# Role of Native Bees on Berry Crops in Yukon: Field Report for 2016

Solitary bee on strawberry flower.

Bumblebee on haskap flower.

Prepared for the Growing Forward 2 Review Committee and the Agriculture Branch, Yukon.

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## Introduction

With the growing interest in the production and consumption of local food in Yukon, understanding how to optimize quality and quantity of crops is a concern (Yukon Government 2016). Remnant wildlands among cultivated lands can provide ecosystem services such as wind blocks to reduce irrigation needs and perches for birds that control crop pests. Ecosystem services can also include pollination. Many crops are dependent or enhanced by insect pollinators (Klein et al. 2007). In Yukon, the domestic crops that benefit most from insect pollination are fruits, including haskaps, raspberries, currants, saskatoons, strawberries, apples and cherries.

Native insect pollinators are a significant part of the fauna, responsible for seed set of many of the flowers and berries of both domestic and wild varieties. In Yukon, the greatest species diversity of pollinators is found among the bees and flies. Wild bees are capable of enhancing the abundance and size of domestic fruit by their pollination services (Garibaldi et al. 2013; Cane 2005). Wild bees can be more efficient pollinators of fruit than commercial honeybees (Garibaldi et al. 2013; Holzchuh et al. 2012).

Information on the insect species providing pollination services to domestic crops in Yukon is largely unknown. Such information could be used support populations of pollinators for the purpose of maintaining or improving crop yields. The likelihood of collecting pertinent data efficiently is increased by choosing a group of insects for which documentation of pollination service for domestic crops is available albeit from southerly latitudes, and for which there is an existing protocol for identifying plant foods. Solitary cavity nesting bees fit these criteria. Members such as the orchard mason bee (*Osmia lignaria*) and the alfalfa leaf cutter bee (*Megachile rotundata*) are known to pollinate fruit orchards and alfalfa fields in more southerly latitudes. Both are more efficient at pollinating their respective food plants than honey bees (Bosh and Kemp 2001; Pitts-Singer and Cane 2011). Solitary cavity nesting bees have been studied by collecting nests built in artificial structures provided by researchers (Armbrust 2004; Barthell et al. 1998; Gaston et al. 2005; Roubik and Villanueva-Gutiérrez 2009; Scott 1994). The focus of this study is to identify wild cavity nesting solitary bee species associated with the agricultural fruit crops of Yukon.

## Study Sites

The farms chosen were within driving distance to Whitehorse (Figure 1). All berries are grown without chemical insecticides and herbicides on these farms.

Circle D Ranch (Figure 2)

This farm has allocated 10 acres for haskap production within a fenced-in 18 acre parcel of land. The haskaps were planted in 2014. A low growing variety of clover (*Trifolium hybridum*) was planted in between the rows. Graminoids are also abundant. Watering is avoided during peak flowering in an attempt to improve berry production. Otherwise, overhead irrigation is used. The plantation is bordered by spruce-aspen forest to the west and east. There is a patch willow growing in a wet area within the forest to the west. Cultivated land occurs to the north and south. Elevation is 655m.

Rivendell Farm (Figure 3)

Haskaps are a minor component of Rivendell Farm within the fenced-in cultivated 6 ¾ acres. There are well established raspberries (*Rubus idaeus*), currants (*Ribes nigrum and Ribes rubrum*), strawberries

(*Fragaria sp.*) and saskatoons (*Amelanchier alnifolia*). A gravity fed watering system is in place, but may not have been in full operation as the farm was put up for sale this spring. The plantations of berries are interspersed with hedgerows of caragana, lodgepole pine, aspen, willow and other native and domestic plants. In previous years, vegetable crops were also grown adjacent to berry bushes and hand weeding kept unwanted plants to a minimum. Ground cover between rows of berries included scorpion weed (*Phacelia franklinii*), wild strawberry (*Fragaria virginiana*), pineapple weed (*Matricaria discoidea*), dandelion (*Taraxacum officinale*), wild rose (*Rosa acicularis*) and hawksbeard. There was also a noticeable amount of unvegetated bare ground. There are fields to the north and west. Mixed forest exists along the Takhini River beyond the fields and to the southeast. Elevation is 650m

Yukon Berry Farm (Figure 4)

Haskaps (Lonicera caerulea) are the main crop on this farm. Twenty of the 40 fenced in acres were planted as plug stock in 2013. There are also a few rows of black currants (Ribes nigrum). The land is leased to Yukon Berry Farm and was previously a pasture. An in-ground irrigation system is used to provide water to each row of bushes. Plant species commonly found in disturbance sites, including hawksbeard (Crepis tectorum), yarrow (Achillea millifolium), clover (Trifolium sp.) and graminoids, are abundant between the rows. There is a strip of pine-dominated forest to the south and west adjacent to the Takhini River. Fallow fields occur to the north and east. Elevation is 640m.

Yukon Grain Farm (Figure 5)

Haskaps and black currants were planted in 2010 on 2 acres. There is no fence. Currant stems were browsed by moose during the winter. There was an extensive growth of pennycress (*Thlaspi arvense*) along the northern and eastern edge of the berry plantation in spring. It was mechanically removed by the end of June. Wild strawberries dominate the flora in between the rows of haskap and currant bushes. Dandelions were also common. A large field of grain borders the west. Watering is by overhead irrigation. To the south and east is a mixed riparian forest along the Yukon River. This forest extends to the north of the berry plantation. Elevation is 640m. There are honeybee hives 360m to the west of the berry bushes.

