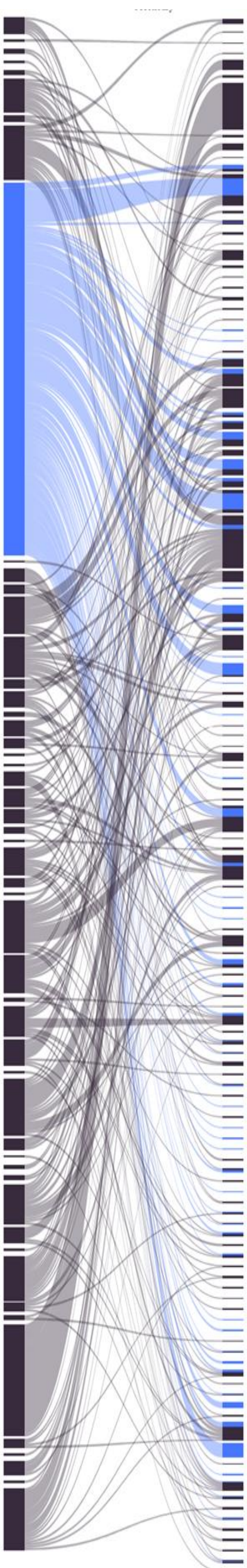

Floral Relations of Native Bees in Camas Meadows

COL-F22-W3485

Prepared for: Fish and Wildlife Compensation Program

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Prepared with the financial support of the Fish and Wildlife Compensation Program on behalf of its program partners:
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Executive Summary

Improving conservation and understanding of culturally important plants and animals has been identified as a high priority action in the Fish and Wildlife Compensation Program (FWCP) Columbia Region Wetland & Riparian Action Plan (FWCP 2019b; COLWRA.CXP.RI.05.01: Culturally important resources.). The FWCP Upland and Dryland Action Plan (FWCP 2019a) supports inventory and monitoring for pollinators to elucidate community structure and act as an indicator of ecosystem function (COLUPD.SOI.ME.33.01: Invertebrate monitoring for pollinators).

This project provides fundamental empirical data on physical, biological, and ecological components of West Kootenay camas meadows necessary to inform future conservation, restoration, and enhancement activities. The Kootenay Native Plant Society is working with the Sinixt peoples to renew people-plant relationships in their traditional territory where most camas meadows have been lost. Documenting plant-pollinator communities in the remaining meadows is a critical first step in a process to understand what species, communities, and interactions remain and it identifies how best to conserve and restore West Kootenay camas meadows.

Ten camas meadow sites were selected at low to mid elevations along approximately 60 km of the Kootenay and Columbia River systems. This corridor has national biological, ecological, and cultural significance. The sites represent a diversity of habitat types including bedrock seepage meadows, rocky shorelines, and open floodplains. General site attributes and plant community structure were recorded at each site. Native bee species were sampled directly from flowering plants at eight of the sites, and soil was sampled at 4 of the sites. 96 species of flowering plants were detected among transects and their phenology was recorded during multiple visits at 8 of the sites. Soil temperature and ambient air temperature were recorded at 8 sites.

No plant or bee species at risk were detected during the 2021 surveys. We observed 148 bee species or morphospecies among eight camas meadow sites. The small carpenter bee genus *Ceratina* (Apidae) was the most abundant, followed by the mining bees, *Andrena* (Andrenidae), the sweat bees, *Lasioglossum* (Halictidae), the bumble bees, *Bombus* (Apidae), and the mason bees, *Osmia* (Megachilidae).

Pollinator-plant networks among the sites clearly demonstrate the critical importance of camas as a crucial network hub, or anchor among the communities at these sites. Camas interacted with 57 species of bees in this sample season which effectively organized the plant-pollinator communities into a rich early-season, camas-associated network, and a later season and much less rich network consisting of approximately half the number of species and interactions. These early season networks had few introduced species in contrast to the later season networks, which contained more introduced plant and pollinator species.

The measured importance of camas in driving species richness and connectivity in early season communities highlights the ecological value of this species and its important function as a network hub. Resilient communities rely on multiple network hubs across the season, and future work to further elucidate critical plant species in these upland, wetland, and riparian habitats will enable the optimization of plant choice in restoration, leading to resilient networks consisting of hundreds of species of plants and pollinators.

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1 Introduction

Pollination is a critical ecosystem service and native bees are our most important pollinators. Pollination sustains native ecosystem health and function, yet little is known about the identity, status, habitat use, and pollinator-plant relationships in West Kootenay (WK) ecosystems. Baseline data on native bee distribution and abundance in the WK is limited (but see Westcott and Irvine 2010, Best 2018, Huff et. al. 2020). Even less is known about the pollinator diversity and abundance in the meadows of common camas (*Camassia quamash* (Pursh) Greene [Asparagaceae]), though wet meadows are known to harbour diverse pollination networks (Moroń et al. 2008), and, in one survey of Garry oak meadows in southwestern British Columbia (BC), camas was the most frequently visited plant species by the largest diversity of bees (Parachnowitsch and Elle 2005). In our previous work in WK camas meadows, we have observed and photographed many invertebrate visitors on camas (Huff and Johansson 2012). Lynn Westcott, a bee specialist familiar with local flora and bee fauna has suggested that up to 60 different bee species may rely on camas meadows for their livelihood (L. Westcott, pers. comm. Sept. 30, 2013). Our 2020 sampling found 84 distinct bee taxa present, exceeding previous estimates. A BC Conservation Data Centre (CDC)- blue listed bumble bee species (*Bombus occidentalis)* has been observed in camas meadows, with a second less common species possible as well (*B. suckleyi).* Only bumble bees have been assessed by the BC CDC; the number of bee species in BC is not yet known, and we are losing high quality habitat faster than we can survey for BC bee diversity.

Camas, known as itqwa/black camas in the Interior Salish language, is a perennial herb with grass-like leaves, light blue to deep purplish-blue flowers, and an edible bulb. It is native to the Pacific Northwest from California, through Oregon, Washington, Utah, Idaho, Wyoming, Montana to southern BC and Alberta. In BC, it occurs along the Pacific Coast, largely restricted to southeastern Vancouver Island and the Southern Gulf Islands, as well as in the Canadian Columbia Basin from Trail to Nakusp (Huff and Johansson 2012; Beckwith 2004). In every place where camas occurs across western North America it has played a dominant role in shaping First Nations/Native American economies and identity for millennia (Thoms 2008; Beckwith 2004; Hunn 1981). The bulbs are a significant resource, a "root food" that was—and still is for many Native Americans—a staple component of the traditional diet. Camas was cultivated primarily by women, who maintained bulb quality and quantity (Beckwith 2004), by creating and maintaining extensive meadows that, when in bloom, were described as blue lakes by Lewis and Clark (Stevens et al. 2001). Widely celebrated in story, legend, and ceremony, it has been called a cultural keystone species (Garibaldi and Turner 2004).

The formerly cultivated camas wet meadow habitats are also ecologically significant, supporting a diversity of other plant, animal, and fungal species/beings. In the Columbia Basin, these communities occur along the Columbia and Kootenay rivers in floodplain meadows, in the upper riparian zone, and in moist seeps in bedrock meadows from Marsden Face, located outside of Nelson, south to the US border. Small populations are known from the Slocan Valley, Pass Creek, and Robson. Historically, camas occurred up the Arrow Lakes as far as Nakusp and Edgewood in locations now underwater after the construction of the Hugh Keenleyside Dam. Ongoing habitat loss, agricultural conversion, forest in-growth, and invasive species have contributed to the decline of these ecologically and culturally significant places and, it is suspected, that changing precipitation patterns with the climate crisis could further imperil the remnant camas populations. In the BC Interior, it is estimated that camas occupies less than 1% of the original, pre-settler extent (B. Beckwith, KNPS Restoration Ethnoecologist, pers. comm., October 15, 2019). The loss of camas meadows is likely accompanied by a corresponding loss of invertebrate pollinator species abundance and richness.

This project was undertaken to provide a baseline understanding of West Kootenay camas meadows to inform future conservation, restoration, and enhancement activities. The Kootenay Native Plant Society is working with the Sinixt peoples to renew people-plant relationships in their traditional territory. Documenting plant-pollinator interactions and diversity in the remaining meadows is a critical next step in understanding how the remaining diversity is interacting, and which species are critical to maintaining ecosystem function. This knowledge along with soil, plant community, insect community and temperature data provide a much more complete picture of the ecological communities present at these sites, which will be invaluable in understanding how best to conserve and restore West Kootenay camas meadows.

2 Goals and Objectives

Improving conservation and understanding of culturally important plants and animals has been identified as a high priority action in the Fish and Wildlife Compensation Program (FWCP) Columbia Region Wetland & Riparian Action Plan (FWCP 2019b):

> COLWRA.CXP.RI.05.01 Culturally important resources. Work with appropriate Indigenous groups and organizations to conduct research and inventory to improve the understanding of culturally important plants and animals. Conservation and increased understanding of culturally important species.

Camas has been identified by our indigenous colleagues from the Colville Confederated Tribes as their highest priority for eco-cultural restoration. Through the mapping of camas meadow vegetation and habitat attributes in the study area, this project will establish a baseline from which to measure progress toward the recovery of these culturally significant ecosystems.

The FWCP Upland and Dryland Action Plan (FWCP 2019a) supports inventory and monitoring for pollinators to elucidate community structure and act as an indicator of ecosystem function:

> COLUPD.SOI.ME.33.01 Invertebrate monitoring for pollinators. Support inventory/monitoring of upland terrestrial invertebrate groups to increase knowledge of community structure and act as an indicator of productivity and ecosystem health/function in areas related to FWCP compensation activities.

Pollinator biodiversity data for the West Kootenay is sorely lacking (Jennifer Heron pers. comm., October 21, 2019), and our collection and identification of native bees in West Kootenay camas meadow will significantly increase our understanding of bee distribution in an important eco-cultural landscape.

3 Study Area

Ten camas meadow sites (see Table 1 below) were selected as independent study sites, separated by either 1 km, or by a significant body of water, i.e., the Kootenay & Columbia Rivers. The sites represent a diversity of habitat types including bedrock seepage meadows, rocky shorelines, and open floodplains, which do not fit well within current provincial ecological land classification systems (e.g., MacKillop and Ehman 2016; MacKenzie and Moran 2004; etc.). The sites occur over an elevation gradient of 700 m, from 425 m up to 1120 m. A common characteristic of each site is that the diversity of flowering plants is high relative to adjacent habitat. Each site represents a small patch of unique habitat within a varied landscape dominated by managed forests, reservoirs, urban development, industrial infrastructure, and transportation corridors. Most sites fall within the Interior Cedar Hemlock - Very Dry Warm (ICHxw) Biogeoclimatic Subzone, though the Upper Marsden Conservancy site is transitional with the Interior Cedar Hemlock - Dry Warm Subzone (ICHdw1) in the North (MacKillop and Ehman 2016). The climate includes very hot, very dry summers and mild dry winters (MacKillop and Ehman 2016). The ICHxw subzone contains forests and brushlands with a diverse assemblage of tree and shrub species and a disproportionately large number of wildlife and plant species at risk (MacKillop and Ehman 2016).

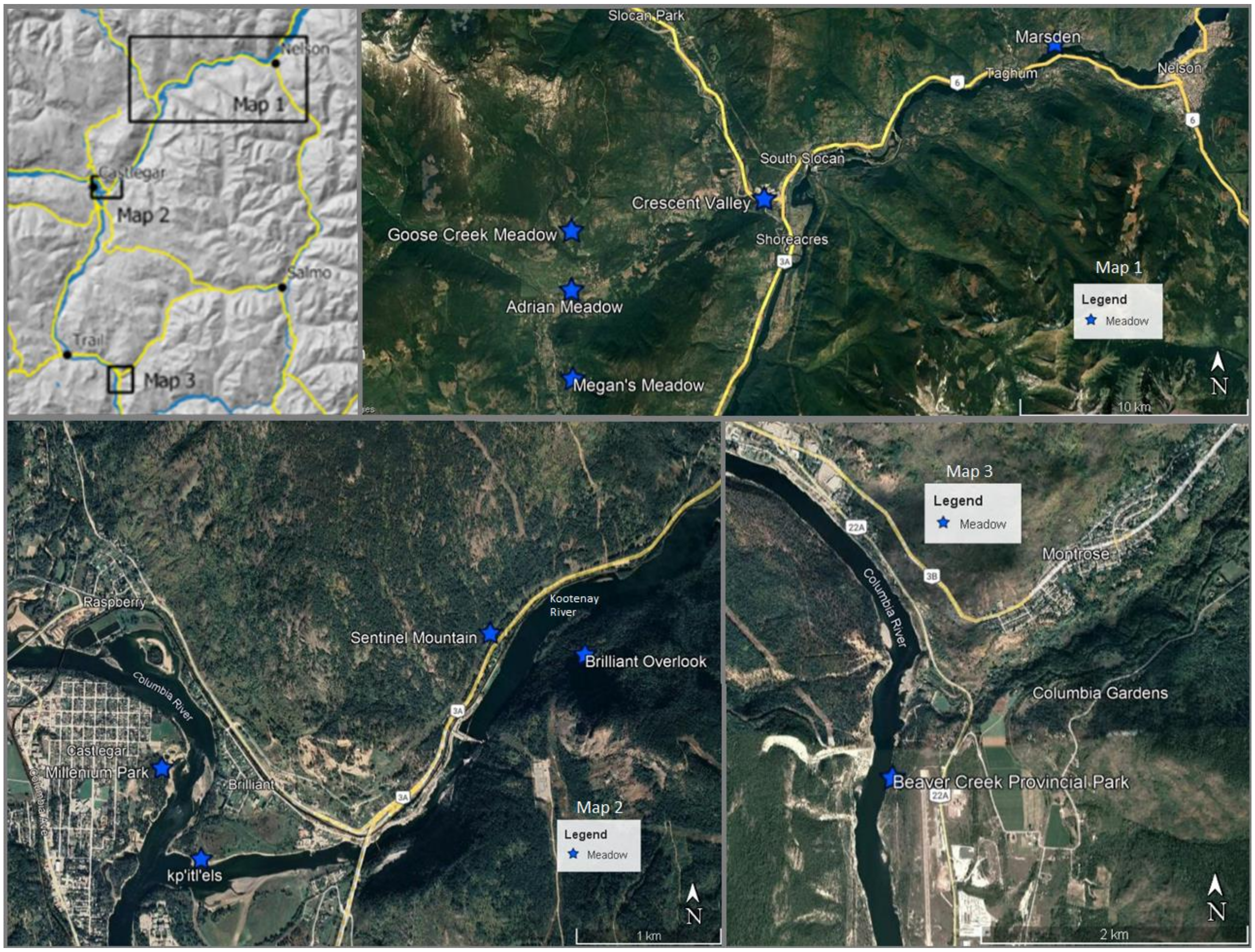

Figure 1. Map of all camas meadows chosen for study in 2021.

3.1 Site Sampling Overview

Ten camas meadows at various locations and elevations that span the range of camas in the Kootenay region were chosen for sampling, but phenology limited the ability to sample Beaver Creek Provincial Park, as peak bloom had passed by the time funding was confirmed for personnel involved in sampling. Another site (Brilliant Overlook along the Skattebo Reach Trail) had uncertain ownership, with permission not granted in time to sample. The remaining eight sites were sampled for floral abundance, floral phenology, and interactions between plants and floral visitors. All floral visitors were collected via hand net to record species identities and interactions with floral resources. Temperature loggers were also piloted at all sites to evaluate changes in temperature between sites.

Table 1. Floral interaction sampling sites, including elevation, whether sampling was done in 2021, and whether it was included in the soil profile assessment.

Site Code	Site Name	Elevation	Sampled 2021	Soil Profile
GCR	Goose Creek Meadow	1120	Y	Y
CRV	Crescent Valley	490	Y	Y
KPI	kp'itl'els	423	Y	Y
MIL	Millennium Park	425	Y	
SEC	Mount Sentinel	520	Y	
MEG	Megan's Meadow	750	Y	
ADR	Adrian Meadow	640	Y	
MAR	Marsden	610	Y	Y
BRO	Brilliant Overlook	590	N	
BCR	Beaver Creek Provincial Park	410	N	

4 Methods

4.1 Site Description

Two SmartButton® temperature recorders (ACR Systems Inc. n.d.) were deployed in each meadow, with one temperature logger in the soil at a depth of 10 cm, and the other measuring ambient air temperature on the North side of an available tree at 1 m above the ground. Loggers were deployed from May 10th to July 10th, 2021, taking a reading every 1 hr and 20 minutes. They were redeployed on July 10th, 2021, to log until May 1st, 2022, logging every 3 hours. These will be used to generate Growing Degree Day (GDD) models for phenological events but will likely require multi-year data for representative results.

