Invasion of the Murder Hornets:

Using communications technology to detect and eradicate the largest hornet in the world

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Executive Summary

The Asian Giant Hornet (*Vespa mandarinia*) is the world's largest species of hornet. It can be up to two inches in length, with a quarter-inch long stinger. While the hornets generally don't attack pets or people, they do attack and destroy honeybee hives. A few hornets can destroy a hive in a matter of hours.

Bees pollinate a third of U.S. crops, an important part of the food supply chain that contributes an estimated $15 billion in value to the agriculture industry. If it becomes established, the Asian Giant Hornet will have significant negative impacts on the environment, economy and public health of Washington state.

The Washington State Department of Agriculture (WSDA) received and verified two reports of Asian giant hornet near Blaine, Washington in 2019. These are the first-ever sightings in the United States. After receiving additional reports in 2020, the WSDA conducted the first-ever eradication of an Asian Giant Hornet nest in the United States.

Honeybee vs. Asian Giant Hornet

This effort involved an innovative use of technology – including social media crowd sourcing, geo mapping and live tracking using a radio tag tied to a hornet – to find and eradicate the only known nest of the hornets. The destroyed nest contained 190 larvae, 112 workers and 76 queens.

The successful eradication of the nest would not have been possible without the support and hard work of 380 citizen scientists who placed and monitored more than 2,000 live hornet traps for months at a time and registered their traps using a WSDA web-based mapping application developed for the effort.

This work enabled the WSDA to narrow down possible locations of the nest over a large geographical area and ultimately destroy it.

Mobilizing citizen scientists and using communications technology to survey, detect and delimit the hornets

When Canadian beekeepers found and destroyed a colony of Asian Giant Hornets in Nanaimo, British Columbia on September 19, 2019, the WSDA knew there was a high probability that the hornets may have entered the Pacific Northwest. And they were right. By December 2019, a specimen found by a local homeowner in October near Blaine, WA was confirmed by Washington State University as an Asian Giant Hornet.

Based on the life cycle of the hornet, the WSDA only had six months to research, design, coordinate and implement a response to this unknown threat. Immediate work was done with partners at the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) to help develop a New Pest Response Guidelines document. This is a document developed for any new invasive species and included recommended trapping densities, nesting habits, identification details and many other pertinent details to conduct a successful survey and eradication program.

The hunt for the hornets began in early June and WSDA recognized they could not accomplish this major undertaking alone. A survey of the area was necessary to determine the location of the hornets. The WSDA had the technology but did not have the people resources needed to conduct the search.

So, they engaged 'citizen scientists' to help. In April 2020, WSDA teamed with local beekeepers in Whatcom County to help set sap traps in an attempt to attract and trap queens after their emergence. This was unsuccessful but was a great introduction to the incredible response and effort received from citizen scientists. To increase the likelihood of further participation by citizen scientists, the WSDA initiated an immense outreach effort to the public utilizing virtual press conferences, blog posts, Facebook, YouTube, documentaries, photography and filming, stakeholder updates, website, email listserv, billboards and mailings. Media coverage of the Asian giant hornets hit national and then international news. WSDA staff conducted dozens of interviews with all of the major news outlets. "Murder hornets" became a cultural phenomenon engendering hundreds of memes and trending on Twitter and in Google searches. In May alone, WSDA's Facebook account, which normally reaches about 200,000 people per month, reached 1.2 million people. Billboards were also used to spread awareness of the Asian giant hornet and encourage residents of Washington to report sightings.

Timeline:

September 19, 2019 – Canadian Beekeepers found and destroyed a colony of Asian Giant Hornet in Nanaimo, British Columbia.

December 2019 – A specimen found by a local homeowner in October near Blaine, WA is confirmed by Washington State University as an Asian Giant Hornet.

April 2020 – WSDA Issues Citizen Scientist bottle trapping instructions and materials; official trapping began during worker and drone emergence in July 2019.

May 27, 2020 – WSDA confirms Asian Giant Hornet queen found on a roadside and reported by a private citizen near Custer, WA and become first Asian Giant Hornet queen detected in the U.S.

July 2020 – Citizen scientist trapping officially begins and cloud-based web mapping application is released to allow citizens to mark and number their individual traps.

August 2020 – First Asian Giant Hornet worker found in a trap, WSDA Begins setting live traps in an attempt to capture and radio tag a hornet in order to find its nest.

