Vertebrate Pest Control

I still remember when I first heard of the vertebrate winged pest called the "Horned Lark". I'd never seen one up to that time and I still haven't seen a live crop plant eating Horned Lark bird. I had just come into the grower's office about ten thirty one morning in the little town of Buttonwillow, California which is located about 30 miles due west of Bakersfield, California.

That March morning in the year of nineteen sixty-five, I had checked several of the growers' sugar beet fields in the early morning hours. We usually met at his office in the mornings around ten thirty A. M. to go over his field reports and see what fields needed something done to them. This included bug sprays and fertility needs. He asked if I'd checked a particular sugar beet field that had just germinated from seed. I told him that I had and that there was nothing to report. He said "I agree there is nothing period. in a lot of the field!"

We got in his jeep and rode out to the field that I'd checked for worms not more than three hours before. As we drove up I could see plenty of bright green sugar beet seedlings that the morning sun highlighted around the edges of the field, but the brown bare ground areas in the middle of the field without any green seedlings were too apparent. This isn't the way that field looked when I finished checking it a couple of hours before. And that's how I learned about Horn Larks. The grower's name was, Dutch, and he was one mad cussing grower.

We looked at all his sugar beet fields for the rest of the day and discovered that some of the others fields had been hit too. After we got back to the office Dutch sent a group of his workers out with shotguns. Then we called the Kern county agriculture agent. We told him what we had seen and he told us that we probably had Horn Larks. He'd supply us with treated grain and he said he'd give us permission in writing to apply it and how to apply it. We were to put the treated grain in trays in the newly planted fields. Dutch raised pheasants that he released for hunters. Some of the pheasants escaped so he had plenty of game birds that he was required to protect; therefore he had to apply the poisoned grain like the commissioner instructed. After that I kept my eye peeled for Horn Larks, but all I ever saw was their damage and some pictures of them.

According to the VERTEBRATE PEST CONTROL HANDBOOK-BIRDS, Horn Larks are ground dwelling birds that are a little larger than a sparrow. There coloring consists of a yellowish face, with black whiskers, a black breast and two small horns. They give off a high pitched and sustained long call.

This bird vertebrate pest is classed as a migratory nongame bird in the US Code of Federal Regulations. Horn Larks may be controlled under the supervision of county agriculture commissions or with a depredation permit from the Fish and Wildlife Service.

Horn Larks are the only true larks that are native to the United States. They can be found in Alaska to southern Mexico. Living in areas of mountain tops to below sea levels in the Imperial Valley of California. They inhabit grasslands, meadows, prairies, deserts, and tundra. When the neighboring fields and plains dry up in spring and summer months the open fields that have been cultivated and the irrigated crops are especially susceptible to the Horn Lark.

They walk or run and do not hop as they move across the field in an erratic pattern when feeding on seeds and insects. They damage crop seedlings of beets, lettuce, alfalfa, broccoli, carrots, sugar beets, beans, peas, spinach, melons, tomatoes, onions, peppers, and flowers. The blossoms of beans and peas are sometimes eaten. Lettuce and peppers are sometimes damaged from pecking. The damage to germinating crop plants occurs when the emerging seedlings push

through the soil surface. The horned lark pecks at the newly emerged seedling damaging the tender parts of the plant. In some cases the lark consumes the entire plant. When seedlings are not destroyed their buds and tender leaflets are eaten as they appear. Fast growing plants are damaged less and less because horn larks prefer only the tender parts of the plant. Damage of plants that are three to four inches tall are reduced and allowed to continue growing. Usually all the heaviest damage to field is in the center of the field in set areas. Heavily damaged horn lark fields will consist of a narrow fringe of growing and undisturbed plants on the outer edge of the fields.

The inspections of dead horn lark innards show that their food intake consists of nine percent animal matter (primarily insects) and ninety one percent plant material. Of the total food tested in their stomachs fifty one percent consisted of seeds and wild grasses. While inspections of the innards of Killdeer birds found in fields show a reverse in their diet two percent plant material and ninety eight percent animal materials. The Killdeer birds were captured in flood irrigated fields with some water in the furrows. Some growers have mistakenly blamed Killdeers for some seedling damage.

Horn larks begin building their nests in treeless locations during the month of March usually in the rolling foothills. They use the hollow in the ground where they build a shallow cup of fine grasses for their nests. Three to five eggs are laid by the larks in these nests and within eleven to fourteen days the young birds hatch. After growing for 10 to 12 days the young start their first flights. The number of broods raised by a pair of horn larks is two per year.

The only legal method of horn lark control is the use of frightening devices. These include propane exploders. These should be moved to keep the birds from accepting them as part of nature. Shot gun blasts, shell crackers, bird bombs and bird whistles can be used to supplement the propane exploders. Raptor or hawk balloon look a likes can be used along with the noise makers. Capsicum repellant granules are federally approved for horn lark control on certain fruit, vegetables and grain crops. Capsicum is a granular made from hot peppers. Avitrol mixed with grains is approved in California. The birds that feed on the Avitrol treated grain give off distress sounds that alarm the other birds in the field to fly away. Avitrol is mixed with grain in trays that are placed in the field right after planting as the seed germinates. The trays are placed in the center of the fields. Placing untreated grain a day before putting Avitrol treated grain in the field will increase the feeding of the horn larks on the treated grain trays. Stakes with cloth streamers placed in the field will frighten horn larks when the wind makes the cloth flags flutter. Contacting the Agricultural Commission's office or the Wild Life Offices will give you some help in obeying the laws as well as solving the horn lark problems that you may encounter.

Diseases by Birds! In order to see that there is a bird problem in agriculture all you have to do is drive by a vegetable crop that has several different cloth scarecrows waving and fluttering near the roadside. And these are located on large international agricultural operations as well as small truck and family farms. Birds are a serious pest in these fields, but they are also a pest in vineyards, some tree crops, farm buildings, feed lots, dairies and food processing areas.

Although health risks are not as severe from birds as we often hear, there is concern from the diseases caused by birds. Most of these diseases come from the droppings, feathers and debris that accumulate when flocks of birds congregate on or in the grain storage, food packing and the livestock and poultry feeding areas. The flocking birds include the pigeons, starlings and sparrows. The food can be contaminated. Livestock foods can be consumed. Parasites carried by the birds can attack human workers in the facilities.

One of the fungal diseases is a systemic mold that is transmitted to humans by airborne

spores. Starling and pigeon droppings when mixed with soil and allowed to set for a period of three years can build up one of the diseases called histoplasmosis capsulatum. This disease has been found in droppings without the presence of soil in very rare instances. These droppings without the presence of soil would occur in attics and eves of warehouses and barns. Usually it requires the presence of some soil for the disease to thrive. Droppings from birds or bats usually require a time period of at least three years in the presence of soil for the spores that carry the disease. The accumulated dust present in these farm areas provides an environment for the disease to thrive and multiply. Cleaning up the dropping areas before this time period of three years is necessary to prevent the disease from becoming a problem.

The disease is not contagious. Antifungal medication treatment is used for severe cases. Mild cases resolve themselves without treatment. The disease spores are carried by the wind and inhaled. When cleaning up the droppings the dust created will carry the disease. The disease, histoplasmosis capsulatum, causes a mild infection, but this can lead to high fevers, blood problems, pneumonia and even death. In one of a number of skin tests where the disease was suspected to be present in high populations of people, it was discovered that 50 million people had histoplasmosis or had been exposed to it. Most of the cases are very mild, but this disease results in about 800 deaths in the United States each year.

Symptoms of histoplasmosis appear within about ten days and include fatigue, fever and chest pains. Most of the people in the general population do not show any symptoms because most of the human population has immune systems that counteract the disease. Humans with weak immune systems such as cancer patients or those with HIV/AIDS are more at risk to the disease. The very old and very young and people with a poor immune system are at risk.

The disease is common in the central and eastern United States. The CDC or Center for Disease Control states that the Histoplasma Fungus is most common in the Ohio, Mississippi and St. Lawrence River Valley and the Rio Grande. The amount of spores that are inhaled accounts for the intensity of the injury to the person inhaling the dust containing the bird dropping. Good ventilation, wearing respirators, disposable coveralls, goggles, gloves and disposable shoe covers help to prevent the uptake of the fungus in the dust when working in clean up operations. The best way of preventing exposure to the fungus is by keeping birds from roosting in any of your buildings that you have to be in.

Another disease caused by the droppings of pigeons, starlings and sparrows is the ocular histoplasmosis syndrome. This is also caused by the infection of histoplasmosis capsulatum. This condition occurs when the central area of the retina of the eye becomes inflamed causing blood vessels to grow and swell. This area of the eye is called the macula. It is used for straight ahead vision by the eye. Close to a hundred thousand people get Ocular Histoplasmosis Syndrome which is a form of the disease that can lead to blindness.

Psittacosis also known as ornithosis or parrot fever is another disease which is very rare and infects birds like parakeets and cockatiels. Pigeons and other birds can be affected. The droppings that dry and become airborne in dusts can be inhaled by humans and cause sickness. This disease is very rare. In 1996 only 50 confirmed cases were reported and these cases were found with people with low immune systems that worked with pet birds.

Cryptococcosis is another bird related disease that is associated with pigeon droppings and known to exist in the soils throughout the world. Again healthy people never know they have gotten the disease because they aren't affected, but people with weak immune systems can be harmed by this disease. People that are harmed by the disease get two forms of infection. One is a cutaneous form that causes acne like skin eruptions or ulcers with nodules under the skin. The

other form begins as a lung infection and spreads through the body in the nervous system. This can be fatal.

Pigeons, starlings and house sparrows also carry ectoparasites that bite and irritate humans. These three birds are not protected by federal laws. All other known birds are protected by one or more federal laws and regulations in most cases. Non target birds in treatment areas are protected and any actions that kill or damage protected birds or their habitats are a violation of various laws. When approved toxicants or repellents are used product label instructions must be carried out during application. In many situations either a government person can be the applicator or a licensed applicator must apply the control materials or method of control. Permits may also be issued by government agents.

Pigeons! The domestic pigeon (Columba livia) developed from the rock doves of Europe and Asia. Brought to the United States as domestic pigeons they multiplied rapidly and became a source of food and a pest at the same time. Once they became wild they multiplied and nested in rocks and caves. As rock doves they eventually moved to buildings in the farms and cities.

In the country farm areas they feed on seed and grain, but in the cities they'll feed on food scraps that they find at outdoor restaurant patios. People who enjoy birds feed them in parks and other areas of the city. They use areas like the eves of buildings for roosting. Farm buildings are a favorite roosting area. Any type of structure that will give the pigeon shelter from the weather is where they'll roost. They also use these locations for nesting and congregating at night.

The pigeons use areas that are several miles from their nesting sites to loaf. In their loafing areas the pigeons spend their time cooing, preening, sun bathing and mating. They pick open areas because of their need to escape by flying away. In the cities the tops of the building are their favorite areas for loafing. I've seen roofs of the tallest homes covered with flocks of loafing pigeons and they tend to pick the same roof day after day.

The tops of particular skyscrapers in cities and particular farm barns are other areas that they loaf on. Building ledges, cooling towers, bridges and signs are also their loafing areas. Pigeons feed in village squares, parks, loading areas, garbage sites, rail sidings, food plants and wherever people or animals feed in outside areas become some of their favorite feeding areas. I seldom see flocks of pigeons in crop fields unless a grain field has just been harvested and there has been some grain spilled in the harvester to the truck loading operation. Years ago large flocks of passenger pigeons were a menace to grain fields before harvest. In Wisconsin the first underground seeder was said to have been built in 1860 to prevent passenger pigeons from eating grain as fast as it was sown.

After hatching mail pigeons become sexually active and female pigeons become sexually active six months after birth. Pigeons mate for life until one of them dies, then the surviving mate will find another mate. They share the incubation of the eggs. The male sits from mid morning through the afternoon then the female takes over for the rest of the day and through the night. Once the eggs hatch the pair will mate again in five weeks. The young can fly within a period of five weeks. The mating continues all year if conditions are right. A pair of pigeons will produce about ten young pigeons per year. The pair of pigeons will use the same nest as long as the pigeons live. The nest becomes hardened over the years by feathers, droppings, other debris and dead birds. The length of the life of a pigeon can last for three to fifteen years for pigeons living in the wild and for a period of thirty years for pigeons that are kept in captivity.

Flocks of pigeons number 50 to 500 pigeons at a time. Populations of pigeons are dependent on the supply of food. Usually pest exterminators of the pigeon problem use poison,

hawks, and nets as a means of reducing pigeons. These methods work on a limited basis, but restricting the pigeon food source and their nesting places are long-term methods. Government legislation on litter or garbage control has been successful in limiting the pigeon problem. Growers of crops face the same problems around their farm buildings and grounds. Some cities even set up locations that pigeons will nest in. Then they destroy pigeon eggs. Any method that reduces feed or nesting reduces the pigeon problem.

Poison control for pigeons has to be applied as restricted chemicals and requires a license. Because pigeons breed several times a year (up to six times a year) the number of pigeons can increase rapidly in an area where food is available. The pigeons that survive the poisons do not leave the area and because of the increase in food caused by the death of the poisoned pigeons the remaining pigeons mate more often and more pigeons move into the area. The poison can also kill predators like hawks. Where peregrine falcons are used to control pigeons, it is illegal to use poisons to kill bird pests.

Avian contraceptives are another method of control for pigeon problems. There is an EPA registered product, OvoControl P. It's a brand name and it contains the chemical, nicarbazin. Contraceptives for avian control have some support from animal welfare groups. These groups include: Humane Society, Society for the Prevention of Cruelty To Animals and PETA (People for the Ethical Treatment of Animals). The development of contraceptives for the control of wildlife is being developed on a more rapid basis at the present time.

Starlings! Starlings when flying have short tails with short pointed wings and long slender beaks. They look similar to stars that have four points. This is what gives them their name, "Starlings". The history story of how starlings came to the United States is that "*less than 100 of them were brought here to Central Park in New York in 1890 by a group of the people headed by Eugene Schieffelin who had a goal of bringing all the different kinds of birds mentioned in the works of William Shakespeare, the playwright and poet".* Starlings now number in the hundreds of millions. They are now seen in most of areas of the United States, Canada and northern Mexico.

They, starlings, often join with other birds like blackbirds, Cowbirds, house sparrows, rock doves and common crows usually feeding in towns, cities and farm areas. Starlings need water, food and nesting areas. They avoid large forest areas or woods, arid grassy plains and deserts. Some of them migrate as the season changes and some of them stay in one area. Migration depends on which part of the earth's area that they occupy. In the areas below or south of the forty degree latitude line the breeding adult starlings stay in one place all year. Starlings above this area migrate on a yearly basis.

Starlings are not protected by the Migratory Bird Treaty Act: therefore federal law allows destruction of starling: adults, nests, eggs and young in a humane manner. Starlings will evict other native birds from their nests. They are a pest because of their immense numbers. It's estimated that each year starlings cause damages amounting to more than eight hundred million dollars a year to agriculture crops in the United States Of America.

About the size of the Robin, Starlings have shiny black feathers with a green mixed purple sheen, short square tail (unlike the grackle with its long tail) and when flying the tail is in a triangle shape. The common black birds have yellow eye rings whereas the starling's eyes are black. Starlings' bills are long and pointed and yellow during the breeding season which is January to June then the bill turns dark. Their legs are pinkish-red. The juvenile starlings have grayish brown feathers with white spots on their head and breast after their first molt. During this time of growth the juvenile look like a different bird. Both the male and female look alike.

Starlings waddle instead of hopping. Unlike the blackbirds that rise and fall during flight the starlings fly direct and fast. Starlings molt one time a year after breeding and spots that show up in the winter wear off in the spring time and they end up with a glossy black look during the summer months.

They have an unusual jaw that springs open to allow them to grip their prey and pry apart plants when feeding. Starlings eat about everything. This includes fruit: strawberries, blueberries, grapes, tomatoes, peaches, figs, apples and cherries. They also eat grains, seeds from seed crops and seeds from plants. Insects, worms, grubs, millipedes and spiders are consumed by starlings. They occasionally consume lizards, frogs and even snails. They can be seen foraging for insects and small animals on newly mowed lawns and pastures.

Their breeding habits allow them to breed in close quarters with other starlings. They fight over breeding sites often to the death. When fighting they grab their opponents with their feet and peck them to death. Year after year they come back and use the same nest for laying their eggs and rearing their young. They will evict other birds from their nests like woodpeckers, wood ducks, tree swallows, bluebirds, purple martins, great crested flycatchers and screech owls.

Starlings enter bird houses built by people for other birds. They can enter round holes in these bird houses that are one and five eighth inches in diameter or slots that are one and a quarter inches. Most of them will not enter crescent shaped holes that are two inches wide by 1 and three sixteenth inches tall. These are built for purple martin birds. The typical insect predatory bluebird nest box hole is one and a half inches wide and starlings cannot enter these tree houses. When squirrels or woodpeckers enlarge the holes the starlings can enter and even if they can't enter they may reach inside and attack the nestlings and the eggs. When they inhabit the nest they will viciously protect it from other animals.

