2020 Insect Report

Utah Department of Agriculture & Food
Division of Plant Industry
February 2021

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Eradication is underway and early success is demonstrated in Salt Lake County.
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Apiary Program
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Invasive Borers
Trapping programs protect managed and natural forests from exotic wood boring beetles.
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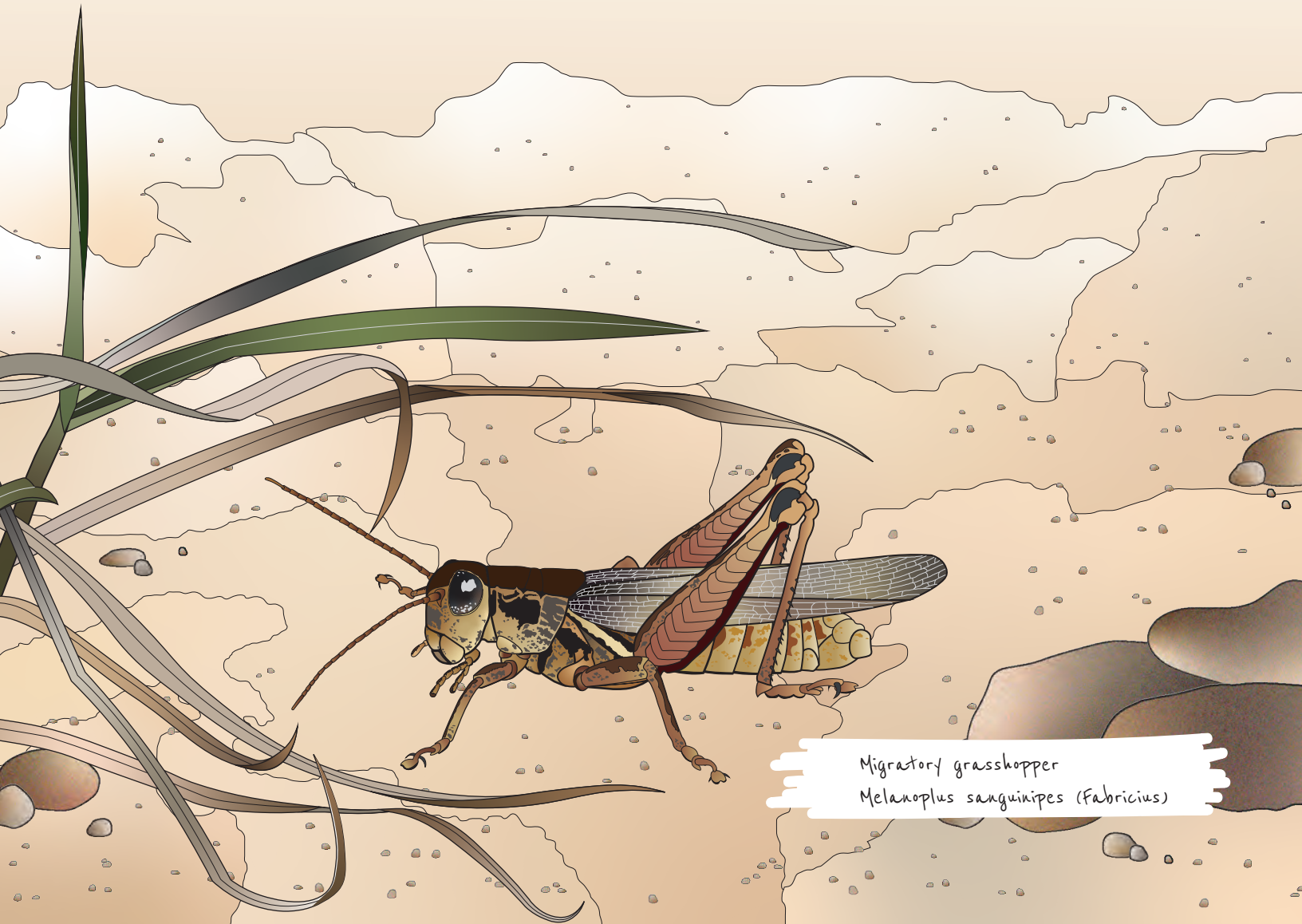

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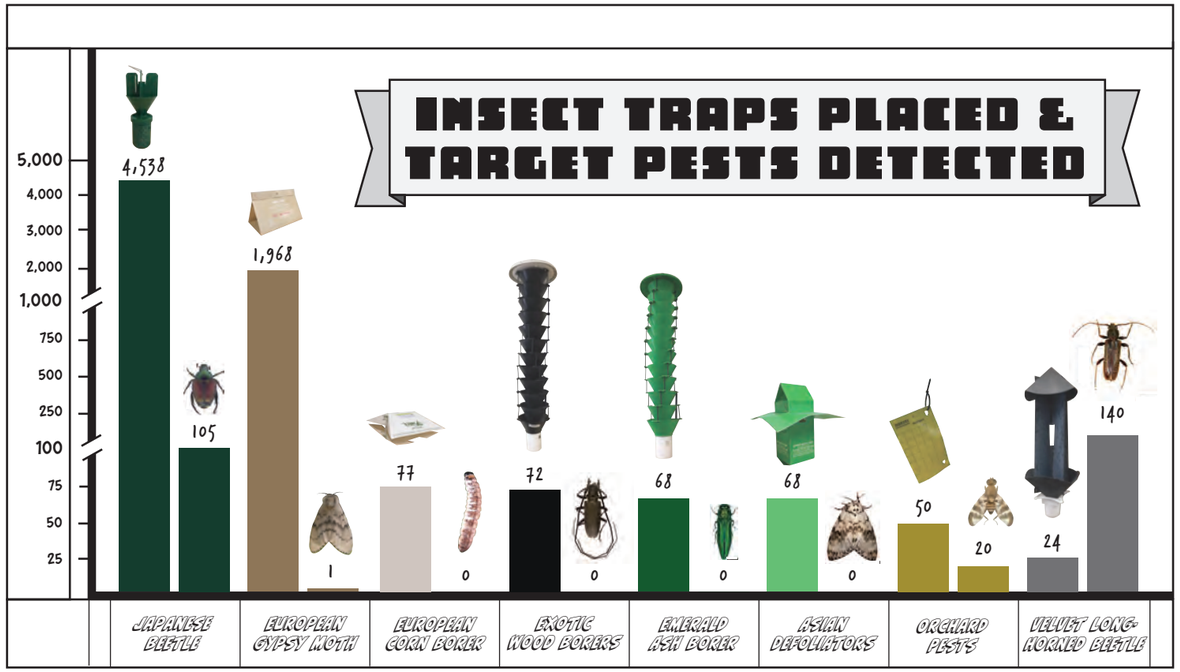

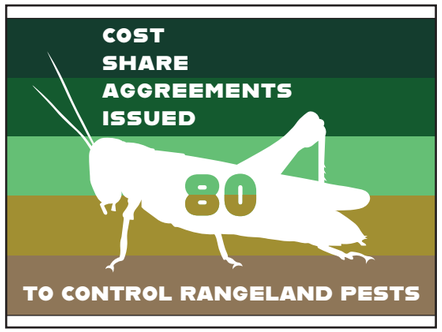

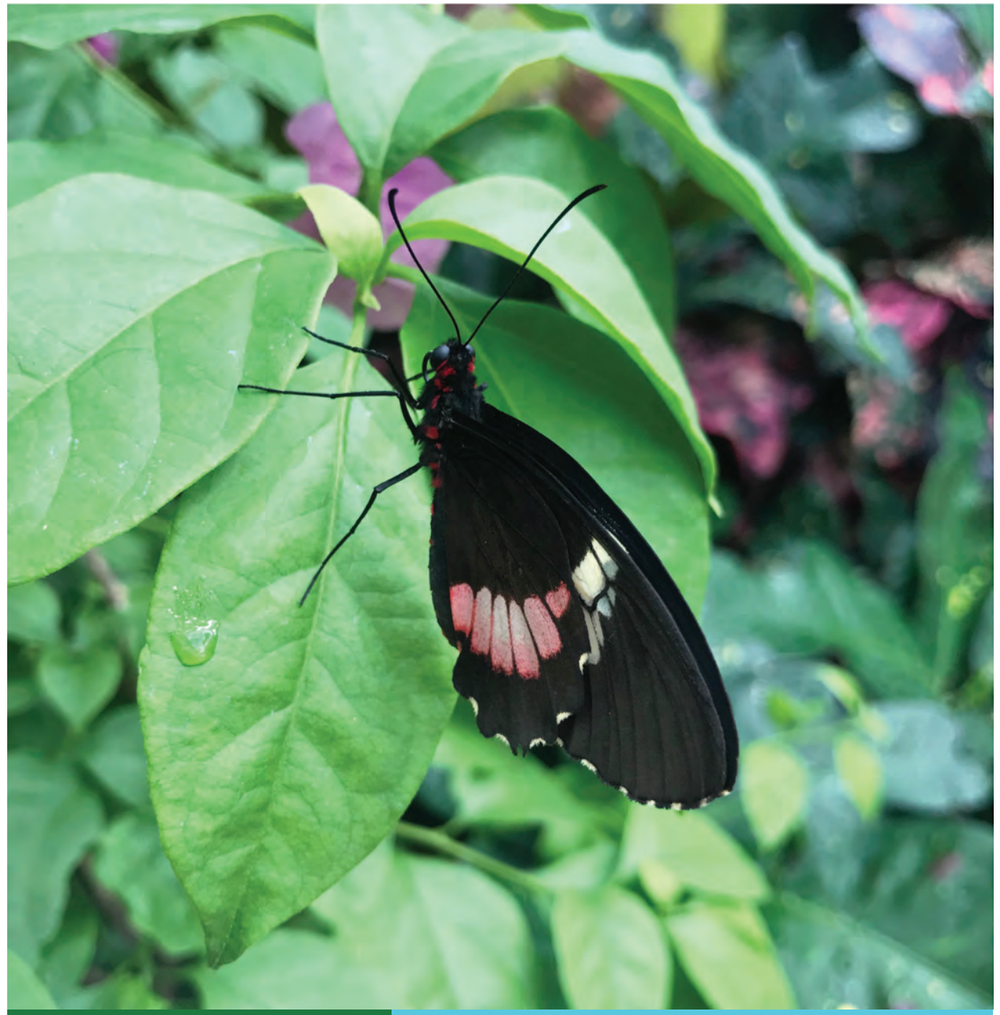

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MESSAGE FROM THE MANAGER

The Utah Department of Agriculture and Food (UDAF) has been addressing insect issues since pioneer agriculture began over 160 years ago. Utah has shown great resilience over the years and last year was no exception. Through the pandemic, earthquake, inland tornado and social unrest we continued to persevere. UDAF pushed forward in helping Utah Agriculture and protecting our natural resources. While this past year was particularly difficult and the whole world slowed down, invasive insects continued to make their way around the world and into Utah.

In March of 2020, UDAF declared a Japanese beetle Insect Infestation Emergency and early spring eradication efforts took place in Salt Lake County. While we saw a significant reduction of beetles from our eradication efforts, unfortunately we had new populations pop up in other counties along the Wasatch Front. Through all the challenges presented in 2020, UDAF set a new record of insect traps placed, as we deployed additional traps around Japanese beetle detections. In the past we have found populations of invasive pests, such as Japanese beetle and gypsy moth, and eradicated their populations to prevent their establishment and associated negative impacts to our great state. Our previous eradication success gives us confidence that with the same attentiveness, effort and support, Utah will again eliminate these pests.

The importance of early detection and rapid response is critical to the success of future projects and the viability of agriculture. Invasive pests and diseases are moving around the world at an alarming rate due to the growth of commerce and worldwide trade. These developments have created challenges and new pathways of introduction. Agricultural pests have the potential to impact our nation's food crops much like a natural disaster, with annual losses estimated to be between 20-25% depending on host and species. While many insects are beneficial and we support pollinators, invasive pest infestations can be devastating to agriculture, as well as our environment.

Thank you to all the farmers, ranchers and constituents of the great state of Utah that support and protect our agricultural and natural resources from new invasive and endemic agriculture pests. Also, I send appreciation to our staff as they work relentlessly to promote, protect, monitor and control invasive pests and diseases. These efforts help to maintain a competitive market, minimize pest losses and protect the future of agriculture here in the state. It is with all of your support and help that we will continue to protect the state's agricultural industries, food supply and our quality of life for years to come.

Respectfully,

Kristopher Watson
State Entomologist

News & Notes

Regulations Update

Ash Quarantine Proposed

Emerald ash borer on a host tree branch.

The Utah Department of Agriculture and Food (UDAF) Insect Program will be proposing an ash *Fraxinus* nursery stock quarantine. The state is proposing the quarantine as a result of the United States Department of Agriculture (USDA) Animal Plant Health Inspection Service's (APHIS) decision to deregulate emerald ash borer *Agrilus planipennis* (Fairmaire).

Utah and many other western states have managed to stay free of the pest since it was first detected in the United States in 2002. USDA-APHIS's regulations prohibited the movement of ash nursery stock and firewood from areas of the country known to be infested with the pest to areas that were uninfested. However, when federal deregulation is complete, potentially infested nursery stock could legally be moved to Utah if the state does not enact its own quarantine. Utah already has a firewood quarantine (UCA R86-23) that prohibits potentially infested wood from being imported.

The ash nursery stock quarantine was proposed to the state Agriculture Advisory Board in January for consideration. An open public comment period will follow.

Insect Infestation Emergency Control Act Changes

The Insect Infestation Emergency Control Act was updated in the 2020 Legislative Session and changes went into effect later in the year. The statute's title was changed to the Plant Pest Emergency Control Act and there were substantive changes to the text, which are already proving useful.

The act was expanded to include plant diseases and arthropods other than insects. Consequently, UDAF Plant Industry now has the ability to quarantine plant pathogens and critters such as nematodes, snails or arachnids.