4.2 Floral transects

Transects were established at each site that totalled 100 m in length and 2 m in width. Many sites were not 100 m in length, so four 25 x 2 m transects were established at each site, approximately in parallel with the nearest river. Along these transects, all flowering plants within 1 m of the centre of the transect (2 m width total) were identified to species and sampled for abundance as below.

4.3 Floral resources

Flowering plants were separated into two types, first were flowers large enough to feasibly count (e.g., *C. quamash* or *Symphoricarpos albus)*, second were plants with tiny flowers too small to feasibly count (e.g. *Valerianella locusta* or *Veronica arvensis*). For the first group, all flowers and inflorescences present in each transect were counted. For the second group, each meter of each transect was evaluated for presence or absence of open flowers. This led to a count out of 25 for each transect. A list of species in group 1 and 2 can be found in Appendix A. This was repeated for a total of five rounds for each site through the spring and summer, from May 10th until July 10th when few flowers were blooming, meadows had dried out, and air quality became hazardous due to wildfire smoke.

Plant phenology was also recorded during each visit for all flowering plants sufficiently abundant to evaluate. Each of these plants were assigned a number on the extended BBCH scale (Hess et. al. 1997) to describe the flowering stage of each species across the transects (Table 3). This will allow for future comparisons of flowering phenology among sites across time.

Table 2. Portion of the BBCH phenology scale (Hess et al. 1997) used to describe the growth stage of forbs that were flowering during the bee sampling period. See Appendix D for complete scale.

Code	Description
Principal growth stage 5: Inflorescence emergence (main shoot)	
51	Inflorescence or flower buds visible
55	First individual flowers visible (still closed)
59	First flower petals visible (in petalled forms)
Principal growth stage 6: Flowering (main shoot)	
60	First flowers open (sporadically)
61	Beginning of flowering: 10% of flowers open
63	30% of flowers open
65	Full flowering: 50% of flowers open, first petals may be fallen
67	Flowering finishing: majority of petals fallen or dry
69	End of flowering: fruit set visible

4.4 Sampling of Plant-Pollinator Floral Interactions

This season focused on net sampling with the goal of discovering the diversity of floral interactions occurring in camas meadows. Floral visitors were sampled with hand nets five times at each of the eight sites from May 10th to July 10th, on the same visit as floral abundance. This net sampling involved collecting all floral visitors on plants flowering throughout each site, dividing attention between all floral resources equally. For each visitor caught, the plant it was caught on was recorded, providing a record of both visitor presence and floral resource use. Each sampling period consisted of one person hour at each site, with the hour representing only searching time, and excluding the time spent catching and processing specimens caught. This resulted in the collection of 951 floral visitors, of which 788 were bees. These bees were recorded visiting 64 unique flowering plant species, representing 386 unique plant-bee interactions. All floral visitors were pinned and labelled for further identification and to prepare for future museum deposition.

4.5 **Bee Identification**

Bee specimens were identified to species-level (92 species) or morphospecies (56 morphospecies) depending on the availability of modern taxonomic revisions, keys for identification, reference specimens, and the condition of specimens. Morphospecies were identified to genus and/or subgenus, then differentiated using morphological characters and assigned a sequential morphospecies number. Appendix C contains a checklist of bee species and their status rankings. The following resources were used in this study to identify the bee specimens: Ascher and Pickering (2013), Bouseman et al. (1978), DeSilva (2012), Gibbs (2010), Hurd and Michener (1955), LaBerge (1969), LaBerge (1986), McGinley (1986), Roberts (1973a), Roberts (1973b), Sheffield et al. (2011), and Stephen (1954). Species occurrence data for the bee specimens collected will be served to the Global Biodiversity Information Facility (GBIF) via the Canadensys Integrated Publishing Toolkit (IPT).

4.6 Soil Sampling

In the fall of 2021, 6 locations (CRV, GCR, KPI1 and KPI2, MAR, and the Selkirk Oxbow-OXB) were identified for soil pit descriptions and classifications. Representative sites within the selected camas meadows were identified for soil pit description based on the surrounding site attributes. Soil pits were dug to 60cm, where soil depth permitted. Data were collected on BC Ministry of Forest and Range Ecosystem Field Form (FS822) and followed provincial standards and codes (B.C. Ministry of Forests and Range B.C. Ministry of Environment. 2015). All appropriate fields on the site and soils cards were filled in at each site; soil and humus structure were excluded. Field observations impacting site and soil factors were recorded in the notes section.

4.7 Data Analysis

Analyses were completed in R 4.1.3 (R Core Team 2022). Network metrics were generated using the *bipartite* package (Dormann et al. 2009) and visualizations were created with the *biparteD3* package (Terry 2021). Non-metric multidimensional scaling (NMDS) and rarefaction analysis (sampling completeness estimates) were done using the *vegan* package (Oksanen et al. 2020). Figures were made using *ggplot2* (Wickham 2016).

5 Results and Outcomes

5.1 Temperature Loggers

Clear differences between sites were observed, nearly in line with the elevation gradient. The highest elevation site (Goose Creek Meadow) had the lowest temperature throughout the season, while the lowest elevation site (kp'itl'els) had the highest temperatures. Temperature loggers were not deployed before spring 2021 snowmelt so were unable to be used to develop models for the past season, although their data may be used to test whether the following year's phenology depends on the previous year. Loggers redeployed in Fall 2021 will be used to develop degree day models for the current year. Despite installing loggers in North facing locations, data appeared to be influenced considerably by solar radiation. It may be necessary to locate air loggers in treed areas at the edges of sites to minimize resulting variation. In contrast, soil loggers were less variable (see figure below) but had other associated challenges. After first being installed, soil loggers were disturbed by wildlife at 3 of 8 sites and were exposed to solar radiation until the next visit to the site. These periods of inaccurate data are statistically complex to recreate, and any recreation will be imperfect (Anderson & Gough, 2018).

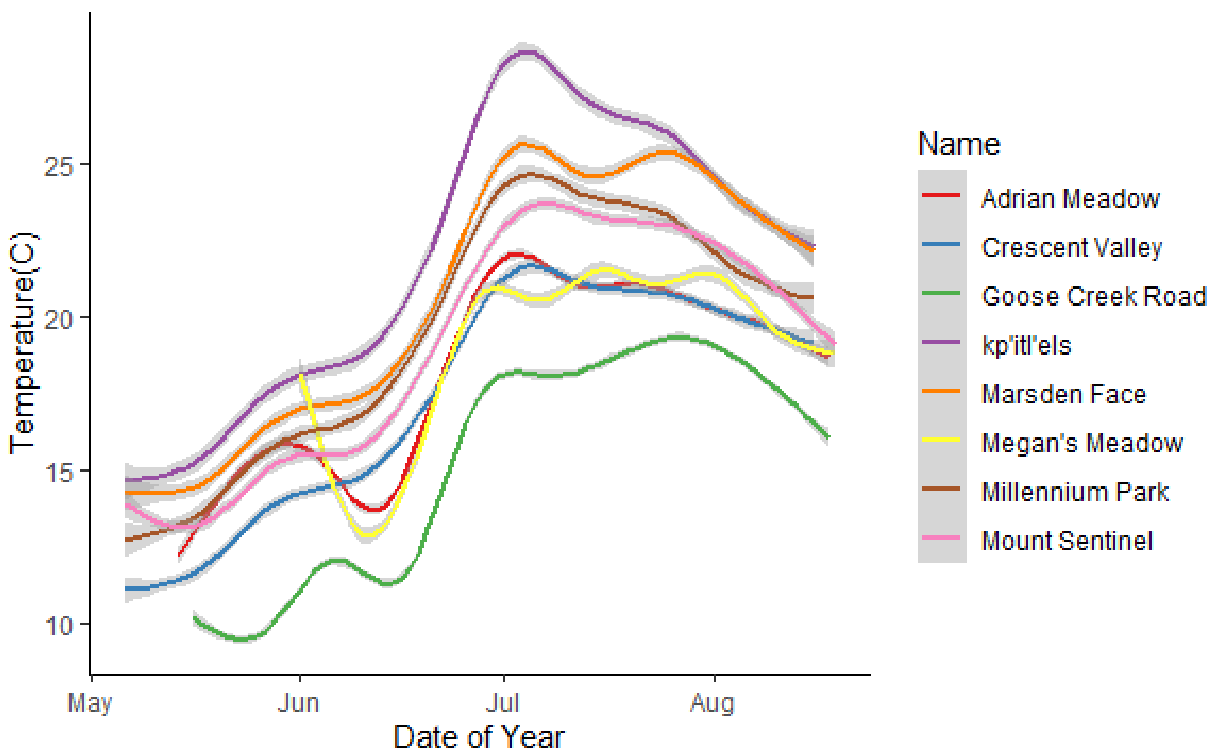

Figure 2. Soil logger data for each site. Soil loggers were less variable than air loggers, which had significant standard errors.

5.2 Floral Transects

A total of 96 flowering plant species were detected in transects, of which 58 were native species, and 38 were introduced species. Group 1 (flowers and inflorescences were counted) contained 51 native species and 16 introduced species, while group 2 (tiny flowers, sampled for presence/absence) contained 7 native species and 22 introduced species. The highest flowering plant diversity occurred at Mount Sentinel followed by the Adrian meadow, with 40 and 37 species respectively. Unsurprisingly, *C. quamash* was present at all sites and was also the most abundant in terms of inflorescences. The only other plant present at all sites was a group 2 flower, *Microsteris gracilis*.

Floral resources generally decreased over the sampling period, as can be seen in figure 2. Peak bloom occurred in early May at low elevations, up to early June at the highest elevation. The highest elevation site (Goose Creek Meadow) was the only site where sampling began early enough to record the ramp up to peak bloom, while the rest of the sites were sampled during or post peak bloom, such that floral resources decreased in later sampling rounds.

Despite decreases in quantity of flowering resources over the season, floral resources were present during most samples, except for several transects during the 5th round of sampling in early July. This can also be seen in the phenology figure (Fig. 4). Most plants had a relatively narrow period of flowering and did not span the whole season. Those that did span longer periods of time tended to be group 2 flowers.

Table 3. Count of flowers at each site for the 20 most abundant flowering plants across sites in 2021. Colour depth indicates relative abundance across all sites.

Plant Species	ADR	CRV	GCR	KPI	MAR	MEG	MIL	SEC
Achillea millefolium	0	0	9	44	81	92	140	141
Aphyllon purpureum	0	0	0	0	338	0	20	131
Camassia quamash	46	407	623	667	353	406	529	5046
Collinsia parviflora	0	355	243	4	211	0	726	249
Delphinium nuttallianum	0	0	0	0	67	0	929	51
Erythranthe guttata	0	0	137	0	173	0	301	0
Lithophragma parviflorum	0	0	200	8	0	2	155	235
Lomatium ambiguum	0	0	0	0	286	0	0	0
Montia linearis	0	635	14	16	0	0	32	2
Montia parvifolia	0	0	0	0	1990	0	0	72
Myosotis scorpioides	567	0	0	0	0	0	0	0
Potentilla recta	0	23	15	180	0	1	32	85
Sedum stenopetalum	0	0	24	54	5	0	22	262
Toxicoscordion venenosum	0	0	2148	188	1344	3	1598	245
Vicia villosa	81	2	151	0	0	0	84	1932

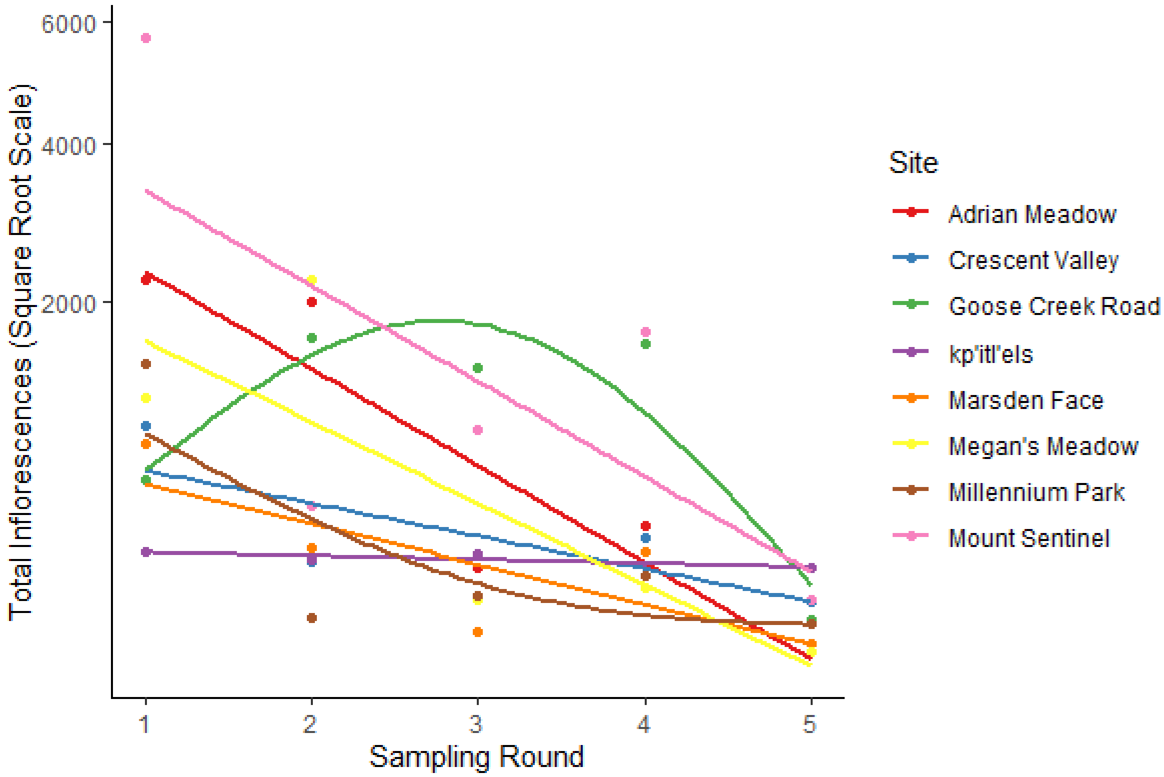

Figure 3. Shows how floral resources changed at each site through the season, split into the 5 rounds of sampling. Each line represents the change in floral resources at each site through the sampling period. The only site where peak bloom occurred after the beginning of sampling was the highest elevation site (Goose Creed Road.

