WELCOME TO LET'S TALK ABOUT HANFORD

WE WILL BEGIN TONIGHT'S CONVERSATION SOON

DEPARTMENT OF ECOLOGY
State of Washington

Pollinators of Hanford and Southcentral Washington

George Peck

June 26, 2024

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What is a pollinator?

- An animal that moves pollen from the male anther of a flower to the female stigma of a flower.
- This pollination process helps bring about fertilization of the ovules (female gamete) in the flower by the male gametes from the pollen grains.
- Insects: bees, bumble bees, wasps, butterflies and moths, flies, beetles, others
- Bats, birds (hummingbirds, honeyeaters, sunbirds),
- Humans (artificial pollination)

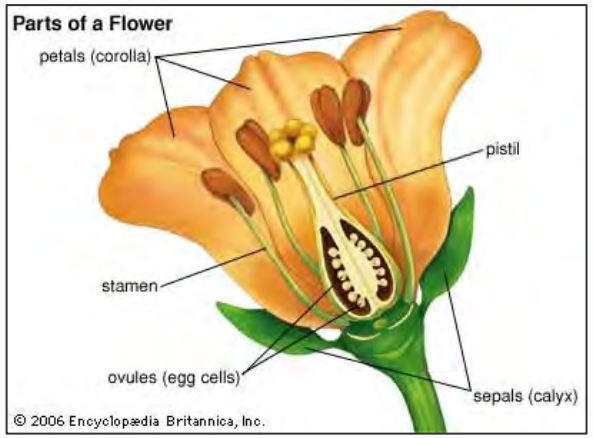
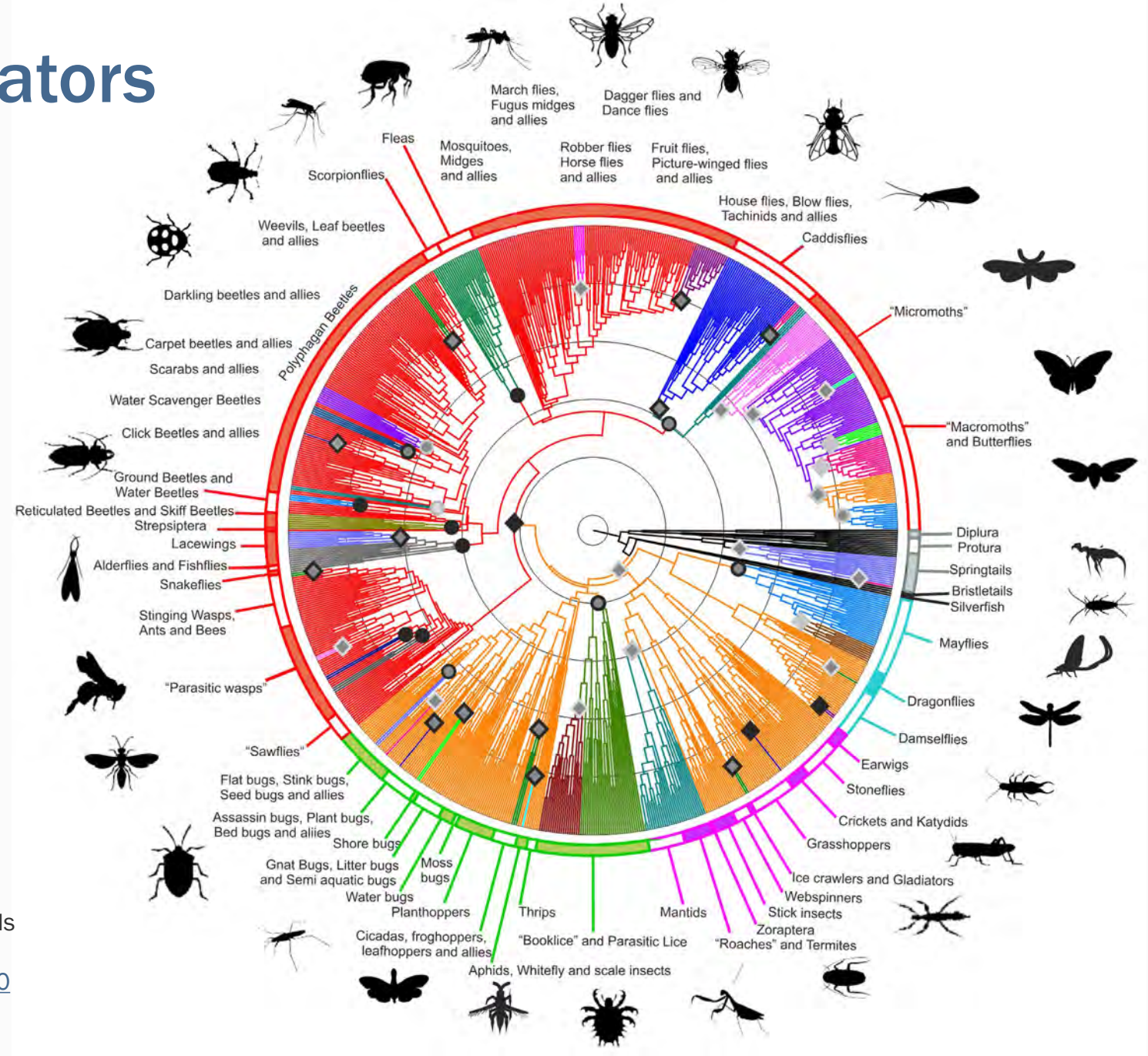


Image: *Lipotriches spp*. Image by Muhammad Mahdi Karim - Own work, GFDL 1.2, https://commons.wikimedia.org/w/index.php?curid=6575681

Diversity of insect pollinators

- Hymenoptera
  - Bees and Wasps
- Diptera – Flies
- Lepidoptera – Butterflies and Moths
- Coleoptera
- Others



Phylogenetic Distribution of Extant Richness Suggests Metamorphosis Is a Key Innovation Driving Diversification in Insects. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0109085

Pollinators of Hanford and Southcentral Washington

- 20 crops constitute most of Washington's agricultural production
- Many factors affect bee pollination of agricultural crops
  - Host plant
  - Weather
  - Suitable habitat
- For fruit or seeds to develop, pollination must occur at blossom time
- Nearly 1,000 species of bees occur in the Pacific Northwest
- Only a small number of species are useful in the pollination of orchard crops
- Pesticide use and loss of appropriate nesting habitat have reduced the numbers of wild bee pollinators
- Most of the pollination for commercial orchards is dependent on honey bees

European honey bee
Aphis mellifera

Resources: USDA ARS Alfalfa Leafcutting Bee (ALCB) WSU Tree Fruit—Honey Bees
https://en.wikipedia.org/wiki/Western_honey_bee

Agriculture in Southcentral Washington

- Apples*
- Potatoes
- Alfalfa Hay (seed*)
- Wheat
- Hops
- Grapes
- Cherries*
- Pears*
- Corn
- Blueberries*
- Raspberries*
- Canola (helps yield)
- Chickpeas
- Peas
- Barley
- Mint
- Pumpkins*
- Lentils
- Peaches*
- Apricots*

Resources: List of Crops pollinated by bees Google Maps ,

Pollinators of Hanford and Southcentral Washington

Important agricultural products (2023) in Southcentral WA

Commodity	Harvested Acres	Production (lb)	Value ($)
Apples	173,000	7,381,700,000	1,991,918,000
Cherries	39,000	411,460,000	289,983,000
Pears	16,400	533,420,000	130,805,000
Blueberries	17,700	137,500,000	78,363,000
Raspberries	9,500	67,100,000	75,500,000
Pumpkins	2,800	49,000,000	15,852,000
Peaches	1,200	12,520,000	10,257,000
Apricots	640	7,040,000	5,859,000

WSU IAREC, Prosser WA

Resources: Economic significance of agricultural products (WA State Ag Overview 2023) , Prosser IAREC | Washington State University (wsu.edu)

Pollinators of Hanford and Southcentral Washington

Commodity	Pollinators
Apples	Honey Bee (mostly), Blue Orchard Bee (Osmia lignaria), Bumble Bees, Solitary Bees, Wasps, Flies, Beetles
Cherries	Honey Bee (mostly), Blue Orchard Bee (Osmia lignaria), Bumble Bees, Solitary Bees, Flies
Pears	Honey Bee (2x density needed), Bumble Bees, Solitary Bees, Hover Flies (*Eristalis* spp. Syrphidae)
Blueberries	Honey Bee, Alfalfa leafcutter bee, Bumble Bee, Solitary Bees including *Colletes* spp. (ground nesting bees), *Osmia ribifloris* (Blueberry Bee), *Osmia lignaria* (Blue Orchard Bee)
Raspberries	Honey Bee (2x density needed), Bumble Bees, Solitary Bees, Hover Flies (*Eristalis* spp. Syrphidae)
Pumpkins	Honey Bee, Squash Bee , Bumble Bees, Solitary Bees
Peaches	Honey Bee, Bumble Bees, Solitary Bees, Flies
Apricots	Honey Bee, Bumble Bees, Solitary Bees, Flies

There are over 4,000 known species of bees in North America, including hundreds of species of solitary bees that can pollinate crops
Resource: Bee

Squash bee
Peponapis pruinosa

Resources: Wikipedia list of crops pollinated by bees Honeybees , Blue Orchard Bee ,

Pollinators of Hanford and Southcentral Washington

Western Honey Bee, *Apis mellifera*

- Genus *Apis* has 8 extant species, and all originated in mainland Afro-Eurasia
- First fossils date to Eocene-Oligocene boundary (34 mya)
- Domesticated 2,600 BC (Bronze age, Age of the Pyramids)
- Brought to Eastern North America in 1622 by German colonists
- Brought by ship to the Pacific Coast in the 1850s
- Dominant pollinator in Washington cropping systems
  - Eusocial bee: forms a colony seasonally of tens of thousands of female worker bees and a few thousand drone bees (males)
  - Worker bees cooperate to find food and use a pattern of dances (waggle dance) to communicate information regarding direction and distance to patches of resources
  - Used extensively in commercial pollination of fruit and vegetable crops
  - Pollination services measured in billions of dollars—adding about 9% to the value of crops around the world