The amendments also created a fund for plant pest emergency needs, such as eradication programs and endemic pest suppression. Previously, such activities did not have dedicated funding, which meant the department would need to hastily find monies when emergencies materialized. In 2020, Japanese beetle eradication efforts (see page 12) were paid for by this newly created fund.

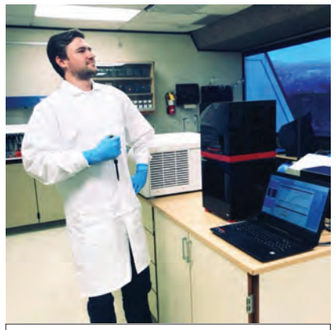
Personnel Changes

UDAF Plant Industry Management

Bracken Davis left UDAF for a Geographical Information Systems (GIS) position with another government agency. Bracken served as the Plant Industry Deputy Director and was a great friend to the UDAF Insect Program. The entomology staff offer thanks for his help over the years and congratulations on his new job.

UDAF Insect Program

Stephen Stanko accepted a molecular biology job in the private sector after six years of service to the state. Stephen worked on the state Apiary Program (see page 4) and provided essential support to the Entomology Lab (see page 22). During his tenure, he inspected thousands of beehives, helped implement the state's Managed Pollinator Protection Plan, incorporated infrared technology into the Apiary Program, assembled the Entomology Lab's molecular testing system and designed the lab being constructed at the Taylorsville State Office Building. The department will greatly miss Stephen and wishes him the best in future endevours.



Stephen Stanko at the helm of the qPCR tower in 2017.

State and County Cooperative Apiary Program

In 2020, Grand County Bee Inspector Jerry Shue and Davis County Bee Inspector Roman Frazier retired. Sadly, Weber County Bee Inspector Brock Lenox passed away in October. Each of these inspectors dedicated a decade or more of service to the cooperative Apiary Program. UDAF Plant Industry offers many thanks to these individuals and condolences to Inspector Lenox's family. UDAF is working to recruit and train replacement inspectors in the counties with vacancies.

Potentially Diseased Plants Intercepted

A geranium infected with Ralstonia solanacearum race 3 biovar 2.

In April of 2020, the UDAF Insect Program assisted USDA-APHIS Plant Protection and Quarantine in intercepting geranium *Pelargonium* shipments that were potentially infected with *Ralstonia solanacearum* race 3 biovar 2. This particular plant disease is not known to be present in the United States and is a serious malady of geraniums and other ornamental and vegetable plants. The potentially contaminated plants were sent from Guatemala and had been in close proximity to flora that were confirmed infected with the exotic pathogen. A total of 2,150 geraniums from 11 different nurseries were intercepted and properly destroyed.

MEET AN INSECT TRAPPER!

SHARON GILBERT

Sharon Gilbert has worked 12 seasons for the UDAF Insect Program and serves as the Lead Trapper. During winter months she is a ski instructor. Every spring, Sharon comes back to the seasonal crew with energy and enthusiasm. This is what Sharon has to say about being an Insect Trapper.

How did you become an Insect Trapper?

Clint Burfitt [the former State Entomologist] used to work at my ski resort and asked if I would be interested in applying. He knew I had previously worked in the nursery and landscaping business and had some knowledge about insects.

What is the best part of the job?

Working with the public and protecting the environment. I enjoy the outreach that comes with the job and telling people about the work we do to protect our trees, gardens and orchards. It's great to meet the people who work in the orchards. They are passionate about their work and are always willing to take time to teach us. There are a lot of nice people in our state.

What is the most interesting thing you have learned about insects?

I think it interested how they live and behave. Their ability to fly is amazing.

What is your favorite insect?

Anything that is fuzzy, shiny or metallic. I like bees and the colorful beetles.

UDAF IS MOVING!

After 38 years of working in the William Spry Agriculture Building, UDAF will be moving to the newly renovated Taylorsville State Office Building. The Insect Program staff and Entomology Lab are expected to transition to the new space in May.

THE UTAH APIARY PROGRAM

State and county governments protect Utah's honey bees from abiotic and biotic threats through registration, inspection and the promotion of best practices.

he history of Utah's Apiary Program dates back prior to statehood, when the area was still a United States (U.S.) territory. It was created by the local legislature at the behest of resident beekeepers, whose hives were being decimated by contagious diseases. At the heart of the law was the ability for counties to appoint bee inspectors to identify these diseases and assist beekeepers in their remediation. Once appointed, the inspectors were successful in containing these diseases and Utah's fledgling industry was saved. Over a century has passed since then, yet the program still remains. While much has changed since its founding, the core goal of protecting honey bee *Apis mellifera* (Linnaeus) health remains the same. Today's inspection program identifies and suppresses the numerous diseases, parasites and other maladies that affect the approximately 37,000 honey bee colonies that call Utah home. These efforts are led by the Utah Department of Agriculture and Food (UDAF), which coordinates efforts between the state and county bee inspectors. This collaborative work protects an industry estimated to annually produce $20-30 million in goods and services.

Inspection Results

State and county inspectors had much work to report in 2020. State inspectors visited 164 operations and inspected 1,092 individual hives. County inspectors looked at another 227 apiaries and 1,069 hives. American foulbrood (AFB) *Paenibacillus larvae*, the most deadly and contagious of brood (larvae) diseases, was found in 1.9% of hives inspected. This was a slight uptick from last year, but still significantly below the 3.9% infection rate in 2018, which marked a decades-long high. The UDAF Apiary Program's goal is to keep this disease's incidence below 1% of colonies. The reduced rate since 2018 demonstrates the effectiveness of the Apiary Program's actions in response to AFB detections (see "Box 1") and outreach to beekeepers regarding antibiotic procurement under new federal rules (see page 6). European foulbrood (EFB) *Melissococcus plutonius* disease was found in 3.6% of hives, which is a dramatic decrease from the previous year (8.4%). EFB is a less serious brood disease than AFB, but it is nonetheless undesirable due to its negative impact on colony health. The fungal brood pathogen chalkbrood *Ascosphaera apis* was found in 1.8% of hives inspected. Like EFB it is considered a less problematic malady than AFB, but persistent infections can nonetheless contribute to colony losses. Varroa mite *Varroa destructor* (Anderson and Trueman), the most devastating honey bee pest, and a condition associated with this parasite known as parasitic mite syndrome (PMS) were up compared to the previous year. In the lead up to the parasite's seasonal population peak phase, the UDAF Apiary Program sent a postcard to all registered beekeepers urging that they take suppression measures during this critical time frame. Data collected indicates this effort facilitated coordinated control success early on, however there was a late season resurgence of the parasite and its associated problems. In 2021, the program will emphasize in communication with beekeepers that late season re-infestations need to be controlled, if hives are expected to survive winter. Despite finding the invasive bee pest small hive beetle (SHB) *Aethina tuminda* (Murray) every year since 2016, no SHB were detected in 2020. The pest has previously been confirmed in Davis, Millard and Washington counties. Utah's dry climate is thought to be unaccommodating to SHB, which may explain why none were found in 2020.

BOX 1: UDAF's Early Detection & Rapid Reponse Approach to AFB

The UDAF Apiary Program has a proven track record in AFB suppression. These efforts prevent the disease from becoming epidemic and causing disruptions in the beekeeping industry. The program follows the "early detection and rapid response" model that is also useful in mitigating invasive insect pests. During apiary inspections, the inspector checks for AFB symptoms. If any signs of disease are found, they take a sample of larvae that is suspected to be infected. The sample is processed in house, at the UDAF Entomology Lab (see page 22) and results are available as soon as the following day. If the sample is positive, the inspector contacts the beekeeper and helps devise a remediation strategy. A follow up inspection ensures that the problem was dealt with appropriately. In addition to this effort, an AFB notification alert, via mail or email, is sent to all registered beekeepers in the vicinity of the AFB case. Beekeepers are encouraged to contact an inspector if any hives they manage are exhibiting AFB symptoms. If the disease has spread from the apiary with a confirmed case to neighboring operations (or the reverse), this communication helps to stop the pathway of future transmission in either direction.

The National Honey Bee Survey

The United States Department of Agriculture (USDA) Animal Plant Health Inspection Service (APHIS) began the National Honey Bee Survey (NHBS) in 2009 to address honey bee health problems. This survey takes an epidemiological approach to document honey bee diseases, pests and pathogens. Additionally, NHBS monitors for invasive threats to honey bees, including the parasitic mite *Tropilaelaps clareae* (Delfinado and Baker), the Asian honey bee *Apis cerana* (Fabricius) and pesticide residues in beeswax.

Although it is a federal program, money is allocated to participating states to conduct sampling and data collection. Sampling involves collection of adult bees, immature bees and wax from operations that have 10 or more hives. These are sent to the USDA Bee Research Laboratory in Beltsville, Maryland where they are tested for exotic pests, pathogens and pesticide residues. Since 2011, the UDAF Apiary Program and beekeepers throughout the state have participated in NHBS and have contributed hundreds of samples to this continually growing body of scientific knowledge.

To date, no exotic pests or pathogens have been detected in Utah. Data collected thus far have demonstrated that Varroa mite infestations are, on average, in excess of levels thought by scientific authorities to be healthful from the months of August through October (mirroring state data). Multiple years of wax analysis suggests that pesticide residues in Utah's beehives are frequently below the national average. In 2020 state inspectors completed 14 NHBS samplings statewide. The complete results of this survey can be viewed at the Bee Informed Partnership website: https://bip2.beeinformed.org/state_reports/

Protecting Bees from Pesticide Misuse

In response to high-profile concerns about pesticide misuse and the associated negative impacts on bees, UDAF brought together beekeepers, commercial food growers, pesticide applicators, landowners and the general public to create a Managed Pollinator Protection Plan (MP3) in 2015. The MP3 promotes practices that will reduce pesticide exposure to bees, facilitates communication between stakeholders and encourages people to plant pollinator-friendly flora. This is accomplished via public presentations, trainings and the distribution of educational literature. Since its implementation the state has undertaken extensive education and outreach efforts. Unfortunately these efforts fell short of previous years' work, primarily due to COVID-19-related restrictions on group gatherings and other public health guidelines. Nonetheless MP3-related educational materials were completely redesigned and distributed around the state (see "Box 2") and staff members were able to conduct some outreach in person and virtually.

In January of 2020, the UDAF Apiary Program presented in-person at the annual Utah Nursery and Landscape Association (UNLA) Green Industry Conference, which represents Utah's floriculture industry. A large group of conference goers were given a one hour talk outlining the best practices for protecting honey and native bees when using pesticides. Attendees were also given recently updated educational literature that they can keep in their workspaces as a reminder of how to appropriately apply plant-protection products. Since this is a large industry, that is heavily dependent on plant protection products, educating this group of people holds possibility of profound positive impact on responsible future pesticide use within the state.

In February, state inspectors also had the opportunity to attend in-person the annual Utah Beekeepers Association Convention where they educated beekeepers about the potential dangers of off-label pesticide applications to their own colonies. Pesticide applications, in the form of miticides, are critical tools used by beekeepers to control Varroa mite infestations in their hives. There are numerous Environmental Protection Agency (EPA) approved miticides which beekeepers can safely use to keep parasites at bay and maintain healthy colonies. However, off-label pesticide applications are sometimes made to reduce cost or for convenience. While this purportedly saves money and time, it often comes at the expense of bee health. Honey bees can suffer inadvertent harm by off-label miticide use because these methods potentially contain too much active ingredient, release the active ingredient too quickly or result in ineffective parasite control. At this convention state inspectors discouraged beekeepers from off-label applications and conducted workshops on how to properly apply EPA-approved miticides per label.

Finally, the UDAF Apiary Program participated virtually in the SLC Bee Fest, hosted by Catalyst Magazine. Normally, this is an in-person event, but because it occurred later in the season, its format had to be altered. State inspector Stephen Stanko participated in both a Facebook Live recorded discussion and KRCL 90.9 FM radio interview about how residents can take simple actions every day to promote bee health and avoid exposing bees to pesticides.

Honey Bees and Antibiotics

As a response to the growing threat of antibiotic-resistant strains of pathogens, the U.S. Food and Drug Administration implemented the Veterinary Feed Directive (VFD) rule in 2017. This rule established new requirements for the use of antibiotics in animal feed. Over the past three years this change has significantly impacted beekeepers by restricting their access to antibiotics and prohibiting prophylactic use in most cases. Perhaps the most substantial requirement of the VFD is that beekeepers are now required to go through a veterinarian to access antibiotics. Previously, beekeepers could purchase these products over-the-counter. This change has likely been a significant contributing factor to Utah's elevated rates of AFB and EFB diseases in recent years.

To lessen the impact of the new regulations on beekeepers the UDAF Apiary Program has been educating veterinarians about their new responsibilities, facilitating communication between stakeholders and providing timely pathogen test results. The addition of molecular disease diagnostic capabilities to the UDAF Entomology Lab (see page 22) in 2018 was critical in the success of this effort; now veterinarians and beekeepers can expect to get highly accurate test results in days rather than weeks.

In November of 2020 the UDAF Apiary Program participated virtually in the Utah One Health Symposium, hosted by Utah State University. The symposium focuses on the juncture of animal and human health, recognizing that the health of Utahans is directly impacted by the health and well-being of animals and our environment. Attendees learned about antibiotic use in beehives, prescribing guidelines for vets, the mechanisms of antibiotic resistance and the importance of using antibiotics judiciously.

Africanized Honey Bee

In 2008, Africanized honey bee (AHB) *Apis mellifera scutellata* (Lepeletier) was first detected in Southern Utah; shortly after the UDAF Apiary Program began monitoring its spread through the state. Though AHB can be dangerous, they have been unfairly sensationalized in the media. Thankfully, education efforts have successfully decreased panic and stinging incidents nationwide. In Utah, there have only been a few instances of AHB attacking humans or animals. Nevertheless, if a person has no experience managing bees, it is best practice to keep clear of any encountered honey bees and to treat all colonies with the respect they deserve.