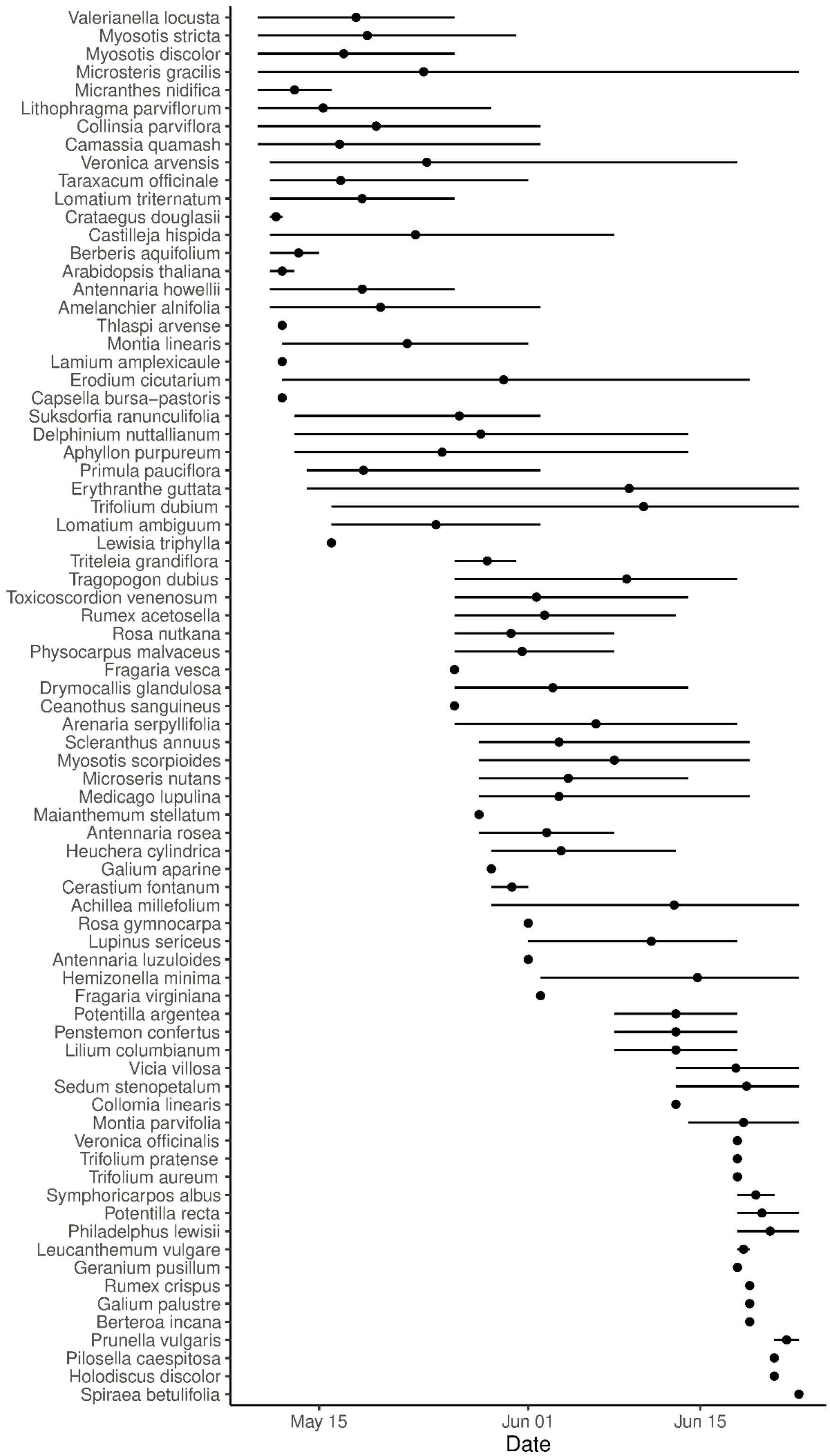

Figure 4. Shows the flowering phenology of many of the flowering plant species present. Lines show the range from when flowers first opened (code = 60) to the time when flowering had finished (code = 69). The black dots show the time when peak bloom occurred. Species with a single dot may have only been observable when in peak bloom, otherwise being too tiny or inconspicuous to confirm phenology for.

Finally, plant community compositions were found to be relatively similar, but differences were observable, possibly corresponding to elevation. This can be seen by comparing the highest elevation site (Goose Creek Road), to the lowest elevation sites (kp'itl'els and Millennium Park). Goose Creek Road barely overlaps with Millennium Park, and only somewhat with kp'itl'els. These differences may also be attributed to site type, with the two floodplain sites (kp'itl'els and Millennium Park) slightly distinct relative to the mountain seepage sites.

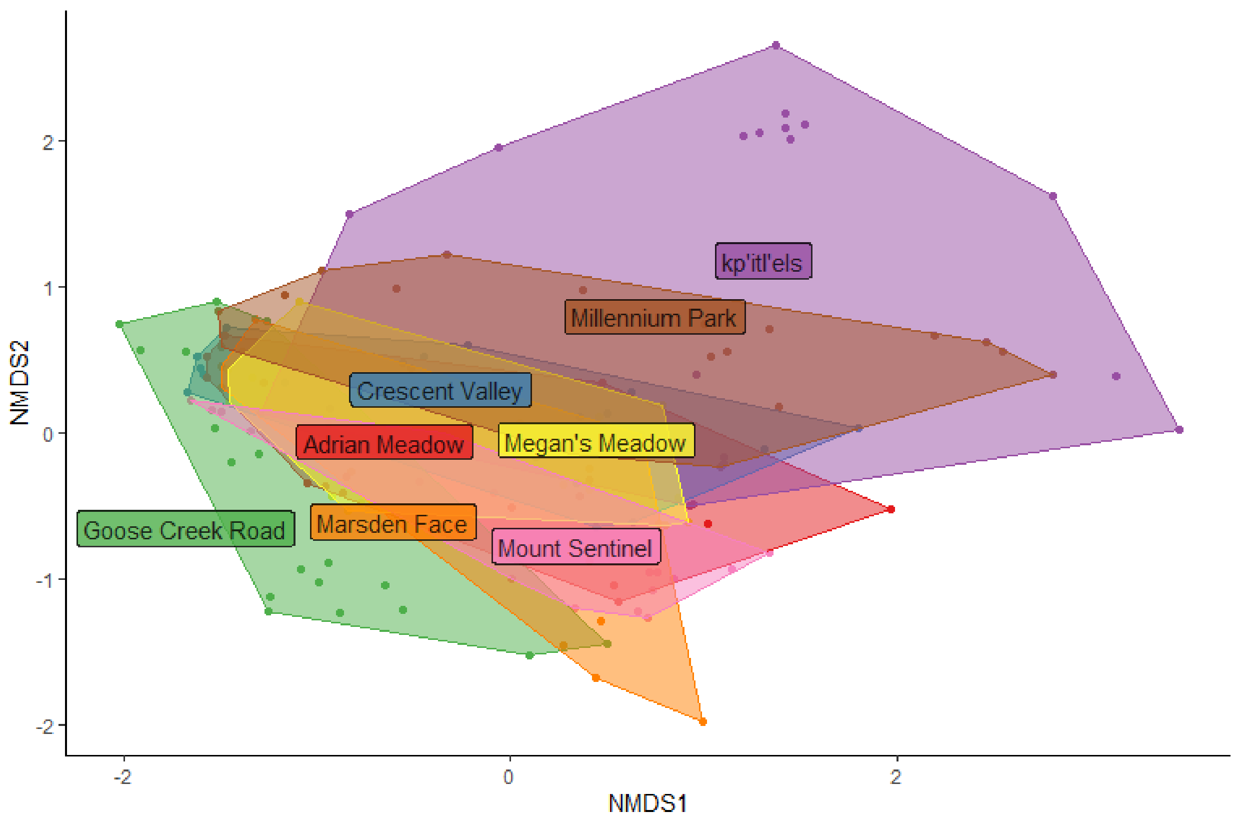

Figure 5. Non-metric multidimensional scaling (NMDS) plots of flowering plant communities at each site, with first and second rotational axes (NMDS1 and NMDS2) displayed on the x- and y-axis. Dimensions were reduced to k = 4, and the stress was 0.08 (indicates minimal loss of community information caused by NMDS rotation).

5.3 Bees

Bees from each of the six bee families known from British Columbia were represented among the collected specimens. The relative abundances of species, genera and families can be found in Figure 6 below. Apidae was the most abundant family, largely because it contains abundant taxa such as bumble bees (*Bombus*), the European honey bee (*Apis mellifera*), and the small carpenter bees (*Ceratina*). A total of 92 species and 56 morphospecies were detected. Overlap with the previous year's blue vane trapping (48 species detected) was not perfect, with only 32 species found in both 2020 and 2021. Morphospecies were not possible to compare because morphospecies 1 in 2020 was not necessarily equivalent to morphospecies 1 in 2021. Species not detected previously were concentrated in the genus *Andrena* and family Andrenidae as well as several genera in the family Megachilidae. Several novel genera were also collected compared to trap sampling, these include *Panurginus* of Andrenidae, *Melissodes* of Apidae, *Dufourea* of Halictidae, and four genera (*Stelis, Chelostoma, Heriades* and *Anthidium*) of the Megachilidae. There was also the collection of an additional bee family compared to trap sampling, *Macropis nuda* of the Melittidae, which specializes on *Lysimachia ciliata* present at the kp'itl'els site. The number of bees identified to species alone was greater than the number of species and morphospecies combined from trap sampling.

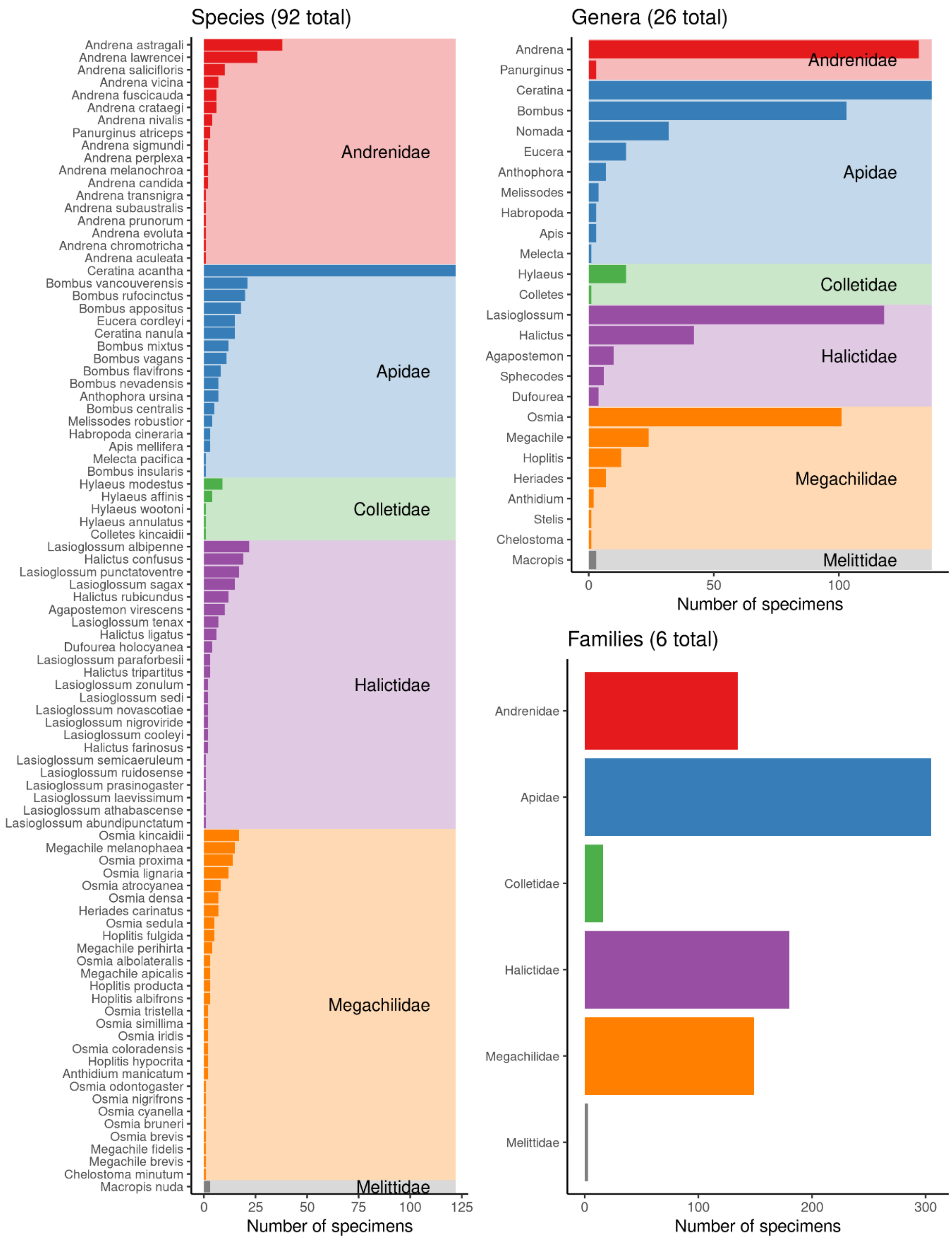

Figure 6. Species, Genus, and Family abundance split into the six families of bee in North America. Morphospecies were included in genera-level counts but not species-level counts.

Millennium Park, Mount Sentinel and kp'itl'els had the highest estimated species richness, with 63, 60 and 59 species estimated, respectively (Figure 7, top panels). There is significant overlap in estimated total diversity between these three sites, although Mount Sentinel had almost double the individuals sampled, so would likely be a more accurate estimate. At all sites the observed richness (curved lines) did not reach the estimated species richness (horizontal line), meaning that more sampling is necessary to detect all species present during the sampling period. Sampling effort was however comparable to the previous year's blue vane traps, and 2022 sampling should improve these estimates, as sampling is planned to focus on peak bloom as estimated from our phenological data which starts in late April at low elevation.

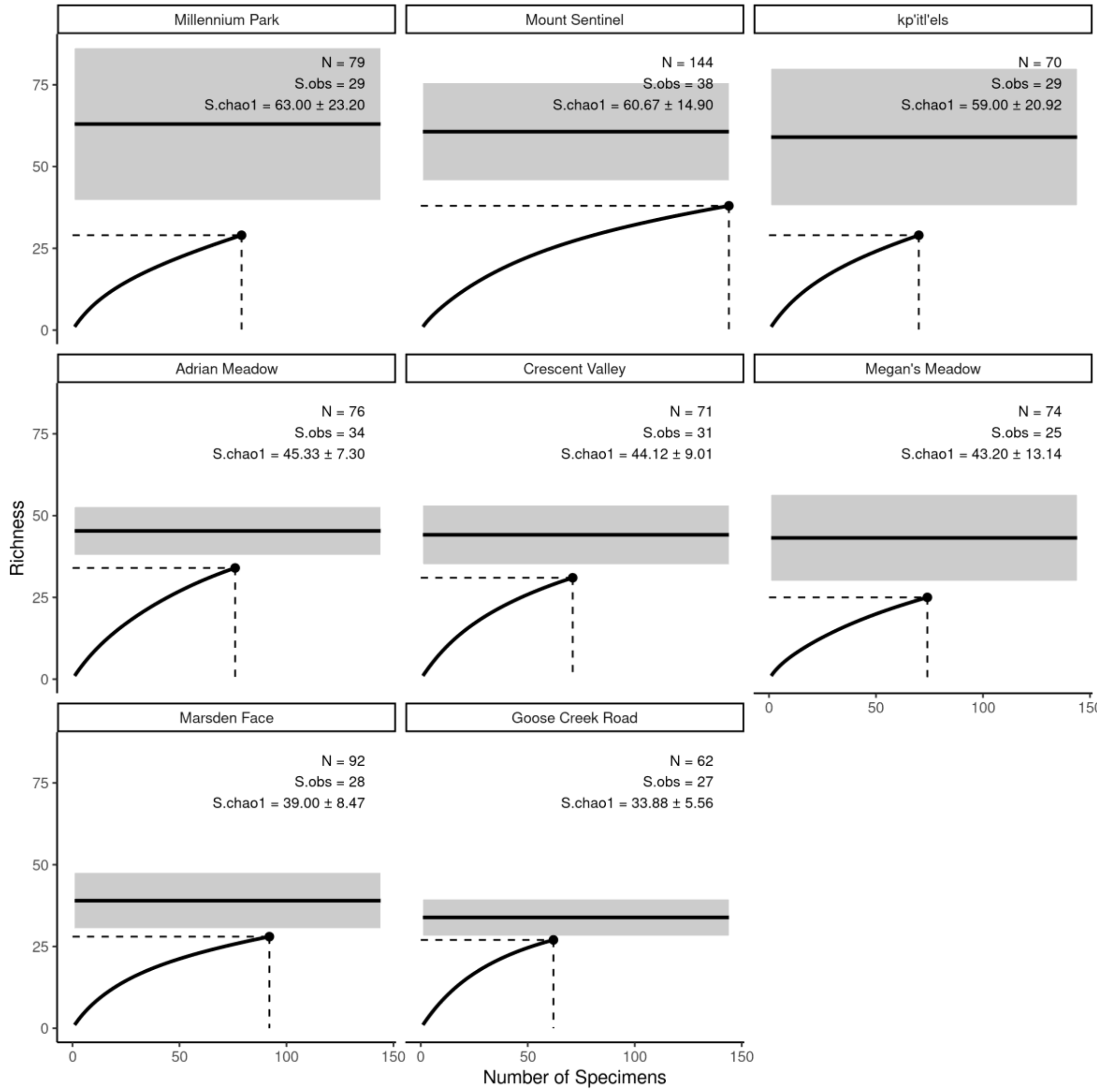

Figure 7. Rarefaction curves for each collection site, along with estimated total species richness, indicating estimated sample completeness. N indicates the total number of specimens, S.obs indicates the number of observed species, and S.chao1 indicates estimator (Chiu et al. 2014).