Little Fox Farm (Figure 6)

Haskaps were planted here in 2012. There are also saskatoons, raspberries and currants in the fenced-in 2 ½ acres. Watering is by overhead irrigation. A copse of forest is retained within the field of berries. The plants growing between the rows were mainly native species, including wild strawberries, chickweed (*Cerastium arvense*), small flower penstemon (*Penstemon procerus*), corydalis (*Corydalis aurea*), Jacob's ladder (*Polemonium pulcherrimum*), bluebells (*Mertensia paniculata*) and graminoids. Land to the north and west is open, with shrub willow. Extensive wetlands lie just beyond the fields to the west. Mixed forest abuts the south. There is a strip of willows between the field and the highway to the east. Elevation is 775m.

## Methods

Forty solitary bee blocks (Figure 7) were built from untreated 6 inch by 6 inch posts and ½ inch plywood. Sixty holes were drilled into each block, divided evenly among three diameters: ¼ inch, 5/16 inch, and 3/8 inch. Each hole was 6 inches deep and spaced ¾ inch from adjacent holes. The plywood back support was 6 inch wide by 15½ inch tall. The roof was 8 inches by 8 inches. Burlap was stapled over the sides and roof. The front was charred with a small torch. Each bee block was labelled with a unique number.

Eight bee blocks were installed at each farm between April 22 and May 20, 2016. Location depended on availability of trees or posts for mounting. GPS coordinates and elevation of each bee block was recorded in decimal degrees and metres respectively (Table 1). Where possible, bee blocks were oriented in a southerly direction. Placement of bee blocks is depicted in Figures 3 through 6. Prior to installation, I lined 30 of the 60 holes in each block with removable paper nesting straws. These were removed for analyses in September. Any inhabitants in the remaining 30 holes of each bee block were left in situ to perpetuate local populations. The bee blocks were left in place at the farms.

The farms were visited at least three times between May and September. Any caps at the entrance of holes were noted. Caps indicate occupation by bees or wasps, but absence of caps does not mean the hole is vacant. The paper nesting straws were collected on September 14 to 16. I placed straws from each bee block in a separate paper bag labeled with the identification number of the bee block. All straws were candled over a light box to enable detection of bees/wasps nests. Straws occupied by bees or wasps were separated out and sent to Jessica Forrest at University of Ottawa where they have been placed in an incubator.

Pollen samples were collected using the protocol provided by J. Forrest (Appendix 1). These serve as a reference collection for identifying pollen in nest cells and faecal samples of the bees in the nesting straws. Pollen samples were taken from flowers of the different berries grown on the farms and from other species of flowers found in the orchards. Additional pollen samples were also taken from other locations in Yukon.

Although not in the original plan, I tallied the bees and other insects along two rows of haskaps at each farm during peak bloom. The method is adapted from the Ward et al. (2014) and Pollard et al. (1977). This was intended to identify the groups of insects using haskap flowers and supplement the information gathered from the bee blocks.

## Results

Prior to the collection of straws in September, bee blocks at all sites were checked for entrance caps up until July 5th. At that time, the only ones visible were in two straws within one bee block at the Yukon Grain Farm. Later, the candling of straws from each of the bee blocks resulted in the detection of insects or spiders in 28 of the 40 bee blocks (Figure 8). Seventeen of the 28 bee blocks contained at least one straw with bee or wasp nests, and each farm had some invertebrate use of bee blocks (Figure 9). The mean number of straws occupied by bee/wasp nests per farm was 9. This ranged from 1 at Yukon Berry Farm to 15 at Little Fox Farm (Figure 10). The greatest number of occupied straws for a single block was 7. This was found in a bee block installed along the south fence at the Circle D Ranch site. Some aphid wasps (*Passaloecus sp.*) were discernable through the straws; their caches of aphids were visible (Figure 11).

The pollen reference collection created in 2016 contains over 50 flowering species native to Yukon, a few invasive species, and samples from the berry crops. See Table 2 for the list of different plant species represented in the collection. Pollen food associated with the bees nesting in the straws will be identified later. For now, the bee/wasp nests are being incubated at the Jessica Forrest's lab at the University of Ottawa. She will be identifying the occupants and their associated pollen food. Some species may require two hibernation periods, meaning they would emerge in 2018.

On May 18 and 19, I tallied insects along two rows of haskaps at each of the farms. The most common taxonomic group encountered were bumblebees (Bombus spp.). These were feeding on haskap flowers at all the farms. The most bumblebees observed occurred at Yukon Grain Farm, but the most bumblebees per metre occurred at Rivendell Farm (Figure 12). Other bees and a few flies were also observed (Table 3).

## Discussion

The main focus of this study, to identify solitary cavity nesting bees associated with berry crops in Yukon, will be addressed later when nests have matured and the contents are analyzed. When the inhabitants of the straws emerge, they can be identified.

Other studies have demonstrated that artificial nest sites for solitary bees and wasps are readily used. Gaston et al. (2005) found that solitary cavity nesting bees or wasps occupied artificial structures in each of 20 different gardens at least once during their three year study. The actual number of holes occupied per structure was always low. Stubbs et al. (1997) found that occupancy of nest blocks placed in blueberry fields increased over their three year study. It is possible that bee blocks left at sites in Yukon could experience increased number of occupants.

Despite being limited by sample size, comparing the counts of bumblebees along rows of haskaps among the farms revealed similar patterns to other studies. Greater amount of edge habitat is correlated with a higher abundance of bumblebees. Such observations concur with other studies that also found higher pollination rates by wild bees in smaller fields (Isaacs and Kirk 2010; Woodcock 2012). It would be worthwhile to sample the Yukon sites more often to find out whether the 2016 pattern of greater number of bumblebees in smaller fields is typical. A more precise measurement of bee visitation rate would require counts of flowers and related crop success would require counts of berries (Freitas et al. 2016; Vaissière et al. 2011). The older larger bushes of haskaps at the Yukon Grain Farm had several times the number of flower than younger smaller bushes at other farms.