Resources: Western Honey Bee , https://en.wikipedia.org/wiki/Western_honey_bee

A beekeeper inspecting a honey bee hive

Western honey bee
Aphis mellifera

Pollinators of Hanford and Southcentral Washington

Blue Orchard Bee, *Osmia lignaria*

- Family Megachilidae, a cosmoplitan family of mostly solitary bees
- Bees emerge from nests when temperature reaches 14ºC (58 ºF)
- Males mate immediately with females
- After ovary maturation (several days) female seeks a nesting site
- Prefer narrow holes or tubes near mud
- Nests arranged as series of partitions
- 25 trips to complete pollen-nectar provision
- Lays egg directly on provision, seals it, repeat

Blue Orchard Bee

Blue Orchard Bee nest with five partitions showing

Blue Orchard Bees provisioning nests

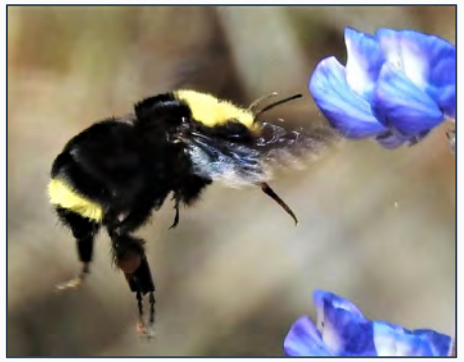
“Nest Condo”

Resources: Osmia lignaria – Wikipedia , Image credits , USDA ARS Pollinating Insects

Pollinators of Hanford and Southcentral Washington

Bumble Bee, *Bombus spp.*

- Globally over 250 species in the genus *Bombus*
- 29 native bumble bee species in Washington
- Eusocial bees that form colonies with a single queen and 50-400 individuals
- Division of labor among female offspring and cooperative brood care
- Overwintering of mated queens usually underground
- Nest is a cluster of ball-shaped wax brood cells in small cavity – abandoned rodent burrow, tree hole, etc.
- Queen and workers forage for nectar and pollen near nest
- Bumble bee 'buzz-pollination' important for tomatoes, peppers, blueberries
- Brood care by regurgitation of nectar and combining nectar with pollen to form pollen ball to provision cell and feed larvae



Yellow-faced bumble bee (*Bombus vosnesenskii*)

Red-tailed bumble bee nest

Resources: Bumblebee - Wikipedia WSU Apidae: Bumble Bees (Bombus spp.) | Hortsense | Washington State University (wsu.edu)

Pollinators of Hanford and Southcentral Washington
Alfalfa Leafcutting Bee, *Megachile rotundata*

- Very important pollinator of alfalfa for alfalfa see production
- Introduced to US from Eurasia in the 1930s
- Increases seed production compared to honey bees or no bee
- Solitary and lives several weeks during summer
- Nest lined with cut alfalfa leaves
- 40,000 to 60,000 needed to pollinate on acre of alfalfa for seed

A domicile “nest condo” of nesting boards in an alfalfa seed field

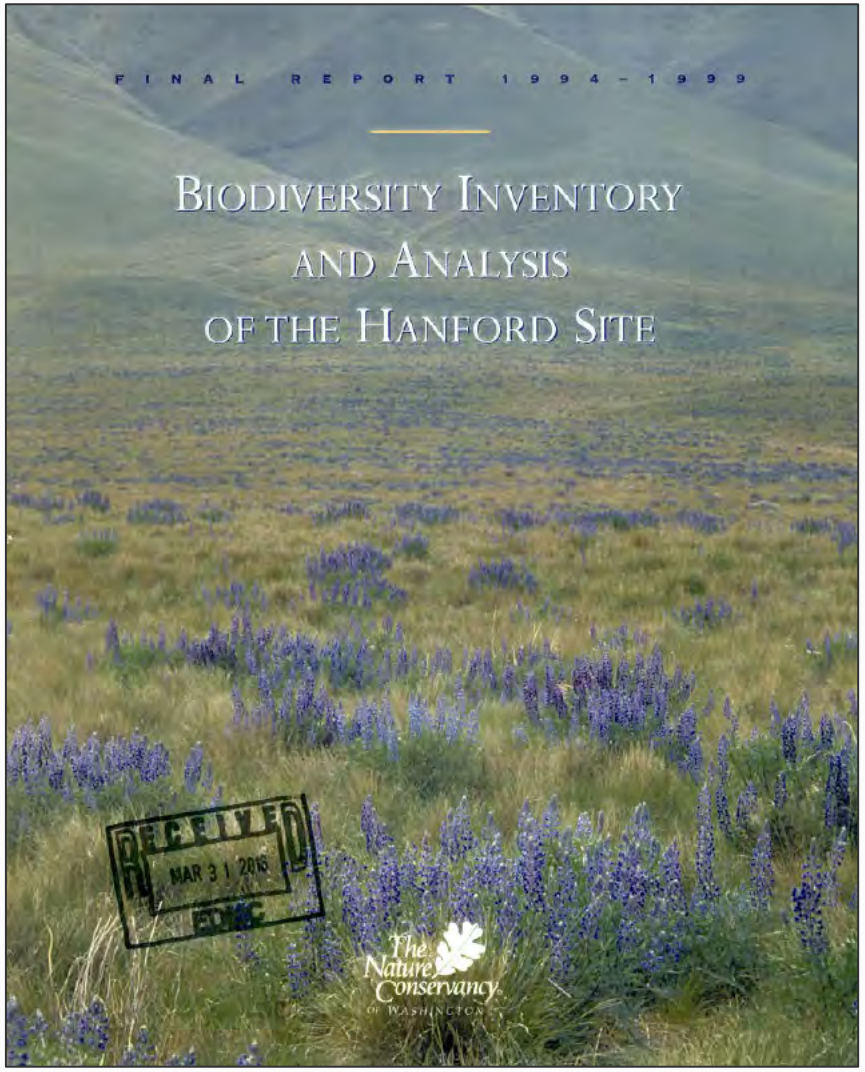
- Bee emergence from nest is synchronized with alfalfa flower bloom – tricky
- Mass production and release requires a few thousand artificial next cavities “nest condos” placed in alfalfa seed fields
- Each female able to find her nest among thousands of others

Alfalfa Leafcutting Bee

Resources: Megachile rotundata - Wikipedia Alfalfa Leafcutting Bee (ALCB) : USDA ARS

Pollinators of Hanford: Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994—1999

- 5 years of insect inventory work
- Almost 40,000 specimens collected
- 1,509 species-level identifications made (1999)
- 49 species of butterflies identified
- 318 species of moths identified
- 41 species and 2 subspecies new to science
- Hanford has many rare or rarely collected species
- Assemblage of microhabitats large enough to support the pre-European insect and plant fauna

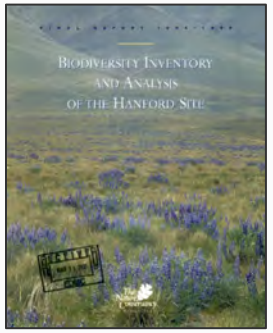


Resources: Biodiversity Inventory and Analysis of the Hanford Site—Final Report 1994-1999, Biodiversity Inventory and Analysis of the Hanford Site 1997.

Pollinators of Hanford: Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994—1999

- Trapping Methods and Insect Processing
  - Sweep nets, beat tarps, hand picking, light traps, and pit-fall traps
  - All insects were mounted and labelled
  - Specimen curation work done at WSU Pullman or WSU Tri-Cities
- Study Methods and Area
  - Dark triangles are invertebrate sampling locations
  - 1994—1995 focus on leafhoppers, true bugs, beetles, bees and wasps, flies, moths and butterflies
  - 1996—1997 focused more on night-time light trapping: Moths, true bugs, beetles, lacewings, and others--Mercury vapor lamp placed on sheet
  - 1998—Pitfall traps included at 4 sites

Resources: Biodiversity Inventory and Analysis of the Hanford Site—Final Report 1994-1999, Biodiversity Inventory and Analysis of the Hanford Site 1997.