Male starlings choose the nest sites then females pick out males and their nesting sites. Males that stay in one area and do not migrate start looking for nest sites at the end of winter. Male starlings that migrate during the year begin checking out nest sites during February and March. The site for nesting by a starling can be any structure or earth location that can contain and support a nest. These locations include: cliffs, rock crevices and burrows also dense vegetation in trees or even on the ground. They usually nest in holes in buildings, poles, and signs, attics, eves of buildings and other bird nests. The female starling once she picks the mate with his nesting site helps build the nest. She will sometimes throw out what nesting products the male puts in the nest and the two of them will often remove objects used in the old nest that the male has taken over. They will use a variety of nesting materials including straw, small limbs, dried leaves, paper, cloth, string and other items. Some starlings use fresh green plants. These are thought to be used as fumigants. As the green vegetation rots it gives off a fumigant against pathogens that are present. The starling's nest depth is around three inches and the diameter is a little over two inches wide.

Their first eggs are produced in the middle of March. Once one female starling lays an egg the rest of the flock join in. They lay eggs from mid March in the south to mid June in the north. Eggs are laid from eight o'clock to eleven o'clock in the morning producing one egg a day. They lay four to seven eggs per batch. The eggs are colored pale bluish or greenish white. Some are spotted with reddish brown spots. These eggs hatch in twelve days or so. The male will brood the eggs while the female feeds. The male will spend about thirty percent of the brood time on the eggs. The female will increase her time as more eggs are laid and this will amount to the other seventy percent of the brood time. In certain cases the starling couple will cover the eggs when they have to both leave the nest.

In eleven to twelve days after the eggs were laid, the eggs begin to hatch. The chicks can fly in twenty one to twenty three days after hatching. The young starlings stay around the nest with the adults for a period of ten to twelve days. In some cases the parent starlings may produce another brood. This will often occur if the first brood takes place early in the year. Once the newborn have left the nest and the adults decide to have a new brood, new nesting is started within a couple of days or nesting may start in forty to forty four days. The same nesting site may be used for several years. Materials similar to the previous nest building are used to cover the old existing nest and laying eggs begins for the second brood for that year. Starlings have a life span of one year under most conditions.

When starlings begin to flock, they shift their main source of food from insects and fruit, to grains, seeds, livestock feeds and garbage. They leave the nesting areas and fly direct in pathways to the location of their food. They will fly as far as sixty miles to the area. These flocks may contain thousands of birds and the sights of the flights are an entertaining spectacle for many people and photographers. While I'm researching this course on the web I can observe some spectacular photographs of flocking by starlings.

After feeding, these birds return to their nesting locations by flying to staging areas such as trees, high wires, bridges and towers. During this move back to their nests the starlings are very social and will sing and call out to one another. This will go on until late evening before returning to their nests. Starlings are pests because of their massive numbers. The large amount of fecal matter that the flock showers down contaminates livestock food, growing crops, food processing areas, water troughs and public areas like sidewalks, parking lots and patios.

Starlings, sparrows and pigeons are not protected by federal laws and in many cases by state laws, but laws are different and control methods should be checked out with agricultural agents when control measures are begun. The toxicant Starlicide is a restricted use pesticide and requires a permit to use. Often only government employees can apply vertebrate pest materials. Because of the flocking habits that starlings carry out the use of nets for trapping the birds is a method of control. The standard poison used is Avitrol (trademark for 4-Aminopyridine). It is most effective in winter, when food is scarce and bait is readily accepted. Grain is typically used, however, it is important to be aware of any local poison control laws before proceeding. Naphthalene, another chemical, is an olfactory repellent.

Sparrows! Sparrows are considered to be one of agriculture's strongest vertebrate pests. They feed on young vegetable plants, peas, turnips, wheat, corn, barley, oats and cabbage. Fruit is one of their favorite foods and include: strawberries, raspberries, grapes, cherries, peaches, plums and apples. Their nesting habits damage manufacturing and food processing plants as they stop up drain pipes and gutters. Their nests result in water damage due to the resulting flooding, electrical shorting and fires in the building's and machinery. Structural damage can be the result of sparrow manure build up which can also cause health risks.

Agricultural efforts to control insect pests in their crops were responsible for bringing the first sparrows called house sparrows from Europe in 1851 to the Brooklyn, New York area. In Europe the sparrow had many natural enemies that kept control on massive outbreaks of the house sparrow, but these enemies didn't come along with them when they were brought to the United States. The house sparrows rapidly multiplied and became a pest. The other areas in the United States like California imported the birds for crop protection before they heard that they can become a very serious pest that could become worse than the insect pests they were meant to control.

It is reported that by 1900 the house sparrow had become the most plentiful wild bird on

the continent. Now at the present time house sparrows are the most widely distributed wild bird on the planet, earth. House sparrows crowded out blue birds and other nester birds. House sparrows do feed on insects, but they also feed on agricultural produced products when available. As the horse drawn form of movement by humans was replaced by the motorized vehicles the horse produced manure and accompanying flies were reduced. The house sparrows populations also reduced. The house sparrows learned to adapt by feeding on garbage and other food sources that humans produce and the population numbers of sparrows came right back, only stronger.

The house sparrow male is adorned with a black throat and white cheeks and is about 6 inches in length. The female has a brown bib and the male has a reddish back and a black bib. It is a stocky bird with short legs and a thick bill. They call with series of metallic sounding "cheep-chirrups".

House sparrows are found throughout the United States. They start their nest building in February and both sexes take part in the building. Nests can usually be build almost anywhere. They use grass, straw, and any type of debris. The female lays three to seven eggs averaging five. The sparrows produce three to four broods each year. The incubation time is 11 to 12 days. The young are able to fly within 15 days. Four females may use the same nest in a year's time.

Swallows! Swallows are small songbirds. The male has a thick black bill during the summer months that yellows during the winter. He has a gray crown with pink legs, a black throat and a black area over this face that makes him look like he's wearing a mask. The sides of his neck and under parts of his body are grayish with a definite gray rump and he has a white patch on his wings. The female has a colored stripe that lies out backwards from her eye. Her under parts are grayish with a white tinge of color. She has black and tawny streaks on her back. Her feathers are black with a white patch on her wing. The bill of the female sparrow is yellow. The female sparrow has narrow body outline while the male has a rounded body shape.

Both the male and the female swallows work together when building their nests. This building of nests starts in the month of February. They construct the nest from straw, grass, feathers, hair and other available debris. The nests are built in and on several locations which is a problem caused by the large numbers of nests that are erected. They nest in vents, ledges, building eves and any other nook or cranny as well as trees and other birds' nests or bird houses. The male may lose a mate, but he keeps the same nest if at all possible. Females go for the male's nest more than the male. Agricultural feed lots and farm buildings are swallows favorite locations, but they also like urban areas because of the food sources.

The female lays three to seven eggs for an average of five. She can lay twenty five eggs per year. The color of the eggs is white and brown speckled. They are incubated for a period of eleven to fourteen days and the young swallows are ready to fly in fourteen to sixteen days. The nest of a swallow may be used by as many as four other females during a season. The swallows do not migrate but they will move within an area of five miles in diameter. After leaving the nest the young swallows gather in flocks. As the season progresses the adults will join the young swallows and the flock will grow to several hundred.

Bird control! Before using control methods for bird pests observation and identification of the birds should be carried out. Using devises that scare the birds away from areas and buildings where birds roost are effective, but in the nesting areas where birds can become used to the noises they tend to ignore them. Noise makers include shell crackers, blank shots and fireworks, but these must be approved by law officials. Around feed lots, buildings and hedges or trees the use of wind moved foil strips, flags and fluttering scarecrows are not effective whereas in crop fields like newly planted lettuce these items are somewhat useful if moved about the

field. Sticky repellents on rafters, beams ledges and other structures that allow birds to land on are able to keep birds off of the treated surfaces, but the amount needed to cover all the places that small birds like swallows land can be very time consuming and expensive. Shooting only gets a few birds and the rest of them keep coming.

Trapping the birds especially in large numbers has been one of the most effective methods of control. Consult a state wildlife official before using a decoy trap. The large box like trap should be twenty feet by twenty feet by six feet. A net enclosure can be used. The top of the cage should have a two foot by four foot entrance. The entrance should have a flap that can be closed with a pull cord or a long handle. A baffle that can be moved from end to end inside the cage can be used to drive the birds to one end forming a catch cage. Any birds that are not the target bird like bluebirds should be released. The pest birds should be put to death in a humane manner. The use of carbon dioxide gas from a CO 2 bottle can be used. Decoy birds and bird food inside the cages can be used to attract the target birds to the trap. The bait food can be millet seed or other seeds that attract the target birds. These traps won't get all the birds, but the traps are good for reducing bird pest populations. There are several trapping methods for both large flocks and small numbers of birds.

Other Bird Pests! Black birds, brown headed cowbirds and grackles can become pests along with starlings, swallows and pigeons. After identification, notification should be reported to game officials and permits should be obtained before proceeding with control methods.

Pocket Gopher Control! The bird pests that I have discussed are found to be pests because of their populations. They are pests because of the overwhelming numbers that they become. They consume a great amount of crops. Whether it is fruit crops, seedling vegetable crops or grain in a field, their high numbers consume enough to cause economic damage. Also their high numbers produce large quantities of fecal matter that is damaging to farms, cities and factories.

The next vertebrate pest that I will discuss causes severe problems as an individual. Adult pocket gophers work alone, eat alone, live alone and damage things alone without help from other gophers. Because they do not live with other gophers, their exposures to deadly communicable disease are almost nonexistent. The only time that gophers do join with other gophers is when they mate. Then the male goes back to his burrow. The period of time when the young are born and grow from babies to young adults only takes two months then the young gophers leave the mother and head out to set up their own underground territory where they'll fight vigorously to keep other gophers out including their brothers, sisters and parents. Each single gopher has to develop a new burrow system for itself. This system of one gopher per burrow system increases the amount of acreage inhabited by gophers. A population of fifty gophers per acre is an exceedingly large number for the average gopher infestation. While the rodent called voles that are located in the areas north of Arizona has populations that number in the thousands per acre. When you have to spend the time and money to kill one rodent compared to killing several hundred the cost and effort per rodent becomes very expensive.

Unlike other vertebrate pests that die off in cycles when diseases strike the large populations, gophers are loners and very seldom have a disease problem. In the area of Taft, California which is near Bakersfield and the town of Buttonwillow, a town where I once lived, a massive outbreak of field mice occurred in nineteen twenty six. This was before my time, but it happened. The large land company in that area called Miller and Lux planted eleven thousand acres of barley and maize on the nearby Buena Vista lake bed. The field became a breeding ground for field mice. Then it started raining and the lake became flooded. The mice headed to

Taft and were also on their way to Bakersfield. The Taft highway became covered with mice both alive and dead from being run over by truck and car traffic

While the people and the government went to war trying to stop the invasion. Over 1500 pounds of poisoned grain was spread in trenches a day. They said there were over one hundred dead mice per foot, but it didn't slow the invasion of these rodents. They took a tally and estimated forty four million live mice were present and the mice kept moving. Finally the mice attracted thousands of sea gulls, hawks and other birds of prey, but the final thing that stopped this mouse invasion was a contagious mouse disease that started up and wiped out the mice invaders.

Gophers don't make enough physical contact with other gophers to spread diseases to one another. Other vertebrate pests like rabbits, birds and rats are more social and diseases can kill off large numbers of these social groups. The young gophers after being weaned are driven out of their underground tunnels by their mother to go about the soil surface looking for a place to start digging their own tunnels. On the soil surface they are subject to danger from predators like the hawks, owls, coyotes, snakes, foxes, badgers, domestic dogs and cats. When the males or females are above ground looking for mates they are subject to the same dangers. But the rest of the time gophers are alone and free from communicable diseases.

In Arizona there are three species of pocket gophers. In California there are five species. The most prevalent in both states is the Thomomys bottae which are called Botta's or valley pocket gophers. The Game and Fish Departments of both Arizona and California classify the pocket gophers as non-game animals. This means that if the animal is causing damage to both commercial and private property it can be controlled by any legal manner.

The burrow system for a gopher is contained in an area of from 200 to 2,000 square feet. The round shaped burrows are from two and a half inches to three and a half inches across. The nesting and storage burrow or chamber may be six feet below the surface of the soil. The gopher seals their openings to the burrow system with plugs made of soil. Gophers make several lateral tunnels that they use for access to the soil surface. These lateral tunnels are sloped from the main burrow to the surface. When they make the main burrow system the gopher uses the lateral tunnels to transfer dirt to the surface. The dirt moved to the soil surface by the gopher results in the gopher mounds that are evidence that gophers are active in the area. Even though you may not see fresh dirt in the mounds they are still busy and may be present. Gophers don't work on the daylight to dusk schedule. They are active during a twenty four hour period resting when they need to.

These gopher mounds are similar to another burrow system identified as the mole. Mole mounds have a ridge of dirt around edges of their mounds with a hole in the middle of the mound that may not look like a hole because the hole may be plugged with soil. The mole mound is similar in shape to a small volcano whereas the gopher mound will have the hole at one end of its horseshoe or fan shaped mound. Also moles burrow just below the soil surface building a visual raised ridge over their route where they have burrowed under the soil. The moles are not present in the drier state of Arizona. In California moles do inhabit the Sierra, the coast Range Mountains, foothills and the coastal zone. Moles usually aren't found in the big valleys of California.

Gophers do not migrate from one area to another every season. In agricultural areas where irrigation makes the soil an easy place to dig gophers will make several mounds per day. The same goes for urban areas that include golf courses, flower beds, lawns and gardens. In these irrigated areas mounds can appear on a year round basis. In areas where irrigation isn't a practice

the gopher mounds appear during the spring and in the fall. In areas that receive snow, gophers continue to make burrows in the snow. After the snow melts the burrows that the gopher made in the snow level that is above the surface of the soil have earthen cores. When feeding in snow covered areas gophers can feed on the bark of tree trunks at a fairly high level above the soil surface by burrowing through the snow.

Pocket gophers are named for the cheek pouches which are external fur lined pockets located on either side of their face. These handy cheek pouches are used by the gopher to carry food and nesting materials. They keep these external pouches free from any dirt.

We humans have teeth and our upper middle front four teeth are called incisors. The pocket gopher has four large incisor teeth that they use for digging. Forty percent of the mammal species are classified as rodents. Rodents are characterized by two continuously growing incisor teeth located on the upper and lower jaws. Gophers are rodents and their incisor teeth grow continuously. This growth of the incisor requires a great deal of gnawing on hard soil, rocks and roots to keep their incisors filed down to a manageable length. The gopher's lips are adapted so that they can close them behind the incisor teeth while digging with them. This unusual ability keeps the dirt from entering the gopher's mouth.

Adult pocket gophers weigh six to eight ounces and they are about nine inches long. The entire body of the pocket gopher is made for their existence below the soil surface. Their fur is very fine and doesn't cake up with mud when in wet soils. They have large front paws with powerful shoulders giving their front quarters the strength needed for digging their many tunnels. Because through most of their lifetime they move about in darkness the eyes and ears are small cutting down the amount of soil that could enter them. To make up for the loss of sight they possess very sensitive facial hairs or whiskers that they use to feel about in the dark. Gophers with their sensitive tails guiding them can move very rapidly when backing through their tunnels. They can run backwards for distances of ninety to two hundred feet.

After the young pocket gophers leave the family burrow and have started their own burrow system they begin mating. The young gophers become sexually active in one year. Gophers manage to live for a period of three years. In areas that are not irrigated pocket gophers will mate during late winter and early in the spring. This mating will usually produce one litter per year. In irrigated areas the pocket gopher will breed more often producing up to three litters a year. Each litter averages five to six young pocket gophers.

The food consumed by pocket gophers includes herbaceous plants, shrubs and trees. One of their favorite crop foods is alfalfa. They locate their food by their sense of smell. The main parts of the plant that they consume are the roots. Pocket gophers use some of their holes as feed holes. These feed holes do not have mounds of soil around them and they are open holes. The gopher will move about a body length from the hole. This allows them to go back into the hole if anything approaches that may harm the feeding gopher. In this way the gopher is able to feed on vegetation above ground near their feeding hole. They will sometimes pull entire plants into one of these tunnels where they feed on them without danger. The feed hole will be blocked off after feeding with dirt plugs made by the gopher below the holes entrance. This prevents snakes and other animal predators from entering the burrow system of the gopher. The gopher feed hole is made by clipping the vegetation immediately around the hole. A hole without a dirt mound can be used to identify the presence of gophers.