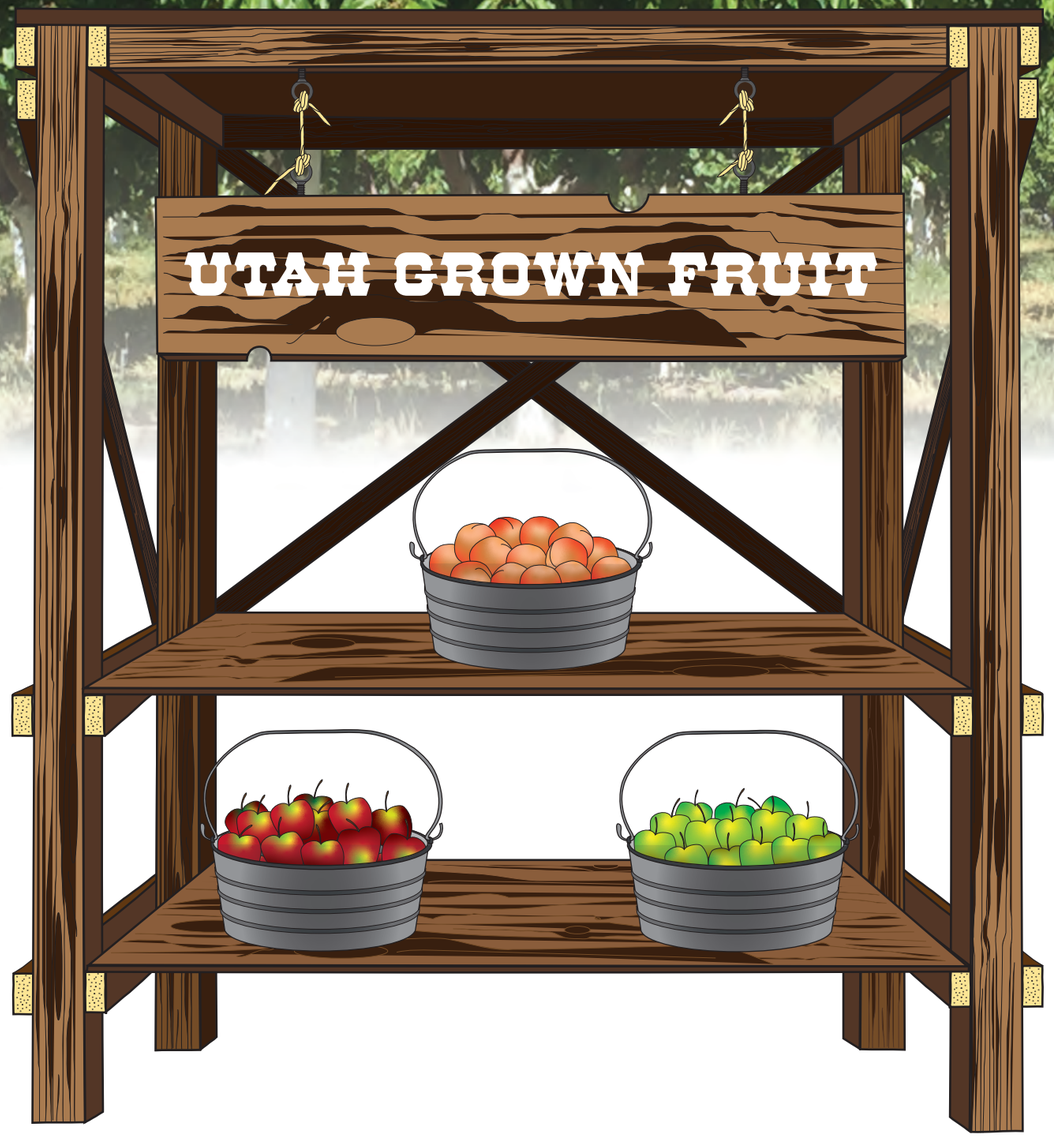
The counties with known established AHB populations are: Emery, Garfield, Grand, Iron, Kane, San Juan, Washington and Wayne. State inspectors continue to track movement to new areas by testing feral bees and aggressive managed colonies in uninfested counties. The UDAF Apiary Program is committed to ensuring that all stakeholders are made aware whenever AHB moves into new areas. No new county records were found in 2020. Looking forward to next year, areas at highest risk for AHB introduction will be the focus of survey efforts.

Health Certification

The UDAF Apiary Program offers health certification services to registered beekeepers in the state. These certificates can be used for various purposes. For instance, many states require that imported colonies are inspected prior to arrival and certified free of certain pathogens or pests. Depending on requirements of other states, certificates may be needed that confirm hives are free of AFB, SHB or the federally regulated human and livestock pest red imported fire ant *Solenopsis invicta* (Buren). Other beekeepers utilize health certificates to maintain eligibility for federal farm assistance programs. Also, some merchants that sell honey bees within the state will request a health certificate so that customers can be assured they are free of disease. In 2020, state inspectors certified 2,400 hives to meet the import requirements of other states, 250 hives were inspected for federal relief programs and 169 were certified as disease free for in-state sales.

BOX 2: MP3 Educational Material Redesign and Deployment

For many years the UDAF Apiary Program has promoted pesticide use best practices at the retail-sales level with educational sign displays and leaflets. These materials were developed in conjunction with stakeholders when the MP3 was first established in 2015. In subsequent years however, leaders in the beekeeping industry and members of the public have made suggestions for improving the messaging and readability of these materials. It had been remarked that the original materials contained too much complicated information for someone casually purchasing pesticides at a store. Based on this feedback, these materials were entirely redesigned with a simpler message and sleeker image. The newly minted materials were placed across the state in Intermountain Farmer's Association (IFA) stores' pesticide sales areas.



The Orchard Sentinel Survey

Working with Utah's fruit growers to keep out invasive insects and suppress established pests.

The Utah Department of Agriculture and Food (UDAF) Insect Program's orchard sentinel survey is an assemblage of three insect traps, targeting four different pests, placed at 11 commercial fruit growing sites. While some locations have been forced to move due to urban development, for the most part, these traps have been put at the same sites for over a decade. The purpose of the survey is threefold:

1) Provide early detection of invasive fruit pests not known to be in Utah.

2) Track movement of pests that are present in certain fruit growing Utah counties but not others.

3) Inform growers of the presence of certain native or established insect pests in their orchards.

Insect pests have the ability to wreak havoc on commercial fruit production; this is especially true of invasive insects. Early detection of non-established invasive insects and reliable data regarding the presence of native or established exotic pests is critical in the management of these insects. The orchard sentinel survey monitors for the following insect pests:

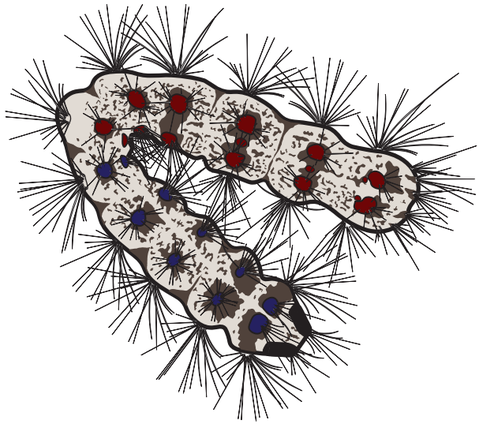
Apple maggot *Rhagoletis pomonella* (Walsh) is native to the Eastern United States (U.S.); the first detection in the West occurred in 1979 in Oregon. It was later found in Utah in 1985. The pest introduction likely occurred via the transport of fruit from infested states. The state of Washington maintains a quarantine of this pest to prevent it from spreading to the east of the state, most of which is uninfested. When the pest is found in Utah, it is usually in abandoned orchards or in home gardens. As the name suggests it is a pest of apples, however it is known to attack other fruits as well. Traps are deployed at the sentinel orchards to monitor populations of this pest and ensure that it does not become a severe problem for professional fruit growers. In 2020, no apple maggots were detected at any trapping sites.

Plum curculio *Contrachelus nenuphar* (Herbst) is a true weevil (family Curculionidae) native to the Eastern U.S. The insect moved from wild host material to cultivated fruit trees in the last century. Since then it has become a major pest of pome and stone fruits in its native range. In 1983, the weevil was found in Box Elder County, Utah. The pest is established in that county, but has yet to be detected anywhere else in the state. Utah is the only part of western North America with a known plum curculio infestation. The UDAF Insect Program surveys for plum curculio in Davis and Utah counties to ensure the weevil is not spreading and in 2020 none were detected in either fruit-producing county.

Light brown apple moth (LBAM) *Epiphyas postvittana* (Walker) is major pest of pome fruits and ornamental plants. It is native to Australia, but it has spread through various parts of the world over the last century. The moth was found in the mainland U.S. in California in 2007. Today 13 counties in California are under quarantine to prevent its spread. To verify that the pest has not been introduced into Utah, trapping is conducted at each sentinel survey on an annual basis. No LBAM have been detected since trapping began.

Western cherry fruit fly *Rhagoletis indifferens* (Curran) is a native insect that was first reported attacking commercial orchards in the early 1900s. It is a serious pest of Utah's commercial tart and sweet cherry industry. Western cherry fruit flies are captured on the same traps that are placed for apple maggot detection. UDAF Insect Program entomologists examine these traps on a bi-monthly basis and will inform growers if detections are made. Though it is not a quarantined pest, data are easy to collect and provide to growers. This information can be used to better time pesticide applications or make changes to pest management strategies. Western cherry fruit fly was found at six of the 11 sentinel locations; a total of 20 targets were at these positive sites.

KEEPING UTAH FREE OF THE EUROPEAN GYPSY MOTH



Perhaps the best known defoliating moth in America is the European gypsy moth (GM) *Lymantria dispar* (Linnaeus). On a quest to find a better silk producing moth, an amateur entomologist imported GM into the United States (U.S.) in the 19th century. The idea was to find a moth that produced silk as well as the silkworm *Bombyx mori* (Linnaeus), but was resistant to the many diseases which inundated commercial production. Some of the adults accidently escaped their containment and began defoliating trees in the city of Medford, Massachusetts. By 1902 the pest had spread throughout much of New England and in subsequent decades it became established in the Mid-Atlantic. Today GM is still present in these areas and has infested some areas in the Midwest and South.

GM is arguably the most devastating forest and shade tree pest in the Eastern U.S. It prefers hardwood trees, such as aspen *Populus spp*., linden *Tilia spp*., oak *Quercus spp*., and willows *Salix spp*., but like many defoliating moths—it isn't picky. GM can feed on over 300 different trees and shrubs. Established populations will fluctuate year-to-year, with some seasons being worse than others.

UTAH HISTORY

Utah's arid climate, mountainous terrain, lack of natural predators and plethora of host material make the state at high risk for GM infestation. However, a decision was made decades ago that Utah would stay free of GM. In 1988 the moth was detected at the University of Utah campus in Salt Lake City. Soon after, insect traps were placed in the area where it was found and in surrounding counties. Trapping revealed that there were moth populations in urban areas and connecting canyons of Davis, Salt Lake, Summit and Utah counties.

A multi-agency effort between the Utah Department of Agriculture and Food (UDAF), United States Department of Agriculture (USDA) Forest Service, USDA Animal Plant Health Inspection Service (APHIS) and Utah Department of Natural Resources (DNR) began work on eradicating the nascent GM populations. Over the next five years a large-scale eradication plan was implemented. First, the public was made aware of the moth detections and a quarantine of recreational vehicles and household articles was enacted around the infestation areas. Next, tens of thousands of traps were deployed. Finally, federal and state authorities financed the treatment of 72,000 acres of public and private land over a five-year period (1989-1993). These areas were treated with the bioinsecticide *Bacillus thuringiensis* (Bt). This pesticide was used because of its effectiveness in killing GM and due to its excellent safety record for humans and other animals. In 1994, no moths were caught in any of the thousands of traps placed; the next year yielded the same result.

However, the battle wasn't quite finished. In 1996 seven GM were detected in Salt Lake County locations where the moths hadn't previously been found. High density trapping the following year resulted in 47 more target insects captured. These findings indicated that there were other growing populations in two separate areas of Salt Lake County's east-bench. More than 1,600 acres would be sprayed over a two year period (1998-1999) to eliminate these populations. By the year 2000 the multi-year, multi-million dollar eradication effort was proclaimed a success. This joint effort had proven that large, separate populations of GM could be eradicated if detected early by pest survey.

To prevent reintroduction of this pest, UDAF administers a quarantine (Utah Administrative Code R68-14) of transportable articles that may harbor the pest. This rule requires inspection of household items, firewood, Christmas trees and vehicles that are entering the state from quarantined areas of the country. Every year, agricultural inspectors visit Christmas tree lots to inspect for GM and other pests. Firewood for sale at retail locations is also regularly inspected.

RECENT TRAPPING EFFORTS

Since the moth was eradicated, the UDAF Insect Program has been vigilantly monitoring for new GM introductions into the state by annually placing thousands of traps across Utah's 29 counties. From the period of 2008 to 2015, not a single GM was captured. In 2016 one moth was caught in Davis County, but subsequent high density trapping did not detect any others. In 2020, 1,926 traps were placed and a single moth was detected in West Jordan in Salt Lake County. In 2021, a delimiting (high density) grid of traps will be deployed around the capture sight to determine if a population is present.

There was also work done to monitor other defoliating moths (various genera), which are not known to be established in the U.S. While GM is from Europe, there are other closely related moths from Asia collectively known as Asian defoliators, which are also serious threats to urban and natural forests. Containerized cargo carried on airplanes, ships and trains are thought to be prime opportunities for the artificial spread of these pests due to the bright lighting in shipping ports at night and the tendency of the moths to lay egg masses in small, hidden crevices. In 2020, 68 Asian defoliator traps were placed amongst Davis, Salt Lake and Weber counties, with no target pests detected.

