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Of Bees and Blooms: A New Scorecard For Selecting Pollinator-Friendly Plants in Restoration

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Birds do it. Bats, butterflies, flies, wasps, and, perhaps most importantly, bees, do it, too. By gathering and transporting DNA-containing pollen from plant to plant, these flying animals are critical for the successful reproduction of flowering plants. Bees and other pollinators are crucial for maintaining biodiversity and, by supporting healthy plant communities, a long list of ecosystem functions (food and habitat for animals, soil stability, and water quality, to name a few).

Bees are among the most industrious of the bunch. Bees coevolved with flowering plants over millions of years and developed physical and behavioral adaptations that are particularly suited to efficiently feeding on plant nectar and pollen. For example, bumble bees have baskets on their legs for collecting pollen and can shake pollen loose from deep within a flower structure by vibrating their bodies. Most bees are generalists that forage on many flower species. Specialist bees tend to be most vulnerable to habitat loss because they forage on one or just a few species.

Scientists estimate that 60 to 80 percent of all flowering plant species require bees for reproduction. More than a third of the food consumed by humans requires pollination by bees.

Yet bees are declining worldwide, including in the United States, and with them the pollination services they contribute to ecosystems on which people and wildlife depend. As much as 40 percent of all pollinator species have declined globally in the last few decades as a result of habitat loss, pesticides, disease, and climate change. Several native bee species in the western United States, including the western bumble bee (*Bombus occidentalis*), are being considered for listing under the Endangered Species Act. For all bees, habitat loss translates into fewer pollinator food

*A bumble bee (*Bombus nevadensis*) visits showy fleabane (*Erigeron speciosus*), a late season plant species with a high pollinator-friendliness score that is used in revegetation projects on the Helena-Lewis and Clark National Forest. Early and late in the season are critical periods for bees. Courtesy photo by Will Glenny, Montana State University.*

sources as well as sites for mating, nesting, roosting, and migration.

Given bees' importance for food production, bee conservation efforts are often focused on agricultural land. However, forests and grasslands also support pollinators. Federally managed lands in the United States add up to 640 million acres—more than a quarter of the country's land area—and include most habitat types. Among these lands are areas with the highest known bee species richness per square mile.

In 2014, a presidential memorandum established a pollinator health task force charged with developing a unified strategy to promote the health of bees on Federal lands. The resulting pollinator research action plan outlines bee habitat improvement as a critical step for bee recovery and conservation. Several national forests including the Helena-Lewis and Clark National Forest in Montana and Manti-La Salle National Forest in Utah have begun to incorporate habitat restoration for bees in their revised forest plans, but land managers often lack specific information and guidance for implementing practical solutions.

Justin Runyon, a research entomologist with the Rocky Mountain Research Station based in Bozeman, Montana, is helping to fill this gap.

"We're learning more every day," he says. "But one thing we do know is that having lots of flowers on the landscape is clearly beneficial for pollinators."

Susan Rhinehart, retired native plant program manager for the Forest Service's Northern Region in Montana, recognized the need to protect native pollinators and wanted to include pollinator-friendly plants in seed mixes for revegetation and restoration projects. She turned to Runyon because she wanted to know which plant species or a mix of species would be best for bees.

The question inspired Runyon to collaborate with Associate Professor Laura Burkle and doctoral student Will Glenny at Montana State University to identify the most pollinator-friendly plants to include in seed mixes for use in the Northern Rockies.

Their findings are synthesized in General Technical Report 429, "Assessing Pollinator Friendliness of Plants and Designing Mixes to Restore Habitat for Bees," which was published early in 2022.

"I've been blown away by how much interest there is in this," Runyon says. "People are very hungry for information about what plants are best for bees. It's really cool that the original question came from a land manager need."