The pocket gophers way of existing can and does do a great deal of damage to our human endeavors. Their need for their favorite food, alfalfa, results in damage to the hay harvest equipment from their mounds. The collapse of the levees by gophers that guide the irrigation

water through the field is one of their irrigation damage activities. The collapse of the cement ditches and these structures results in costly repairs. The burrowing damage near buried sprinkler systems, drip irrigation systems, concrete pipe systems and cement canals is a costly damage done by the living activities of gophers. Their underground tunnels can carry off water to neighboring fields where unwanted water can cause severe yield damage. Gophers with their sharp incisor teeth gnaw on and destroy underground plastic pipe systems.

We have a very wide concrete sidewalk near our residence that connects two schools. The young students use it to walk to school and physical education activities. The mature residents use it to exercise: bike riding, jogging, running and strolling. The amount of malva weeds growing near the walk during the spring and summer months become a dining need for the gophers in the area. Heavy illegal motorized vehicle traffic that uses the wide sidewalk have broken through the concrete where gophers have tunneled under to harvest the malva weeds on either side of the sidewalk. The gophers are hunted down and exterminated periodically, but the motorized vehicles keep tearing up the city sidewalks.

Prevention of golf course damage by gophers is one of their management's biggest expense items. Cemeteries and public parks used to beautify cities and towns are constantly maintaining damage from gophers. Dirt trails with gopher tunnels under them are a hazard to hikers. Cattle and other livestock break legs when stepping through the underground burrow systems of gophers in their pastures. Damage to bushes, flower beds and trees can be caused by gophers. Direct damage to growing crops and home gardens by gopher feeding is a major problem in most areas. Mounds containing soil that comes from below the level that herbicides have been applied allows annual weed seeds to germinate in this new soil.

Controlling Gophers!

The two best methods of controlling pocket gophers are by baiting with poisons and trapping that physically kills them. In order to do either one of these methods of control the location of the gopher must be found. The mounds produced by the gopher are used to find their location. If the mound contains fresh soil the gopher is usually in the area. The fresh soil in the mound is soil that the gopher has moved from its main burrow up one of the slanting lateral tunnels to plug the tunnel and at the same time it's used to enlarge the burrow.

Probes are used to locate the burrow where you may either place a trap or some poison bait. The gopher probes are available at farm stores or available on line. Probes can also be constructed either with pipe and a metal rod or from dowels or sticks. The metal rods are used in hard soils and the dowels, sticks and pipes are used for soft soil.

A probe can be made from a ¾ inch iron gas pipe that is 30 inches long that has been threaded on both ends. To this pipe thread on a ¾ inch T joint with the bottom of the T into one end. Then add another T joint threading it onto the other end of the 30 inch pipe to one side of the top of the T joint. Then take another ¾ inch pipe that is 14 inches long that is threaded on one end and thread it into the other side of the top of the T joint that you threaded to the top of the T joint to the 30 inch pipe . Cut another ¾ inch pipe that is 15 inches long into three equal pieces. Thread one end of each of the 5 inch pieces and fit one 5 inch piece into the bottom of the T joint that is sticking out of the 30 inch pipe joined with the 14 inch pipe. Take the other two 5 inch pieces of pipe and screw them into the top two holes of the T joint on the other end of the 30 inch pipe. To enlarge the tip that increases the speed of locating the burrow you should take a piece of round iron ½ inch pipe that is 2 inches long and weld it to the unthreaded end of the ¾ inch pipe that is 14 inches long. Now you should have a probe that is over 44 inches long with a Tee handle at the top and foot rest near the bottom to press in the probe with your foot. In hard soils

this same design using heavier gage pipe that is welded instead of threading at the T joints will increase the strength of the probe.

After you have located a pocket gopher mound that has fresh soil and you are able to see the plug side of the mound you can start probing. You should start in this side of the mound at about 8 to 12 inches from the plug itself. The burrow will be located at a depth of 6 to 12 inches. You will know when you hit the burrow with the probe because the probing depth will have a sudden penetration of the soil of 2 inches when the probe encounters the burrow. This awareness of the sudden drop in depth to find the right location may take some practice on your part. Because pocket gophers do not often use the lateral tunnels it is necessary that you find the main burrow where the gopher spends most of its time. You can also use a shovel or trowel to locate the main burrow by digging in the same locations around the mound plug.

Once you have located the main burrow and you are using poison baits use a long handled spoon to place the proper amount of poison in each direction. Then block off the burrow tunnel. The long handled spoon will place the poison far enough from the soil block that you made to the gopher's burrow. Gophers will add another amount of soil to any disruption and they may cover the poison if it isn't placed far enough away from the dirt that you added to cover your hole in the burrow.

Some probes have a dispenser on the top of the probe. With these probes you push a button that dispenses the poison into the burrow. You then cover the hole caused by the probe with sod. Otherwise the gopher will cover the applied bait with soil to plug the hole. When applying poison with the probe dispenser you should dispense the poison in two or more areas in the burrow system. The dispenser type of probe application is a faster method of application. Some of the gophers may die above ground; therefore the area treated should be checked 10 to 14 days after application and if any dead gophers are found they should be buried or incinerated.

A mechanical burrow builder is available at some farm stores, implement dealers and on-line. These implements are for treating entire fields by building burrows that are at the same depth as the native gopher burrows. The unit is pulled by a tractor with a three point hitch. It has a coulter blade that cuts roots ahead of the knife that cuts the soil ahead of a torpedo assembly. A seeder with a container dispenses poisoned bait followed by a packer wheel that closes the soil behind the knife. A metering device on the seeder box dispenses the poison baits at different rates. The burrows made by this machinery make burrows across the gopher burrows. The gopher will enter the new burrow and if it finds the bait it will fill its cheek pouches and go to its burrow to eat the bait. The recommended amount of bait dispensed, amounts to 1 to 2 pounds per acre of 0.3 to 0.5% strychnine alkaloid grains. The burrows should be made at 20 to 25 foot intervals across the field. Kill rates have been in the 85% to 95% rate. The soil should not be too wet or too dry for best results. Pest control licenses are required when burrow forming baits are used in most states.

Using the probe or a shovel to place gopher traps in a gopher infected area is another method of gopher control. Trapping is often the method of gopher control in smaller infestations and some trapping may be used after using the mechanical torpedo method of gopher control. This can be used to eliminate the 5% to 15% percent missed by the torpedo method.

The poison baits include: strychnine at 0.5% and 2.0%, zinc phosphide. Both of these poisons are lethal after a single feeding. Anticoagulants require multiple feedings and need a large amount of bait. You should figure on using as much as ten times more bait with anticoagulants as you have used with strychnine. Anticoagulants are safer and can be used where pets are present. When used in burrows with high moisture content baits will decompose in a

short period of time. A new bait that has a mixture of toxicant plus anticoagulants and is contained in a paraffin block. This extends the life of the poison bait and can be consumed by another gopher that moves into the burrow system after the previous gopher dies. Always follow label requirements.

Trapping gophers is another popular method of controlling this vertebrate pest. There are several types of traps available. The Macabee is one of the most famous. It is called a pincher trap. When the gopher triggers the trap by pushing against a flat, vertical pan the trap releases the pincer spikes that come together catching the gopher's body from either side. There are several gopher traps besides the Macabee. The box trap is the easiest to work with, but you will have to do a little more excavating to put the box trap in the right position. Box traps fit in the smaller burrows that are less than 3 inches in diameter. The pincer type traps require larger than 3 inch diameter burrows; therefore you will have to enlarge the burrow size when placing these traps. Use two traps once you have located the burrow. Place the traps with their openings facing in opposite directions. This will trap a gopher if it is coming from either direction.

Some gopher trappers use a bait to attract the gophers, but many trappers are successful without a bait. The baits include: apples, alfalfa greens, carrots and even peanut butter. Put the bait in back of the pan that triggers the pincer trap and in back of the box trap behind the trigger wire. Use wire to attach the trap to a stake placed above the trap. This will allow you to retrieve the trap from the burrow. Some type of flag can be used to mark the stakes so that you can find them.

Again some trappers cover the gopher traps to keep light from shining in, but other successful trappers leave the trap hole uncovered. Covering and uncovering traps takes time; therefore you may want to do both and see which way works best for you. The box trap should be covered because the gopher in order to block out the light may trip the trigger on the trap when it starts pushing soil around to block out the light. Covering can include cardboard, canvas, plywood or dirt clods.

Fumigants that are registered for gopher control include aluminum phosphide and various gas cartridges. Fumigants usually move too rapidly through the tunnel system to do much harm to the gophers. The soil can be too dry and may contain enough air for the gopher's breathing needs and enough air to disperse the gas. Carbon monoxide from auto exhaust pipes is lethal to gophers if the hose to transport it is placed in a tunnel near a fresh mound of dirt. Pack the soil around the transport hose and run it for over three minutes. The newer cars with antipollution devices will need to run the engine for a longer time. This method is said to be ninety percent effective.

The uses of gravel barriers around cables will prevent gophers from gnawing them if the gravel is over one inch in diameter. The gravel should be six to eight inches thick around the gables. Cables and irrigation lines that are covered with material to protect them will protect the cables or irrigation lines if they have an outside diameter of over 2.9 inches. This diameter is too great for the gopher to obtain a grip on it. This diameter is almost a flat surface to the gopher's incisor teeth. Any soft material like aluminum or lead will be gnawed into unless the surface is rounded at over the 2.9 inch diameter.

Rabbits! The vertebrate pest identified as the rabbit includes: the black tailed hare called the jackrabbit from the way it travels rapidly across the crop fields hopping instead of running; the desert cottontail with its white fluff of a tail; and the brush rabbit which is the smallest of the three with fur that is pale gray containing yellow tints. All three of these animals are a pest when their need for food is such that they have to invade crops for a meal.

Jack rabbits are hares not rabbits and because of their size they are a more destructive pest than the brush rabbit and the cottontail rabbits. Hares have longer legs and ears and they are larger than the true cotton tail and the brush rabbit. They hop instead of run and they flee from their predators while rabbits hide from their predators. Their bodies are grayish brown with black tipped ears and the top of their tail is black. Jack rabbits and other hare babies are born with fur, eyes that are open and able to hop and see. They take shelter in hollow spots in the ground or vegetation and do not build nests when they give birth. Their new born are ready to, see, hop, are covered with fur and they don't require a nest other than the low spot in the soil. Adult Jack rabbits weigh 3 to 7 pounds and are 17 to 21 inches in length.

They inhabit open areas of land in California and Arizona. Jack rabbits are able to exist at the edges of cities and in the urban developments' as well as the golf courses, parks, airports and farming areas. They spend their days hiding in a depression in the soil, which is referred to as a *form* under a bush or other vegetation. They use this shelter to hide in during the day, but during dusk until early dawn they are out and active. There are an average of 1 1/5 jackrabbits per acre when they are present. This number can increase rapidly when they reproduce with plenty of food present. They have litters of 2 to 3 young and 5 to 6 litters per year. As I said the young jackrabbits are able to move about rapidly within a day after birth.

Jackrabbits consume plants that are available, but they prefer succulent, green plants. Grasses and herbaceous plants are their main source of diet. They will eat leaves, bark, and seeds of the woody plants. They can survive without drinking water thus obtaining the needed moisture from plants. As long as food is in one area they will stay in that area. Travel of 1 to 2 miles is common for jackrabbits, but during drought conditions they will travel up to 10 miles in a day. They use the same noticeable paths caused by their travels.

One way of knowing that rabbits are present in an area is from their fecal matter droppings. The fecal pellets are rounded with the jackrabbit's ball of fecal matter having a diameter of ½ inch while the cottontail and brush rabbit have fecal pellets with diameters of ¼ inch.

Brush Rabbits and Cottontail Rabbits are found in areas where there is abundant brush and wooded areas. This is the opposite of the jackrabbit's living areas. The brush rabbit and the cottontail will be found living in piles of rocks, raised shed corners and other abandoned buildings. At night they forage in open areas and in the dense foliage areas during the daylight hours. They stay in the areas with cover and only venture a couple of feet from any cover when feeding. In areas with good cover and eatable vegetation brush rabbits and cottontail will occupy an area of about 10 to 15 acres. They don't travel as much to obtain food as the jackrabbits, but like the jackrabbits they do make trails that they use to travel to and from feeding areas.

Brush rabbits and cottontails breed from December to the following June producing 6 litters numbering 3 to 4 young rabbits per litter. Their nests are just a shallow dip in the ground scratched out by the female who pulls fur from her chest along with grass, twigs and straw from the surrounding area with which to line it. The young brush rabbits and cottontail rabbits are born naked and blind. The female will forage for food and return to the nest at dawn and at dust to feed the baby rabbits. Unlike the jackrabbit newborn the brush rabbit and cottontail stay in the nest for several weeks. Because the adult rabbits spend most of their time away from their nests people will often come on the nests and think that these young rabbits have been abandoned. This isn't the case and the young rabbits should be ignored. Handling them may allow disease carrying vermin to bite human beings. If a person handles the young rabbit's the mother will abandon them.

Rabbits feed on and destroy vegetable crops like lettuce, beans, broccoli, carrots, beets and peas. They will damage the bark on fruit trees and ornamental plants. In crop areas next to rabbit infested wild areas around Yuma, Arizona and Bakersfield, California I've seen heavy damage done to cotton and alfalfa fields. Coyote hunters used to come out from the L. A. area and the City of Bakersfield with their spotlights and coyote calling horns killing the coyote predators that kept rabbit colonies in check. They thought the growers would appreciate this deed, but the rabbit infestations after these coyote hunts caused drastic crop damage.

Jack rabbits will consume ½ to 1 pound of vegetation per day. Older trees have bark that is tough enough to discourage gnawing, but young trees can be girdled by rabbits. Clipping of the terminal shoot and lateral branches of small landscaping bushes and plants by rabbits causes expensive damage. Rabbits will also gnaw and cut irrigation lines and tubes. Rabbits can be carriers of rabbit fever or tularemia. This a disease that can be passed onto humans who handle the rabbits with bare hands or eating wild rabbit flesh that has not cooked enough to kill the disease.

California and other states have a Fish and Game Code that classifies jackrabbits, cotton tails and brush rabbits as game mammals. If the rabbits are damaging crops, landscaping, ornamental plants or gardens the owner or an employee working on that person's behalf can control these animals anytime or in any legal manner.

There are several methods for the control of rabbits. These control methods include: fencing, tree trunk guards, trapping (especially the cottontail and the brush rabbit), repellents and destroying areas where rabbits tend to nest like brush piles, rock piles and unneeded brushy areas. Shooting is a control method where it is safe to do so. The use of devices that scare rabbits like: noisemakers and flashing lights aren't effective. Toxic methods of rabbit control have to be cleared with the state that it occurs in. Contact your farm advisor office or the state US Fish and Wildlife Service for permission for methods of legal control of rabbits, also the state office of USDA/APHIS Wildlife Service

Meadow Mice! Another vertebrate pest is the meadow mouse or the vole. In Arizona the vole can only be found at elevations of 4,000 feet or more. Voles, *(M. montanus,)* sub-species *M.m. arizonans* can be found in East-central Arizona in the White Mountains and Blue Range in Apache and Greenlee counties.

California voles are a serious vertebrate pest in the central valley and along the California coast. These meadow mice should not be confused with the house mice that invade homes. The populations go through increases over a period of 3 to 4 years that can infest a field with several thousand mice or voles per acre. The damage is devastating. Crops that voles infest include: Brussels sprouts, cabbage, lettuce spinach, tomato, turnips, cauliflower, artichokes, carrots, and celery. Tree crops damaged by voles include: apple, avocado, citrus, olive and almond. Voles gnaw the bark off of the trees a couple of inches above and below the ground. They can also climb up the low branches of the trees and damage the high parts of the trees. The damage to the trees after the voles remove the bark stops the flow of water and nutrients to other parts of the tree. This damage causes the tree to produce lower yields and the tree yellows and eventually can die.

Unless the voles are noticed their populations can increase to the damage level because of the steady multiplication of their numbers. The first sign of a population of voles is their droppings on the ground. They make runways on the ground and through the weeds. Their gnaw marks are 1/8 of an inch wide and 3/8 of an inch long. These gnaw marks are in irregular patches. Their burrows in the soil are another sign of their presence. Removing the soil from the

base of the tree where they have removed the bark will keep any disease from the soil from entering the trees living system.

As we check fields and crops for other signs of pests and their damage we should be on the alert for vole damage in the areas that have a history of vole infestations. By controlling a small population the damage of voles can be stopped. Killing the cover that these pests use which includes weeds and other low growing vegetation will allow you to see the voles as they start to multiply. The neighboring areas that provide cover for the vole activity should be checked also. If it's a neighbor's field notify the owner or their help.

Voles are a small rodent that is 3 to 8 inches long and this includes their tail covered with short fur. They have the appearance of a small gopher. Their heavy body is compact with short legs. Their eyes are small and their ears are partially hidden. Their body is covered with long coarse fur that is blackish brown to grayish brown. They are sometimes described as looking like a cross between a mouse and a gopher. Voles like gophers spend a lot of their time below ground in their burrows, but they spend enough time above ground to lay down well traveled runways on the soil surface between the 1 ½ to 2 inch diameter openings of their burrows. These grass or other ground covered runways are a sure sign of the presence of voles. If you pull back the grass or ground cover the runways become visible. The vole runways contain fresh clippings of green grass and fecal droppings that are 3/16 inch long and green colored. As they age the droppings lose the green color and turn brown or grey. These are signs of the presence of voles although once in a while you can see these small creatures running back and forth on their runways.