EUROPEAN CORN BORER

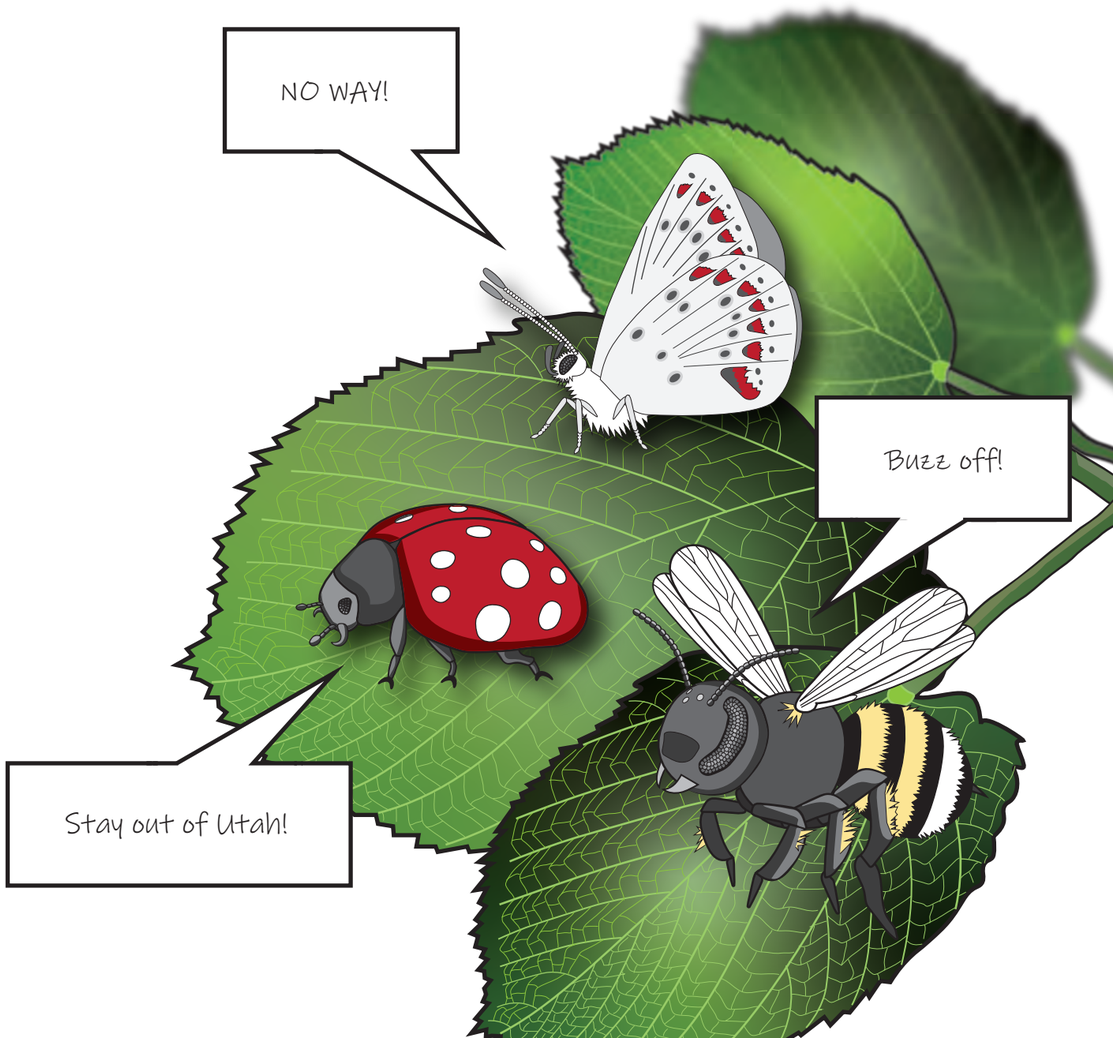
European corn borer (ECB) *Ostrinia nubilalis* (Hübner) was first identified in Boston, Massachusetts just over 100 years ago. It is thought to have made its way into the country on broom corn *Sorghum spp*. imported from Hungary and Italy. Over the years, the pest spread throughout the East and Midwest and became a serious pest of corn *Zea mays*. During most of its history in the United States (U.S.), the pest was notoriously difficult to control because the larvae bored into cornstalks and therefore was protected from insecticide applications. An assessment of ECB damage published in 1996 put the annual costs due to yield loss and control measures at $1 billion annually.

However, the situation was dramatically improved with the extensive adoption of transgenic *Bacillus thuringiensis* (Bt) corn by growers in the late 1990s. Many infested areas have reported steep declines in ECB populations since this technology became widely utilized in corn growing and the seriousness of the pest has been downgraded. Despite this success, there is concern that ECB may develop resistance to Bt corn. If in the future, transgenic corn is no longer effective in controlling ECB it will likely become a pest of great importance once again. Furthermore, ECB continues to cause major damage to other plants, such as peppers *Capsicum annuum*, certain ornamental plants, and non-Bt corn.

Utah has successfully maintained a quarantine of this pest for many decades. The effort to keep Utah free of ECB includes pest-free certification of certain agricultural commodities imported into the state, as well as a state-wide trapping survey. In 2020, 76 traps were placed across Beaver, Box Elder, Cache, Davis, Duchesne, Emery, Grand, Iron, Millard, Morgan, Uintah and Utah counties. No ECB were detected from these efforts.

UTAH SAYS NO TO JAPANESE BEETLE

Utahns unite to eliminate the invasive agricultural pest from the state.



Since 1993,

the Utah Department of Agriculture and Food (UDAF) Insect Program has taken extensive measures to exclude Japanese beetle (JB) *Popillia japonica* (Newman) from the state. JB is a destructive invasive agricultural pest first introduced to the United States (U.S.) over a century ago. In its native Japan, JB is not known to be a serious pest; this is likely due to host-plant resistance and numerous natural enemies that keep their populations regulated. However, the insect has been quite problematic in the U.S. In spring months, the larval (grub) stage feeds on the roots of grass and is a severe turf pest. The beetle pupates under the soil in late spring and emerges as an adult in early summer. Adults have voracious appetites and can feed on the foliage of over 300 host plants, including many popular and economically important fruit, vegetable and ornamental plants. It is estimated that approximately $460 million is spent annually among the infested states to directly control the pest and to replace damaged host plants.

JB history

JB was first detected in the U.S. at a New Jersey nursery in 1916. Despite that state's effort to get rid of the pest, it quickly spread throughout other New England and Mid-Atlantic states. By mid-century the beetle was sporadically appearing in many Midwestern and Southern states. In the 1990's a few Western states began detecting populations. Today only a dozen states (including Utah) are considered to be uninfested. Most of these states are west of the Rocky Mountains.

UDAF has demonstrated that it can keep the state JB-free with a multipronged strategy of prevention, monitoring and eradication of introduced populations. Prevention is achieved by the implementation of quarantine rules, which are imposed on infested states and restrict the import of commodities that may harbor JB, such as nursery stock, turf and soil. Another protective measure is an annual statewide trapping survey, which detects these insects quickly if they are introduced. Finally, if a sizable population is discovered, swift eradication measures must be taken to prevent it from establishing. Utah demonstrated the efficacy of this approach in 2006 when a large JB population was detected in Orem. The state declared an Insect Emergency Infestation (per UCA § 4-35-101 et. seq.) and began intensive pesticide treatments of turf and other host plants for multiple years. As a result of this speedy response, the annual captures of JB began falling rapidly year over year. By 2011, not a single beetle was detected and just three years later it was declared eradicated. At the time, it was the largest successful JB eradication effort in U.S. history. In recent years, Idaho and Oregon have both detected even larger populations of JB and are taking substantial eradication actions to maintain their JB-free status. Idaho has all but eliminated their infestation and Oregon continues to make significant progress.

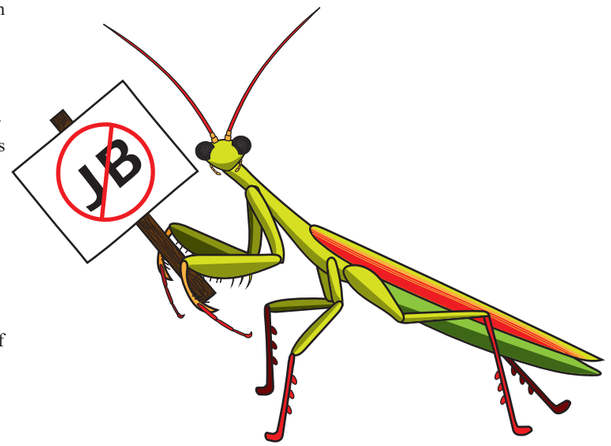
In the years after eradication, the number of JB traps placed was substantially increased. Today, all of Utah's 29 counties are part of the annual JB survey. Over the years a small number of beetles have been detected in areas far from Orem. Between 2012 and 2015 a few were found in downtown Salt Lake City and in the Avenues neighborhood. Intensive trapping of these locations in succeeding years demonstrated that JB did not establish.

A new population is introduced

In July of 2018, routine trapping of Salt Lake City's west-side industrial district detected a single JB. 150 traps were immediately deployed to determine the extent of infestation. Two more specimens were found near the previous capture site shortly after. In 2019, high density trapping continued at the same location. Numerous additional beetles were found in the vicinity. Complicating matters further, standard detection traps discovered five other locations across Salt Lake and Davis counties where JB was present. All of these areas were trapped heavily to illuminate the population size and distribution. By season's end, trappers had found 36 beetles in Salt Lake County and seven beetles in Davis County for a total of 43 beetles.

Spring 2020 eradication activities

Although 43 beetles are far fewer than the thousands detected in the Orem infestation over a decade ago, it is enough that a permanent population could take hold if action was not taken. Consequently, the UDAF Insect Program devised a comprehensive eradication plan to ensure that the new population would not gain a foothold in the state. The plan focused exclusively on treating irrigated turf in the infested areas. This host material was targeted because it is a favorable medium for the pest's early life stages. Irrigated turf is where JB females prefer to dig into the soil and lay eggs. After the eggs hatch, JB larvae feed on turf roots, grow and pupate. Adult JB typically emerge from the soil in May through June and feed on various above-ground plants. While the adult life-stage can be targeted for control, this approach is not nearly as effective as killing the beetle in its immature stage. Therefore, in the interest of keeping costs low and minimizing pesticide usage, the plan only prescribed treating irrigated turf. Staff utilized the previous year's trapping data as a guide for determining where to target interventions and ultimately proposed treating all irrigated turf within 200 meters (approximately 650 feet) of a female capture or two or more beetles (male or female) captured in the same location. Numerous Salt Lake County parcels were identified as needing control measures based on these guidelines. No parcels in Davis County were identified to be treated because the number of JB captured in the previous year were so low; more trapping data was necessary to inform an appropriate control strategy.



The first step in enacting this plan was the creation of a JB Decision and Action Committee, which first convened in January of 2020. Members of the committee included biologists, county extension agents, city parks personnel and ag-industry leaders. The UDAF Insect Program presented committee members with maps demonstrating where JB had been found in the previous year, information about the consequences of inaction and a thorough outlining of the eradication plan. The committee reconvened in March to vote on the eradication proposal; in a unanimous motion the committee recommended the plan go forward and advised the Commissioner of Agriculture to declare an Insect Emergency Infestation.

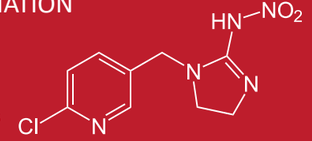
The emergency was declared and one month later, a UDAF-contracted lawn care company conducted pesticide applications to potentially infested turf in parts of Salt Lake County. The areas targeted were diverse in their zoning and land use. In Salt Lake City's "Northwest Quadrant," parcels in a commercial office park and properties in the warehouse district were treated. In South Salt Lake City, light-industrial properties, a county park, government properties, a golf course, a water treatment plant and a few single-family homes were included in the eradication. In total, 167 acres across 217 parcels were treated during spring. UDAF took extensive measures to ensure that the applications were safely applied and did not contaminate water or harm pollinators (see "Box 1").

Trapping results

The JB trapping survey conducted after the treatments indicate that Salt Lake County eradication efforts were highly successful. In total 15 beetles were found at various locations, most of which were in close proximity to the known Salt Lake City and South Salt Lake City sites of infestation from the previous year. This was an approximately 58% reduction in the number of captures in the emergency infestation area compared to the preceding season. Most encouraging were the results from the International Center, a commercial office park, where zero beetles were found. This development suggests that JB has been entirely removed from this area, despite a half dozen specimens being found in the same place just one year ago. Of the beetles that were detected in Salt Lake County, many were found just outside the treatment area periphery. Based on history of other eradication efforts, it is not unusual for beetles to be detected in subsequent years close to areas where pesticide applications were made in previous years. This phenomenon, sometimes called a "donut hole," indicates that while the target was mostly controlled in the area where treatment occurred, there were places just beyond the eradication edge that missed the pest. This shortcoming is easily corrected by including these areas in future planned control efforts. Another encouraging development was that no beetles were found in Salt Lake City's Rose Park

BOX 1 Environmental Protection Efforts

PESTICIDE INFORMATION



Imidacloprid was the pesticide selected for the eradication effort due to its effectiveness in controlling JB and low mammalian toxicity. This pesticide is non-restricted use, can be purchased by the general public and is a commonly used product. Nonetheless, enormous efforts were taken to protect human health, prevent watershed contamination and minimize pesticide exposure to bees.

WATER QUALITY PROTECTION

- An application buffer was mandated between treated turf areas and streams, ditches, ponds and other waterways. This prevented the chemical from entering watersheds.
- Drop spreaders were utilized in turf at a water treatment plant in the eradication area. Drop spreaders provide superior control and significantly reduce runoff.

POLLINATOR PROTECTION

- The state's registered beekeeper list was utilized to identify nearby apiarists and inform them of eradication plans.
- Screening material was offered to beekeepers that wanted to keep bees in their hives during applications
- Granular insecticide was used, which is the least hazardous formulation to bees.

USE INSPECTION

The UDAF Pesticide Program enforces federal and state pesticide laws that protect human health and the environment. Inspectors from this program monitored the entirety of the contracted lawn care company's pesticide applications. They verified that the equipment used was correctly calibrated and ensured that all federal and state pesticide regulations were followed.

