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COLLEGE OF AGRICULTURE AND LIFE SCIENCES
COOPERATIVE EXTENSION

Backyards & Beyond

RURAL LIVING IN ARIZONA

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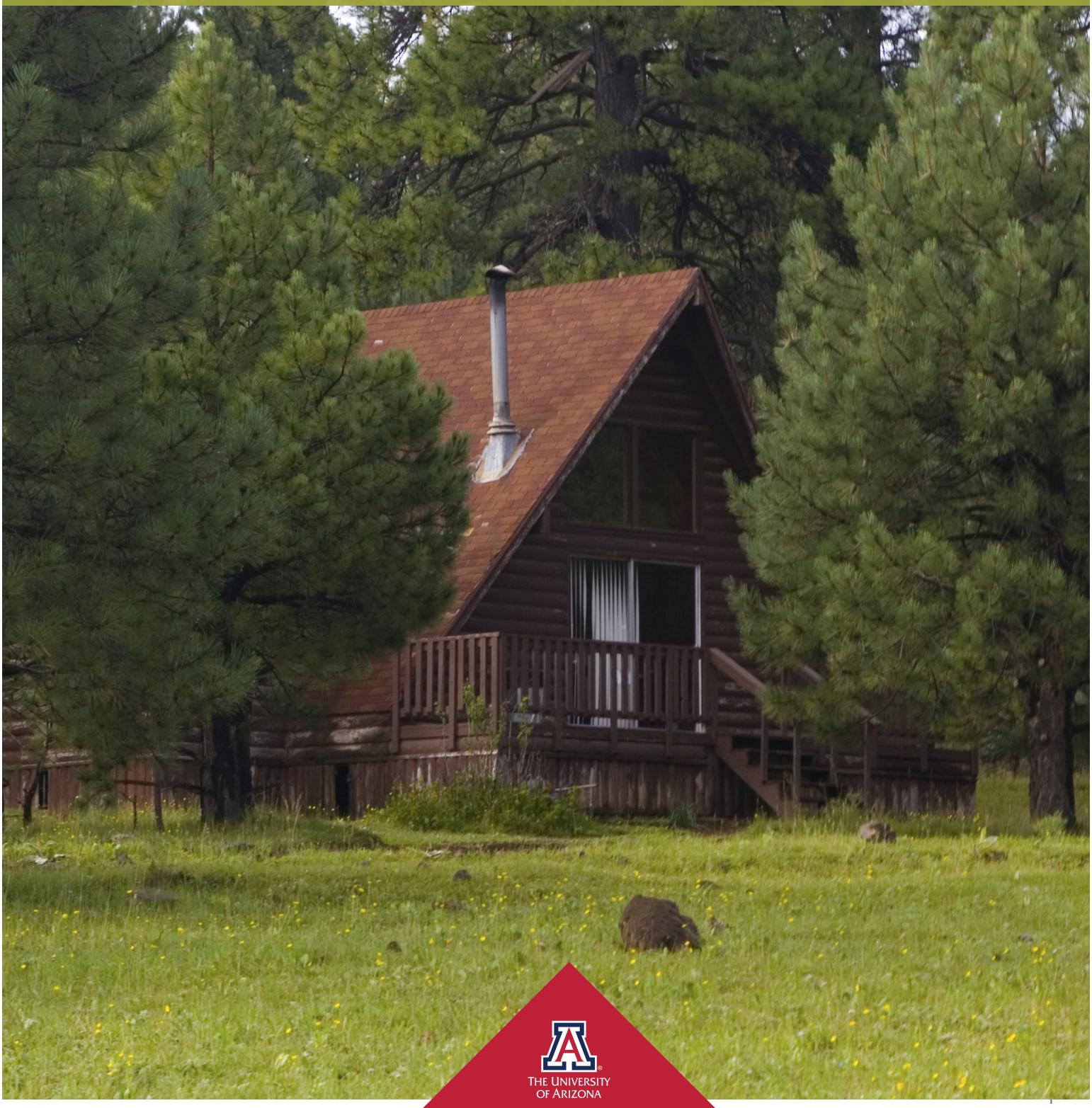

THE UNIVERSITY OF ARIZONA

FEATURED PLANT

Susan Pater, Area Extension Agent, 4-H Youth Development, University of Arizona, CALS Cooperative Extension, Cochise County

Common Name: Pointleaf manzanita (Also called manzanilla or Mexican manzanita.)
Scientific Name: *Arctostaphylos pungens*

Manzanita is a woody evergreen shrub and member of the heather family (Ericaceae). It is characterized by smooth, deep red bark, thick green leaves and crooked branches. Manzanita is commonly a key component of the Arizona chaparral vegetation community and a primary understory species in the pine-oak woodlands. Arctostaphylos pungens is native to the Southwestern United States and to northern and central Mexico. The genus name is from the Greek where "Arktos" refers to bear and "staphyle" refers to a cluster of grapes. "Pungens" refers to the sharp points at the ends of the leaves. Manzanita means little apple in Spanish and refers to the shape, color, and taste of the fruits.

Pointleaf manzanita an erect, spreading shrub, found on dry hillsides and uplands at 3,500 to 6,500 feet in elevation and may reach heights of five to seven feet. It often forms dense thickets. It has a fibrous, shallow root system, except in sandy soils, where taproots are usually well developed. Most roots are found in the top eight inches of soil. The simple leaves are leathery, green to blueish-green, glossy, elliptical in shape, and about 1½ inches long with smooth margins that come to a point at the tip and base. The leaves are alternately arranged on branches.

The flowers are a delicate white to pale pink, urn-shaped, found in clusters at the tip of the branches, and often attract hummingbirds and insects. They are hermaphrodite, having both male and female organs, and are pollinated by insects. The fruit is an apple-like drupe, about ¼ inch wide that turns red at maturity. It is only occasionally browsed by deer, but the tasty berries are eaten by birds, rodents & bears.

SUSAN PATER

Inset flower image: Patrick J. Alexander, hosted by the USDA-NRCS PLANTS Database

Manzanita is noted for its beautiful smooth, shiny red-mahogany bark and branches which makes a great contrast with the evergreen foliage. Arctostaphylos pungens is found in eleven of our fifteen counties.

FEATURED BIRD

Dan L. Fischer - Author of Early Southwest Ornithologists, 1528-1900. University of Arizona Press

Common Name: White-winged Dove
Scientific Name: *Zenaida asiatica*

Early spring marks increased bird activity of many species along with more distinct and delightful songs. This is especially true with the beginning of courtship. The northern migration from Mexico during this period includes one of the more vocal and conspicuous birds, the White-winged Dove. Not limited to riparian corridors of mesquite thickets or cottonwood, they also gather into loose flocks among areas of paloverde and saguaro. At higher elevations they also frequent oaks. There is much energy expended as they compete for nesting sites and mate selection. Aerial displays become a common occurrence, with males suddenly rising with vigorous flapping and slight whistling of wings. They quickly gain elevation before making a broad, single circle on extended wings in a glide back to a nearby perch. Their white crescent wing markings can be seen from above, and the rounded tail with white outer tips, almost completing a white band, contrast sharply against the overall gray to light brown body. On closer inspection they exhibit a beautiful orange to reddish iris surrounded by a circular ring of blue.

As the season progresses, cooing intensifies, especially if the colony, or rookery, is large. This repetitious song is reminiscent of a phrase "who cooks for you." When the perched male is displaying before a female, he tilts his body forward with head down while raising his tail high. Then, maintaining a stationary position, amid continuous cooing, he spreads and flashes his tail while momentarily opening his wings displaying the upper white wing crescent. This behavior is performed repeatedly during courtship.

Nests are quickly constructed in three to five days in a variety of situations that may include mesquite, paloverde, cholla cactus, desert hackberry and saguaro. Two white eggs are then laid in a very flimsy nest of small sticks by early May. Both parents incubate and after the young hatch they often shade their chicks as the nests are often exposed to direct sunlight with very little relief from the intense heat. If their nesting occurs in the lower deserts it generally coincides when saguaros are crowned with lovely white flowers. The doves greatly aid in their pollenation as they move from flower to flower in search of nectar and perhaps pollen. When the saguaro fruit ripen, turn bright red and split, they quickly indulge in the pulp and black seeds. At this time some birds become very protective of their food source. The birds many have two or more broods depending on food availability before migrating back to their wintering grounds in Mexico. Their departure begins rather abruptly in September.

DAN L. FISCHER

Naming this dove dates back 250 years to Swedish taxonomist Carl Linnaeus (1707-1778) who, after acquiring a somewhat historically obscure painting of the bird from English naturalist George Edwards (1694-1773), described and published his account of it in 1758. Linnaeus applied the Latin name asiatica, "Asian," for the specific name mistakenly thinking the original specimen came from that region. Charles L. J. Bonaparte (1803-1857), nephew to Napoleon and cousin to his wife Zenaide, named the genus Zenaida for her. Bonaparte was a systematic ornithologist, and at that time, was residing in America from 1822-1858.

DJ MCKINNEY

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URSULA SCHUCH

Backyards & Beyond

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COVER PHOTO CREDIT: MACIEJ BOGACZ

PINES OF ARIZONA

Christopher Jones, Extension Agent, Agriculture and Natural Resources, Gila County and Jack Kelly, Former Extension Agent, Pima County, University of Arizona CALS Cooperative Extension

JOHN KAVA

The pine (Pinus species) is an important group of trees within the "conifers" designation. There are many different species, each having its own physical characteristics and cultural requirements. Identifying features of different species include cone size and shape, and the number of long, slender needles in each bundle. Various pine species are very well suited to environments from the low deserts to the mountains. They are tolerant of many types of soils and temperature ranges, and are relatively pest free.

A pine tree is a classic form for many home landscapes. The benefit of a pine is obvious: it is a beautiful evergreen tree that is typically low maintenance and a low water user. It provides shade all year round. The aromatic foliage has a pleasant fragrance. Birds and other wildlife will use the pine tree for food, shade and shelter, offering great opportunities for viewing.

Fortunately in Arizona, we have many native and non-native pines to choose from when selecting a tree for our yard or landscape. Many are fast growing. Many are tall and statuesque. Some are dwarf or smaller in stature to accommodate a smaller growing space. They can break up traffic noise as well, or be used as a screen for privacy.

BOTANICAL

Pine trees are vascular seed-bearing plants. They are multi-cotyledonous (germinating with between four and twenty "seed" leaves) and monoecious, meaning they have both male (pollen) and female (seed) cones, rather than flowers. The seeds and pollen are usually wind dispersed. They are part of the Sub Kingdom Gymnospermae (naked-seeded) and formerly part of the Division Coniferae (cone-bearing). The recent scientific classification for the pine family is as follows:

Kingdom: Plantae
Division: Pinophyta (previously Coniferae)
Class: Pinopsida
Order: Pinales
Family: Pinaceae
Genus: Pinus

The pine family may also be divided into the subgenus Pinus (Diploxylon or hard pines), which includes the three-needled yellow pines such as the Ponderosa, and Strobus (Haploxylon or soft pines), which includes the five-needled white pines such as the limber pine (Gernandt et al 2005). Gernandt et al also include pinyon pines within the Strobus subgenus, whereas earlier botanists classified pinyon pines in the subgenus Ducampopinus.