The voles only live for a short period of time when compared to other vertebrate pests. After breeding the female produces a litter of eight young voles in about 21 days. They breed throughout the year. The meadow mice or voles live for a period of 10 to 16 months. Voles do not hibernate and they feed during any time of the 24 hour day. Once they reach adulthood which is in about two to three weeks after birth they set up their territory which is only an area of a few square yards depending on the available food.

The use of snap traps set out in their runways for checking the presence of voles is also a way of deciding the size of the infestation. For control the use of poison baits when approved by the state authorities is allowed. The toxic baits when allowed are effective in controlling voles. Poisons include zinc phosphide at the rate of 1 to 2 pounds mixed with a hundred pounds of grain bait with a mineral oil used to make the poison stick to the grain bait. Another poison that is severe is the 1080 that is used by permits issued by the state. This should be broadcast or spread on the visible runways made by the voles. The treated grain can be spread by ground or by aircraft at the rate of 5 to 10 pounds per acre if the vole infestation is large enough.

The use of a safer poison like anticoagulants mixed with grain may be needed if other animals that do not cause a problem are present. These anticoagulant materials include: chlorophacinone, diphacinone, Fumarin, Pival and warfarin. Applications should be spread in tablespoon quantities near the active burrows and in the runways. These applications should be made on a repeated basis every other day.

Squirrels! In the Arizona and California areas there are three species of squirrels that are a problem in agricultural production. One of these species, the rock squirrel is considered to be an agricultural pest because it can spread the plague and is found in Arizona. The other two species which includes the Belding and the California squirrels are a problem in California agricultural crops. The Belding Squirrel is a problem in the northern part of California. The California Squirrel is an agricultural problem on the west coast of Mexico and California. It is a serious rodent pest in the central valley and coastal regions of California. The Rock Squirrel is

found in Arizona, New Mexico, Southwestern Texas, Southern Nevada, Utah, Colorado and northern Mexico.

All three of these squirrels will feed on agricultural crops depending on whether the crop is in their area. In some cases the rock squirrel can also become an agricultural pest if a crop is grown in their area. The burrowing that ground squirrels carry out can be discovered easily when an area is surveyed for cause of damage. The burrowing results in damage to levees, ditch banks and earthen dams. They can undermine roadways and building that are in their vicinity. They can increase soil erosion. The livestock that are pastured in fields where the burrowing occurs are subject to leg injuries.

The Belding ground squirrel can reach very high populations. When these populations reach high levels the amount of crop losses can be very high. Crops that are damaged include: pastures, oats, barley, wheat, rye and alfalfa. One of the main feeds of the Belding squirrel is seeds. This is especially true during the short very active period that occurs from February to July in the higher elevations where Belding squirrels are active. The amount of squirrel food is primarily vegetables instead of seeds. Because seeds are used in the squirrel baits, seeds are used as the main ingredient of bait stations. In this area the use of bait stations is used later in the year when the Belding squirrel's diet turns to the more available seeds and they will accept the seed baits.

California ground squirrels when populations are high will infest pastures and range lands causing loss of grazing output. Irrigated pastures are a target of these ground squirrels along with grains, almonds, apricots, peaches, prunes, citrus, tomatoes, apples, walnuts and pistachios. Vegetable crops like sugar beets, beans, and peas are consumed during their seedling stage. Tree crops are injured when California ground squirrels gnaw on their bark.

Under high population densities rock squirrels will feed on apples, cherries, apricots, pears and melons. This feeding is to consume the seeds of the fruit. They will dig up and consume planted seed. Usually rock squirrels are only a pest when crops that I just mentioned are planted in their habitat. That's why it is necessary to avoid planting crops near their native areas or if the crop is going to be planted in an area that has been scouted and evidence of rock squirrel presence is found methods of control should be taken.

These three species of ground squirrels; California, Belding, and Rock are regarded as pests, and are not protected. Local authorities should be consulted before control methods are used. Several squirrel species and other rodents are on the endangered lists and must be protected.

Ground squirrels use burrows as their homes. The access holes or openings are never plugged like the gopher holes. The burrow system is extensive with a great deal of openings. The California and rock squirrels will have several families sharing the same burrow system whereas the Belding squirrel has scattered burrows with a lower population. You may see the ground squirrels in trees because they are very adept at climbing trees, but when frightened ground squirrels will run for their burrow holes.

During the colder times of the year ground squirrels go into hibernation. The ground squirrels born during the previous spring may not go into hibernation in their first year. In the hot regions like Arizona low lands the ground squirrels estivate. This is a summer sleep that can last a couple of days or even a few weeks. The male California and Belding squirrels come out of hibernation in 10 to 14 days before the females. The rock squirrel females come out of hibernation before their male counter parts.

The ground squirrels start breeding after hibernating. The breeding period lasts about

three weeks. This breeding period depends on the weather and altitude; therefore the breeding period may vary. The pregnancies last for 28 to 32 days. The births take place in nests that are located in the burrows. The young are born with their eyes closed and without hair. The young are nursed for 6 to 7 weeks and then will be about a third the size of the adults. The California ground squirrel litters number over 7 young babies and the rock and Belding ground squirrel liters contain 5 to 8 babies. Ground squirrels only produce one litter in a year, but they live to be 4 to 5 years old. This longevity of the ground squirrels makes up for the higher rates of yearly reproduction that other rodents enjoy therefore ground squirrel populations are about the same.

The area surrounding cropland is where squirrels are located. They move into the crops for feed. Barriers to keep the squirrel population from invading the crop are usually too expensive and because squirrels are good climbers the fencing is ineffective. Flood irrigation for the crop where squirrels have become a problem discourages the squirrel whereas sprinklers and drip irrigation do little to prevent squirrel invasions. Any type of cover around the crop field like brush, old irrigation pipes, rock piles should be removed. These are ideal places where squirrels like to build their burrows.

Frightening devices haven't worked in preventing squirrel infestations. Seed treatments will give limited protection of newly planted seeds. A material called Thiram is used as a seed treatment in some cases.

Baits treated with rodent pesticides are the most economical method of squirrel control. These include: zinc phosphide and the anticoagulants (diphacinone and chlorophacinone. Some states allow the use of these materials while others do not. Check with your farm advisor before using any toxic material. When allowed baits are either spread on bare ground over 3 to 4 foot squares next to the squirrel burrows. Some labels permit broadcast applications of zinc phosphide and anticoagulant treated baits. These are applied with hand-cranked seeders from the back of a vehicle. Double strength application rates are used for broadcast applications. The anticoagulants require repeated applications. 3 to 4 applications per day every other day may be required for the anticoagulants. Bait stations can be made or purchased. Bait spreading to see if baits are going to be taken by the squirrels should be tried before applying large quantities.

Fumigants can be applied to the burrow systems with good results. The drawbacks include the plugging of their holes the squirrels use especially during hibernation. This form of control is especially effective when hibernation is over and also when newborn young are still in the burrows. When soil moisture is high the fumigation method gives the best results. Some fumigants have cylinders of combustible materials with a fuse attached. The cylinder is placed at the entrance of the burrow. The fuse is lit and the cylinder is pushed back into the burrow and the hole is covered with soil and sealed by tamping the soil. Aluminum phosphide tablets can be placed in the burrow. A wad of newspaper is pushed into the burrow. Then the burrow opening is tightly sealed with soil.

Traps are available for squirrel control and they have been very successful. Gopher box traps and several other types of traps are available. The amount of traps necessary to catch squirrels has to be adequate to catch the squirrel population that you are trying to control. At least 100 traps may be needed. If you can count the population one trap per 10 to 15 squirrels would be sufficient. Bait the traps with whatever the squirrels are eating. You can find this out by pre baiting unset traps with various foods. The bait may be walnuts, almonds, orange slices or melon pieces. Once you see that the bait is being taken from the unset traps you can start setting the traps. Unlike the fumigants, traps can be used year after year. Traps that catch the squirrels live are used when public relations are involved. Because it is illegal in some states to catch

squirrels alive and release them in other areas the captured squirrels should be humanely killed by gassing them with carbon dioxide. Destroying the burrows after controlling ground squirrels is done by using a tractor with soil ripping equipment that rips the soil to a depth of 20 inches and with ripping blades spaced at three feet apart. You obviously can't do this in rocky soils or tree infested areas.

The reported damage studies on Belden ground squirrel damage to the agricultural crop, alfalfa, is estimated to be 1,790 pounds of alfalfa per acre in northern California over one growing season. The reported damage by California ground squirrels was estimated to be 30 to 50 million dollars of agricultural and other damage annually in California. The rock squirrels damage to agricultural crops is reported to be low, but the disease problem of the transmission of plague is severe enough to warrant control.

Rats! When scouting an agricultural crop for pests the need for checking for the presence of rats is usually the last thing we think of. We know that the presence of rats in agricultural field crops is a rare occasion, but rats can be a vertebrate pest problem when we least expect it. One year I got in on a deal to grow a couple of fields of cantaloupes. When we started to harvest I went to the field with the picking crew. This is when we harvested with bags to put the melons in and then carried them to a trailer where we placed the melons in the trailers by heaving the full bags or sack up into the trailers. We had guys and even some women in the crews and they never seemed to mind the occasional gopher snake, but when a rat was found they left the field. When we didn't see the rats we were able to see their feeding damage. Rats will also feed on citrus crops. They don't like the rind, but they do eat the citrus flesh of orange crops and leave the rind hanging from the tree limbs, but in lemon citrus crops they'll eat the rind and leave the sour fruit hanging from the stems.

The rat damage to agriculture usually occurs to the crops in storage or contamination of animal feeds. Farm buildings can be damaged by rats. This is especially true of the Norway rats who are rodents that live in burrows that they dig out near and under buildings causing damage to the building. Roof rats nest in buildings and they normally do not dig burrows in the soil. The roof rats and the Norway rats cause damage by gnawing on soft metals like wiring, plastic materials and wooden structures.

One year we had an outbreak of Norway rats in the Yuma area. They were found in several citrus orchards. We used several baits. The rats carried off the paraffin blocks containing the anticoagulant chemicals. We finally solved the control problem by locating their nesting areas that were in piles of brush near the fields. By burning the brush and old building materials on the field borders the rat problem was taken care of.

We have a hard time talking about rats without mentioning one of the severest diseases that exists and that is the plague. Plague is a severe and potentially deadly disease. Most of the rodents can carry this disease, but rats are usually the pest that is mentioned when plague is the topic of discussion. The plague bacteria is spread by the fleas that rats carry. If a person is bitten by a flea that is infected by the plague this person can get the plague. It is very rare for the disease to occur, but it is still possible. This is one reason not to handle rats especially dying rats or dead rats. If a person is bitten by a diseased flea from a rat, they should seek medical care as soon as possible.

There are three types of plagues carried by fleas that infest rats: Bubonic, Septicemia and pneumonic. The bubonic plague infects the lymph nodes located in neck, armpit and groin areas of the body. The septicemia plague infects the blood and the pneumonic infects the lungs. Immediate treatment is required when symptoms appear. The symptoms for bubonic plague

include: chills, fever, general ill feeling, headache, muscle pain, seizures or swelling in the groin, neck or armpits. These symptoms occur in 2 to 5 days. Septicemia symptoms include: abdominal pain, bleeding, diarrhea, fever, nausea and vomiting. This disease, septicemia, may cause death before the symptoms appear. The pneumonic symptoms include cough, difficulty breathing, fever, frothy bloody sputum, chest pains when breathing deeply and severe cough. People with the plague need treatment immediately. Treatments include antibiotic injections, oxygen, intravenous fluids and respiratory support. Without treatment they predict a death rate of 50%. There are vaccinations available for people that work in high risk jobs. Plague is very rare in the United States, but it has been known to occur in parts of California, Arizona, Colorado and New Mexico.

Roof rats and Norway rats can be found in the same areas, but they fight one another. The Norway rats are stronger and larger and they do not inter-breed with one another. They do not feed together either. In most cases both rats carry off the food to store and consume later. If the two kinds of rats are present in a building the roof rats who are more agile and better climbers will dwell in the upper part of the building. They both can enter the building through the sewer systems, toilets and drains of the building. Norway rats are larger than the roof rats weighing 7 to 18 ounces while the roof rat weighs from 5 to 10 ounces. The roof rat's belly is gray to white and The Norway rat's belly is mostly gray. The Norway rat has a blunt muzzle while the roof rat has a pointed muzzle. The roof rat ears are long enough to reach the eyes while the Norway rat's ears don't reach the eyes.

Norway rats stay within a radius of 50 to 75 feet of their burrows. They have litters of 4 to 6 per year. They produce 20 or more young rats in a year. Unlike other rodents who get their water needs from the food like green vegetable leaves and roots, rats drink from available water supplies. Norway rats feed on cereal grains, meats, nuts and available fruit. Roof rats have the same diets, but in the Salinas area they are a real serious pest on the artichoke crop. In the San Diego area they are often found in avocado and citrus orchards. Roof rats are usually found nesting above the ground in structures. They seldom dig and nest in soil burrows. Roof rats feed in an area that is 300 feet from their nests. They will live in one building and feed in another. Wires that connect buildings are used to travel from one building to another. During early evening and at sun-up roof rats can be seen traveling on these overhead wires. They can balance themselves with their long tails. Roof rats are more agile than the larger Norway rats. Roof rats have 3 to 5 litters per year giving birth to 5 to 8 young rats per litter.

Control of a rat population includes: toxic baits, trapping and in some cases flooding. Predators will kill rats, but like all predators they only kill a few and save some to have the pest around as a source of food. Not allowing the area to harbor rats is the best form of rat control. Just like the citrus growers in the Yuma area who burned the trash and old buildings near their citrus groves, all areas should be scouted to learn if rats would nest and feed there.

The use of toxic baits is legal in some states and a call to the local farm advisor will give the necessary information on what is legal when controlling rats. Bait stations are used and required for some toxic baits for safety reasons. The bait stations must be placed where the rat can find them easily. Both Norway and roof rats are very shy around anything new or out of place; therefore it may take some time before the rats will become used to the bait stations. The placement of the station has to be where the rats travel or feed. The bait station should be secured especially if it's placed up in a tree or elevated structure. For Norway rats the bait station should be placed near their burrows. Securing the bait station will keep it from children and pets. Sometimes the bait stations can be placed in permanent locations like buildings. These bait

stations can hold a continuous supply of poison baits to avoid the intrusion or build up of a damaging rat population. Usually by the time you discover the presence of rats the population is already very high. Toxic baits are quick but the anticoagulants are slower and can take a week to kill the rats. You should check the baits regularly to avoid allowing the baits to get old and unappetizing to the rats. The federal government or EPA restrictions only allow the use of wax block, gel or paste rat and mouse baits that are sold ready to use along with the bait stations that are disposable. Licensed applicators can buy and use restricted pesticides for rat and mouse control. Traps are available for mice and rat control. The captured live rat is destroyed by bludgeoning. Releasing live rats isn't recommended. The use of baits and the prevention of rat living conditions are the best methods of rat control.

The use of trade names in this course is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that they are approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.

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Citrus Pest Control

My wife and I boarded a cruise ship in Miami, Florida bound for the islands. As we were getting on the ship I noticed a truck that was unloading boxes of fresh citrus to the hold of the ship. The citrus had the Sunkist label on the crates. Here we were in Florida, the leader in citrus production. Then I found out that when it comes to all forms of citrus, juice and fresh, Florida is number one. When it comes to fresh citrus the western citrus groves lead the pack. I've tasted a lot of orange juice and I usually pick the sweetest which I think happens to be Florida orange juice. Getting good rind quality without blemishes is a battle against citrus pests that feed on citrus rinds to stay alive.

Citrus Thrips! Citrus thrips have a complete life history: egg, first instar larvae, second instar, third instar, pupa and adult. A complete life history or generation in the growing season has duration of fifteen days. In the Yuma area the citrus thrips may have 10 to 12 generations during a season. The eggs are laid during spring and summer. They lay around 25 eggs in the new young flush of leaves, green twigs and young fruit during this period. A single female citrus thrips can lay around two hundred and fifty eggs in her lifetime. The eggs that do not hatch during the warm months will over winter in the season's last flush of leaves and stems.

The eggs laid in the over wintering growth will hatch when the spring's first flush of growth occurs. Eggs laid during the warm spring and summer will hatch in 6 to 8 days. As the eggs hatch the very small first instar larvae start feeding on the new leaves and available fruit. There are three instar stages of growth. The second instar is almost the same size as the adult thrips. The third instar moves to the tree branch crevices or soil and does not feed. The third instar thrips go into its pupa stage and then emerges from the pupae case as an adult with wings. The adult citrus thrips may live for a period of twenty five to thirty five days in mild conditions, but when temperatures are below fifty eight degrees they do not develop.

