probing wet, softened, or stained areas may reveal fungal decay and termite activity.

Conditions Conducive To Termite Infestations

The main food of termites is cellulose found in wood and wood byproducts. In addition to the lumber used in construction, other termite food sources include fiberboard, paper, and fabrics. Sometimes large termite colonies can damage plant roots. Termites will often chew through other materials to reach cellulose. Cutting off all wood to soil contact is the principal subterranean termite management strategy.

The presence of winged adults around the outside of a property or inside near plumbed appliances is often the first indicator of a termite infestation to a homeowner. Mating swarms are not usually produced until the colony is mature so inspections may prevent widespread termite infestation. The easiest way to find signs of termite activity is to look for situations attractive to workers and winged adults. Again, the most critical feature for termite activity is wood to soil contact.

The United States Forest Service (USFS) has identified potential conditions that frequently lead to termite infestations. These conditions include:

- Cracks and open voids in concrete foundations can serve as points of entry;
- Wooden posts, supports, or steps set in concrete that are in contact with the soil;
- Dirt filled concrete porches that may provide wood to soil contact;
- Leaking pipes and dripping faucets in the crawl space that keep the soil moist;
- Crawl space vents blocked with shrubbery or debris that will reduce air flow and keep areas damp and warm;
- Wooden fences, trellises, and other such items that may allow access by termites;
- Form boards and other construction debris left around that may allow termite access;
- Low foundations and footings which increase the likelihood of wood to soil contact;
- Stucco or brick veneer carried down below the concrete foundation may allow access to the structure by termites:
- Soil filled planters built up against the side of the structure may allow direct access into the foundation cracks;
- Heating units in crawl spaces that maintain warm soil temperatures for termite colonies year round;
- Paper collars and other wood byproducts around pipes and ducts may also provide access to the structure; and

- Any sub-slab ductwork for venting or heating offers opening that allow termites to enter below the soil grade.

TERMITE PREVENTION

Successful termite prevention requires an understanding of general termite biology and background knowledge in construction. Common structural housing diagrams, the identification of structural components, and examples of termite access points are shown in Appendix 1. There are several preventive tactics that can be implemented to discourage infestations.

Protecting Structural Foundations

Slab on ground foundations are the most susceptible to termite attack because the termites gain access by crawling over the edge of the slab or through expansion joints, cracks, and other openings. A monolithic slab is the best preventive foundation type for termites. Supported slabs and floating slabs offer some protection, but less than a monolith slab.

Termites can move through cracks as small as 1/32˝ (0.8 mm), so it is important to seal all cracks and openings. Physical barriers are most effective against termites if installed during construction:

- Sand grains, 3/32 to 1˝ (1.6 to 2.5 mm), are too heavy for termite workers to move and the spaces are too small to fit in between. A four inch layer of sand under a concrete slab and around the foundation can be an effective barrier.
- Stainless steel mesh can also prevent termites from entering a structure if installed under and around foundations. Termites cannot chew through a finely woven steel mesh, like Termimesh™.
- Termite shields are metal barriers placed on top of the foundation and any piers that come in contact with wood. Installing metal flashing to porch and stair additions can protect treated lumber. Subterranean termites will build or attempt to build mud tubes around the shields that will be visible during inspections.

Managing Structures

When the likelihood of termite infestation exists, construction materials such as concrete and steel should be used where possible. Homeowners can do several things to minimize the likelihood of termite infestation. The final soil grade around structures should be sloped away from the foundation. All crawl spaces and enclosed areas should be managed to reduce moisture and regularly inspected for termite activity. Lumber should be at least 12 inches above soil. Wood piers and posts that will be in the soil should be pressure treated with a wood preservative. Woods with natural termite resistant are listed in Appendix 2.

The voids, cracks, and expansion joints in structures should be filled with concrete, masonry cement, grout, or other materials that will form a barrier against termites. Minimize wood mulch next to the foundation or keep mulch levels at least four inches below the siding and wooden structures. Firewood and other wood or paper products should be stored away from foundations and crawl spaces. Divert rain water away from the structure by cleaning gutters and using downspout extensions. Promptly repair leaky roofs, faucets, water pipes, and air conditioning units. Replace heavily damaged wood with sound material. Substitute metal or masonry where wood is in contact with the soil.

SUBTERRANEAN TERMITE MANAGEMENT

Controlling termites can be a time consuming and expensive process. Knowledge of termite biology, soils, pesticide safety, government regulations, building construction, and termiticide application equipment is required to manage termites.

Soil Texture

The relative amounts of sand, silt and clay in the soil refer to the soil texture. Figure 9 depicts the relative percentage of sand, silt, and clay for 12 different soil types. Soil particles are defined by size; sand ranges from 0.05 to 2.0 mm, silt ranges from 0.002 to 0.5 mm, and clay is less than 0.002 mm. Water permeability can be estimated by soil texture, with clay soils moving water more slowly than sandy soils. Compaction caused by heavy equipment forces soil particles together and can reduce the permeability of water and termiticides.

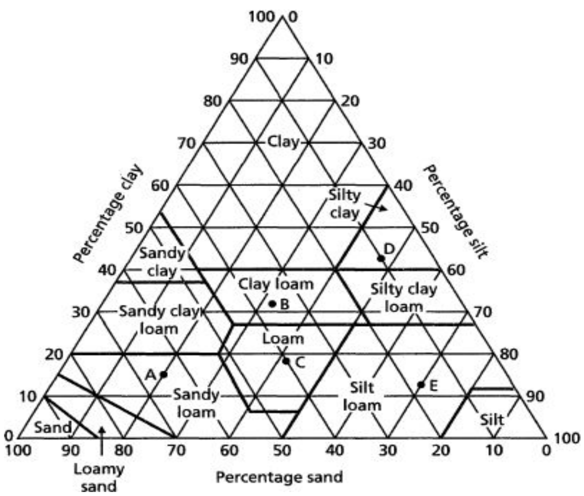


Figure 9. Soil Types Based On Percentage Sand, Silt, and Clay

Termiticide Applications

Precautionary measures should always be taken with pesticides, but additional hazards are associated with making applications to structures. Improperly applied termiticides can contaminate plumbing or heating ducts, and leach into groundwater. The most effective termiticide treatments require special equipment and a licensed technician. Some of the specialized equipment needed for termite management include:

- A stainless steel of fiberglass tank large enough to avoid frequent refilling. Tank shut off valves and drain plugs should be located for easy accessibility.
- Agitators may be required depending on the termiticide being used and tank shape. Wet-able powder suspensions in a square tank will require better agitation than emulsions in a round tank.
- Spray pumps must deliver the required pressure and volume within the normal capacity. Metal parts must be resistant to corrosive materials, and gaskets must be resistant to swelling.
- A pressure regulator controls the pressure and therefore quantity of termiticide delivered by the nozzles.
- A heavy duty electrical hammer drill is required for drilling through concrete. Multiple masonry drills will be needed for a single job.

Some of the cleaning and operating concerns related to termiticide spray equipment include the following. Large amounts of clean water should be passed through sprayers and nozzle tips when changing pesticide products. Brushes should be used to clean nozzles rather than metal objects such as pins, nails, or knives. Compressed air may be used to clean nozzles, but do not blow by mouth into a nozzles to clean them. Care should be taken to keep unclean water or debris from entering the spray tank. Operators should follow the manufacturer's instructions when operating and maintaining pesticide equipment.

Various types of implements are used to treat termites depending on the location being treated. Several application methods are used to make termiticide applications.

- Trenching involves excavating soil 6″ wide adjacent to the foundation, piers, and pipes inside and outside of the foundation walls. A termiticide is applied to the trench and backfill soil. The trench depth depends on the foundation type, so follow label instructions for specific details.
- Rodding uses specialized metal pipes that are 1/4 to 1/2″ in diameter and 4 feet long, with various nozzle types. The termiticide is directed down to the external perimeter of the property foundation. The rodding angle is dependent on the foundation type. Rod

spacing depends on the termiticide label and soil type, but is usually every 12″ or less. Follow the label instructions for specific details.