CLIMATE

The Sunset Western Garden Book (Brenzel et al 2001) divides the state into eight distinct climate zones. These zones range from subalpine to tropical desert and no one of the pines can grow satisfactorily across this entire range. Minimum winter temperature, frost, maximum summer temperature, precipitation, humidity and the sun's intensity are all important. The primary factor influencing frost hardiness is usually the expected minimum winter temperature influenced by elevation. Sites at elevations bordering the climate zones will often have temperatures that grade into each zone. Species that overlap these zones will be best adapted. The climate zones are:

Zone 1A: Coldest mountain and intermountain areas of the contiguous states; i.e., Greer (40° to -25° F).
Zone 2A: Cold mountain and intermountain areas; i.e., Summerhaven (-20° to 30° F).
Zone 2B: Warmer-summer intermountain climate; i.e., Flagstaff, Williams, Payson (-10° to -20° F).
Zone 3A: Mild areas of mountain and intermountain climates; i.e., Prescott, Holbrook (-8° to -18° F).

Zone 3B: Mildest areas of intermountain climates; i.e., Tuba City (-2° to -15° F).
Zone 10: High desert areas of Arizona and New Mexico; i.e., Globe, Kingman, Bisbee (10° to -10° F).
Zone 12: Arizona's intermediate desert; i.e.,Tucson, Wickenburg, Safford (6° to -15°F).
Zone 13: Low or subtropical desert areas; i.e., Phoenix, Yuma (19° to 13° F).
Zone details are available at: http://www.sunset.com/garden/ climate-zones

LANDSCAPE USE

There are about 115 species of pine. At least twenty of these are well-adapted to Arizona's different climates, although irrigation is often necessary in landscape situations. Landscape architects, contractors and homeowners rely on pines heavily for ornamental uses. Golf courses, parks, malls, industrial and residential sites use pine cultivars for large and sometimes small landscape plantings. Most pine species grow into large trees, so attention to size at maturity and planning sufficient area in which to grow is critical. Pines offer a variety of forms, needle structures, color, from blue to dark green, and texture, from fine to coarse. Pines can be used for windbreaks, accent trees or even foundation plantings.

Planting and caring for evergreens requires a considerable investment of time and money, and so it is important to make the right decisions when choosing these plants for your yard. To choose a species wisely, you need to know two basic pieces of information. First, you need to know the ultimate size of the space that you want filled by the evergreen, and second you need to be sure that the species or variety you are considering can grow vigorously in the climate and site conditions of your property. The following information will provide guidelines to help you select the most appropriate pine trees for your yard.

Learning about the habits and needs of evergreens is worth the effort. Nursery grown evergreens of landscape grade are often expensive and take years to mature. If you make the right choice at the beginning, not only will you save time and money, but your landscape evergreens will provide years of pleasure.

SELECTION, PLANTING, STAKING, AND PRUNING

All coniferous plants that are purchased from a nursery will be either sold in a plastic container or balled and burlapped (B&B). When selecting containerized stock, look for any of the following defects: rootbinding, brown or dried out foliage or roots, insect damage, weeds in the container or rootball, an extremely large trunk diameter in relation to the container size, or a broken or loose rootball.

Early spring or late fall (when the tree is dormant) are the best times of the year to plant B&B plants. Winter may also be acceptable in mild climates. Summer planting should be avoided and will require more attention, irrigation and care than trees planted during the more desirable time of the year. Containerized stock may be planted year round but will establish more rapidly when planted during spring to early summer and late summer to fall.

Rootbinding is a condition when the roots have circled the rootball. This condition will lead to a serious problem with establishment if not corrected before planting, often resulting in blowdown or root strangulation. It is best to avoid root binding by selecting another tree with a healthy rootball that is not overgrown and circling. If root binding appears minimal and not too advanced, use a sharp knife to cut vertically into the rootball to a depth of 1-3 inches, depending on the size of the container.

Before planting, contact Blue Stake to mark where underground utilities such as water, gas and electricity are located. Do not plant over sewer, gas or water lines. Look upward for overhead wires or other obstructions within the expected crown at maturity. Keep trees away from buildings to minimize fire risk, and under no circumstances plant under power lines, an eave, or other covering.

Pines prefer well drained soils and will not tolerate extended periods of wet soil. If the soil drains poorly, try to locate another area with good drainage. Poorly drained soil will interfere with root development as the tree establishes, and may lead to the eventual death of the tree.

Preparation of the planting hole is typically not difficult. Dig a large, wide hole no deeper than the rootball depth and 2-½ to 4 times the container diameter. Mixing soil amendments in the backfill is not recommended as they may inhibit root development into the native soil. Loosen the soil on the sides of the hole to aid root penetration. If the tree is B&B, remove the wire or mesh from the root ball before planting. To prevent the rootball from drying out remove the topmost part of the burlap or cover the existing burlap with soil. Likewise, be careful not to bury the root collar (where the root ball meets the trunk) of container grown trees. Soil against lower trunks can induce disease. The root collar should be visible and at final grade.

Backfill the hole using native soil. Remove large rocks from the backfill soil if present. Carefully tamp the soil down and water in to settle the soil and to check the final planting grade. Create a temporary berm of soil at the edge of planting hole, about three to five inches high. This will permit a thorough irrigation of the rootball and help the newly planted tree initiate new roots.

Stake the tree if it is unable to stand on its own or when the root ball is cracked. Staking allows new roots to grow into the soil without constant trunk movement. Place stakes perpendicular to the prevailing wind. Tree ties should be made of a material that will not harm the tree's bark. All stakes should be placed outside the rootball in the native soil to avoid damaging the root. Branches should not be in contact with the staking material because this will cause rubbing and bark loss on the branches. Trim the tree stakes to help avoid such problems.

After the tree is planted, final grade checked, temporary irrigation berms installed and stakes installed (if necessary), apply a 3-4 inch layer of mulch to an area roughly corresponding to the drip line of the tree. Mulches suppress weed growth, reduce water evaporation, moderate cold and heat, are aesthetically pleasing and if organic, add much needed humus to the soil over time.

If staked, inspect the tree ties occasionally, and adjust as necessary to prevent any damage or cutting into the bark. The tree should be firm within two or three years, at which point the stakes and ties can be removed.

Under normal circumstances, pruning newly planted trees is not necessary. Remove only dead, dying, broken, diseased parts and any branches that are growing inwardly, crossing or rubbing another branch. Prune when the tree is dormant or after the first flush of growth in spring. Springtime pruning is often limited to pinching, or removing part of the soft new growth.

PROBLEMS AND PESTS

Cold and freeze damage may be avoided by careful selection of a tree species that is appropriate for your area. Take time to observe which trees do well in your neighborhood or area. Serious freeze damage can kill a tree. In less severe situations, the tree will outgrow the damage. The affected foliage will likely remain on the tree for two seasons and the damage will be there until all the old foliage is shed. Heat damage may limit species from higher altitudes from establishing in the lower deserts. This damage is often fatal. Symptoms include very slow growth or foliage damage.

Improper irrigation especially during prolonged drought may result in trees growing poorly. In extreme cases the tree will lose foliage and appear thinly foliated. The following summer, the tree will turn brown and die. Drought impacts are evident for two to three years after the drought. Irrigation should be scheduled to reflect your weather conditions at different times of the year. You cannot simply set an irrigation controller and walk away. In years of heavy seasonal rainfall, supplemental water is not normally required. Whether you use a drip and automated irrigation system, soaker hose or conventional irrigation, be sure that the water is directed to the rootzone and just beyond the drip line. This is where the newer, active water conducting root hairs are located.

Trees that are native to the Mediterranean in particular need adequate winter moisture. During dry winters, provide supplemental irrigation for species such as Italian Stone, Eldarica and Allepo pines. For well-established trees, water should penetrate to a depth of three feet of soil. This will create a reservoir that the tree can use for up to six weeks. A common irrigation error is to assume that watering the lawn under and around a tree is sufficient for the tree too. The grass tends to soak up all the water before it can get to the tree roots. Watering right next to the trunk does little to satisfy the tree's water requirements.

Soil conditions can impact the overall health of your tree. In addition to good drainage, other conditions may be problematic. Occasionally, species that are not adapted to alkaline soil conditions fail to thrive, become chlorotic (yellow) and eventually die. There is no long-term solution to this problem. The addition of soil sulfur during planting will only be a temporary solution and of doubtful effectiveness. The best solution is to plant a species that tolerates high alkalinity and local soil conditions.

Planting depth may adversely affect many conifer species survival. The parts of the trunk above the soil level are not anatomically the same as those below ground. By planting too deep, the part of the trunk that is incorrectly buried is subject to soil pathogens and possible death of the tree. Insects and other living pests frequently attack a tree that is struggling to survive from either transplant shock or drought.

The below information has been excerpted from Pines of Arizona, authored by C. Jones and J. Kelly. The complete publication including descriptive information on 17 pine species commonly found in Arizona can be viewed at cals.arizona.edu/pubs/garden/az1584.

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List of Common Pine Infections

INFECTION	SUSCEPTIBLE SPECIES	CONTROL	COMMENTS
Aphids	Most species	Soapy water for small plants, systemic insecticides for large trees	Watch for natural predators and parasites
Bark Beetles	Ponderosa pine Pinyon pine	Avoid drought stress	
Comandra Blister Rust	Eldarica pine Ponderosa pine	Avoid planting within one mile of Comandra	Comandra is also known as bastard toadflax
Dwarf Mistletoe	Eldarica pine Ponderosa pine	Avoid planting in areas of high mistletoe infestation	Prune out on smaller specimens
Needle Miner	Ponderosa pine Pinyon pine	Systemic insecticide, prune out infected branches	Foliar sprays and trunk implants aid in control
Pinyon Needle Scale	Pinyon pine	Systemic insecticide	Remove egg masses, timely application of insecticides, keep tree well irrigated to avoid stress
Sawflies	Ponderosa pine Pinyon pine	Broad spectrum insecticides, B.T. not effective	Natural parasites often keep populations low
Spider Mites	Most species	Keep plants dust free, broad spectrum insecticides or miticides	Do not use carbaryl (Sevin®) or malathion because they will kill natural predators
Tip Moth	Austrian pine Ponderosa pine Pinyon pine	B.T., broad spectrum insecticides	Apply when new growth is still (fuzzy) and not fully developed
Shoot moth	Ponderosa pine	B.T., broad spectrum insecticides	
White Pine Blister Rust	Limber pine Bristlecone pine Southwestern white pine	Remove wild currants (Ribes) from area	Ribes are currants and their relatives

Source: Fairweather et al 2006.

BASICS of Evaporation and Evapotranspiration

Paul Brown, Associate Director, Programs, CALS Cooperative Extension and Biometeorology Specialist, Department of Soil, Water and Environmental Science, University of Arizona

Introduction

Local information on evapotranspiration (ET) is now readily available from on-site weather stations and/or public weather networks to assist turfgrass professionals with irrigation management decisions. Proper utilization of ET information can provide accurate estimates of daily water use and thus can assist irrigation managers with the all important decisions of when to apply water and how much water to apply. The concept of ET can be confusing and often is presented in a highly technical manner. This article provides some basic background on the related subjects of evaporation and evapotranspiration.

Evaporation

Water can exist in the natural environment in three different forms or states — solid (ice), liquid and gas. The process by which water changes from a liquid to a gas is known as evaporation. We are all familiar with liquid water as we drink, bath and irrigate with it daily. The gaseous form of water, known as water vapor, is less familiar since it exists as an invisible gas. However, we all have a feel for water vapor during the late summer months when it is called by the more common name of humidity. To the irrigation manager, the most important points about evaporation are 1) it is the process by which most of the liquid water we apply as irrigation leaves vegetation and 2) that evaporation requires energy (Fig. 1).

Two common household items — the clothes dryer and the evaporative cooler — clearly show the energy requirement of evaporation. In the case of the dryer, a gas burner or an electric heating element provides the heat energy required to evaporate water from the wet clothes. The evaporative cooler works in a somewhat opposite manner. Energy stored in the hot, dry, outside air is consumed by the evaporation process as the air passes through the wet pads. This energy consumption reduces the temperature of the air and allows us to use evaporative cooling as a means of air conditioning.