Scoring Pollinator Friendliness

To begin to answer the question of pollinator friendliness, Runyon and his colleagues started with a list of 24 insect-pollinated, native plant species that are grown in

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Summary

Bees are declining in the United States and with them the pollination services on which people and wildlife depend. Among the threats to these pollinators are pesticides, disease, climate change, and habitat loss. Several national forests have begun to include habitat restoration for bees in their forest plans. But land managers often lack specific information and guidance that could help them implement practical solutions to support bees. Justin Runyon, a research entomologist with the Rocky Mountain Research Station based in Bozeman, Montana, is helping to fill this gap. He collaborated with Montana State University scientists to identify the most pollinator-friendly plants to include in seed mixes for use in restoration projects in the Northern Rockies. On the Helena-Lewis and Clark National Forest, the scientists collected information on the timing and bloom duration of 24 focal plant species and recorded the number of bees and the bee species that visited the plants. They ranked the plants across each of these metrics and developed a scorecard that managers can use to select pollinator-friendly mixes based on local factors such as budget, habitat type, or plant availability. These findings and more are synthesized in General Technical Report 429, "Assessing Pollinator Friendliness of Plants and Designing Mixes to Restore Habitat for Bees," which was published early in 2022.

the Forest Service's Coeur d'Alene Nursery for use in the Northern Rockies. The scientists chose 63 sampling sites with naturally occurring populations of the 24 focal plant species under a variety of habitat types and disturbance conditions across the Helena-Lewis and Clark National Forest. At each site they recorded the number of bee species observed, the number of individuals per flower per minute, and the number of specialist bees among the focal plant species. They also included bloom duration and location of the plant species in the evaluation to help with designing seed mixes with plants that provide floral resources at different times and in a range of habitats.

To make all of this information useful to land managers, the scientists ranked early, middle, and late season flowering plants across each of the metrics and came up with a composite score. The resulting scorecard can be used to select and tailor pollinator-friendly mixes.

Based on the composite scores, the overall best mix of pollinator-friendly plants that span the growing season includes these nine species:

Early season
- Bebb's willow (*Salix bebbiana*)
- Oregon grape (*Berberis repens*)
- Kinnikinnik berry (*Arctostaphylos uva-ursi*)

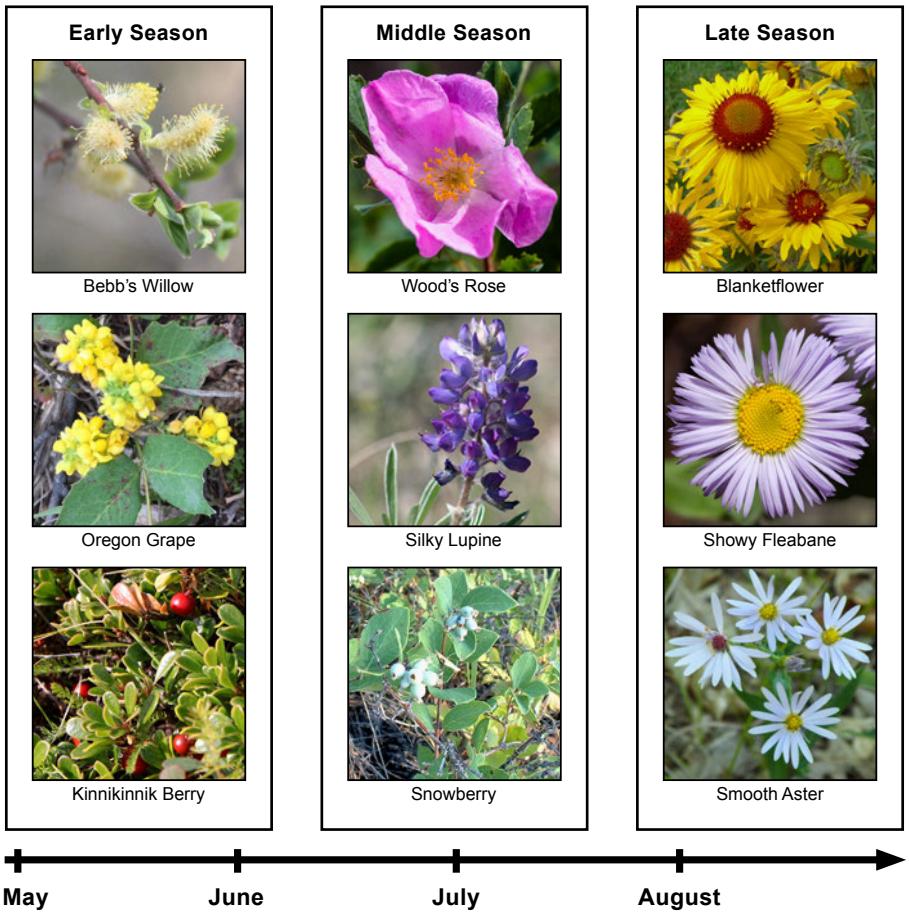
Middle season
- Wood's rose (*Rosa woodsii*)
- Silky lupine (*Lupinus sericeus*)
- Snowberry (*Symphoricarpos albus*)