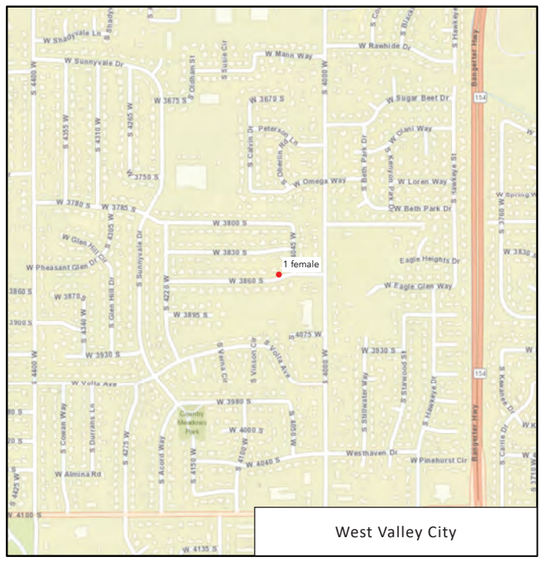
2020 JB Detection Maps

Map Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Salt Lake County

Salt Lake City
(Northwest Quadrant)

South Salt Lake City



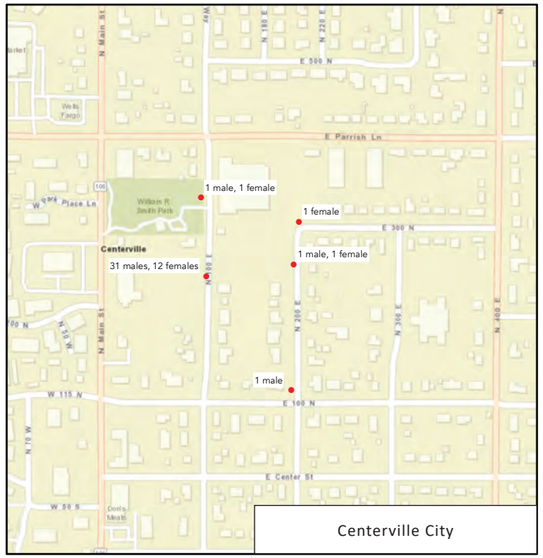
West Valley City

Salt Lake County Japanese beetle captures in 2020 compared to 2019:

↓ 58%

Indicates that eradication activities were highly successful.

Davis County



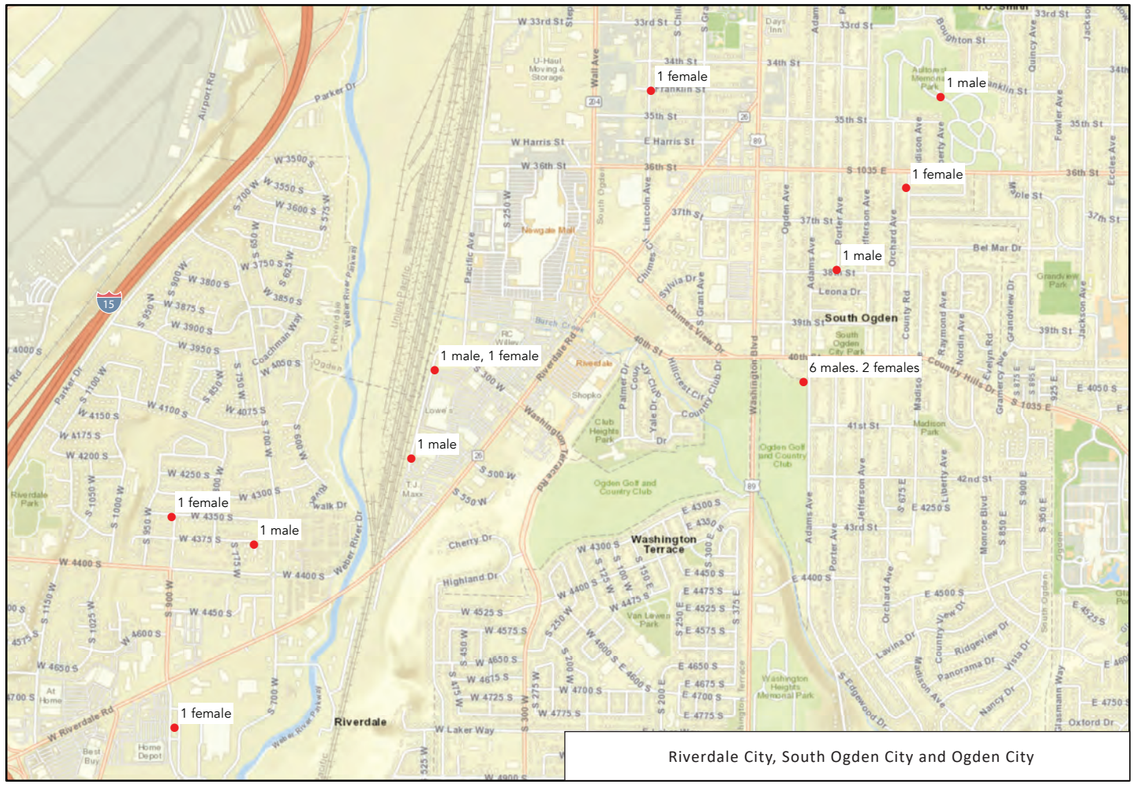
Centerville City

Farmington City

West Point City
(Bingham Park)

Kaysville City

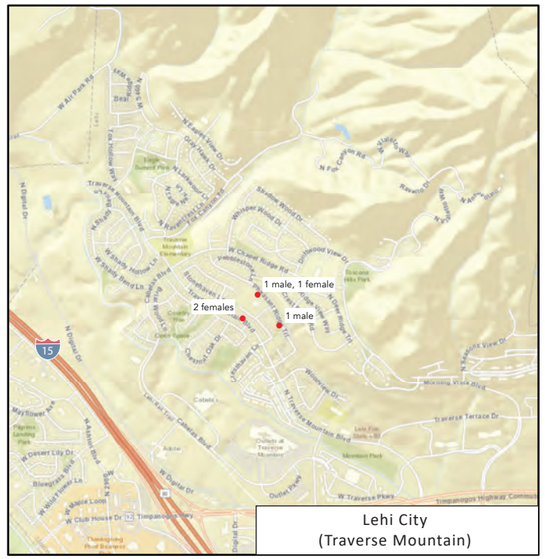
Weber County



Riverdale City, South Ogden City and Ogden City

Utah County

Provo City
(Franklin Neighborhood)



Lehi City
(Traverse Mountain)

neighborhood. In the previous year, a single beetle was found there but no treatments were made in the vicinity because the number of captures were so low. If another year of trapping reveals the neighborhood to be JB-free, it will be assumed that the beetle did not establish in this area. However, not every development in Salt Lake County was good news. Indeed, a single beetle was found in West Valley City. JB has never previously been found in this part of the county. Though treatment of the area does not appear to be merited at this time, close monitoring is necessary in subsequent years.

While the JB population in Salt Lake County appears to have been significantly reduced by eradication measures, the JB captures in Davis County swelled and new detections were made in Weber, Utah and Carbon counties. As previously mentioned, seven beetles were found in Davis County in 2019. Four were discovered in Centerville City and three were detected in Kaysville City. Since the beetles were split between the two areas and seemed widely spaced, control efforts were deferred until more trapping data could elucidate infestation centers. In 2020 the JB epicenter became quite clear in Centerville; of particular concern was an approximately three square block section of the city where 49 beetles were trapped. This area included a public park and school, both of which have large tracts of turf. Beetles continued to be captured in Kaysville, though the numbers were considerably fewer and more loosely distributed compared to detections in Centerville. In Weber County, 18 beetles were found dispersed across swaths of Riverdale, South Ogden and Ogden cities. Most were found in shopping areas, parks or at the edge of a golf course; yet, a single beetle was found in the small town of West Point. A small number of beetles were also found in Utah County. They were about evenly divided between Lehi City's Traverse Mountain development and Provo City's Franklin neighborhood. Finally a single beetle was found at a truck stop in Carbon County. This beetle was found late in the season as traps were being retrieved. Since the area is surrounded by habitat that is hostile to JB survival and the beetle was found long after flight activity, it is suspected that it did not arise from the area, but was instead brought in from somewhere else by vehicle.

In virtually each of the cases where JB was found, a delimiting (high density) trapping grid was placed around the capture area (see "Box 2"). The only exception was in Carbon County. In this case, the beetle was found too late in the season for delimiting traps to be placed, however next year the area will be trapped heavily. For the year, a total of 1,872 standard detection traps were scattered across all of Utah's 29 counties. An additional 2,666 delimiting traps, placed in response to JB captures were distributed among Davis, Salt Lake, Weber and Utah counties. All combined, these traps detected 105 JB for the season, which is the most that have been captured since 2008.

Fall 2020 eradication activities

The UDAF Insect Program was able to facilitate a series of treatments in Centerville before year's end by working in cooperation with the Davis County School District and Centerville City. Of all areas where JB were found in the state in 2020, this was the most important location to get an early start on mitigation. Indeed, nearly half of all beetles detected statewide in that year were found in a three square block section of this area. UDAF provided pesticide to Davis County governments and their pesticide-applicator licensed employees applied the product. In total, nine acres across three parcels were treated with flowable imidacloprid. In order to eliminate the infestation in this area, more treatments are likely needed. Nonetheless, this was an important first step in eradicating JB from Centerville.

2021 plans

The preliminary success of 2020 eradication efforts in Salt Lake County demonstrates that these recently detected JB populations are small enough to eliminate. Thus the UDAF Insect Program intends to continue targeted treatments in Salt Lake County and expand eradication efforts to other infested counties in 2021. All areas that have detected beetles within the last two years will continue to be heavily trapped and irrigated turf sections in known infestation epicenters are likely to be treated. The program will reconvene the JB Decision and Action Committee in January to present members with the latest findings and seek approval for new interventions.

UDAF Insect Trapper Vale Nielsen prepares to place JB traps near Salt Lake International Airport.

Consequences of inaction

Taking decisive and swift eradication measures in response to these recent JB detections reflects the UDAF Insect Program's invasive species intervention philosophy of "early detection and rapid response." Thorough pest surveillance that identifies exotic insect populations soon after they arrive, coupled with quick action in eliminating the pest has great advantage over a "wait and see" approach. Invasive populations can grow quickly by underfunding survey activities or delaying action when target pests are found. Either tactic increases eradication costs later or permits the pest to fester so long that eradication becomes unfeasible. Consequently, in the former case the eradication "bill" to taxpayers rises and in

Rallying the Crew

State Entomologist Kristopher Watson (second from right) educates the contracted pest control employees about the significance of JB on the first day of eradication.

Treatment in Action

A licensed pesticide applicator drives a ride-on spreader to apply granular insecticide to turf at the Redwood Trailhead Park in West Valley City.

Protecting the Environment

In environmentally sensitive areas, such as this water treatment facility, insecticide is applied using drop spreaders. This delivery method is significantly more labor intensive than others, however it provides better control of application and ensures that pesticide does not runoff into the watershed.

Following the Pesticide Label

State Pesticide Compliance Specialist Drew Matthews supervises the eradication activities to ensure federal and state pesticide rules are followed.

BOX 2 How does UDAF know where JB is (and where it isn't)?

The UDAF Insect Program has one of the most robust JB detection programs in the country. All of Utah's 29 counties are annually surveyed for this invasive pest via trapping. Traps placed as a method of early detection are part of the standard detection survey. Standard detection traps are placed at a density of approximately two traps per square mile in areas of the state that have host material that is suitable for JB survival. Therefore, in years where not even a single Japanese beetle is detected, there will be roughly 1,800 traps placed just as a precaution! However, when a Japanese beetle is detected, trappers will set up a "delimiting grid," which usually involves placing 100 traps, about 75-150 meters (250-500 feet) apart in a square block centered around the capture site. These traps are checked on a bimonthly basis. If no other beetles are found in this delimiting grid for two subsequent years, it can be assumed that JB did not establish in the area.

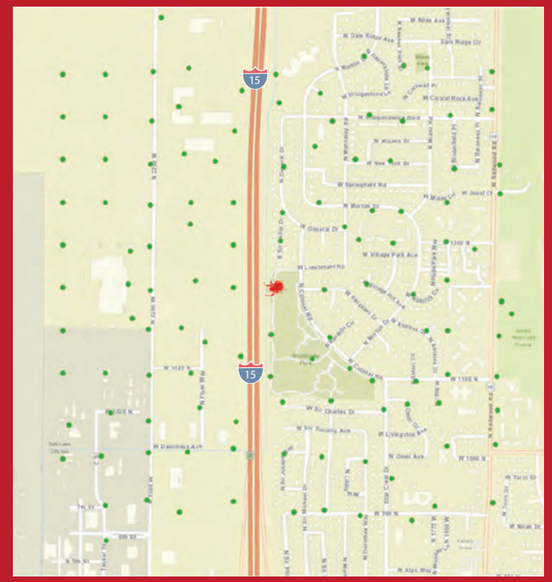
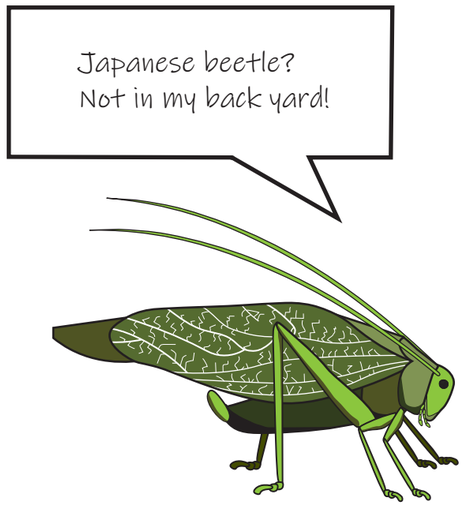


Figure 1: An example of a delimiting grid. The red beetle icon symbolizes a JB capture. The green circles represent traps that are placed as a response to the detection.