Energy is also required for evaporation to proceed from vegetation. Meteorological conditions impact the amount of energy available in the natural world and therefore play a key role in regulating evaporation from vegetation. A more detailed discussion of the impact of meteorological conditions on evaporation is provided in the next section of this report.

Evapotranspiration (ET)

Evaporation from vegetation is generally given a more specific term — evapotranspiration or ET for short. By definition, ET is the loss of water from a vegetated surface through the combined processes of soil evaporation and plant transpiration (Fig. 2). The term evapotranspiration comes from combining the prefix "evapo" (for soil evaporation) with the word transpiration. Both soil evaporation and plant transpiration represent evaporative processes; the difference between the two rests in

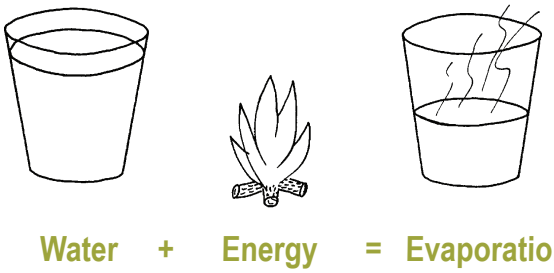

Figure 1. Energy is required for evaporation.

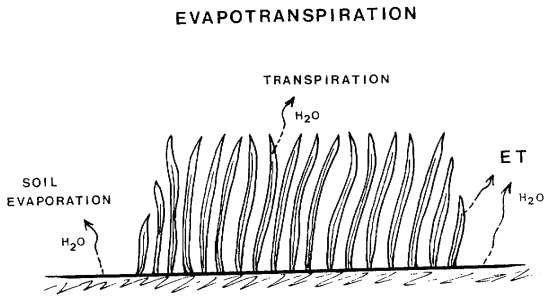

Figure 2. Evapotranspiration (ET) is the loss of water (H_2O) from vegetation through the combined processes of soil evaporation and plant transpiration.

the path by which water moves from the soil to the atmosphere. Water lost by transpiration must enter the plant via the roots, then pass to the foliage where it is vaporized and lost to the atmosphere through tiny pores in the leaves known as stomata. In contrast, water lost through soil evaporation passes directly from the soil to the atmosphere. Evapotranspiration data are usually presented as a depth of water loss over a particular time period in a manner similar to that of precipitation. Common units for ET are inches/day or millimeters/day.

The rate of ET for a given environment (vegetation) is a function of four critical factors. The first and most critical factor is soil moisture. Evaporation (ET) simply can not take place if there is no water in the soil. However, if adequate soil moisture is available, three additional factors — plant type, stage of plant development and weather — affect ET rate.

Plant type refers to the species or variety of plant being grown and can greatly influence the rate of ET. Grass and many non-native plants require considerable water when grown in the desert. In contrast, many native plants are adapted to the desert and require much less water.

Stage of plant development also plays a critical role in determining ET. Plant development encompasses both the relative activity of the plant (e.g. dormant vs. actively growing) and plant size. For example, dormant plants use and therefore need very little water, while lush, actively growing plants (under similar conditions) will require considerably more water. Plant size and density also impact ET. Small plants and areas with sparse plant canopies use far less water than large plants and areas with dense plant canopies.

Weather is the fourth and last of the critical factors affecting ET. Weather conditions dictate the amount of energy available for evaporation and therefore play a crucial role in determining ET rate. Four weather parameters — solar radiation (amount of sunshine), wind speed, humidity, and temperature — impact the rate of ET. Solar radiation contributes huge amounts of energy to vegetation in the desert and thus is the meteorological parameter with the greatest impact on ET on most days. In actuality, solar radiation is one component of the total radiant energy balance of vegetation referred to as net radiation. Invisible, infrared radiation represents the other component of net radiation. On most days, however, solar radiation is the dominant component of net radiation because the infrared balance is negative and often small.

Wind is the second most important factor in determining ET rate. The wind has two major roles; first, it transports heat that builds up on adjacent surfaces such as dry desert or asphalt to vegetation which accelerates evaporation (a process referred to as advection). Wind also serves to accelerate evaporation by enhancing turbulent transfer of water vapor from moist vegetation to the dry atmosphere. In this case, the wind is constantly replacing the moist air located within and just above the plant canopy with dry air from above.

Humidity and temperature work in concert with each other to determine the dryness or drying power of the atmosphere. The vapor pressure deficit (VPD) is the meteorological variable used to quantify the drying power of the atmosphere. The VPD estimates the difference (or gradient) in vapor pressure (concentration of water vapor) between the moist vegetation and the drier atmosphere above. Relative humidity, the humidity variable most commonly reported in weather forecasts, is a poor indicator atmospheric dryness. For example, the drying power (VPD) of an atmosphere with a 30% relative humidity and a 86°F temperature is 2 times that of an atmosphere with the same 30% relative humidity and a 68°F temperature.

The final parameter affecting ET rate is temperature. We have already indicated that temperature impacts ET through its impact on VPD and advection. In addition to these factors temperature impacts ET is some more subtle ways. When all other factors are equal, ET will be higher for warm as compared to cool vegetation because less energy is required to evaporate water from the warm vegetation. Temperature also impacts the relative effectiveness of the radiant energy and wind in evaporating water. Radiant energy is more effectively utilized for ET when temperatures are high. In contrast, wind has more impact on ET when temperatures are low.

Reference Evapotranspiration (ETo)

Reference ET (ETo) is defined as the ET rate from a uniform surface of dense, actively growing vegetation having a specified height and surface resistance (to transfer of water vapor), not short of soil water, and

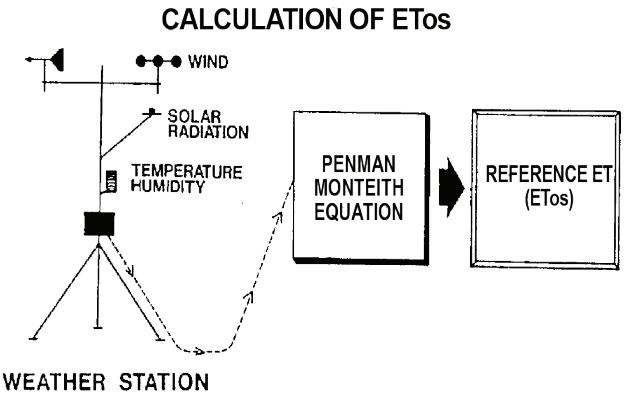

Figure 3. Schematic depicting how ETos is determined. Wind, solar radiation, temperature and humidity data from a weather station are used as inputs to the Penman Monteith Equation which, in turn, provides the ETos value.

representing an expanse of at least 100 m of the same or similar vegetation (Allen et al., 2005). This definition leaves open the option of using more than one reference surface when measuring or computing ETo. The Arizona Meteorological Network has chosen to use the short crop reference as defined by the American Society of Civil Engineers which is equivalent to a 12-cm-tall, cool-season grass (e.g., fescue). Reference ET computed using a short crop reference is abbreviated as ETos. In the real world, ETos is not routinely measured but instead is computed using a meteorological model known as the Penman-Monteith Equation (Allen et al., 2005). Weather data are required for the computation of ETos (Fig. 3). The four meteorological parameters used in the computation of ETos are solar radiation, wind speed, temperature and humidity.

Because the ETos computation is always made for the same reference surface (12-cm-tall, cool-season grass) three of the four factors that can affect ET: crop type, stage of crop development and soil moisture do not change and cannot affect the ETos calculation. Only the fourth factor – weather – is allowed to vary in the computation process. One can therefore consider ETos a measured of atmospheric (or environmental) demand for water. Any difference in ETos between two days is caused by changes in the weather, not changes in the reference surface or soil moisture.

The relative size of the ETos value is a function of weather conditions. Three of the four weather parameters used in the ETos computation – solar radiation, temperature and vapor pressure deficit (VPD) – have distinct annual cycles with minimum values in winter and peak values in summer (Fig. 4,5, and 6). Wind speed is more variable on a day to day basis and exhibits a less definitive annual cycle that varies with location (Fig. 7). The cyclical nature of solar radiation, temperature and VPD produce a distinct annual ETos cycle (Fig. 8). Notice that ETos in the Phoenix area will vary by about a factor of five over the course of the year. Over shorter periods of time, say a week, ETos is relatively stable provided skies are clear. However, winter and fall storm systems or periods when the monsoon is quite active can create large day-to-day swings in ETos.

Variation of ETos Across Metropolitan Areas

Potential users of ETos may worry that local differences in weather conditions could render the ETos value from a nearby weather station useless. After all, weather phenomena such as rainfall can vary drastically from one location to another. ETos values are, however, surprisingly stable over large areas. This stability results because the weather variable that most affects ETos—solar radiation—tends to be fairly constant across large areas in the desert. Except on rare days, the level of solar radiation in Phoenix and Tucson is nearly uniform across the respective metropolitan areas. Temperature and humidity have a much lower impact on ETos (relative to solar radiation) and the observed local variations do not greatly impact ETos. This leaves wind speed as the only weather parameter with substantial local variation. However, even wind speed variations, unless quite extreme, do not cause a large change in ETos. For example the 20–30% variation in

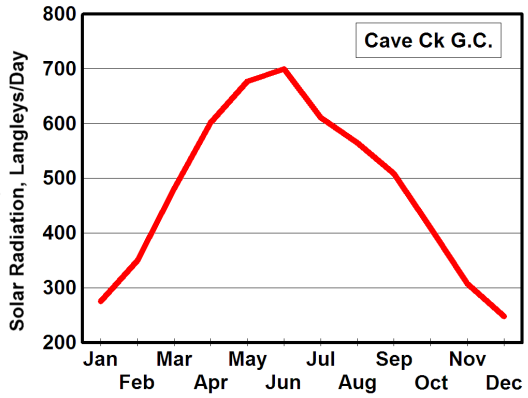

Figure 4. Annual trend of solar radiation at Cave Creek Golf Course in Phoenix, AZ.

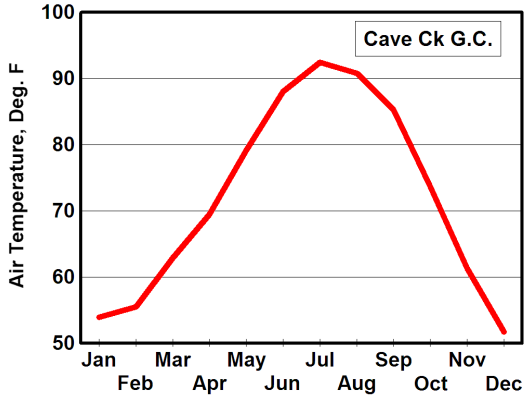

Figure 5. Annual trend of air temperature at Cave Creek Golf Course in Phoenix, AZ.

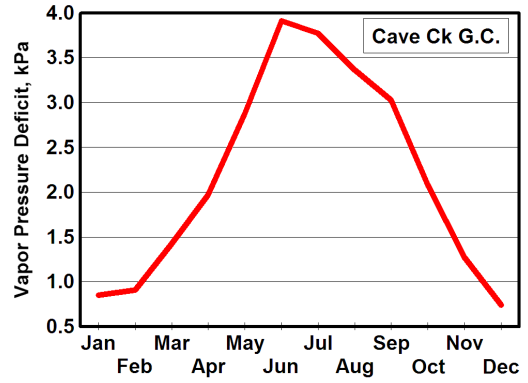

Figure 6. Annual trend of vapor pressure deficit at Cave Creek Golf Course in Phoenix, AZ.