- Sub-slab injectors deliver termiticide to the soil through holes drilled in the concrete slab. Injectors treat near expansion joints and other cracks in contact with soil. Horizontal rodding is more complicated, but common for areas beneath bathrooms and kitchens. Spacing requirements for sub-slab injection are outlined on termiticide labels. Drilling for sub-slab injections can drill into a gas line, water line, electrical wiring, or heat ducts. Cautionary measures must be taken to avoid termiticide exposure to humans.
- Low pressure sprayers, those operated at less than 25 pounds per square inch, are used during the pre-framing phase for applying termiticides to the soil surface beneath the slab area, footings, and interior and exterior foundation walls.

Termiticides applied during after the initial site preparation and prior to the start of framing allows for a termiticide treatment that provides a more uniform barrier. This is compared to applications made after construction is complete or when the structure is older. Applications to older or completed structures require liquid termiticides to be injected through drill holes and the flooding trenches dug in the soil around the foundation. Generally, spot treatments for subterranean termite control are not effective or guaranteed because the termites can circumvent the localized chemical injection. Spot treatments are considered risky and discouraged except in re-treatment situations.

Conventional Liquid Termiticides

Traditionally, termiticide technology has relied on creating a chemical barrier in the soil. Termiticides were either repellents or fast acting nerve poisons. Termite workers can detect the repellent and avoid the treated soil. If termites contact the termiticide they die very quickly. To achieve complete control, a continuous termiticidal barrier must be applied to the soil next to and under the foundation. Any chemical gaps in the soil can be exploited by subterranean termites. A disruption to the soil barrier after treatment such as from landscaping can compromise the continuous barrier.

Examples of conventional repellent and fast acting termiticides include synthetic pyrethroids, such as Talstar® (bifenthrin), Dragnet® (permethrin) and Demon® or Prevail® (cypermethrin). An example of a fast acting organophosphate pesticide is Dursban® (chlorpyrifos).

Applying repellent or termiticides may prevent an infestation to a structure with a continuous barrier; however, the termiticide may not kill the entire colony. Most colony members, including the queen, never come in contact with the termiticide. Workers that survive contact with the product will begin building new tunnels to other food sources.

Modern Liquid Termiticides

New termiticide technology has emerged that kills the entire colony. The soil applications are applied in the same way, but the products are attractive to eat for workers. The termiticides are slow-acting, and are eventually passed on to all of the colony members. The colonies, including the queen, slowly die out.

Some modern termiticides are stomach poisons that slowly concentrate in the body. Other modern termiticides kill termites by disrupting molting. These products are chitin synthesis inhibitors that reduce cuticle formation in the exoskeleton. As the infected termites attempt to molt, the exoskeleton never hardens and they eventually die. These slow acting termiticides allow the workers to live long enough to return to the nest. Infected termites become carriers that transfer the termiticide to all other colony members, including the queen, via trophallaxis.

Examples of slow acting termiticides that are attractants include Phantom® (chlorfenapyr), Termidor® (fipronil), and Premise® (imidacloprid). If a continuous soil barrier is maintained, Termidor® can kill termite colonies and prevent a re-infestation for more than 10 years.

Baiting Termites

In addition to liquid soil barrier applications, bait stations offer a supplemental tool for subterranean termites. Bait technology uses attractive wood in stations strategically placed around a property. In some cases, the stations are used to monitor for termite activity. More often, stations have termiticides impregnated into the wood to supplement soil barrier control. Baiting systems are typically used outside the perimeter of a structure, but they can also be used indoors.

Bait stations use slow acting termiticides that can suppress a subterranean termite colony. Workers randomly forage under the soil for wood and use pheromones to recruit other individuals. Bait technology hopes to utilize that behavior. When termites encounter a bait station, they eat treated wood and pass on the termiticide to other colony members through trophallaxis. The goal is to use a slow acting termiticide that is be carried back to the parent and satellite nests by workers and passed on to the entire colony.

Most bait systems are monitored regularly and their locations may be changed depending on termite activity. Several months of baiting may be required to pinpoint tunneling and feeding near a structure. As a result, termite bait systems work more slowly than a liquid termiticide, but are considered more environmentally friendly since small quantities of pesticides are released. The majority of current baiting systems promote suppression and not control. Several bait systems are available. Each bait system has different monitoring regimes, so read and follow the label directions.

DRYWOOD TERMITE MANAGEMENT

To control drywood termites it is critical that the applicator and/or homeowner must identify the locations in the wooden structures infested with termites. If possible the infested wood should be replaced and the infested pieces destroyed. The most successful treatments for drywood termites include fumigation or site specific termiticide applications. Fumigation is recommended if infestations are not localized or if they are difficult to access. Liquid termiticides are recommended when drywood termite infestations are isolated and accessible. Heat and cold treatments for small wooden items, such as furniture, picture frames, and tools, may be effective.

If practical, several hours of high temperature exposure of about 130 degrees Fahrenheit can kill termites inside wood. Heat treatments may warp wood and damage the finish and is therefore not a desirable control method for most infestations. Cold treatments can also kill termites if the infested item can fit into a freezer for a few weeks. Alternating cold and heat treatments is also effective at disrupting termite development.

INFORMATIONAL WEB SITES

Utah Plant Diagnostic Laboratory
www.utahpests.usu.edu

National Termite Survey
www.termitesurvey.com/introduction.shtml

Kelly Solutions
www.kellysolutions.com/ut/

CDMS Pesticide Labels
www.cdms.net/LabelsMsds/LMDefault.aspx

USDA Forest Products Lab
www.fpl.fs.fed.us/documnts/fplgtr/fplgtr113/fplgtr113.htm

III. OTHER WOOD DESTROYING INSECTS

TOPIC | **PAGE**

PROPER INSECT IDENTIFICATION

Effective pest management requires that the pest must be properly identified and that any factors contributing to the infestation be remedied. Examples of such factors include improperly designed structures or building additions that have allowed pest to gain access. Pest identification must often be made from evidence of visible damage and pest droppings or frass. Incorrect identification of a pest can result in costly and/or ineffective pesticide treatments. Pest inspectors should carefully determine what pest is causing the problem and implement a pest management strategy that is timely and appropriate.

Termites are the most economically important structural pests, but other wood destroying insects also cause problems. There are several other groups of wood destroying insects in Utah such as beetles, bees, ants, and wasps. Identifying other wood destroying insects can be difficult because the adults are not often found in the infested wood. Proper diagnoses are based on larval activity and other evidence left behind. The frass and its texture or appearance is used to identify wood boring insects.

Although other wood destroying and nuisance insects occur in Utah, only the groups that cause significant structural damage are discussed in this study guide.

WOOD BORING BEETLES

Beetles in the order Coleoptera, are the most abundant and diverse animals in the world and very few species are actually wood destroying. Of the more than 30,000 beetle species in the United States, less than 100 are structural wood pests. Ambrosia beetles in the families Platypodidae and Scolytidae, bark beetles in the family Scolytidae, and wood boring weevils in the family Curculionidae rarely cause structural damage in Utah.

Beetles go through complete metamorphosis which includes egg, larva, pupa, and adult stages. They have basic insect characteristics and are further distinguished from other insects by several attributes. These distinguishing attributes include:

- The forewings (elytra) are hardened and meet in a straight line down the back;
- The hind-wings are clear and used for flight;
- They have chewing mouthparts as adults and larvae;
- They are broad waisted between the thorax and abdomen; and
- They have antennae, normally with 11 segments.

POWDERPOST BEETLES

The powderpost beetles are the most destructive of all the wood boring beetles. In addition to lumber and other wooden structures, powderpost beetles can infest tools, picture frames, furniture, books, toys, and flooring. The two powderpost beetle families that are found in Utah include Bostrichidae and Anobiidae.