It is not uncommon for the program to find a couple of beetles in a given vicinity, heavily trap the area and find no beetles in succeeding years. While there are many explanations as to why this may happen, the most likely scenario is that a handful of beetles were artificially transported within the state, however there were not enough individuals to create a stable population.

Nonetheless, there are instances where a beetle is found, a delimiting grid is set and more beetles are found later. In this case, the delimiting grid will be enlarged and it will expand in the direction of the capture. For instance, if a JB is found on the northwest corner of a grid, then additional traps will be placed surrounding the existing grid in that direction. However, if additional beetles are found in the same trap that originally caught the target pest, there is no need to enlarge the grid. This is because the entire purpose the delimiting grid is to determine the extent of an infestation; there is no reason to expand the trapping because it is already known where the beetles are located.

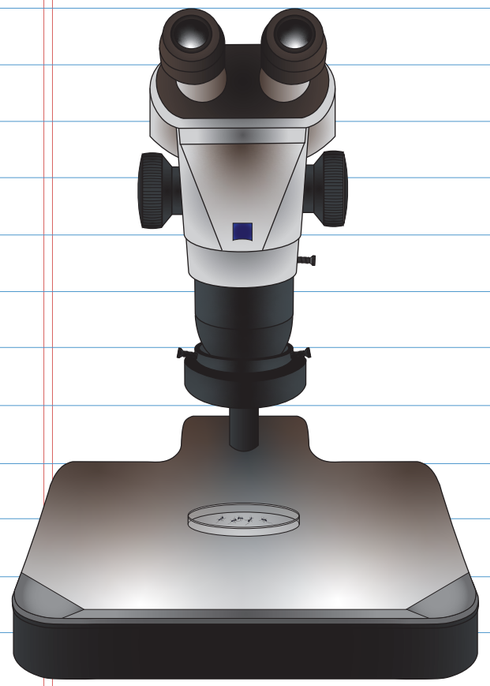
Delimiting grids are especially helpful in determining if and where interventions are needed to eradicate a target pest. As mentioned, Utah's JB standard detection survey is large and covers the entire state. The same is true of the state's gyspy moth survey (see page 10). Therefore there is a great degree of confidence in where these two pests are or are not present.

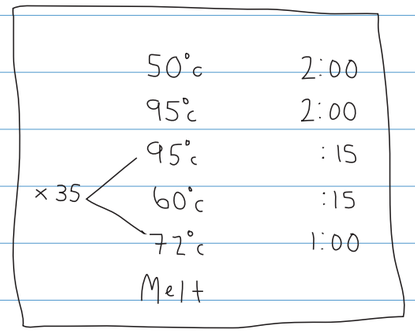


the latter case huge financial burdens are placed on producers who must control a pest that was previously absent.

As previously noted, JB-infested states are estimated to spend about a half billion dollars annually in control and plant replacement costs. However, the impact on Utah's economy if the pest were to become established has never been throughly investigated. To elucidate this unknown, the UDAF Insect Program approached the Economic's Department of Westminster College located in Salt Lake City. The department assigned two senior students to build an economic model that estimated future damage costs of a hypothetical widespread infestation in the state. Although JB attacks over 300 plants, turf and corn were the focus of the project because extensive production value data were available for these plants. The results of this analysis were startling. It was determined that by the year 2027, under the most likely damage scenario, there would be cumulative costs of $234 million dollars worth of turf injury and $1.6 million dollars in corn losses. These costs would widely fall on the state's landscape and park managers, golf courses, cities, homeowners and farmers. Acting now, when the JB population is small, will prevent Utah's industries and residents from having to bear any of these financial burdens.

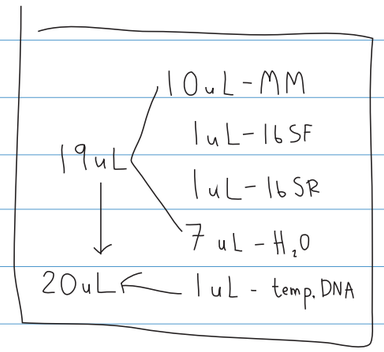
THE ENTOMOLOGY LAB





The Utah Department of Agriculture and Food (UDAF) Entomology Laboratory's beginnings can be traced back to the mid-2000's. The impetus to create such a space came more out of sheer necessity than any deliberate vision of building what it is today. At the time of its founding, UDAF entomologists were suddenly tasked with work that could not be easily accomplished in an office setting, including simple things such as basic taxonomic identification and sex determination of target pests. Two programs were driving the need for a new workspace: the Japanese beetle (JB) *Popillia japonica* (Newman) survey and the red imported fire ant (RIFA) *Solenopsis invicta* (Buren) survey. At the time, there was a substantial JB infestation in Orem and a plethora of beetles were routinely being captured (see JB article, page 12). For the purposes of developing effective eradication strategies, these specimens needed to be sorted into male and female cohorts and quantified. They also needed to be labeled and stored. At the same time, the UDAF Insect Program was beginning a new survey of the federally regulated human and livestock pest RIFA. Southern Utah is already home to a native ant in the *Solenopsis* genus; separating the native species from the exotic species is difficult to do without a microscope and reference specimens. Something needed to change.

The UDAF Entomology Lab has transformed from "shabby chic" to state of the art.



Thus, a tiny, windowless room in the corner of the Plant Industry floor was set aside to perform this work. To call this space a lab when it first began would have been a stretch. There were no microscopes, insect storage cases, or chemical storage cabinets. However, as the utility of a dedicated lab space was recognized, equipment began to be purchased. A dissecting scope was acquired to get a closer look at incoming specimens. Insect storage cases were purchased to house the numerous JB specimens. A compound scope was even procured, which was occasionally used by the state bee inspector to test honey bees for microspordian pathogens. A fledgling lab was being created.

"To call it a lab when it first began would have been a stretch."

Then in 2011, the UDAF Insect Program took on the Exotic Wood Borer Survey (see page 26), a federally funded trapping effort that targeted nearly a dozen wood boring beetle pests. This survey involved the placement of approximately 50 traps statewide. These traps resulted in the capture of an enormous number of insects, which required sorting and identification. At the same time, it was realized that a native insect reference collection would be extremely helpful in distinguishing target pests from the thousands of native beetles being found in the traps. A decision was made to expand the lab's functionality and capacity. A seasonal lab technician was hired and more insect storage cases and cabinets would be purchased.

Ten years after its founding, the lab would be the permanent workspace for three UDAF Insect Program employees. These staffers utilized the lab's space and capabilities for multiple programs. Much congestion was created by the tight work environment and the program was seeking a larger area for future growth. In 2017 the lab moved within the William Spry Agriculture building from the tiny, corner space where it was founded to a 736 square foot area that comfortably fit the employees and lab equipment.

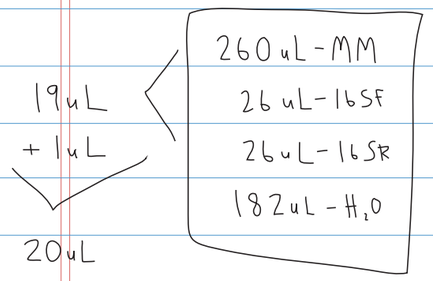
The following year, the lab would receive its latest upgrade when real-time quantitative polymerase chain reaction (qPCR) testing equipment would be purchased. This cutting edge technology was added to the lab in order to test for honey bee diseases.

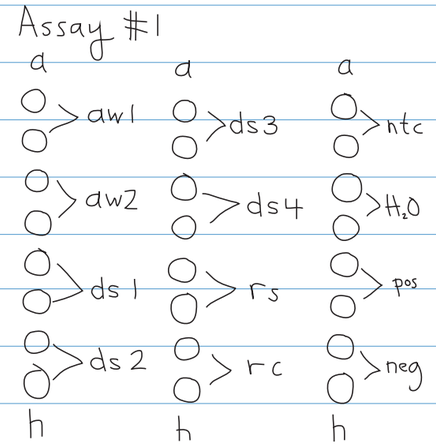
Previously, these samples were sent to an outside lab that took considerable time to process. This new, in-house testing capability allowed for faster and more accurate results. In less than two decades, the Entomology Lab had gone from "shab-by-chic" to state of the art.

Today, the lab provides help to all of UDAF's entomology-related efforts. The lab processes all Exotic Wood Borer and Sentinel Survey (see page 8) trap catches. This amounts to approximately 150 individual traps that are sampled multiple times in a given season. From these traps, thousands of beetles and other insects are identified to species each year. Honey bee disease diagnostics in support of the state Apiary Program (see page 4) have been expanded; testing services are available for five different honey bee maladies. The lab has a substantially larger insect reference collection than when it was started. It houses over 5,000 individual specimens representing 150 families of insects. New specimens continue to be added, with emphasis placed on families of agricultural importance. The lab also takes hundreds of insect-related phone calls annually and offers walk-in identification requests for agriculturally-significant insects.ext

"Today, the lab provides help to all of UDAF's entomology-related efforts."

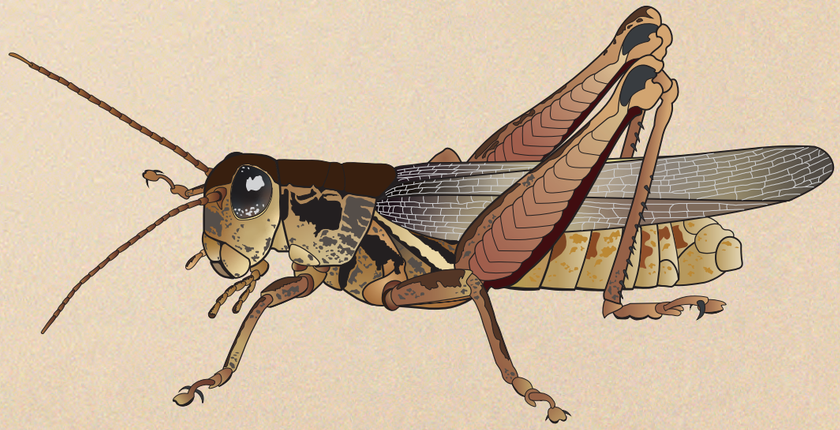
year, the UDAF Entomology Lab will be merging with the UDAF Seed Lab to become the UDAF Plant Industry Lab. This newly combined lab will be moving to the Taylorsville State Office Building. Although this will be a significant change for the lab, it presents many opportunities for growth and improvement. All of the core functions of the existing lab will continue to be fulfilled. The new space will allow for much greater growth in the insect reference collection, possibilities for adding new testing capabilities and more collaboration between Seed Program and Insect Program staff. The new facility will also make the lab eligible to seek International Organization for Standardization (ISO) accreditation, which may be pursued in the coming years. Although the old spaces will be missed, this new chapter in the Entomology Lab history is likely to build on the success and resourcefulness of the past and continue the lab's trajectory of greatly exceeding its original expectations.





1. The original make-shift Entomology Lab was in a tiny office room.
2. The new lab is spacious, with 736 square feet and provides services to the Apiary, Exotic Wood Borer and Orchard Sentinel programs.
3. Cabinets hold over 5,000 insect specimens as part of the state's permanent reference collection.
4. & 5. The new lab utilizes state of the art technology such as the qPCR testing system pictured.

Grasshopper and Mormon Cricket SUPPRESION



Utah has been suppressing populations of endemic pests such as grasshoppers (various genera) and Mormon crickets *Anabrus simplex* (Haldeman) since it was a territory. While these insects are native to the area, many species threaten rangeland and crop production throughout the state. There are millions of rangeland acres in Utah, which provide prime habitat for these pests. If left unmanaged, these insects will destroy rangeland and compete for food with livestock and wildlife. The Utah Department of Agriculture and Food (UDAF) and the United States Department of Agriculture (USDA) Animal Plant Inspection Service (APHIS) collaborate on rangeland pest management and suppression efforts. In response to these efforts a total of 3,187 surveys of grasshopper and Mormon crickets were conducted throughout the state by USDA-APHIS staff in 2020. Mormon cricket populations were found to be spotty with relatively low populations and there were very few reports of these insects causing damage. However, grasshopper populations continue to increase with nearly 600,000 infested acres across the state.

When assistance is needed on state or private land, UDAF may approve projects for the state cost share program. To qualify, land must be infested in excess of eight insects per square yard and the applicant must be an agriculture producer. The cost share program is intended to help with grasshopper and Mormon cricket suppression on private land. When assistance is needed to reduce populations on federal land, USDA-APHIS may be able to provide relief. When possible, both federal and state governments bring resources together to create large biologically sound projects that support the state's producers.

Pest populations were largely detected in historical areas of concern. These areas include but are not limited to: Box Elder, Sanpete, Millard, Tooele, Duchesne, Uintah and Beaver counties. Some farmers and ranchers experienced grasshopper populations as high as 30-50+ per square yard and reported severe damage to cropland in those areas. According to survey data, private landowners experienced the highest grasshopper populations with 321,679 infested acres; federal property was second with 205,680 infested acres. Cost share support was offered to 80 private landowner applicants. No aerial or ground treatments were carried out by state or federal governments.

The predominant grasshopper species found in 2020 were: *Melanoplus confusus* (Scudder), *Camnula pellucida* (Scudder), *Aulocara elliotti* (Thomas), *M. packardii* (Scudder) and *M. sanguinipes* (Fabricius).

INVASIVE BORERS

The Insect Program's trapping efforts provide defense against invasive wood boring beetles.

In recent years, when people observe large swaths of a forest's dead trees while passing through in a car or flying over in a plane they often remark that it is an unfortunate result of "the beetle" that's killing the forests. This explanation is partially correct, but misses that natural and urban forests across the country face multiple threats that can profoundly influence their ecosystem dynamics. Among other contributing factors are fire, disease, weather, drought and insects besides beetles.