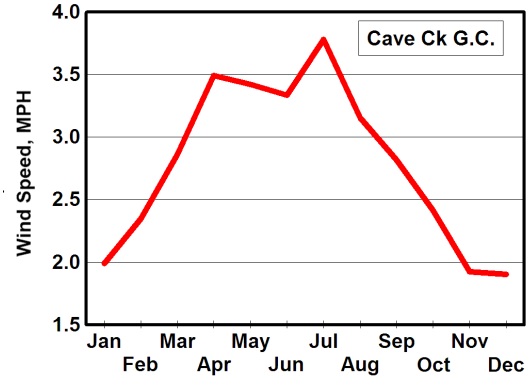

Figure 7. Annual trend of wind speed at Cave Creek Golf Course in Phoenix, AZ.

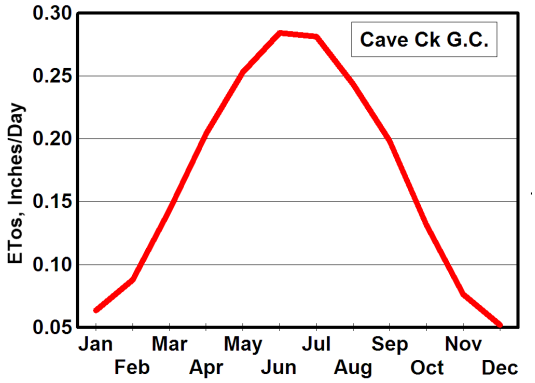

Figure 8. Annual trend of reference evapotranspiration (ETos) at Cave Creek Golf Course in Phoenix, AZ.

mean wind speed observed (by AZMET) across the Phoenix metropolitan area impacts ETos by about 5–10%.

To summarize, most of the local variation in ETos is due to changes in wind speed. Typically, this variation is less than 10% across a metropolitan area. The highest rates of ETos will occur in open areas with high winds. Areas with large buildings and trees that inhibit wind flow will typically have lower ETos values.

A Precaution on Procedures for Estimation of Reference ET

Scientists have developed a number of meteorological procedures for estimating reference ET over the past six decades. The Penman and the Penman Monteith equations represent the two most commonly used methods today. Both procedures have been subjected to modifications in an effort to improve the estimates of reference ET. Unfortunately, this proliferation of "modified" Penman and Penman-Monteith Equations has led to considerable confusion, particularly when using reference ET in operational irrigation management where the use of crop coefficients is required (see next report in this series). The scientific community has addressed this issue in recent years and has developed a standardized computation procedure for estimating reference ET that is based on the Penman-Monteith Equation (Allen et al., 1998, Allen et al., 2005). This standardized computation procedure has been adopted by the research community, most manufacturers of weather stations and the public weather networks that disseminate reference ET data. Turf Managers should be aware that older weather stations manufactured by Rain Bird, Toro and other irrigation companies may still use the older, non-standardized procedures for estimating reference ET. These older procedures may produce reference ET values with a bias relative to the new standardized procedure. Turf Managers are encouraged to upgrade their weather stations and/or irrigation management software to provide reference ET computed using this new standardized procedure so they can more effectively utilize future research on irrigation scheduling and management.

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MOSQUITOES

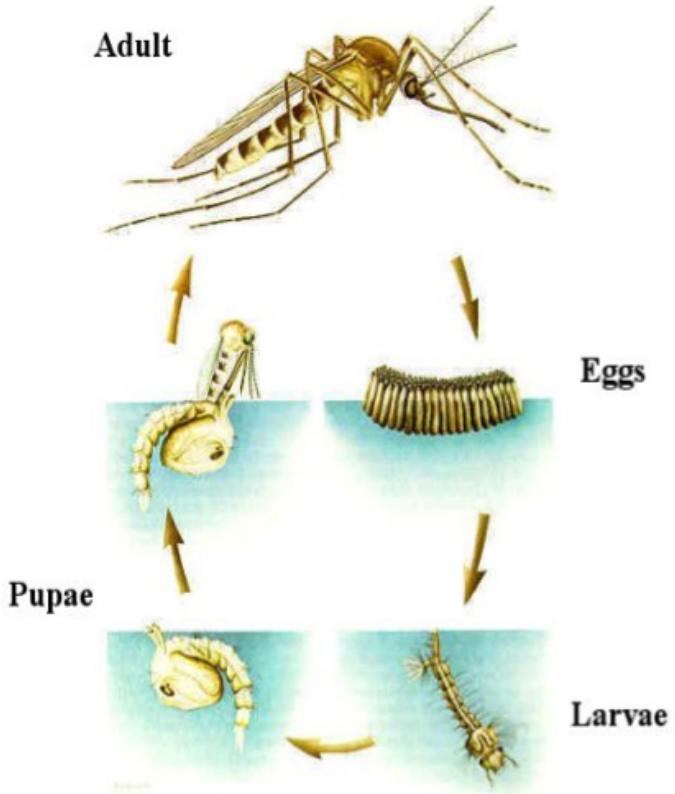


Fig. 1 Generalized mosquito life cycle: Mosquitoes need water to complete their life cycle.

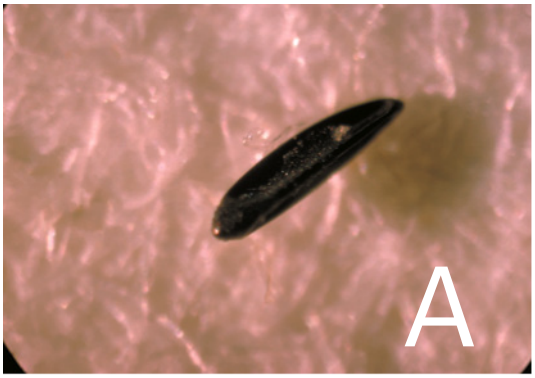
Mosquitoes are one of the most important insect pests that affect the health and wellbeing of humans and domestic animals worldwide. They can cause a variety of health problems due to their ability to transfer (vector) viruses and other disease-causing pathogens even in the arid Southwest. Female mosquitoes require a blood meal for egg production, and they can produce a painful bite as they feed. While feeding they can transmit to humans and other animals—brain inflammation (encephalitis), dengue fever, yellow fever, malaria and filariasis. The most susceptible to the effects of these mosquito-borne pathogens are children and the elderly. However, in some instances life-threatening illness and/or permanent debilitation can occur in infected human hosts of any age.

THE MOSQUITO LIFE CYCLE

Understanding the basics of mosquito biology will help to reduce mosquito problems. All mosquitoes must have water to complete their life cycle, although some species require very little water and can develop in a thin moisture film. The mosquito life cycle is an example of complete metamorphosis. There are four distinct stages in the life of a mosquito: egg, larva (aquatic feeders), pupa (aquatic non-feeders) and adult (Fig. 1). Like most insects with complete metamorphosis, mosquitoes have developmental stages that look very different from one another.

They begin life as tiny eggs. Female mosquitoes usually lay eggs a few days after acquiring a blood meal. Depending on the species the eggs can be laid either singly (e.g. *Aedes aegypti*, Fig. 2A) or in rafts (e.g. *Culex* mosquitoes) (Fig. 2B). The eggs are laid on the surface of water, on the sides of containers, or on damp soil.

The eggs hatch into squiggly little larvae or "wrigglers" that swim in the water and feed on microorganisms or decaying organic matter. A larva goes through four growth stages called instars, in which they grow in size, before reaching the relatively inactive pupal stage. The larvae must come to the surface of the water to breath (with the exception of a few specialized mosquitoes). Mosquito larvae have a siphon at the tail end of the body (Fig. 3). The siphon permits larvae to breathe by penetrating the surface of the water to access air directly.



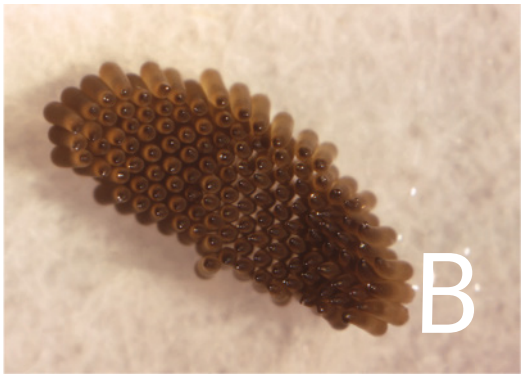


Fig. 2 Mosquito eggs. A, single egg of *Aedes aegypti*. B, eggs of *Culex quinquefasciatus* in rafts. Photograph by the Centers for Disease Control and Prevention (CDC) Public Health Image Library; CDC/Harry Weinburgh.

KEY SPECIES OF MOSQUITOES IN URBAN SETTINGS OF ARIZONA

Although there are about 150 species of mosquitoes in the United States and over 40 in Arizona, only a few are problems for urban residents. There are two main types of mosquitoes in Arizona: Stagnant water mosquitoes (*Culex* mosquitoes) and flood water mosquitoes. In addition, an exotic species of mosquito known as *Aedes aegypti*, while not native to Arizona, have spread into many populated urban areas of the state. Here we focus on the six key mosquito species important to human and animal health issues in Arizona:

1) Western encephalitis mosquito, *Culex tarsalis*;

2) Southern house mosquito, *Culex quinquefasciatus*;

3) Yellow fever mosquito, Aedes *aegypti*;

4) Malaria mosquito, Anopheles *freeborni*;

5) Inland floodwater mosquito, *Aedes vexans*;

6) Dark ricefield mosquito, *Psorophora columbiae*.

Fig. 3. Siphon at the tail end of mosquito larva (*Aedes vexans*). Photo by Michelle Cutwa-Francis, University of Florida - Florida Medical Entomology Laboratory.

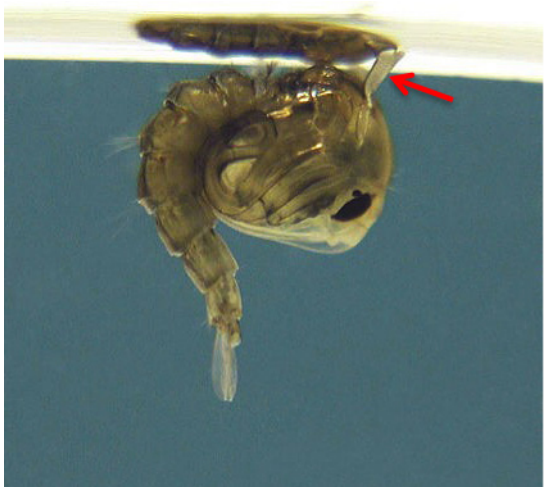


Fig. 4 Respiratory trumpet in mosquito pupa (*Psorophora columbiae*). Photo by Michelle Cutwa-Francis, University of Florida – Florida Medical Entomology Laboratory.

After the fourth larval instar, the inactive pupa forms. Pupae, often called "tumblers", do not feed. Mosquito pupae breathe by using their respiratory "trumpets" (Fig. 4) to draw air directly from the atmosphere. Larvae and pupae can be killed by cutting off their access to air with oils or monomolecular films. The pupal stage is normally quite short (1-2 days), after which the adult mosquito emerges.

The last stage is the only one that gets much public attention—the adults that fly, or specifically, the adult females that bite. After a few days, the adult mosquito emerges from the pupal skin and flies away. Only adult female mosquitoes take blood meals, and the blood is used to produce eggs. Male and female mosquitoes also feed on flower nectar. Male mosquitoes look similar to females but can be identified by having feathery antennae (Fig. 5). The long hairs on their antennae help them to locate flying females. Because male mosquitoes travel shorter distances than female mosquitoes, when you find male mosquitoes the source of water that produced them is likely nearby.