Powderpost Beetle Life Cycle

Newly emerged powderpost beetle adults mate and lay eggs on the surface of bare unfinished wood. Females lay eggs in cracks, exposed pores, or at the ends of cut wood. Sometimes eggs are laid near emergence holes of previous generations. When the eggs hatch the larvae bore directly into the wood and begin feeding. Larval development may take one to five years depending on the species and environmental conditions. Pupation occurs near the surface of the wood and adult powderpost beetles emerge and look for mates. Adults are short lived, nocturnal, attracted to light, and they typically emerge in April or June.

Powderpost Beetle Damage

Powderpost beetle larvae consume wood and create powdery frass. Although most of the damage occurs to the sapwood, feeding may extend to the heartwood. Structural damage may go unnoticed if the adults keep re-infesting the same piece of wood. When the powderpost beetles finally emerge, they create shot holes where they exit and leave piles of frass outside the infested wood. Shot holes are small and round, and about 1/32 to 1/8˝ (0.8 to 3 mm) in diameter depending on the species. Homeowners are more likely to see shot holes and frass rather than emerging adults.

Wood infested with powder-post beetles is often abandoned before it is completely destroyed. Knowing if the beetles are active is essential for control. In many cases, the infestations die out after one generation because the wood becomes too dry. Active infestations have frass the color of fresh cut wood. Inactive infestations have exit holes that look weathered similar to the surrounding wood and the frass may be covered with dust or debris. If there is any uncertainty about a powderpost beetle infestation the following procedure can determine if new activity is occurring. Remove any debris or old frass from the vicinity of the suspected wood members. Seal or cover the existing shot holes and monitor for any new frass or exit holes.

Bostrichidae

There are more than 550 different species within the Bostrichidae family and 73 of those species are found in the United States. Common names are the true powderpost beetle, the auger beetle, false powderpost beetles, and horned powderpost beetles. Bostrichid beetle larvae are not capable of digesting cellulose like termites. Bostrichid beetle larvae feed on the starches, proteins, and sugars found in wood.

Bostrichid adult beetles attack hardwood and hardwood byproducts, such as wood paneling, molding, door frames, plywood, hardwood floors, and furniture. Oak, ash, walnut, and hickory are preferred, and imported tropical hardwoods are especially prone to attack. Other structural wood, like rafters, joists and studs are not commonly infested since they are made out of softwoods.

Bostrichid adults are 1/8 to 13/16″ (3 to 20 mm) long, elongated, and cylindrical, and reddish brown to black. The eyes are round and bulging, and the head is usually directed down and is concealed from above. Clubbed antennae are often visible from above. Fully developed larvae are 1/8 to 13/16″ (3 to 20 mm) long and white. Larval frass is powder like and tightly packed together compared to other wood boring beetles with loosely packed frass.

The true powderpost beetles are in the subfamily Lyctinae and their frass is very fine and powder like. The true powderpost beetle rarely infests wood older than five years and is more common in new homes. Adult powderpost beetles are shiny, rusty brown, and have hairy striated forewings (elytra). False powderpost beetles have concealed heads and clubbed antennae. The adult true powderpost beetles are flattened, narrow, and slender with obviously clubbed antennae. For comparison purposes the true powderpost beetle is shown in Figure 9 and the false powderpost beetle is shown in Figure 10.

Figure 9. True Powderpost Beetle

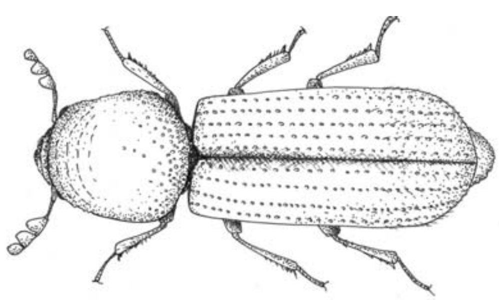
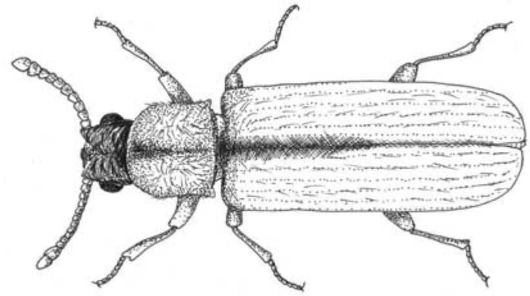


Figure 10. False Powderpost Beetle

The exit or shot holes produced by these beetles are round and range from 1/32 to 1/16″ (0.8 to 2 mm) in diameter. Fully developed larvae are yellowish to white, and 1/4″ (6 mm) long. One species in Utah is



the velvety powderpost beetle (*Trogoxylon parallelopipe-dum*).

Anobiidae Beetle

There are more than 310 species in the anoiidae family in the United States, but they are not common in Utah. Anobiid beetle larvae are capable of digesting cellulose with the help of symbiotic yeast cells. Adult anobiids will attack softwoods or hardwoods, including almost any lumber used in construction, including furniture. Maple, beech, poplar, and pine are the preferred wood types of these beetles. Infestations usually begin in moist, poorly ventilated areas, such as crawl spaces and basements. Anobiid exit from holes that are 1/16 to 1/8″ (2 to 3 mm) in diameter.

The two anobiid beetles found in Utah are the furniture beetle (*Anobium punctatum*) and the deathwatch beetle (*Xestobium rufovillosum*). The furniture beetle is shown in Figure 11. Furniture beetles do not have a neck like other powderpost beetles. Adults are 1/8 to 1/4″ (3 to 6 mm) long, elongated and cylindrical, and reddish brown to black in color. The forewings (elytra) are hairy and punctured or pitted. The adults have well concealed heads and clubbed antennae. Fully developed larvae are 1/2″ (12 mm) long, hairy, and white. Anobiids produce loosely packed frass that feels coarse and gritty.

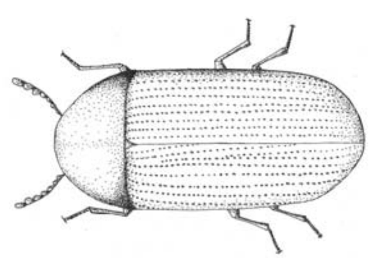


Figure 11. Furniture Beetle

Preventing Powderpost Beetle Damage

Most powderpost beetles are accidentally introduced into structures by infested lumber or finished wood products such as furniture and flooring. Any wood product that has shot hole damage is likely to be infested. Infestations are likely in lumber from old barns or woodpiles.

Females prefer to lay eggs on bare wood so painted, varnished, or waxed wood is somewhat protected. Bare wood can be protected by finishing exposed surfaces and sealing any existing exit holes. Adults emerging from finished wood can re-infest by laying eggs in their own exit holes.

Powderpost beetles must extract water from the wood they are infesting. Wood moisture levels below 13 percent are typically unsuitable for larval survival. Moisture barriers such polyethylene sheeting placed over soil surfaces can reduce water migration into the substructures, walls, and upper portions of a building. Improving ventilation also reduces moisture accumulation that is attractive to powderpost beetle adults.

Powderpost Beetle Control

Wood infestations by powderpost beetles are slow to develop and rarely persist in dry wood. Insecticidal treatments are usually not necessary. Insecticides may be required for those situations where continuous re-infestation occurs. Spraying or brushing the insecticide on wood will kill adults as they attempt to bore out of the wood and also kill newly hatched larvae before they bore into the wood. It is important to treat the ends of cut wood prior to the time when egg laying occurs.

A number of insecticides are labeled for bare wood surface treatments that control powderpost beetles. Exterior liquid applications will not kill larvae in wood greater than one inch thick or in finished wood. Valuable wood items that are infested with powderpost beetles may be fumigated for control. Active ingredients that are labeled for powderpost beetle control in Utah include bifenthrin, beta-cyflurthrin, boron, sodium oxide with tetrahydrate, chlorpyrifos, copper naphthenate, cyfluthrin, cypermethrin, esfenvalerate, imidacloprid, and permethrin. Applicators should read individual labels for specific applications to wood surfaces, especially for indoor use.