Late season
- Blanketflower (*Gaillardia aristata*)
- Showy fleabane (*Erigeron speciosus*)
- Smooth aster (*Symphyotrichum foliaceum*)

Together, these 9 species were visited by 80 percent of the 246 bee species observed in the study across the most common habitat types in western Montana. However, Runyon cautions against using the same nine plant species everywhere.

"Any nine species, three for each season, chosen from the higher scoring species were almost as good as this best mix and supported most bee species,"

Optimal Seed Mix Across All Habitat Types



Based on a composite rating of pollinator friendliness, these top scoring plant species are suggested for the early, middle, and late season and for most habitat types in the Northern Rockies. However, any nine species (three per season), chosen from the higher scoring species, are expected to support most of the bee community across the most common habitat types in western Montana.

he says. "Even mixes of six plant species, two from each season, that ranked highly on the scorecard should support around half of the bee species observed in the study."

Seeds for Bees

A better understanding of the relationships between plant species and the bees that visit them can help managers like Jessie Salix, forest botanist on the Beaverhead-Deerlodge National Forest in Montana, develop seed mixes for bee habitat restoration. Salix has been collecting seeds for the native plant program since 2012.

Commercially available seed mixes used for revegetation and restoration typically include non-native and native grasses that can outcompete invasive species and limit soil erosion but offer little value for bees. These mixes contain very few herbaceous flowering plants that bees prefer.

"We've collected a lot of grass seed and shrub seed," Salix says. "Now we're trying to bulk up with pollinator-friendly seeds so that we can start putting more of those in our native mixes."

Each year, botanists in the Forest Service's Northern Region decide on two native plant species to collect from sites across the region to use in future revegetation projects. The samples they collect are then sent to the Coeur d'Alene Nursery to test and grow out for bulk seed. Seeds collected and cultivated from native plants are the gold standard for habitat restoration because they are adapted to native growing conditions and require minimal maintenance.

The group chose two species in 2022, Alberta beardtongue (*Penstemon albertinus*) and showy fleabane (*Erigeron speciosus*), based on the results reported by Runyon in the General Technical Report. "What was great about *Erigeron speciosus* is it ranked super high in pollinator species richness. Over 60 [species of] bees pollinate that species," Salix says. "So that's a good reason for choosing that species."

Salix was glad to see that birchleaf spiraea (*Spiraea betulifolia*) and Canada goldenrod (*Solidago canadensis*), two species the group had selected to grow out for seed production in a previous year, were also among the plants in the study that were visited by the western bumble bee, a species being considered for federal listing under the Endangered Species Act.

"The report confirms that what we're doing is headed in the right direction and the information will be very useful for choosing the next plant species to collect for the program," Salix says.

*A western bumble bee (*Bombus occidentalis*) with a load of pollen on its leg visits a spirea flower. Spirea (*Spirea betulifolia*) is a mid-season plant species included in the study. Photo by Casey Delphia, Montana State University.*

POLLINATOR FRIENDLINESS SCORECARD

Scorecard for early, middle, and late season focal plant species based on the species richness, abundance, uniqueness of visiting bee communities, and bloom duration. Plants with the highest total score are considered the most pollinator friendly within their seasonal group. These cards can be used to select and tailor pollinator-friendly mixes.