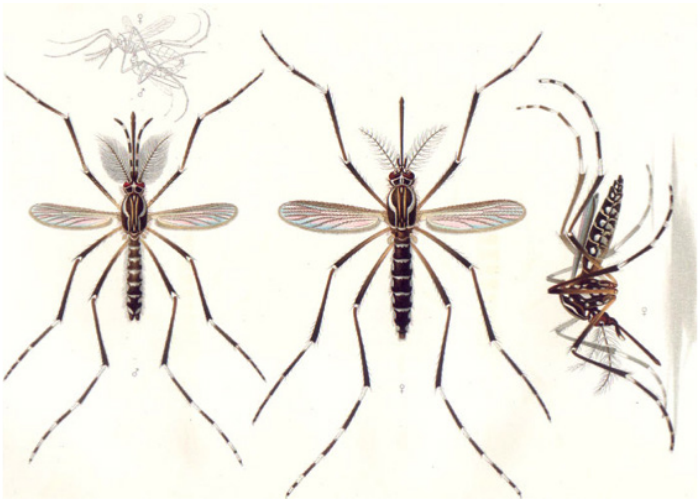


Fig. 5 Color print of the yellow fever mosquito *Aedes aegypti.* The male on the left, the female to the right. Original by E. A. Goeldi (1905). From Wikimedia Commons.

1) Western encephalitis mosquito, *Culex tarsalis*

Culex tarsalis, or Western encephalitis mosquito (Fig. 6), is the most important vector of arboviruses (refer to a group of viruses that are transmitted by arthropod vectors) in western North America including Arizona. It has a prominent white band across the piercing mouthparts (proboscis) and two white bands across all lower legs. It is the primary vector of West Nile virus, Western equine encephalitis, and St. Louis encephalitis. This mosquito breeds in nearly every freshwater source except tree holes and is commonly found in areas using flood irrigation. Adults can be found in diverse places such as vegetation, ground burrows, barns and culverts. They feed on birds and mammals including humans. In fact the Western encephalitis mosquito, *Culex tarsalis* will fly 2-10 miles (sometimes much further) in search of a blood meal (Olkowski 1991).

Fig. 6 Photo of adult Western encephalitis mosquito *Culex tarsalis*. Photograph by Joseph Berger, Bugwood.org

2) Southern house mosquito, *Culex quinquefasciatus*

Culex quinquefasciatus, more commonly called the Southern house mosquito (Fig. 7), is found throughout the southern half of the United States and can be identified by the five lines that can be seen on the abdomen. It is an annoying pest at night, not only due to its bite but also its distinct high-pitched buzz that announces its presence.

The female *Culex quinquefasciatus* mosquitoes lay 6-7 broods (egg clusters) each containing ~300 eggs in her six weeks of life (Marin/Sonoma Mosquito & Vector Control District website, Cotati, CA). The southern house mosquito can transmit nematodes that cause dog heartworm and viruses causing encephalitis diseases in humans. As adults they have arrange of 1-5 miles from their origin (Olkowski 1991).

Both species of *Culex* females deposit their eggs on the water's surface in tight groupings, or rafts (Fig. 2B). The females' preferred egg-laying habitats include nearly every source of standing water ranging from small sources, such as mud-puddles, bird baths, outdoor trash cans, landscape ponds, pet water dishes/troughs, and empty flower pots, to larger sources such as school playing fields, over-irrigated lawns, drainage ditches, septic tanks and wells (Gouge 2004a, b). Agricultural fields and other flood-irrigated fields also can support high populations of *Culex* mosquitoes (Gouge 2004a, b).

As for disease, the West Nile and St. Louis encephalitis viruses are vectored by both *Culex* species from infected birds, and transmitted to humans (an incidental host) (CDC). Both *Culex* species feed on birds and mammals, making transmission of the viruses between bird and human hosts more common where the virus is present. *Culex tarsalis* is especially recognized for vectoring West Nile virus and populations of this mosquito are being monitored by the Arizona Department of Public Health.

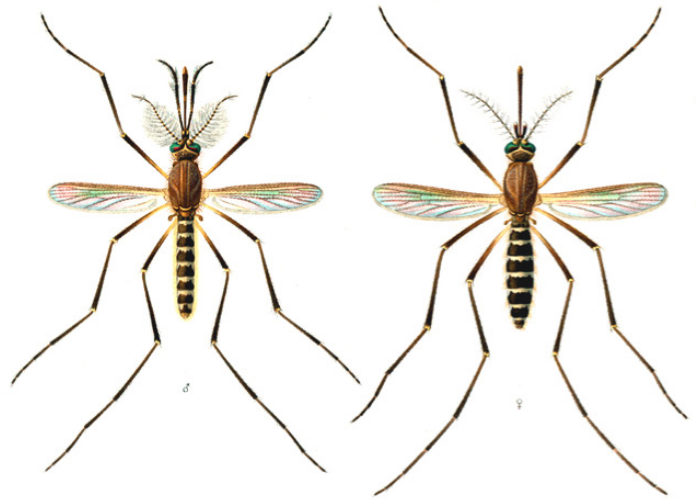


Fig. 7 Color print of the Southern house mosquito *Culex quinquefasciatus*.The male on the left, the female to the right. Original by E. A. Goeldi (1905). From Wikimedia Commons.

3) Yellow fever mosquito, *Aedes aegypti*

Aedes aegypti, or yellow fever mosquito (Fig. 8), is from the tropics, and responsible for transmitting several diseases in humans and dog heartworm. The diseases in humans include West Nile virus (CDC), yellow fever (not occurring in the US), and dengue fever (occurring in some southern US states but not in Arizona). This mosquito can be identified by the white bands on the hind legs and distinct white lyre-shaped markings on the body.

The yellow fever mosquito *Aedes aegypti* is not native to the desert Southwest and has been spreading into many populated areas of Arizona. It is dependent on human environments for its food and breeding habitat. Unlike our native *Culex* mosquitoes, *A. aegypti* lives in close association with human habitations and appears to disperse much less than most other mosquitoes. This is probably based on the availability of egg-laying sites and the ability to obtain human blood (yards not miles). Its flight range is usually 5-100 meters, although sometimes it may be capable of flying longer distances —as far as 850 meters or about half a mile (Reiter et al. 1995).

Its native breeding habitat is tree holes, but in Arizona and other introduced areas the female lays eggs on the sides of artificial containers such as old tires, flower pots, barrels, cans, ornamental ponds, and various containers that hold a limited quantity of water (Bennett et al. 2003). Eggs are laid singly (Fig. 2A) on the ground on a moist surface just above the water line, and they hatch when water level is raised by a rain, or an overhead sprinkler, etc. *Aedes aegypti* eggs are very resilient. They can withstand dry

Fig. 8 Photos of yellow fever mosquito *Aedes aegypti* adult (up) and larva (down). Photograph by Muhammad Mahdi Karim. From Wikimedia Commons.

Fig. 9 This female malaria mosquito, *Anopheles freeborni*, is taking a blood meal from a human host. Photograph by CDC/James Gathany.

conditions for up to a year, and resume development when water becomes available (Womack 1993). Once they hatch the larvae develop in a relatively short time depending on the temperature. Adult females often bite around the ankles throughout the day, especially early evening. So far their documented range in Arizona extends from the southeast Mexico border to north of Phoenix.

4) Malaria mosquito, *Anopheles freeborni*

Anopheles freeborni, or the malaria mosquito (Fig. 9), is the most important vector of malaria in Arizona and California. The mosquito also transmits West Nile virus to humans (CDC), avian malaria to bird species and the *Myxomatosis* virus to rabbits. This species transmitted malaria in Arizona until the disease was eradicated in the early 1900's. Since then integrated pest management strategies have enabled us to keep this mosquito under control.

Larvae of this species prefer clear, fresh seepage water in sunlit or partially shaded pools. Roadside ditches and grassy fields provide overwintering sites for adults. The malaria mosquito feeds aggressively on humans, and it bites rabbits, cattle, horses, and dogs as well.

5) Inland floodwater mosquito, *Aedes vexans*

Aedes vexans, or the inland floodwater mosquito (Fig. 10), is one of the most widespread pest mosquitoes in the world and is found throughout the United States. Inland floodwater mosquitoes are vicious biters and are responsible for most mosquito nuisance complaints. They are recognized as the most serious pest mosquitoes due to their abundance, widespread distribution and breeding potential in floodwater habitats. They are known vectors of West Nile virus (CDC), Western equine encephalitis, St. Louis encephalitis, and dog heartworm. This mosquito is most active at sundown when they attack humans and animals in swarms. The adults are brown with pale V-shaped marks on their abdomens (Fig. 10).

Aedes vexans eggs are laid on soil in areas that have a history of standing water and where they could lay dormant until flooded by water from the next rain or irrigation, allowing the eggs to hatch and larvae to grow and develop in temporary pools. Only one generation is produced per flooding. Their larvae are numerous in these floodwater habitats—irrigation or rainwater that ponds and stands for more than three days —such as over-irrigated or poorly leveled yards and pastures, tail-water ponds, desert ponds, stock tanks, backed up washes and flood control drainage areas. In most cases, this abundant mosquito will dominate these floodwater habitats. *Aedes vexans* has a propensity to disperse and can cause nuisance far from its breeding habitat. They may fly more than 10 miles from their larval development sites in search of blood meals.

6) Dark ricefield mosquito, *Psorophora columbiae*

Psorophora columbiae, or the dark ricefield mosquito (Fig. 11), has a broad range of warm-blooded animal hosts but appears to have a preference for bovine blood. It has been reported to kill livestock when they are in

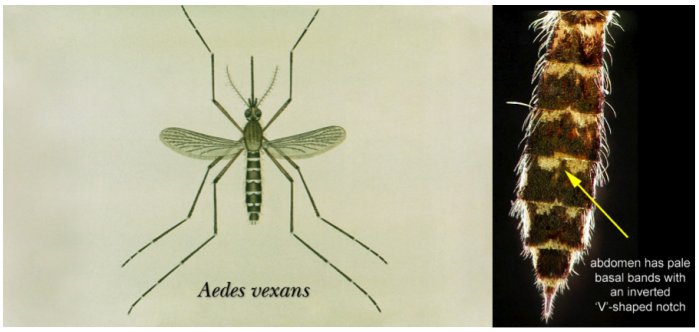


Fig. 10 Left: an illustration of an adult *Aedes vexans* mosquito from the Centers for Disease Control and Prevention; Right: a dorsal view of *A. vexans* abdomen, showing the pale V-shaped marks. Photo by Michelle Cutwa-Francis, University of Florida - Florida Medical Entomology Laboratory.

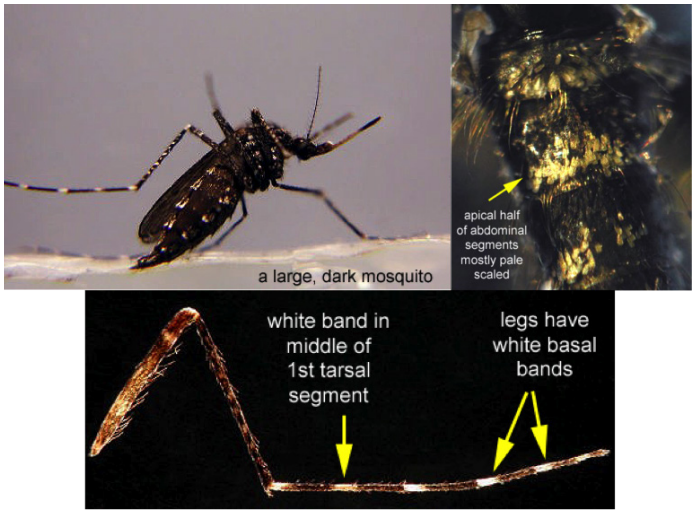


Fig. 11 Dark ricefield mosquito *Psorophora columbiae* adult, abdomen segments and leg. Photos by Michelle Cutwa-Francis, University of Florida - Florida Medical Entomology Laboratory.

large numbers. The females are furious biters during day or night. Well-documented studies of cattle have demonstrated severe losses in weight gain and milk production resulting from the blood-feeding activity of this mosquito. The mosquito is an important vector of West Nile Virus in humans (CDC), Venezuelan equine encephalitis and anaplasmosis in cattle.