The second instar does the most damage. Their greatest damage is done under the sepals of the stem of the very small fruit. As this damaged fruit grows in size the scars of the sepal feeding enlarges and causes rind quality to plummet. This damaged fruit has to be sold for juice at a much lower price to the grower. The citrus thrips damage the citrus rind by puncturing epidermal cells. They also puncture and feed on the epidermal cells of new growth of young stems and leaves. The damage is cosmetic. It doesn't take away other qualities of the fruit like the sweet flavor that I found in the rind damaged citrus that I purchased at a roadside stand in Florida. This damage doesn't make the citrus taste bad but when on display at the market it doesn't sell as well as fresh unblemished citrus fruit. The damage that citrus thrips do to new flush growth includes defoliation. This is true when the citrus is at its young non-bearing stage when the growth can be stunted. The leaf and stem damage is referred to as "buggy whipping". As the damaged areas dry out the damaged new growth will defoliate. When the nonbearing trees are in a bearing orchard the use of pesticides to control the thrips may increase the amount of pesticide resistant thrips; therefore treatment to non bearing citrus is usually avoided..

Knowing the difference between flower thrips which feed on flowers and do not harm the citrus crop is vital when the flower thrips are active in the field. Just after petal fall flower thrips can be seen on some new fruit. Then they pupate and become adults. The Western Flower thrips abdomen extends beyond its wing tips with long bristle like hairs at the end of its abdomen. Citrus thrips and flower thrips both have the same coloring and may be counted in with the citrus thrips infestation. The second instar of the citrus thrips has a slightly bulging abdomen while the Western Flower thrips second instar is narrower without the bulge.

The scouting for citrus thrips is up to the person doing the field checking. Knowing when to spray is decided by whoever checks the field. There are some guides to follow. The two instars that do the damage are the first instar and the second instar. The first instar is so small that a hand lens should be used when counting fruit. The thrips will either be located on the young tender flush growth and the new fruit. The fruit can be checked by lifting the calyx around the stem of the fruit. When a count of one or more thrips in the first and second instar on the fruit reaches more than ten percent, treatment should be made. Often the inspection of twenty to fifty fruit may be needed to decide if treatment is necessary. The experts that check fields inspect four quadrants of the field being scouted and these experts suggest an inspection of at least one hundred fruit per individual field. Another method of scouting for citrus thrips is the use of sticky cards Adult citrus thrips are attracted to the white and yellow colors. The use of these sticky cards is used to attract the adult citrus thrips to be used as an indicator of the citrus thrips infestations.

There are natural enemies of citrus thrips. These predators include: predacious mite, minute pirate bugs, lace wings, spiders and dusty wings. Over the past several years pest control advisors have learned to work with predators and pesticides. The use of Integrated Pest Management or IPM has allowed citrus producers to operate under very heavy citrus thrips populations. At one time the use of pesticides that reduced the predator populations and increased the number of pesticide resistant thrips had growers treating several times during a season with poor results. Some chemical use goes hand in hand with a predator count. An example is the use of Sabadilla applications. During the field check of twenty five-leaf terminals that have fully expanded leaves from the shady areas of the tree canopy, a count is made of adult predatory mites per leaf. If a minimum of one predacious mite is found per two leaves then enough mites are present to assist in the control of citrus thrips when Sabadilla is to be applied.

The predacious mite, Euseius tularensis, is the size of red mites found in citrus, but they are pear shaped, shiny, and translucent. They feed on citrus red mite, pollen, citrus thrips larvae, leaf sap, nectar and honey dew. Use a hand lens when scouting for them.

Some studies on the use of chemicals that cause outbreaks of resistant citrus thrips have shown that the resistant thrips population is limited to local areas. This explains the control of citrus thrips in certain areas with a chemical in an application and a complete failure in the other areas of the same field and results in more scouting time with check backs to make sure the sprays work. Because repeated treatments increase the population of pesticide resistant citrus thrips, treatment should be done only when necessary. Hot weather increases the number of citrus thrips and many of the pesticides are less effective in these warmer temperatures.

Integrated Pest Management uses the following techniques: 1. Inspection of the stage that the insect is in. 2. What predators are present in the field? 3. The knowledge of what pesticide will eliminate the predators. 4. Are the citrus thrips immune to the pesticide of choice? 5. In what temperatures will the pesticide kill the citrus thrips? 6. Does the infestation require a treatment?

The following pesticides are used in citrus growing areas for thrips control:

Spinosad (Success, Entrust) Spinosad is used as a leading citrus thrips spray in the Yuma area according to the Arizona Extension Service. It is macro cyclic lactones which has been isolated from soil microorganisms called Saccharopolysora Spinoza. It is very effective against citrus thrips. Spinosad controls citrus thrips in hot and cool weather. It has a residual killing power that lasts for 10 to 14 days. The addition of a non-ionic surfactant or when used with a narrow-range oil Spinosad gives the best results. When adding a buffering agent keep the pH above six otherwise the residual will be reduced. The use of Spinosad is not to be used in

nurseries. It cannot be applied more than two times a year unless another class of products is used in the interim of thirty days or two sprays, whichever is longest. The re-entry period is four hours.

Dimethoate This is an organophosphate that is and has been used more on citrus for citrus thrips control than any other pesticide. In most of Arizona it is used. In Yuma the resistance is so strong that its use is now limited. When using Dimethoate its use is not allowed during any time of day when the citrus grove has ten percent or more open blooms until there is at least seventy five percent of petal fall on the north side of the trees. It can be used between one hour after sunset and three hours before dawn. This use has to be before petal fall when less than ten percent of blooms have opened, after the initiation of petal fall when there are less than twenty five open blooms remaining in the orchard, and it is between the calendar dates of February fifteenth and May one. Dimethoate will give good control of citrus thrips when it is cool and moderate control when the weather is hot. At the most, control of Dimethoate will last a period of three days when citrus thrips pressure is constant. Using Dimethoate as a spray application on non bearing citrus seedlings is prohibited. Trees with mature fruit are restricted to two applications of Dimethoate. The re-entry period after an application of Dimethoate is four days

Danitol Just as in Dimethoate temperature plays a big role in Danitol application in citrus. Do not apply Danitol when temperatures rise above 94 degrees. No more than one application of Danitol can be made per year. Danitol is toxic to beneficial insects. Yuma County citrus thrips has shown resistance to Danitol applications. Restriction on re entry after applications of Danitol is twenty four hours.

Carzol is a carbamate and is used for citrus thrips control in Arizona. The Yuma lemon growers use it. Carzol works in hot and cool weather. It has controlled citrus thrips for as long as ten to fourteen days. If mature grapefruit or Valencia oranges from the previous season are present an application can be made 30 days before harvest. Carzol will also kill most of the beneficial insects in citrus groves. Re entry restrictions on Carzol are sixteen days for hand labor and ten days when workers will not come in contact with the trees.

Cyclotron (Baythroid, Renounce) Baythroid is a pyrethyroid that is very effective in temperatures below ninety five degree. Baythroid is a broad spectrum pesticide and has residual control of five days. Only one application per crop per season is permitted. Danitol is a pyrethyroid and should not be applied during the same season on the same crop that Baythroid has been applied. Application of Baythroid isn't permitted on citrus trees under three years of age. The restricted re-entry period is twelve hours..

Kaolin (Surround, Snow) Kaolin is a refined clay mineral product. It has little immediate killing potential. Kaolin is primarily a disrupter of feeding by citrus thrips. It will kill twenty to thirty percent of the citrus thrips. Kaolin is used before the thrips arrive in the orchard. Application rates are from thirty five pounds to one hundred pounds per acre depending on how good the spray equipment is at applying this material; therefore good coverage is essential. On mature orchards Kaolin is applied at petal fall. Then ten to fourteen days later and again a third time in three to five weeks. A non-ionic adjuvant should be used with it. Good coverage is needed. A plus to the use of Kaolin is sun burn control and it is non-toxic to bees. Kaolin is recommended for organic growers and it has shown to increase fruit earliness. It still has a four hour re-entry period.

Abamectin (Agri-Mek) Agri-Mek cannot be applied to nurseries and it cannot be applied by air. It is non toxic to predacious mites and beneficial insects. When there are high numbers of predators Agri-Mek is more effective as a pesticide. It has a residual life of three to four days.

Agri-Mek can only be applied three times per year and only with thirty days between each application. The re-entry time is twelve hours.

The above chemicals are used in Arizona and the following pest control products as well as those listed for Arizona are used in California:

Sabadilla (Veratran D) Acidify water to a pH of four point five before using Sabadilla. Use citric acid or other acidifying agents. Sabadilla is a stomach poison and sugar is added to spray water at ten pounds of sugar to fifty to two hundred gallons of water. Treat during the citrus thrips mid hatch. Sabadilla is most effective during warm weather. Do not apply during heavy dew, fog of drizzle. Adding fertility materials will taint the mix and citrus thrips won't eat the spray material. Sabadilla is a poison that affects the stomach of the insect and it is applied with sugar or molasses for the baiting effect.

Spinetram (Delegate) is used with narrow range oils. It is more effective with the presence of the predacious mite, Euseius tularrensis. Do not apply thirty days after a sulfur application and if the temperature is or is expected to be over ninety five degrees. F. and the humidity dries out below twenty percent. It should not be applied more than twice per year.

Spirotetramat (Movento) is used with narrow range oil. It has the same precautions as Spinetram. Movento is a systemic.

Citrus Scale Insects Another rind damaging insect is the citrus scale insects. The California red scale is found in citrus groves throughout California, parts of Mexico and in Arizona. The Coachella Valley of California and the Yuma area of Arizona are under eradication and abatement programs. These areas are considered to be scale-free areas. Isolated pockets of Maricopa County in Arizona have occasional outbreaks of California red scale. The Yuma County Citrus Pest Control District and Arizona Department of Agriculture have programs to monitor for California red scale. Then they abate the infestations that they discovered. They use a grid network with pheromone traps to detect the presence of male California red scale. Once the scale males are detected scouting of the area is used to find the exact location of the infestation. Then the control efforts are carried out by these agencies. This method of control has been very effective.

There are a few types of armored scale that attack citrus, the California red scale and the yellow scale are the two of the more common. The California red scale is found on the fruit, the leaves and the mature wood of the citrus trees; whereas the yellow scale is not found on the mature wood. The yellow scale is controlled for the most part by natural enemies and is usually not a problem for the citrus growers.

After mating with a California red male scale the female produces eggs that hatch inside of her body and leave her body as crawlers. The female that gives birth to these crawlers is immobile and stuck to the leaf, twig, or fruit. She can produce from a hundred to a hundred and fifty crawler. These crawlers can go to other areas by crawling or they can be moved by the wind, on animals especially birds, moving agricultural implements, pruning equipment, or even human workers in the field. The colors of the crawlers' bodies are yellow.

Once the crawlers settle down for their first meal they insert a feeding tube into the stem, leaf or fruit and begin feeding. This hair like feeding tube holds the scale to one place on the plant. Male and female scales develop differently; therefore I'll start with the females growth. As the female scale which is in her first instars stage of growth develops she will put out a material that covers her body with a white cover that is rounded. This is referred to as the nipple stage. The white material of the cover will continue to flow onto the plant's surface and turns to

a whitish gray color. The scale is still in its first instars life stage and the scale‘s body and the cover can be separated. Then the scale removes its feeding tube and starts to molt and the scale’s body rounds out taking on an orange color and the edge where the scale’s body and the rounded cover meet seal together and cannot be separated. The molting stage lasts for a period of four days. As the female scale goes into the second instars stage of growth the scale inserts a new feeding tube into the plant. The second instars put out another fluid that forms the second cover under the first cast skin of the first molt skin then changes from grey white to orange in color. Now the feeding scale in its second instars has a gray skirt or ring around the orange molt cover. The gray skirt is a secretion of wax and protein that the scale put out in its second instar stage of growth. By counting the pigment rings around the scale a person can decide the age and stage of growth of the scale. The scale pulls out her feeding tube and develops into her second molt. Her body and the latest cover she made stick together and cannot be separated. The cover that she secreted for the second instar turns orange and is sealed to the cover. This second molt lasts six days.

After the second molt the female scale inserts her feeding tube and begins her third instar stage. As she again issues her secretion of wax and protein she develops lobes on both sides of her rear end or her pygidium containing her sex organs. This gives her body a more circular shape than she had in the second instar stage. Her pygidium in her third instar protrudes out and under the edge of the skirt. The male scale will use this when they mate. If the female does not mate she will continue to grow but she will not mature. Once the female has been impregnated by an adult male scale she will retract her pygidium to prevent other male scales from mating with her. After mating the female is sealed inside the scale cover. She will look similar to the molt stages and will begin to produce crawlers in about twelve days.

Male scales go through the first instar in the same way that the female does. The male crawler forms the same white cap caused by the scale’s secretion that flows onto the plant covering the scale in a circular cap that covers a yellow body. As the secretion flows onto the plant it turns a whitish gray. The first instar male puts his hair like tube into the plant and begins feeding. His body takes on the same round shape and the secreted material forms a cover that can be removed from the yellow body of the male scale. When the male scale pulls out his feeding tube and stops feeding the males first and only molt begins. The male scale is sealed off inside the cover and the cover is orange. The male scale’s first molt lasts four days which is the same as the female scale.

After the molt stage the male scale starts to feed again pushing his feeding tube into the plant. The first changes between the male and female scale take place. As the male scale starts to feed he starts his second instar and he goes through different changes when compared to the female scale. The male scale secretes white material that covers his new body. The cover is white to start with and turns to a gray white. He develops eyes and his body grows to an elongate shape whereas the female scale has a rounded shape. He gains a brown color instead of the female’s orange color and his rear end or pygidium is now V-shaped. After feeding for five days the male scales begin to pupate. He enters a life stage called the prepupal stage. His rear end starts to square off and he loses his brown color. His rear end forms into a slight nub which is his genitalia or sex organ. After a day and a half the prepupal males grow into pupae. After another three days the adult males come out of the pupa cover as adult male scales with wings. The male adult California Red Scale starts flying to pick up the female red scale pheromone that she releases from her stationary scale on the plant where she lives. The male finding the female scale impregnates her pygidium which she withdraws after the sex act. The male adult has a total of

six hours to find and impregnate a female scale before he dies. Some entomologists claim that the male scale adult doesn't have a mouth, because he doesn't need to feed before he dies. The male red and yellow male adult scales have an average of four generations with flights per year.

Scale Damage! Citrus trees can be damaged when red scale attacks the twigs, leaves, branches and fruit while the yellow scale attacks the same areas except the twigs in most cases. The citrus tree can be damaged to the point of death of the tree on occasion, and less damage like yellow leaves, leaf drop and twig and limb dieback. Heavily infested fruit can be downgraded by the packinghouse company.

Scouting For Red and Yellow Scale with Pheromones! In Arizona and the desert area of California the state and districts use pheromones followed with intense scouting of the immediate area. In the rest of California the other citrus growing areas include the coastal areas, the inland areas of San Bernadino and the San Joaquin valley area. In the San Joaquin Valley the pheromone traps are used to monitor the adult male scale flights which occur during the following months: first flight in May; second flight in Jun-July; third flight in August and fourth flights in September through October. Degree days are used for estimating when flights take place. Treatment is usually set up for the next season when an average of more than a thousand or more adult males are trapped in the fourth flight and fruit is found to be infested at harvest. The growers doing the monitoring try to set a goal to maintain the population levels at no more than ten scale per fruit. The degree day information is available from the farm advisor's office.

Aphytis Predator! In some of the San Joaquin Valley areas growers release the Aphytis predators that parasitize the female scales. There are problems that do occur. Males are not affected and therefore the male population count will be very high when the female population is very low. Also when growth regulators are used the males are more sensitive to the growth regulators and the pheromone cards will give too low an infestation count. Growers are aware of these problems and can work around them. There are several other insect predators that feed on California red scale. These include; lady beetles, Chilocorus orbus and C. cacti. To reduce the number of applications of harsh chemicals, which reduce predator populations, growers treat only the portions of the orchards where red and yellow scale populations are above the treatment levels. Before releasing Aphytis parasites they test the area for pesticide toxicity by putting ten to twelve one year old twigs with leaves in gallon jars; then they add some Aphytis for a period of twenty four hours If more than thirty five percent are killed the residue of harmful chemicals in the field are too great for Aphytis releases in the tested area.

In the San Joaquin Valley it is recommended that releases of rates of one hundred thousand parasites per acre per year for orchards that are using the IPM program. These releases of Aphytis should begin by the first of March. The plan is to release five thousand to ten thousand parasites per acre every two weeks and release fifty percent of them during the spring. Then release twenty five percent in the summer and another twenty five percent in the fall. They stop releases when second and third scale is not available and this should be in mid-June to mid July. Then they continue to release the Aphytis through mid-November. The later releases of Aphytis should be in areas of the groves where the higher densities of California Red scale exist. After a period of two to four years, the total number of Aphytis released can be lowered to a level of fifty to seventy thousand per acre. In the southern California citrus areas where natural Aphytis are native to the area releases of Aphytis are only made on a basis of one to four releases and then only ten thousand Aphytis per acre at two week intervals are required. During April and May these releases can be made. In this cooler area of California annual releases are needed on young grapefruit and lemon trees if biological control is not taking place.