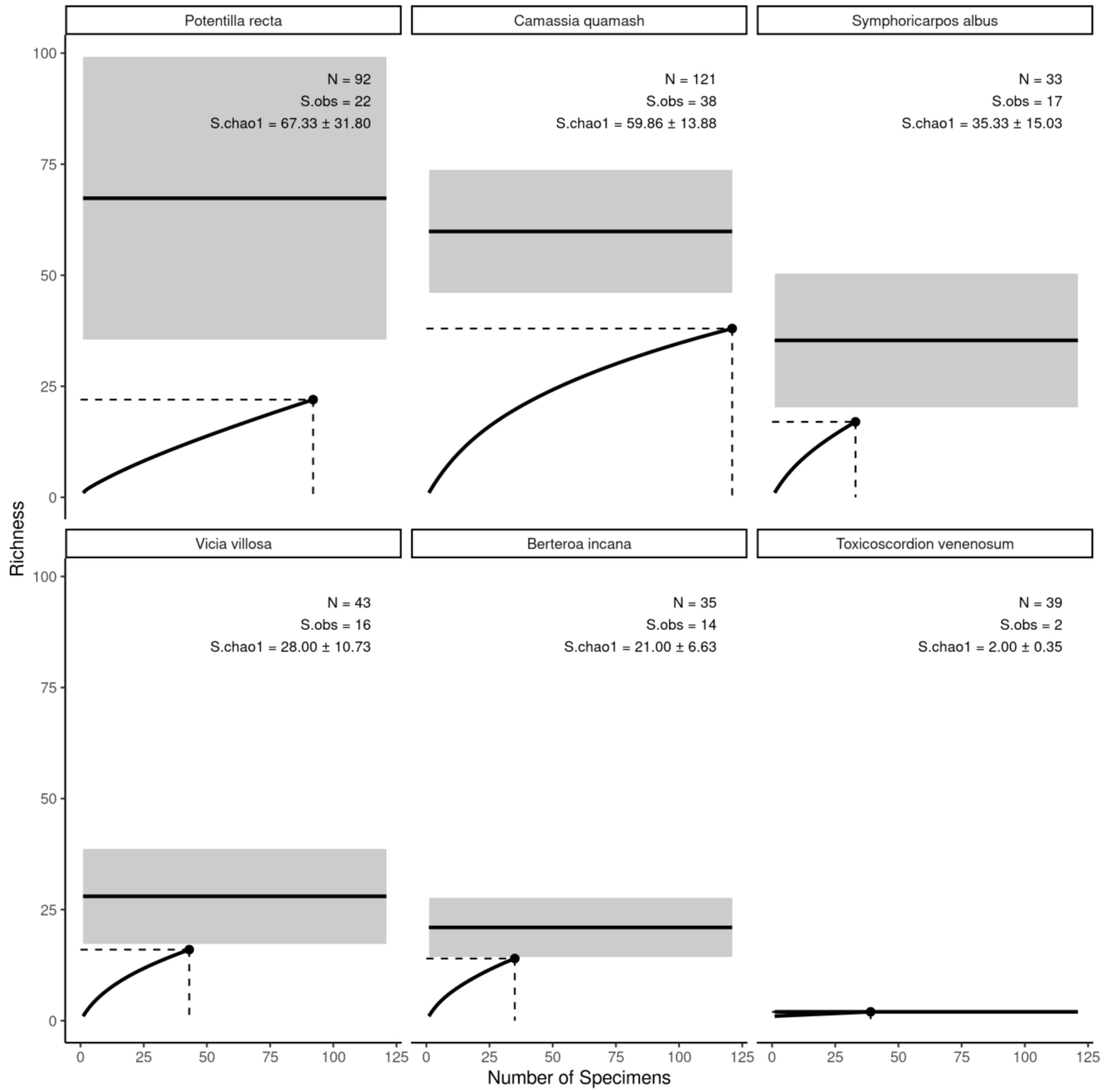

Figure 8. Rarefaction curves for the six most abundant flowering plants, along with estimated total species richness. N indicates the total number of specimens, S.obs indicates the number of observed species, and S.chao1 indicates estimated total richness using the Chao1 estimator (Chiu et al. 2014)

5.4 Plant-Bee Floral Interactions

Floral interactions were split into early and late season due to significant changes in which plant species were flowering. Early season was defined as sampling rounds 1 to 3, which occurred between May 10th and June 14th. Late season was defined as sampling rounds 4 and 5, which occurred between June 18th and July 10th. Separating floral networks across time decreases the number of "forbidden links" (i.e., links that cannot occur due to lack of phenological overlap or other constraints, see Olesen et al. 2011).

Abundance of bees was determined for each plant during early and late season sampling, with results displayed in figures 9 and 10 below. More bees were observed visiting flowers during the early season than the late season. In the early season, more bees were caught visiting *C. quamash* than any other flowering plant. In the late season, bees were distributed more evenly across several plants, many of which were introduced, such as *Potentilla recta, Vicia villosa,* and *Centaurea stoebe*.

Floral interaction networks representing which bees visited which flowers were also derived for the early and late season (Figures 11-13). The network for the early season contained approximately double the number of plants and bees (n =175) compared to the late season network (n = 92) , and accordingly involved slightly more than double the number of unique interactions (n = 288 vs. n = 130). The number of interaction partners was similar for both bees and plants across both networks, although in the early network, *C. quamash* had many more unique interactions than any other plant, interacting with a total of 57 bee species and morphospecies. The early network is based heavily around *C. quamash,* in contrast to the later season network, where bees are effectively spread out across more species of plants. This can be observed by looking at interaction partners as well, with the plant second in interaction partners after *C. quamash* interacting with 15 bee species. In the later network, several plants interacted with around 15 bee species and bee species were accordingly spread across more plants. In the late network, *Potentilla recta* had the most interaction partners despite almost three quarters of its interactions being with a single species of bee. This species, *Ceratina acantha* was the most common bee in both early and late networks, and is a species known for being highly abundant across its range. The bee species that interacted with the most plant species tended to be found in both early and late season networks, with the top 20 bees in both networks sharing 10 of the same species.

The early network had fewer introduced species than the later network which presents important hypotheses about the integrity of networks. In the early network, 3% of interactions involved the introduced European honey bee (*Apis mellifera*), while in the late network, 15% of interactions involved introduced pollinators, mostly involving *A. mellifera,* but also two other introduced pollinators, *Anthidium manicatum* and *Megachile apicalis*. For plants in the early network, 23% of interactions involved introduced plant species, in contrast to the later network, where 55% of interactions involved introduced plants.

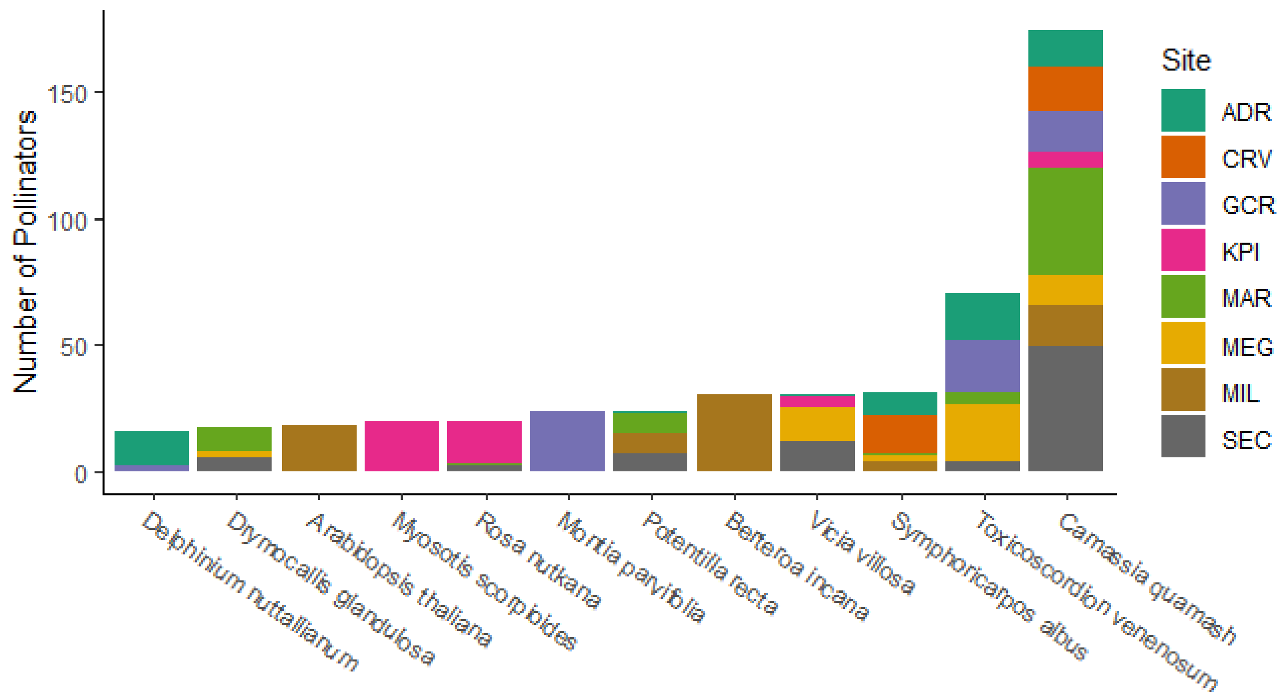

Figure 9. Shows which flowering plants pollinators were caught on during sampling rounds 1-3 (early season, separated by species and site.

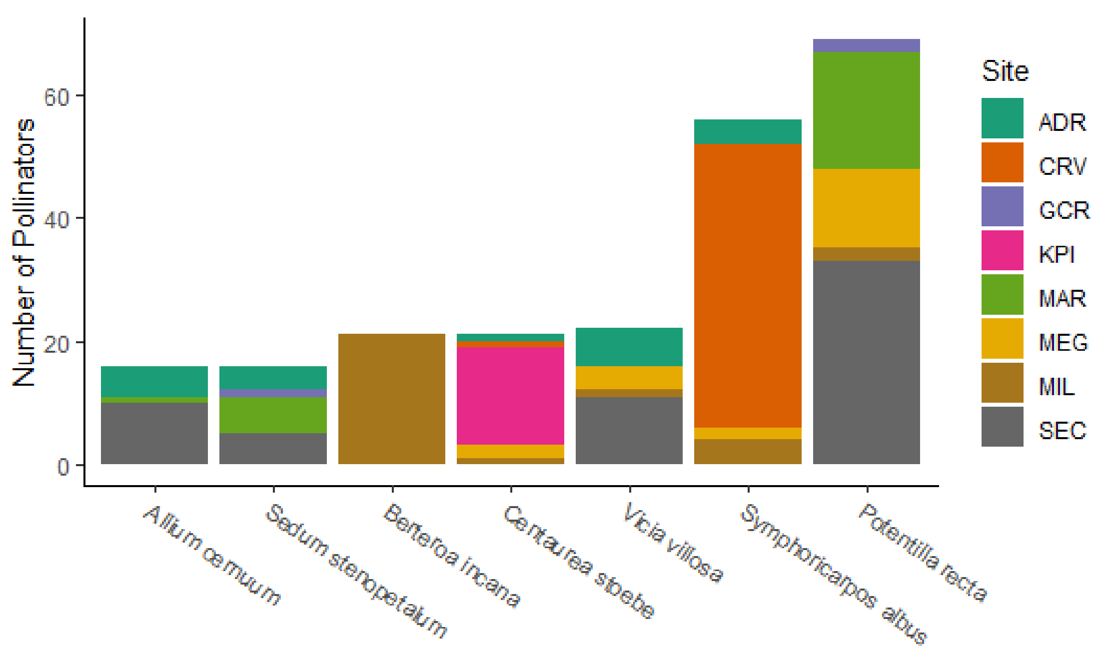

Figure 10. Shows which flowering plants pollinators were caught on during rounds 4 and 5 (late season), separated by species and site.

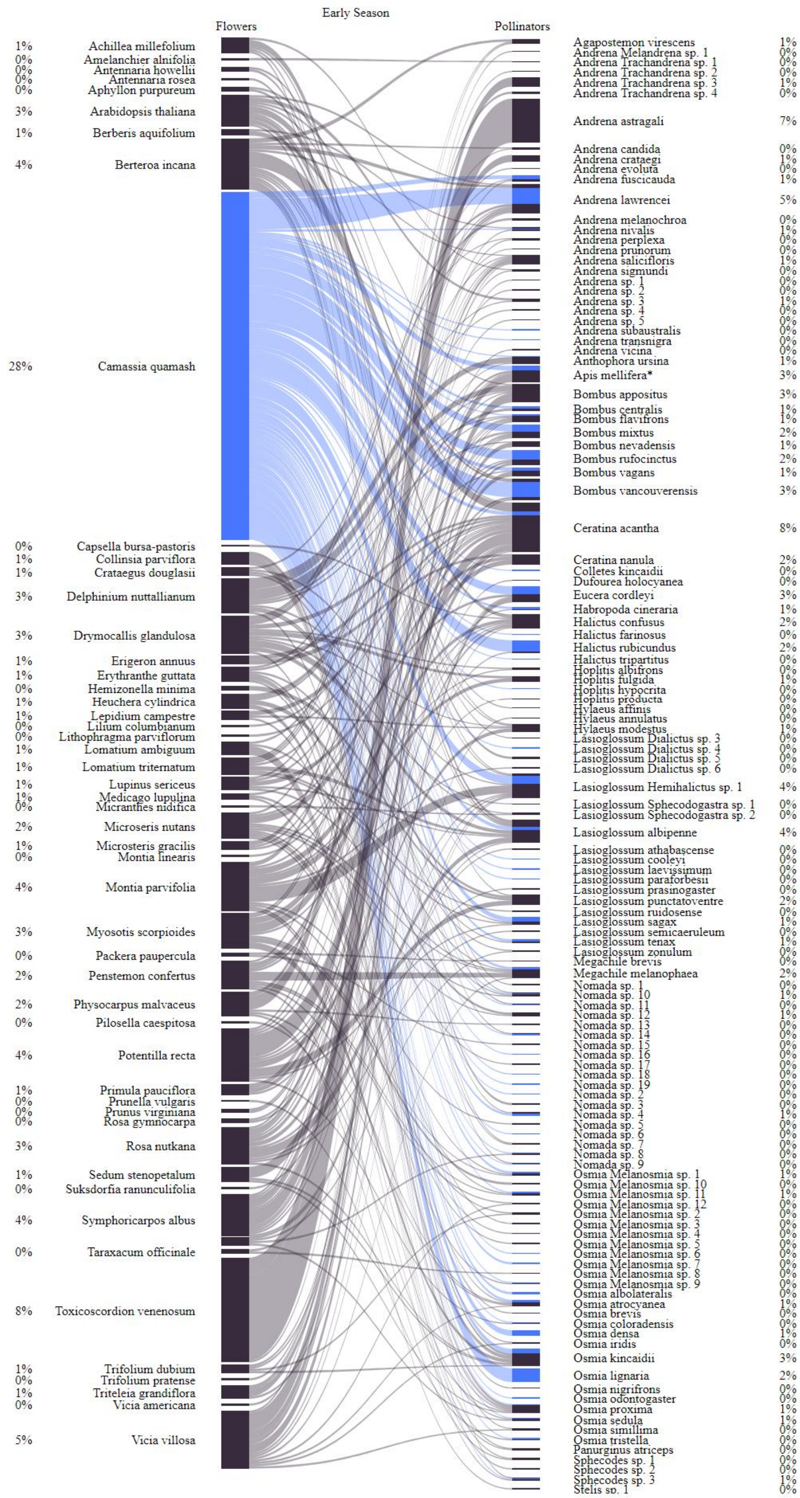

Figure 11. The network for sampling rounds 1 to 3, or early season sampling. Flowering plants are on the left, with pollinators on the right. Each interaction is shown by a connecting line between the plant and pollinator, with the size of the line proportional to the number of interactions. The bars and percentages represent the percentage of interactions attributed to a plant or pollinators out of the total interactions for all plants or all pollinators. Camas (C. quamash) is coloured in a similar colour to its flowers, and each pollinator bar on the right effectively represents what proportion of each pollinators plant interactions were with Camas. An asterisk next to a pollinator name indicates that the species is introduced