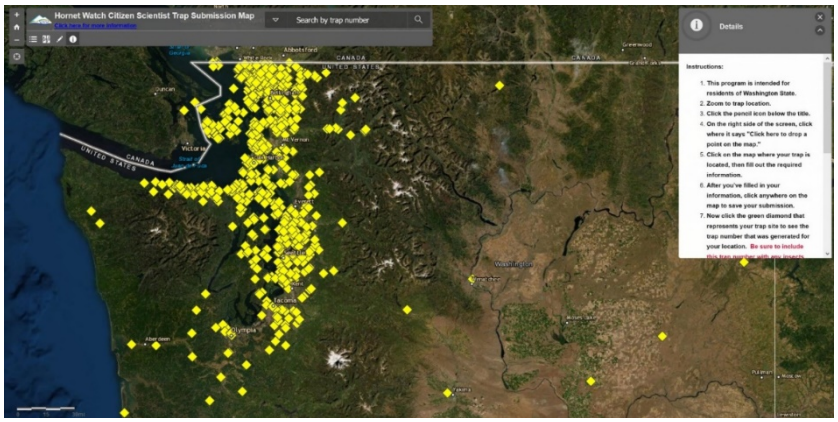
October 22, 2020 – WSDA attaches radio tags to a live Asian Giant Hornet captured in an experimental live trap. The hornet is successfully tracked through heavy forest and vegetation back to its nest eight feet up in an alder tree.

October 24, 2020 – WSDA conducts successful eradication of the first nest found in the United States.

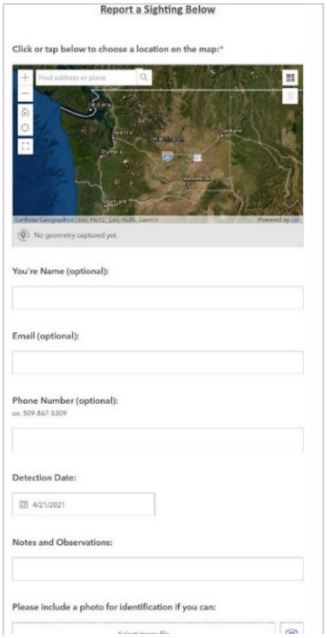
After much research it was determined that a bottle trap would be the best method of trapping using orange juice as the main attractant. Traps would be placed by both WSDA and citizen scientists from June through October. Citizen scientists were asked to check the traps weekly and submit all contents to WSDA using designated pickup and drop off locations that would then be transported back to Olympia for staff sorting and identification of samples. To help with tracking the locations of the traps, an intuitive cloud-based web mapping application was developed that allowed participants to mark the location of traps and enter their information as well as provide a unique trap identification number back to the user.

Another tool developed by WSDA was a cloud and web-based hornet watch sighting report form. This allowed any person the ability to quickly access an online and secure tool to mark a location of a potential sighting, add in their contact info along with an image of the specimen. The submissions were then added to a web mapping application monitored by WSDA's entomology lab where they were

labeled as unprocessed, negative, unverified or positive ID by the lab staff along with comments/feedback for the submitter. This proved to be an amazing way to expand the reach of the survey outside the scope of citizen scientists and allow for quick and direct engagement with WSDA staff on the results of their work accessible any time they chose.



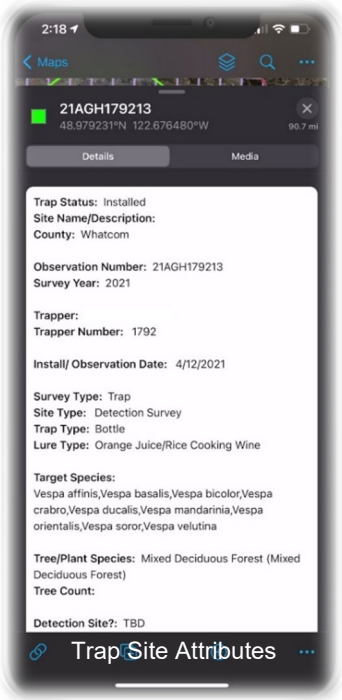
ArcGIS Online Cloud Based Mapping Web App used to allow Citizen Scientists to mark their trap locations throughout the state.