If practical, several hours of high temperature exposure of about 130 degrees Fahrenheit can also kill larvae inside the wood. Heat treatments may warp the wood and damage the finish, and is therefore not a desirable control method for most infestations. Cold treatments can also kill larvae if the infested item can fit into a freezer for a few weeks. Alternating cold and heat treatments is also effective at disrupting the complete development of the beetles and may prevent them from making shot holes when they emerge.

ROUNDHEADED BORERS

There are than 20,000 known species of round-headed borers, about 1,200 different species are in the United States, and all belonging to the family Cerambycidae. The term round-headed refers to the rounded and enlarged thorax of the larvae. A roundheaded beetle is shown in Figure 12. These wood boring beetles are also called longhorned beetles because the adults typically have antennae longer than the body. As with powderpost beetles, the roundheaded larvae damage wood and adults can cause exterior damage to wood when they make exit holes. Adult longhorned beetles do not re-infest wood after the wood becomes seasoned. These beetles cause worm hole damage that some people consider to be aesthetically pleasing.

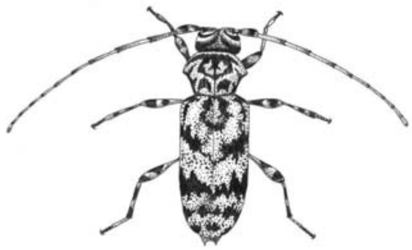


Figure 12. Roundheaded or Longhorned Beetle

Longhorned beetle adults are 3/8 to 1″ (9.5 to 25 mm) long, elongated and cylindrical. The forewings (elytra) are hardened, variable in color, and cover the entire abdomen. The antennae are very long and usually extend well past the body. Fully developed larvae are 3/8 to 3 1/8″ (9.5 to 79 mm) long, creamy or white in color, have elongate bodies, and are legless. The area just behind the head or thorax is greatly enlarged and rounded.

A longhorned beetle found in Utah is the California root borer (*Prionus californicus*). These beetles attack hardwood and softwood trees, but prefer fruit trees. They show greatest preference for sweet cherry trees growing in sandy soil. Complete life cycle development may take three to four years. Adults are reddish brown, have relatively smooth and shiny forewings (elytra), and can be 2 1/4″ (57 mm) long. Fully developed larvae can be up to 4 1/2″ (108 mm) long and 3/4″ (19 mm) in diameter. As the common name suggests, California root borer larvae prefer to eat tree roots.

Roundheaded Borer Life Cycle And Damage

Mated females are attracted to unseasoned wood, logs, and lumber. Eggs are deposited in wood or bark crevices. Larvae bore into the wood and feed just below the bark layer in an irregular pattern. These openings, referred to as galleries start small, but gradually increase to 1/2″ (12 mm) in diameter. As the larvae get older, the galleries can extend into the sapwood of softwood or hardwood trees. Frass can be loosely or tightly packed into the galleries and can be fine or very coarse depending on the species. Larval development can take a few months to several years depending on the species and environmental conditions. After completing development, adults make round exit holes 1/8 to 3/8″ (3 to 9 mm) in diameter.

Log homes constructed in wooded areas can be damaged by roundheaded borers. If bark is left on the logs, the wood will retain moisture and allow larvae to complete development. Infested wood that is cut green or air dried and not properly sealed will also promote larval survival. Infested firewood can spread roundheaded borers to urban areas. Storing firewood indoors can provide favorable conditions to complete development.

Roundheaded Borer Control

Keeping trees healthy with optimal water and fertilization, when practical, can discourage adults from laying eggs on the bark. Living trees can be protected with an insecticide in early summer when adults are emerging. Active ingredients labeled for roundheaded borer control are variable depending on the type of living tree. Structural wood without bark is rarely re-infested in Utah because the moisture is too low. Drying or pressure treating can kill existing borers within the wood. Insecticidal treatments for roundheaded borers are generally not effective and therefore not recommended for finished wood.

FLATHEADED BORERS

There are more than 14,600 different known species of flatheaded borers and about 760 different species are in the United States, all belonging to the family Buprestidae. The term flatheaded refers to the flattened and enlarged thorax of the larvae. These wood boring beetles are also called metallic wood boring beetles because the adults have bronzed metallic forewings (elytra) and other body parts. During the larvae stages, wood is damaged by boring and the adults can cause damage as they make exit holes.

Longhorned beetle adults are 3/8 to 1˝ (10 to 60 mm) long, elongate, and cylindrical. Flatheaded beetles have prominent eyes and shiny tapered wings. The flatheaded beetle is shown in Figure 13. The forewings (elytra) are hardened, metallic, pitted or deeply grooved, and are tapered at the end of the abdomen. Fully developed larvae are 3/16 to 2˝ (5 to 50 mm) long, creamy colored, elongated, and legless. The area just behind the head or thorax is greatly enlarged and flattened.

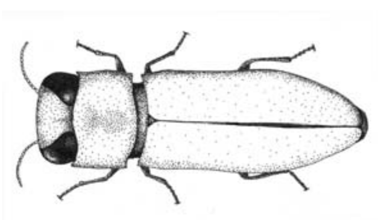


Figure 13. Flatheaded or Metallic Beetle

A common buprestid beetle in Utah is the flatheaded apple borer (*Chrysobothris femorata*). These beetles will infest a variety of hardwood trees, including maples, crabapple, hawthorn, apple, linden, and oak. The adult is dark metallic brown, flattened, and 1/2˝ long. The head is blunt and the forewings (elytra) taper at the end of the abdomen. Fully developed larvae are legless, yellowish, and 1 1/4˝ long. The larvae have an enlarged thorax but a slender abdomen.

Flatheaded Borer Life Cycle And Damage

Adults do not re-infest seasoned wood and are pests that can cause aesthetic damage. Mated females are attracted to unseasoned wood, logs, and lumber. Eggs are deposited in wood or bark crevices. Larvae bore into the wood and feed in the sapwood layer in an irregular pattern. Galleries start small, but gradually increase to 1/2˝ (12 mm) in diameter. As the larvae get older, the galleries can extend into the heartwood. Galleries are oval, but flat, and the frass is tightly packed. Depending on the species, larval development can take a few months to several years. After completing development, adults make oval exit holes 3/16 to 1/4˝ (5 to 6 mm) across, with the width being at least three to four times the height.

Flatheaded Borer Control

Living trees must be kept healthy and vigorous to discourage flatheaded borers adults from laying eggs on the bark. Living trees can be protected with an insecticidal treatment in early summer when adults are emerging, mating, and laying eggs. Active ingredients labeled for flatheaded borer control are variable depending on the type of living tree that is infested. Structural wood without bark is rarely re-infested in Utah because the moisture is too low. Drying or pressure treating wood can kill borers within the wood. Insecticidal treatments for flatheaded borers are generally not effective and therefore not recommended for finished wood.

WOOD BORING ANTS AND BEES

Ants and bees are in the order Hymenoptera and are most closely related to wasps and sawflies. Ants and bees go through complete metamorphosis including egg, larva, pupa, and adult. Some species in the order Hymenoptera have a social caste system, while others are solitary. Ants and bees have basic insect characteristics and are distinguished from other insects by several attributes. These distinguishing attributes include:

- Forewings are clear and connected to the hind-wings during flight with small hooks (hamuli); the forewings are larger than the hind-wings;
- Constricted waist between the thorax and abdomen (except for sawflies);
- Tarsi (feet) with 5 segments;
- Well developed compound eyes; and
- Chewing mouthparts.