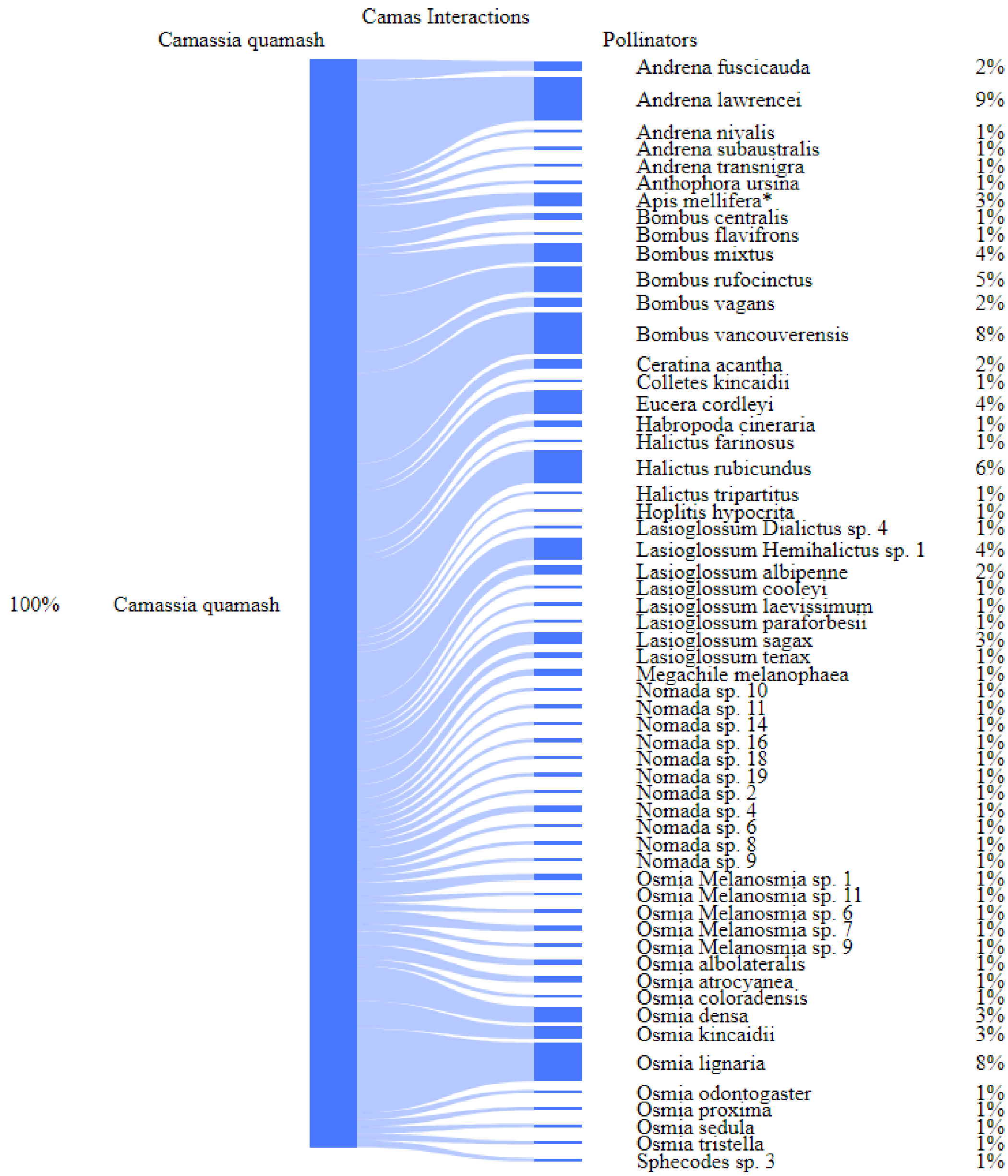

Figure 12. Shows species and morphospecies of bees that visit camas and the proportion of total visits attributable to each bee species. An asterisk next to a bee name indicates the species is introduced.

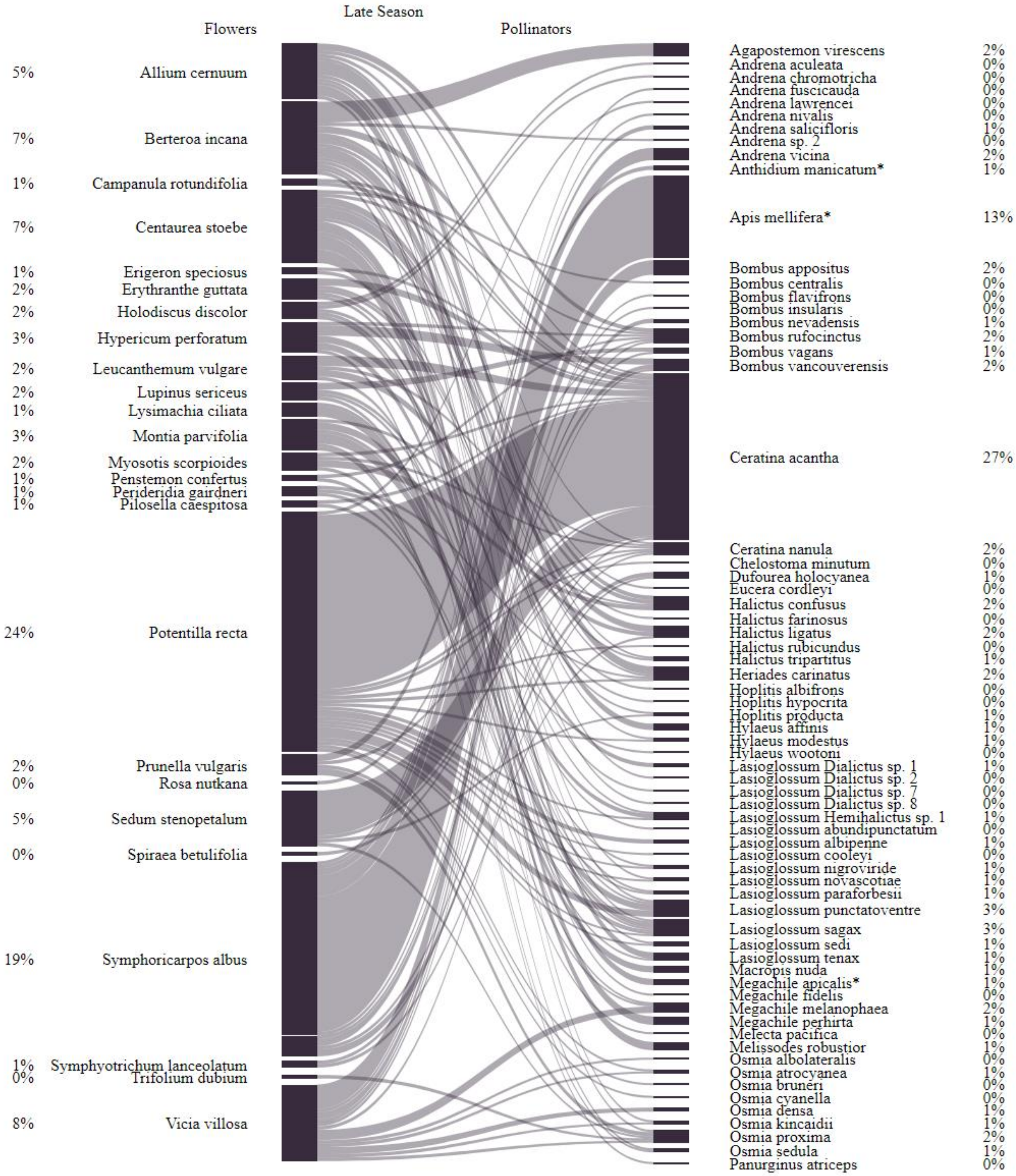

Figure 13. The network for sampling rounds 4 and 5, or late season sampling. Flowering plants are on the left, with pollinators on the right. Each interaction is shown by a connecting line between the plant and pollinator, with the size of the line proportional t to the number of interactions. The bars and percentages represent the percentage of interactions attributed to a plant or pollinators out of the total interactions for all plants or all pollinators. An asterisk next to a pollinator name indicates that pollinator is an introduced species.

5.5 Soils

In the fall of 2021, six locations from the Kootenay Camas Project were identified for soil pit descriptions and classifications. Representative sites within the selected camas meadows were identified for soil pit description based on the surrounding site attributes. Soil pits were dug to 60 cm, where soil depth permitted. Data were collected on BC Ministry of Forest and Range Ecosystem Field Form (FS822) and followed provincial standards and codes (BCMOFR 2015). All appropriate fields on the site and soils cards were filled in at each site; soil and humus structure were excluded. Field observations impacting site and soil factors were recorded in the notes section.

Field data cards were scanned and are contained in Digital Appendix I (KNPS_Soils_2021_Scanned.pdf). These data were entered into VPro, BC's provincial ecosystem software, and exported to Excel for ease of summary (Digital Appendix II: KNPS_Soils_2021.xlsx).

Table 4 summarizes the site characteristics for each plot. Of the 6 plots, 5 occurred within the Very Dry Warm Interior Cedar-Hemlock (ICHxw) and one occurred within the West Kootenay Dry Warm Interior Cedar-Hemlock (ICHdw1) (MacKillop and Ehman 2016). Elevation, slope, aspect, and meso slope position varied with site. Locations are contained within the Digital Appendices (I and II).

Table 4. Key site features of camas meadow sites sampled fall, 2021.

Plot Number	Field Location	BEC Subzone	Elevation (m)	Slope (%)	Aspect (Degrees)	Meso Slope Position
01KNP21	MAR	ICHxw	608	27	164	Mid-slope
02KNP21	GCR	ICHdw1	1129	20	180	Mid-slope
03KNP21	KPI	ICHxw	423	16	199	Toe
04KNP21	KPI	ICHxw	424	3	999	Level
05KNP21	CRV	ICHxw	479	0	999	Level
06KNP21	OXB	ICHxw	420	0	999	Level

Soil moisture regimes (SMR) varied from xeric (SMR 1) to subhygric (SMR 5) (Table 5; BCMOFR 2020). Soil nutrient regimes ranges from Medium (C) to Rich (D). Sites occurred on shallow, weathered-bedrock soils with Orthic Humic Regosols (O.HR) or on deep, fluvial-derived soils with Gleyed Melanic Brunisols (GL.MB) or Orthic Melanic Brunisols (O.MB). Humic enriched A-layer horizons (Ah) of variable depths was found at all locations. Additional site and soil data are contained in Digital Appendices I and II.

Table 5. Key soil features of the camas meadow sites, fall 2021.

Plot Number	SMR	SNR	Soil Texture	Overall Soil Depth (cm)	Ah Depth (cm)	Parent Material	Soil Classification
01KNP21	1	C	SL	19	18	Weathered bedrock	O.HR
02KNP21	1	C	SL	9	9	Weathered bedrock	O.HR
03KNP21	5	D	SL	>100	5	Fluvial	GL.MB
04KNP21	4	C	SL	>100	7	Fluvial	O.MB
05KNP21	3	C	SL	>100	15	Fluvial	O.MB
06KNP21	5	C	SL	>100	15	Fluvial	GL.MB

6 Discussion

We observed 92 species and 56 morphospecies of bees across 26 genera, and 6 families, an approximately 75% increase from last year's total of 84 combined species and morphospecies. These bees occurred across eight sites, visiting 64 flowering plant species. However, the rarefaction analysis revealed that more sampling is likely necessary to quantify the true diversity of bee species occurring at these sites, and especially to quantify the relationships between individual flower species and pollinators and vice versa. Overall, in 2020 and 2021, 107 unique bee species have been detected in camas meadows, with an additional number that were only identifiable to morphospecies.

6.1 Logger data

As described in Section 5.1, working with temperature loggers is challenging. However, they have value in collecting local, high resolution temperature data for unique habitat patches (Fawcett et al. 2019).

This data is necessary when comparing sites that differ in growing conditions, such as differences in temperature and weather that occur over elevational or other environmental gradients. Growing degree days (GDD) measure the heat accumulation over a season, and were developed to predict timing of agricultural events, such as a pest reaching adulthood, or onset of crop flowering (Wilson & Barnett, 1983). GDD have also been used to explain global change trends, with more GDD related to earlier phenological events (Xu et al. 2016). Elevation gradients have been suggested as "natural experiments" that can provide information about what to expect under global change (Rasmann et al. 2013). By computing GDD, temperature loggers can be used to quantify differences across the ~700m elevation gradient camas meadows occur across in the Kootenays. These differences matter because experimental increases in temperature (1.5 C) corresponding to the minimum expected due to global change, have been shown to alter flower availability, plant-pollinator network metrics, and plant reproduction (Moss & Evans, 2022). Any relationship changes in plant and pollinator metrics explainable by temperature changes across elevation could be used to provide an idea of how camas meadows will be expected to respond to changes in climate.

6.2 Plant data

Sites were found to support a diverse community of flowering plants in addition to *C. quamash.* Transects are a rigorous sampling method necessary for repeatability and making scientific inferences, but they may not detect all the diversity present, particularly species that are not distributed uniformly throughout a site, or those that occur at site edges (Gillison & Brewer, 1985 & Vermeersch & Van Kerckvoorde, 2016). This is particularly noticeable in camas meadows, as the hydrology and site conditions that allow camas to be present exclude species only found in the surrounding drier habitat (e.g., *Apocynum androsaemifolium* or *Lonicera ciliosa*). It should also be noted that sampling began at the end of peak bloom at low elevation sites, so early plant data may have underestimated early season abundance and diversity at such sites. Goose Creek Road was the best sampled site, as sampling began several weeks before peak bloom. This was possible because its phenology was several weeks later than the lowest elevation sites, likely due to a decrease in GDD or delayed snowmelt at higher elevation.

Peak bloom in camas meadows occurred relatively early in spring, coinciding with the flowering time of camas itself. Even though peak bloom was early, a succession of flowering plants bloomed after the peak, such that even within the meadows, there was floral availability throughout the sampling period. These sequential floral resources are known to be important for bee visitation to flowers (Guezen &

Forrest, 2021 & Russo et al. 2013). Further investigation is needed to quantify this overlap at each site over the season, and to determine whether floral resources were present in sufficient abundance and diversity to support high pollinator diversity.

6.3 Pollinator data

Blue vane (BV) trap sampling can passively sample sites with low human input (excluding post collection processing and identification). This is useful to provide a baseline of pollinator species present at a site. However, BV traps provide no information on the floral use or requirements of collected pollinators. BV trapping from the previous year provides a baseline of species present at sites and seems to have detected species that net sampling did not. Despite lower quantities of bee specimens collected via net sampling (n = 788 for net sampling vs. n = 1440 for BV traps), specimens from net sampling consisted of many additional species (n = 92 vs. n = 48) and morphospecies (n = 56 vs. n = 36). These increases were not confined only to species, the current year's sampling detected several more genera spread across existing families, and even detected a member of an additional bee family, which was only recently found for the first time in the Kootenay region (Best, 2018). Some of this increase in species may be due to sampling a greater number of sites (8 vs. 6 in the previous year), as well as year to year variation in plant and pollinator communities, which is well documented and can be significant (Flo et al. 2018). However, traps may detect different species than net sampling and differences will vary based on study system (Gibbs et al. 2017). It may then be possible that the species making up most visits to flowers in camas meadows tend to be less attracted to blue vanes and are better detected with net sampling.

Sampling intensity relative to estimated species was comparable to the previous year, although it appears that due to sampling after peak bloom at the lowest elevation site (kp'itl'els), sampling intensity was poorer at that site than the previous year. Sites sampled in both years had similar estimated species present, indicating that species estimates are relatively robust. With floral visitation data, estimates of pollinator species visiting individual plants were also generated. These estimates indicated that even for the best sampled plants, sampling intensity was not high enough to detect most species visiting each flowering plant. This is a challenge of sampling a community of plants and pollinators, and it may be necessary to sample up to 200 visiting pollinators per plant to get a complete picture of its visitors as estimated from rarefaction curves (Best 2018). This is complicated by some flowering plants having very low visitation rates, such that collecting sufficient pollinators while sampling all flowers at a site equally would involve large personnel investment and even larger overall pollinator sample size. However, this level of detail is likely not required for guiding conservation and restoration, which can be achieved using plant-pollinator networks that account for visitation rate and other factors.

Species occurrence data for 1529 pinned specimens collected from BV traps and nets in Year 1 (2020) of this study are publicly available on the Global Biodiversity Information Facility, with the data resource housed at, and served from Canadensys' Integrated Publishing Toolkit (Best et al. 2022).