Aphytis lay their eggs and feed on the third instar stage of scale insect. The scale at that stage is not in molt and the gray white material that the scale puts around the previous orange molt circle to cover its body is still soft. Also the third instar scale is larger than the first and second instars and their size can feed more of the Aphytis larva that hatch from the eggs that the Aphytis lays in the scale's body. Scales in molt have hard bodies that are difficult to penetrate for egg laying and the new born Aphytis have trouble feeding on scales that are molting. Before the Aphytis lays eggs in the scales body she will inject venom that kills the scale. Many dead scales can be found under the scale covers that have not had Aphytis eggs laid in them. The Aphytis also will probe the scales body before injecting her eggs. This probing allows the scales body fluids to seep out and the Aphytis sucks this up as food. This causes the death of scales that receive this molestation. As the scouting procedure uncovers the scales the dead scales will be flat or collapsed. The injured and dead scales will be discolored and flattened from the siphoning by the Aphytis mouth parts.

When using the Aphytis the control of ants is necessary. These ants in the San Joaquin Valley disrupt the red scale predators. Mulching and spreading manure cause dust that also interferes with predator control. This caution also includes white washing tree trunks, kaolin sprays and ash from brush fires that produce ash on the tree's surfaces that will hamper the predator's pest control activities. Delaying these activities until after the Aphytis have done their job is one way of using the Aphytis program. Watering roads and washing trees help's to reduce these problems.

Organic and biological control growers have approval to use the Aphytis program along with petroleum oil sprays.. They also make use of the high pressure washing in the packing houses.

Where scale resistance to organophosphates and carbamates (Lorsban, Supracide. and Sevin) are prevalent the use of insect growth regulators, oil, Esteem, or Movento are used because the resistance to these pesticides has not been noted in these areas. Oil is applied to Aphytis because oil does not persist and the Aphytis can be released after oil treatments. Oils will suppress some of the mite predators but when the oil residues subside the predators will do their job. The use of oil to control red scale should only be done when field checking show a need for oil sprays. Oil sprays will kill the younger scale instars that the Aphytis doesn't kill and the Aphytis won't have a place to lay their eggs so the field won't be covered. Some other considerations when using pesticides and predators include: IGRs, Esteem and Applaud do not kill predator wasps, mites, spiders and lacewings but kill vedalia beetles which are needed to control cottony cushion scale. Movento is not toxic to wasps and vedalia beetles but kills predatory mites.

<u>What Is Good Parasite Control</u>! In the San Joaquin Valley control of Red and Yellow scale has occurred when more than seventy percent of the third instar female scales are parasitized by mid to late October by the parasites: Aphytis or Comeriells. Also at least fifty percent of the second instar female scales and second instar males should be parasitized. In the interior southern California citrus area treatment is recommended if monitoring shows that more than fifteen to twenty percent of healthy unparasitized third instar female scale are present by the end of September. In the interior southern California citrus area if by late September to early October there is almost no third instar female scale and the second instar male and female scales are fifty percent or greater, treatment is not required. In the inland areas treatment is not required unless infestations reach twenty five to forty percent of the fruit. When high pressure washers are used in packing the fruit the infestation rate levels can be increased. In California coastal areas of

citrus production usually treatments are not required. Monitoring with pheromone releases are used, but fruit examination is used to back up the pheromone method.

Red and yellow scale beneficial insects or parasites are the general predators that include beetles and lacewings, but three of the main ones are the Aphytis melinus, the Comperiella bifasciata, and the Encarsia perniciosi.

The stages of the life of an Aphytis include the egg stage. Aphytis lay their eggs on the ventral or dorsal side of the scale's body increases near the pygidium or rear end of the body. Because of the high number of Aphytis, eggs can become damaged or flattened when other Aphytis lay their eggs on the same scale. The eggs that make it and hatch do so in two days after being laid. The larvae stage of the Aphytis look like elongated sacs. The gut material in these sac like bodies can be seen with lens. As the larvae feed and grows the gut material changes from yellow to brown. You can see through the clear skin of the larvae. It takes another five days of growth before the larvae grow into the prepupal stage of their life cycle. You will see brown pellets that the larvae excreted around its body. The pellets can be found even after the adult Aphytis has left the area. After one day the prepupal stage is done and the pupa is formed. Over a four to five day period the pupa develop eyes. These eyes change color as the days pass. The eye color starts as a pink, then turns to red, then reddish brown, and then green. About one day after the green eyes are seen the adult Aphytis emerges. You can see all of this with the use of hand lens.

The predator, Hymenoptera Comperiella bifasciata Howard, is found in the coastal areas of citrus production in lower numbers. The Comperiella are a common predator of red and yellow scale in the California San Joaquin valley and the inland southern California citrus growing areas. This scale predator prefers the female red scale when in her third instar life stage. Comperiella does not paralyze the scale like the Aphytis does. This allows the Comperiella to parasitize most of the life stages of the red scale and this includes the mature female scale. Comperiella deposits her eggs inside the body of the female scale. When scouting for these the Comperiella, their eggs and larvae inside the scales bodies are not visible, even with a hand lens. Once the larvae grow into their pupa stage their green colored bodies become visible inside the scale bodies. If there is more than one larva in a scale one of them will consume the other. After the larva pupates the same type of excretion pellets put out by the Aphytis pupa are visible with a lens. These excretions are referred to as meconia. The Comperiella meconia are inside the body of the scale. The meconia of the Aphytis are seen scattered outside the mummified body of the scale. This is one way of identifying the Comperiella parasite presence over the Aphytis. The scale's mummy eventually turns dark and can be observed without a lens. The adult Comperiella emerges leaving the mummified scale body with an exit hole and the meconia inside. The scale body will remain on the fruit until the growth of the fruit will cause the scale remains to fall off the fruit.

Aphytis will consume Comperiella if they are laid and hatched in the same third instar scale. Comperiella survive better than the Aphytis during extreme heat and cold and Aphytis can attack scale for around ten days where as Comperiella can feed on scale for their life cycle of forty five days. In the San Joaquin Valley Comperiella significantly reduce red and yellow scale populations during winter and midsummer periods. This is the time that Aphytis are less effective. The Aphytis are more effective during the late summer and early fall. Aphytis have a shorter developmental period. They also produce more larvae per scale. There are comments that the Comperiella' mummies stick to the fruit, but this can be overcome by the high pressure washers in the packing houses. Comperiella are a very important parasite for scale control.

The third known parasite of the red and yellow scale is named Encarsia perniciosi. It is found mainly in coastal areas of central and southern California. This is the smallest of the three parasites that will be discussed in this hour. It has been almost replaced by the introduction of the Aphytis predator in the inland citrus areas of southern California. When the two predators, Aphytis and Encarsia, compete for scale the Aphytis always wins. Encarsia are affected more by high summer temperatures than the Aphytis predator. The two parasites do work together where they are present. Encarsia like to parasitize scale on twigs and Aphytis prefer scale on leaves and fruit. The two of them work together in groves dividing up the scale population and clean up both areas of the tree. Encarsia need less food because they are so much smaller than the other two predators. They can lay their eggs in the second instar stages of the scales of both the male and female scale, but they can lay their eggs in all stages of the female. When they lay their eggs in their preferred second instar scale the larvae grow and develop in ninety days, but when they lay their eggs in the other stages of scale growth like the third or adult stages they take twenty eight days to fully develop.

Scale Pesticides! Three of the registered pesticides for use on scale have shown that some scale is now resistant to them. This has been a problem primarily in the California San Joaquin Valley these include the organophosphate, Lorsban, the methidathion, Supracide, and the carbamate carbaryl, Sevin. The growth regulator, buprofezin Applaud, is still effective, but some resistance has been found with the growth regulator, pyriproxyfen, Esteem. To operate in these conditions it has been suggested by UC Pest Management Guidelines to avoid using organophosphates and carbamates. In these particular citrus groves use the Aphytis wasps or use a treatment of Applaud, oil, Esteem or Movento.

Oil kills pests and predators that it comes in contact. It will suppress some beneficial mites, but is doesn't last in a grove therefore oil can be used before a release of the wasps even though some of the scale will be controlled that Aphytis are good on.

The growth regulator, Applaud, should be applied after the emergence of the first generation of scale crawlers. Applaud should be applied when the crawlers have formed their first instar white caps and have started feeding. Applaud is slow acting and will not kill the scale until after they have started to molt. Allowing sixty days between applications; therefore only two applications can be made. Both Applaud and Esteem growth regulators are toxic to the vedalia beetles therefore wait until the second generations of scale crawlers have formed their white caps. This will give time for the vedalia beetles to kill the cottony cushion scale during March to June. This IGR doesn't kill the scale until they molt and only one application per season is allowed.

The systemic pesticide Spirotetramat, Movento, will control mites, thrips, leafminers, aphids, and armored scales (Red scale and Yellow scale). It should be applied in five hundred gallons of water per acre. It takes two weeks for the material to move through the plant to the feeding scale. Two applications per season are allowed and these can be made at least twenty one days apart. Use an adjuvant and do not apply before bloom, or ten days after petal fall. Movento is toxic to predatory mite but it is okay with vedalia beetles and Aphytis. To prevent pest resistance apply no more than once per year.

Lorsban (Chlorpyrifos) is applied with thorough coverage in twelve hundred to sixteen hundred gallons of water per acre. Do not apply during daylight hours of the bloom period or use more than twelve pints per acre per application, or fifteen pints per acre of Lorsban. Do not apply more than two applications per fruit year and no closer than thirty days apart. Do not apply during December, January or February. Sevin (Carbaryl) is applied when crawlers are active.

Do not apply during bloom or exceed twenty five pounds per acre and only one application per season. The addition of the narrow range oil will give a smothering and a barrier effect. Do not apply during bloom or use more than twenty five pounds per acre per crop. Supracide, Methidathion, Do not apply during bloom and do not use more than forty pounds per season. Only use two applications per fruit year that are forty five days apart. Low volume sprays are available under local needs permits. These can be used with narrow range oils. Follow label instructions.

Cottony-Cushion Scale! A lesser citrus pest but still a pest at various times in both California and Arizona is the cottony-cushion scale. This citrus pest likes high humidity and with our desert conditions in Arizona the cottony-cushion scale is found in heavy soil with closely planted trees resulting in tree shading and humid conditions. If you have checked pecan groves in Arizona you have experienced high humidity conditions in a grove. In the San Joaquin Valley during the summer months these conditions exist.

The female cottony-cushion scale will lay her eggs from her egg sac which is one of her distinguishing characteristics. Her egg sac contains six hundred to a thousand eggs. The egg sac itself is two to two and a half times as long as her body. It's large, long, white and cottony. As the egg sac grows her abdomen tilts to the point that the female cottony-cushion looks like she is standing on her head. She lays her eggs on the citrus leaves and stems. It usually takes a couple of days before the eggs hatch, but under cool conditions hatching may take several months. The nymphs that hatch are bright red with black legs and antenna. After two weeks the larvae grow a light-yellow cottony material on their back. This cottony material gets denser as the scale ages. The nymphs feed on the leaves along the midrib and vein. As they grow larger the scale feed on the leaves, twigs and trunk. Seldom are they found on the fruit. Unlike the red and yellow scale both the female and male cottony-cushion scale nymph and adults have legs to move around on throughout most of their life. In their movement they are aided by the wind, they ride on animals, birds, and equipment moving through the orchard. Cottony-cushion scale grows through three nymph instars before they molt to become adults. This takes a period of about thirty days in warm conditions. There are three to four generations produced per year.

The very tiny male adult cottony cushion scale is so small that it is rarely seen. The male is dark red in color and has wings unlike the female. The male goes through two instars and in its third instar it goes into its pupae stage and then emerges as a winged adult. The adult females are bright orange-red, yellow or brown bodies that are covered with yellow or white wax. Female cottony-cushion scale is hermaphrodites. They have both male (testes) and female (ovaries) sex organs. When the female fertilizers herself the offspring are female hermaphrodites. When a male cotton-cushion scale mates with a female hermaphrodite she gives birth to both male and hermaphrodite female babies.

When I first went to work in Bakersfield a woman called our office and said her citrus tree was turning black and dying. It was on a Saturday and I went to her house to see it. Her citrus tree was along side of her backyard patio and it was a shocker. The tree was covered with black sooty mold and the patio pavement was covered with honeydew. My boss had told me to take along some Malathion so I had a small sprayer and a bottle of Malathion with me. I mixed it with water and gave the tree a bath. I went by her house about two weeks later and the tree had survived and had started growing again. This was in June of nineteen fifty nine.

Most of the damage done to citrus is by the very active early immature stages of the Cottony-Cushion scale that includes the sucking of plant juices from the veins of new leaves and tender twigs. This reduces the tree's vigor and leaf and fruit drop can occur. The scale secretes

honey dew which allows mold to grow which affects the photosynthesis and the fruit can be discolored. Usually the sprays applied for thrips and other insects take care of the cottony-cushion insect in Arizona and if the sprays used will allow the natural predators to exist these natural enemies which include the vedalia beetle and lace wings will manage the cottony-cushion scale.

According to history cottony-cushion scale first came to California on a kangaroo acacia plant from Australia in the year eighteen sixty eight. It took about ten years for this pest to cause severe damage to the citrus industry in California. The Australians sent over some vedalia beetles or lady bugs. The way the growers controlled this pest changed and introduced a new control method that is still used today. This was one of the first methods of using predators to control pests in a growing crop. This is one of the methods used in Integrated Pest Management. Other methods include: field checking, use of leaf and root systemic pesticides, Insect Growth Regulators, and release of insect predators.

The adult lady bug or vedalia beetle has a complete life cycle; adult, egg, four larva stages and a pupa stage. The adults lay their oblong red eggs on or near the cottony-cushion scale's white egg sac. The length of the life cycle of lady bugs is five to six weeks in warm weather and they have eight or more generations. The adult vedalia beetle has a shiny red with black rounded spots, a convex, half dome shaped body that is three sixteenths of an inch long. They have two short clubbed antennae. The oblong eggs are a bright red. The larva is reddish in color and look like small ferocious alligators. Both adults and mature larva feed on all stages of scale growth the young larva feed only on the scale eggs. The red and black pupa develops in the gray skin of the last larval stage of growth and then emerges as adult male or female vedalia beetles.

I went to a meeting where the migration of vedalia beetles was discussed at length. It was held at a restaurant with an airplane stuck in the roof just south of Fresno, California in the winter of nineteen fifty nine. These two scientist from the University of California Extension Service had taken a Cessna aircraft and flown back and forth over the San Joaquin Valley at different altitudes during different times of the day collecting vedalia beetles that squashed and stuck to fiber board that they stuck out of the aircraft's door. They found the beetles in the air when temperatures were warm. As the temperatures dropped during the day they didn't find any vedalia beetles flying in the air. They landed and inspected the ground to see where the beetles had landed. They found beetles at high elevations in the mountains of the Sierras, different areas of the valley and even on the beach of the Pacific Ocean. They said that at different temperatures the beetles closed their wings and fell to the ground. As long as the beetles were had their wings out the prevailing winds carried the beetle in the air. The scientists carried this study on through the year's different seasons as long as there were vedalia beetles flying. The prevailing winds blew toward the west or coast of California during the spring and early summer months and during the late summer and fall months toward the east or Sierra Mountains.

According to the scientists' data the vedalia beetles could be found flying at some high altitudes. The researchers decided that the vedalia beetles maintained the altitudes until they got cold and closed their wings and fell to the ground. As long as their wings were open the wind took them either west or east. The temperature would raise them higher depending on how warm it was. In cool temperatures the beetles dropped and in warm temperatures the beetles kept traveling. Once the beetles were in the mountains they would start feeding on pollen and other foods other than insects. This diet increased their weight enormously. Once they were well nourished the beetles hibernated. As their bodies consumed the body weight the vedalia beetles

awoke from their hibernation and gradually started flying. The prevailing winds blew them over the valley and as the temperature dropped so did they.

In the valley again the vedalia beetles started looking for water. When they couldn't find water they found insects like aphids and cottony-cushion scales, when they took their water from these insects the beetles were able to take in proteins for their bodies. The proteins activated their sex drive and they began mating. Then they started laying their eggs on the insects and they became predators. The biologists at that restaurant went to great lengths to explain the if a person finds lady bugs in the mountains they should wait until they get hungry. Feed them bugs before they started flying away. This would make the beetles predators again. But if you just put them on your crop they'd just fly away looking for water.