Although several ants, bees and wasps can use wood to make nests, only carpenter ants and bees will be discussed in this study guide. Bumble bees (*Bombus* spp.), honey bees (*Apis melllifera*), mud daubers (family Sphecidae), and wood wasps (family Siricidae) rarely cause structural damage in Utah. Social wasps such as yellow-jackets, hornets, and paper wasps are in the family Vespidae and rarely damage structural wood.

CARPENTER ANTS

Carpenter ants are in the genus *Camponotus*, family Formicidae, and order Hymenoptera. They are considered serious pests to wood structures worldwide. There are over 900 species of carpenter ants in the world, 50 in the United States and Canada, and 12 in Utah. Carpenter ants have a single node between the thorax and abdomen, while many other wood dwelling ants have two nodes. A picture of the carpenter ant appears in Figure 14. Adults are red, yellow, and/or black, and range from 1/8 to 5/8″ (3 to 15 mm) in length.

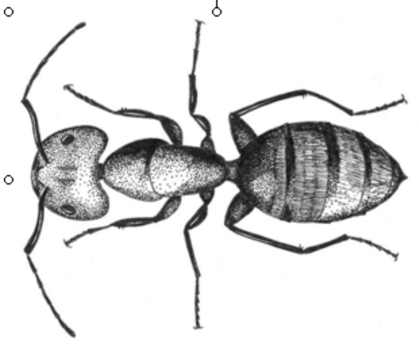


Figure 14. Carpenter Ant

Carpenter ants are most abundant in forests and can be found under the loose bark of dead trees, stumps, or fallen logs. They are predators, scavengers, and help accelerate the decomposition of wood. Carpenter ants prefer wood with high moisture content, especially when the wood is infested with mold and/or fungi. If conditions are similar to soil, carpenter ants may accidentally form nests within wooden structures.

Carpenter ants are social insects with a caste system. Ants have a queen and workers, and a division of labor. They also exchange food with the queen and larvae through trophallaxis. Carpenter ants workers vary in size, with the largest ones called majors, the smallest ones called minors, and other sizes in between called Medias. The number of ants in a colony varies by species, but can have more than 50,000 to 100,000 workers. Some species have multiple queens to supplement their egg laying potential.

Carpenter Ant Life Cycle

Like termites, carpenter ants start new colonies when winged male and female ants swarm. After the female ant has successfully mated, she drops to the ground, breaks off her wings, and begins to search for a suitable site to start a nest. Once a site is selected, the queen will begin foraging, egg laying, and expanding the nest. The queen will focus on egg production after workers develop and can contribute to the colony. Eventually the new workers will take over raising the brood. Carpenter ants build the nest for three to four years before swarmers are produced. In Utah, homeowners are most likely to see winged carpenter ants in the spring.

Locating Ant Nests

Ants will forage away from the parent nest where the queen is housed, which makes finding the main colony difficult. Carpenter ant nests are usually noticed indoors when the ants leave piles of frass outside of their tunnels. Following ant trails can help pinpoint infested wood behind walls. Difficulty in tracking ants can occur when trails enter wall voids along plumbing or electrical pathways. The following are examples of locations where carpenter ants are detected:

- Firewood, tree stumps, and dead tree limbs; landscape timbers, fence posts, and decking materials;
- Voids in walls, under porches, and above bay windows; under attic insulation, hot tubs, bathtubs, and roofing boards; and
- In hollow doors, curtain rods, and ceiling beams.

Carpenter Ant Control

Effectively reducing carpenter ants is dependent on finding the nest or nests. In some cases, multiple nests may be formed indoors and outdoors. As with termite inspections, all the exterior and interior parts of the structure should be examined. Pay particular attention to areas where moisture accumulates such as plugged drain gutters, poor fitting siding, wood shingle roofs, hollow posts, leaking doors, and deteriorating window frames. Look for wood to soil contact, any wood debris near the structure, or under dirt filled porches.

Eliminating moisture will discourage carpenter ants from nesting in a structure. Use insecticidal dusts in any accessible nesting areas and liquids in available galleries. A number of active ingredients are labeled for carpenter ant control in Utah. These include beta-cyfluthrin, bifenthrin, bio-allethrin, boron sodium oxide with tetrahydrate, chlorpyrifos, cyfluthrin, deltamethrin, esfenvalerate, hydramethylnon, imidacloprid, lambda-cyhalothrin, and permethrin. Refer to the pesticide labels for specific applications to wood and note any limitations for indoor use.

CARPENTER BEES

In Utah, the two common species of carpenter bees are *X. californica* and *X. tabaniformis*. In general, carpenter bees are robust, heavy bodied bees ranging from 1/2 to 1″ (12.5 to 25 mm) in length. The carpenter bee as shown in Figure 15, often have a bare spot on the thorax and are frequently confused with bumble bees. They have bright yellow, orange, or white hairs on the thorax, dense hairs on the hind legs, and a black shiny abdomen. The male carpenter bees have white markings on the head.

Figure 15. Carpenter Bee

Carpenter bees are large, hairy bees in the genus *Xylocopa*, family Apidae, and order Hymenoptera. There are over 500 species of carpenter bees distributed worldwide, and seven species in the United States. Unlike honey bees, carpenter bees are solitary insects without a caste system. Females take care of their own young by making small nests in wood and providing food. In some cases, some carpenter bees live in tunnels alongside their daughters or sisters. Carpenter bees do not eat wood, but are capable of chewing through and nesting in a variety of hardwoods and softwoods. Wood that is weathered is preferred. Adults are active from early spring through summer, and are common around wooden structures.

Nest Building

Females will nest in buildings that have wood, such as shingles, shutters, roof eaves, fascia boards, and porches. Carpenter bees will make nests in a variety of other wooden structures, including fence posts, utility poles, firewood, lawn furniture, and arbors. Females construct nests by scraping their mandibles against the wood, excavating a cavity at a rate of 1.5 cm per week. The beginning hole of a tunnel is circular and about 12 mm wide which is about the diameter of the adult. Initially, she bores into wood perpendicular to the grain for 2 to 5 cm, and then turns 90 degrees along the wood grain to finish the tunnel.

The female then lays an egg at the far end of the tunnel and provision it with a mixture of pollen and regurgitated nectar formed into a ball. The provision provides all the nourishment needed for the immature bee. She then seals the cell with a plug of chewed wood and continues building more cells until she fills the tunnel. An average tunnel will contain seven cells with eggs. Gallery construction is labor intensive, so females prefer to use old nests rather than construct new ones. Often the same nesting area will be active for many years.

Carpenter Bee Life Cycle

Carpenter bees go through the complete metamorphosis cycle including egg, larva, pupa, and adult, and have one generation per year. The life cycle takes about seven weeks depending on the temperature. Eggs hatch within the cell and larvae begin to feed on their respective provisions. Larvae develop in reverse order so that the eggs laid last are the first to emerge from the tunnel. This way, the bee closest to the tunnel exit can leave first. Newly developed adults may remain in the nests for a couple of weeks before leaving. New adults have to chew their way through the cells and generally wait to emerge from their tunnel until late August. Male and female adults will hibernate in these galleries as shelter during winter.

Carpenter Bee Damage

Carpenter bees will often nest in bare wood near roof eaves and gables, fascia boards, porches, decks, railings, siding, shingles, and other weathered wood. Nail holes, exposed saw cuts, and unpainted wood are attractive sites for bees to begin excavation. Sometimes carpenter bees clean out the nest while building galleries. Castings of wood particles and excrement will be pushed out the exit hole. Sawdust like piles around wood may indicate a carpenter bee infestation. Structural damage is not likely unless repeated nesting occurs in the same area or if moisture gets in the wood through the holes. Rarely woodpeckers drill the wood to try and get carpenter bee larvae.

Carpenter Bee Control

Carpenter bees often reuse or construct new tunnels near old ones, which can create a complex system of galleries that can sometimes cause excessive damage. Control measures for carpenter bees are usually not warranted and insecticides should be considered a last resort. However, repeated infestations and tunneling into structures can significantly damage a structure and should be prevented.