- Wood boring beetles are indeed one of many major causes of forest disturbance. However even this individual contributor is multifaceted because it is not merely a single beetle that is responsible. Indeed, a complex of beetle species is attacking the nation's forests. Making matters even more complicated are that many of these wood boring beetles are invasive species. Exotic wood boring beetles tend to have few natural enemies and therefore, their populations are poorly regulated and grow at a much faster rate than in their native range. When populations are high, healthy trees are more prone to being attacked by pests that may otherwise only attack unhealthy trees. Also, many trees have inadequate defenses against these exotic wood boring beetles, making them even more vulnerable to attack compared to native beetle fauna.

The state administers a quarantine (Utah Administrative Code R68-23) which is meant to prevent importation of exotic wood boring pests into the state (see Box 1). Quarantines can be thought of as a "first line" of defense. Another line of defense are trapping programs, which serve as essential tools in preventing the decline of forest health. When trapping detects exotic insects early, their populations can be eradicated or, if eradication isn't possible, advanced knowledge of their presence can give landscape or crop managers time to develop effective suppression strategies.

The Utah Department of Agriculture and Food (UDAF) Insect Program monitors for several exotic wood boring beetle species, all of which fall into one of three large beetle families. The bark and ambrosia beetles (family Curculionidae subfamily Scolytinae) are diminutive beetles that mine the inner bark of woody material in their adult and larval stages. Longhorned beetles (Cerambycidae) and jewel beetles (Buprestidae) can range in size from half a centimeter to upwards of several, with a great variation of colors and habits. The larval stages of these families infest the inner wood of trees. This feeding by the immature beetle results in tunnels and galleries. Eventually the adults emerge from the tree, become free-living and will sometimes feed on host material as well.

Cooperative Agricultural Pest Survey

The United States Department of Agriculture (USDA) Animal Plant Health Inspection Service (APHIS) coordinates the Cooperative Agricultural Pest Survey (CAPS), a science-based federal and state collaborative effort to detect exotic organisms that threaten national agriculture and/or the environment. Every year the program allocates money to participating states to place traps for high-priority target pests. Utah annually participates in the CAPS wood-borer survey and in 2020, 96 traps were placed in riparian corridors, wood processing facilities and municipal parks to target seven different pests. With the exception of the velvet longhorned beetle *Trichoferus campestris* (Faldermann), none of these wood boring beetles have ever been found in Utah. In 2021 the UDAF Insect Program will continue participation in the CAPS exotic wood borer survey.

CAPS Wood borer targets

Black fir sawyer & Japanese pine sawyer

Monochamus is a genus of large longhorn beetles that are widely distributed throughout the world, including several native species found in Utah. Most species host primarily on coniferous trees. Black fir sawyer *Monochamus urussovii* (Fischer-Waldheim) is native to spruce *Picea spp.* and fir *Abies spp.* forests from Finland to Japan, and is considered a serious pest in Siberia. Japanese pine sawyer *Monochamus alternatus* (Hope) is indigenous to China, Korea, Laos and Japan. Both of these beetles can vector pathogenic nematodes to healthy trees which causes large annual losses in forests and plantations in Asian and European counties. Neither species are known to be established in the United States (U.S.), though *M. alternatus* was intercepted once in a New York warehouse in the 1990s.

Large pine weevil

Large pine weevil *Hylobius abietis* (Linnaeus) is a commercially important pine plantation pest in Europe and Asia and causes millions of dollars in damage annually. The beetle's larval stage does not cause significant damage to living trees as eggs are laid in recently cut tree stumps, but adult weevils feed on a large variety of coniferous and some deciduous seedlings. Plantations will often have complete loss of new transplants without pesticide treatments. This pest is not established in North America but has been intercepted at ports of entry and through the mail.

Mediterranean pine engraver

Mediterranean pine engraver *Orthotomicus erosus* (Wollaston) is a bark beetle native to southern Europe, Asia, and northern Africa. Populations of the invasive pest were found in California in 2004. It is currently present in 10 counties within the Central Valley of the state. There have been no other reported established populations in the U.S., but there have been interceptions at several ports of entry. This beetle has a large primary host range of pine *Pinus spp.* species, but can attack other coniferous trees such as spruce, cedar *Cedrus spp.*, and fir. Pine populations in areas where the beetle is established have seen significant damage from this pest. It will normally feed and oviposit on dead trees but will attack stressed living trees, such as North American pine forests under stress.

European spruce bark beetle & six-toothed Ips

Ips bark beetles are moderate to large bark beetles (up to eight mm in length) that feed on coniferous trees. European spruce bark beetle *Ips typographus* (Linnaeus) specializes in spruce trees and is native where Norway spruce *P. abies* is naturally found in Europe. Six-toothed Ips *Ips sexdentatus* (Boerner) has a larger host list of coniferous trees and is native to Eurasia. Both are normally considered secondary pests of dead or weak trees, but stressors such as fire, drought, or windstorms will cause large outbreaks. They also transmit blue-stain fungi (various genera), which are pathogens associated with higher tree mortality. Six-toothed Ips has been intercepted 157 times in the U.S. at various ports, while positive identifications of European spruce bark beetle were made twice in Indiana and Maryland during surveys. Subsequent trapping in both of these areas did not find further specimens.

Velvet longhorned beetle

Velvet longhorned beetle (VLB) *Trichoferus campestris* (Faldermann) was detected in South Salt Lake City, Utah in 2010. In subsequent years, hundreds of VLB would be found near this area and in a Utah County commercial fruit orchard. This was distressing because VLB was known to attack live apple *Malus spp*. trees in its native range. The state was not in a good position to deal with this pest after detection because there was not a proven trap and lure methodology for capturing the pest, nor was there treatment protocol. Eradicating insects is much easier if there is a reliable and cost-effective way to determine the extent of infestation, a clear method to eliminate the pest and the population is detected quickly after introduction. Utah possessed none of these advantages.

Just a few years after early detection the prospect of eliminating VLB from Utah dimmed, however an opportunity to learn more about this insect and perhaps prevent it from spreading to other states presented itself. Upon learning of the Utah infestation, scientists from the USDA Center for Plant Health Science and Technology (CPHST) Otis Laboratory and Xavier University became interested in conducting scientific research of VLB in the state. They were especially interested in developing a trap and lure methodology and determining what other valuable host trees VLB might attack, aside from those already known. The UDAF Insect Program agreed to assist CPHST with these endeavors and by mid-decade a number of scientific projects began.

After many years of research, these scientists identified a male-produced aggregation pheromone and created a synthetic analog, which could be used as an attraction lure for cross vane panel traps. This trapping method is currently in use around the country and in Utah for survey purposes. Scientists also identified new plant hosts that VLB attack, such as peach *Prunus spp.* and cherry *Prunus spp*. This was a stunning and disconcerting development. As mentioned, it was previously known that this pest attacked apple trees; however it was not known whether it would feed on other fruit trees.

While these scientific projects were happening, the UDAF Insect Program began surveying multiple counties in the state with the new trap and lure methodology to determine where VLB had spread. It was eventually learned that the beetle was present in Box Elder, Davis, Salt Lake, Summit, Tooele, Utah and Weber counties.

After a decade working on VLB-related projects, the state is now considered "generally infested." VLB spread will continue to be monitored by the exotic wood borer survey, but the research collaboration is over and there are no plans to attempt eradication. Although many of the UDAF Insect Program's contributions are wrapping up, the achievements made over the past decade have been meaningful. An effective trap and lure have been developed, which will help other states monitor and possibly exclude VLB. New host materials have been identified as well. Finally, education and outreach has helped prepare Utah's producers and landscape managers to deal with the newly established pest.

State wood borer targets

Pine shoot beetle

Pine shoot beetle *Tomicus piniperda* (Linnaeus) is an invasive bark beetle with a large native range in Eurasia and North Africa that was first detected in Cleveland, Ohio in 1992. Since its introduction, pine shoot beetle has spread throughout much of the Northeast and Midwest. Most damage is caused by adults feeding inside young shoots of heathy pine trees. Utah maintains a quarantine of this insect because of its ability to kill healthy trees and due to its pest status in its native range. Pine shoot beetle has never been detected in Utah.

Emerald ash borer

Popularly known as "The Green Menace" emerald ash borer (EAB) *Agrilus plannipennis* has lived up to its nickname by decimating all species of ash trees *Fraxinus* in the U.S. since its first detection in Michigan in 2002. Although small (25 mm in length), it should not be underestimated. In the last two decades EAB has spread to 30 states and destroyed tens of millions of ash trees. The pest is established in many Eastern, Southern and Midwestern states. The beetle came even closer to Utah when it was found in the neighboring state of Colorado in 2013. It is now found in four counties of that state.

In recent years, the UDAF Insect Program has been preparing for EAB introduction by forming a task force of partner agencies and groups, including USDA-APHIS, USDA Forest Service, Utah State University (USU) Pest Diagnostics Laboratory, Utah Department of Natural Resources (DNR), Tree Utah and city arborists. This coalition has embarked on a multifaceted campaign to prevent introduction and facilitate early detection. Efforts include deploying EAB traps statewide, educating the public about the dangers of moving firewood and outreach to local tree care professionals on EAB identification. In areas of the state deemed high-risk for introduction, state, federal and local officials have been involved in trapping, visual surveys and caged rearing of ash limbs which are suspected to be infested. The UDAF Insect Program and others have also responded to dozens of EAB infestation claims by homeowners and landscape managers. To date, there have been no confirmed cases of EAB in Utah.

As the pest has continued spreading to other states, there have been considerable strains on federal funding dedicated to containment. In 2017, USDA-APHIS announced that it was considering removing their domestic EAB quarantine. Consequently federal funds directed toward trapping would be reallocated to biocontrol and research. As a result of this announcement, the Utah task force stepped up efforts to exclude and monitor for this pest. Utah DNR applied for a USDA Forest Service grant to fund increased trapping efforts; some of this money was passed to UDAF for improved surveillance and outreach efforts. The UDAF Insect Program also enacted a firewood quarantine in 2017 and is now proposing a nursery stock quarantine (see "Box 1"). Firewood and nursery stock movement are considered the highest risk pathways for EAB to enter the state, so regulating their movement will be critical in reducing introduction risk.

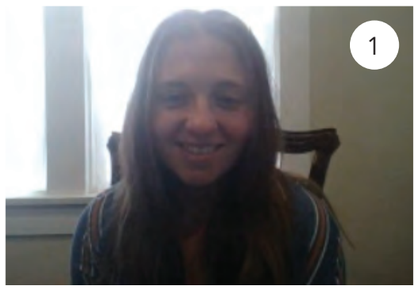
In 2020, the UDAF Insect Program placed a total of 68 EAB traps throughout Cache, Carbon, Davis, Duchesne, Salt Lake, Tooele, Uintah, Utah and Weber counties. Utah DNR placed an additional 30 traps across Emery, Grand, Iron, Juab, Millard, San Juan, Sevier, Washington and Wayne counties. Trap site placement was prioritized for high-risk areas such as: places that were likely to have out-of-state firewood introduced, vicinities where trees have been reported as potentially infested by arborists or homeowners and neighborhoods identified as having numerous ash trees in decline. In 2021 the UDAF Insect Program will continue leading task force efforts such as regulatory measures, trapping, visual survey and outreach efforts.

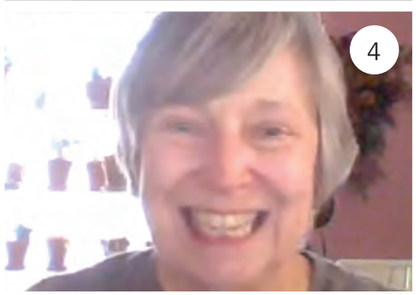
BOX 1

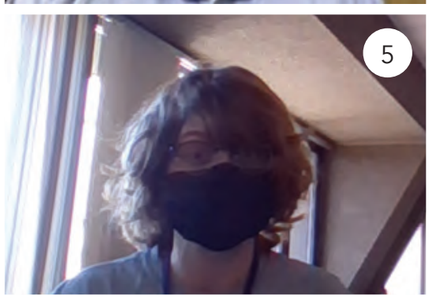
To prevent the entry of new exotic wood borers, the state enforces the Utah Firewood Quarantine (see Utah Administrative Code R68-23), which was enacted in 2017. This rule prohibits the importation of firewood from other states unless the materials are certified to be free of plant pests. Both commercial firewood distributors and members of the general public are subject to these new rules. The UDAF Insect Program has conducted media outreach and distributed literature to educate firewood distributors and the general public about the new rules. State compliance specialists have also been visiting retail locations that sell firewood, to make merchants aware of the new rules.

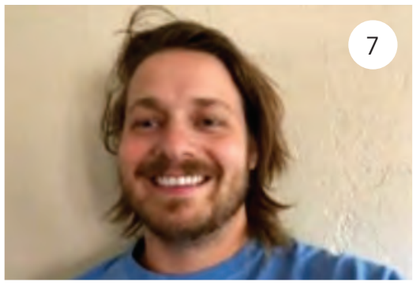
UDAF is also proposing a quarantine of ash nursery stock, as a result of USDA-APHIS' recent decision to deregulate EAB. Provisions of the rule would limit ash tree importation into the state by requiring that all such nursery stock come from areas that have met the precautionary requirements to exclude the pest. This quarantine will focus on nursery stock because it is considered to be one of the highest risk introduction pathways. Firewood also presents a high risk for EAB introduction however, it is already covered by the existing firewood quarantine.