Other parasitic insects that attack cottony-cushion scale are the parasitic fly, Cryptochaetum iceryae. This is another insect introduced from Australia at the same time that the vedalia beetle was brought over. The predator is most abundant in the coastal areas of California where as the vedalia dominates the San Joaquin Valley and the inland areas of California. The Cryptochaetum adult is a dark blue or green to black fly that is one and a half inches long. The wings are gray in color. They have about five to six generations and each generation takes a month to complete. A dozen or more eggs are laid in the larger insects that it encounters, but in small scales only one egg is laid. The pupa is black with tiny breathing tubes. Cryptochaetum has a complete life cycle. Lace Wing predators also feed on cottony-cushion scale. Ants will interfere with the predators and they should be controlled in orchards. Pruning the trees will cut down on cottony-cushion scale because this allows air and sunlight to reduce the environment that the scale multiplies in.

When scouting citrus groves for cottony-cushion scale the best time is early March through April. If the scale is found, look for the presence of vedalia beetles along with scales. Vedalia beetles will complete four generations in the time that it takes cottony-cushion scale to complete one generation. They can control the infestation in four to six weeks if they are not killed with a pesticide application or a growth regulator. Because the predators have a complete life cycle growth regulators will kill them. If no parasites are present applications of pesticides are needed. When monitoring the cottony-cushion scales examine twenty five trees. Be sure the scale is alive by pulling their bodies apart looking for liquid. If the count is four scales per two foot of a branch, treatment is needed. When scouting for cottony-cushion it's easy to mistake the pest for the parasite. The two look similar but the scales have black legs and black antennae the vedalia have red legs and no antennae.

If the infestation is great enough for pesticide application the following products can be used In Arizona: Lorsban, Supracide, Malathion, The growth regulator is Esteem. California recommendations include: the growth regulator, Applaud, and the pesticides: Malathion, Supracide, and Sevin. Close timing of field inspections may show that more applications may be needed.

Wooly Whiteflies! Another honeydew producer in citrus production is the Woolly Whiteflies. Yuma has some damaging populations, but they can be found almost anywhere that citrus is grown. The damage to citrus occurs primarily on grapefruit, tangerines and tangelos, but lemons and oranges can be hit by large colonies. The woolly white flies go right for the sugar rich phloem tissues of the citrus trees. This feeding causes the leaves to wilt and drop off of the infected trees. The sooty mold grows on the high amount of dust covered honeydew produced by these insects. Similar to the cottony-cushion scale the trees infected by the wooly whiteflies can turn black and this cuts down on the photosynthesis that the trees can carry out causing smaller

fruit sizes. Contamination of the citrus fruit by the honey dew and sooty mold causes problems. Harvesting is slowed down and extra washing in the packing house is required.

The wooly whitefly in the warm Arizona weather needs about twenty one days to compete a life cycle. They have a complete life cycle with eggs, crawlers in the first instar. Then the second and third instar is a sedentary stage where they feed and are covered by large amounts of waxy filaments, honeydew droplets and cast-off skins. A fourth instar acts as the pupa stage of its life cycle, then an adult that emerges from the vertically split skin of the pupa. Woolly whiteflies go through five to six generations. August will generally have the highest population, although some high populations can occur during the months of late May and June. The year's last generations, the fifth and sixth occur in October or November. Wooly Whiteflies will over winter in their third and fourth instars or as eggs. The adults are white with wings like a moth. They have a yellowish abdomen with white dust like powdery scales They roost on the bottom side of the citrus tree leaves. Unlike the other whitefly insect these wooly whiteflies are not as active and do not fly out in clouds if disturbed. They will fly slowly away, but they will quickly go back to roosting. The adults exist for as long as twenty four days.

The adults lay their eggs on the bottom of leaves that have fully expanded. The eggs are laid on stalks attached to the leaf. They are small and sausage shaped and laid in circles or semi circle arrangements. These egg circles are surrounded by a light dusting of waxy scales. When laid the eggs have a pale white color, and then they begin to darken to a brown color as they age. In four to twelve days the eggs hatch except in the late fall months when they may last through the winter months. Each female wooly white fly may lay two hundred eggs. The young that hatch are oval shaped and flattened. They resemble scales. As they grow they will cover their bodies with "wooly white and waxy filaments. The nymphs go through four instars and the first instar is the only time that they are mobile and move around.

Scouting for wooly whiteflies should begin in March in Arizona. By turning the leaves over and looking carefully not to alarm the insects look for eggs, adults, crawlers and nymphs. At the same time look for parasites young and adults. Weekly scouting continues through the warm temperatures until it cools off in October and November. The waxy cover should be gently scraped away to expose the large nymphs and the empty pupa if the adult has already emerged. The empty skin will vertically split where the adult left the cocoon. If the pupa case is intact with a round hole in the rear of the case, the parasitoid, Eretmocerus sp. has done its work. These parasites that control wooly whiteflies are common in the desert citrus of Arizona especially in Yum, Arizona. Other predacious insects are present during the citrus season. The Yuma spider mite and Tydeus are predacious mites working in the area. The Eretmocerus sp. parasites are identified by three small yellow dots that are found on top of their heads between their eyes when you look down on them. They have the small body and yellow color of a small yellow gnat. Other predators include: coccinellid beetles, nabids, Orius, six-spotted thrips and lacewings. Some selective pesticides will allow these predators to aid in wooly whitefly control.

Esteem, the growth regulator, will control wooly whiteflies but it will take about a month to control them. It sterilizes the adult and causes infant mortality. Esteem can harm the vedalia beetles and lacewings, but it is easy on many parasites. Re entry period is twelve hours. Read and follow the label. Provado can be sprayed on the tree leaves as a systemic control for all whiteflies. Admire is the same chemical but it has to be applied in the soil around the trees or through drip irrigation. The drip irrigation method has worked, but soil injection with flood irrigations hasn't been proven to this date. When applied during cool months Provado is effective on citrus thrips. Provado cannot be applied during bloom or within ten days before bloom. Do

not exceed one pound of Provado per year and allow ten days between applications. The chemicals: Baythroid, Danitol, Lorsban and Dimethoate have shown activity on the wooly whiteflies. These chemicals will knock down the parasites, but if the infestation warrants the use of these chemicals they will do the job.

Citrus Peelminer! Where ever citrus and cotton fields are close to one another citrus Peelminer may become a problem pest in the citrus crop. Peelminer in citrus are problem in the cotton growing areas of the San Joaquin Valley and Coachella in California and the citrus producing areas of Arizona. In Arizona the citrus peel minor is more prevalent in central Arizona than in the Yuma area. And it isn't just cotton that citrus peel miners come from. Other hosts include melons, peppers, oleander bushes and grapes (especially in the California's central valley and Coachella vineyard regions). In citrus the peel minors will sometimes damage the stems of new growth. The real damage occurs to the peel of the fruit. In California and Arizona the favorite citrus fruits of this pest are the grapefruit and navel oranges. Lemons can have them in their peels also. Populations of peel minors will show up in their hosts: cotton and oleanders during the May, June and July months before moving into the citrus groves in August. Because the citrus peel minor is not an economical pest to these crops this insect is not treated as a pest and are allowed to exist and multiply. Then they migrate to the citrus groves.

When the peel of the fruit is damaged it has to be harvested and sold for juice and this sale returns a lower price than fresh fruit does to the grower. The smooth-skinned varieties of navel oranges like the Fukumoto and Atwood are damaged more severely by the citrus peel minor, but this pest will damage all varieties of citrus. These smooth skinned varieties can suffer a five to eighty percent amount of fruit damage. Other citrus that is not as susceptible to peel damage may only have as low as three percent damaged fruit. The practice of growing BT engineered cotton has reduced the infestations of citrus peel minors that start in the cotton crops.

Citrus Peelminer adults lay their eggs on the stems and fruit of citrus. The months of August through October are when citrus Peelminer populations are found in their highest numbers. The adult is a dark gray moth with brown and cream colored markings on their wings. They are the size of a mosquito. They can be seen flying around in the morning and early evening hours. The adults live for a period of eleven days. The female lays her eggs one at a time separate from one another on the skin of the fruit or in some cases on new stems. Each female may lay as many as ten to fifty eggs. The eggs are very small, convex on top and oval shaped with sculpturing on their surface. These eggs hatch in four to five days and begin feeding through the rind below the eggs. The larvae that hatch are semi transparent with a liquid yellow color, flat bodied and laterally sculptured. They feed on the sap of the fruit or the young stem just inside the epidermal cell layer of the rind or of the skin of the stem. They will feed and grow through four to seven instars. Each of these instar stages of growth will last a period of three days. As the larvae grow it mines the rind or the stem and creates a winding tunnel that is seen through the epidermal skin as a white winding path. In the last instar stage the larvae will not feed. After not feeding it will molt into a spinning form with spinning mouth parts. This life stage is reddish-brown to pink colored. The spinning form will last for one day. Then it leaves the peel rind. It lowers its body from the fruit or stem attached to a silken thread to a crevasse in the tree's bark, or a niche in the leaf's axial or in the trash on the ground. It raps itself into a silken cocoon where pupation will take place for a period of ten to twelve days. The silken cocoon is covered with small white, silk balls. The time needed for the whole life cycle can take about thirty days to complete. The Citrus Peelminer does not have an over wintering stage. The peel minor continues development throughout the year. During warm weather the generation life

time is shorter than during the cool months. There is six to eight generation during the year.

Citrus leaf minors stay with leaves and unlike the citrus Peelminer they leave frass trail in the mine of the citrus leaves that they inhabit. Their pupa is found in the leaves without the white silk balls found on the citrus Peelminer pupa.

Controlling citrus peel minors is difficult because the fruit that Peelminer prefer is inside the tree and close to the ground; therefore application is hindered. Another fact is that the insect is covered inside the peel. There has been some success with the pesticide named Micromite 80 (diflubenzuron). This material kills the egg only; therefore scientists are determining when the moth flights or this insect occurs to contact the best egg stage. Micromite 80 can be applied during citrus bloom. If this material is applied with Danitol, Lorsban or Baythroid, the combinations will require have bloom restrictions.

The native parasites that attack citrus Peelminer are in all the citrus growing areas. One of the parasites that is common in the Coachella Valley area is the wasp, Cirrospilus coachellae. Leafminers parasites will work on the Peelminer when they are in to same areas.

The use of trade names in this course is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that they are approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.

Acknowledgements

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ADJUVANTS

Application is vital to the desired results of pesticides. Researchers have claimed that up to 70% of the effect of a pesticide is dependent on its application. Even today with the advancement of modern pesticide formulations and application techniques, adjuvants will reduce several of the spray application problems. Problems encountered during pesticide application include: drift, coverage, adherence, volatilization, penetration, solubility, surface tension, foaming, suspension, evaporation, stability, incompatibility, alkalinity degradation and odor. Color or the uses of dyes is also an application problem in some situations. Adjuvants are formulated to reduce these application problems by: buffering, sticking, reducing foam, spreading, reducing evaporation, emulsifying, reducing drift, reducing volatilization, reducing odor problems, highlighting where spray has been applied, increasing compatibility, dispersing, and wetting. Other adjuvants include those used in vertebrate pest control for taste and stomach absorption. Food and sex attractants are also used in insect control as adjuvants.

An adjuvant would be any substance added to a pesticide, but separate from the pesticide formulation, which will improve the pesticide's desired effect. The adjuvant can either affect the diluent, the mixture, the pesticide, or the target by its improvements of the pesticide's performance. An adjuvant can adhere to the pesticide on the area where the pesticide is functional. An adjuvant can change the epidermal layer of the leaf surface permitting pesticide entry. An adjuvant can attract the target pest to the pesticide as when the adjuvant is used as a food for the pest in baits. The pesticide carrier or diluent is not usually considered to be an adjuvant. A diluent is used to dilute the pesticide concentration. The label usually states the amount of diluent to use. Diluents can include water, dry and liquid fertilizer, clay and even recycled paper. A diluent is also called the carrier.

Since the very beginning of pesticide use, adjuvants have been added to pesticides. This made pesticides more effective and reduced the handling problems. When pesticides were first used applicators had many problems to deal with. Many pesticides wouldn't disperse well in water. They plugged up nozzles, settled to the bottom of the spray tank, beaded up on the leaf and didn't penetrate and rain washed them off of the target.

One of the first pesticides, lead arsenate, had animal proteins added with it to improve its spray capabilities. Animal bone ingredients were used as sticking agents. University researchers during this early period of pesticide usage spent a great deal of their time on adjuvants and formulations of pesticides trying to get the greatest amount of effectiveness out of the few pesticides that were available.

During the Second World War and right after the war the increase in the number of reliable adjuvants and available pesticide formulations actually decreased the need for university research on adjuvants and pesticide formulations. Without these university extension recommendations, the use and types of adjuvants for pesticide applications has become confusing. Studying the label of the pesticide requirements for adjuvants is a method of determining what and how to use adjuvants, because you won't find very many University research papers available as a guide to what you need. Another way of finding out what is the best adjuvant for what you need; try calling the manufacturer of the pesticide that you are using.

There are pesticides formulated with adjuvants, and the label will specify that the formulation contains a spreader, an example is Roundup Ultra®. Pesticides like Pursuit® and Gramoxone® specify that an adjuvant should be added. There are so many adjutants on the market today that the user has a problem trying to choose the right one for any particular task. One publication by George Kapusta of Southern Illinois University contains 411 entries from 37

companies.

Water! Most of the adjuvants are used to improve water when it is used as a carrier of the pesticides used in the application of pesticides. Water is the main material that is used for a diluent and water still has many mysteries that scientists are working on to increase our knowledge of just how water reacts in fulfilling all our needs not only in agriculture but in medical, environmental, economical, geological, outer space and many other areas of scientific endeavors.

The story goes that: Jesus and his disciples decided to take a day off to play golf. Jesus teed off over one of the lakes on the course and the ball went into the water. He then proceeded to walk out on the water's surface to retrieve his ball. A guy in another foursome saw this and yelled to the disciples and asked "Who does he think he is? Jesus?" and Saint Peter said "No! He thinks he's Tiger Woods."

There are animals on this earth that can walk on water. They are insects or invertebrates with exoskeletons in the order Hemiptera in the true bug family called Gerridae. They have several common names: water striders, water bugs, water spiders just to name a few. They are even called Jesus Bugs. Over 1700 species of gerrids have been identified. Gerrids are mainly referred to as "water striders". Although most of the gerrids are fresh water dwellers, a genus of them with 40 species called Halobates dwell in coastal sea waters while 5 of these species of Halobates are able to stride and exist on the open seas. The coastal water Halobates are predators and feed on other insects, the Halobates in the oceans feed on plankton. This is mainly a microscopic organism that exists in the oceans.

The Halobates water striders were the first of these Gerridae to be studied. In 1872 these sea striders were studied during the Challenger expedition which was carried out by the Royal Society of London on the Royal Navy's ship, the Challenger. During 1873 to 1876 the scientists were able to catalogue over 4,000 unknown species. Among them were the Halobates. This started a study of all Gerridae and found that the largest amount of gerrids occupy most fresh water lakes, ponds and rivers.

Since then the water striders have been studied because of their unique talent for walking on water. With new techniques of studying micro anatomy, striders have been discovered to have as one of their most valuable attributes very fine micro hairs that cover their entire bodies. These hair piles on their bodies allow the water striders to repel water molecules from clinging and weighing down their bodies. Gerrids also have six elongated legs that spread their weight over the surface of the water. The front pair of legs has claws for catching their prey. The middle pair of legs is longer than their front legs and is used to propel them through the water. The back legs are their longest and are used to spread their weight over a large surface of the water. The front legs are close to the head and the eyes. The middle legs are close to the back legs that are attached to the middle of the thorax and extend well beyond the terminal end of the entire body.

Gerrids wings vary. Some gerrids do not have wings. The availability and need for wings depend the habitat that the gerrids live in. Gerrids without wings have the advantage of not being weighted down in the water, but if the water dries up or they run out of food their chances of flying to another location don't exist. They are equipped with either: no wings, short wings, medium wings and long wings. This is why the study of gerrids is so biologically different and intriguing. Hibernation, food supply, mating, water supply and many other factors decide the need for wings.

Gerrids have an incomplete life history. They go through an egg stage, a nymph stage where they are similar to an adult without wings, and then they become adults. Some of them

will have wings and others will not. Water strider adults mate on the water's surface and then lay their eggs on shore plants, floating objects or on moist soil bordering the water. The eggs hatch and the young nymph who look like smaller adult water striders without wings go through five instars or nymph stages until they become adults with or without wings and can mate to produce eggs.

The main reason for the water striders ability to walk on water is the fact that water bodies like ponds, seas, bird baths and other containers of water have a surface where the water molecules are held together by their own attraction energy causing a surface tension film that can hold the water striders and keep them from breaking through the water's surface. The water strider uses its unique legs to distribute its weight over a large enough area of this film of water molecules with the surface tension great enough to support the water strider. The water's surface combined with the surface of the air above it provides enough energy or strength to allow water striders to land walk and even run on the water's surface. As the water strider walks on the surface film of water molecules its feet dig into the film of surface water and their indentions increase the surface area thus increasing the surface tension's area.