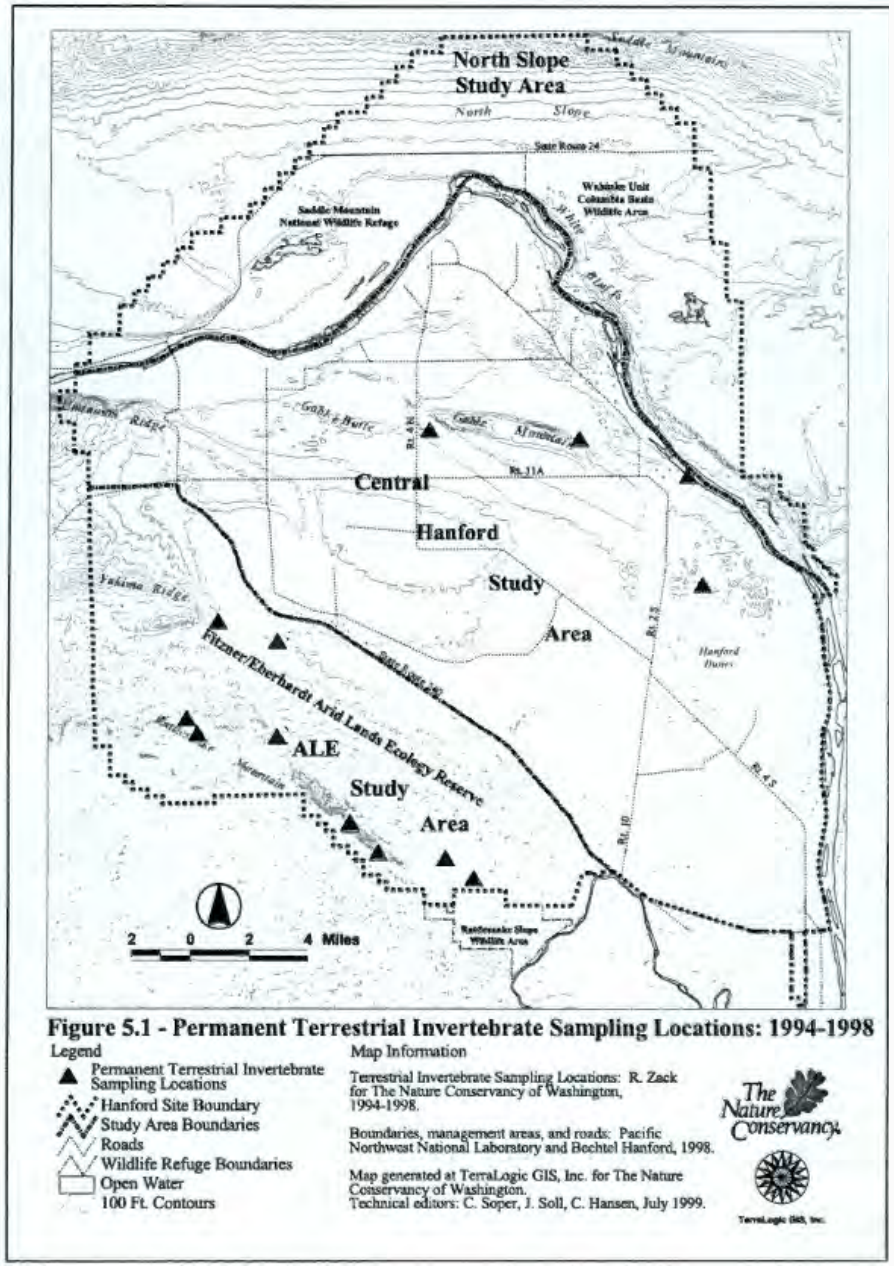
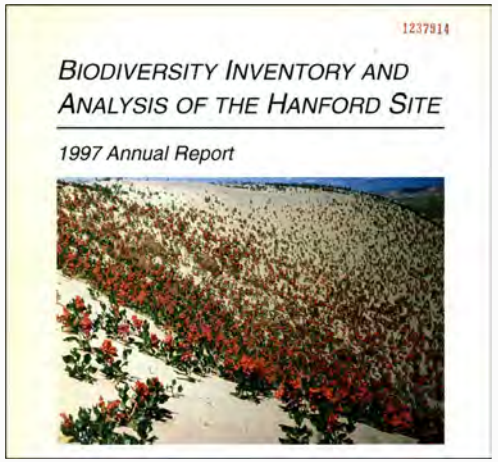
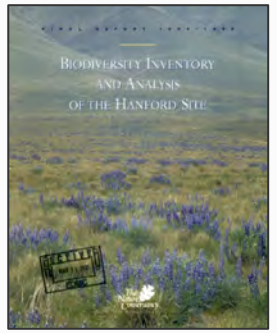


Figure 5.1 - Permanent Terrestrial Invertebrate Sampling Locations: 1994-1998

Pollinators of Hanford: Biodiversity Inventory and Analysis of the Hanford Site, 1994—1999 and 1997





- 16 orders of invertebrates were identified
- 1,536 individual insects identified to species level*
- All 5 Xerces Society 'main' pollinators were present
- 142 new occurrence records for WA
- 43 'new to science' species identified

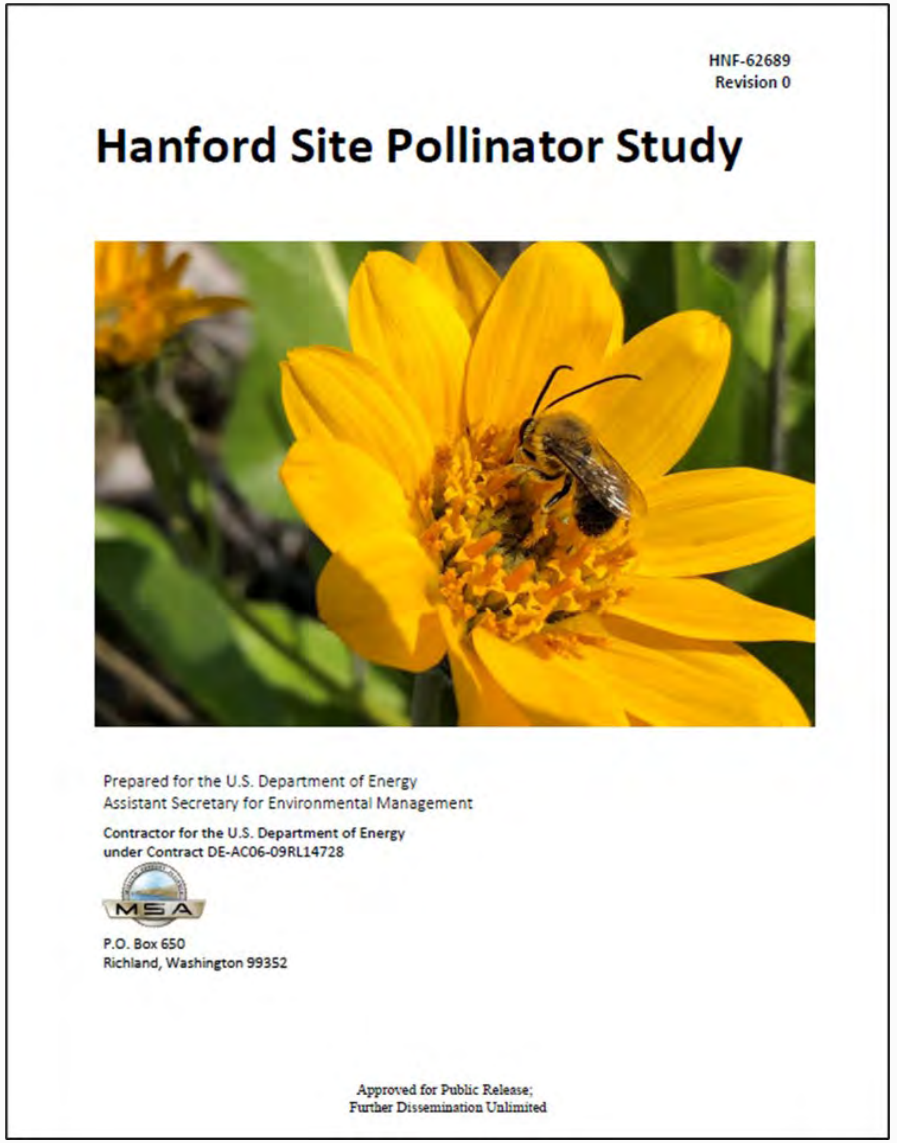
Insect Order (common pollinators)	Number identified at species level*
Coleoptera (beetles)	242
Diptera (flies)	322
Hymenoptera (bees, wasps, and ants)	364
Lepidoptera (butterflies)	50
Lepidoptera (moths)	320

Resources: Biodiversity Inventory and Analysis of the Hanford Site—Final Report 1994-1999, Biodiversity Inventory and Analysis of the Hanford Site 1997.

*In 1999 there were between 383 and 672 individual insects yet to be identified to species level.
https://www.xerces.org/pollinator-conservation/about-pollinators

Hanford Pollinator Study

- Investigated abundance and diversity of bees over 6 months (April to October 2017)
- 4 study sites
  - Steppe/Grassland (native bunchgrass)
  - Rabbitbrush dominated areas (early colonizers)
  - Mixed shrubland: mid-successional mix of big sagebrush, antelope bitterbrush, spiny hopsage, and rabbitbrush
  - Mature sagebrush: late-successional with mostly mature stands of big sagebrush


HNF-62689
Revision 0

Hanford Site Pollinator Study

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

MSA

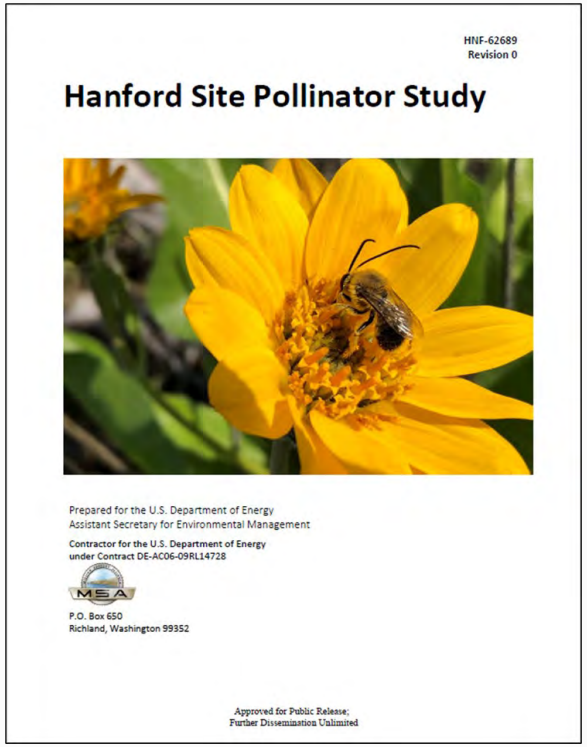
P.O. Box 650
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

Resources: Hanford Site Pollinator Study DOE-RL-96-32-01.pdf (hanford.gov)