The adult *Psorophora columbiae* is a large dark mosquito with white or yellowish markings on its abdomen (Fig. 11). The legs and mouthparts are dark brown and banded with white scales. The hind femora have an apical

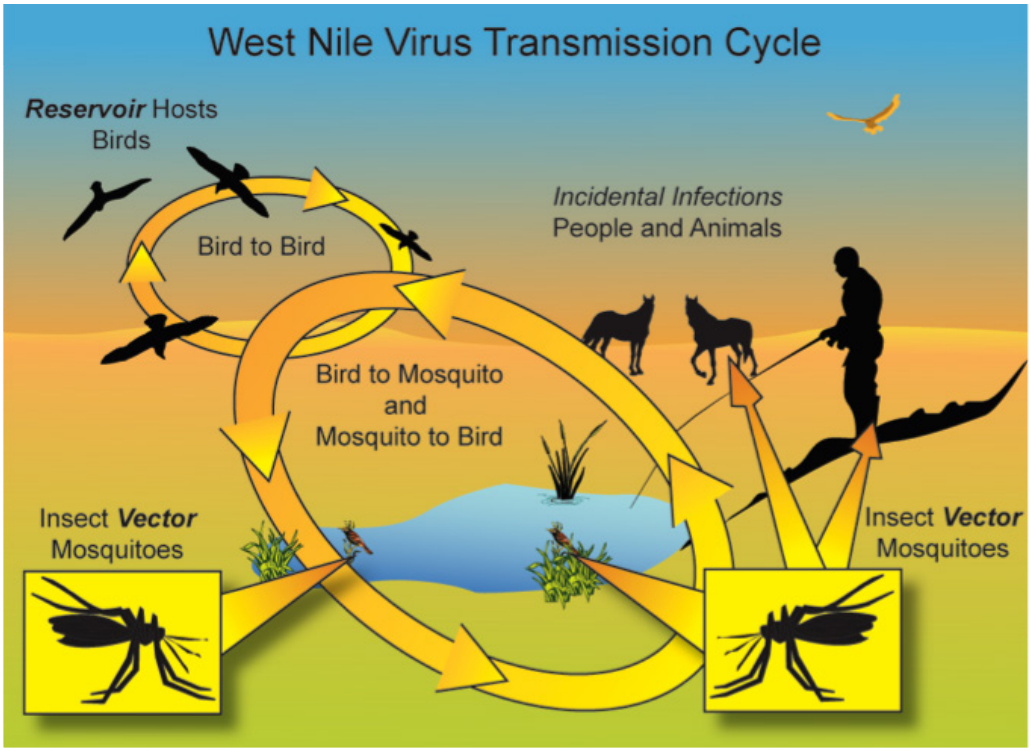


Fig. 12 West Nile virus transmission cycle. Photograph by Deborah Misch - STG Inc. From Global Climate Change Impacts in the United States 2009 Report - US Global Change Research Program.

white band and white knee spots. The first segment of the hind tarsus is brown with a white ring in the middle. The wings are speckled dark brown and white.

Female mosquitoes lay eggs on moist soil that is subject to flooding by water from rainfall or irrigation. The incubation period is about 3-5 days in the rice growing areas of Arkansas. The larvae mature rapidly during the hot summer, often developing from first instar to pupae in as few as 3.5 days. The larvae develop in temporary shallow freshwater pools and puddles where there is vegetation and may occasionally be found in slightly brackish water. Ideal sites for production of larvae are lawns and athletic turf, grassy roadside ditches, and grassy swales (Meisch 1994).

DISEASES SPREAD BY MOSQUITOES IN URBAN AREAS OF ARIZONA

West Nile Virus (WNV)

West Nile Virus is a mosquito-borne virus contracted through mosquito bites. All six species of mosquitoes mentioned above are potential vectors for West Nile virus. The bites generally happen at dusk and dawn, indoors, in shady areas, or when the weather is cloudy. People of all ages (including children) can contract the virus. About 20% of those who contract WNV will come down with what is called "West Nile fever"; the other 80% of those infected show none or only mild symptoms of the virus. Symptoms of West Nile fever can include: fever, headache, body aches, swollen lymph glands, tiredness and rash on the trunk of the body (Gouge 2012).

About one out of every 150 people with West Nile Virus will develop a severe infection resulting in encephalitis (inflammation of the brain) or meningitis (inflammation of the lining of the brain and spinal cord). Unlike West Nile Fever, which develops with equal likelihood in persons of any age, the *severe infection* forms tend to occur more in people over 50 years of age. Symptoms of encephalitis or meningitis include: high fever, neck stiffness, disorientation, muscle weakness, paralysis, headache, stupor, tremors, convulsions and coma.

Transmission Cycle of West Nile Virus

After a mosquito feeds on the blood of a bird infected with West Nile Virus, the virus undergoes a short growth period before it is capable of being retransmitted to humans – as few as four days for some mosquito species in Arizona. The infected mosquito, full of virus and ready to feed again, will look for a bird, human, or other animal for its next blood meal (Fig. 12). This is the basic transmission cycle of the virus as it moves easily from bird (reservoir host) to mosquito (vector) and then, incidentally, on to humans or other animals.

Humans and other animals are considered the incidental hosts for West Nile virus. A mosquito cannot become infected by biting a human or pet infected with West Nile Virus. Therefore, humans or other warm-blooded animals cannot further virus transmission and are referred to as "dead end" hosts for the virus.

Encephalitis

Encephalitis is an inflammation of the brain. The causal virus is primarily transmitted by the mosquito *Culex tarsalis*. The mosquito transmits the virus to birds, horses, mules and occasionally people. Birds serve as the most important host reservoir for the virus in the disease cycle. During the mosquito season public health officials routinely trap and test mosquitoes for viruses, and undertake sentinel chicken flock testing. The chickens are bled once or twice a month and tested for antigens indicating the presence of viruses. Health officials may also survey local and migrating bird populations to determine the incidence of virus and the potential for transmission. However, this is only usually done under special circumstances such as during severe floods.

Western equine encephalitis (WEE) is known to occur in Arizona. Arizona state livestock officials periodically warn horse owners to make sure their horse vaccinations are up to date for the potentially fatal equine sleeping sickness or Western equine encephalitis. The Arizona Department of Health commonly finds mosquitoes carrying the virus that causes WEE.

Mosquitoes carrying WEE are most common during the summer and early fall months. Symptoms of WEE in horses include neurological signs such as depression and lack of coordination. A sick horse may also go down and not be able stand back up. The illness is fatal in 20-50% of horses that are stricken with the disease. Human symptoms include high fever, convulsions, delirium and other characteristic central nervous system dysfunctions. Medical assistance should be obtained quickly if symptoms occur.

St. Louis encephalitis (SLE) is another viral disease transmitted by *Culex tarsalis* in Arizona. Birds are again the most important hosts, but humans

can also be infected (Fig. 13). Unlike WEE, horses are not involved with the SLE disease cycle. Infected mosquitoes are commonly found in Phoenix, Tucson, Yuma and other sites. Fatal human cases are uncommon and occur sporadically. SLE is a much more serious threat to humans than WEE. Children and the elderly are most susceptible to fatal infections.

Dengue Fever

Dengue fever is an infectious disease caused by dengue virus transmitted between humans by *Aedes aegypti* (Fig. 14). No other animals are involved in the disease cycle. This disease is currently endemic (naturally transmitted) in Mexico and sporadically occurs in southern Gulf States. It is not endemic in Arizona, but this situation is likely to change in the future given the presence of this mosquito throughout Arizona.

Dengue fever is characterized by a high fever, a rash, severe muscle and joint pains, and vomiting (Fig. 15). Recovery normally occurs in a few weeks. Dengue hemorrhagic fever and/or dengue shock syndrome are much more serious forms of the disease that occur in people that have had dengue previously. Both hemorrhagic dengue and dengue shock syndrome can be fatal, and children and the elderly are most susceptible.

Dog Heartworm

Mosquitoes also transmit heartworm *(Dirofilaria immitis)* to dogs. The heartworm is a type of filaria, a small thread-like worm that causes filariasis. Heartworm can cause severe circulatory problems and produce symptoms such as coughing, labored breathing and general loss of vitality in advanced stages.

First, adult female heartworms release their young, called microfilariae, into an animal's bloodstream. Then, mosquitoes become infected with microfilariae while taking blood meal from the infected animal. During the next 10 to 14 days, the microfilariae mature to the infective larval stage within the mosquito. After that, the mosquito bites another dog, cat or other susceptible animal, and the infective larvae enter through the bite wound. Larvae mature into adult worms within about 6 months in heart and blood vessels and then reproduce in the infected dog. In dogs, the worms may live for up to 7 years. Microfilariae cannot mature into adult heartworms without first passing through a mosquito (American Heartworm Society).

Because of the impracticality of protecting dogs from mosquito feeding, the most effective means of controlling heartworm is to prevent worms from reaching the adult stage inside the dog. Veterinarians can prescribe excellent drug treatment to protect pets from heartworm.

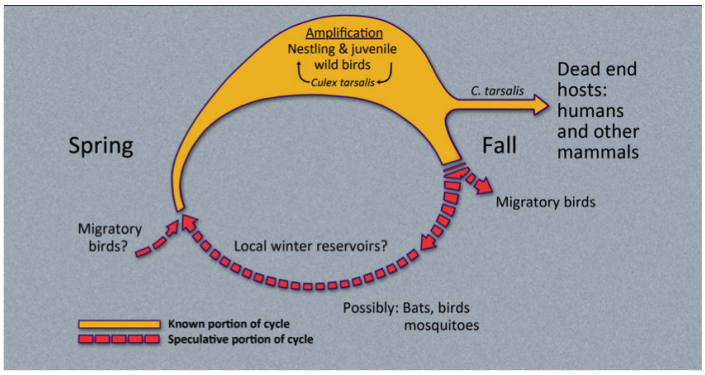
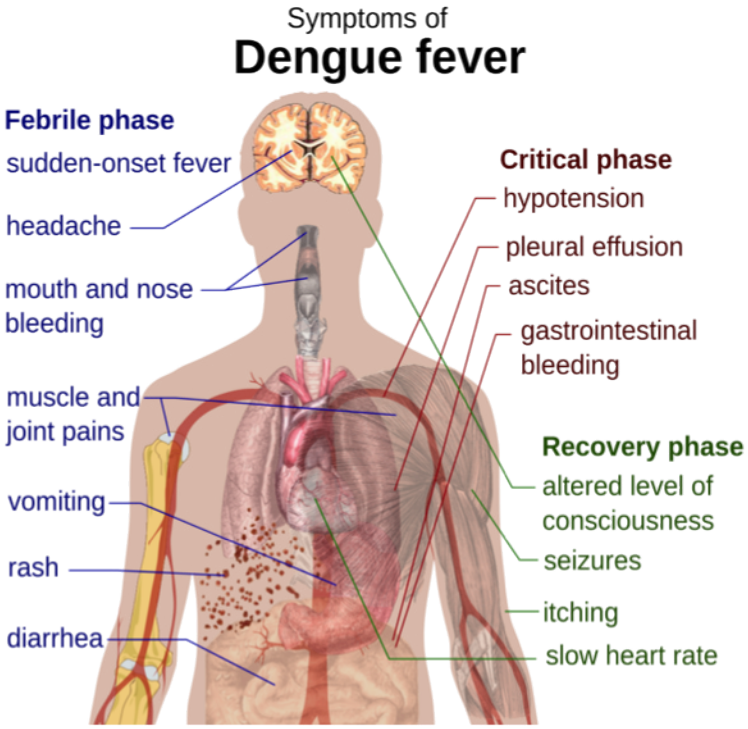


Fig. 13 Transmission cycle of St. Louis encephalitis virus in Western US from CDC.