Hornet Watch web-based Report Form

Internal WSDA trapper and field staff accessed even more advanced data collection tools utilizing iPhones and mobile data collection applications ESRI Field Maps which tied directly into ArcGIS Online along with Zerions iFormbuilder application. These apps work together to allow ease of data input while working with both form and map-based interfaces to allow for trap installation input, inspection information, detection information as well as accessing reference layers such as high-density grids, public trap locations, county and country boundaries, detection location, etc. This allowed for a highly accurate, near real-time, offline capable, secure and robust flow of data and information from field to office during this dynamic and fast paced survey. Through this process WSDA had the most up to date information for analysis and helped expedite decision making at all levels at WSDA and USDA.

Field Maps App



Trap Site Attributes

iFormbuilder Mobile App

How Bluetooth technology and dental floss helped find the hornet's nest

Round 1 – Bluetooth Trackers

On September 30, 2020, WSDA conducted its first release and tracking attempt of the Asian Giant Hornet using Bluetooth radio tags, receivers and a custom Android app built by the University of Washington computer science department. Over the previous months, WSDA entomologists and the location intelligence team worked with a developer/graduate student in the UW CSE department to purchase three Bluetooth receiver tags, three Bluetooth handheld receivers and develop a custom android app to record location and signal strength of the hornet as it flew away. After unsuccessful attempts to affix the receiver to the hornet with glue, the trick turned out to be a simple piece of dental floss that was tied around the abdomen of the hornet. Unfortunately, this first attempt was unsuccessful, although it proved that it was possible to trap a live specimen, keep it alive, attach a radio transmitter and attempt to follow it back to its nest.

Round 2 – Radio Trackers

On October 21, a WSDA trapper discovered two live Asian giant hornets in an experimental live trap. Upon arrival on October 22, the WSDA discovered two more live hornets in a nearby trap.

Staff were able to visually track this hornet to a nearby tree. They were also equipped with new radio transponders to follow it further. The hornet took flight again, quickly leaving visual detection. WSDA followed the signal from the tracker as it grew increasingly stronger until it reached the max signal. There was no visible nest; however, hornets were spotted flying near an alder tree, and then confirmed to be entering it through a tree cavity. **This was the first Asian giant hornet nest located in the United States.**

Using the detect and delimit strategy, the team slowly tighten the hotspot zone and ultimately the second live release point ended up less than 750 ft. from the actual nest. This shows the power of technology, spatial analysis, location intelligence and the years of methodology used across a vast array of invasive species by WSDA and throughout the United States to successfully track and discover the exact source of infestation for possible reproduction.

During tracking efforts, WSDA also deployed use of the ESRI quick capture mobile application that allowed for the creation of real-time tracklines which tracked the routes taken by all field staff as they raced through trails, brush and heavy foliage. This allowed the location intelligence team to analyze areas of lost signal when tracking the hornet, feature more detailed inspection areas, potential nest locations and determine areas of concern and gaps in ground surveys.

Destroying the nest

The original plan was to deploy insecticide on any nests found overnight. This was to ensure as many individuals were in the nest as possible. After a practice eradication in late August, it was

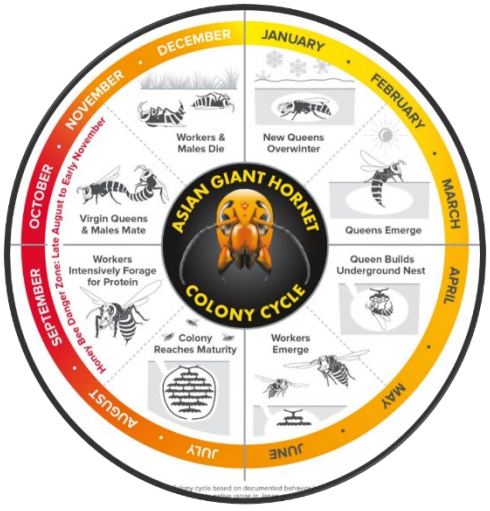
determined that a vacuum extraction in the early morning was a better approach, as visibility is improved, temperatures are cooler, and there were still many hornets in the nest.

On the morning of October 24, WSDA quickly sealed the entrance of the nest and the surrounding fissure in the tree with foam and wrapped the tree with plastic wrap. The crew then opened a small hole in the entrance where a vacuum with a collection chamber was inserted and collected all specimens that were exiting the nest.