Edge habitat such as forest margins, hedgerows or copses, provide suitable nesting sites for wild bees. Distance of crops from sources of wild pollinators affects crop success. Steffan-Dewenter and Tscharntke (1999) found that distance of Sinapsis arvensis and Raphanus sativus to suitable pollinator habitat was negatively correlated to number of visits by bees, number of seeds per plant, and number of fruit per plant. Where bees are required to fly further to find food, reproductive success was reduced (Zurbuchen 2010).

The average size of bees visiting isolated patches of food plants are larger than for plants that are not isolated. Generally, larger bees have longer foraging distances (Gathman and Tscharnke 2002). Gathmann and Tscharntke (2002) estimated foraging range of solitary bees to be between 150m and 600m in sandy grassland in Germany. Elliot (2009) found that subalpine bumblebees in Colorado foraged within 1000m of their nests. Others have reported foraging distance from 100m to well over 1.5 km, depending on species and habitat composition (Rao and Strange 2012; Wolf and Moritz 2008). Just because a crop is grown within the foraging distance capable of a wild bee, pollination is not guaranteed. Woodcock (2012) states that "crops grown more than about 75m from suitable habitat are unlikely to be visited by [bees]".

## Implications

The data and analyses are thus far limited. These recommendations are preliminary based on the present data, but supported from other studies. It is evident from the counts of insects on haskaps that bumblebees are prime pollinators for the berries. Supporting bumblebees in a subarctic environment for pollination of an early flowering crop such as haskaps would prove fruitful. Native bumblebees are well adapted to flying in cooler weather than honey bees (Woodcock 2012). Bumblebees raise their colonies throughout the growing season. Providing alternate forage after haskaps are finished blooming supports the production of future generations and future pollination services. This can be in the form of crops or non-harvested plants that bloom successively. Providing nesting and overwintering habitat in the form of hedgerows, copses and forest edges close to the haskaps would enhance pollination. In

Yukon, most species of bumblebees nest close to or in the ground in such places as old rodent burrows. A few nest in cavities above ground level. Overwintering queen bumblebees nest underground.

## Acknowledgements

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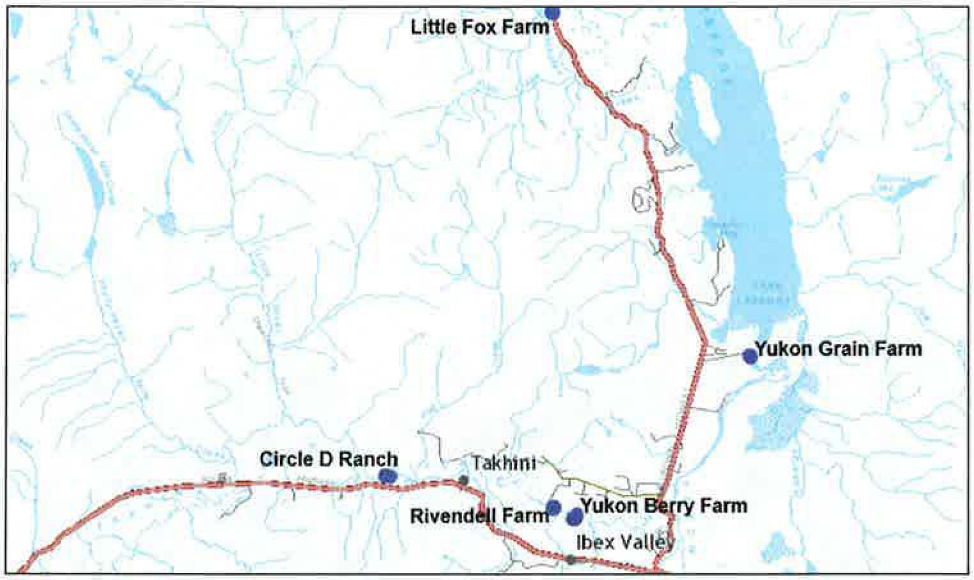