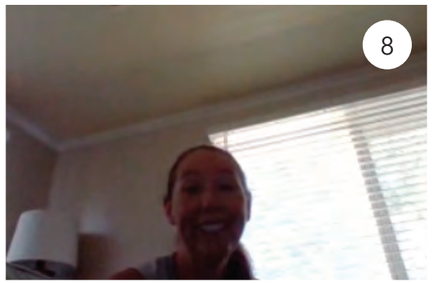
UDAF Insect Program Staff & Seasonal Crew

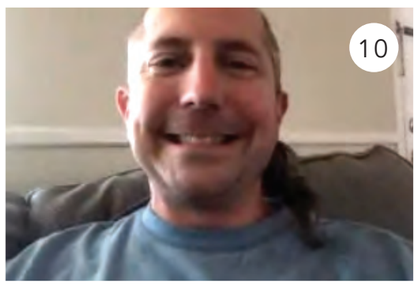


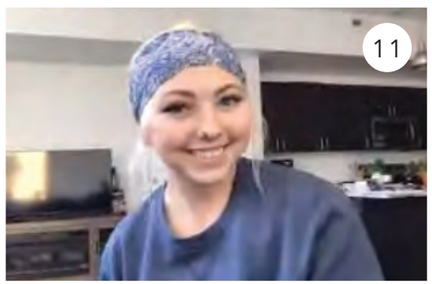


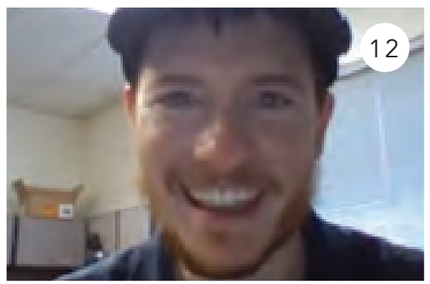












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Not pictured: Erin Vale Nielsen, Japanese Beetle and Gypsy Moth Trapper | Jerry Shue, Japanese Beetle and Gypsy Moth Trapper

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Apiary Resources

UDAF Apiary Program
ag.utah.gov/farmers/plant-industry/apiary-inspection-and-beekeeping/
USDA-ARS Pollinating Insect-Biology, Management, Systematics Research
ars.usda.gov/pacific-west-area/logan-ut/pollinating-insect-biology-management-systematics-research/
Project Apis m.
projectapism.org/
Apiary Inspectors of America
apiaryinspectors.org/

Invasive Insect Resources

UDAF Invasive Insect Program
ag.utah.gov/farmers/plants-industry/
Japanese Beetle Eradication
ag.utah.gov/jberadication/
USDA-APHIS-PPQ
aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases
Utah Cooperative Agricultural Pest Survey Program
utahpests.usu.edu/caps/utah-caps-program
Utah Plant Pests Diagnostic Laboratory
utahpests.usu.edu/uppdl/
National Plant Board
nationalplantboard.org/

Trade Associations

Utah Nursery and Landscape Association
utahgreen.org/
Utah Horticulture Association
extension.usu.edu/productionhort/fruit/tree/untitled
Utah Beekeepers Association
utahbeekeepers.com/

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Print and Web Works Cited

Alston, D., Spears, L. and Burfitt, C. (2016). 2016 INVASIVE FRUIT PEST GUIDE FOR UTAH Insect & Disease Identification, Monitoring & Management. Utah State University Extension.
Alston, D. and Murray, M. (2013). Apple Maggot [Rhagoletis pomonella (Walsh)]. Utah PESTS Factsheet ENT-06-87. Utah State University Extension.
Alston, D. and Murray, M. (2006). Western Cherry Fruit Fly [Rhagoletis indifferens]. Utah PESTS Factsheet ENT-102-06. Utah State University Extension.
Anhold, J. (1991). Utah Gypsy Moth Eradication. USDA Forest Service – Forest Pest Management.
Blackwood, J.S. (2010). Survey activities conducted in response to detections of Chinese longhorned beetle, Hesperophanes (Trichoferus) campestris, in Schiller Park, Illinois in 2009. Internal report submitted 16 September 2010.
Brunner, J.F. and Klaus, M.W. (1993). Apple maggot Rhagoletis pomonella (Walsh)
(Diptera: Tephritidae). Washington State University Orchard Pest Management Online. http://jenny.tfrec.wsu.edu/opm/displaySpecies.php?pn=140 [accessed 13 December 2018].
Burfitt, C.E. (2015). How we stopped the Japanese Beetle. Utah Department of Agriculture and Food. https://ag.utah.gov/home/blog/518-how-we-stopped-the-japanese-beetle.html [accessed 8 December 2018]
CABI (2019). Lymantria mathura (pink gypsy moth). In: Invasive Species Compendium. Wallingford, UK: CAB International. https://www.cabi.org/isc/datasheet/31809 [accessed 9 January 2019]
CABI (2019). Lymantria monacha (nun moth). In: Invasive Species Compendium. Wallingford, UK: CAB International. https://www.cabi.org/ISC/datasheet/31811 [accessed 9 January 2019]
Cavey, J. F. (1998). Solid wood packing material from China, initial pest risk assessment on certain wood boring beetles known to be associated with cargo shipments: Asian Longhorned Beetle (Anoplophora glabripennis), Ceresium, Monochamus and Hesperophanes. USDA PPQ, 22pp.
Davis, R.S. and McAvoy, D. (2012). Bark Beetles. Utah PESTS Factsheet ENT-165-12. Utah State University Extension.
Davis, E.E., French, S. and Venette, R.C. (2005). Mini Risk Assessment Pink Gypsy Moth, Lymantria mathura (Moore) [Lepidoptera: Lymantriidae]. USDA and Purdue Extension Entomology.
Elliot, S.E. (2015). Global scientists meet for integrated pest management idea sharing. USDA-NIFA. https://nifa.usda.gov/blog/global-scientists-meet-integrated-pest-management-idea-sharing [accessed 7 January 2019
Frank, K.D. (2016). Establishment of the Japanese beetle (Popillia japonica newman) in North America near Philadelphia a century ago. Entomological News, 126 (3), 153-174
Gates, S., Lockwood, R., Mason, L., Schaubert, K.T., West, D., and Wood K. (2016). QUICK GUIDE SERIES UCF 2016-1 Emerald Ash Borer. Colorado State Forest Service.
Grebennikov, V.V., Gill, B.D. and Vigneault, R. (2010). Trichoferus campestris (Faldermann) (Coleoptera: Cerambycidae), An Asian wood-boring beetle recorded in North America. The Coleopterists Bulletin, 64 (1),13-20.
Gyeltshen, J. and Hodges, A. (2005). Featured Creatures: Japanese beetle. University of Florida. http://entnemdept.ufl.edu/creatures/orn/beetles/japanese_beetle.htm [accessed 6 December 2018]
Haack, R.A. (2005). Exotic bark- and wood-boring Coleoptera in the United States: recent establishments and interceptions. USDA Forest Service.
Holland, D.G. (1991). Case Study Gypsy Moth Infestation Salt Lake City, Utah. USDA Forest Service.
Hoover, G.A. (2000). Gypsy moth Lymantria dispar (Linnaeus). Entomology Notes, Penn State College of Agricultural Sciences – Cooperative Extension.
Humphreys, A.G. (1995). Oliver B. Huntington and His Bees. History Blazer. http://historytogo.utah.gov/utah_chapters/pioneers_and_cowboys/oliverbhuntingtonandhisbees.html
Kostin, I.A. (1973). The Dendrophagous beetles of Kazakhstan (Buprestidae, Cerambycidae, Ipidae). Nauka, Alma-Ata, 286 (In Russian.) Translation by Marina Zlotina (PPQ-CPHST Risk Analyst and Entomologist), April 22, 2011.
Law, B.E., Yang, Z., Berner, L.T., Hicke, J.A., Buotte, P. and Hudiburg, T.W. (2015). Drought, Fire and Insects in Western US Forests: Observations to Improve Regional Land System Modeling. American Geophysical Union, Fall Meeting, abstract id. B11N-03
Mason, C.E., Rice, M.E., Calvin, D.D., Van Duyn, J.W., Showers, W.B., Hutchison, W.D., et al. (1996). European corn borer ecology and management. North Central Regional Extension Publication 327, Iowa State University Ames IA.
Messina, F.J. and Smith, T.J. (1993). Western cherry fruit fly Rhagoletis indifferens Curran. Washington State University Orchard Pest Management Online. Last updated August 2000. http://jenny.tfrec.wsu.edu/opm/displaySpecies.php?pn=150 [accessed 13 December 2018].
Nature Conservancy (2015). Asian Gypsy Moth. https://www.dontmovefirewood.org/pest_pathogen/asian-gypsy-moth-html-0/ [accessed 9 January 2019]
Nature Conservancy (2004). Mediterranean Pine Engraver Beetle. https://www.dontmovefirewood.org/pest_pathogen/mediterranean-pine-engraver-beetle-html/ [accessed 12 December 2019].
Oregon Department of Agriculture (Undated). Current Suppression and Eradication Projects. https://www.oregon.gov/oda/programs/ippm/suppressioneradication/pages/suppressioneradication.aspx [accessed 26 December 2018]
Penn State University (2010). European Corn Borer in Field Corn. College of Agricultural Sciences Cooperative Extension Entomology Notes. https://ento.psu.edu/extension/factsheets/european-corn-borer-in-field-corn [accessed 12 December 2018].
Purdue University CAPS (Undated). Ips sexdentatus. http://download.ceris.purdue.edu/file/3086 [accessed 12 December 2019]
Purdue University CAPS (Undated). Orthotomicus erosus. http://download.ceris.purdue.edu/file/3088 [accessed 12 December 2019]
Purdue University CAPS. (2016) Dendrolimus pini. http://download.ceris.purdue.edu/file/3031 [accessed 17 December 2019]
Purdue University CAPS (2016). Dendrolimus sibiricus. http://download.ceris.purdue.edu/file/3033 [accessed 17 December 2019]
Purdue University CAPS (2016). Monochamus urussovii. http://download.ceris.purdue.edu/file/3077 [accessed 12 December 2019]
Purdue University CAPS (2016). Monochamus alternatus. http://download.ceris.purdue.edu/file/3059 [accessed 12 December 2019]
Purdue University CAPS (2014). Hylobius abietis. http://download.ceris.purdue.edu/file/3158 [accessed 12 December 2019]
Purdue University CAPS (2013). Ips typographus. http://download.ceris.purdue.edu/file/3092 [accessed 12 December 2019]
Ray, A.M., Francese, J.A., Zou, Y., Watson, K., Crook, D.J. and Millar, J.G. (2019). Isolation and identifcation of a male-produced aggregationsex pheromone for the velvet longhorned beetle, Trichoferus campestris. Nature Magazine Scientific Reports, 9:4459: 1-10
Siegfried, B.D., Spencer, T.A., and Head, G.P. (2007). Ten Years of Bt Resistance Monitoring in the European Corn Borer: What We Know, What We Don't Know, and What We Can Do Better. American Entomologist, Winter issue, 208-214
Siegfried, B.D. and Hellmich, R. L. (2012). Understanding successful resistance management, GM Crops & Food, 3:3, 184-193, DOI: 10.4161/gmcr.20715
Smithsonian (1999). Buginfo: Gypsy moths. Information Sheet Number 36. https://www.si.edu/spotlight/buginfo/gypsy-moths [accessed 20 Dec 2018].
Thomas, M.C. and Dixon, W.N. (2004). Featured Creatures: Pine Shoot Beetle. University of Florida. http://entnemdept.ufl.edu/creatures/trees/beetles/pine_shoot_beetle.htm [accessed 19 December 2018]
University of California IPM. Pest Notes: Bark Beetles UC ANR Publication 7421 http://ipm.ucanr.edu/PMG/PESTNOTES/pn7421.html [accessed 19 Dec 2018]
UN Food and Agriculture Organization (2007). FOREST PEST SPECIES PROFILE Lymantria monacha (Linnaeus, 1758).
USDA-APHIS (Undated). Asian Gypsy Moth. https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/asian-gypsy-moth/asian-gypsy-moth [accessed 26 December 2018]
USDA-APHIS (2018). Emerald Ash Borer. https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer [accessed 7 January 2019]
USDA-APHIS (2012). New Pest Response Guidelines: Dendrolimus Pine Moths https://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/dendrolimus.pdf [accessed December 23 2019]
USDA-APHIS (2000). Managing the Japanese Beetle. A Homeowner's Handbook. US Department of Agriculture http://www.pueblo.gsa.gov/cictext/housing/japanese-beetle/jbeetle.html
(PDF) Biology and management of Japanese beetle. Available from: https://www.researchgate.net/publication/11626984_Biology_and_management_of_Japanese_beetle [accessed 6 December 2018].
USDA Forest Service (2015). A 25-year history of forest disturbance and cause in the United States. USDA FS Rocky Mountain Research Station. https://www.fs.usda.gov/rmrs/science-spotlights/25-year-history-forest-disturbance-and-cause-united-states [accessed on 22 December 2020]
USDA Forest Service (Undated). Elongated Hemlock Scale. Forest Service Northeastern Area NA-PR-01-02.
USDA Forest Service (2007). Invasive Bark Beetles. Forest Insect & Disease Leaflet 176.
USDA Forest Service Research and Development (2014). Bark Beetles. https://www.fs.fed.us/research/invasive-species/insects/bark-beetle/ [accessed 9 January 2019)
Utah Fruit and Berry Survey (2006). National Agricultural Statistics Service. Released 7 June 2007, by Utah State University.
Washington State Department of Agriculture (2017). Gypsy moth. https://agr.wa.gov/PlantsInsects/InsectPests/GypsyMoth/ [accessed 26 December 2018]

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HELP STOP THE SPREAD OF INVASIVE PESTS & DISEASES.

Our forests are threatened by invasive tree-killing insects and diseases that can hitchhike on firewood. Pests like the emerald ash borer, gypsy moth, and Asian longhorned beetle don't move far on their own - but they can travel hundreds of miles in a single day in a bundle of contaminated firewood. Once transported to uninfested areas, these insects and diseases can emerge and start new damaging outbreaks.

How you can help:

- Leave firewood at home – buy local firewood at or near your destination, or collect firewood on site when permitted.
- Buy or collect only what you'll need, and burn it all completely by the end of your stay.
- If you have already moved firewood, use it immediately. Do not take it home with you, and do not leave any excess firewood on site.

BUY IT WHERE YOU BURN IT.

Utah Department of Agriculture and Food

Extension
Utah State University

DontMoveFirewood.org

Forest Service U.S. Department of Agriculture

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