6.4 Plant-pollinator Interaction data

Greater numbers of pollinators were caught during the early season, which may be due to the greater availability of floral resources relative to the later season. There were also more species of both bees and plants involved in the early season, and late season plants, particularly those that were visited the most, tended to be introduced species. In camas meadows, moisture levels may drive this distribution, with low moisture levels a limiting factor later in the season. This may result in the apparent bias of camas meadows towards supporting spring species, both plants and bees. Many solitary bees are known to be active over a short period of time that coincides with abundant floral resources (Danforth et al. 2019), so the greater number of bee species during the early season coinciding with high floral resource availability is not particularly surprising, especially for solitary bee genera such as *Osmia* and *Andrena*. However, bees that fly over the entire season such as *Bombus* (bumble bees) and make up a significant portion of visits to both camas and other plants in camas meadows, are known to require resources over the entire season. In *Bombus,* landscape structure (amount of agricultural or disturbed habitat) may be more important than floral resource availability, possibly due to their ability to increase travel distances up to 1 km to collect resources, though this ability may not be consistent across species (Liczner & Colla, 2020, Redhead et al. 2016). In camas meadows, introduced plants provide relatively abundant local floral resources to such species during the late season, which may lead to unintended consequences if restoration actions remove them (as in Carvalheiro et al. 2008). This dependence on introduced species has been noted as a concern in networks, with introduced, generalist species attracting pollinators that then become dependent on them, to the detriment of both native plants and network stability (Aizen et al. 2008). The late season network appears to suffer from this problem, with introduced species interacting with many pollinators each, and pollinators interacting with relatively few native species. It may then be necessary to restore not just camas meadows and the plant species within them by removing invasive species, but also restoring nearby areas that provide habitat for late flowering native plants. This could result in restored camas meadows both supporting a community of diverse and abundant native flowering plants plus their associated pollinators, as well as containing plant-pollinator interaction networks that possess greater stability and resilience. More investigation is necessary to quantify the overlap between early and late season bees and the degree to which introduced plants are supporting bees that are key to camas reproduction. It is also important to have more than one year worth of data, as climatic events such as the early summer heat domes may have had disproportionate impacts on native compared to introduced species (Welshofer et al. 2018).

Camas clearly supported the most pollinators, having both the greatest number of visits and interactions with bee species. This demonstrates its importance to bee communities and the value in ensuring existing camas meadows remain intact and that degraded meadows are restored. Also of interest is the presence of a rare, near mutually specialized plant-pollinator relationship between *Andrena astragali* and *Toxicoscordion venenosum*, as described in Cane (2018), with each species interacting almost exclusively with the other. Our data followed a similar pattern, with *A. astragali* only visiting *T. venenosum,* while most of the time, *T. venenosum* was visited by *A. astragali,* with *Andrena salicifloris* and a morphospecies of *Andrena* occasionally observed as well.

Such keystone (camas supporting/supported by many pollinators) and specialized (*A. astragali* & *T. venenosum)* interactions are important to consider when making management or restoration decisions, as missing plants may result in missing pollinators, and missing pollinators may prevent plants from reproducing successfully as self-sustaining populations (Burd, 1994, Ashman et al. 2004). Camas is relatively unique in that it is both a plant of conservation interest, and a generalist plant that acts as a network "hub". A network hub connects many species that would otherwise be unconnected, only interacting with separate species or groups of species. It is likely that loss of hub plant species would lead to loss of the pollinators that rely on them, which would subsequently decrease reproduction of other plants present that rely on the lost pollinators, likely leading to network collapse (Tylianakis et al. 2010 & Elle et al. 2012). This means that camas is a primary concern for restoration, as it facilitates a diverse pollinator community that in turn supports other plants. Camas alone cannot support a complete community of pollinators however, and in the event of a failed or poor year of camas flowering, other plants are necessary to support pollinators. Networks can be used to identify these plants which also support camas pollinators, as well as to identify plants which are supporting unique pollinators that would otherwise not be present in camas meadows, such as the specialist bee *Macropis nuda,* that is supported by *Lysimachia ciliata*. One other aspect of networks that can be useful is information on the phenology of interactions. Periods of distinct floral resources can be identified, and at each site, management can ensure that adequate floral resources are provided during each period (e.g., Russo et al. 2013). Elle et al. (2012) describe the considerations necessary when using networks to inform conservation actions (like restoration). These considerations include how to remove introduced species without disrupting the network as discussed above, whether suitable pollinator nesting habitat is present nearby, whether global change will disrupt timing or synchrony of interaction partner activities, and finally to what degree observed bee visits correspond to increased plant reproductive output. These are all future directions to pursue using network data.

Overall, networks can help to make sense of the complex interactions that occur between the diverse communities of species that are present in camas meadows, and this information can be used to inform restoration decisions, such as priority plants to support as many pollinators as possible, who in turn support plant reproduction.

6.5 Soils

Sites sampled occur on two unique types: shallow soils over bedrock and fluvial-derived soils. Sites are summarized in these groups.

6.5.1 Shallow-Soils

Field locations Marsden (01KNP21) and Goose Creek (02KNP21) occur on shallow soils over bedrock (Table 5). Rich Ah-layers and high pH measurements contribute to high nutrients content within the limited soil profile of these meadows. Although these soils dry out quickly due to their shallow depth, moisture during spring and after rain events is held in the rooting area and highly available to plants when present (E McKenzie, pers. comm. 2022)[1]. Water was observed and noted on the rock surface at the Goose Creek site (Digital Appendix I: KNPS_Soils.PDF).

The shallow soils of the Marsden and Goose Creek sites, make these areas highly sensitive. Erosion-causing activities can be challenging to reverse where soil is already limited. Trail construction, as noted at Goose Creek will likely be difficult to rehabilitate (Digital Appendices I and II). Although vegetation data was not collected, these sites were noted as being non-forested. Lack of shade in these areas may increase the risk of invasive species, where soil depth permits.

Both Marsden Face and Goose Creek camas meadow s occur in complex with other rare and at-risk ecosystems. Areas of Marsden Face are classified as a non-forested brushland (Gb): Gb03 Ninebark – Oceanspray – Bluebunch wheatgrass (MacKillop and Ehman 2016). This site association is currently in the process of being ranked by the Ministry of Environment Conservation Data Centre (CDC) and will likely be red-listed very soon (E. Cameron, pers. comm, 2022) Portions of the Goose Creek site can also be classified as a non-forest rock-outcrop: Ro09.2 (*Rock outcrop*) Saskatoon – Poverty oatgrass – Rock-moss – Clad lichen (MacKillop and Ehman 2016). Although this site association is not listed or ranked with the CDC currently, it is a sensitive ecosystem with numerous rare and at-risk plants and animals associated with its habitat features.

6.5.2 Fluvial-Derived Sites

Sites occurring at kp'itl'els (02KNP21, 03KNP21), Crescent Valley (05KNP21), and Oxbow Island (06KNP21) occur on rich, fluvial-derived soils (Table 5). The 2 sites closest to the river (02KNP21 and 06KNP21) have mottles and gleying within the top 60 cm of the soil profile; the other 2 may have mottles deeper in the soil profile. These soils are rich in nature with high pH, Ah-horizons, and mottling where it occurs.

Soils found in these parent materials are also sensitive to erosion due to their saturation in the spring or at high water times. Level, floodplain areas such as kp'itl'els, which was previously accessible to motorized vehicles, shows long term effects of rutting (personal observations, spring 2021).

Camas meadows found on these sites also occur in complex with rare and at-risk ecosystems (MacKillop and Ehman 2016). Of note, the Fm01 (Middle bench floodplain) Cottonwood – Snowberry – Rose is considered a red-listed ecosystem in BC (BC Conservation Data Centre 2022). Other non-forested and related ecosystem occurring in complex with these floodplain sites could include wetland ecosystems, low bench floodplain (Fl) and active channel floodplains (Fa).

7 Conclusions

The current year's results paint a picture of an ecological community that is as rich in ecological interactions as it is in plants and pollinators. This provides further support for last year's results which highlighted the ecological value of camas meadows. Additionally, soil sampling found that all six camas meadow sites sampled occur on sensitive soil types and in complex with rare at at-risk ecosystems. Although camas meadows do not currently fit within the BC's provincial classification system, it is clear they need to be recognized for their ecological uniqueness and sensitivity. These meadows do however show impacts of many years of human disturbance and absence of First Nations stewardship, with late season flora containing many introduced and invasive species, which present a complex challenge to reverse, due to their current level of integration in pollination networks. We are ultimately piecing together many pieces of the ecological puzzle of these sites with our research. We have plant community information, pollinator community information, plant and pollinator network information, some phenology information, and habitat information, both involving soil conditions and temperatures experienced at each site. Collecting an additional season of information in the coming year will improve resolution and confidence in the results of previous years, and additional experiments are planned to evaluate camas seed set in relation to several aspects of pollination, with the goal of evaluating whether even the most intact sites are functioning at maximum pollination capacity.

8 Recommendations

Several factors influencing the organization and function of Camas Meadow communities remain largely unknown. Additionally, increasing the resolution of the participants and their interactions are expected to improve our knowledge on species, function, resiliency, and decision-making in conservation, and restoration.

1. **Seed set.** It's currently not well-known what variables contribute to successful camas seed set, such as whether reproduction is limited by the abundance of pollinators or resource availability, and to what degree pollinator visits, or the identity of visiting pollinators relate to reproductive output. Reproduction may also be limited by temperature, precipitation, wind, and other climatic factors.
2. **Phenological Mismatch.** There is a growing body of evidence for phenological mismatch between flowering plants and their insect pollinators, particularly in montane systems. Climate change is certain to change the temperatures and precipitation patterns experienced by camas meadows, however it is unclear what impacts these will have on the timing of camas bloom and activity of its associated pollinators. It is possible timing shifts will not be synchronous, in which case plants will be pollinated poorly, and pollinators will miss out on important food sources.
3. **The Taxonomic Impediment.** The western North American Bee fauna is the richest in the world, and this extends into the southern interior of British Columbia where we have more than half of all known species recorded for Canada. New provincial and national species records are not uncommon, but many genera are lacking contemporary taxonomic resources to aid in their identification. COI DNA barcoding has proven an invaluable tool when working with this fauna. The production of sequence data for morphospecies would clarify species identity and associate

their sexes. This would improve the accuracy of community analysis and provide additional occurrence data for particularly poorly known bee species from western Canada.

4. **Data Quantity.** These biodiverse communities consist of many participants. Sampling is often limited by the number of personnel, the number of sites, the number of flowering plant species, weather, and other landscape events. Pooling data for our sites demonstrated that we are sampling the pollinators reasonably well, generating estimates of species richness with modest error. However, much more work is needed to accurately describe the pollinator communities of key flowering plant species and to quantitatively identify additional important network hubs.

The baseline data of bee and plant communities documented here can provide a robust argument for conservation and restoration of West Kootenay camas meadows. We recommend the following:

1. Protect existing camas meadows from further degradation by engaging both traditional ecological knowledge and western science.

2. Use Mount Sentinel and kp'itl'els as reference sites for restoration planning, providing information on appropriate plant species for re-introduction to other camas sites.

3. Work collaboratively with the Colville Confederated Tribes to re-introduce traditional land management practices, including camas cultivation methods.

4. Develop restoration plans that include different ways of knowing to deepen the pathway toward the ecocultural restoration of plant-pollinator-people relationships in West Kootenay camas meadows.

9 Acknowledgements

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11 Appendix A

11.1 Group 1 Flowering Plant Species

Achillea millefolium	*Lomatium triternatum*
Allium cernuum	*Lupinus sericeus*
Amelanchier alnifolia	*Lysimachia ciliata*
Antennaria howellii	*Maianthemum stellatum*
Antennaria luzuloides	*Melilotus albus*
Antennaria rosea	*Micranthes nidifica*
Aphyllon purpureum	*Microseris nutans*
Berberis aquifolium	*Montia linearis*
Berteroa incana	*Montia parvifolia*
Camassia quamash	*Myosotis scorpioides*
Campanula rotundifolia	*Packera paupercula*
Castilleja hispida	*Penstemon confertus*
Ceanothus sanguineus	*Perideridia gairdneri*
Centaurea stoebe	*Philadelphus lewisii*
Collinsia parviflora	*Physocarpus malvaceus*
Collomia linearis	*Pilosella caespitosa*
Crataegus douglasii	*Potentilla argentea*
Delphinium nuttallianum	*Potentilla recta*
Drymocallis glandulosa	*Primula pauciflora*
Erodium cicutarium	*Prunella vulgaris*
Erythranthe guttata	*Prunus virginiana*
Fragaria vesca	*Rosa nutkana*
Fragaria virginiana	*Sedum stenopetalum*
Heuchera cylindrica	*Suksdorfia ranunculifolia*
Hieracium scouleri	*Symphoricarpos albus*
Holodiscus discolor	*Symphyotrichum lanceolatum*
Hypericum perforatum	*Taraxacum officinale*
Lamium amplexicaule	*Toxicoscordion venenosum*
Leucanthemum vulgare	*Tragopogon dubius*
Lewisia triphylla	*Trifolium pratense*
Lilium columbianum	*Triteleia grandiflora*
Lithophragma parviflorum	*Vicia villosa*
Lomatium ambiguum	

Group 2 Flowering Plant Species

Agoseris heterophylla	*Myosotis stricta*
Arabidopsis thaliana	*Myosotis verna*
Arenaria serpyllifolia	*Plantago lanceolata*
Capsella bursa-pastoris	*Rumex acetosella*
Cerastium fontanum	*Rumex crispus*
Galium aparine	*Scleranthus annuus*
Galium palustre	*Sisymbrium altissimum*
Geranium pusillum	*Thlaspi arvense*
Hemizonella minima	*Trifolium arvense*
Lepidium campestre	*Trifolium aureum*
Madia gracilis	*Trifolium dubium*
Medicago lupulina	*Valerianella locusta*
Microsteris gracilis	*Veronica arvensis*
Myosotis arvensis	*Veronica officinalis*
Myosotis discolor	

12 Appendix B

12.1 Checklist of Bee Species from 2020 and 2021 sampling years, along with their BC conservation status, COSEWIC assessment, and origin (N=Native). List excludes morphospecies.

Family	*Species*	2020	2021	BC Status	COSEWIC	Native Status
Andrenidae	*Andrena aculeata*		X	SU		N
	Andrena astragali		X	S4S5		N
	Andrena candida		X	S5		N
	Andrena chromotricha		X			
	Andrena crataegi		X	S5		N
	Andrena evoluta		X	S2S4		N
	Andrena fuscicauda		X	S2S3		N
	Andrena lawrencei		X	S3S5		N
	Andrena melanochroa		X	S3S4		N
	Andrena nigrocaerulea	X		S5		N
	Andrena nivalis	X	X	S5		N
	Andrena perplexa		X	SU		N
	Andrena prunorum	X	X	S5		N
	Andrena salicifloris		X	S3S4		N
	Andrena sigmundi		X	S3S4		N
	Andrena subaustralis		X	S3S4		N
	Andrena transnigra	X	X			
	Andrena vicina		X	S5		N
	Panurginus atriceps		X	S5		N
Apidae	*Agapostemon virescens*	X	X	S5		N
	Anthophora ursina	X	X	S3S4		N
	Apis mellifera	X	X	SNA		Exotic
	Bombus appositus	X	X	S5		N
	Bombus bifarius	X		S5		N
	Bombus centralis	X	X	S5		N
	Bombus flavidus	X		S3S4		N
	Bombus flavifrons	X	X	S5		N
	Bombus insularis	X	X	S4?		N
	Bombus melanopygus	X		S5		N
	Bombus mixtus	X	X	S5		N
	Bombus nevadensis	X	X	S5		N
	Bombus occidentalis	X		S2S4	Threatened	N
	Bombus rufocinctus	X	X	S5		N
	Bombus vagans	X	X	S5		N
	Bombus vancouverensis		X			
	Ceratina acantha	X	X	S5		N
	Ceratina nanula	X	X	S4S5		N

Family	*Species*	2020	2021	BC Status	COSEWIC	Native Status
	Dufourea holocyanea		X	S3S4		N
	Eucera cordleyi	X	X	SU		N
	Habropoda cineraria	X	X	S5		Unknown/ Undetermined
	Halictus confusus		X	S5		N
	Halictus farinosus	X	X	S4S5		Unknown/ Undetermined
	Halictus ligatus	X	X	S5		N
	Halictus rubicundus	X	X	S5		N
	Halictus tripartitus	X	X	S4S5		N
	Hylaeus modestus		X	S5		N
	Hylaeus wootoni		X	SU		N
	Melecta pacifica	X	X	S2S3		N
	Melecta thoracica	X		S2S3		N
	Melissodes robustior		X			
Colletidae	*Colletes compactus*	X		S4		N
	Colletes kincaidii		X	S5		N
	Hylaeus affinis		X	S5		N
	Hylaeus annulatus		X	S5		N
Halictidae	*Lasioglossum abundipunctatum*		X			
	Lasioglossum albipenne		X	S5		N
	Lasioglossum athabascense		X	S5		Unknown/ Undetermined
	Lasioglossum cooleyi		X	S5		N
	Lasioglossum cressonii	X				
	Lasioglossum egregium	X		SU		N
	Lasioglossum laevissimum		X	S5		N
	Lasioglossum leucozonium	X				
	Lasioglossum mellipes	X		SU		N
	Lasioglossum nigroviride	X	X	S5		N
	Lasioglossum novascotiae		X	S5		N
	Lasioglossum paraforbesii		X			
	Lasioglossum prasinogaster		X	S5		N
	Lasioglossum punctatoventre		X	SU		N
	Lasioglossum ruidosense		X	S5		N
	Lasioglossum sagax		X	S5		N
	Lasioglossum sedi		X	S2S4		N