**Figure 1. The five farms chosen as study sites.**

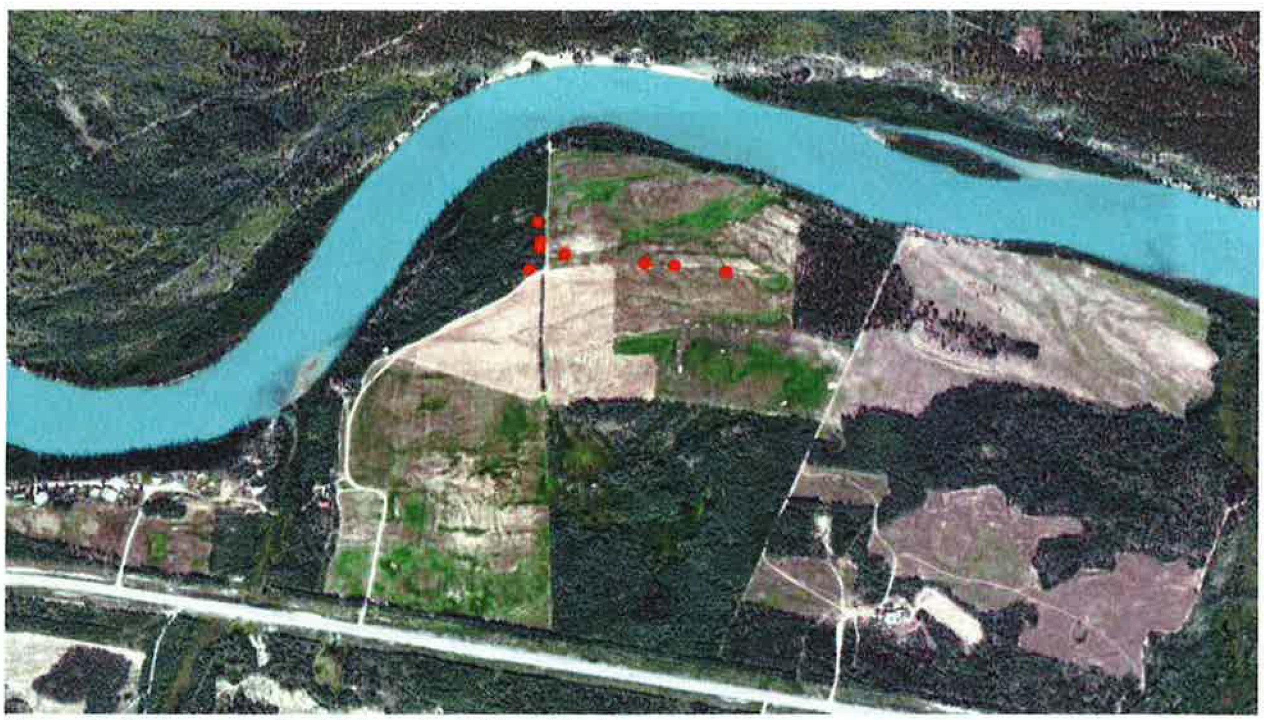

**Figure 2. Circle D Ranch with location of bee blocks.**

**Figure 3. Rivendell Farm with location of bee blocks.**

**Figure 4. Yukon Berry Farm with location of bee blocks.**

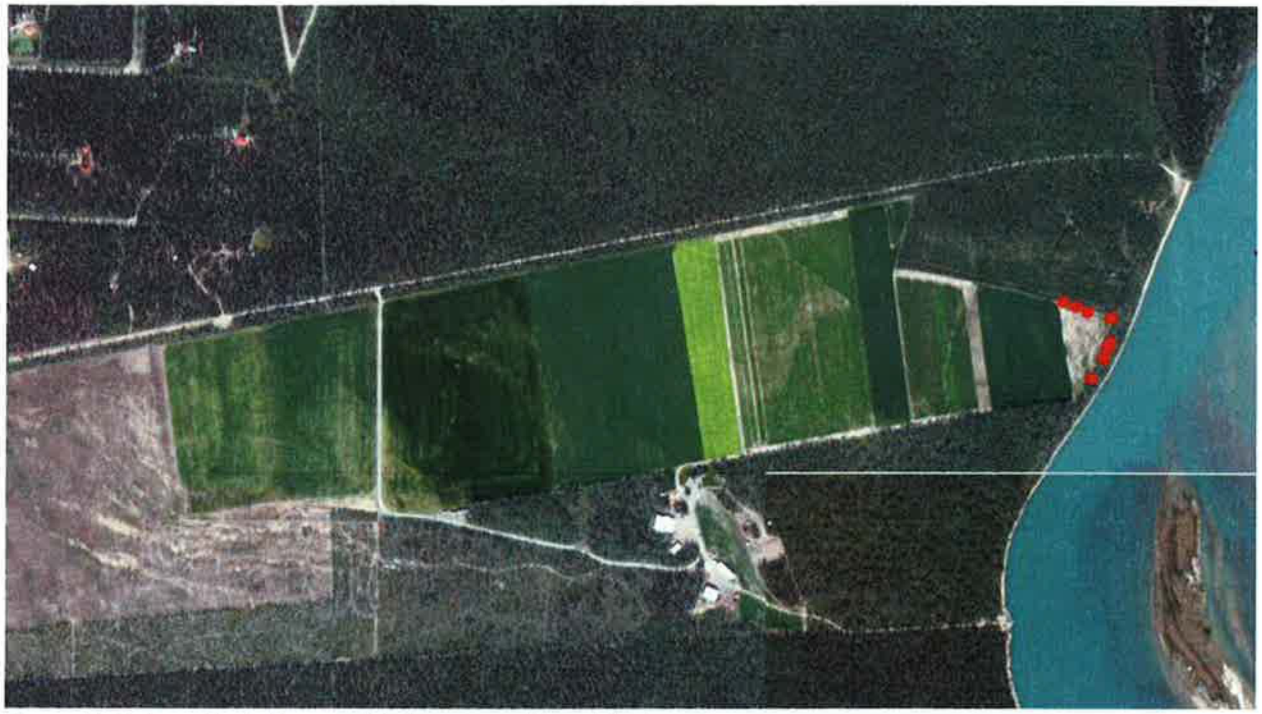

**Figure 5. Yukon Grain Farm with location of bee blocks.**

**Figure 6. Little Fox Farm with location of bee blocks.**

**Figure 7. Solitary bee block at Yukon Grain Farm.**

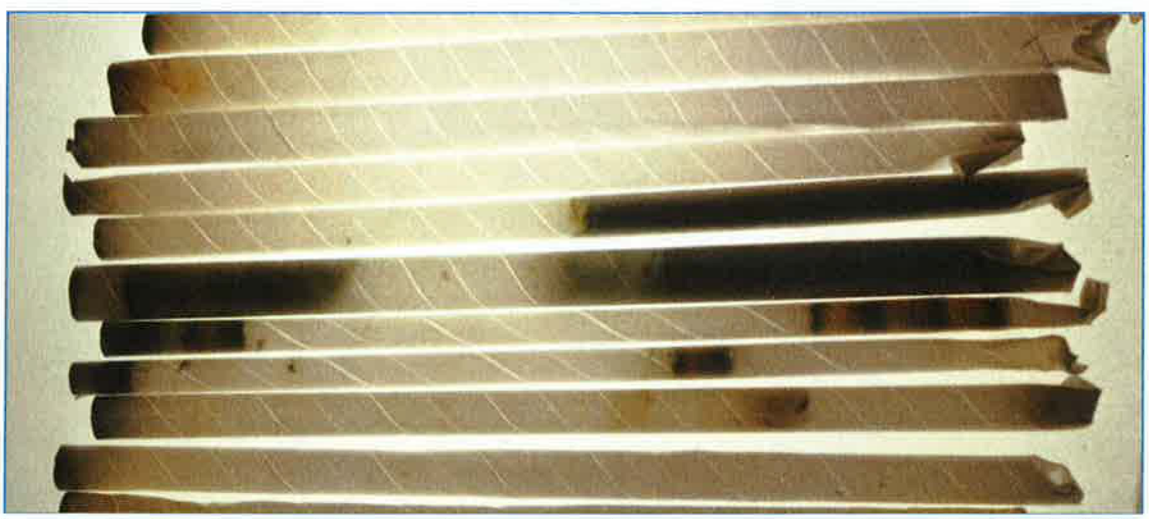

**Figure 8. Nesting straws with bee and wasp nests. These were collected from bee block SB74 at Rivendell Farm.**

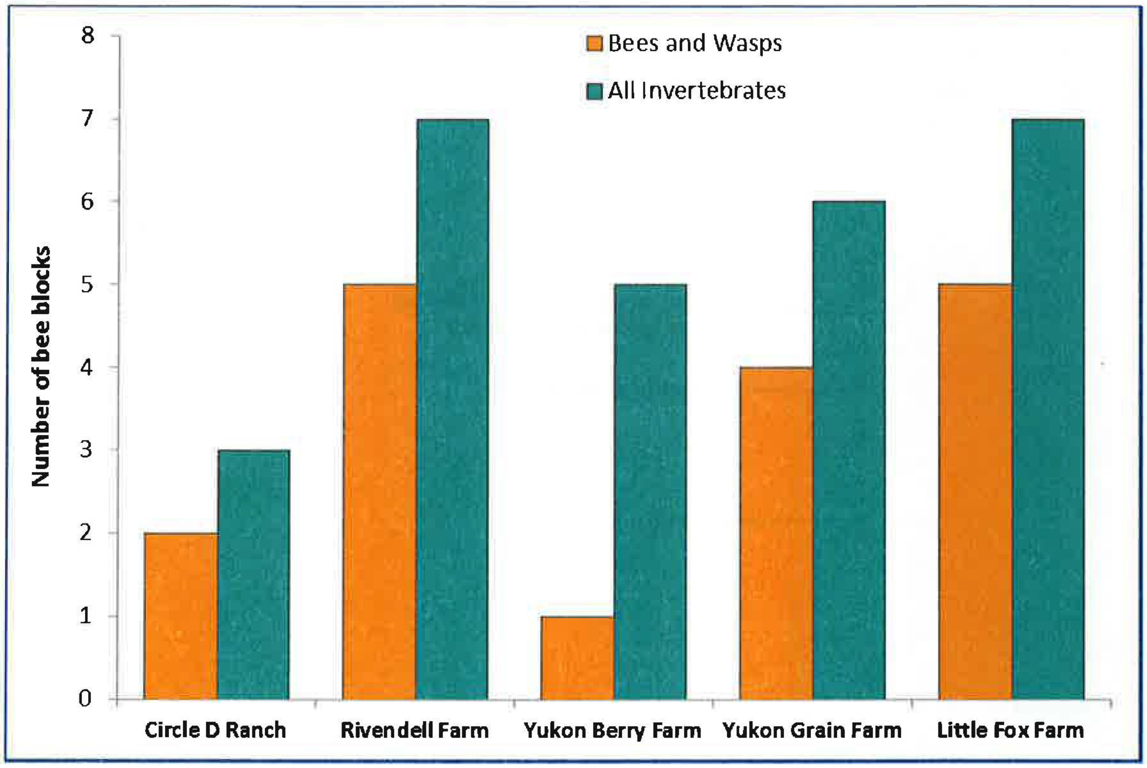


**Figure 9. The number of bee blocks occupied by bees, wasps and other invertebrates at each farm.**

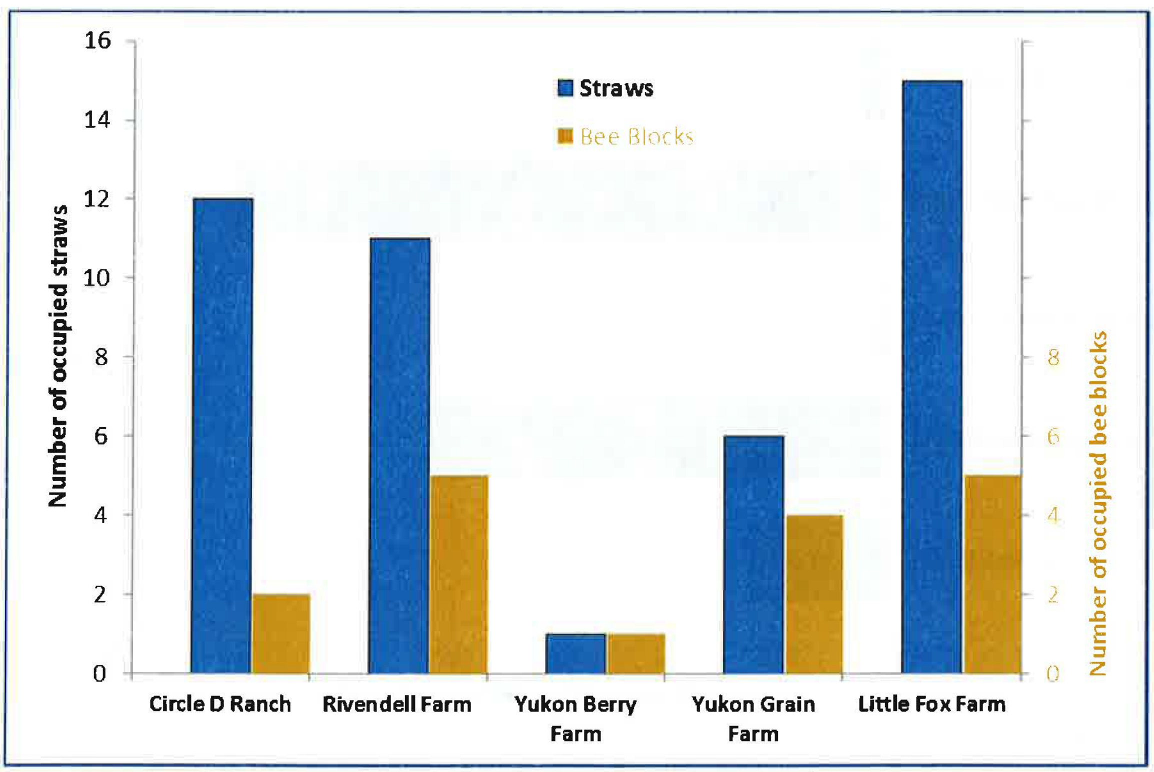