Pollinators observed

- 1,902 total bees collected over twenty-three weekly site surveys
- Five bee families observed
- Halictidae "Sweat Bees" (**1,374**)
- Megachilidae "Mason and Leaf-cutting bees" (**273**)
- Apidae "Bumble Bees and Honey Bees" (**156**)
- Andrenidae "Mining Bees" (**96**)
- Colletidae "Plasterer Bees" (**3**)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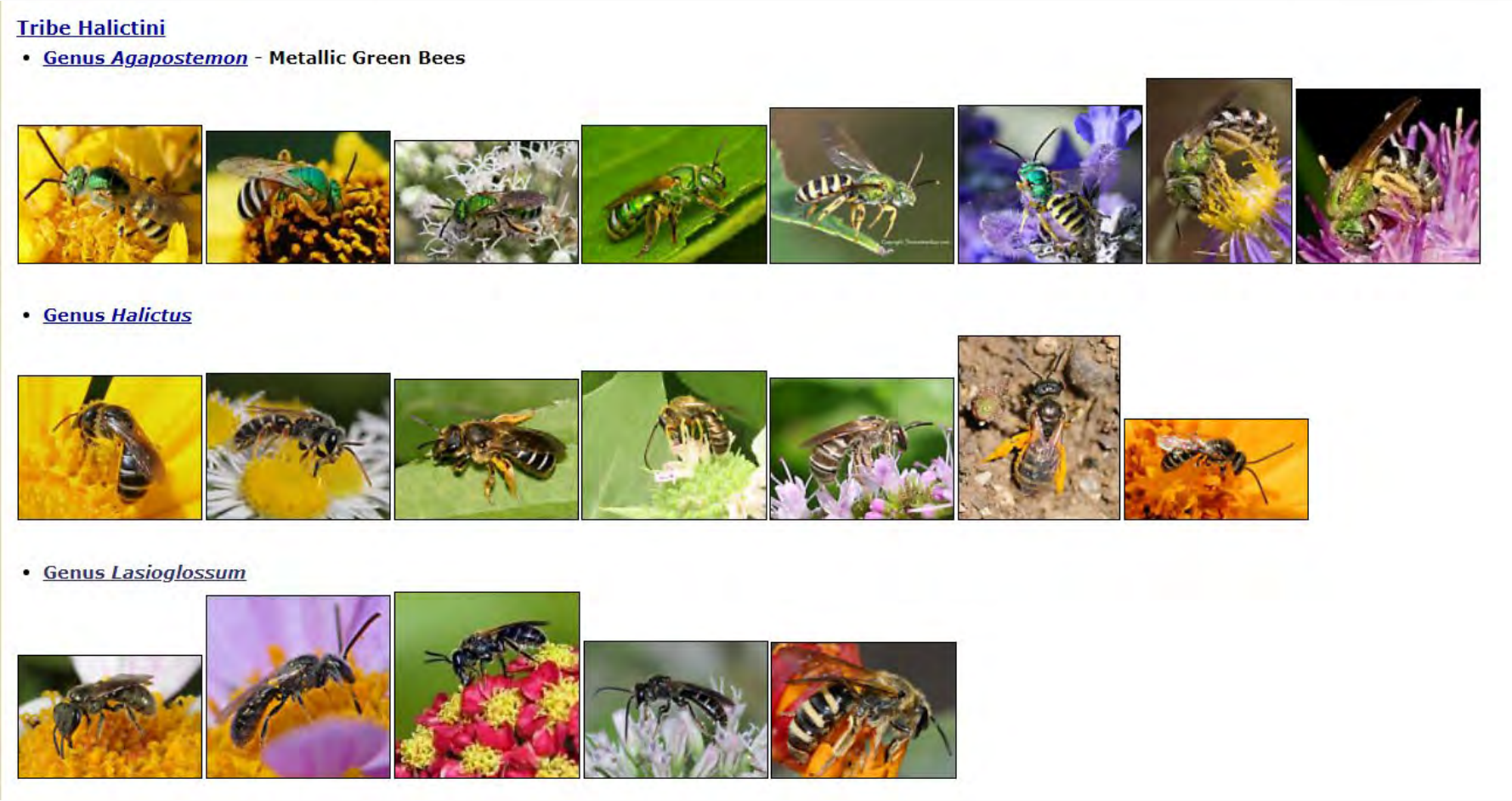
Resources: Hanford Site Pollinator Study WSU image of Halictidae WSU image of Megachilidae Apidae

Sweat Bees: Halictidae

- Mostly ground nesters
- Single cell provisioning
- Pollen and nectar feeders
- 1,374 collected
- *Lasioglossum* (1,068)
  - 100+ species in WA
  - 2 -8 mm long
- *Agapostemon* (281)
  - ~ 10 species in WA
  - All have green coloration
- *Halictus* (25)
  - ~ 10 species in WA
  - Dusky black with striping, identified by wing venation

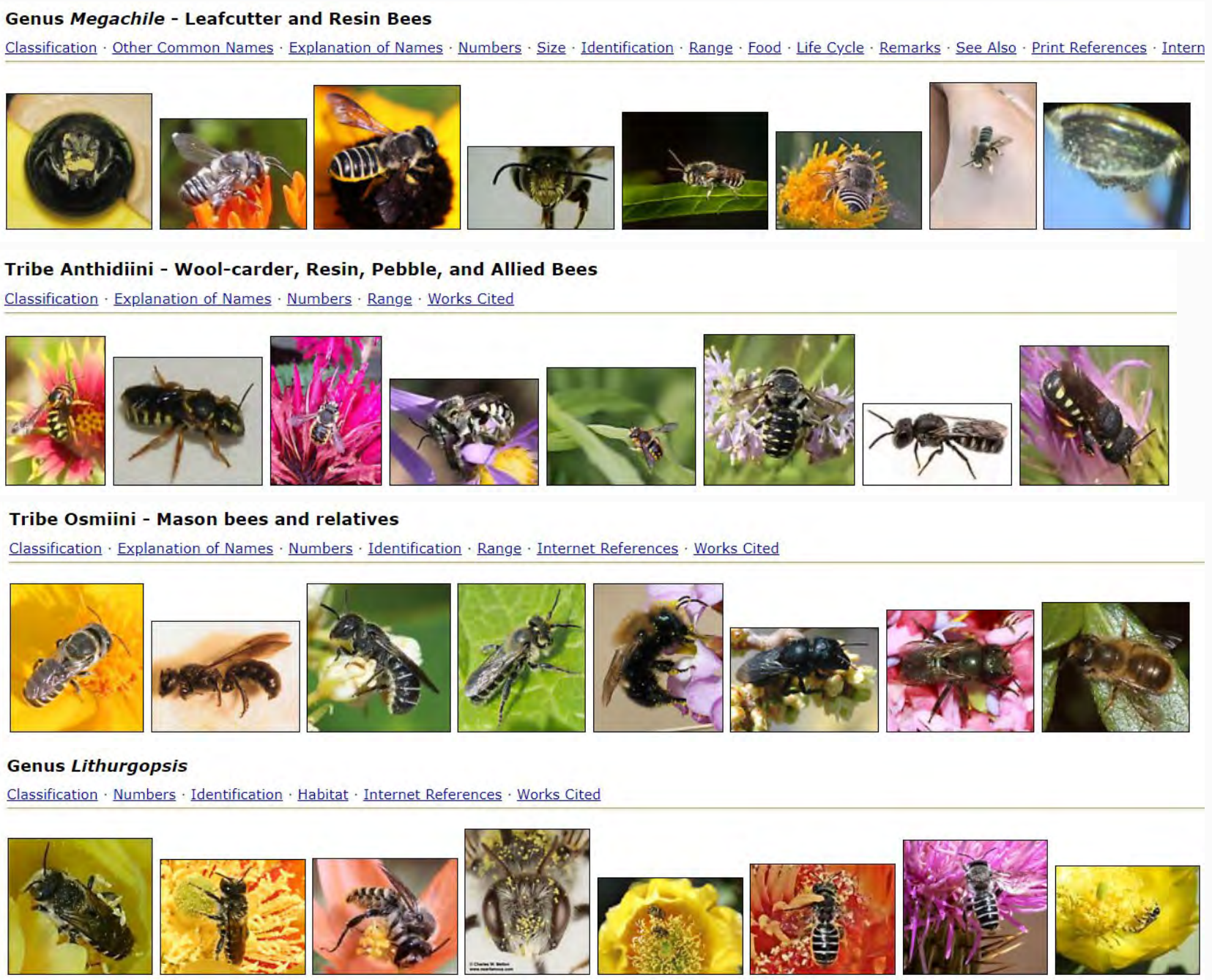


Resources: Hanford Site Pollinator Study https://en.wikipedia.org/wiki/Halictidae https://bugguide.net/node/view/128 https://www.fs.usda.gov/wildflowers/pollinators/pollinator-of-the-month/halictid_bees.shtml

Mason and Leafcutting Bees: Megachilidae

- Nests built in cavities
- Single cell provisioning
- Pollen and nectar feeders
- 273 Collected
- *Megachile* (19)
  - 1,520 spp globally
  - Includes alfalfa leafcutter bee
- Anthidiini (65)
  - > 830 spp globally
- Osmiini (13)
  - ~ 1,100 spp globally
- *Lithurgopsis* (1) [9 global spp.]