Exit holes should be located during the day when adults are actively foraging. Wear protective clothing before taking any preventive or control measures during the evening. Fill the nest with an expanding foam or sealant. Consider covering the exit hole with wood putty or a caulking to discourage re-infestations. Insecticidal dusts (cyfluthrin or deltamethrin) may be more effective than liquids. Use dust insecticides in and around exit holes so adults will pick up dust particles and distribute to eggs while constructing cells. Liquid or aerosol insecticides registered for carpenter bee control in Utah include materials such as beta-cyfluthrin, esfenvalerate, imidacloprid, permethrin, and deltamethrin.

IV. WOOD DECAYING FUNGI

WOOD DECAY

Decay fungi are fungi that use the cell wall which is the structural part of wood for food. These fungi produce special enzymes that can destroy cell wall materials such as cellulose, hemicellulose, and lignin. This can reduce the structural strength of the wood and in serious cases render the wood useless for construction.

Severe wood decay occurs only in wood with moisture content greater than 20 percent. Most wood rotting fungi grow only on wood subjected to wetting by rain, roof leaks, plumbing leaks, condensation, or contact with moist soil. An exception to this is the dry rot group of fungi which absorb water from the air, allowing fungi to attack drier wood. Common groups of wood decay fungi include cubical brown rot, white rot, dry rot, and blue stain fungi.

Cubical Brown Rot

Cubical brown rot causes wood to break into small cubes with cracks running perpendicular to the grain. This condition is caused by recurring changes in moisture content from wet to dry. The wood becomes brittle and shrinkage occurs because of these moisture changes. The cellulose of the wood is destroyed, leaving the lignin and producing a brown crumbly material. The strength of the wood decreases rapidly and it can be crushed into a powder.

White Rot

Fungi that cause white rot attack cellulose and lignin. Destruction of the lignin results in a whitish bleached appearance. The wood has a stringy texture and spongy consistency. Wood with white rot loses its strength much more gradually than wood with cubical brown rot. White rot is common in areas that are consistently wet.

Dry Rot

Dry rot fungi are types of brown rot fungi that can conduct water into the wood. As a result, wood that is immune from attack by other fungi may be attacked by dry rot fungi. This is achieved by means of vine like structures called rhizomorphs, which can move water from moist soil or wood into dry wood. The rhizomorphs are dirty white and become brown or black with maturity.

Blue Stain Fungi

Blue stain fungi are a group of fungi that do not cause decay. Instead of destroying cell walls the fungi develop within the cells of the sapwood causing a bluish or bluish gray stain. Although blue stain fungi do not cause structural damage they can make wood more susceptible to damage by decay fungi.

Blue stain fungi are commonly associated with various bark beetles that attack stressed or declining stands of timber. In Utah, the most common blue stain fungi are those transmitted to pines by the mountain pine beetle or to Douglas fir by the Douglas fir beetle. The fungus actually assists beetles by killing or reducing the vigor of trees and making them more suitable for the beetle larvae to develop. In lumber, both the beetle larvae and the blue stain fungi cease to develop further. Furthermore, the blue staining is sometimes considered attractive, with stained wood receiving special use in paneling.

CONTROLLING FUNGI

In order for wood fungi to grow they require a food source, favorable temperatures, and adequate oxygen and moisture. A deficiency in any of these requirements will inhibit the growth of a fungus even if it is well established in the wood.

The most practical method of controlling fungi in structures is to control the moisture content of wood. Methods of moisture control include:

1. Isolate structural lumber and other woods from the soil.
2. Install moisture barriers between soil and the structure.
3. Provide adequate ventilation to enclosed spaces.
4. Improving drainage to remove rain and irrigation water.
5. Applying chemical preservatives to wood that inhibit fugal growth.

The following checklist can be used as a guide in helping to avoid problems with decay fungi.

Decay Problem Conditions and Locations

1. Flower beds adjacent to the home are a problem. Wood should be at least three inches above adjacent finish grades for framing members and six inches above finish grade for siding.
2. Persistent wetting of exterior wood by lawn sprinklers creates a high decay hazard.
3. Decay is likely in wood joints where boards or beams are jointed end to end. Also, the ends of boards or beams absorb moisture more rapidly than do board faces or edges. Metal caps are commonly used to protect the tops of wooden posts.
4. Cracks that open in wooden beams as they dry allow for extensive rain wetting. Exposed beams should be treated with a preservative. Metal caps may also be appropriate for the ends of exposed wooden beams.
5. Roof overhangs on structures direct rain and other runoff away from exterior walls.
6. Metal or other similar flashing should be used to shield joints between roofs and chimneys, roof and pipe vents, and similar joints.
7. Backfill around structures should move water away from buildings.
8. Waterproof drip edge and roofing materials should be installed to protect the exposed
9. Rain gutters and down spouts direct rain and other water runoff away from building walls and decks.
10. Porch surfaces and walkway should slope away from building.
11. Runoff water should be directed away from the ends of wooden posts and beams. The bottoms of wooden supports should not touch concrete or other masonry materials in locations where wood is regularly exposed to wetting.
12. Plumbing leaks should be repaired and ventilation methods employed to reduce moisture around wood structures.
13. If condensation accumulates under or adjacent to a building a vapor barrier or other waterproofing material should be installed between the ground and the structure.
14. Subsurface leaks into basements or crawl spaces should be stopped using waterproof barriers, drain tiles, water pumps, or some combination of these strategies. Drain water away from the house.

WOOD PRESERVATIVES

The proper application of chemical preservatives can protect wood from decay, stain fungi, and insects, thus prolonging the service life of wood for many years. The effectiveness of wood preservative treatment depends on the pesticide formulation selected, method of application, proportion of sapwood to heartwood, moisture content of the wood, amounts of preservative retained in the wood, depth of chemical penetration, and distribution of pesticide throughout the material.

Preservatives are applied on the basis of how and where the products will be used, the expected conditions of exposure to wood-destroying agents, and the cost per year of service life. Crossties, poles, posts, and other wood products that contact the ground or are exposed to the weather must be protected with preservatives to insure a reasonable service life. Other wood products not in contact with the ground may be treated as a precautionary measure, even though they are not exposed to moisture and the weather.

The sapwood of most commercial wood species accepts preservatives much better than heartwood and softwood species are generally more receptive to penetration than the hardwoods. Preservative treatment by pressure is still required for most wood products used for construction and applications exposed to high risk of attack by fungi and/or insects.

MOISTURE CONTROL

The moisture content of living trees and the wood products obtained from them may range from about 60 percent for heavy or hard woods to 200 percent for light or soft woods. Much of this moisture must be removed for most uses. Green lumber usually must be dried to:

1. To prevent stain and decay.
2. To reduce damage by insects.
3. To reduce uncontrolled dimensional change such as shrinkage and warping.
4. To reduce weight and increase strength.
5. To prepare the wood for treatment with chemical preservatives.

STORAGE AND HANDLING

Lumber must be protected from pests during storage and handling. The following procedures should be followed to prevent damages to lumber from pests:

- Convert logs into lumber as quickly as possible.
- Dry the lumber as quickly as practical, even after pressure treatment with a preservative chemical, to prevent problems such as surface checking and end cracking.
- Locate air drying yards and storage sheds on well drained sites with good air circulation, and keep the yards free of weeds.
- Practice good sanitation by removing debris or rotted wood that serves as a favorable environment for fungal infection and insects.
- Inspect stored wood products often. Termites or other wood destroying organisms may invade untreated lumber if it remains undisturbed for extended periods of time.
- Avoid rough handling of treated wood. Chipping, gouging or splitting can expose unprotected interior wood and allow attack by decaying fungi.

Under proper use conditions wood can give centuries of good service. Under unfavorable conditions wood may readily be damaged and destroyed by fungi and insects. These pests can attack in many ways, using the wood for food or shelter. As a result, wood must be protected to insure maximum service life when used under conditions favorable to these pests.