Forb and shrub species	Season	Visitation rate	Bee richness	Specialists	Temporal availability	Spatial availability	Total score
Salix bebbiana	Early	4	4	6	6	6	26
Arcostaphylos uva-ursi	Early	6	6	4	5	4	25
Berberis repens	Early	5	3	3	3	5	19
Cornus sericea	Early	3	5	5	2	3	18
Antennaria rosea	Early	1	1	2	4	1	9
Antennaria microphylla	Early	2	2	2	1	2	9

Forb and shrub species	Season	Visitation rate	Bee richness	Specialists	Temporal availability	Spatial availability	Total score
Rosa woodsii	Middle	8	9	7	3	5	32
Lupinus sericeus	Middle	3	3	8	9	8	31
Symphoricarpos albus	Middle	9	1	7	6	7	30
Achillea millefolium	Middle	1	8	4	7	9	29
Phacelia hastata	Middle	5	6	9	5	3	28
Penstemon spp.	Middle	4	5	3	8	4	22
Hedysarum boreale	Middle	7	7	3	2	1	20
Erogonum umbellatum	Middle	2	4	3	4	6	19
Spiraea betulifolia	Middle	6	2	5	1	2	16

Forb and shrub species	Season	Visitation rate	Bee richness	Specialists	Temporal availability	Spatial availability	Total score
Gaillardia aristata	Late	9	5	7	6	8	35
Erigeron speciosus	Late	6	8	8	1	9	32
Symphyotrichum ascendens	Late	8	6	9	3	5	31
Eurybia conspicua	Late	7	9	4	9	2	31
Solidago canadensis	Late	3	7	6	7	1	24
Symphyotrichum foliaceum	Late	5	3	5	2	7	22
Senecio triangularis	Late	4	1	4	8	4	21
Anaphalis margaritacea	Late	2	4	4	5	3	18
Penstemon procerus	Late	1	2	4	4	6	17

A bee on the brink: Help for the western bumble bee

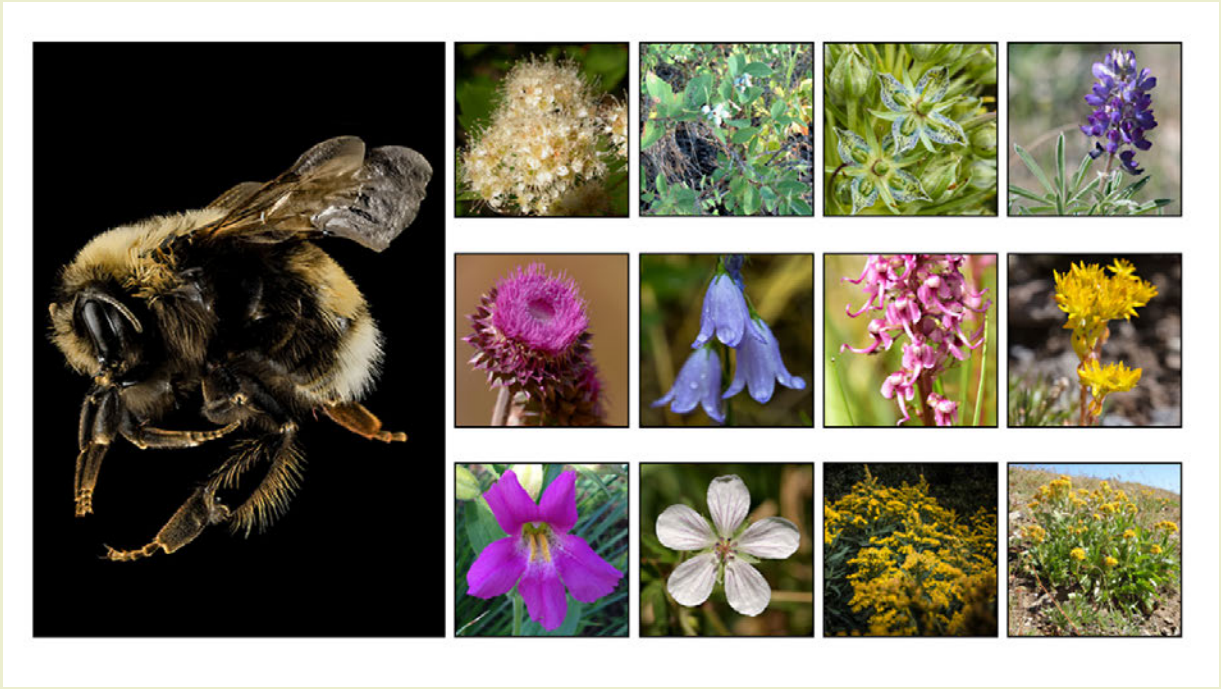
Among the pollinators in northern climates bumble bees prevail. Bumble bees, with their larger, furry bodies can carry on with the business of collecting pollen even on cool, cloudy days when other insect pollinators need to lie low. Because they feed on a diverse range of pollen and nectar sources, bumble bees are important pollinators for many plant species, including alpine flowers and plants that are important food sources for wildlife—think huckleberries and bears.