Resources: Hanford Site Pollinator Study
BugGuide > Bee

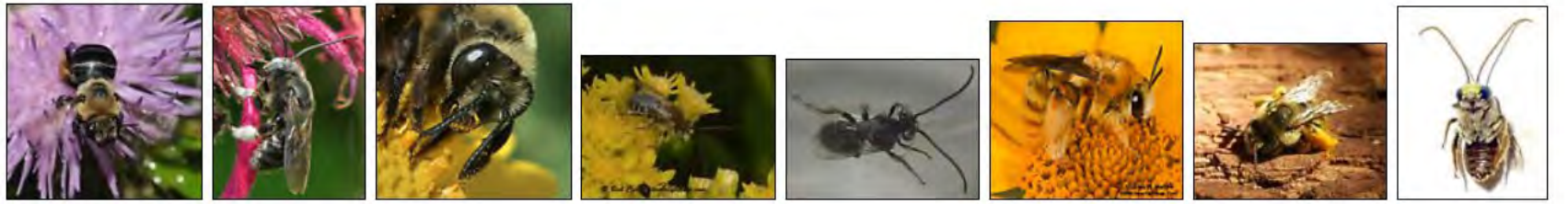


Cuckoo, Carpenter, Digger, Bumble, and Honey Bees: Apidae

- Mostly social expect orchid bees
- 156 collected
- Eucerini (69)
  - Long-horned bees
- *Diadasia* (54)
  - Oligolectic - pollen
- Anthophorini (18)
  - Digger Bees - soil
- *Bombus* (8)
  - Bumble Bees
- *Apis* (3)
  - Honey Bees

Tribe Eucerini - Longhorn Bees

Classification · Other Common Names · Synonyms and other taxonomic changes · Explanation of Names · Numbers · Identification · Range · Life Cycle · Print Referenc



Diadasia bee on opuntia blossom

Tribe Anthophorini - Digger Bees

Classification · Explanation of Names · Numbers · Range · Remarks · Internet References · Works Cited

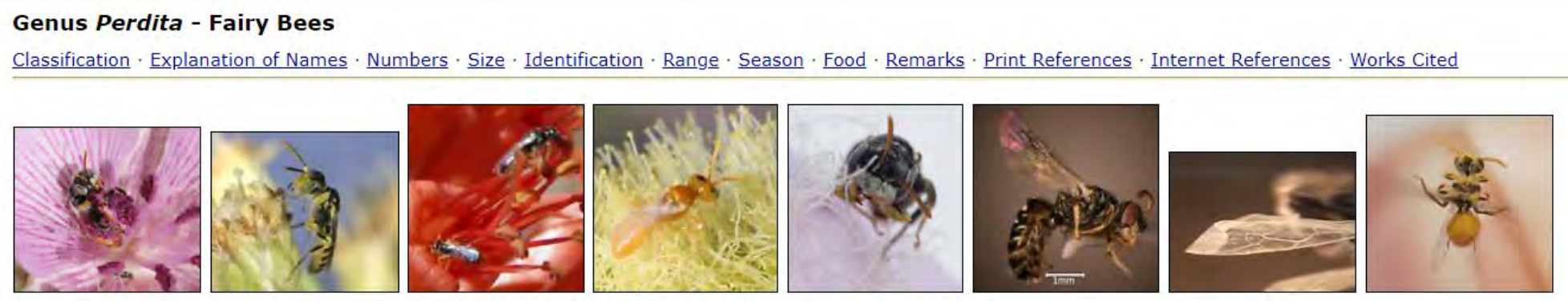
Yellow-faced bumble bee (*Bombus vosnesenskii*)

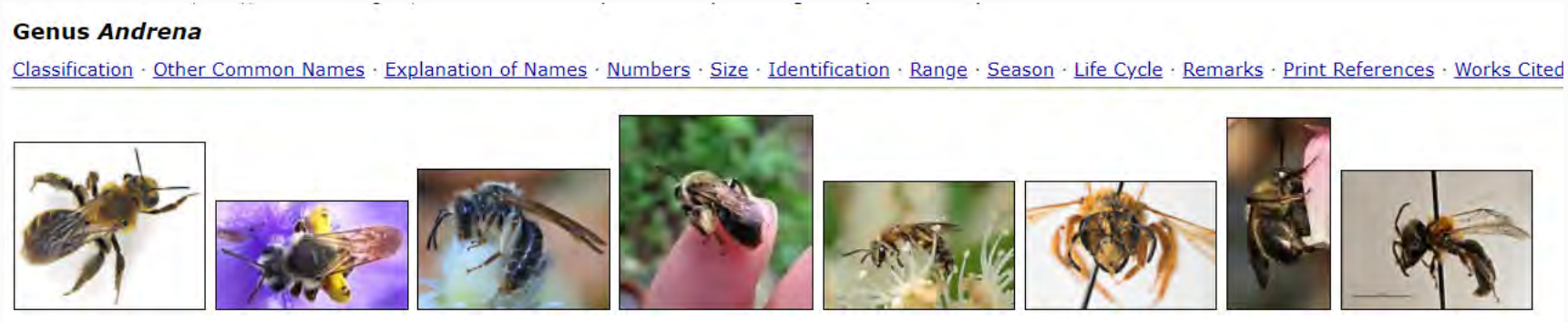
Western honey bee *Aphis mellifera*

Resources: Hanford Site Pollinator Study BugGuide-Apidae Bumble bee

Mining Bees: Andrenidae

- Solitary and ground nesting
- Most diverse in arid regions
- 96 collected
- *Perdita* (87)
  - Fairy Bees
  - 2 to 10 mm
  - Extreme oligoleges - pollen
- *Andrena* (9)
  - Mining Bees
  - Solitary

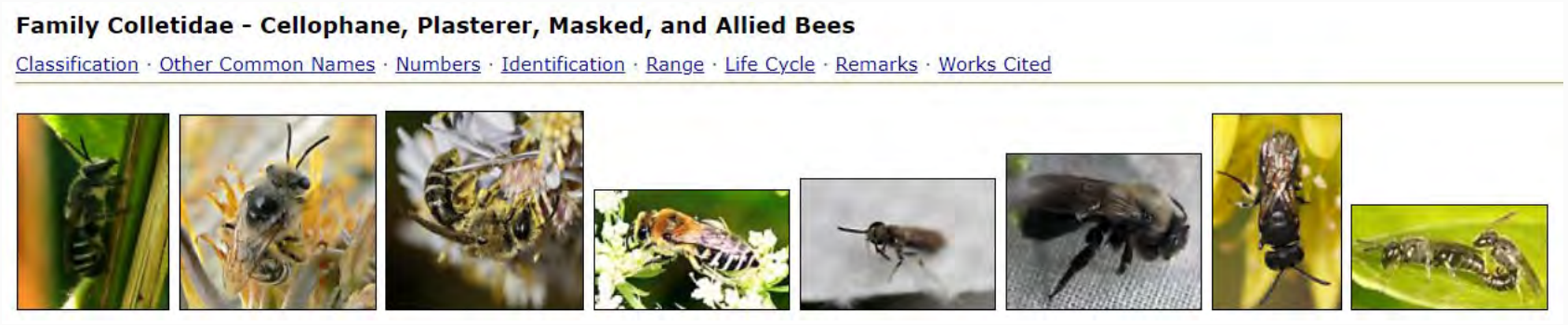


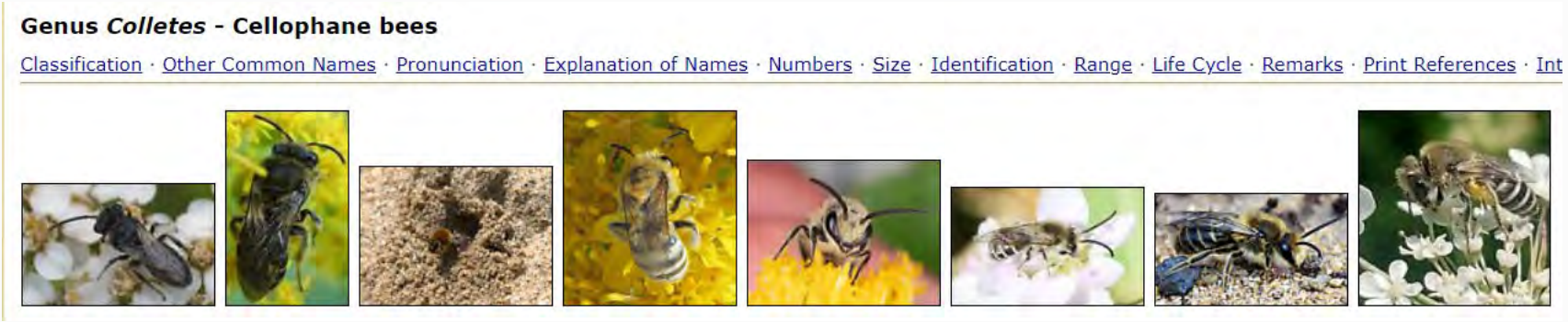


Resources: Hanford Site Pollinator Study Andrenidae Wikipedia Wikipedia-Perdita BugGuide-Andrena

Plasterer Bees: Colletidae

- Plasterer bees or polyester bees
- Smooth walls of nest cells with secretions from mouthparts that dry like cellophane lining
- Solitary but like aggregations
- Carries pollen in crop (no scopa)
- 2,000 species globally
- 3 collected
- *Colletes* (3)





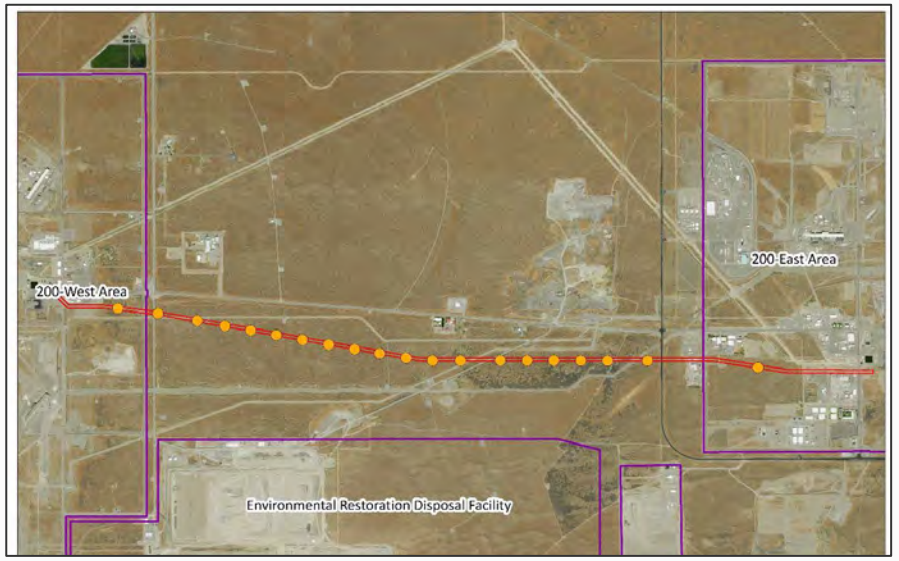
Resources: Hanford Site Pollinator Study Wikipedia – Colletidae BugGuide-Family Colletidae