Fig. 14 The mosquito *Aedes aegypti* is feeding on a human host. Taken by Muhammad Mahdi Karim. From Wikimedia Commons.

Fig. 15 Schematic depiction of the main symptoms of dengue fever. Original by Mikael Häggström (2011). From Wikimedia Commons.



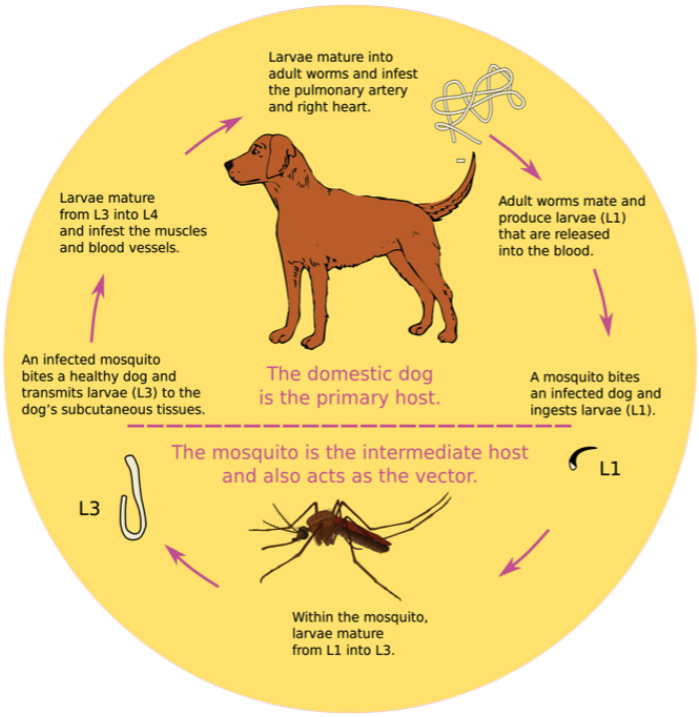


Fig. 16 Heartworm *Dirofilaria immitis* life cycle from Wikipedia.

NON-CHEMICAL CONTROL MEASURES

1. Prevention

Mosquitoes need water to complete their life cycle. They need wet conditions to lay eggs and grow from an aquatic larva into a flying adult. Humans create the vast majority of the wet conditions used by mosquitoes in Arizona. It is likely that many of us have mosquitoes developing in our neighborhood and own backyards. Stagnant water left from monsoon rains and irrigation water can increase mosquito activity and produce hundreds of thousands of mosquitoes if larva are allowed to live as little as three days (Maricopa County Vector Control). Stagnant water in neglected swimming pools is the ideal habitat, though mosquitoes cannot live in a well-maintained swimming pool.

The most effective strategy for mosquito management in communities in general is prevention. The best way to prevent mosquito-borne diseases is to minimize the number of mosquitoes and to prevent them from breeding in the first place. Here are some tips on what you can do to manage mosquitos and eliminate mosquito-breeding sites around you. Consider the following:

1. Check for standing water in plant pots, bird-baths, fountains, tires, tarpaulins covering boats or other objects, and backyard trampolines and other items (Fig. 17A, D). Drain the water regularly (twice a week is ideal).
2. Remove unnecessary clutter. Keep rain gutters free of leaves and other debris that prevent water from draining. Store boats, canoes and other objects so they do not collect rainwater.
3. Repair water leaks (leaky pipes, sprinkler systems, and outside faucets). Correct drainage problems in yards and playing fields. Report drainage problems in ditches (Fig. 17B), etc. Fill holes or depressions in trees with sand.
4. Empty water containers for pets and check livestock watering troughs and tanks (Fig. 17C).
5. Add *Gambusia* (mosquito eating fish) into personal ponds or stagnant swimming pools to reduce the number of mosquitoes. The fish are available free of charge from the Vector Control office. Just call (602) 506-0700 to schedule a pickup time.
6. Larvicides use bacteria (*Bti*) that are specifically targeted against the larval life stage of an insect, while harmless to humans, pets and the environment. Mosquito larvicides will kill mosquito larva in a non-consumptive water source.

2. Avoid Mosquito Bites

Additionally, when outdoors, consider the following safety tips:

1. Wear light colored clothing with loose fitting long-sleeves, long pants and socks. Use protective clothing when exposure to mosquitoes cannot be avoided.
2. If possible, avoid outdoor activity before dawn and after dusk when mosquitoes are most active and avoid being bitten by mosquitoes at any time.
3. Properly apply insect repellant even if you are outside for just a short period of time, and share your insect repellant with those around you. For additional help selecting which repellant is right for you, go to the EPA search page: http://cfpub.epa.gov/oppref/insect/#searchform
4. Use a DEET product or a good non-DEET alternative (organic all natural or plant-based insect repellent), and, if you are outside for more than a few hours, reapply repellent frequently. The higher the temperature the more frequently you must reapply repellent for it to be effective.
   - Apply repellents only to exposed skin and/or clothing (as directed on the product label). Do not use under clothing.
   - Never use repellents over cuts, wounds, or irritated skin.
   - Do not apply to eyes and mouth, and apply sparingly around ears. When using sprays do not spray directly onto face; spray on hands first and then apply to face.
   - Do not allow children to handle the products, and do not apply to children's hands. When using on children, apply to your own hands and then put it on the child.
   - Do not spray in enclosed areas. Avoid breathing a repellent spray, and do not use it near food.
   - After returning indoors, wash treated skin with soap and water or bathe. If you suspect that you or your child is reacting to an insect repellent, discontinue use, wash treated skin. Call your local poison control center if symptoms persist.
   - When properly used, personal repellents can discourage biting arthropods from landing on treated skin or clothing.
   - Using repellent and sunscreen products at the same time is acceptable practice. However, the use of combination products that contain both an insect repellent and a sunscreen is not recommended.
5. Type of repellents: According to the Centers for Disease Control and Prevention (CDC) the three most common active ingredients in repellents are DEET, picaridin, and oil of lemon eucalyptus. The CDC considers DEET and picaridin to be the most effective. Between the two active ingredients, picaridin products are less problematic when used repeatedly over extended periods of time. EPA characterizes the active ingredients DEET and picaridin as conventional repellents and oil of lemon eucalyptus, PMD, and IR3535 as biorepellents, which are derived from natural materials. For more information on repellent active ingredients, see http://www2.epa.gov/mosquitocontrol.

3. Mosquito-Proof Your Home and Yard

Drain Standing Water: Mosquitoes lay their eggs in standing water. Limit the number of places around your home for mosquitoes to breed by getting rid of items that hold water (Fig. 17A, C, D).

Install or Repair Screens: Some mosquitoes like to come indoors. Keep them outside by having well-fitting screens on both windows and doors. Offer to help neighbors whose screens might be in bad shape. Do not prop doors or keep doors open, particularly early or late in the day when mosquitoes are most active.

Check for Indoor Breeding Sites: If a female mosquito wonders inside your home she will utilize any water reservoir she can find. Check for

Fig. 17 A. Flush out birdbaths periodically. B. Keep roadside ditches and drainage areas clear of debris so that storm water drains off easily. C. Discard containers that may collect water. D. Avoid prolonged flooding of playing fields. Organic acids can be used to improve turf drainage.

wriggling larvae in the toilet cisterns that are not flushed daily. Maintain water in drain traps. Use sticky tape over floor drains, sink over flows, etc. to see if you can catch mosquitoes emerging from areas you cannot see.

4. After-Bite Care

Consider the following tips for relieving the itch of mosquito bites:

The first step is to clean the bite area with soap and water. Topical corticosteroids can reduce the rash, itching, and discomfort. Topical diphenhydramine and caine-containing derivatives should be avoided because of concerns about inducing allergic contact sensitivity. Oral antihistamines can be effective for reducing the symptoms of mosquito bites. Use of a cold compress can be helpful, but do not apply ice directly to the skin.

TOXICOLOGY AND CHEMICAL CONTROL

Effective mosquito control can often be complex and expensive, and frequently requiring the cooperative efforts of communities as well as such groups as industry, agriculture, state and local governments. Many people are concerned about harmful effects of pesticides on the environment, their animals and plants, and themselves. Pesticide toxicity and pesticide hazard is not the same thing. "Toxicity" is the "killing power" under experimental conditions, whereas "hazard" is the risk of poisoning when a product is normally used. Hazard includes both the chemical toxicity and the chance of exposure to the product.

The dosage used and the type of chemical compound determines the hazard level of the pesticide. For example, if an individual were to consume an oral dose of 400 milligrams of table salt per kilogram of body weight the person would become violently ill. In fact every year about 60 people die from aspirin overdose. At lower doses both aspirin and salt are not hazardous. Thus, it is important that the dosage levels recommended on pesticide labels be followed very carefully.

Adulticides

Adulticides are pesticides used to kill adult mosquitoes. Mosquito control districts in the U.S. commonly use adulticides such as permethrin, piperonyl butoxide, and etofenprox. Applications of over-the-counter synthetic pyrethroids applied to vegetation, tree trunks and walls of buildings and catch basins will help control certain adult mosquito species but not others.

Larvicides

Larvicides are products that are used to control mosquitoes in their larval stage and include the following:

1. *Bacillus thuringiensis israelensis*

Bacillus thuringiensis israelensis, or *Bti*, is a naturally occurring soil bacterium. The bacterium produces proteins in a crystalline form. When the mosquito larvae eat these crystals, the proteins attack their gut wall, killing the larvae. Bti has a highly specific mode of action, and is of minimal environmental concern. It is quickly biodegraded and leaves no residue. Always store Bti products under cool conditions prior to use.

2. *Bacillus sphaericus*

Bacillus sphaericus (*Bs*) is a common soil-inhabiting bacterium. The bacterium produces a protein toxin that may be used to control mosquito larvae. *Bs* is commonly used to control mosquito larvae in highly polluted water, such as sewage treatment plants. Bs is nontoxic to non-target organisms. Some natural recycling of this organism is likely and products usually last for about 21 days.

3. Spinosad (a mixture of spinosyn A and spinosyn D)

Spinosad insecticide is derived from a family of natural products obtained by fermentation of bacteria species *Saccharopolyspora spinosa*. This insecticide contains a mixture of two spinosoids, spinosyn A and spinosyn D. Spinosad has high efficacy, a broad insect pest spectrum, low mammalian toxicity, and a good environmental profile. It kills insects via hyperexcitation of the insect nervous system.

4. Methoprene

Methoprene is a synthetic pesticide that mimics the insect juvenile hormone. When methoprene is present, the development of the mosquito larvae is disrupted, and they do not develop to the adult stage. Mosquito control districts use methoprene in situations like cisterns and abandoned

swimming pools. The breeding site needs to be treated periodically depending upon the formulation of the product used. Thirty day and 150-day briquettes are available as well as granular formulations (lasting a few days). The compound is not destroyed by heat. Methoprene is toxic to some other insects but is safe for use around humans.

5. Temephos

Temephos is an organophosphate larvicide and used to treat water infested with disease-carrying insects, including mosquitoes, midges, and black fly larvae. Temephos affects the central nervous system through inhibition of cholinesterase. In larvae, this results in death before reaching the adult stage. It is commonly used in areas of standing water where yellow fever mosquito *Aedes aegypti* breeds in order to reduce the population of this disease-carrying insect.