**Figure 10. The number of straws and bee blocks occupied by bee/wasp nests for each farm.**

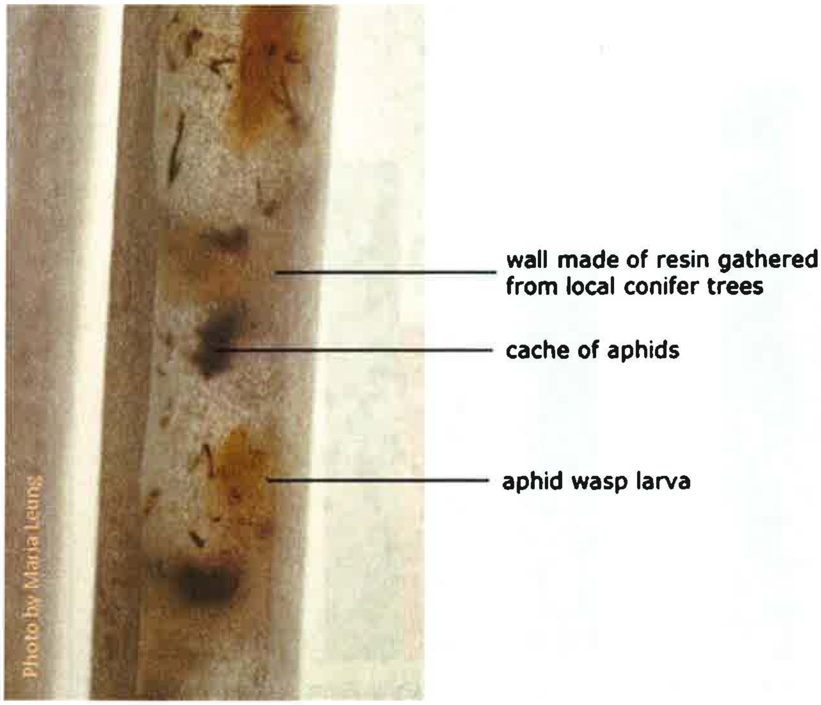


**Figure 11. Parts of an aphid wasp nest.**

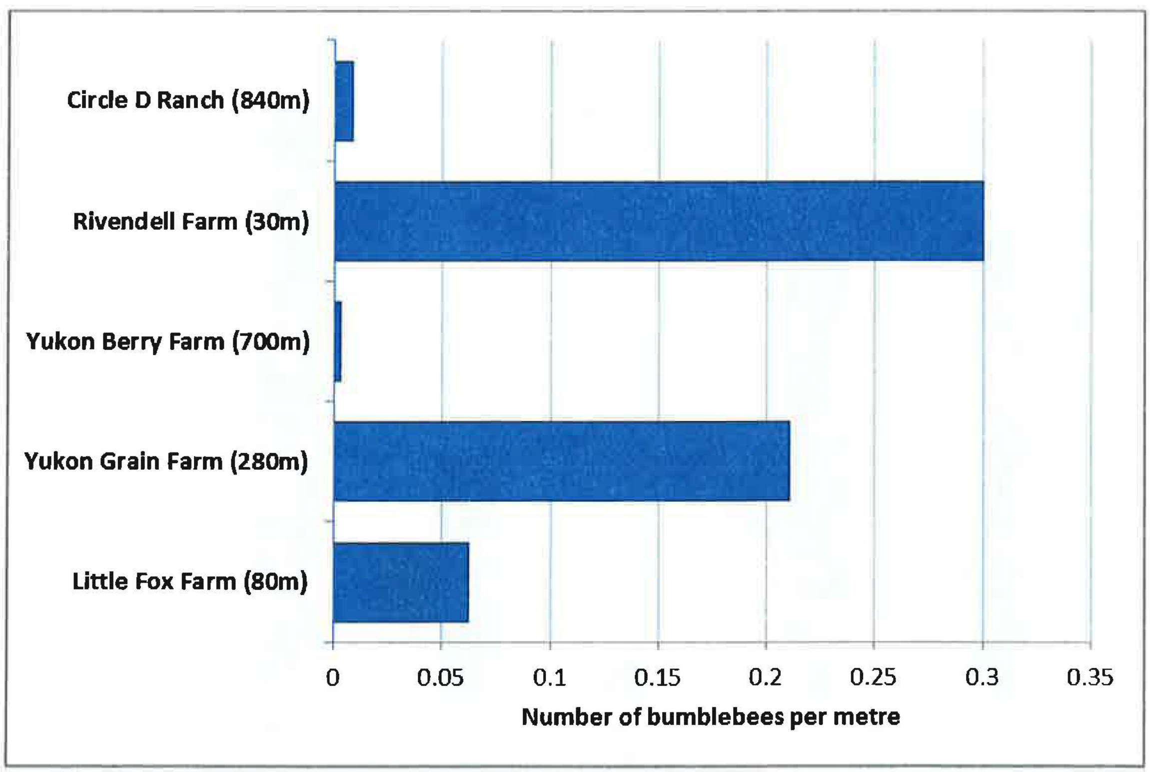


**Figure 12. The number of bumblebees encountered per metre surveyed. Survey lengths are in parentheses.**

**Table 1. Coordinates for each solitary bee block**

| Location Name | ID# | Latitude | Longitude |
|---|---|---|---|
| Circle D Ranch | SB50 | 60.861450 | -135.555690 |
| Circle D Ranch | SB49 | 60.861750 | -135.555800 |
| Circle D Ranch | SB51 | 60.861360 | -135.555710 |
| Circle D Ranch | SB68 | 60.861270 | -135.554890 |
| Circle D Ranch | SB69 | 60.861170 | -135.551350 |
| Circle D Ranch | SB70 | 60.861180 | -135.552310 |
| Circle D Ranch | SB66 | 60.861110 | -135.549670 |
| Circle D Ranch | SB67 | 60.861000 | -135.556000 |