In total, 85 hornets were vacuumed out of the nest on Oct. 24. All were workers. After the extraction, WSDA introduced CO2 gas and sealed the entrance with expanding insulation foam. On October 28, a contractor was hired to cut down the tree and remove the section with the nest. The section was transported to a secured cold room at the Washington State University for examination. On Oct. 28, a few live queen hornets were captured while attempting to exit the nest. On October 29, CO2 gas was again introduced and the section with the nest was split open. The 76 recently emerged queens were collected, and the following nest statistics were recorded:

- The nest had 6 combs.
- The combs had 776 cells.
- The widest comb was 9" in diameter.
- 108 cells were capped (These are presumed to be mostly queens).
- There were 190 larvae.
- There were 9 males collected.
- There were 76 queens.
- There were 6 unhatched eggs.
- 112 workers were collected (85 from the extraction on the 24th).

Mission accomplished?



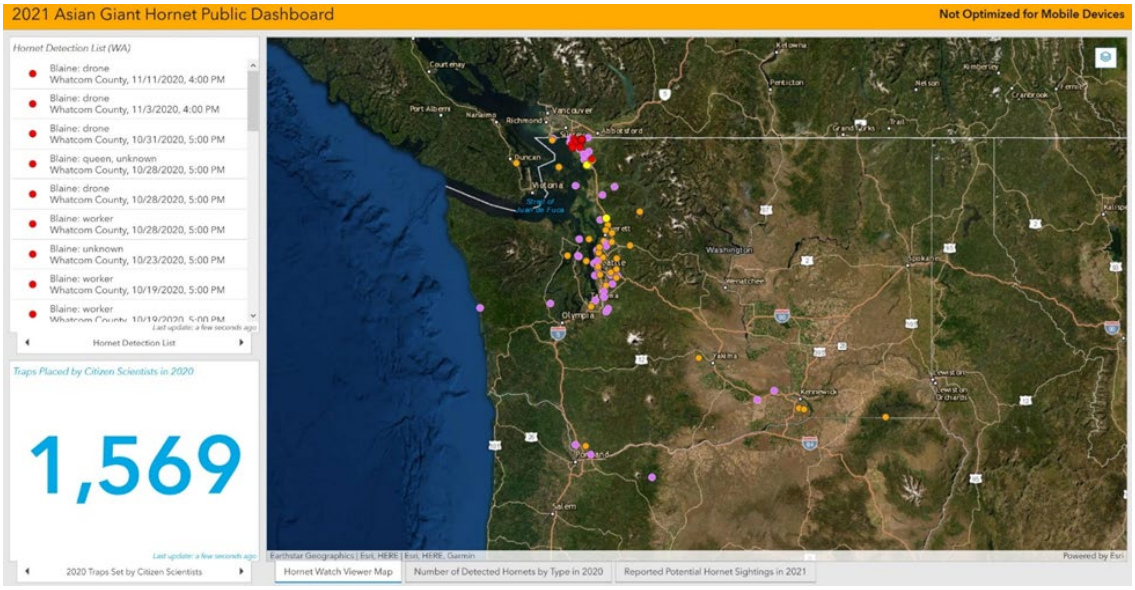
Although the first Asian Giant Hornet nest in the U.S. was eradicated, there is a high probability there are more nests in Whatcom County.

However, WSDA believes early detection provides a fighting chance to continue to detect and fully eradicate this apex predator in the coming years. Until there are multiple years of negative survey seasons, it will never be fully deemed as a successful invasive pest eradication. Every year, in every part of the globe, the threat and potential negative impact of invasive species is a constant ecosystem concern that you rarely, if ever, see coming. That is the ever-present challenge at the Washington State Department of Agriculture Pest Program and a constant reminder to always remain vigilant and prepared.

Additional Resources:

Media:

- WSDA Hornets Webpage: https://agr.wa.gov/departments/insects-pests-andweeds/insects/hornets
- WSDA AGH Media: https://agr.wa.gov/departments/insects-pests-and-weeds/insects/hornets/news-media
- WSDA Hornet Facebook Page: https://www.facebook.com/groups/hornets/
- Original Murder Hornets NY Times: https://www.nytimes.com/2020/05/02/us/asian-giant-hornet-washington.html
- Public Dashboard: https://wsda.maps.arcgis.com/apps/dashboards/522e518f00084cee84a41151169c9418



- Public Trapping Web Application: https://wsda.maps.arcgis.com/apps/View/index.html?appid=7361831d85b246288c93170d87e6de07
- Hornet Watch Report Form: https://survey123.arcgis.com/share/f453e20988714d1a8459891b888b5def
- Asian Giant Hornet Storymap: https://wsda.maps.arcgis.com/apps/Cascade/index.html?appid=a5a8a7a208a04f01a521fcc2895264d9