The western bumble bee (*Bombus occidentalis*) was once one of the most wide-ranging bees in western North America. It was found from the Pacific Ocean to the Colorado plains and from Alaska to the border of Mexico. But the species has declined dramatically in recent decades and is now primarily restricted to high elevations in the northern extent of its range. In one study, U.S. Geological Survey scientists estimate that between 1998 and 2018, the occurrence of the western bumble bee declined by 93 percent in the continental United States. Among the list of threats are habitat loss, pesticides, disease, invasive insects, and climate change—which affects the timing and availability of the flowers the bees depend on.

The western bumble bee is being considered for listing under the Endangered Species Act and is a species of conservation concern (SCC) within the National Forest System. Protecting and recovering the species will require a better understanding of its spatial distribution and how populations and distributions change over time. Habitat restoration is also critical. Using seed mixes that include plants preferred by the western bumble bee in revegetation and restoration projects is one tool being developed now to aid managers.

In Montana, federally managed lands including the Forest Service's Northern Rockies Region (Region 1) serve as a refuge for populations of the western bumble bee. Across a range of sites in the Helena-Lewis and Clark National Forest, RMRS research entomologist Justin Runyon and scientists at Montana State University observed the western bumble bee visiting 12 plant species. Four were species available from the Northern Rockies native plant program, seven were other native species, and one was an invasive plant species (musk thistle; *Carduus nutans*).

The four focal plant species are already commercially available in quantities large enough to incorporate into seed mixes that can be used for bee habitat rehabilitation. Identifying additional plants favored by the western bumble bee that bloom throughout the growing season and across different habitat types is the next step. In addition, studies have shown that some native plants have medicinal value to bumble bees, for example reducing gut parasites. Including these plants in revegetation mixes could further benefit the western bumble bee.



*The western bumble bee (*Bombus occidentalis*) visited 12 plant species (including musk thistle, an invasive species) during a study in Montana. The 11 native species could be important components in plant mixes focused on restoring habitat for this potentially endangered species. Public domain photos via Flickr; courtesy photos by Matt Lavin, Montana State University.*

"The report confirms that what we're doing is headed in the right direction and the information will be very useful for choosing the next plant species to collect for the program," Salix says.

Creating Bee-friendly Plant Mixes

Native plants can be difficult and expensive to cultivate. However, selecting the best native plant mixes that support the most pollinator species can maximize benefits to bees and help to reduce costs. In addition to cost, managers who want to develop plant mixes that are likely to support bees must weigh several factors.

Timing is a key consideration. Plant species with the highest bee visitation rates bloomed predominantly early or late in the season, critical periods for bees. At the beginning of the season, few plants are flowering and late in the season, bees need all the resources they can collect before they wind down and prepare for winter survival. Improving the availability of floral resources when they might otherwise be scarce could help to increase bee populations. Plants like silky lupine that flower for long periods during the growing season are good candidates to consider.

Environmental conditions are important, too. Seed mixes that can be applied broadly throughout diverse ecosystems require plants that can grow across a variety of conditions and habitat types.

"Several national forests have begun to include habitat restoration for bees in their revised forest plans, but land managers often lack specific information and guidance for implementing practical solutions."