Hanford Bee Nest Box monitoring study

- Solitary bee nest box occupation monitoring (2019, -20, -21)
- 20 nest boxes were installed as mitigation to replace lost nesting habitat
- Boxes placed 200 m apart along a water line near replanted native plant species
- Bee nests were examined in the fall for evidence of solitary bee occupation
- Occupancy rates for all three years were 30% (6/20 nest boxes occupied by a bee nest)

Bee nest boxes

Report cover page



200 West Area

200 East Area

Locations of bee nest boxes marked by orange dots

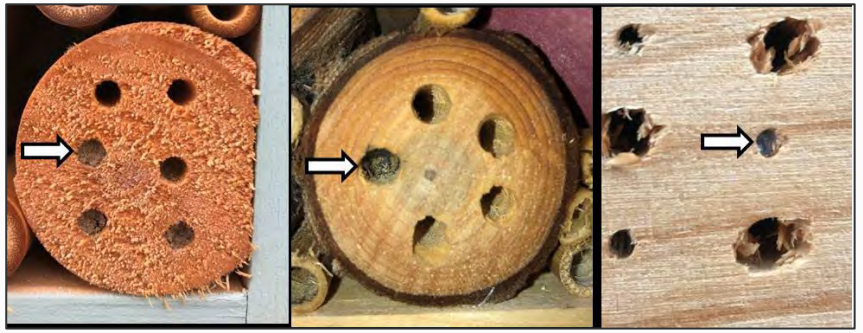
Tee-bar secured nest box with Emergence box below

Resource: 2022 Bee Nest Box Monitoring Report is here.

Results from Bee Nest Box monitoring study

Study year	Number of nests (all boxes)
2019	10
2020	15
2021	20

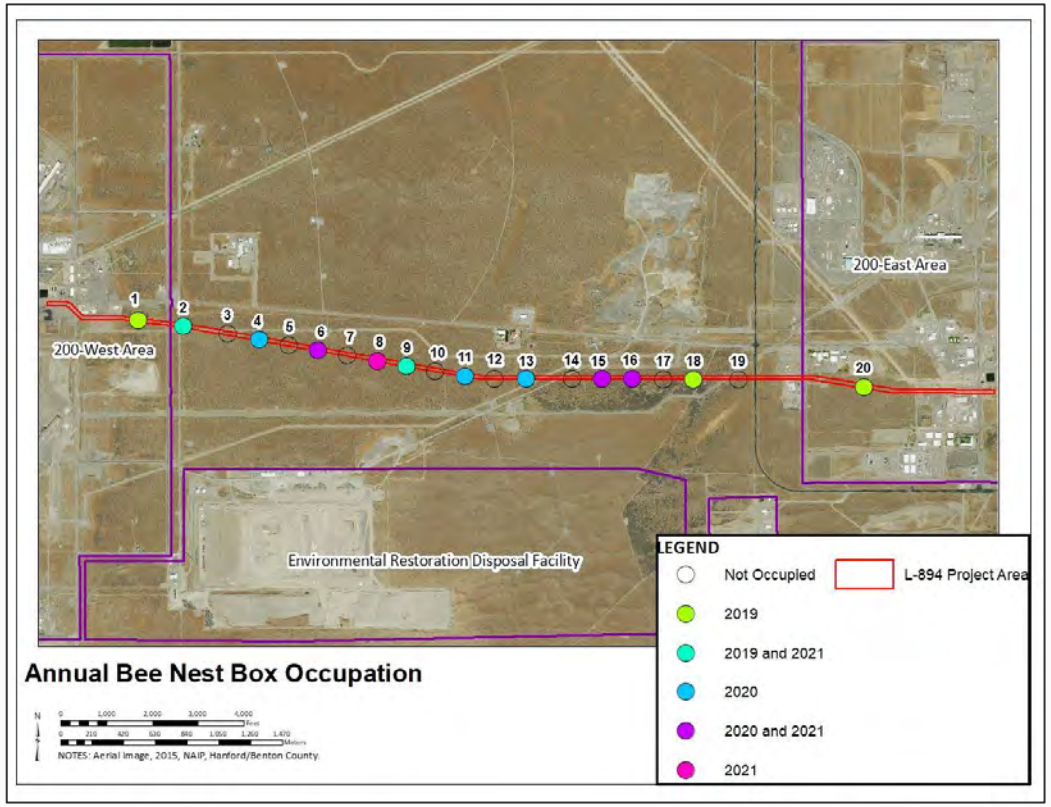
- Bee tribe Osmiini suspected to be main user of nests in family Megachilidae
- Weather, resource abundance, and bee species unique ecology influenced occupancy rates
- Artificial nest boxes may be a key habitat restoration tool



Occupied nesting holes (mud, leaves, cellophane)

Occupied cells (sealed and emerged)

200 West Area



200 East Area

Occupancy of bee nest boxes:

- 2019
- 2019 & 2021
- 2020
- 2020 & 2021
- 2021

Resource: 2022 Bee Nest Box Monitoring Report is here. Bee taxonomy here

What are we missing?

- Butterflies, Wasps, Flies, and Beetles as pollinators?
- Effects of Pesticides?
- Factors affecting pollinator population dynamics?
- Conservation strategies?

Resources: Hanford Site Pollinator Study . Showy Milkweed photo page 74 (pdf 82/112)

Figure 60. A suite of pollinators visits a showy milkweed flower near the Columbia River. Photo taken on the Hanford Site by Ecological Monitoring Staff (June 2017).

Importance of Pollinators: Monarch Butterflies

- The Story of the Monarch
  - *Danaus plexippus* (Linnaeus 1758)
- Monarch Butterfly Swarm – PBS Nature
  - https://www.youtube.com/watch?v=lW0ySU_hAz0
- Unraveling the Great Monarch Butterfly Migration Mystery – It's OK to Be Smart
  - How they make the migration:
  - https://www.youtube.com/watch?v=fBakLuH6kDY
- Discovering Mexico's Monarch Butterfly Migration
  - Details: Tagging,
  - Site https://www.atlasobscura.com/videos/gaze-upon-a-million-monarch-butterflies-in-mexico

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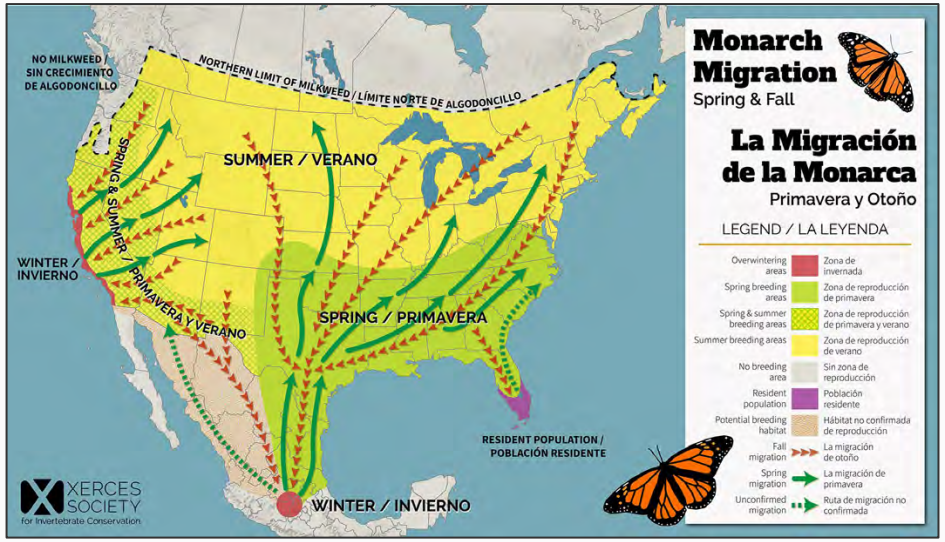
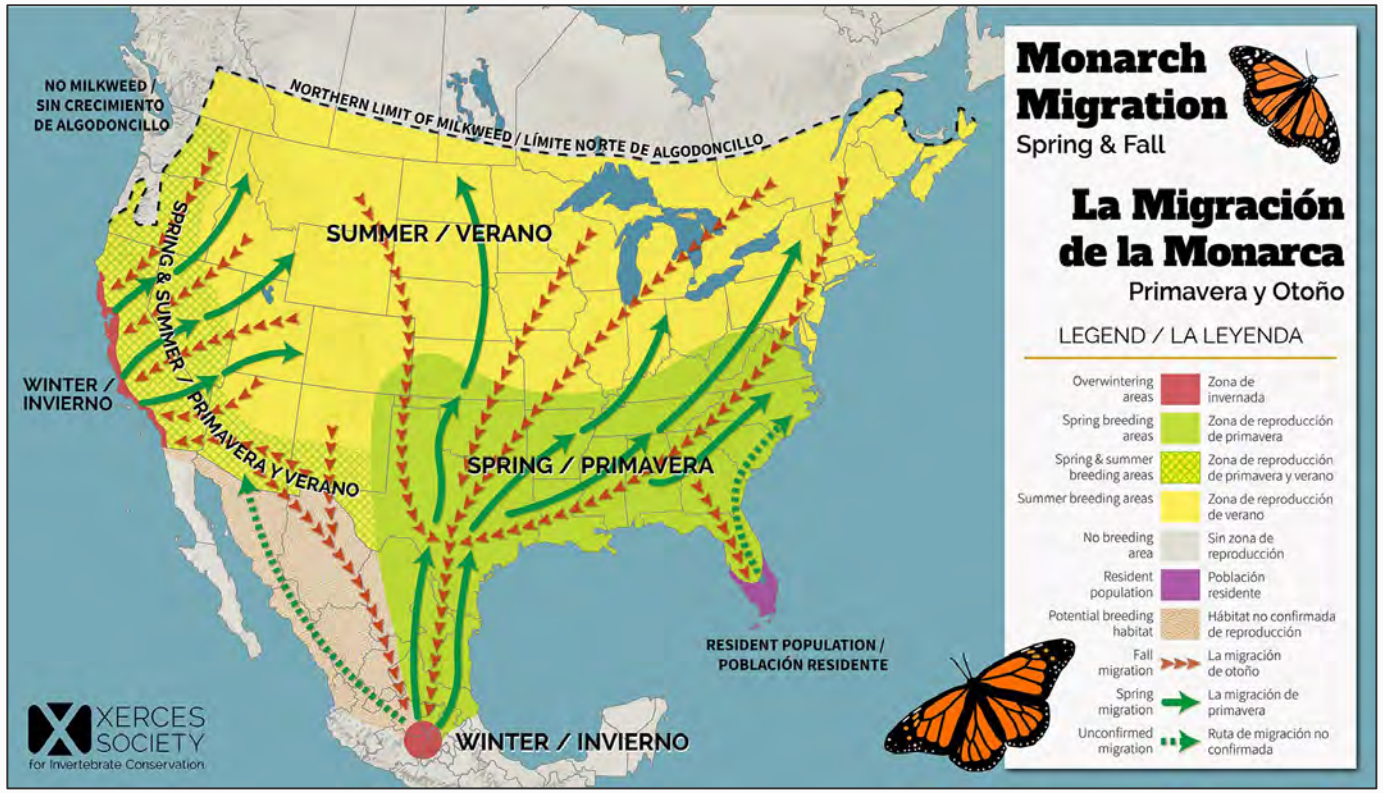