| Rivendell Farm | SB72 | 60.846170 | -135.337940 |
| Rivendell Farm | SB76 | 60.846330 | -135.338420 |
| Rivendell Farm | SB74 | 60.847120 | -135.339420 |
| Rivendell Farm | SB71 | 60.846840 | -135.340130 |
| Rivendell Farm | SB75 | 60.845910 | -135.339980 |
| Rivendell Farm | SB77 | 60.845870 | -135.340210 |
| Rivendell Farm | SB73 | 60.846670 | -135.338560 |
| Rivendell Farm | SB78 | 60.846080 | -135.338730 |
| Yukon Berry Farm | SB45 | 60.840270 | -135.310210 |
| Yukon Berry Farm | SB44 | 60.839900 | -135.313540 |
| Yukon Berry Farm | SB42 | 60.841050 | -135.309600 |
| Yukon Berry Farm | SB48 | 60.841920 | -135.309200 |
| Yukon Berry Farm | SB41 | 60.842910 | -135.308810 |
| Yukon Berry Farm | SB80 | 60.840210 | -135.314320 |
| Yukon Berry Farm | SB84 | 60.839820 | -135.312360 |
| Yukon Berry Farm | SB82 | 60.840020 | -135.311490 |
| Yukon Grain Farm | SB58 | 60.946090 | -135.096850 |
| Yukon Grain Farm | SB55 | 60.946030 | -135.096450 |
| Yukon Grain Farm | SB54 | 60.945880 | -135.095310 |
| Yukon Grain Farm | SB57 | 60.945240 | -135.095500 |
| Yukon Grain Farm | SB59 | 60.945490 | -135.095310 |
| Yukon Grain Farm | SB56 | 60.944910 | -135.095860 |
| Yukon Grain Farm | SB86 | 60.945950 | -135.096070 |
| Yukon Grain Farm | SB85 | 60.945400 | -135.095380 |
| Little Fox Farm | SB63 | 61.153420 | -135.370740 |
| Little Fox Farm | SB60 | 61.153710 | -135.370590 |
| Little Fox Farm | SB62 | 61.153330 | -135.368130 |
| Little Fox Farm | SB64 | 61.153660 | -135.368350 |
| Little Fox Farm | SB61 | 61.153720 | -135.368770 |
| Little Fox Farm | SB65 | 61.153720 | -135.369350 |
| Little Fox Farm | SB79 | 61.153270 | -135.369080 |
| Little Fox Farm | SB83 | 61.152980 | -135.369980 |