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Plants that occurred most frequently among the study sites and could be a reliable food source for bees regardless of habitat type were showy fleabane, silky lupine, and blanketflower. But not all frequently occurring and long-blooming plants interest bees. Yarrow (*Achillea millefolium*) was the most common plant species found, and one of the longest-blooming plants; however, bees visited it the least.

Riparian habitats are likely to play a critical role in conserving bee communities because they tend to have flowering plants, structural vegetation, and microclimates that are important for nesting. Bebb's willow, an early bloomer often found along the edges of streams and lakes, was visited by 12 unique specialist bee species (defined in this study as bees observed visiting a single plant species), more than any other plant species. This observation is evidence that riparian areas are concentrated areas of bee diversity, particularly early in the growing season.

Including plants in seed mixes that support specialist bees is

*Bebb's willow (*Salix bebbiana*) is an early season, high-scoring pollinator friendly plant that was visited by more specialist bee species than any other plant species in the study. Photo by Thaddeus Charles Jones, via iNaturalist (CC BY-NC 4.0).*

Buzz, buzz, who's there? Monitoring pollinator populations

Addressing concerns about the status of any species often begins with two questions: Where is the species on the landscape and how big are its populations? Enough information has been collected about the distribution and abundance of the western bumble bee to establish that the species is declining, and it is considered a species of conservation concern (SCC) on many western forests. However, information about most other pollinator species is lacking, making it difficult to know if they warrant the same consideration.

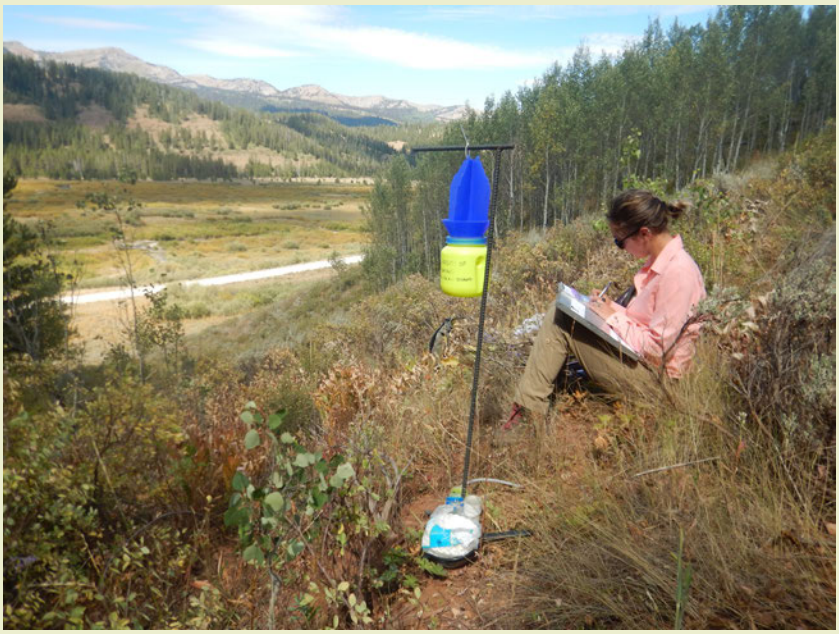
"Knowing what species are out there is going to be huge for us," says Don Delong, Wildlife and Habitat Program Manager for the West Zone of the Bridger-Teton National Forest in Wyoming. "We know very little about the species of bees and butterflies on the forest, and it will be tremendous to have that information."

DeLong, in close collaboration with Lusha Tronstad with the Wyoming Natural Diversity Database at the University of Wyoming and RMRS research entomologist Justin Runyon, is conducting a baseline inventory of pollinators in the Greys River Ranger District in west-central Wyoming.

Pollinator samples collected from bee cups are processed through a coffee filter set inside a strainer before bagging and transport from the field. USDA Forest Service photo by Don DeLong.

"We want to know what species are present, how they're distributed across the landscape, what types of habitats they're using, and to the extent that we can, what flower species are they pollinating," DeLong says.