Family	*Species*	2020	2021	BC Status	COSEWIC	Native Status
	Lasioglossum semicaeruleum		X			N
	Lasioglossum tenax		X	S5		N
	Lasioglossum zonulum	X	X	SNA		Exotic
Megachilidae	*Anthidium manicatum*		X	SNA		Exotic
	Chelostoma minutum		X	SU		N
	Coelioxys sodalis	X		S3S4		N
	Heriades carinatus		X	S5		N
	Hoplitis albifrons		X	S5		N
	Hoplitis fulgida		X	S5		N
	Hoplitis hypocrita	X	X	SU		N
	Hoplitis producta		X	S5		N
	Megachile apicalis		X	SNA		Exotic
	Megachile brevis		X	S5		N
	Megachile fidelis		X	S3		N
	Megachile melanophaea	X	X	S5		N
	Megachile perihirta	X	X	S5		N
	Osmia albolateralis		X	S5		N
	Osmia atrocyanea	X	X	SU		N
	Osmia brevis		X	SU		N
	Osmia bruneri	X	X	SU		N
	Osmia californica	X		S4S5		N
	Osmia coloradensis		X	S5		N
	Osmia cyanella		X	SU		N
	Osmia densa	X	X	S5		N
	Osmia iridis		X			
	Osmia kincaidii		X	SU		N
	Osmia lignaria	X	X	S5		N
	Osmia longula	X		S5		N
	Osmia marginipennis	X		SU		N
	Osmia nigrifrons		X	S5		N
	Osmia odontogaster		X	S5		N
	Osmia proxima		X	S5		N
	Osmia sedula		X	S5		N
	Osmia simillima	X	X	S5		N
	Osmia tristella		X	S5		N
Melittidae	*Macropis nuda*		X	S3		N

13 Appendix C

13.1 All species and morphospecies detected in the 2021 samples separated by family

Family	Species/Morphospecies
	Andrena aculeata
	Andrena astragali
	Andrena candida
	Andrena chromotricha
	Andrena crataegi
	Andrena evoluta
	Andrena fuscicauda
	Andrena lawrencei
	Andrena Melandrena sp. 1
	Andrena melanochroa
	Andrena nivalis
	Andrena perplexa
	Andrena prunorum
	Andrena salicifloris
	Andrena sigmundi
	Andrena sp. 1
	Andrena sp. 2
	Andrena sp. 3
	Andrena sp. 4
	Andrena sp. 5
	Andrena subaustralis
	Andrena Trachandrena sp. 1
	Andrena Trachandrena sp. 2
	Andrena Trachandrena sp. 3
	Andrena Trachandrena sp. 4
	Andrena transnigra
	Andrena vicina
Andrenidae	*Panurginus atriceps*
	Anthophora ursina
	Apis mellifera
Apidae	*Bombus appositus*

	Bombus centralis
	Bombus flavifrons
	Bombus insularis
	Bombus mixtus
	Bombus nevadensis
	Bombus rufocinctus
	Bombus vagans
	Bombus vancouverensis
	Ceratina acantha
	Ceratina nanula
	Eucera cordleyi
	Habropoda cineraria
	Melecta pacifica
	Melissodes robustior
	Nomada sp. 1
	Nomada sp. 10
	Nomada sp. 11
	Nomada sp. 12
	Nomada sp. 13
	Nomada sp. 14
	Nomada sp. 15
	Nomada sp. 16
	Nomada sp. 17
	Nomada sp. 18
	Nomada sp. 19
	Nomada sp. 2
	Nomada sp. 3
	Nomada sp. 4
	Nomada sp. 5
	Nomada sp. 6
	Nomada sp. 7
	Nomada sp. 8
	Nomada sp. 9
Colletidae	*Colletes kincaidii*
	Hylaeus affinis
	Hylaeus annulatus
	Hylaeus modestus

	Hylaeus wootoni
	Agapostemon virescens
	Dufourea holocyanea
	Halictus confusus
	Halictus farinosus
	Halictus ligatus
	Halictus rubicundus
	Halictus tripartitus
	Lasioglossum abundipunctatum
	Lasioglossum albipenne
	Lasioglossum athabascense
	Lasioglossum cooleyi
	Lasioglossum Dialictus sp. 1
	Lasioglossum Dialictus sp. 2
	Lasioglossum Dialictus sp. 3
	Lasioglossum Dialictus sp. 4
	Lasioglossum Dialictus sp. 5
	Lasioglossum Dialictus sp. 6
	Lasioglossum Dialictus sp. 7
	Lasioglossum Dialictus sp. 8
	Lasioglossum Hemihalictus sp. 1
	Lasioglossum laevissimum
	Lasioglossum nigroviride
	Lasioglossum novascotiae
	Lasioglossum paraforbesii
	Lasioglossum prasinogaster
	Lasioglossum punctatoventre
	Lasioglossum ruidosense
	Lasioglossum sagax
	Lasioglossum sedi
	Lasioglossum semicaeruleum
	Lasioglossum Sphecodogastra sp. 1
	Lasioglossum Sphecodogastra sp. 2
	Lasioglossum tenax
	Lasioglossum zonulum
	Sphecodes sp. 1
Halictidae	*Sphecodes sp. 2*

	Sphecodes sp. 3
	Anthidium manicatum
	Chelostoma minutum
	Heriades carinatus
	Hoplitis albifrons
	Hoplitis fulgida
	Hoplitis hypocrita
	Hoplitis producta
	Megachile apicalis
	Megachile brevis
	Megachile fidelis
	Megachile melanophaea
	Megachile perihirta
	Osmia albolateralis
	Osmia atrocyanea
	Osmia brevis
	Osmia bruneri
	Osmia coloradensis
	Osmia cyanella
	Osmia densa
	Osmia iridis
	Osmia kincaidii
	Osmia lignaria
	Osmia Melanosmia sp. 1
	Osmia Melanosmia sp. 10
	Osmia Melanosmia sp. 11
	Osmia Melanosmia sp. 12
	Osmia Melanosmia sp. 2
	Osmia Melanosmia sp. 3
	Osmia Melanosmia sp. 4
	Osmia Melanosmia sp. 5
	Osmia Melanosmia sp. 6
	Osmia Melanosmia sp. 7
	Osmia Melanosmia sp. 8
	Osmia Melanosmia sp. 9
	Osmia nigrifrons
Megachilidae	*Osmia odontogaster*

	Osmia proxima
	Osmia sedula
	Osmia simillima
	Osmia tristella
	Stelis sp. 1
Melittidae	*Macropis nuda*

Digital Appendix I

Attached: KNPS_Soils_2021.xlsx

Group 2

Digital Appendix II

Attached: KNPS_Soils_2021_Scanned.pdf

ECOSYSTEM FIELD FORM

MINISTRY OF FORESTS AND RANGE
MINISTRY OF ENVIRONMENT

DATE Y	M	D	PLOT NO.
2021	10	01	01KNP21

PROJECT ID	FIELD NO.	SURVEYOR(S)
CAmas soils	01MAR21	T.E / A.E

SITE DESCRIPTION

LOCATION

GENERAL LOCATION: Marsden face FSR, West of Nelson BC on HWY 3A					
FOREST REGION/ DISTRICT: DKB	MAPSHEET:	UTM ZONE: 11	EAST: 4 7 3 1 5 5	NORTH: 5 4 8 3 4 3 4	ACCUR.(m): 5.00m
AIR PHOTO NO.:	X CO-ORD.:	Y CO-ORD.:	LAT.: 49.502940 N	LONG.: 117.370765 W	ECOSEC.:

SITE INFORMATION

PLOT REPRESENTING: Camas meadow on warm aspect, shallow soils

BGC UNIT: ICHxw	SITE SERIES:	REALM/ CLASS: Ro	TRANS./ DISTRIB.:	MAP UNIT:	
SMR: 1	SNR: C	SUCCESS STATUS: –	STRUCT. STAGE: 2/3a	STAND AGE: –	
ELEV.: 608.0 m	SLOPE: 27 %	ASPECT: 164 °	MESO SLOPE POS.: MD	SURFACE SHAPE: CV	MICROTOPOG.: sli

NOTES

site transitional between Ro and Gb03
bedrock outcrop with pockets of shallow soil

SITE DIAGRAM

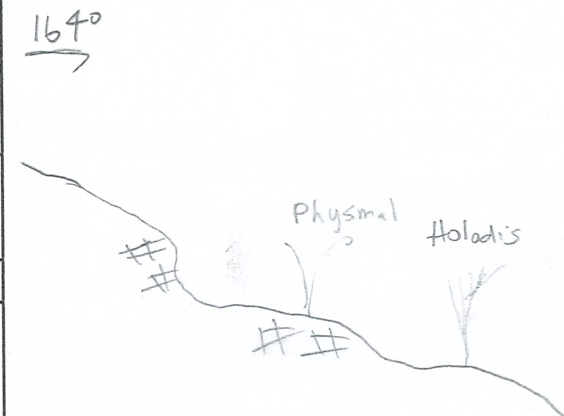

PHOTO:

SITE DIST.				EXPOS. TYPE	IN

SUBSTRATE (%)

ORG. MATTER	65	ROCKS	15
DEC. WOOD	0	MINERAL SOIL	0
BEDROCK	20	WATER	0

FS882 (1) HRE 2008/03

SOIL DESCRIPTION

GEOLOGY	BEDROCK gd	C. F. LITH. gd	**SURVEYOR(S)** TE AE	**PLOT NO.** 01KNP21
TERRAIN	TEXTURE 1 dzs 2	SURFICIAL MATERIAL 1 M 2 R	SURFACE EXPR. 1 xv 2 a	GEOMORPH. PROCESS 1 2
SOIL CLASS. O.HR	**HUMUS FORM** Null	PHASE	**HYDROGEO.** u	
ROOTING DEPTH 19 cm	ROOT RESTRICT. LAYER TYPE L		WATER SOURCE p	DRAINAGE r
R. Z. PART. SIZE KLS	DEPTH 19 cm		SEEPAGE NP cm	FLOOD RG. x

PROFILE DIAGRAM

ORGANIC HORIZONS/LAYERS

HOR/ LAYER	DEPTH	FABRIC STRUCTURE	FABRIC vPOST	MYCEL. AB.	FECAL AB.	ROOTS AB.	ROOTS SIZE	pH	COMMENTS (consistency, character, fauna, etc):
L	1-0			x	f				worms in Ah

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS G	C	S	TOTAL	SHAPE	ROOTS AB.	ROOTS SIZE	STRUCTURE CLASS	STRUCTURE KIND	pH	COMMENTS (mottles, clay films, effervesc., etc):
Ah	0-18	10yr3/2	7	SL	15	10	0	25	S	v/f	f	-	-	6.0	rich soil
R	-														rock

NOTES: soil of variable depth with bedrock in parts of plot

FS882 (2) HRE 2008/03

ECOSYSTEM FIELD FORM

MINISTRY OF FORESTS AND RANGE
MINISTRY OF ENVIRONMENT

DATE	Y	M	D
	21	01	02

PLOT NO. 02KNP21

PROJECT ID: Camas Soils

FIELD NO. 01GCR21

SURVEYOR(S): TE AE

SITE DESCRIPTION

LOCATION

GENERAL LOCATION: Approx. 3 km up Goose Creek FSR

FOREST REGION/ DISTRICT	MAPSHEET	UTM ZONE	EAST	NORTH	ACCUR.(m)
DKB		11	445787	5497243	5.00

AIR PHOTO NO.	X CO-ORD.	Y CO-ORD.	LAT.	LONG.	ECOSEC.
			49.429866 N	117.663672 W	

SITE INFORMATION

PLOT REPRESENTING: Camas meadow on warm aspect, shallow soils

BGC UNIT	SITE SERIES	REALM/ CLASS	TRANS./ DISTRIB.	MAP UNIT
ICHdw	9	R009		

SMR	SNR	SUCCESS STATUS	STRUCT. STAGE	STAND AGE
1	B	–	2	–

ELEV. (m)	SLOPE (%)	ASPECT (°)	MESO SLOPE POS.	SURFACE SHAPE	MICROTOPOG.
1129.8	20	180	MD (UP)	CV	–

NOTES

Areas of seepage on bedrock

Very shallow soils, bedrock below surface

SITE DIAGRAM

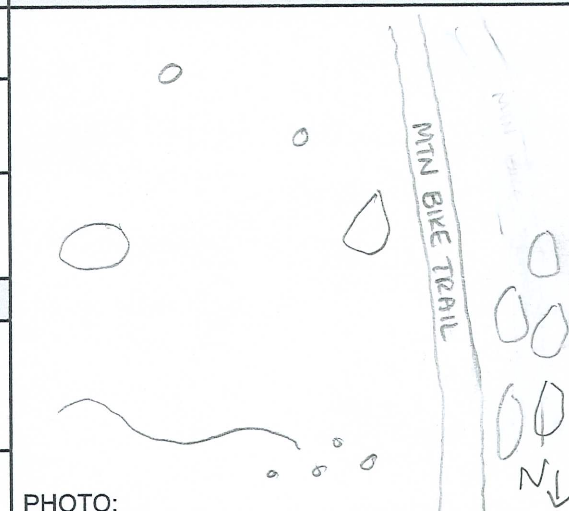

PHOTO:

SITE DIST.: R.t.ec

EXPOS. TYPE: IN

SUBSTRATE (%)

ORG. MATTER	65	ROCKS	10
DEC. WOOD	0	MINERAL SOIL	0
BEDROCK	25	WATER	0

FS882 (1) HRE 2008/03

SOIL DESCRIPTION

GEOLOGY	BEDROCK gr	C. F. LITH. gr	SURVEYOR(S) TE AE
PLOT NO. 02KNP21			
TERRAIN	TEXTURE 1 2S / 2	SURFICIAL MATERIAL 1 D / 2 R	SURFACE EXPR. 1 x / 2 a
GEOMORPH. PROCESS 1 / 2			
SOIL CLASS. O.HR*	HUMUS FORM N/A	PHASE	HYDROGEO. u
ROOTING DEPTH 9 cm	ROOT RESTRICT. LAYER: TYPE L	WATER SOURCE p(s)	DRAINAGE x
R. Z. PART. SIZE KL	DEPTH 8 cm	SEEPAGE 8 cm	FLOOD RG. x

PROFILE DIAGRAM

ORGANIC HORIZONS/LAYERS

HOR/ LAYER	DEPTH	FABRIC STRUCTURE	FABRIC vPOST	MYCEL. AB.	FECAL AB.	ROOTS AB.	ROOTS SIZE	pH	COMMENTS (consistency, character, fauna, etc):
S	0.5-0			x	x			/	moss, some grass litter

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS G	C	S	TOTAL	SHAPE	ROOTS AB.	ROOTS SIZE	STRUCTURE CLASS	STRUCTURE KIND	pH	COMMENTS (mottles, clay films, effervesc., etc):
Ah	0-9	10yr3/2	7	SL	10	0	0	10	A	v	f			6	rich Ah, seepage on rock
R															

NOTES: areas of seepage on rock * soil class is orthic humic regosol or non-soil (9cm)

FS882 (2) HRE 2008/03

ECOSYSTEM FIELD FORM

MINISTRY OF FORESTS AND RANGE
MINISTRY OF ENVIRONMENT

DATE Y	M	D	PLOT NO.
21	10	01	03KNP21

PROJECT ID	FIELD NO.	SURVEYOR(S)
Camas soils	01KP121	TE AE

SITE DESCRIPTION

LOCATION

GENERAL LOCATION: North bank of the Kootenay River, East from the Columbia-Kootenay river confluence

FOREST REGION/ DISTRICT	MAPSHEET	UTM ZONE	EAST	NORTH	ACCUR.(m)
DKB		11	452913	5462825	5.00 m

AIR PHOTO NO.	X CO-ORD.	Y CO-ORD.	LAT.	LONG.	ECOSEC.
			49.316341 N	117.647888 W	

SITE INFORMATION

PLOT REPRESENTING: Camas meadow on warm aspect, in flood plain

BGC UNIT	SITE SERIES	REALM/ CLASS	TRANS./ DISTRIB.	MAP UNIT
ICHxw		Ff		

SMR	SNR	SUCCESS STATUS	STRUCT. STAGE	STAND AGE
5	C	-	3a	-

ELEV.	SLOPE	ASPECT	MESO SLOPE POS.	SURFACE SHAPE	MICROTOPOG.
423.2 m	16 %	199 °	TO	CV.	