**Table 2. List of plant species represented in pollen reference collection.**

| **Scientific Name** (from Cody 2nd ed.) | **Common names** |
|---|---|
| *Achillea millifolium* | yarrow |
| *Androsace septentrionalis* | rock jasmine |
| *Anemone multifida* | cutleaf anemone |
| *Antennaria rosea* | rosy pussytoes |
| *Arabis sp.* | |
| *Arctostaphylos uva-ursi* | kinnickinnick |
| *Arnica cordifolia* | heartleave arnica |
| *Capsella bursa-pastoris* | shepherd's purse |
| *Caragana arborescens* | caragana |
| *Cassiope tetragoma* | white heather |
| *Cerastium arvense* | field chickweed |
| *Cornus canadensis* | bunchberry |
| *Corydalis aurea* | golden corydalis |
| *Crepis tectorum* | hawksbeard |
| *Dryas octopetala* | mountain avens |
| *Epilobium angustifolium* (*Chamerion angustifolium*) | fireweed |
| *Erigeron compositus* | dwarf mountain fleabane |
| *Erysimum coarctatum* | small-flowered prairie wallflower |
| *Fragaria virginiana* | Virginia strawberry |
| *Hedysarum alpinum* | alpine sweetvetch, wild potato |
| *Hedysarum boreale* | boreal sweetvetch |
| *Ledum groenlandicum* (*Rhododendron groenlandicum*) | labrador tea |
| *Linnaea borealis* | twinflower |
| *Lupinus arcticus* | arctic lupine |
| *Mertensia paniculata* | tall lungwort, northern bluebells |
| *Oxytropis campestris* | field locoweed |
| *Pedicularis labradorica* | Labrador lousewort |
| *Penstemon gormanii* | Gorman's penstemon |
| *Penstemon procerus* | small-flowered penstemon |
| *Phacelia franklinii* | Franklin's scorpionweed |
| *Phyllodoce empetriformes* | pink mountain heather |
| *Polemonium pulcherrimum* | showy Jacob's ladder |
| *Potentilla fruticosa* (*Dasiphora fruticose*) | shrubby cinquefoil |
| *Potentilla hookeriana* | rocky mountain cinquefoil |
| *Pulsatilla ludoviciana* | prairie crocus |
| *Ranunculus nivalis* | snow buttercup |
| *Ribes oxyacanthoides* | Canadian gooseberry |
| *Rosa acicularis* | prickly wild rose |
| *Salix sp.* | willow |
| *Saxifraga tricuspidata* | three toothed saxifrage |
| *Sedum lanceolatum* | lanceleaf stonecrop |
| *Senecio indecorus* | rayless mountain butterweed |
| *Senecio lugens* | small blacktip ragwort |

Table 2. Continued.

| **Scientific Name** (from Cody 2nd ed.) | **Common names** |
|---|---|
| *Shepherdia canadensis* | soapberry |
| *Solidago multiradiata* | rocky mountain goldenrod |
| *Stellaria longipes* | longstalk starwort |
| *Stellaria sp.* | |
| *Taraxacum officinale* | common dandelion |
| *Thlaspi arvense* | pennycress/ stinkweed |
| *Trifolium hybridum* | alsike clover |
| *Vaccinium ovalifolium* | oval leaf blueberry |
| *Vaccinium uligonosum* | bog blueberry |
| *Vaccinium vitus-idaea* | lingonberry |
| *Viburnum edule* | highbush cranberry |

| **Berry Crops** | |
|---|---|
| *Ribes nigrum* | currant (black) |
| *Ribes rubrum* | currant (red or white) |
| *Lonicera caerulea* | haskap |
| *Rubus idaeus* | raspberry |
| *Amelanchier alnifolia* | saskatoon |
| *Fragaria sp.* | domestic strawberry |

**Table 3. Counts of insects along rows of haskaps in 2016. "Other bees" include mining and cavity nesting bees that are not bumblebees.**

| **Farm** | **Date** | **Distance surveyed** | **Insects encountered** |
|---|---|---|---|
| Circle D Ranch | May-18 | 840m | 7 bumblebees |
| Rivendell Farm | May-19 | 30m | 9 bumblebees, 1 other bee, 2 syrphid flies |
| Yukon Berry Farm | May-18 | 700m | 2 bumblebees, 4 other bees, 1 syrphid fly, 1 crane fly |
| Yukon Grain Farm | May-19 | 280m | 59 bumblebees, 25 honeybees, 5 other bees, 1 syrphid fly |
| Little Fox Farm | May-19 | 80m | 5 bumblebees |

**Appendix 1. Jessica Forrest's protocol for sampling pollen from flowers (for a reference collection).**

**Materials needed:**

- Fuchsin jelly (recipe below)
- Glass beaker or jar
- Hotplate with stirrer
- Razor blade or scalpel
- Jar or vial to hold cubes of jelly
- Alcohol lamp and lighter
- Microscope slides (one per plant species)
- Cover slips
- Box for holding slides
- Forceps/tweezers

**Procedure:**

- Locate at least one plant with freshly dehisced anthers (i.e., fresh pollen visible).
- Prepare a microscope slide (write name of plant taxon on it).
- Take a cube of fuchsin jelly with the forceps.
- Rub fuchsin jelly over anthers to coat with pollen (ideally, repeat for >1 plant to sample intraspecific variation).
- Place pollen-coated jelly cube on slide; cover with cover slip.
- Light alcohol lamp.
- Using the forceps (or pliers), hold the slide with jelly and cover slip over the flame *just until the jelly starts to melt.* As soon as it starts to melt, remove from heat. (If you leave it over the flame too long, the jelly will boil.) Gently tap cover slip to spread the jelly and position the cover slip on the slide.
- Once the slide is cool, place in slide box.
- Thoroughly wipe forceps before continuing to next plant species.

**Recipe for fuchsin jelly (adapted from Kearns & Inouye 1993):**

- 35 mL distilled water
- 30 mL glycerin
- 10 g gelatine
- crystalline basic fuchsin stain (as needed)—stains the pollen exines and facilitates identification

In a wide-mouthed glass jar or beaker, add the distilled water to the gelatine and heat until it dissolves completely. Then add the glycerin and stir while warming gently. Add basic fuchsin crystals until you get a solution "the colour of claret". Pour solution into sterile containers (e.g. petri dishes), to a depth of approximately 3 mm. Cover to prevent contamination and allow to cool. Once the jelly has hardened, use a clean scalpel or razor blade to cut it into small cubes (~2 $mm^3$) to make it easy to use in the field. Place cubes in a sealed container and keep cool. Room temperature is fine, but jelly will melt if kept in the sun; we usually keep it in a cooler on ice during field work.