The team is conducting the inventory following procedures described in a newly developed pollinator inventory and monitoring protocol for the Forest Service's Intermountain Region (Region 4). The need for a standardized protocol for Region 4 was identified by RMRS Regional Botanist and Invasive Species Program Manager John Proctor. The protocol was collaboratively developed by DeLong, Tronstad, Runyon, Terry Griswold of the USDA Agricultural Research Service, and several other agencies and organizations, including the North American Butterfly Monitoring Network, Utah Department of Natural Resources, Utah State University, Xerces Society, The Pollinator Partnership, and the University of California, Riverside.



Following a newly developed pollinator inventory and monitoring protocol for the Forest Service's Intermountain Region (Region 4), Taelyn Cathchart collects data for the Greys River Pollinator Inventory Project using a vane trap hung from an L-shaped rod. USDA Forest Service photo by Don DeLong.

The protocol includes guidance on how to deploy and retrieve bee traps and how to complete bee and butterfly netting along the transects. It specifies the types of traps to use and supplies that are needed and includes a data collection form.

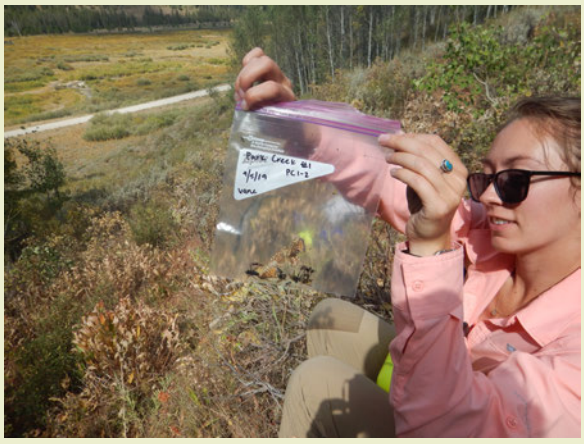
Forest Service wildlife technicians supervised by DeLong collected data and insect samples from 71 sites in the Greys River Ranger District between 2019 and 2021 and are continuing the effort in 2022. The insects are

sent to the Tronstad Lab at the Wyoming Natural Diversity Database for processing and identification. Once that work is completed, DeLong expects to receive a report that will include the pollinator genera and species that are present, the type of habitat they use, and the flower species they visit.

"An inventory sets the groundwork for a long-term monitoring program," DeLong says. "The information provides an important foundation for future conservation and management of pollinators."

In the Northern Rockies, Forest Service forest botanist Jessie Salix is set to begin baseline bee surveys in the Gravelly Range on the Beaverhead-Deerlodge National Forest following a protocol developed for that region. With guidance from Runyon and scientists from Montana State University, the inventory project will involve training high school students to collect pollinators and continuing to monitor pollinators through a youth employment program.

Pollinator inventory not only sets the stage for monitoring, but it may also prove useful for answering future research and management questions.



Pollinators collected from traps in the field are placed in bags, labeled, and stored in a cooler until they are transported to a lab. USDA Forest Service photo by Don DeLong.

important because they are the most vulnerable to habitat loss. Altogether, the scientists observed 71 specialist bee species. Additional plant species with many specialist bee species were silverleaf scorpion weed, also referred to as silverleaf phacelia (*Phacelia hastata*), visited by nine specialist bee species, and showy aster (*Symphyotrichum ascendens*), visited by seven specialist bee species.

With the frequency and severity of fires and associated increases in need for restoration expected in the future, mixes that include both grasses and forbs could offer restoration benefits that include bees, but research is needed to better understand the effects of such mixes.

A First Step and Beyond

Runyon makes it clear that the optimal seed mix the scientists identified is not a silver bullet for bee habitat restoration.

"I think it's important to look beyond the nine species we identified in the optimal seed mix," he says. "I look at using those plants as a temporary sort of patch to support bees until more or other native plants can become established. It's a starting place, so bees won't go too long without enough floral resources. Choosing to use any of the pollinator friendly plants, even just one or two of the species, will provide benefits for bees."