The Mosquito! Another well known insect, the mosquito, uses the water's surface tension film to stand and stretch while emerging from its pupae life stage or its cocoon to become an adult. Mosquitoes have a complete life history: egg, larva, pupae and adult. Most of the female adult mosquitoes require a blood meal that they get by biting an animal. If she does not obtain this blood meal she will die. Only the female feeds on animals for her blood meal, but the male and female feed on plant juices with their piercing sucking mouth parts. Most of the females choose calm water to lay her eggs on. This water can be in tide waters, tin cans, bird baths or pasture land that is irrigated as long as the water is calm enough to allow a mosquito to stand on its surface. When they are laying their eggs on the water they usually have to stand on the water's surface. The eggs are usually laid in raft like layers that float on the water. The larva hatches into the water where they feed and grow through four stages then go into a pupa to develop their adult bodies. When the young adult mosquitoes break out of their pupa case they must stand, dry out and stretch to fill out their new adult bodies. The water's film of surface tension is used by the new adult mosquitoes to stand long enough to fill out their entire body.

Water Molecules! The water's surface tension is why the surface of water can resist some external objects from penetrating the surface of a body of water even though these objects are denser than the water. Water is made up of water molecules and water molecules contain hydrogen and carbon. There are two hydrogen ions which are positive (+) cations and one carbon anion and it is a negative (-) anion. Therefore they are stuck together by electrical charges, which is a form of energy. This molecule of water has weak charges on its surfaces. This is called cohesiveness. These water molecule charges are weaker with less energy than the ion charges. A weaker plus charge (+) is on the hydrogen side of the water molecule and the carbon has a weaker negative charge (-) on its side of the water molecule. Even though these water molecules have a weak charge they are still strong enough to attract the water molecules to one another.

Below the surface the overall cohesive pull on the water molecules for each other is to all of their sides. This includes their top sides, bottom sides, left sides and right sides. The water molecules that are at the surface do not have a pull from the top. The top molecule's charge of electrical energy is still present and is split up within the top water molecules but it has moved down from the top and is present on all of its sides. This extra energy added to the surface water molecule sides (all around: front sides, back sides, left sides and right sides) gives a greater strength to the forces holding the molecules together at the surface and is called the "*surface*

tension" of water.

Angle of pull! These charges are not at either end of the water molecule. Therefore the molecules are not held together in a straight line or at 180 degrees. The molecules are held together at an angle of almost 105 degrees by cohesive forces. When you look at a face of a clock 180 degrees would have the clock hands at 9:15 in a straight line. At 105 degrees the clock hands would be at 9:02. Because of the angle of pull of almost 105 degrees instead of in a straight line of 180 degrees, the water's surface tends to bend. When a drop of water is formed in the air this 105 degree angle of bend will give the surface of a drop of water a sphere shape as it falls through the air. If the water is applied to the flat surface of a weed leaf, the water will form beads of water on the surface of the weed's leaf. This beading is what we try to prevent when we spray weeds with herbicides mixed in water.

We use a material called a surfactant that breaks up this surface tension of the beads of water. This allows the beads of water with the herbicide to break down and spread over the leaf's surface. The greater the area on the weed's leaf that we can cover with herbicide, the more herbicide will penetrate into the weed's growing system and the more weeds we can kill. That's why we add surfactants to mixtures of herbicides and water.

Ice! Another way of walking on water is to wait for very cold temperatures and allow ice to form on the water. When temperatures drop the water molecules change by swelling. The angle of the joining of the two hydrogen cations and one oxygen anion increases from around 105 degrees to an angle of around 109 degrees. The change brought about by this swelling allows air to get between the iced water molecules and this cause the lighter ice molecules to rise to the surface of water. In order for the water molecules to become ice there has to be a great loss of energy or heat.

The water's surface tension can also be broken by an increase in the temperature usually by the sun's energy which will activate the motion of the water molecules to the point that they can escape from the surface of the water to the air or sky where they become clouds. The water molecules are then in a gas stage. Water molecules can either be in a solid state as ice, in a liquid state as water or in a gas state as free water molecules or clouds.

When the water molecules receive enough energy to escape from the surface they take with them a great deal of energy, this loss of energy is called evaporation. The same thing happens when we sweat. Our skin cools down. The loss of water molecules take away enough heat in energy that we get a cooling effect to our skin. Evaporative coolers are based on this process. The sun provides enough energy to heat the water's surface again and again until the container whether it is a pond, flooded area or a birdbath loses all the water and the container dries up.

Surfactant: The water surface tension can be broken by the addition of surfactants to the water. A pesticide surfactant is an adjuvant but not all adjuvants are surfactants. The word, surfactant, comes from three words: "surface, active, agent". (Surf-act-ant). Most of the adjuvants on the market contain surfactants. The surfactant is the principal active ingredient of many adjuvants. Surfactants can be nonionic with no charge (o), anionic with a negative charge (-) or cationic with a plus charge (+). You will often see a statement on the label of a pesticide "use a non-ionic surfactant". Ionic is an adjective that means containing or involving ions. Ions are metal atoms that have either lost or gained one or more electrons.

The structure of elements is made up of several particles. One group of these particles of the atom is called electrons. Some of the elements, sodium for example, holds the electron very weakly and can lose the electron to other elements. Chlorine is one of the elements that can gain

electrons. There are elements like calcium that can lose more than one electron and groups of elements, sulfate for example, that can gain more than one electron. These elements, sodium and chlorine are ionic. They lose or gain ions.

The atom losing an electron becomes electrically charged with a positive (+) charge. The atom that gains an electron becomes electrically charged with a negative (-) charge. They become two ions that attract one another. They are held together by electrostatic energy. When they are held together in this way they are solids. Table salt, sodium chloride, is a solid. Another example of this is gypsum or calcium sulfate.

This electrical bonding or sticking together can be very weak or very strong depending on the elements involved. When the solid material is placed in water the electric bonding is broken and the solid dissolves in the water. The two charged atoms or groups of charged atoms, one charged as negative and one charged as positive, become free to wander about independently in the solution. These are called ions from the Greek word, ion, meaning "to wander". In an electrolytic cell or battery with two charged poles called electrodes, the positive charged ions will go to the negative CAthode pole and are called CAtions. The negative charged ions will go to the positive ANode pole and are called ANions.

Sugar is made up of molecules that contain atoms of carbon, hydrogen and oxygen which are not metals. The carbon, hydrogen and oxygen atoms unlike the sodium and chloride ions do not separate from one another in a solution. They stay together as a molecule. They do not give an electron to one another and they do not become ions. Sugar is non-ionic. It is not a salt. Dissolved salt and dissolved sugar in water are both clear solutions. Sugar is similar to the nonionic surfactants with carbon, hydrogen and oxygen held tightly together as molecules in the solution. These nonionic surfactant molecules are free to move about in the solution and aid in the activity of the pesticides.

Ionic elements in solution with their electric charges can become joined with other charged particles to form solids that can interfere with the activity of the pesticides. Most of the surfactants that are formulated with pesticides are nonionic or anionic. The exceptions to this are in Round Up Ultra®, which uses a cationic surfactant as its primary surfactant in its formulation. Round Up Ultra's® label doesn't state the need for any surfactant. The cationic surfactant in Roundup splits with the main ingredient in Roundup, glyphosate, after the two materials are inside the cuticle of the growing plant or weed. Some herbicides and insecticides are equipped with surfactants and some are not and these need surfactants. The best information on the need for a surfactant is from the label. Pesticides formulated as emulsified concentrates, flowables and wettable powders are formulated with 2 to 3 surfactants. These are usually both anionic and nonionic.

When applying pesticides that we want to enter the plant we need a material added to the pesticide that will allow diffusion to occur. Diffusion takes place when molecules that are in great supply in one area and low supply in a neighboring area move from the area with the high supply to the area of low supply. In order for an object to move from one area to another the wall separating the two areas has to allow the passage of the material or molecules. If the wall is made of wax or oil the molecules have to be non ionic or neutral. This is where a surfactant should be used if the label calls for it.

The spray droplet must be able to spread out on the leaf surface. The more leaf surface the pesticide is able to contact the more effective the diffusion is. Wetter-spreader surfactants added to the water, reduces the surface tension of the water on the surface of the drop. At the same time the surfactant reduces the interfacial tension between the droplet of applied spray and

the surface of the leaf. The surfactants added in the pesticide formulation or concentrate may not be adequate for reducing both the droplet and the leaf surface tensions. When the spray droplet doesn't spread out as needed on the leaf surface, other surfactants are added to the spray mix as adjuvants to increase the leaf surface coverage.

Two segments make up the surfactant. One segment is water soluble. It is hydrophilic. The other segment of the surfactant is oil soluble. It is lipophilic. The lipophilic segment is made up of a long alkyl chain (made up of hydrogen and oxygen "similar to alcohol"). These two segments together allow the surfactant molecule to mix with liquids that have the two different solubility's (water and oil}.

Silicone surfactants have the carbon-based lipophilic chain modified with silicone. This changes the characteristics of the surfactant. The silicone surfactants greatly reduce the surface tension of water. In some cases this increase in spreading is beneficial, but it can be so great that the pesticide runs off the leaf surface reducing the pesticide effect. Silicone surfactants can be very effective in entering the leaf by causing flooding into the leaf's open stomates. Leaf stomates are small slits or openings in the epidermis of the leaf through which gases and water pass. Most of the stomates are located on the underside of the leaf.

Surfactants are often measured by the hydrophilic/lipophilic balance. This is referred to as the HLB. Water-soluble compounds would associate better with high HLB numbered surfactants because they contain more of the water-soluble segment of the surfactant. A low HLB surfactant would associate better with oil soluble compounds.

Oils In the past oil was used as a herbicide. It was called *weed oil*. Citrus growers used so much oil that many of them had huge storage tanks to hold bulk oil. The oil was sprayed directly on the weeds in the orchards. The smell of oil in the spring and summer months replaced the smell of oil burning smudge pots that the citrus growers used to protect their trees from frost damage during the winter months..

Now, oil is one of the oldest adjuvants and is still very popular today. The petroleum oils used as crop oil concentrates are phytobland. This simply means that they are not irritating to plants. The mistaken name for oil adjuvants is crop oil. But the oils used as agriculture adjuvants are usually petroleum based not from vegetables. Petroleum based oils have a paraffin or naphtha base. Oil based adjuvants aid in the penetration of sprays through the waxy or oily cuticle. These oil adjuvants aid in the penetration of the insect's outer skeleton which is a chitinous shell material like the chitin exoskeletons of insects and some bacteria. Adjuvant oils are used at the rate of 1 to 2 gallons per acre.

Oils will help some specific pesticides penetrate the waxy coating of the cuticle of the leaf surface.

Crop Oil Concentrates are materials designed for crop applications. These can include petroleum and vegetable oils. The vegetable oils include soybean, sunflower, canola and cotton and are not irritating to plants. Both vegetable and phytobland petroleum oils are treated with surfactants that emulsify and decrease the surface tension of the total spray.

Activator adjuvants are light oils combined with surfactants that emulsify the oil. These activators increase pesticide penetrations of specific pesticides on the surface of specific plants. These adjuvants are called Plant Penetrants or Translocators. With increased penetration the systemic insecticides will give better results. This is true for the weed killers that need to penetrate the plant like the auxins (2-4 D), Assure, Poast, Fusilade, Select, and fungicides that require translocation to the inside of the growing plants where the fungi infestation is located.

Vegetable oil concentrates haven't been as effective as the petroleum oils in the

agricultural field of pesticide spraying. Some manufacturers are working on an improvement of vegetable oils by adding more lipophilic characteristics.

Compatibility Agents! Some pesticide formulations have compatibility problems. They break down when added to diluents like liquid fertilizer. This can also happen when two incompatible pesticides are added together in a mix. The result is a creaming or settling out of the pesticide mix. The result can be clogging of the application equipment lines. This can cause uneven application and other negative application problems.

There are compatibility agents that can be added to the mixed solution to prevent these problems. The label will usually state that sample amounts should be mixed before making large batches. This will give an indication of the amount of compatibility agent needed and whether the compatibility agent will do the job.

Drift Retardants! The drift of pesticides to other crops not on the pesticide label is a problem that can be reduced by the use of adjuvants called drift retardants. Drift retardants usually increase the droplet size by increasing the tensile strength and viscosity of the water. The goal is to limit the amount of very small droplets that are carried by the air to non-target locations. In most cases a combination of the use of low drift spray nozzles and avoidance of winds or air inversions that carry the material are combined with the use of drift retardants.

The need for increased agitation in mixing these drifts retardants with the pesticides requires extra supervision of the people doing the preparation. Because drift retardants make the applied material thicker, it becomes difficult to handle. Without this extra supervision the drift retardant may never be used because of the added time and effort required when using drift retardants.

Foam Retardants! Agitation and the use of surfactants will cause some foam to form. This results in the taking up of useable space in the spray tank. Foam is an emulsion of air in water. When the surfactants added to the water increase the tensile strength of the air to water interface, then the foam increases to undesirable levels for application. Foam retardants are surfactants that will destabilize the air in water emulsions breaking up the foam. After washing dishes the foam in the sink can be washed down the drain by spraying water on the foam. This becomes a solution of less air and more water thus getting rid of the foam. (My wife makes me wash a lot of dishes.)

There are several surfactants that will break up this foam. A silicone/carbon polymer (Dimethylpolysiloxane) is either sold in the wetter spreader formulation of the pesticide or can be added separately. It is applied directly to the foam from a container that squirts the material into the foam on the top of the spray mix in the spray tank.

Buffers! Many of the pesticides are susceptible to alkaline hydrolysis degradation. When these pesticides are added to the water that has a high pH, buffers that lower the pH can be added to the mix water to decrease the degradation of the pesticide. Phosphoric acid or a salt of phosphoric acid is used as the main ingredient of buffers in pest control. Phosphoric acid, a weak acid, acidifies or lowers the pH of the mix water, and keeps it stabilized at the lower level needed to prevent alkaline hydrolysis degradation of the pesticide. Strong acids like sulfuric or hydrochloric acid will lower the pH of the mix water too rapidly to buffer the solution at the desired pH level for the required activity of the pesticide.

When the pH is high, the amount of phosphoric acid is increased. Some labels have in their directions the amount of phosphoric acid needed to buffer. However, many labels do not have this information. Testing for pH in the mix water may be required when applying buffers. Because the cost of buffering agents is so inexpensive many applicators add buffers to any water

with a pH over 7.5.

There are buffers on the market that contain enough surfactant to act as a spreader, wetter and buffer. Many of the foliar nutrient materials contain phosphoric acid salts that can act as buffers. Insecticides like carbamates and some of the organophosphates are susceptible to a high pH in the mix water. But, not all pesticides are affected by the pH levels of the mix water.

Activators! Spreaders (wetters), Stickers (builders and extenders), Emulsifiers (dispersants and suspending agents), Plant penetrants, Translocators, Emulsifiable oils,

Special purpose! Compatibility agents, Drift retardants, Foam retardants, Buffers, Inverting agents, Soil penetrants, Stabilizing agents (UV filters), Feeding stimulants, Washing agents and Protective blenders.

Ammonium Sulfate! Many of our waters have high amounts of magnesium and calcium that can tie up the Roundup. Colorado river water is basic with a pH of 8.0 or higher with high amounts of basic salts. Ammonium sulfate, when added to the mix water, reduces the loss of Round Up® that will tie up with magnesium and calcium in hard water forming solid crystals that will fall to the bottom of the spray container.

Inverting Agents or Drift Retardants! Inverting agents are emulsifiers that are used as adjuvants to invert oil/water emulsions to water/oil emulsions. The mix becomes very viscous. These inverting agents are primarily used as drift retardants. Drift retardants can contain polyacrylamide, polyethylene polymers, poly saccharine, long chain sugars or vegetable oils. They reduce the volatility of pesticides and cause the solution to become heavier and more viscous. The spray doesn't drift as much, the odor and waste is less. As you observe aircraft applying pesticide sprays with thickeners you can see the very fine streams of spray being applied to the crop. Always follow label instructions because if thickeners are used excessively clogging of nozzles and heavy deposits can appear on foliage.

Dyes! Adjuvants that add color to the mix and are used to indicate to the applicator where the spray material was applied are called stains, markers or dyes.

Odorizers! Odorizers are materials that add a pleasant odor or reduce the odor of the pesticide. These adjuvants when used with pesticides mask or reduce unpleasant odors that can associate with pesticides.

Suspending Agents! Pesticides like sulfurs and other solids have a tendency to settle to the bottom of the mix tank. When treated with suspending agents the particles of these pesticides remain suspended in the water.

The use of trade names in this course is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that they are approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.

Acknowledgements
James M. Witt, Extension Chemist and Toxicologist, Oregon State University
IOWA STATE UNIVERSITY, WEED CONTROL, EXTENTION AGRONOMY
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