NATURALLY RESISTANT WOOD

The sapwood of most native tree species and the heartwood of most species have a low natural resistance to decay. Examples of trees with heartwood resistant to decay include old growth bald cypress, cedar, redwood, and post oak. The heartwood from these trees is resistant but definitely not immune to attack by decaying fungi and insects.

Many of the naturally resistant woods are expensive and/or unavailable in commercial quantities or in the dimensions needed for construction. The variable and undependable resistance of these species precludes their use for most construction applications where pest are a significant problem.

Most of the trees identified as lumber sources resistant to decay are based on studies involving old growth trees (see appendix 2). Wood cut from second growth trees exhibits less resistance to decay and insects, even for those woods traditionally considered as highly resistant to attack from insect pests and decay.

V. WORKER PROTECTION STANDARD

The U.S. Environmental Protection Agency's Worker Protection Standard (WPS), as revised in 1992, must be complied with when pesticides are used on agricultural establishments, including farms, forests, nurseries, and greenhouses, for the commercial or research production of agricultural plants. The WPS requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides. Persons who must comply with these instructions include owners or operators of agricultural establishments and owners or operators of commercial businesses that are hired to apply pesticides on the agricultural establishment or to perform crop-advising tasks on such establishments. Family members who work on an agricultural or commercial pesticide establishment are considered employees in some situations.

WPS requirements for employers include:

- **Displaying information** about pesticide safety, emergency procedures, and recent pesticide applications on agricultural sites.
- **Training** workers and handlers about pesticide safety.
- Helping employees get **medical assistance** in case of a pesticide related emergency.
- Providing **decontamination sites** to wash pesticide residues off hands and body.
- Compliance with **restricted entry intervals** (REI) the time after a pesticide application when workers may not enter the area.
- **Notifying** workers through posted and/or oral warnings about areas where pesticide applications are taking place and areas where REI are in effect.
- Allowing only **trained and equipped workers** to be present during a pesticide application.
- Providing **personal protective equipment** (PPE) for pesticide handlers and also for workers who enter pesticide treated areas before expiration of the REI.
- **Protecting pesticide handlers** by giving them safety instructions about the correct use of pesticide application equipment and PPE and monitoring workers and handlers in hazardous situations.

One of the provisions of the WPS is the requirement that employers provide handlers and workers with ample water, soap, and single use towels for washing and decontamination from pesticides and that emergency transportation be made available in the event of a pesticide poisoning or injury. The WPS also establishes REI and the requirements for PPE. PPE requirements are specified for all pesticides used on farms and in forests, greenhouses, and nurseries. Some pesticide products already carried REI and PPE directions. This rule raised the level of protection and requirements for all pesticide products.

Other major provisions require that employers inform workers and handlers about pesticide hazards through safety training. Handlers must have easy access to pesticide label safety information and a listing of treatments site must be centrally located at the agricultural facility. Handlers are prohibited from applying a pesticide in a way that could expose workers or other people.

References: ***The Worker Protection Standard for Agricultural Pesticides–How to Comply: What Employers Need to Know.*** Web site <www.usda.gov/oce/oce/labor-affairs/wpspage.htm>**.**

VI. PROTECTING GROUNDWATER AND ENDANGERED SPECIES

INTRODUCTION

Federal and state efforts to protect groundwater and endangered species have resulted in special requirements and restrictions for pesticide handlers and applicators. Pesticides that are incorrectly or accidentally released into the environment can pose a threat to groundwater and endangered species. Whether pesticides are applied indoors or outdoors, in an urban area or in a rural area, the endangered species and groundwater must be protected and state and federal agencies rigidly enforce this requirement.

The need for special action by the pesticide handler/applicator depends on site location. Groundwater contamination is of special concern in release sites where groundwater is close to the surface or where the soil type or the geology allows contaminants to reach groundwater easily. In the case of endangered species, special action is normally required in locations where the species currently live or in locations where species are being reintroduced. The product labeling is the best source to determine if pesticide use is subject to groundwater or endangered species limitations.

The U.S. Environmental Protection Agency (EPA) establishes the specific limitations or instructions for pesticide users in locations where groundwater or endangered species are most at risk. These limitations and instructions may be too detailed for inclusion in pesticide labeling. In such cases the labeling will direct the applicator or handler to another source for instructions and restrictions. The legal responsibility for following instructions that are distributed separately is the same as it is for instructions that appear on the pesticide labeling.

PROTECTING
GROUNDWATER

Groundwater is water located beneath the earth's surface. Many people think that groundwater occurs in vast underground lakes, rivers, or streams. Usually, however, it is located in rock and soil. It moves very slowly through irregular spaces within otherwise solid rock or seeps between particles of sand, clay, and gravel. An exception is in limestone areas, where groundwater may flow through large underground channels or caverns. Surface water may move several feet in a second or a minute. Groundwater may move only a few feet in a month or a year. If the groundwater is capable of providing significant quantities of water to a well or spring, it is called an aquifer. Pesticide contamination of aquifers is very troubling, because these are sources of drinking, washing, and irrigation water.

Utah has implemented a comprehensive and coordinated approach to protect groundwater from pesticide contamination.

Formulation of the Utah Groundwater and Pesticide State Management Plan is a cooperative effort between federal, state, private agencies, producers, and user groups. It provides a basis for continuing future efforts to protect groundwater from contamination whenever possible. Furthermore, this plan provides agencies with direction for management policies, regulations, enforcement, and implementation of groundwater strategies.

Utah recognizes that the responsible and wise use of pesticides can have a positive economic impact, yield a higher quality of life, enhance outdoor activities, and give relief from annoying pests. The EPA has authorized the Utah Department of Agriculture and Food (UDAF) to enforce the protection of groundwater from pesticides.

The UDAF, in concert with cooperating agencies and entities, demands strict compliance with all pesticide labels, handling procedures, and usage to protect groundwater in the state.

Prevention of groundwater contamination is important, because once the water is polluted, it is very difficult and costly to correct the damage and in some instances impossible. City and urban areas contribute to pollution because water runoff can contain pesticides. Shallow aquifers or water tables are more susceptible to contamination than deeper aquifers or water tables. Sandy soils allow more pollution than clay or organic soils, because clays and organic matter adsorb many of the contaminants. For more information about what groundwater is and where it comes from, read the study manual ***Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.***

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, establishes a policy for determining the acceptability of a pesticide use or the continuation of that use, according to a risk/benefit assessment. As long as benefits outweigh adverse effects, the EPA can continue to register the pesticide. Although the intent of a pesticide application is to apply the pesticide to the target or pest, part of the pesticide will fall on the area around the target or pest. Rain or irrigation water then can pick up the part that is not degraded or broken down and carry it to the groundwater via leaching.

There are many factors that influence the amount of pesticide contamination that can get into groundwater. The major factors are the soil type, soil moisture, persistence in soil, placement of the pesticide, frequency of application, pesticide concentration and formulation, pesticide water solubility, and precipitation. Each of these factors will influence the amount of pesticide that can penetrate the soil surface, leave the root zone, and percolate into groundwater.

Although some pesticides may have a high adsorption quality, when they are applied to sandy soil, they may still migrate to the water table because there are few clay particles or little organic matter to bind them. The management and use of pesticides is up to the individual applicator and/or landowner as to whether safe practices are used. Groundwater is a very valuable resource and it must be protected from pesticide contamination.

PROTECTING ENDANGERED SPECIES

The Federal Endangered Species Act lists the three classifications as endangered, threatened, and experimental. Endangered has the highest level of protection. The phrase "endangered species" is used when referring to these classifications. This Act was passed by Congress to protect certain plants and wildlife that are in danger of becoming extinct. A portion of this Act requires EPA to ensure that these species are protected from pesticides.

EPA's goal is to remove or reduce the threat to endangered species that pesticides pose. Achieving this goal is a portion of the larger continuing effort to protect species at risk. Normally these restrictions apply to the habitat or range currently occupied by the species at risk. Occasionally the restrictions apply where endangered species are being reintroduced into a habitat previously occupied.