Nursery programs can support bee habitat restoration in the near future by increasing the availability of plant materials from the focal plant species that scored well on pollinator friendliness. Down the road, many more native plant species could be evaluated for pollinator friendliness. In addition to the 24 focal plants in the study, bees were observed visiting 195 other native plant species. If any of these plant species prove to be

Management Implications

- Increasing the availability of floral resources by revegetating landscapes with native flowering plant species that bloom in the early, middle, and late season is an effective way to support pollinators.
- Plant mixes that include species favored by the western bumble bee (including four that are available from the Northern Rockies native plant program) may support habitat rehabilitation for this species of conservation concern.
- Scientists developed a scorecard based on metrics of pollinator friendliness that managers can use to select plant mixes for restoration and revegetation projects based on local factors such as budget, habitat type, or plant availability.
- A guide to selecting pollinator-friendly mixes of native plants is now available for use by land managers in the Northern Rockies. The framework can be used to assess pollinator friendliness of native plant species for other areas, forests, and public lands.

more effective, then efforts to make them available for restoration could be prioritized.

Runyon is glad he's been able to develop a tool that managers in the Northern Rockies can use to help pollinators.

"If you ask me, that's what it's all about: having a positive effect on management that benefits the environment," he says. "I'm very excited to see the tool get used and look forward to assessing how these mixes do in terms of helping bees."

Land managers in other forests and regions can adapt the methods developed for the Northern Rockies to create pollinator-friendly seed mixes that are best suited for conditions in their areas. Doing so could contribute to a nationwide strategy for pollinator conservation on public lands.

Key Findings

- Nine native plant species were visited by 80 percent of the 246 bee species observed in the study across the most common habitat types in western Montana. However, any nine plant species (three per season) chosen from the higher scoring species can be expected to support most of the bee community across the most common habitat types in western Montana.
- Plant species with the highest bee visitation rates were predominantly early or late-season blooming plants.
- Riparian plants were visited by a high number of bee species and specialist bees, an indication that riparian habitats are important for bees. Bebb's willow (*Salix bebbiana*) supported the most specialist bee species.
- A broadly applicable seed mix should include plants that can tolerate a wide variety of environmental conditions and occur across a range of habitat types. Three species that occurred most frequently across the study area and could represent a reliable source for floral resources regardless of habitat type were showy fleabane (*Erigeron speciosus*), silky lupine (*Lupinus sericeus*), and blanketflower (*Gaillardia aristata*).

Further Reading

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Check out this short video about this Science You Can Use Bulletin.

Scientist and Manager Profiles

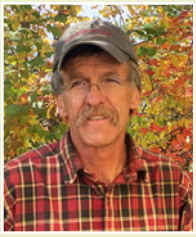
The following individuals were instrumental in the creation of this Bulletin:

Justin Runyon is a research entomologist with the Rocky Mountain Research Station at the Bozeman Forestry Sciences Lab in Montana. In addition to assessing "pollinator friendliness" of native plants for restoration, his research focuses on plant-insect chemical ecology. He has a Ph.D. in entomology from Penn State University.

Will Glenny is a doctoral student in the Department of Ecology at Montana State University in Bozeman, Montana. He focuses on pollinator health including honeybee virus transmission between honeybees and native bumble bees, and the effects of climate change on flower volatiles and pollinator communities.

Laura Burkle is an Associate Professor in the Department of Ecology at Montana State University in Bozeman, Montana and the Director of the Conservation Biology and Ecology Program. Her research centers on understanding how environmental factors affect the biodiversity of native plants and their interactions with animals.

Jessie Salix is a forest botanist on the Beaverhead-Deerlodge National Forest in Montana. She is part of the Region 1 botany group that has been collecting and increasing native seed from local sources for restoration needs since 2012. The group also now focuses on increasing pollinator-friendly plant species for restoration projects.



Don DeLong is Wildlife and Habitat Program Manager for the West Zone of Bridger-Teton National Forest (BTNF). He provides wildlife expertise on the protection, restoration, and management of habitat and wildlife within the framework of multiple-use management. He is the pollinator coordinator for the BTNF.

WRITER'S PROFILES

Sylvia Kantor is a science writer for the Rocky Mountain Research Station in Fort Collins, Colorado. She also has written for the Pacific Northwest Research Station in Portland, Oregon. She has a master's degree in forestry from the University of Washington and lives in Seattle, Washington. Her portfolio is available at **www.sylviakantor.com**.

About the

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