Resources: Wikipedia Monarch page ,

The Great Migrators: Monarch Butterflies



- The Mid-Columbia region is one of the few known breeding areas for the Monarch within Washington State
- Discovering Mexico's Monarch Butterfly Migration
  - Site https://www.atlasobscura.com/videos/gaze-upon-a-million-monarch-butterflies-in-mexico
- Monarch Butterfly Swarm – PBS Nature
  - https://www.youtube.com/watch?v=IWOySU_hAz0
- Unraveling the Great Monarch Butterfly Migration Mystery – It's OK to Be Smart
  - https://www.youtube.com/watch?v=fBakLuH6kDY

Resources: Xerces Society Monarch Migration site

Monarchs at Hanford

- Confirmed in 1998 study along Hanford Reach
- Found around patches of Showy Milkweed, *Asclepias speciosa*
- Easy to grow this species of milkweed in home gardens

♂

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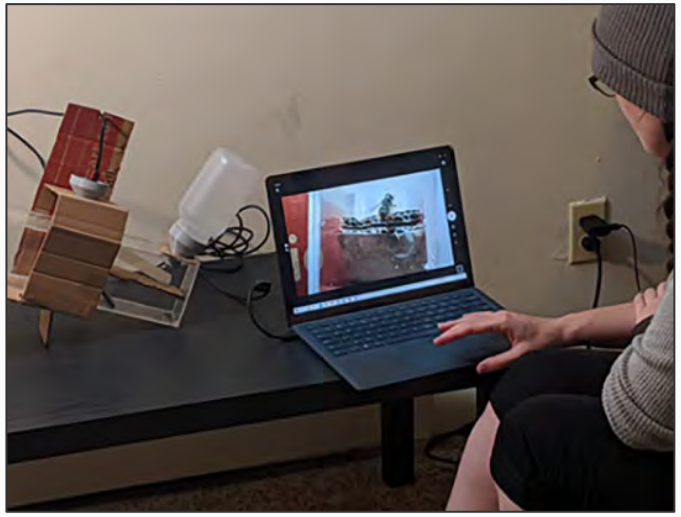
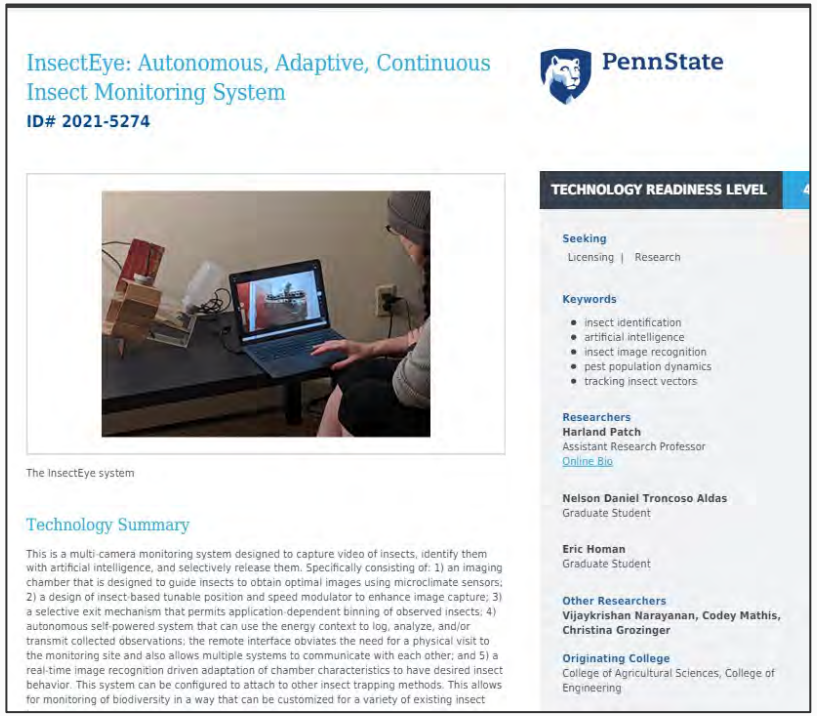
Milkweed images taken at WSU Tri-Cities by G Peck

Resources: https://en.wikipedia.org/wiki/Asclepias_speciosa Xerces Society Monarch Migration site Wikipedia Monarch page , https://pdw.hanford.gov/document/1603310631

The Future of Pollinator monitoring

- InsectEye: Autonomous, Adaptive, Continuous Insect Monitoring System
  - Multi-camera monitoring system designed to capture video of insects, identify them with artificial intelligence, and selectively release them
  - Image chamber with insect guide and microclimate sensors
  - Insect-based tunable position and speed modulator to enhance image capture
  - Selective exit mechanism permits application-dependent binning of insects
  - Autonomous self-powered system that can log, analyze, and transmit collected observations—remote interface obviates the need for physical visit to monitoring site and allows multiple systems to communicate with each other
  - Adaptable to many insect trapping methods
  - Allows for monitoring of biodiversity in a way that can be customized for a variety of existing insect traps





InsectEye: Autonomous, Adaptive, Continuous Insect Monitoring System

ID# 2021-5274

PennState

The InsectEye system

Technology Summary

This is a multi-camera monitoring system designed to capture video of insects, identify them with artificial intelligence, and selectively release them. Specifically consisting of: 1) an imaging chamber that is designed to guide insects to obtain optimal images using microclimate sensors; 2) a design of insect-based tunable position and speed modulator to enhance image capture; 3) a selective exit mechanism that permits application-dependent binning of observed insects; 4) autonomous self-powered system that can use the energy context to log, analyze, and/or transmit collected observations; the remote interface obviates the need for a physical visit to the monitoring site and also allows multiple systems to communicate with each other; and 5) a real-time image recognition driven adaptation of chamber characteristics to have desired insect behavior. This system can be configured to attach to other insect trapping methods. This allows for monitoring of biodiversity in a way that can be customized for a variety of existing insect

TECHNOLOGY READINESS LEVEL

Seeking

Licensing | Research

Keywords

- insect identification
- artificial intelligence
- insect image recognition
- pest population dynamics
- tracking insect vectors

Researchers

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Eric Homan
Graduate Student

Other Researchers

Vijaykrishan Narayanan, Codey Mathis, Christina Grozinger

Originating College

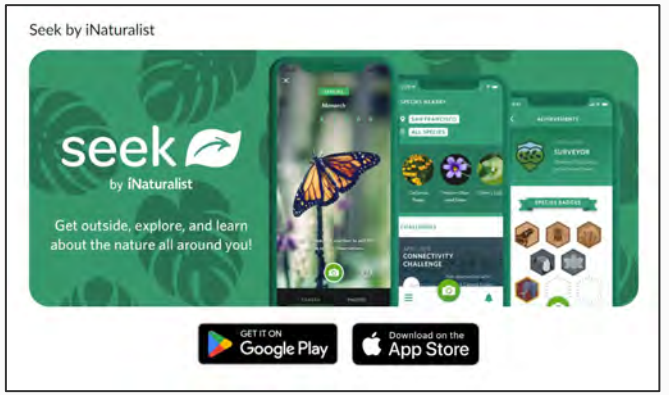
College of Agricultural Sciences, College of Engineering