Habitats are the areas of land, water, and air space that an endangered species needs for survival. Such areas include breeding sites, sources of food, cover, and shelter, and the surrounding territory that provides space for normal population growth and behavior.

Utah's endangered species plan is a cooperative effort between federal, state, private agencies, producers, and user groups. This plan provides agency direction for regulations, enforcement, management policies, and implementation of threatened and endangered species protection strategies.

EPA launched a major project known as Endangered Species Labeling (ESL). The goal is to remove or reduce the threat to endangered species from pesticides. EPA has the responsibility to protect wildlife and the environment against hazards posed by pesticides. The ESL program is administered by the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of Interior. The FWS reports to EPA concerning endangered species. EPA and FWS work cooperatively to ensure that there is consistency in the pesticide restriction information provided to agencies and pesticide users.

The UDAF acts under the direction and authority of EPA to carry out the ESL project as it relates to the use of pesticides in Utah. Many states have web sites with maps designating the habitat boundaries and listings of endangered plants and wildlife. Utah's site is www.utahcdc.usu.edu.

References: ***Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.*** Also, Endangered Species Act of 1973, with amendments through 1996 <www.house.gov/resources/105cong/reports/105_c/esaidx.htm>.

VII. CALIBRATION INFORMATION

Conversion:
Units

One acre = 43,560 square feet

Example: ½ acre = 21,780 square feet

One mile = 5,280 feet — Example: ¼ mile = 1320 feet
One gallon = 128 fluid ounces — Example: ½ gallon = 64 fluid ounces
One quart = 2 pints = 4 cups = 32 fluid ounces — Example: 2 quarts = 64 fluid ounces
One pint = 2 cups = 16 fluid ounces — Example: ½ pint = 1 cup = 8 fluid ounces
One tablespoon = 3 teaspoons = 0.5 fluid ounces — Example: 2 tablespoons = 1 fluid ounce
One pound = 16 ounces — Example: ¼ pound = 4 ounces
One gallon = 231 cubic inches — Example: 2 gallons = 462 cubic inches

Weights

1 ounce = 28.35 grams
16 ounces = 1 pound = 453.59 grams
1 gallon water = 8.34 pounds = 3.785 liters = 3.78 kilograms

Liquid Measures

1 fluid ounce = 2 tablespoons = 29.573 milliliters
16 fluid ounces = 1 pint = 0.473 liters
2 pints = 1 quart = 0.946 liters
8 pints = 4 quarts = 1 gallon = 3.785 liters

Lengths

1 foot = 30.48 centimeters
3 feet = 1 yard = 0.9144 meters
16 1/2 feet = 1 rod = 5.029 meters
5280 feet = 320 rods = 1 mile = 1.6 kilometers

Areas

1 square foot = 929.03 square centimeters
9 square feet = 1 square yard = 0.836 square meters
43560 square feet = 160 square rods = 1 acre = 0.405 hectares

Speeds

1.466 feet per second = 88 feet per minute = 1 mph = 1.6 kilometers per hour (kph)

Volumes

27 cubic feet = 1 cubic yard = 0.765 cubic meters
1 cubic foot = 7.5 gallons = 28.317 cubic decimeters

Area and Volume Calculations:

Area of Rectangular or Square Shapes

The area of a rectangle is found by multiplying the length (L) times the width (W).

(Length) x (Width) = Area

Example: (100 feet) x (40 feet) = 4000 square feet

Area of Circles

The area of a circle is the radius (radius = one-half the diameter), times the radius, times 3.14.

(radius) x (radius) x (3.14) = Area

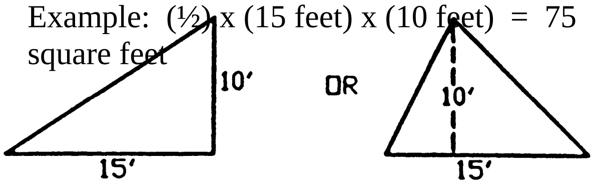
Example: (25 feet) x (25 feet) x (3.14) = 1962.5 square feet

Area of Triangular Shapes

To find the area of a triangle, multiply ½ times the width of the triangle's base, times the height of the triangle.

(½) x (base width) x (height) = Area

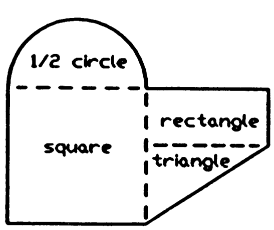
Example: (½) x (15 feet) x (10 feet) = 75 square feet



Area of Irregular Shapes

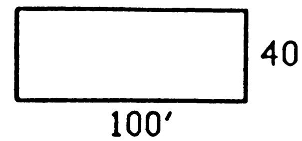
Irregularly shaped sites can often be reduced to a combination of rectangles, circles, and triangles. Calculate the area of each shape and add the values together to obtain the total area.

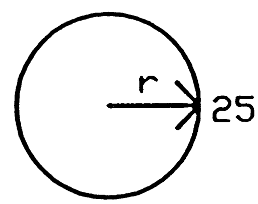
Example: Calculate the area of the rectangle, triangle, square, and one-half of a circle.



Another method is to convert the site into a circle. From a center point, measure the distance to the edge of the area in 10 or more increments. Average these measurements to find the radius, then calculate the area using the formula for a circle.

Example: Approximate the area by calculating the area of a similarly sized circle.



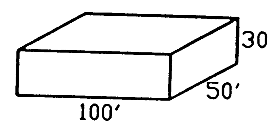


Volume of Cube and Box Shapes

The volume of a cube or box is found by multiplying the length, times the width, times the height.

(Length) x (Width) x (Height) = Volume

Example: (100 feet) x (50 feet) x (30 feet) = 150,000 cubic feet



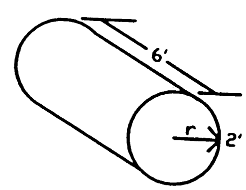
Volume of Cylindrical Shapes

The volume of a cylinder is found by calculating the area of the round end (see formula for circle) and multiplying this area times the length or height.

Example: (radius) x (radius) x (3.14) = Area of Circle

(Area of Circle) x (Length) = Volume of Cylinder

(2 feet) x (2 feet) x (3.14) x (6 feet) = 75.36 cubic feet



Sprayer Calibration Formulas:

To Calculate Travel Speed in Miles Per Hour

The travel speed of a sprayer is determined by measuring the time (seconds) required to travel a know distance (such as 200 feet). Insert the values in the following formula to determine the miles per hour.

$$\frac{\text{Distance in Feet} \times 60}{\text{Time in Seconds} \times 88} = \text{Miles Per Hour}$$

Example: $\frac{(200\ \text{feet}) \times (60)}{(30\ \text{seconds}) \times (88)} = \frac{12{,}000}{2640} = 4.55$ mph

To Calculate the Gallons Per Minute Applied During Broadcast Spraying

The application rate in gallons per minute (GPM) for each nozzle is calculated by multiplying the gallons per acre (GPA), times the miles per hour (MPH), times the nozzle spacing in inches (W); then dividing the answer by 5940. For small adjustments in GPM sprayed, operating pressure is changed. For large adjustments in GPM sprayed, travel speed (miles per hour) is changed or nozzle size is changed.

$$\frac{\text{GPA} \times \text{MPH} \times \text{W}}{5940} = \text{GPM}$$

Example: $\frac{(12\ \text{GPA}) \times (4.5\ \text{MPH}) \times (24'')}{5940} = \frac{1296}{5940} = 0.22$ GPM

To Calculate the Gallons Per Minute Applied During Band Spraying

Broadcast spraying applies chemicals to the entire area. Band spraying reduces the amount of area and chemicals sprayed per acre. To use the above formulas for band sprayer applications, use the band width (measured in inches) rather than nozzle spacing for the "W" value.