NOTES

SITE DIAGRAM

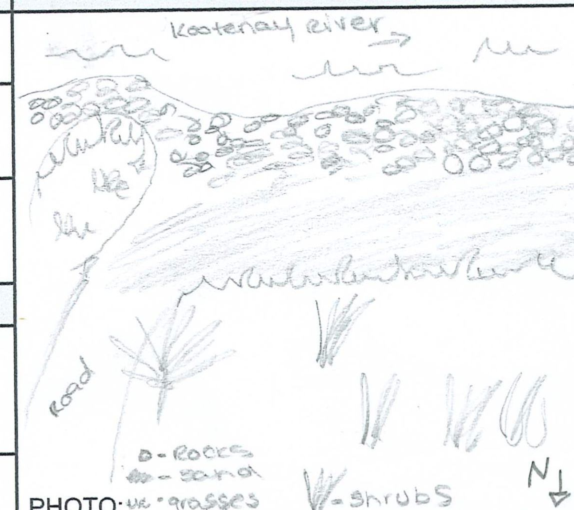

PHOTO:

SITE DIST.				EXPOS. TYPE		

SUBSTRATE (%)

ORG. MATTER	94	ROCKS	5
DEC. WOOD	0	MINERAL SOIL	1
BEDROCK	0	WATER	0

FS882 (1) HRE 2008/03

SOIL DESCRIPTION

GEOLOGY BEDROCK —	C. F. LITH. gd | mx	**SURVEYOR(S)** TE AE	**PLOT NO.** 03KNP21

TERRAIN TEXTURE 1 sg 2	SURFICIAL MATERIAL 1 F 2	SURFACE EXPR. 1 t 2	GEOMORPH. PROCESS 1 2
SOIL CLASS. GL.MB	**HUMUS FORM** —	PHASE	**HYDROGEO.** u
ROOTING DEPTH 45 cm	ROOT RESTRICT. LAYER TYPE NP	WATER SOURCE p(G)	DRAINAGE m
R. Z. PART. SIZE KLS	DEPTH — cm	SEEPAGE 0 cm	FLOOD RG. x

PROFILE DIAGRAM

ORGANIC HORIZONS/LAYERS

HOR/ LAYER	DEPTH	FABRIC STRUCTURE	FABRIC vPOST	MYCEL. AB.	FECAL AB.	ROOTS AB.	ROOTS SIZE	pH	COMMENTS (consistency, character, fauna, etc):
L				–	–				trace grass litter

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS G	C	S	TOTAL	SHAPE	ROOTS AB.	ROOTS SIZE	STRUCTURE CLASS	STRUCTURE KIND	pH	COMMENTS (mottles, clay films, effervesc., etc):
Ahj	0-5	10yr4/3	7	SL	10	5	0	15	R	f	v/m			6.5	
Bm1	5-19	10yr 5/3	7	SL	10	10	0	20	R	f	v			6	
Bm2	19-39	10yr 5/3	7	SL	20	15	0	35	R	f	vf			6	
Bgj	39-60+	7.5y 5/6	7	LS	40	15	0	55	R	f	v			–	mottled, very coarse

NOTES: mottles @ 40 cm

ECOSYSTEM FIELD FORM

MINISTRY OF FORESTS AND RANGE
MINISTRY OF ENVIRONMENT

DATE	Y	M	D	PLOT NO.
	21	10	01	04KWP21

PROJECT ID	FIELD NO.	SURVEYOR(S)
Camas soils	Ø1KP121	TE AE

SITE DESCRIPTION

LOCATION

GENERAL LOCATION: in a stand of cottonwood trees on the east bank of the kootenay river at the kootenay-Columbia confluence

FOREST REGION/ DISTRICT	MAPSHEET	UTM ZONE	EAST	NORTH	ACCUR.(m)
		11	4 5 2 8 6 1	5 4 6 3 0 7 5	5.00

AIR PHOTO NO.	X CO-ORD.	Y CO-ORD.	LAT.	LONG.	ECOSEC.
			49.318543 N	117.648653 W	

SITE INFORMATION

PLOT REPRESENTING: Camas growing site in a forested area.

BGC UNIT	SITE SERIES	REALM/ CLASS	TRANS./ DISTRIB.	MAP UNIT
ICHkw	Fm01	Fm		

SMR	SNR	SUCCESS STATUS	STRUCT. STAGE	STAND AGE
4	C	YS	4	—

ELEV.	SLOPE	ASPECT	MESO SLOPE POS.	SURFACE SHAPE	MICROTOPOG.
424.3 m	2 %	999 °	DP	CC	—

NOTES

SITE DIAGRAM

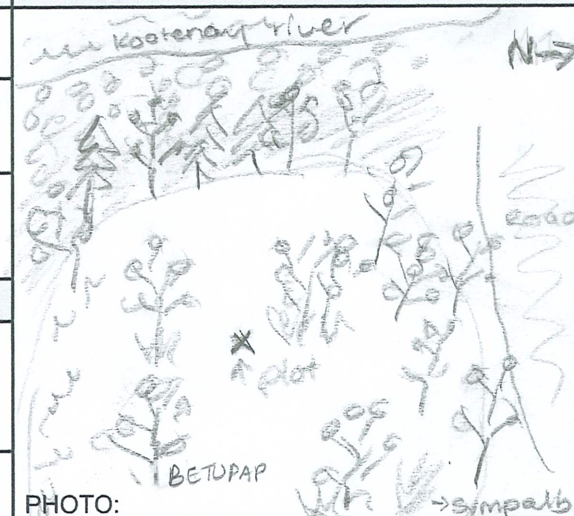

PHOTO:

SITE DIST.		EXPOS. TYPE	

SUBSTRATE (%)

ORG. MATTER	100	ROCKS	
DEC. WOOD		MINERAL SOIL	
BEDROCK		WATER	

FS882 (1) HRE 2008/03

SOIL DESCRIPTION

GEOLOGY BEDROCK –	C. F. LITH. –	**SURVEYOR(S)** TE AE	**PLOT NO.** 04KNP21

TERRAIN	TEXTURE 1 ZS / 2 SZ	SURFICIAL 1 E / MATERIAL 2 FG	SURFACE 1 x / EXPR. 2 p	GEOMORPH. 1 / PROCESS 2
SOIL CLASS. O.MB		**HUMUS FORM** L	PHASE	**HYDROGEO.** u
ROOTING DEPTH 25 cm	ROOT RESTRICT. LAYER	TYPE p*	WATER SOURCE p	DRAINAGE m
R. Z. PART. SIZE FL		DEPTH 30 cm	SEEPAGE NP cm	FLOOD RG. B

PROFILE DIAGRAM

ORGANIC HORIZONS/LAYERS

HOR/ LAYER	DEPTH	FABRIC STRUCTURE	FABRIC vPOST	MYCEL. AB.	FECAL AB.	ROOTS AB.	ROOTS SIZE	pH	COMMENTS (consistency, character, fauna, etc):
L	0.5-0								grass litter

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS G	C	S	TOTAL	SHAPE	ROOTS AB.	ROOTS SIZE	STRUCTURE CLASS	STRUCTURE KIND	pH	COMMENTS (mottles, clay films, effervesc., etc):
Ah	0-7	10yr 3/2	7	SL	2	0	0	2	S	p	v/f			6.0	
Bm1	7-30	10yr 5/2	7	SiL	0	0	0	0	-	f	v/f			6.0	
Bm2	30-35+	10yr 5/2	7	SiL	0	0	0	0	-	x	x			-	very compact!

NOTES: compact silt - very strange, slight depression, old pool?

FS882 (2) HRE 2008/03

ECOSYSTEM FIELD FORM

MINISTRY OF FORESTS AND RANGE
MINISTRY OF ENVIRONMENT

DATE	Y	M	D	PLOT NO.	
	21	10	01	05KNP21	

PROJECT ID	FIELD NO.	SURVEYOR(S)
Camas Soils	01CRV21	TE/AE

SITE DESCRIPTION

LOCATION

GENERAL LOCATION: In the ditch east of playmor rd, west of Brent Kennedy Elementary, parallel to HWY 6

FOREST REGION/ DISTRICT	MAPSHEET	UTM ZONE	EAST	NORTH	ACCUR.(m)
		11	4 6 0 3 3 9	5 4 7 6 7 4 3	5.00

AIR PHOTO NO.	X CO-ORD.	Y CO-ORD.	LAT.	LONG.	ECOSEC.
			49.442060 N	117.547107 W	

SITE INFORMATION

PLOT REPRESENTING: Road side Camas meadow

BGC UNIT	SITE SERIES	REALM/ CLASS	TRANS./ DISTRIB.	MAP UNIT
ICHxw		Xa		

SMR	SNR	SUCCESS STATUS	STRUCT. STAGE	STAND AGE
3	C	—	3a	—

ELEV. (m)	SLOPE (%)	ASPECT (°)	MESO SLOPE POS.	SURFACE SHAPE	MICROTOPOG.
479.2	Ø	—	LV	ST	

NOTES

X-Ditch adj. to N side of HWY6, potential pH impact from winter road salt

SITE DIAGRAM

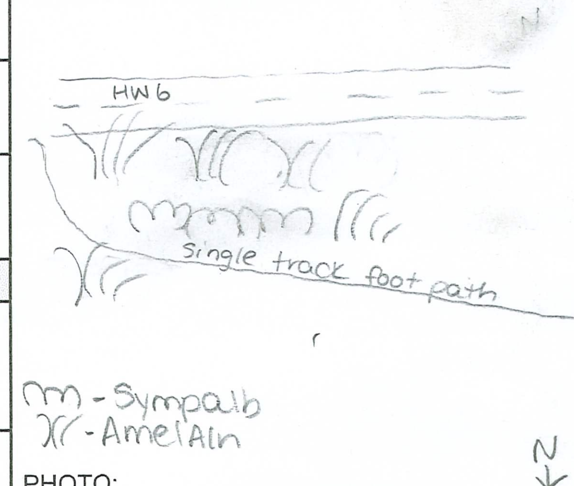

PHOTO:

SITE DIST.	EXPOS. TYPE
R.t, it	

SUBSTRATE (%)

ORG. MATTER	100	ROCKS	0
DEC. WOOD	0	MINERAL SOIL	0
BEDROCK	0	WATER	0

SOIL DESCRIPTION

GEOLOGY BEDROCK –	C. F. LITH. mx	SURVEYOR(S) TE AE	PLOT NO. 05KNP21

TERRAIN TEXTURE 1 2S 2 sg	SURFICIAL MATERIAL 1 E 2 FG	SURFACE EXPR. 1 x 2 p	GEOMORPH. PROCESS 1 2
SOIL CLASS. O.MB	HUMUS FORM	PHASE	HYDROGEO. ✓
ROOTING DEPTH 45 cm	ROOT RESTRICT. LAYER TYPE N/A	WATER SOURCE P	DRAINAGE W
R. Z. PART. SIZE KLS	DEPTH cm	SEEPAGE NP cm	FLOOD RG. X

PROFILE DIAGRAM

ORGANIC HORIZONS/LAYERS

HOR/ LAYER	DEPTH	FABRIC STRUCTURE	FABRIC vPOST	MYCEL. AB.	FECAL AB.	ROOTS AB.	ROOTS SIZE	pH	COMMENTS (consistency, character, fauna, etc):
L	1-0			x	f			–	moss and grass litter

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS G	C	S	TOTAL	SHAPE	ROOTS AB.	ROOTS SIZE	STRUCTURE CLASS	STRUCTURE KIND	pH	COMMENTS (mottles, clay films, effervesc., etc):
Ah	0-15	10yr3/2	7	FSL	0	0	0	0	–	v/f	p	\	\	7	Eolian b/c no CFs + finer
Bm1	15-26	10yr4/3	7	SL	15	10	0	25	S	v/f	p	\	\	6.5	
Bm2	26-43	10yr5/3	7	SL	20	15	0	35	S	v/f	f	\	\	6	lighter than Bm1
BC	43-60+	2.5y5/4	7	LS	40	20	0	60	S	f	f				very grey, more gravels + cobbles

NOTES: pit beside highway 6

FS882 (2) HRE 2008/03

ECOSYSTEM FIELD FORM

MINISTRY OF FORESTS AND RANGE
MINISTRY OF ENVIRONMENT

DATE	Y	M	D	PLOT NO.
				06KNP21

PROJECT ID	FIELD NO.	SURVEYOR(S)
Camas Soils	010x21	AE

SITE DESCRIPTION

LOCATION

GENERAL LOCATION: Oxbox island, Selkirk College

FOREST REGION/DISTRICT	MAPSHEET	UTM ZONE	EAST	NORTH	ACCUR.(m)
DKB		11	452900	5462408	±5

AIR PHOTO NO.	X CO-ORD.	Y CO-ORD.	LAT.	LONG.	ECOSEC.
			49.312599	117.6480	

SITE INFORMATION

PLOT REPRESENTING: Camas meadow on floodplain

BGC UNIT	SITE SERIES	REALM/CLASS	TRANS./DISTRIB.	MAP UNIT
ICHxw		Fm/Ff		

SMR	SNR	SUCCESS STATUS	STRUCT. STAGE	STAND AGE
5	D	DC	2(6)*	-

ELEV.	SLOPE	ASPECT	MESO SLOPE POS.	SURFACE SHAPE	MICROTOPOG.
420 m	0 %	999 °	LV	-	-

NOTES
*Some areas of open grass-dominated flood and some Act-dominated areas

SITE DIAGRAM

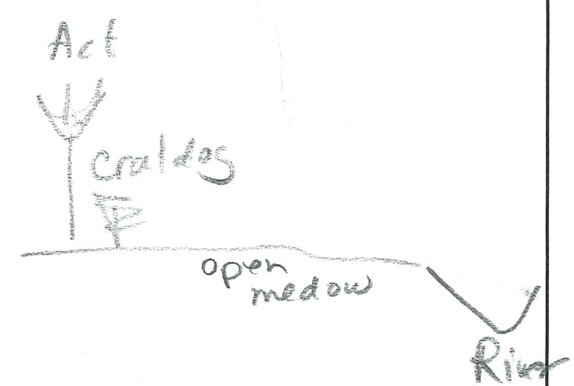

PHOTO:

SITE DIST.				EXPOS. TYPE	
	-				-

SUBSTRATE (%)

ORG. MATTER	100	ROCKS	0
DEC. WOOD	0	MINERAL SOIL	0
BEDROCK	0	WATER	0

FS882 (1) HRE 2008/03

SOIL DESCRIPTION

GEOLOGY BEDROCK	C. F. LITH. mx	**SURVEYOR(S)** AE	**PLOT NO.** 06KNP21

TERRAIN	TEXTURE 1 dgs 2	SURFICIAL MATERIAL 1 F 2	SURFACE EXPR. 1 p 2	GEOMORPH. PROCESS 1 2
SOIL CLASS. GL.MB	**HUMUS FORM** –	PHASE	**HYDROGEO.** F	
ROOTING DEPTH 35 cm	ROOT RESTRICT. LAYER TYPE NP		WATER SOURCE F(P)	DRAINAGE m
R. Z. PART. SIZE KL	DEPTH cm		SEEPAGE NP cm	FLOOD RG.

PROFILE DIAGRAM

ORGANIC HORIZONS/LAYERS

HOR/ LAYER	DEPTH	FABRIC STRUCTURE	FABRIC vPOST	MYCEL. AB.	FECAL AB.	ROOTS AB.	ROOTS SIZE	pH	COMMENTS (consistency, character, fauna, etc):
h	0-1			x	x				0-1 to trace; grass

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS G	C	S	TOTAL	SHAPE	ROOTS AB.	ROOTS SIZE	STRUCTURE CLASS	STRUCTURE KIND	pH	COMMENTS (mottles, clay films, effervesc., etc):
Ah	0-11	10yr4/3	7	FSL	5	0	0	5	R	p	v/f			6	eolian? rich
Bm1	11-25	10yr 5/3	7	SL	10	5	0	15	R	p	v/f				
Bm2	25-45	10yr 5/3	7	SL					R	F	v/f				few more coarsefrags
Bgj	45-60+	7.5y 5/6	7	SL					R	f	m				mottles + slight gleys

NOTES:

FS882 (2) HRE 2008/03