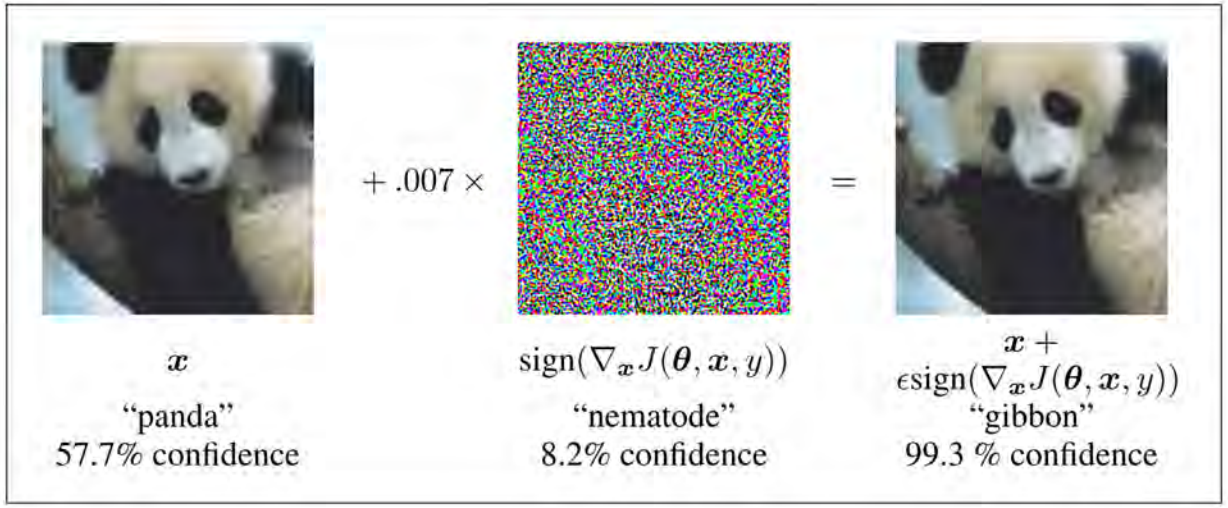
Website: InsectEye

The Future of Pollinator monitoring

- WILDLABS.NET
  - Conservation Technology Network
  - Camera trapping using advances in camera technology, AI, and autonomous systems technologies
  - Discussions on latest advances, experiences, and funding for anyone interested in the technology
- Seek by iNaturalist
  - Freely downloadable app
  - Uses image recognition technology to identify plants and animals
  - Drawing from millions of wildlife observations on *iNaturalist*, Seek shows you lists of commonly recorded vertebrates, invertebrates, and plants in your area

Website: iNaturalist WildLabs.Net



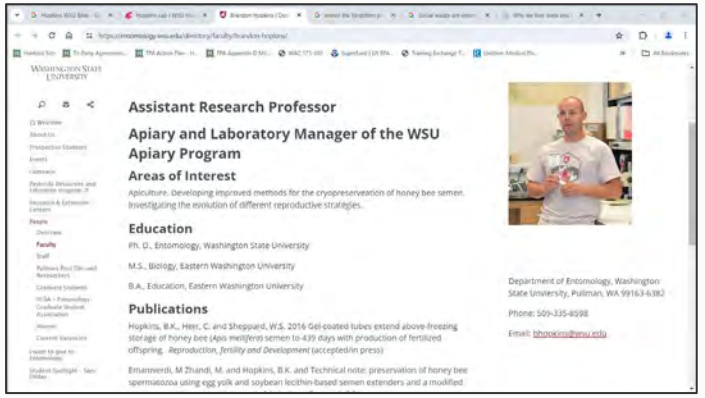


AI model considers the original image as a "panda" (57.7%). Added a tiny perturbation (nematode) and model classified image as a "gibbon" (99.3%). Human eyes sees a panda.

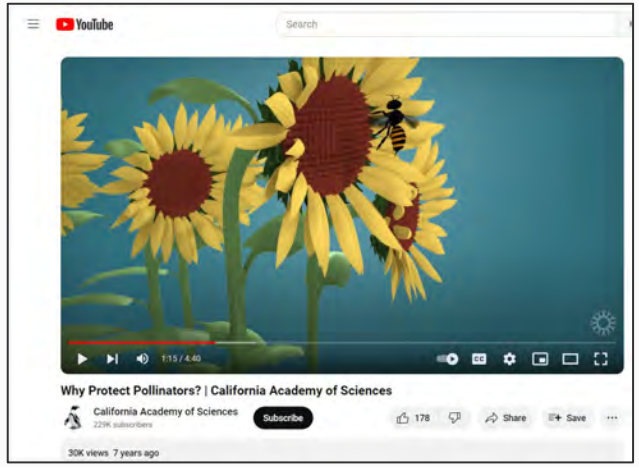
Image: Review of AI Adversarial Attack and Defense Technologies https://www.mdpi.com/2076-3417/9/5/909

Recent Research and Resources on Pollinators

- See https://en.wikipedia.org/wiki/Pollinator
- See website and publications of Dr. Brandon Hopkins at WSU Apiary Program https://entomology.wsu.edu/directory/faculty/brandon-hopkins/
  - Recent story of European Honey Bee Apis mellifera and cold storage to mitigate the effects of climate change (more frequent and more extreme hot periods followed by cold snaps during usual cool winters
  - Summer indoor queen banking study (Webb et al inc Hopkins) here https://www.tandfonline.com/eprint/KAJSICTJDMJYBDSEWZQN/full?target=10.1080/00218839.2023.2165747



- Climate change impact on honeybees here (Rajagopalan and Hopkins et al https://news.wsu.edu/press-release/2024/03/25/honey-bees-at-risk-for-colony-collapse-from-longer-warmer-fall-seasons/
  - Actual report here https://news.wsu.edu/press-release/2024/03/25/honey-bees-at-risk-for-colony-collapse-from-longer-warmer-fall-seasons/



- General interest: Dr. Samuel Ramsey USDA-ARS Bee Research Laboratory
  - https://www.youtube.com/watch?v=eDxZojp9yNg
- California Academy of Sciences– Why Protect Pollinators?
  - https://www.youtube.com/watch?v=p8uxJnNteNY

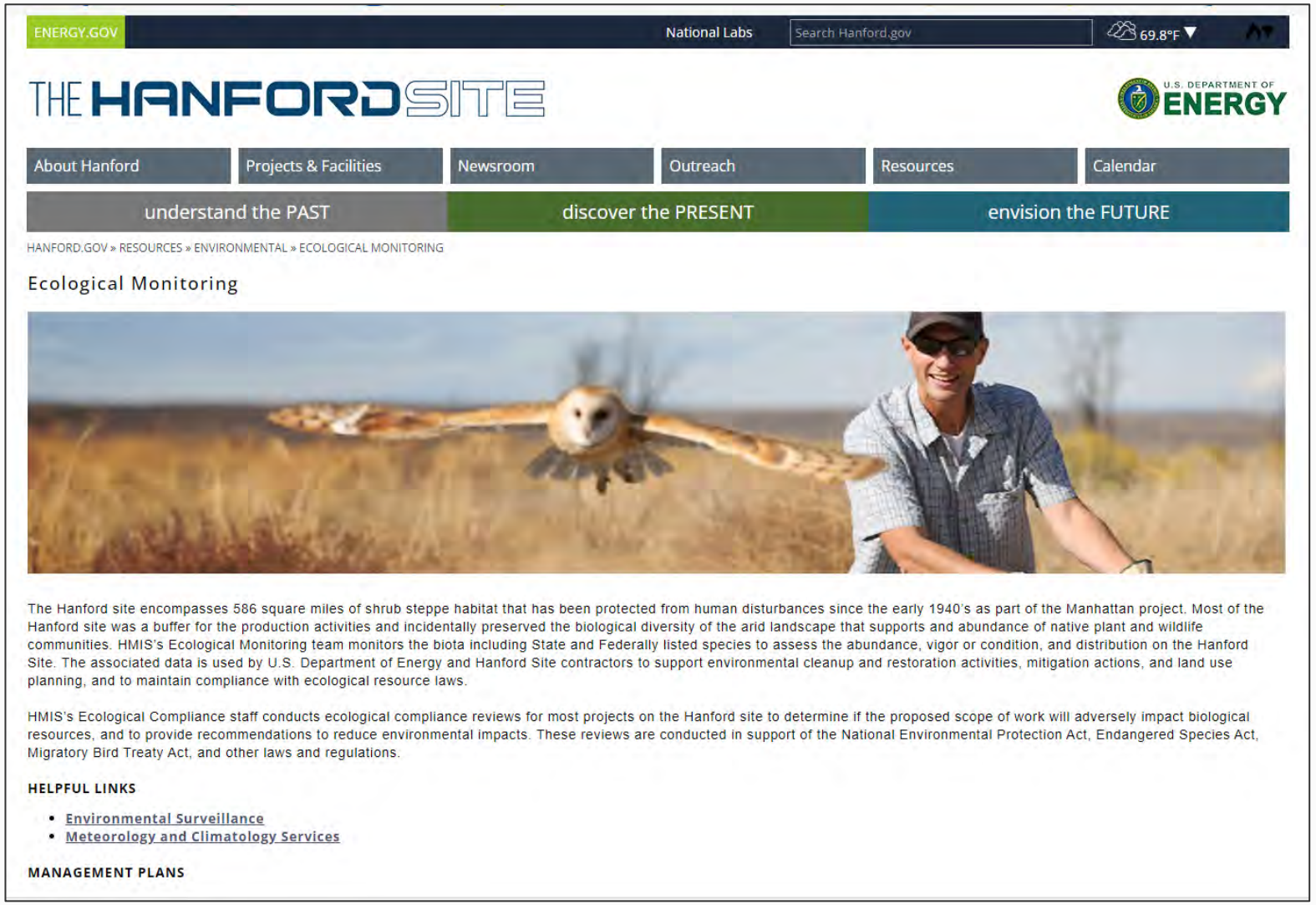
Essential Resources on bees and other pollinators

- See the WSU Honey Bees + Pollinators Program
- See the OSU Extension Service page on Bees and Pollinators
- See the UC Davis Arboretum and Public Garden > Gardening for Pollinators and Biodiversity
- See Xerces Society Pollinator Conservation Resources: Pacific Northwest Region and Xerces Society Who Are The Pollinators?
- See USDA ARS Pollinating Insect—Biology, Management, Systematics Research

Image credit: UCCE Santa Clara County –Kathy Keatley Garvey

How Pollinators fit into the Hanford cleanup

- Hanford Ecological Monitoring by Hanford Mission Integration Solutions (Contractor)
- HMIS's Ecological Monitoring team monitors the biota including State and Federally listed species to assess the abundance, vigor or condition, and distribution on the Hanford Site.
- The associated data is used by U.S. Department of Energy and Hanford Site contractors to support environmental cleanup and restoration activities, mitigation actions, and land use planning, and to maintain compliance with ecological resource laws.
- Many laws and regulations apply to pollinators



Ecological Monitoring website is here

Thank you!

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Questions comments or ideas?

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