ALTERNATIVES TO PESTICIDES

Oils and monomolecular surface films are used to control pupae and late-fourth instar larvae by interfering with their ability to breath. These products are usually used when an adult emergence will occur without treatment (at this point it is usually too late to utilize the other options). However, oils and monomolecular films will control all immature stages.

Gambusia is mosquito-eating fish. Some mosquito control districts raise the fish and use them to stock man-made water bodies. These fish will reproduce and continue to eat mosquito larvae. *Gambusia* should never be released into natural watercourses as they out compete native fish species. The Gila topminnow is now a protected fish because of competition with *Gambusia*. In many areas where *Gambusia* have been released the Gila topminnow no longer exists. Most small minnow fish (such as guppies, flathead minnow and shad) are good at reducing mosquito larvae populations and are suitable for release into garden ponds.

AREA-WIDE MOSQUITO CONTROL

Because of the complexity of controlling mosquito populations, technical assistance may be required. Mosquito control personnel may be necessary on a permanent basis and communities may wish to investigate the desirability of an area-wide approach. *The most important element in mosquito control is you.* By reducing mosquito-breeding habitats on your property you can significantly reduce mosquito populations with no side effects.

IN SUMMARY: SOME FINAL FACTS

- There are 150 different species of mosquitoes occurring in the United States and over 40 species in Arizona.
- A single female can lay hundreds of eggs over her lifetime.
- *Aedes aegypti* eggs can survive for more than five years under certain conditions.
- All mosquitoes need water to complete their life cycle.
- Not all species bite humans; some prefer birds, others prefer horses.
- Only females take a blood meal; both males and females feed on plant nectar.
- Some mosquito species fly considerable distances, 20 miles or more. Some species tend to remain close to their larval habitats.
- Adult females can survive several weeks.
- Mosquitoes are responsible for more human mortality around the world than any other living creature.

ACKNOWLEDGMENTS

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BIRD OF PARADISE SHRUBBERIES
FOR THE LOW DESERT

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The bird of paradise is one of the most popular non-native well-adapted shrubs that are suitable for the low desert of Arizona. There are three species in the family *Fabaceae* and genus *Caesalpinia* (formerly called *Poinciana*) that often go by the common name of bird of paradise and each of them have additional descriptive modifiers on the common name: yellow, Mexican, and red. While they all have similarities, they also have differences and understanding them allows the gardener to make an informed decision about putting the right plant in the right place. None of these three plants should be confused with the bird of paradise plant grown commonly in southern California and Florida gardens, which is in a different botanical group (*Strelitzia* genus) and is not easily grown in desert gardens because it requires a cool moist climate. In addition, there are three more shrubs in the *Caesalpinia* genus that could be considered in a low desert situation. They are cascalote (*Caesalpinia cacalaco*), palo Colorado (*Caesalpinia platyloba*), and copper *Caesalpinia* (*Caesalpinia pumila*).

The table below compares differences between the three bird of paradise species and is followed with general information applicable to all three species.

Caesalpinia species comparison:

	C. gilliesii (Figure 1) Yellow Bird of Paradise	*C. mexicana* (Figure 2) Mexican Bird of Paradise	*C. pulcherrima* (Figure 3) Red Bird of Paradise
Landscape Use	Informal shrub that should be allowed to grow to its natural form; native to Argentina and Uruguay but has escaped cultivation in Arizona and naturalized in washes	Background shrub or can be trained to small tree; native to Mexico and cultivated in Arizona, occasionally escapes cultivation	Background or specimen shrub; origin unknown due to widespread cultivation; widely distributed and naturalized in tropical areas of America
Size	5 to 10 feet with spread of 4 to 6 feet; grows rapidly	10 to 15 feet with spread of 10 feet; grows rapidly if regularly irrigated	4 to 10 feet with spread of 4 to 6 feet; grows rapidly; mature size determined by irrigation and severity of winters
Water Needs	Drought-tolerant but will look best if watered every month	Every month once established; water every week during spring and summer for continuous blooms	Every month once established; water every week during spring and summer for continuous blooms
Hardiness	Hardy to 10-15° F	Hardy to 18° F	Damaged at 32° F
Exposure	Full or reflected sun	Full sun or light shade	Full sun or light shade; avoid northern exposures
Flowers	Yellow with long red stamens, mid-spring through late summer	Solid yellow; may flower year-round in warm-winter areas, spring through fall elsewhere	Red and orange, also solid red and solid yellow cultivars, blooms through the warm months
Leaves	Bipinnate, 10–15 cm long, bearing 3-10 pairs of pinnae, each with 6-10 pairs of leaflets 5–6 mm long and 2–4 mm broad	Bipinnate, 4–9 cm long, bearing 5-9 pairs of pinnae each with 4-5 pairs of leaflets that are 1–2.5 cm long and 0.7–1.3 cm broad	Bipinnate, 20–40 cm long, bearing 3-10 pairs of pinnae, each with 6-10 pairs of leaflets 15–25 mm long and 10–15 mm broad

Figure 1. Yellow Bird of Paradise (*Caesalpinia gilliesii*)

Figure 2. Mexican Bird of Paradise (*Caesalpinia mexicana*)

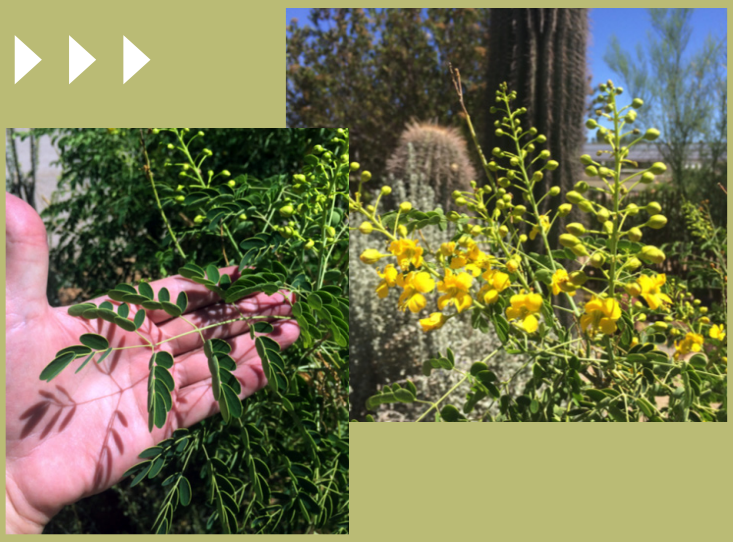

Figure 3. Red Bird of Paradise (*Caesalpinia pulcherrima*)

ALL PHOTOS COURTESY OF PETER L. WARREN.

SOIL

All three species are tolerant of any soil type as long as there is good drainage.

MAINTENANCE

When grown as a shrub, pruning is necessary only to remove frost-damaged limbs or to remove dead, crossing, or damaged branches. More pruning will be needed if the Mexican Bird of Paradise is to be developed and maintained as a small tree.

Once blooming is finished, the flower stalks on all three species may be removed to prevent seed pods from forming and to reduce the likelihood of volunteer seedlings. If the pods are left on the plant to dry and split, the seeds can be thrown a surprising distance. Cleanup of the split pods and any volunteer seedlings will be needed for a tidy landscape.

The Red Bird of Paradise dies back to ground at temperatures below freezing. It generally regrows in spring from the ground and can be pruned to a few inches above the ground in late winter. Mulching the base of plant in colder areas may protect the plant's crown until spring.

PROPAGATION

If you want to save the seeds for producing new plants, it is best to remove the flower stalks when the seed pods first turn brown and put them into paper bags to fully dry. The seeds have a hard coating that needs to be penetrated to ensure germination. The horticultural term for breaking through the seed coat is scarification, which can be done by scraping and nicking the seed with sandpaper or a wood file until a color change is seen. The scarification should be done on the seed's surface and not on the edge to prevent damage to the embryo.

CAUTION

The ripe seeds of all three species are poisonous.

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FOOD ALLERGIES

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INTRODUCTION

Food allergies are on the rise and as a result more people are becoming in tune with this very important issue. A true food allergy, sometimes called a food hypersensitivity, causes the body to produce an immune reaction in response to eating a certain food. Recent studies show that almost 1 in 20 children under the age of five years of age and nearly 1 in 25 adults have an allergy to at least one food. Allergies are often inherited and most oftentimes diagnosed early in life.

CAUSES

A food allergy is caused when the body reacts to a usually harmless food substance perceiving it as harmful. The allergen, a protein found in the food, sets off a chain reaction. When this allergen is consumed in the food, the body protects itself by making antibodies. These antibodies then trigger the release of certain chemicals such as histamine. In turn, these chemicals produce uncomfortable symptoms like nausea, wheezing, hives or itching.

COMMON FOOD ALLERGIES

There are several types of foods that can cause allergic responses. The most common food allergies with a few examples are listed below:

- Milk: fluid milk, yogurt, cheese
- Eggs
- Fish: bass, flounder, and cod
- Shellfish: crab, lobster, and shrimp
- Tree nuts: almonds, pecans, walnuts
- Peanuts
- Wheat: wheat bread, flour tortillas
- Soybeans: lecithin, tofu

It is important to note that for children, allergies to eggs, milk and soy products can oftentimes be outgrown, however adults that develop food allergies tend to have their allergies for the rest of their lives.

SYMPTOMS

The most common symptoms include swelling, itching, and nausea. Most symptoms affect the skin, respiratory system, stomach or intestines, and may vary depending upon the person and the food consumed. The following is a basic list of symptoms caused by food allergies:

Skin Reactions:

- Swelling of the lips, tongue and face
- Itchy eyes, mouth, and skin
- Hives or rash

Respiratory Tract:

- Itching and/or tightness in the throat
- Shortness of breath
- Dry or raspy cough and/or wheezing
- Runny nose

Digestive Tract:

- Abdominal pain and cramping
- Nausea
- Vomiting
- Diarrhea

Usually symptoms are not serious. However, sometimes a very severe reaction or "anaphylaxis" can cause severe illness and even death.

Symptoms of anaphylaxis include rash, swelling and tightening of the throat, low blood pressure, irregular heartbeat and gastrointestinal distress. These symptoms usually begin within a few minutes after eating the food. If this should happen, the person needs to seek medical treatment immediately. Oftentimes epinephrine (found in an EpiPen) is given to treat the severe reaction.

PREVENTING SYMPTOMS

Unfortunately, there is no cure for food allergies. The only way to prevent a reaction with the food is to avoid the allergenic food altogether. Some useful tips in helping to avoid foods that cause allergies are listed below:

- Read all food labels and understand food terminology to make sure the problem food is not listed as an ingredient. Since 2006, the United States food manufacturers have been required by law to list all ingredients by their common/usual names and even disclose if the food item was prepared on or near areas where known food allergens have once been prepared.
- Be careful with cooking and serving to avoid any cross-contamination between the food allergen and foods prepared without the allergic ingredient.
- When eating away from home, make sure that the ingredients in the foods are known before ordering. Play it safe by ordering plain foods such as grilled meats, steamed vegetables, and fresh fruit. Bringing food from home helps ensure that the person with the allergy knows what it is and where it came from. Also, if the doctor has prescribed an *EpiPen*, it is important to keep it with the individual in case they consume food with the allergen.

PREVENTATIVE MEASURES FOR INFANTS INCLUDE

- Breast-feeding infants for the first year of life and waiting until infants are four to six months of age before introducing solid foods.
- Introduce rice cereal first.
- Introduce foods slowly to a baby's diet, one at a time, and feed it for several days before adding another food in order to easily identify an offending food.
- Do not introduce whole eggs until the child is one year of age, and wait until three years of age before feeding a child peanuts or seafood.

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